

22nd Annual Scientific Meeting



Ergife Palace Hotel, Rome, Italy

Proceedings – Small Animals

Edited by: Stephen Baines and Martin Owen

July 4–6, 2013

Welcome to Rome, welcome to Italy

A Warm Welcome to Rome!

Dear ECVS Diplomates, residents and colleagues

Rome is the place to see! Rome, one of the most famous and historical cities in the southern part of Europe – one of the most important ancient cultural centres of Europe - offers a variety of architectural, cultural and historical highlights.

Rome is easily accessible by train and car and by direct flights from most cities in Europe and the rest of the world.

Further, we have the marvellous opportunity to host the scientific part of the congress in the Ergife Palace Hotel where all delegates have the possibility to stay. We were able to negotiate very favourable rates and we hope that delegates as well as exhibitors and sponsors will profit from this exceptional deal.

The Ergife Palace Hotel caters for all our needs and wishes. It has modern equipped lecture halls that can host the three parallel small animal and the large animal session, and plenty of small lecture rooms and meeting spaces for side events and discussion groups. There is ample space for a large number of exhibitors and lots of space for the luncheon and coffee breaks

The scientific programme will feature state-of-the-art lectures and in-depth seminars, for large and small animal specialists, a short communication section, the Residents' forum and poster presentations. Invited speakers from all over the world, who are established specialists in their field, will present seminars and state-of-the-art lectures.

Platinum Sponsors



Gold Sponsors



We would like to thank all our sponsors and exhibitors for their support and presence during the 22nd Annual Scientific Meeting at the Ergife Palace Hotel, Rome, Italy

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Scientific programme outline



Small animal programme
22nd Annual Scientific Meeting
July 4–6, 2013

Thursday, 4 July

Pre-congress labs / workshop

ERGIFE PALACE HOTEL

Residents sessions

MERIDA

08.00-12.00 **How to get your research published: Avoiding common pitfalls in study design**

T. Parkin & M. Duz

EFESO

10.00-12.00 **Critical article reading**

O. Gauthier

MERIDA

13.30-15.30 **Interactive clinical session**

L. Déjardin and MA. Radlinsky

Dry labs

TARRAGONA

08.00-15.30 **Urinary and tracheal stenting lab** supported by Infiniti (Theory 08.15 – 10.30 Group A & B/ practicals Group A 10.45 – 12.15 / Group B 12.45 – 14.15)

C. Weisse

POLA

08.00-12.00 **Unicompartmental elbow replacement (CUE)** supported by Arthrex

P. Böttcher, A. Andreoni & P. Winkels

SPALATO

08.00-12.00 **TATE** supported by Biometrix

L. Déjardin & M. Owen

CESAREA

08.00-15.30 **Proximal abducting ulnar osteotomy (PAUL)** supported by Kyon

A. Vezzoni, I. Pfeil

Thursday, 4 July

Start of the main programme

ERGIFE PALACE HOTEL

15.00-16.30 **Registration**

Opening Session – State of the art

SALA 2

Chair: C. Lischer

16.30-17.30 **Limb sparing surgery for osteosarcoma in humans**

N. Baldini

Resident Forum

SALA 1

Chair: H. de Rooster

17.45-18.00 **Evaluation of crural release and ischial osteotomy for relief of tension in the repair of large segmental urethral defects in male cats.**

O. Zemer

Discussant: A. Hamaide

18.00-18.15 **COX-2 Expression in canine anal sac adenocarcinoma and in non-neoplastic anal sacs**

C. Knudsen

Discussant: J. Kirpensteijn



- 18.15-18.30 **Pericardioscopic imaging findings in cadaveric dogs; comparison of an apical pericardial window and sub-phrenic pericardectomy**
O. Skinner Discussant: H. Brissot
- 18.30-18.45 **The comparative biomechanics of the reinforced interdental crossover and the Stout loop composite splints for mandibular fracture repair in dogs.**
A. Kitshoff Discussant: D. Griffon
- 18.45-19.00 **A model of canine hepatic functional units to guide partial canine hepatic lobectomy**
J. Hall Discussant: G. Chanoit
- 19.00-19.15 **Feasibility of optical-guided resection of feline injection-site sarcomas on twelve cats**
M. Millet Discussant: P. Buracco
- 19.15-19.30 **Influence of treatment on the outcome of dogs with incompletely excised grade-2 mast cell tumours**
S. Vincenti Discussant: J. Liptak
- 19.30-19.45 **Bi-oblique dynamic proximal ulnar osteotomy: surgical technique and clinical outcome in 120 dogs**
A. Caron Discussant: D. Koch
- 19.45-20.00 **Role of the quadriceps muscle-tendon unit in a cranial cruciate ligament deficient stifle: A pilot study**
J. Ramirez Discussant: U. Reif
- 20.00-20.15 **Choosing the right mesenchymal stem cells for canine fat-, bone- and cartilage tissue engineering: Preliminary indications.**
F. Verseijden Discussant: D. Clements

Welcome get together

GARDENS OF THE ERGIFE PALACE HOTEL

20.30-23.30 Welcome get together in the gardens of the ERGIFE PALACE HOTEL

Friday, 5 July

Soft tissue surgery – VSSO-ECVS

ORANGE I

In depth – Oncology for the surgeon

Chair: P. Buracco

08:30-09:00 **Relevance of cancer biology for the surgeon**

S. Baines

09:00-09:30 **Rules of oncologic surgery: Any evidence**

J. Liptak

09:30-10:00 **Radiotherapy for surgeons – what, when and how**

L. Findji

10:00-10:30 **Surgical margins**

J. Liptak & S. Boston

10:30-11:00 **COFFEE BREAK**

Combined Small and Large animal

SALA 1

In depth – Infection control in surgical practice

Chair: E. Singer

08:30-09:10 **Strategies to prevent and interrupt contagious diseases in my surgical practice**

G. van Galen

09:10-09:50 **Multi-resistant infections: Current knowledge and strategies**

A. Loeffler

09:50-10:20 **Evidence based hand hygiene in veterinary surgery: what is holding us back?**

D. Verwilghen

10:20-10:30 **Discussion**

10:30-11:00 **COFFEE BREAK**

Neuro- and Orthopaedic surgery

ORANGE II

In depth – Lumbo-sacral disease in dogs and cats: diagnostic and surgical treatments

Chair: B. Meij

08:30-09:15 **Clinical signs: Is it a lumbo-sacral disease**

F. Forterre

09:15-10:00 **Diagnostic imaging**

M. Konar

10:00-10:30 **COFFEE BREAK**

Chair: F. Forterre

10:30-11:15 **Lumbo-sacral disease: static or dynamic problem?**

B. Meij

11:15-12:00 **Decompression and pitfalls**

P. Moissonnier

12:00-12:30 **Foraminotomy and pitfalls**

G. Schwarz

12:30-13:00 **Stabilisation and pitfalls**

P. Meheust

13:00-14:30 **LUNCH BREAK**



Friday, 5 July (cont.)

Urogenital and colo-rectal neoplasia; What's new?

Chair: A. Hamaide

11:00-11:30 **Colorectal tumors: from transanal pull-through approach to bilateral pelvic osteotomy. A critical review**
P. Buracco

11:30-12:00 **Bladder and urethral neoplasia: What's new**
G. Romanelli

12:00-12:30 **Management of intra-pelvic masses**
D. Murgia

12:30-13:00 Discussion

13:00-14:30 **LUNCH BREAK**

Small animal

In depth – What can you learn from my mistakes?

Chair: A. De la Forcade

11:00-11:30 **Soft tissue surgery cases**
MA. Radlinsky

11:30-12:00 **Orthopaedic cases**
U. Krottschek

12:00-12:30 **Soft tissue cases**
J. Kirpensteijn

12:30-13:00 **Orthopaedic cases**
L. Déjardin

13:00-14:30 **LUNCH BREAK**

EFESO

13:15-14:00 **Meet the expert – Minimally invasive osteosynthesis. What are the benefits and the risks?**
L. Déjardin

MERIDA

13:15-14:00 **Meet the expert – Pitfalls in tracheal stenting**
C. Weisse

SALA 1

13:15-13:45 **Information session for residents and supervisors: credentials / grants / exam**

Friday, 5 July (cont.)

Short communication: Oncologic surgery

ORANGE I

Chair: S. Scharvogel

14:30-14:50 **Use of vaginectomy for treatment of vulvar and vaginal neoplasia**
P. Nelissen

14:50-15:10 **Analysis of factors influencing wound healing complications following wide excision of feline injection site sarcomas**
M. Cantatore

15:10-15:30 **Bone cementation of appendicular osteosarcoma with a calcium phosphate cement releasing bisphosphonates. A preliminary case series in dogs and cats**
H. Le Pommellet

15:30-16:00 **COFFEE BREAK**

Short communication: Soft tissue surgery

Chair: S. Baines

16:00-16:15 **The role of lipopolysaccharide in the hepatic response to the attenuation of congenital portosystemic shunts in dogs**
M. Tivers

In depth - Infection in small animal surgery

SALA 1

Chair: L. Findji

14:30-15:00 **Surgical site infection: Where are we at in small animal surgery**
A. Loeffler

15:00-15:30 **Infection's biology: Biofilms**
A. Loeffler

15:30-16:00 **Sepsis: New strategies/biomarkers**
A. De la Forcade

16:00-16:30 **COFFEE BREAK**

In depth - Infection in small animal surgery

Chair: D. Spreng

16:30-17:00 **Animal models of implant related infection**
F. Moriarty

17:00-17:30 **Can we influence the risk of infection by implant design**
F. Moriarty

17:30-18:00 **Current strategies for treating pleural and peritoneal infections**
E. Monnet

Neuro- and orthopaedic surgery

ORANGE II

In depth – Lumbo-sacral disease in dogs and cats: controversial issues and complications

Chair: P. Moissonnier

14:30-16:00 **Round table discussion**

Panel: F. Forterre, P. Moissonnier, P. Meheust, G. Schwarz, B. Meij, M. Konar

16:00-16:30 **COFFEE BREAK**

Short communication: Neuro- orthopaedic

Chair: M. Owen

16:30-16:45 **Minimally invasive approach to the thoracolumbar spinal canal in dogs**
D. Griffon

16:45-17:00 **Evaluation of the effect of a dynamic proximal ulnar osteotomy on the radio-ulnar congruence in 26 elbows**
A. Caron



Friday, 5 July (cont.)

16.15-16.30 **Computed tomography-based anatomical classification of an extrahepatic portosystemic shunt in dogs.**

K. Asano

16.30-16.45 **The use of contrast-enhanced computerized tomography (CT) for presurgical planning in dogs and cats with recurrent draining tracts (RDT) in the thoracic and abdominal wall: 37 cases.**

V. Viateau

16.45-17.00 **Autologous platelet gel to treat chronic decubital ulcers: a randomized blind controlled clinical trial in dogs**

A.M. Tambella

17.00-17.15 **Modified axial pattern flap for the repair of caudal defects of the hard palate. A cadaveric study in dogs.**

J. Milgram

17.15-17.30 **Diagnostic value of echolaryngography to assess laryngeal paralysis in dogs: Evaluation of a new examination protocol.**

F. Arnault

17.30-17.45 **Outcomes and complications associated with a dual chamber pacemaker implantation in 25 dogs (2008-2012)**

N. Hildebrandt

17.45-18.00 **Decision making for caesarean operation in primary uterine inertia: use of vaginal endoscopy and measurement of plasma progesterone**

G. England

17.00-17.15 **Correlation between histopathology, arthroscopic and MRI findings in medial coronoid disease in dogs**

S. Girling

17.15-17.30 **Effect of monocortical vs. mixed monocortical-bicortical fixation on the torsional stability of 3.5mm string of pearls locking plate constructs**

L. Déjardin

17.30-18.00 **Discussion**

Friday, 5 July (cont.)

Resident presentation

ORANGE I

18.10-19.10 **Resident talk and discussion orthopaedic surgery**

U. Krotscheck

Intensive care

A. De la Forcade

ECVS Annual Business Meeting for ECVS Diplomates mandatory

SALA 1

18.10-19.30 **ECVS Annual Business Meeting for ECVS Diplomates mandatory**

Evening free to explore Rome

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Saturday, 6 July

Soft tissue

ORANGE I

In depth – Endocrine surgery

Chair: G. Niebauer

08.30-09.00 **Thyroid**

S. Boston

09.00-09.30 **Parathyroid**

E. Monnet

09.30-10.00 **Pheochromocytomas: Surgery**

E. Monnet

10.00-10.15 **Short-term outcome after laparoscopic adrenalectomy for resection of adrenal masses in 20 dogs and 3 cats.**

P. Mayhew

10.15-10.45 **COFFEE BREAK**

10.45-11.15 **Pancreas**

J. Kirpensteijn

11.15-11.45 **Hypophysis**

B. Meij

11.45-12.45 **Peri-op management of endocrine patients**

A. De la Forcade

12.45-14.00 **LUNCH BREAK**

Vet endoscopic society session

ORANGE II

In depth – Thoracoscopy

Chair: G. Chanoit

08.30-09.00 **Anesthesia for thoracoscopic surgery**

MA. Radlinsky

09.00-09.30 **How to get a space to work in thoracoscopic surgery**

P. Mayhew

09.30-10.00 **Thoracoscopic pericardectomy**

MA. Radlinsky

10.00-10.30 **COFFEE BREAK**

10.30-11.00 **Chylothorax: Does thoracoscopy play a role?**

MA. Radlinsky

11.00-11.30 **Use of thoracoscopy in the management of pyothorax in dogs and cats**

E. Monnet

11.30-12.00 **Thoracoscopic approach for PRAA/PDA**

E. Monnet

12.00-12.30 **Complications of thoracoscopic surgery**

P. Mayhew

12.30-14.00 **LUNCH BREAK**

Orthopaedic

SALA 1

In depth – Osteotomies for elbow incongruities

Chair: P. Böttcher

08.30-09.10 **Current understanding of medial compartment disease**

T. Gemmill

09.10-09.40 **Traditional proximal ulnar osteotomy**

U. Krotscheck

Rationale and clinical outcomes

09.40-10.10 **Dynamic proximal ulnar osteotomy [DPUO]**

M. Olivier

10.10-10.40 **Proximal abducting ulnar osteotomy [PAUL]**

A. Vezzoni

10.40-11.10 **COFFEE BREAK**

11.10-11.40 **Sliding Humeral Osteotomy SHO**

M. Hamilton

11.40-12.00 **Rotating humeral osteotomy**

A. Gutbrod

12.00-12.45 **Round table: Critical review of clinical outcomes**

Panel: P. Böttcher, T. Gemmill, U. Krotscheck, M. Olivier, A. Vezzoni, M. Hamilton, A. Gutbrod

12.45-14.00 **LUNCH BREAK**

Saturday, 6 July (cont.)

EFESO

13.00-13.45 **Meet the expert – How to manage humeral condylar fissures**

T. Gemmill

MERIDA

13.00-13.45 **Meet the expert – How to get started in thoracoscopic surgery**

MA. Radlinsky

Poster session - soft tissue & orthopaedic combined

SALA 1

14.00-15.00

Chair: P. Moissonnier Evaluation panel soft tissue: V. Lipscomb & G. Chanoit Evaluation panel orthopaedic: S. Langley-Hobbs & H. Radke

During Friday 4 soft tissue- and 4 orthopaedic posters of the two lists below will be selected for presentation:

Posters – soft tissue

Evaluation panel: V. Lipscomb & G. Chanoit

Structural characteristics of the soft palate and meatus nasopharyngeus in brachycephalic and non-brachycephalic dogs analysed by CT. J.G. Grand

Intranasal epidermoid cyst in three brachycephalic dogs: preliminary considerations D. Murgia

Splenic neoplasia: Does the dog's size play a role? B. Degasperis

Successful treatment of an extrahepatic portosystemic shunt with an azygos continuation of caudal vena cava in dogs. K. Ishigaki

Use of cone-shaped polypropylene mesh for perineal herniorrhaphy in 39 dogs K. Teshima

Posters – orthopaedic

Evaluation panel: S. Langley-Hobbs & H. Radke

Medial shoulder instability in 5 small breed dogs N. Connery

Comparison of two crimping devices for use in extracapsular stabilization of the canine stifle K.C. Maritato

Quasi-isometric points for the application of the lateral suture technique in cats R. Sousa

Effects of rotation and osteotomy angulation on patellar tendon insertion position during circular tibial tuberosity osteotomy N. Katic

Peri-operative administration of antimicrobials during tibial plateau levelling osteotomy in dogs: 224 cases (2008-2010) A. Singh



Posters - soft tissue (cont.)

Sublumbar abscesses in 46 dogs: A review of clinical findings, diagnosis and treatment R. Thorne

Outcome and prognostic factors for dogs with a histopathological diagnosis of splenic hematoma following splenectomy: 35 cases (1992-2012) S. Boston

Ovary visualisation during laparoscopic ovariectomy in dogs: Comparison of dorsal, semi-lateral and lateral recumbency G. Dupré

Effects of variable pressure pneumoperitoneum on cardiorespiratory parameters and working space during laparoscopy in cats P. Mayhew

Risk factors for gastric spirochete infection in dogs K. Smith

Validation of the use of a uniaxial extensometer to study the biomechanical properties of the dog skin C. Bismuth

Is open or closed castration technique associated with a higher complication rate in dogs? K. Hamilton

Post-operative complications after small intestine surgeries: a retrospective study in 111 cats M. Manassero

Survival, functional and cosmetic outcome of free skin graft standard procedure in dogs and cats: 25 cases K. Minier

Intraoperative bacterial contamination in veterinary medicine N. Andrade

Evaluation of the single port access gastropexy and ovariectomy using a multitrocar port, articulating instruments and angled telescopes in dogs J. Runge

15.00-15.30 **COFFEE BREAK**

Posters - orthopaedic (cont.)

Comparison of post operative infection of tibial tuberosity advancement in 197 stifles with or without post operative antibiotics F. Yap

Non-invasive measure of bone density to predict mechanical properties of the vertebral endplate in the canine cervical spine A. Caron

Trochlear block transposition in treating concomitant medial and lateral patellar luxation in dogs; an experimental study L. Theijse

Guided bone regeneration (GBR) membrane used for management of non-union in small animals I. Tsur

Mechanical torsional properties of tibiae following modified maquet technique or tibial tuberosity advancement L. Brunel

Treatment of thoracolumbar leptomeningeal adhesions and subarachnoid cysts associated with chronic disc herniation in 5 dogs C. Bismuth

Intra-articular botulinum toxin A for treatment of osteoarthritic pain in dogs: a randomized, double-blinded, placebo-controlled clinical trial H. Heikkilä

Total shoulder arthroplasty in two dogs for the treatment of severe glenohumeral arthrosis T. Sparrow

Comparison of two natural resorbable scaffolds containing autologous mesenchymal stem cells for bone regeneration in a sheep model A. Decambron

Efficacy of ultrasonography in canine orthopedic disorders: comparison with other diagnostic imaging tools and investigation of diagnostic validities K. Edamura

Biomaterial wedge for modified tibial tuberosity advancement technique in dogs L. Muzzi

Posters - orthopaedic (cont.)

Omini procedure, a modified over-the-top approach for the reconstruction of the cranial cruciate ligament in the dog using an artificial implant: a cadaveric study L. Omini

Radiographic measurement of the angle formed by the tibial plateau slope and the ground during stance in dogs Y. Fujita

Results of conservative management of intraarticular hyaluronic acid application in dogs with osteoarthritis of the elbow joint M. Hluchy

Plasma concentrations of transforming growth factor beta 1 in dogs with stifle osteoarthritis secondary to cranial cruciate ligament rupture J.U. Carmona

Patellar ligament allograft conserved in glycerin and fixed with interference screws as a substitute of the cranial cruciate ligament in dogs G. Oliveira

The effect of configuration on the biomechanical performance of three different suture materials when used in combination with a metallic bone anchor S. Wasik

Partial para-sagittal patellectomy, a novel method for augmenting surgical correction of patellar luxation in 4 cats L. Rutherford

The effect of contouring a tibial plateau leveling osteotomy plate on the magnitude of osteotomy compression K. Mathis

Influence of tibial rotation on cage size measurement for TTA A. Bolia

Kinematic gait analysis of the thoracic limb of normal dogs and patients with confirmed medial compartment disease using a six-degrees of freedom marker set A. Caron

15.00-15.30 **COFFEE BREAK**



Short communications

ORANGE I

Neuro, orthopaedic and soft tissue

Chair: M. Unger

- 15.30-15.45 **An innovative acellular bi-phasic scaffold for articular cartilage reconstruction**
J. Shani
- 15.45-16.00 **Tightrope® versus percutaneous lateral fabellar suture repairs: technical errors and biomechanical properties**
D. Griffon
- 16.00-16.15 **The association between meniscal injury and the degree of lameness in dogs with cranial cruciate ligament rupture**
B. Wusterfeld-Janssens
- 16.15-16.30 **Comparison of the detection of meniscal tears by arthroscopy and arthrotomy in dogs with cranial cruciate ligament ruptures: A retrospective, cohort study**
P. Gilbert
- 16.30-16.45 **Use of the Kyon revision cup for treatment of acetabular cup loosening: surgical technique and clinical application in 30 cases**
L. Vezzoni

Short communications

ORANGE II

Endoscopic and interventional radiology

Chair: G. Dupré

- 15.30-15.45 **Thoracoscopic resection of right auricular masses in 9 dogs**
S. Libermann
- 15.45-16.00 **Cardiac tumor stenting**
C. Weisse
- 16.00-16.15 **Laparoscopic ovariectomy versus ovariectomy via midline coeliotomy or flank laparotomy in cats: effects on postoperative pain**
O. Gauthier
- 16.15-16.30 **Minimally invasive unilateral arytoid lateralization in dogs - A cadaveric study**
J. Milgram
- 16.30-16.45 **Arterial and central venous thrombosis, thrombectomy and thrombolysis: Preliminary experience**
C. Weisse
- 16.45-17.00 **Thoracoscopic management of cranial mediastinal masses**
P. Mayhew

Orthopaedic

SALA 1

In depth: Elbow replacements

Chair: A. Vezzoni

- 15.30-16.15 **Development of TATE and clinical cases**
L. Déjardin
- 16.15-17.00 **Development of unicompartmental elbow replacement [CUE] and clinical cases**
P. Böttcher
- 17.00-17.30 **Round table discussion: Elbow replacement**
Panel: A. Vezzoni, P. Böttcher, G. Schwarz, L. Déjardin

- 16.45-17.00 **Cyclic testing in torsion of 2 standard and 5 locking plate constructs using the staircase method**
J. Cabassu
- 17.00-17.15 **Effect of intramedullary rod diameter on the bending behavior of SOP-rod construct**
L. Déjardin
- 17.00-17.15 **Learning curve and Initial experience with laparo-endoscopic single site (LESS) ovariectomy using a multitrocar port, angled telescopes and articulating instruments in the dog**
J. Runge
- 17.15-17.30 **Evaluation of short-term outcome after VATS lobectomy versus open thoracotomy for removal of primary lung lobe tumors in dogs**
P. Mayhew

Closing Session – State of the art – Jörg Auer lecture

SALA 2

Chair: T. Phillips

- 17.40-18.30 **Treatment of bone deformity with the Ilizarov method**
Prof. Maurizio Catagni

Farewell Dinner

- 19.30 **Bus departure from the Ergife Palace Hotel**
- 20.30 - end **Farewell Dinner and awards at the *L'Antico Casale La Carovana* – with disco until 1.00 AM**





Large animal programme
22nd Annual Scientific Meeting
July 4–6, 2013

Thursday, 4 July

Pre-congress labs / workshop

ERGIFE PALACE HOTEL

Residents sessions

MERIDA

08.00-12.00 **How to get your research published: Avoiding common pitfalls in study design**

T. Parkin and M. Duz

EFESO

10.00-12.00 **Critical article reading**

O. Gauthier

HAMA

13.00-15.30 **Bovine surgery case discussion**

A. Steiner and T. Schmid

Workshop

HAMA

08.00-12.00 **Case based imaging session**

P. Clegg and E. Bergman

Thursday, 4 July (cont.)

Start of the main programme

ERGIFE PALACE HOTEL

15.00-16.30 **Registration**

Opening Session – State of the art

SALA 2

Chair: C. Lischer

16.30-17.30 **Limb sparing surgery for osteosarcoma in humans**

N. Baldini

Resident Forum

SALA 2

Chair: C. Tessier

17.45-18.00 **Risk factors for large colon volvulus in the UK**

J. Suthers

Discussant: T. Launois

18.00-18.15 **Acute Phase Protein Measurements as a Aid in Differentiating Surgical and Severe Infectious Abdominal Disease**

S. Jacobsen

Discussant: A. Rötting

18.15-18.30 **A topographical anatomical study of the equine omental foramen and comparison with laparoscopic visualisation**

T. van Bergen

Discussant: F. Rossignol



Thursday, 4 July (cont.)

18.30-18.45 **Ex vivo** biomechanical comparison of two types of surgical attachment to the thyroid for the tie-forward procedure

A. Vitte

Discussant: E. Strand

18.45-19.00 **An inertial sensor-based system can objectively assess diagnostic anaesthesia of the equine foot**

S. Maliye

Discussant: M. Schramme

19.00-19.15 **Repeat dynamic endoscopic examination of 34 Thoroughbred racehorses diagnosed with intermittent dorsal displacement of the soft palate.**

P. Kelly

Discussant: S. Barakzai

19.15-19.30 **Use of a transthecal bursoscopic approach for the treatment of navicular bursa sepsis**

J. Kane-Smyth

Discussant: M. Smith

19.30-19.45 **Knot security of 5 metric (USP 2) sutures: influence of knotting technique, suture material, and incubation time in various physiological fluids.**

R. Sanders

Discussant: K. Velde

19.45-20.00 **Experimental model of metacarpo-phalangeal degenerative joint disease in adult horses: an equine groove model**

U. Maninchedda

Discussant: P. Brama

20.00-20.15 **Evaluation of success rate of laparoscopic castration without orchidectomy in 32 mature horses**

C. de Fourmestraux

Discussant: A. Rijkenhuizen

Welcome get together

GARDENS OF THE ERGIFE PALACE HOTEL

20.30-23.00 **Welcome get together in the gardens of the ERGIFE PALACE HOTEL**

Friday, 5 July

In depth - Medical imaging session

SALA 2

Chair: M. Schramme

08.30-09.00 **The use of contrast enhanced CT in equine orthopaedics**

E. Bergman

09.00-09.15 **Comparison of conventional radiography and computed tomography in horses with carpal slab fractures**

C. Steel

09.15-09.45 **Navicular bursoscopy and its correlation to MRI data?**

T. Hughes and M. Smith

09.45-10.15 **How can ultrasonography improve my results of surgery?**

F. David

10.10-10.30 **Discussion**

10.30-11.00 **COFFEE BREAK**

Combined Small and Large animal

SALA 1

In depth – Infection control in surgical practice

Chair: E. Singer

08.30-09.10 **Strategies to prevent and interrupt contagious diseases in my surgical practice**

G. van Galen

09.10-09.50 **Multi-resistant infections: Current knowledge and strategies**

A. Loeffler

09.50-10.20 **Evidence based hand hygiene in veterinary surgery: what is holding us back?**

D. Verwilghen

10.20-10.30 **Discussion**

10.30-11.00 **COFFEE BREAK**

Short communications - general

SALA 2

Chair: A. Martens

11.00-11.15 **Virus-like particles protect efficiently from experimentally bovine papillomavirus type 1-induced pseudo-sarcoids**

S. Brandt

11.15-11.30 **Oesophageal reflux following prosthetic laryngoplasty**

S. Barakzai



Friday, 5 July (cont.)

- 11.30-11.45 **Effect of a stent bandage on the likelihood of incisional infection following exploratory celiotomy for colic in horses: A comparative retrospective study.**
A. Tnibar
- 11.45-12.00 **Experiences with primary closure of equine laryngotomy incisions: A retrospective study of 180 horses.**
C. Lindegaard
- 12.00-12.15 **Acquired inguinal hernias in horses: A retrospective multicenter study of 48 cases recorded between 2005 and 2010**
I.B. François
- 12.15-12.30 **Long-term outcome following laser surgery in the treatment of histologically-confirmed equine sarcoids**
P.C. Compston

12.30-14.00 LUNCH BREAK

POLA

- 13.00-13.45 **Meet the expert – comminuted phalangeal fractures: how to obtain optimal results**
D. Richardson

SPALATO

- 13.00-13.45 **Meet the expert – Tips and tricks in equine laparoscopy**
D. Hendrickson

SALA 1

- 13.15-13.45 **Information session for residents and supervisors: credentials / grants / exam**

Friday, 5 July (cont.)

In depth: Endoscopic versus conventional surgery

SALA 2

Chair: A. Rijkenhuizen

- 14.00-14.20 **Minimally invasive surgery: evidence based ligation and hemostatic techniques**
D. Hendrickson
- 14.20-14.50 **Equine urolithiasis: lithotripsy versus surgical removal**
M. Röcken
- 14.50-15.10 **Results of laparoscopic uteropexy**
P. Brink
- 15.10-15.30 **Ovariohysterectomy in the horse**
M. Röcken
- 15.30-16.00 **Laparoscopy in foals: indications and challenges**
Laparoscopic vasectomy for population control in free ranging african elephants
D. Hendrickson

16.00-16.30 COFFEE BREAK

Surgical case based discussion

- 16.30-18.00 **Surgical Case based discussion: what can you learn from my complications?**
Chair: T. Phillips Panel: M. Schramme, D. Richardson, C. Lischer, B. Bladon, E. Santschi



Friday, 5 July (cont.)

Resident presentation

SALA 2

18.10-19.00 **Equine wound management: from common pitfalls to the most advanced techniques**

D. Hendrickson

ECVS Annual Business Meeting for ECVS Diplomates mandatory

SALA 1

18.10-19.30 **ECVS Annual Business Meeting for ECVS Diplomates mandatory**

Evening free to explore Rome

Saturday, 6 July

Short communications - orthopaedic

SALA 2

Chair: M. Smith

08.30-08.45 **Focal subchondral bone attrition of the metacarpal condyles in Thoroughbred racehorses is associated with accelerated resorption of fatigued subchondral bone during rest periods**

C. Whitton

08.45-09.00 **Is there a risk of inadvertent penetration of the lateral cortex of the radius in LCP fixation of ulnar fractures?**

J. Kümmerle

09.00-09.15 **Preliminary investigation of the treatment of subchondral cystic lesions in the equine medial femoral condyle with a transcondylar bone screw**

E. Santschi

09.15-09.30 **Minimally invasive surgical pastern arthrodesis: an ex vivo study comparing 3 cartilage destruction techniques**

L. van Hecke

09.30-09.45 **Pharmacokinetic and tolerance of intraarticular cefovecin sodium in horses**

M. Perez-Nogues

09.45-10.00 **Dose-dependent effects of intra-articular tiludronate in healthy horses**

K. Duesterdieck-Zellmer

10.00-10.30 **COFFEE BREAK**

In depth: fracture repair and arthrodesis: techniques

Chair: J. Kümmerle

10.30-11.00 **Arthrodesis of low motion joints: the choice between laser, chemical or mechanical cartilage destruction**

L. Lamas

11.00-11.40 **Minimal invasive surgery for arthrodesis and fracture repair: when is it an advantage?**

D. Richardson



Saturday, 6 July (cont.)

11.40-11.55 **Management of small metacarpal / metatarsal bone fractures: conservative approach**

B. Bladon

11.55-12.10 **Management of small metacarpal / metatarsal bone fractures: surgical approach**

C. Lischer

12.10-12.30 **Discussion**

12.30-14.15 **LUNCH**

POLA

13.00-13.45 **Meet the expert – tips and tricks for the treatment of sesamoid bone fracture**

D. Richardson

In depth: fracture repair and arthrodesis: aftercare

SALA 2

Chair: P. Clegg

14.00-14.30 **How to improve the recovery of fracture patients when no pool is available**

M. Senior

14.30-14.50 **Biology of infection and the importance of biofilms**

A. Loeffler

14.50-15.10 **Facts and figures on regional perfusion in the horse**

L.R. Martinez

15.10-15.45 **Optimal management of the infected fracture case**

D. Richardson

15.45-16.00 **Discussion**

16.00-16.30 **COFFEE BREAK**

Saturday, 6 July (cont.)

Poster Session

16.30-17.30 Chair: R. Smith & H. Tremaine

During Friday 8 of the following posters will be selected for presentation:

Two step-surgery combining standing laparoscopy and recumbent ventral midline laparotomy for removal of enlarged pathologic ovaries: 20 cases

F. Rossignol

Use of white blood cell counts, percentage of neutrophils and protein concentration in synovial fluid in monitoring the treatment of horses and foals with septic arthritis or tenosynovitis

M. Cousty

Bovine thoracoscopy: surgical technique and normal anatomy

D. Scharner

Monitoring of surgical site infections in three equine hospitals in Sweden

U. Grönlund

The effect of age on NSAID efficacy in an explant model of cartilage inflammation

S. Freeman

Comparison of the area of cartilage accessible for curettage in arthrodesis of the equine proximal interphalangeal joint using a conventional versus a collateral ligament sparing approach

J. Kümmerle

Tenoscopic-guided annular ligament desmotomy using scissors in 8 cases

T. Gudehus

Structural characterisation of the repair of equine articular cartilage full-thickness defects via micro-computed tomography: comparison between autologous chondrocytes grafting, microfracture and empty defects at 18 months

E. Lallemand

Intra-articular injection of autologous and allogeneic mesenchymal stem cells (MSCs) in horses: clinical and laboratory findings

F.J. Vázquez Bringas

Evaluation of the pharmacokinetics of imipenem following regional limb perfusion using the saphenous and the cephalic veins in standing horses

E. Haziz

Arthroscopic removal of osteochondral fragments in the dorsal pouch of the proximal intertarsal joint in horses

P. Espinosa

Penetrating injuries to the foot: diagnosis, management and outcome of pedal osteitis and sequestra

F. James



Saturday, 6 July (cont.)

- Transthecal arthroscopy of the palmar distal interphalangeal joint in the horse L.M. Rubio Martinez
- Radius medullary decompression as treatment for lameness in a horse L.M. Rubio Martinez
- Evaluation of transport conditions for equine mesenchymal stem cells used in clinical applications, Part 1: Influence of transport containers U. Delling
- Assessment of the sperm motility patterns after standing laparoscopic peritoneal flap hernioplasty of the inguinal rings L.A. Gracia-Calvo
- Comparison of IV pentobarbital and IV propofol for induction and maintenance of anesthesia in sheep M. Goossens
- Perianesthetic morbidity and mortality in the equine: a retrospective study V. Ragno
- Mandibular condylectomy and meniscectomy for the treatment of severe osteoarthritis of the temporomandibular joint (TMJ) in a standing horse R. Sanders
- Temporal antibacterial effect and growth factor degradation rate of equine platelet rich plasma and other blood components against methicillin-sensitive *Staphylococcus aureus* J.U. Carmona
- Intestinal ischemia/reperfusion induces liver inflammatory response in horses G. Marañón
- Ex-vivo biomechanical comparison of three laryngoplasty techniques A. Lechartier

Saturday, 6 July (cont.)

Closing Session – State of the art – Jörg Auer lecture

SALA 2

Chair: T. Phillips

17.40-18.30 Treatment of bone deformity with the Ilizarov method

Prof. Maurizio Catagni

Farewell Dinner

19.30 Bus departure from the Ergife Palace Hotel

20.30 - end Farewell Dinner and awards at the *L'Antico Casale La Carovana* – with disco until 1.00 AM



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Small animals

Resident Forum

Thursday July 4
17.45 – 20.15

Evaluation of crural release and ischial osteotomy for relief of tension in the repair of large segmental urethral defects in male cats.

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Objective

To examine if the tension at the site of a urethral anastomosis can be relieved by performing either a crural release technique or an ischial osteotomy technique.

Study Design

Cadaveric study and 2 case reports.

Animals

Adult male cat cadavers (n=18).

Methods

Cats were divided into two groups; crural release (n=9) and ischial osteotomy (n=9). In each group, 20%, 25% and 30% of the pelvic urethra was excised in 3 cats. The length of the urethral defect was measured after excision of the urethra, and after approximation, prior and subsequent to the tension relieving technique performed. Two clinical cases are described.

Results

Both crural release and ischial osteotomy were effective in relieving the tension encountered at the urethral anastomosis after the removal of 20% of the urethral length. In the ischial osteotomy group, apposition without tension after removing up to 30% of the intrapelvic urethral length was easily achieved. A similar technique was successfully used in 2 clinical cases.

Conclusion

Crural release and ischial osteotomy techniques allow approximation and tension-free anastomosis of large segmental defects of the pelvic urethra in cats.

Cox-2 expression in canine anal sac adenocarcinoma and in non-neoplastic anal sacs

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Introduction

Anal sac adenocarcinoma (ASAC) is a clinically significant canine neoplasm characterised by early lymphatic invasion. Upregulation of COX-2 has been confirmed in several animal and human tissues. The aim of the current study was to evaluate COX-2 expression in canine ASAC and compare it to COX-2 expression in non-neoplastic canine anal sacs.

Material and methods

Formalin embedded histological sections of canine ASAC, some associated metastatic lymph nodes and non-neoplastic anal sacs were recruited for the study from previously archived cases. COX-2 expression in these groups of tissues was evaluated with immunohistochemistry, and the samples were then scored for percentage positivity and intensity of staining.

Results

Twenty-five neoplastic samples and 22 control anal sacs samples were evaluated. All of the neoplastic tissue and the control anal sac tissue stained positively for COX-2 but staining varied with cell type, in addition to varying percentage positivity and intensity between the neoplastic and the control samples. Seventy-six percent of the ASAC had over 50% of the neoplastic glandular cells staining positively whereas in the normal anal sacs, only the ductal epithelial cells stained positively.

Conclusion

These results confirm that COX-2 is up-regulated in canine ASAC and indicate a potential role for COX-2 inhibitors in the management of ASAC. Furthermore, the results indicate that the COX-2 enzyme is expressed in unaffected anal sac apocrine cells.

Pericardioscopic imaging findings in cadaveric dogs; comparison of an apical pericardial window and sub-phrenic pericardectomy

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Introduction

The objectives of this study were to provide pericardioscopic images and to compare the visible pericardioscopic cardiovascular anatomy between apical pericardial window (PW) and sub-phrenic pericardectomy (SPP).

Materials and Methods

Thoracoscopy was performed using a 3-portal technique, with a transdiaphragmatic sub-xiphoid and right and left-sided intercostal portals. A 4 x 4 cm apical PW was created with endoscopic scissors. The intra-pericardiac structures were then assessed pericardioscopically using a subjective ordinal scale (0: not visible, 1: less than 50% seen, 2: greater than 50% seen) prior to SPP. Assessment was repeated after SPP as for the PW. Kruskal-Wallis tests were used to determine if significant differences existed between the techniques.

Results

An apical PW provided limited access to most cardiac structures, with only the right ventricle and branches of the right coronary artery showing > 50% visualization. The right atrium, right auricle, left ventricle and interventricular paraconal branch of the left coronary artery were all visible in the majority of cases via an apical PW. The left atrium and auricle and heart base could not be consistently visualized via PW. Sub-phrenic pericardectomy provided significantly improved visualization of all intrapericardiac structures assessed apart from the right atrium and right ventricle.

Conclusions

A pericardial window centred over the cardiac apex limits evaluation of the pericardial space during pericardoscopy compared to a SPP in cadaveric dogs. An apical PW may, therefore, not be the best surgical option for dogs with pericardial effusion where the aetiology is unknown at the time of surgery.

The comparative biomechanics of the reinforced interdental crossover and the stout loop composite splints for mandibular fracture repair in dogs.

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Introduction

Several methods of mandibular fracture repair have been described in dogs. Ideally these methods should aim for unimpaired fracture healing, restoration of dental occlusion, rapid return to normal function, avoidance of tooth root damage and minimal or no disturbance of perifractural soft tissue. Unfortunately, many commonly used mandibular osteosynthesis procedures do not meet these requirements. Noninvasive fracture repair techniques provide fracture stabilisation while avoiding several iatrogenic complications inherent to conventional fracture fixation.

Materials and Methods

Six pairs of mandibles of young adult small breed dogs, euthanised for reasons unrelated to the study, were evaluated. Osteotomies were created in a standardised fashion and stabilised with either a reinforced interdental crossover composite splint (RIC) or the recognised reinforced interdental Stout loop composite splint (RIS). All constructs were tested biomechanically under standardized conditions. A cantilever bending force was applied using a single column testing machine at a rate of 2 mm/min.

Results

No statistically significant difference was found between the times taken to apply the RIC and the RIS to the osteotomised mandibles. All implants failed by fracturing of the composite over the area of the fracture or by acrylic lifting on the lingual aspect of the 1st molar. The mean ($\pm$ SD) ultimate load was 80.5 N ($\pm$ 40.3) and 58.7 N ($\pm$ 41.7) whereas the mean ($\pm$ SD) stiffness was 0.016 N/m ($\pm$ 0.004) and 0.01 N/m ($\pm$ 0.004) for the RIC and the RIS respectively (both $p=0.03$). There was no statistical difference between the amount of displacement between the treatment groups nor for the total forces absorbed by the two techniques.

Discussion and Conclusion

The conical shape of dog's teeth, the wide diastemas between the teeth and the absence of a supragingival "neck" make interdental wiring technically difficult and the wire prone to dorsal slippage. Subgingival placement and

notching the teeth are both used to prevent dorsal slippage of the wire, but these presumably result in postoperative patient discomfort, significant soft tissue impingement and subsequent trauma.

When applying the RIC, compomer buttons were bonded to the enamel surface of the teeth before wire application. Although a lot of time was consumed by constructing the "buttons" in the RIC group, this time loss was compensated by the relatively easy application of the interdental wire for the RIC as compared to the more elaborate wire application required for the RIS.

Macroscopically, breakage or lifting off the enamel surface was noticed on the lingual aspect preceding either breakage or lifting off the buccal aspect in both composite splint constructs. During testing, a small amount of buccal rotation of the rostral segment together with dorsal opening of the osteotomy site was noted. The authors feel that this resulted in more tension on the lingual aspect and this could explain the observed failure pattern.

The "buttons" attached onto the bonding agent could interdigitate with the composite, potentially creating a strong bond, potentially accounting for the superior biomechanical properties of the RIC construct compared to the RIS. Moreover, the subgingival course of the wire in the RIS could result in less of the "tensioned" wire being incorporated in the reinforced composite splint, resulting in a lesser load being shared by the interdental wire during the initial phases of testing.

The RIC is biomechanically superior to the RIS in the experimental setting used. Further in vitro and in vivo studies should be conducted to assess whether RIC is a valuable alternative to the currently performed procedures used in the management of mandibular fractures in small animals.

A model of canine hepatic functional units to guide partial canine hepatic lobectomy

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Introduction

Surgical resections based on hepatic functional units, each with an independent vascular supply, facilitate partial liver lobe resections in humans without compromising surrounding hepatic parenchyma. This study divided the canine liver into functional hepatic units and the surgical practicality of this division.

Methods and materials

Six cadavers without hepatic or systemic disease were included. In situ portal and hepatic venous acrylic resin casts were created. CT scans and 3D volume rendered images of casts were then produced. In 1 cadaver, a hepatic CT contrast angiogram was performed and a vascular cast then created.

Results

The vascular supply at the hilus of the liver lobes followed a consistent pattern with minor variation in the number of branches of the hepatic and portal veins to each lobe. There was no difference between the CT contrast angiogram scan and the subsequent cast manufactured from the same liver. The size and number of functional hepatic units depended on how distally along the vascular tree they were defined, ranging from many small units if terminal vascular branches were considered to a single functional unit if primary hilar vascular divisions were examined. Practically resectable functional areas were the same for all livers. Partial lobectomy of the left lateral lobe may be performed at the tip, centrally or cranially if care is taken to avoid damaging the hepatic vein running along the medial third of the lobe supplying its distal areas. The right medial lobe can be divided into a smaller dorsal region and a larger ventral region. The remainder of the liver lobes should be removed en bloc or partially resected beyond the site of vascular occlusion.

Discussion and conclusion

Partial hepatic lobectomy is conventionally performed by removing tissue distal to the site of vascular occlusion. The model created in this study describes specific regions of the left lateral lobe and right medial lobe that may be removed

without compromising their remaining parenchyma. This knowledge is useful in planning surgical resections where it is important to preserve liver function.

This study demonstrates a reproducible technique of corrosion casting and CT imaging of the canine hepatic vasculature. Hepatic CT angiography of clinical patients may help guide specific patient hepatic resections by detecting minor individual variations in anatomy and associated with disease processes.

Partial resection of liver segments is possible using current available surgical techniques and instrumentation. Complete lobectomy at the hilus may be practically easier in some situations. Increasing availability of technology largely confined to human surgery may further facilitate partial hepatic resections in veterinary species in the future.

Feasibility of optical-guided resection of feline injection-site sarcomas on twelve cats

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Tumor resection is the first therapeutic indication for feline injection site-associated sarcoma. The most important prognostic factor for local recurrence and thus survival time is clean surgical margins but the major obstacle is the difficulty in delineating preoperative tumour margin.

The primary objective of the study was to investigate if near-infrared imaging using a tumor targeting probe and a portable clinical imaging device is feasible in detecting feline fibrosarcoma cells. A secondary objective was to determine an optimal dose and time of injection before surgery.

Twelve fibrosarcoma-bearing cats were included in the study. The diagnosis was based on clinical and morphological data. Primary tumor spreading or metastases were evaluated by computed tomography.

Cats received a single dose of Raft-RGD-probe intravenously at different doses and times before surgery. Tumor resection was performed by the surgeon with wide margins as recommended. Fluorescence imaging was made and at several steps of the surgery as well as on the tumor tissue, tumor margins and surrounding healthy tissues. Histological analyses were carried out and the sample's tumor infiltration were compared to the fluorescent signals of the samples.

All cats displayed a fluorescent tracer. For the first experimental condition (Raft-RGD-probe (0.6mg/kg, 16h preoperatively) the tumor/healthy tissue ratio was 4 ± 1 , then the tracer dose was decreased and the delay before surgery was augmented leading to a tumor/healthy tissue ratio of 14 ± 1 when cats were injected with Raft-RGD-probe at 0.3mg/kg 36 hours before surgery. Regarding the anatomic pathology analyses, no false negatives were found and the percentage of tumor cells per sample was linearly correlated with the intensity of the fluorescent signal.

In conclusion, our results demonstrated the feasibility of optical-guided resection of fibrosarcoma, without any reported complications. The optimal fluorescence intensity was obtained with 0.3mg/kg of Raft-RGD-probe injected 36 hours before surgery. This system seems to be a promising tool for the accurate, safe and complete resection of feline fibrosarcoma and potentially for resection of other tumors in small animal or human medicine. Nevertheless, it still needs to be established in a randomized, double blinded prospective study, whether optical guided surgery truly improves the survival time and minimises the reoccurrence rate.

Influence of treatment on the outcome of dogs with incompletely excised grade-2 mast cell tumours

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Introduction

The aim of our study was to report and compare the outcomes of incompletely-excised grade-2 mast cell tumours (IEG-2MCTs) being treated immediately and of those being only monitored.

Material and Methods

Dogs were included in the study if they had a grade-2 mast cell tumour (MCT) incompletely excised or excised with narrow (<5mm) margins, a minimum of 10 months follow-up and no signs of metastatic disease at presentation. Dogs were separated into treatment (any combination of surgery, radiotherapy and chemotherapy) and no treatment groups. Follow-up information was obtained from the medical records and contact with the referring veterinarian or owner. For statistical analyses, P-values of <0.05 were considered significant.

Results

115 dogs met the inclusion criteria (92 treatment, 23 no-treatment). The original excision was incomplete in 90 dogs and narrow in 25 dogs. 44 dogs had revision surgery alone, 10 had revision surgery and chemotherapy, 2 had surgery and radiotherapy, 5 had chemotherapy only, 26 had radiotherapy only, and 5 had chemotherapy and radiotherapy. Pathology after revision excision found no signs of residual disease in 46/56 cases (84%). Revision excision led to complete excision in all but one dog (55/56; 98%). The mean follow-up time was 1377 days (range 244-3062). Local recurrence was confirmed in 7 dogs and suspected but not confirmed pathologically in 2 dogs. Metastatic disease was confirmed in 13 dogs and suspected but not confirmed pathologically in 11 dogs. At the end of the study, 45 dogs were dead and 70 still alive. 12 dogs died from causes related to the MCT, 12 died from causes possibly related to the MCT and 20 died from causes unrelated to the MCT. The overall disease-free interval and survival time were 1092 ± 677 days and 1128 ± 669 days, respectively. The 1-yr and 2-yr survival rates were 92% and 82%, respectively. No statistical differences were found regarding disease-free intervals, survival times, recurrence rates, metastatic rates, 1-year survival rates

and 2-year survival rates between groups, or within the treatment group.

Discussion and conclusion

We found signs of residual MCT in only 16% of cases after revision excision and no significant differences in the outcomes of treated and non-treated dogs. This could be explained by a poor ability to differentiate histologically between neoplastic and non-neoplastic mast cells at the resection margins or by alterations in tumour biology following the initial surgery. Based on these findings, it cannot be recommended to systematically and immediately treat IEG-2MCTs rather than monitoring them closely and acting upon potential recurrence.

Bi-oblique dynamic proximal ulnar osteotomy: surgical technique and clinical outcome in 120 dogs

Caron A, Fitzpatrick N, Solano M.

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Objective

Our objectives were to describe a bi-oblique dynamic proximal ulnar osteotomy (BODPUO) technique and to evaluate medium-term clinical outcome in a large canine case series.

Material and methods

Dogs operated by a BODPUO were included. Preoperative clinical and radiographic findings, arthroscopic findings, final diagnosis, surgical procedure, complications, gait platform analysis results and subjective lameness scores (graded from 0-10) over the follow-up period were reviewed. Time to osseous union, osteotomy geometry and osteotomy position were determined from post operative radiographs.

Results

120 elbows (86 dogs) were included in the study. Mean lameness score at first presentation for the 54 scores recorded was 4.02 ± 1.92 . Pre-operative radiographs were taken for all dogs and these suggested elbow incongruence in 43% of the elbows ($n=52$). Arthroscopic findings included elbow incongruence and in addition, 72 elbows were diagnosed with medial coronoid process disease alone (MCD), 22 with MCD associated with osteochondritis dissecans (OCD) lesions of the medial aspect of the humeral condyle, in 8 elbows, MCD coupled with ununited anconeal process (UAP) was identified, 5 elbows had UAP alone, 2 elbows had MCD coupled with humeral intracondylar fissure (1 dog) and one elbow had a lesion of the lateral coronoid process. Ten elbows were affected by incongruence only and no visible cartilage lesions were detected. MCD lesions were recorded as lesions of the radial incisure ($n=20$), the tip ($n=50$) or the entirety ($n=22$) of the medial coronoid process (MCP). The modified Outerbridge score was used to report the severity of MCP cartilage disease: Grade I diffuse ($n=2$), II focal ($n=10$), II diffuse ($n=17$), III focal ($n=5$), III diffuse ($n=34$), IV focal ($n=8$) and grade IV diffuse ($n=25$). Cartilage disease of the medial aspect of the humeral condyle was recorded in 69 elbows. The caudo-cranial and latero-medial mean

osteotomy angles were $55 \pm 7^\circ$ and $48 \pm 10^\circ$ respectively. The most caudo-proximal point of the cut was located at a mean of $39 \pm 5\%$ of the total ulnar length. Sixty-eight BODPUOs were re-examined radiographically up to 4 months after surgery: 88% had radiographic union.

Complications were recorded in 15 elbows (12.5%). No complication required surgical treatment. The mean final follow up time was 23.4 ± 35.6 weeks. Lameness score significantly improved over the time for the scores reported across the whole population (4.02 vs. 0.81; ANOVA; p -value= 0.000). In dogs diagnosed with MCD in isolation, peak vertical force measured on the operated leg significantly increased (84%BW vs. 92%BW; ANOVA - p -value=0.000).

Discussion

This BODPUO technique study provides both subjective and objective clinical outcome measurements for patients with developmental elbow disease treated using the technique. The complication rate was low and all reported complications resolved within the six-month follow-up period.

Role of the quadriceps muscle-tendon unit in a cranial cruciate ligament deficient stifle: a pilot study

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Introduction

The quadriceps muscles-tendon unit (QMTU) has been proposed to be antagonistic to the cranial cruciate ligament (CrCL) in dogs. Application of a tension in the QMTU could trigger the cranial tibial thrust (CrTT) in case of CrCL rupture. However, the effect of this tension could vary between individuals.

Objective

To evaluate the effect of pre-tension applied in the QMTU on the magnitude of CrTT after CrCL rupture, and to identify anatomical and mechanical factors that could influence CrTT

Materials and Methods

In this cadaveric study, the QMTU and the gastrocnemius muscles/ achilles tendon unit (GMATU) were replaced by a strain gage and a turn-buckle to adjust tension.

In a first experimental phase, limbs were placed in a servo-hydraulic testing machine, which applied 50% of body weight (BW) on each limb until a plateau was reached. The target load was maintained during 30 seconds before unloading the limbs. In the second experimental phase, the CrCL was transected, and the limbs were tested in a similar manner. In the third experimental phase, pre-tension of 15% BW was applied in the QMTU, prior to loading the limbs.

Before and after loading the limbs, stifle and tarsal flexion angles were measured using a goniometer. Kirschner wires were placed in the point of origin and insertion of the stifle medial collateral ligament and plain radiographs of the limbs were taken under load in order to measure CrTT. Forces in both the QMTU and the GMATU were recorded and treated via a data logger and an acquisition software.

The differences in forces, CrTT and joints angles were evaluated by means of repeated measures analysis stratified by test condition. To study the influence of TPA,

limbs were divided in 2 groups: Group 1 included TPAs < 23° and Group 2 included TPAs > 23°. A comparison between these groups was conducted by means of a one way ANOVA. In addition, the relation between TPA, CrTT and other parameters was measured in the same limb by means of Pearson correlation.

Results: In QMTU pre-tensioned limbs average CrTT was significantly higher in Group 1 (TPA > 23°) than Group 2 (TPA ≤ 23°). Higher forces were recorded in the QMTU of the limbs with CrCL rupture compared to CrCL intact and CrCL rupture + pre-tension limbs (P<0.05) and in GMATU of the limbs with CrCL rupture compared with CrCL rupture + pre-tension.

Discussion

Under these experimental conditions, pre-tension in QMTU seemed to reduce CrTT upon loading of the limb after CrCL transection. This beneficial effect seemed more pronounced in limbs with TPA ≤ 23. The lesser the TPA, the lesser the tendency of the the tibia to subluxate cranially in the case of CrCL insufficient stifle.

Conclusion

Our results suggest that in certain anatomic conformatiions, pre-tension in QMTU could contribute to the stability of the CrCL deficient stifle under loading.

Choosing the right mesenchymal stem cells for canine fat-, bone- and cartilage tissue engineering: preliminary indications.

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Canine adipose-derived mesenchymal stromal cells (cASC) and bone marrow-derived mesenchymal stromal cells (cBMSC) both possess the capacity to differentiate into multiple different tissue types. In addition, both tissues are readily accessible and can be obtained under local anesthesia, and are therefore perceived as attractive sources of stem cells for tissue engineering and cell therapy in veterinary medicine. Although cASC and cBMSC share biological characteristics, detailed information about their ability to differentiate into different tissue types remains largely unknown. In the present study, we compared cASC and cBMSC in terms of their ability to differentiate into fat-, bone- and cartilage tissue. Cryopreserved cASC and cBMSC were cultured as monolayers and in 3D cell pellets on basal, adipogenic, osteogenic or chondrogenic medium. After 21 days, both cASC and cBMSC monolayer cultures contained Oil Red O positive fat vacuoles when cultured using adipogenic medium and Von Kossa positive calcium depositions when cultured using osteogenic medium. Following 35 days of pellet culture in chondrogenic medium, expression of glycosaminoglycans (GAG) as observed by Alcian blue staining was predominantly present in cBMSC pellets, particularly from the young donors. Likewise, pellet size and GAG concentration was enhanced in these cBMSC pellets compared to the cASC pellets, suggesting that cBMSC may have a superior chondrogenic potential when compared to cASC. In conclusion, our results indicate no difference in the adipogenic and osteogenic differentiation ability of cASC and cBMSC. cBMSC however, may have a superior chondrogenic potential when compared to cASCs. Whereas adipose tissue is an attractive, easily accessible alternative to bone marrow as source for isolating mesenchymal stromal cells, this difference suggests that cBMSC are potentially the better choice for canine cartilage tissue engineering applications.

Small animals - Soft tissue surgery - VSS0

In depth – Oncology for the surgeon

Friday July 5

08.30 – 12.30

Cancer biology

Baines S*.

Willows Veterinary Centre & Referral Service, Solihull, GB

Introduction

In any multicellular organisms, the individual cells form a society that co-operates to ensure the health and survival of the organism. Within this organized society, certain fundamental processes such as cell birth, division, proliferation, differentiation and migration are carefully controlled and there is a balance between cell birth and cell death, so that any net cell gain or loss is appropriate.

Loss of adherence to the society's rules can lead to uncontrolled proliferation, loss of the ability to die, or other abnormal proliferation resulting in a normal cell taking on a malignant phenotype.

1. Normal Cell Division

In any multicellular organism, the cells may die for a number of reasons, making cellular proliferation an essential process to ensure the health of the individual. Reproduction of somatic cells occurs by mitosis (nuclear division) and cytokinesis (cytoplasmic division). The alternation between interphase and mitosis is referred to as the cell cycle.

During **interphase**, which is the longest phase, the chromatin shortens and thickens. In **prophase**, the first phase of mitosis, the chromosomes appear as two identical sister chromatids, and spindle fibres form and radiate from the centrioles at either pole of the cell. In **metaphase**, the spindle fibres pull the centromeres of the chromosomes which become aligned to the middle of the spindle, the equatorial plate. During **anaphase**, the centromeres split and the chromatids are pulled apart by contraction of the spindle fibres. In **telophase**, the final stage, a nuclear membrane is formed around each group of chromosomes and the cytoplasm divides to produce two identical diploid cell.

1.1 The Cell Cycle

The cell cycle comprises four phases (M phase, S phase, G1, and G2). Non-proliferating cells, which are majority of cells in normal tissues, are in a state of arrest (G0) between the M (mitosis) and S (DNA synthesis) phases.

Cells enter the cell cycle in response to external factors including growth factors and cell adhesion. During the G1 phase of the cell cycle, cells are responsive to mitogenic signals. Once the cell cycle has passed the restriction point (R) in the G1 phase, movement through the cell cycle transitions is autonomous.

Cell cycle progression is mediated by sequential activation and inactivation of a family of proteins called cyclin-dependent kinases (CDKs). The activity of CDKs is tightly regulated:

- CDKs associate with regulatory subunits called cyclins, which vary in concentration in the cell during the cell cycle.
- Activity of cyclin/CDK complexes is regulated by phosphorylation.
- CDK inhibitors (CDKI) regulate CDK/cyclin function and can block G1/S progression

Following mitogenic stimulation of the cell to enter G1, class D cyclins are induced, which in turn activate CDK4 and CDK6. Cyclin D/CDK complexes cause phosphorylation of retinoblastoma protein (Rb), resulting in dissociation of the transcription factor E2F from the Rb protein. Rb acts as the switch for the restriction (R) point. Release of E2F enables transcription of numerous genes involved in DNA synthesis.

As G1 progresses, activation of E2F also leads to induction of cyclin E, which associates with CDK2 and this cyclin E/CDK2 complex maintains Rb in the phosphorylated state and is essential for cells to enter the S phase of cell cycle.

At the G1/S phase transition, E2F induces cyclin A and, during early S phase, cyclin D and E are degraded, and cyclin A associates with CDK2 and CDK1. This kinase activity is required for entry into S phase, completion of S phase, and entry into M phase.

Mitosis is regulated by CDK1 in association with cyclins A and B causing phosphorylation of cytoskeletal proteins, such as histones and lamins. This tight regulation of events prevents the uncontrolled passage of normal cells through the cell cycle. However, loss of this control can drive uncontrolled cellular proliferation and cancer.

2. Cellular Responses to DNA Damage

When normal cells are subjected to stress signals, radiation, DNA damage, or oxygen depletion, most cells may enter cell cycle arrest in G1, S, and G2, may undergo programmed cell death (apoptosis) or may do both.

In normal cells, numerous surveillance systems or checkpoints operate to recognize and respond to DNA damage. These cell cycle checkpoints occur in the G1 phase (in response to DNA damage), during S phase (to monitor the quality of DNA replication and the occurrence of DNA damage), and during the G2/M phase (to examine the status of the spindle).

The checkpoint mediated by the tumour suppressor protein p53 (which is induced by DNA damage) is the most well studied. This protein helps to maintain genomic stability and is part of a stress-response pathway when the cell is subjected to damaging stimuli (either exogenous or endogenous) such as gamma irradiation, ultraviolet (UV) irradiation, chemicals, and oxidative stress.

2.1. p53 Functions as a Genomic Guardian

In normal cells, p53 is short lived. However, once phosphorylated p53 is stabilized and then functions as a transcriptional regulator binding to sequences and transactivating a number of genes, including p21. p21 has a high affinity for G1 CDK/cyclin complexes and acts as a CDKI, inhibiting kinase activity, thereby arresting cells in G1. By holding cells in G1, the replication of damaged DNA is prevented and the cell's own DNA repair machinery has the opportunity to repair damage prior to re-entering the active growth cycle

The cellular levels of p53 protein are regulated by the product of another gene MDM2, which acts as a negative regulator of p53 function. MDM2 may do this by targeting p53 for degradation via a ubiquitin proteasome pathway and by suppressing p53 transcriptional activity.

2.2 Cell Death

Cell death typically involves one of two processes: necrosis and apoptosis.

Necrosis is the death of cells through injury or disease and may result from ischaemia, infection, trauma and hyperthermia. Necrosis is characterized by swelling of the cell and lysis.

Apoptosis is a distinct type of cell death generally characterized as the programmed self-destruction of cells that occurs in disease states, as well as part of normal physiologic cell turnover. In apoptosis there is cellular and nuclear shrinkage followed by fragmentation and subsequent phagocytosis.

The morphologic features of apoptosis result from a number of effector proteins (i.e., caspases) and regulators (particularly the Bcl-2 protein family). A wide variety of signals can initiate apoptosis, including Fas ligand (CD95 or FasL) and its interaction with the Fas receptor, tumour necrosis factor (TNF) and its receptor interaction, and certain oncogenes.

The Fas and TNF receptors are members of the death receptor family. These transmembrane proteins with cysteine rich extracellular domains and intracellular regions share a common structure (the death domain). The ligands for these receptors are soluble or cell surface peptides. Ligand binding induces receptor clustering, which itself promotes the binding of a soluble cytosolic protein called Fas-associated death domain (FADD), to the clustered death domains of the receptors. FADD contains a caspase-binding site and activates caspase 8 resulting in downstream activation of effector caspases for apoptosis.

If cells are damaged and unable to repair DNA, p53 expression can upregulate p21 and cause cell cycle arrest or apoptosis through upregulation and expression of Bax (a pro-apoptotic Bcl-2 family protein) and also through priming of caspases. The expression of p53 can also downregulate expression of the Bcl2 gene itself (a pro-survival, negative regulator of apoptosis).

3. From Normal Cell to Cancer Cell

It is difficult to provide an accurate definition of what a cancer cell actually is.

Tumours are generally described phenotypically by being comprised of cells that show abnormal patterns of growth and behaviour which are no longer under homeostatic control mechanisms. A large number of mechanisms are involved in tumour genesis and the resulting types of tumours are varied, but they can be classified into 3 basic types:

Benign tumours: These tumour grow locally and cause clinical signs by their physical presence, e.g. exert pressure, cause obstruction or form a space-occupying lesion, but do not metastasise.

In-situ tumours: These are small epithelial tumours where the neoplastic cells remain in the epithelial layer

and do not invade the basement membrane or supporting mesenchymal tissue.

Cancer: This describes a malignant tumour with the capacity for both local invasion and distant metastasis.

3.1. Multistep Carcinogenesis

Cancer is the end result of a number of different cellular changes that have taken place over a period of time. For example, the number of genetic alterations in a given tumour is 63 for pancreatic tumours and 60 for brain tumours. However, within this large list of genetic abnormalities there is a small number of commonly mutated genes that may act as key driving forces for the development of the cancer phenotype.

Any single carcinogen will not lead to the immediate development of a tumour, but will begin the process of carcinogenesis by **initiation**. This is a rapid step and affects the cellular genetic material and, if this damage is not repaired, the cell may progress to the cancer phenotype.

After initiation, period of tumour **promotion** then follows when the same initiating agent or other agents, e.g. normal hormones or growth factors. This phase is a slow process and indeed may not proceed to the development of cancer in the individual's lifetime.

Each stage of this multi-step process involves genetic changes within the cell that confer a survival advantage for that cell and drives the cell towards a malignant phenotype. Evidence of the relationship between age and the incidence of cancer suggests that between 4 and 7 rate-limiting stochastic events are required to produce a malignant cell. Cancer is a disease involving dynamic changes in the genome of the cell. Among these, the role of the oncogenes (and gain of function mutations) and tumour suppressor genes (and loss of function mutations) are key.

3.2 Oncogenes

The first evidence that genetic changes were involved in carcinogenesis came from studying RNA tumour viruses (retroviruses). The demonstration that a lymphoid tumour may be passed from a tumour-bearing chicken into another chicken after passing a tumour homogenate through a filter led to the identification of avian leucosis virus.

Retroviruses have 3 core genes (gag, pol and env) and an additional gene (viral oncogene or v-onc) that enables the virus to transform cells. These viral genes were subsequently shown to have normal cellular homologues (cellular oncogene or c-onc). The term proto-oncogene refers to a cellular oncogene that cannot transform a cell in its native state, but can be altered to result in transforming ability. As might be expected, most cellular

proto-oncogenes are key genes involved in the control of cell growth and proliferation.

These cellular proto-oncogenes may be classified, following a logical flow from the cell surface to the nucleus, as:

Growth factors: These are molecules that interact with a cell surface receptor. Overproduction of the growth factor or its expression in a cell type that does not normally express it may contribute to carcinogenesis.

Growth factor receptors: These molecules bind growth factors and lead to signalling within the cell. Alterations in these receptors so that cellular signalling occurs without ligand binding or no signalling occurs when the ligand is bound may lead to tumour development.

Protein kinases: These enzymes are involved in signal transduction once a ligand has bound its cognate receptor. Alterations in these proteins may lead to increased cellular signalling independent of ligand binding.

Signal transducers: These are intermediary molecules (e.g. GTPase) that pass the signal from the cell surface receptor to the nucleus of the cell. Mutations in these proteins may lead to excessive signalling.

Nuclear proteins and transcription factors: These proteins control gene expression and aberrant gene expression may affect growth and proliferation.

3.2.1. Mechanisms by which Oncogenes Become Activated

The conversion of proto-oncogene to oncogene is a result of somatic mutations in the genetic material. The mutated allele dominates the wild-type allele, resulting in a dominant gain-of-function mutation and as such, only one allele needs to be mutated. For tumour-suppressor genes, carcinogenesis results from loss-of-function mutations and, since these are recessive mutations, both alleles must be affected.

Mechanisms of oncogene activation are:

Chromosomal translocation:

This involves reciprocal exchange of part of a chromosome between two different chromosomes, leading to an alteration in function. For example, chronic myelogenous leukaemia results from a translocation between chromosomes 9 and 22, which leads to the formation of a small, abnormal chromosome (the Philadelphia chromosome). This results in 2 genes, c-abl and bcr, coming together on the same chromosome. The

BCR/ABL hybrid gene produces a novel protein with elevated tyrosine kinase activity and results in uncontrolled proliferation.

Gene amplification:

An increased number of copies of a gene is probably the most common method of oncogene activation. Examples include human neuroblastoma (myc) and canine soft tissue sarcoma (MDM2)

Point mutations:

These are changes in a single base in the DNA sequence, caused by ionizing radiation, chemical carcinogens or errors in DNA replication and repair, which may lead to an abnormal protein. This may result in sustained proliferation signals or a failure to respond to negative feedback signals. Examples include K-ras mutations in canine lung tumours and Erg-B (epidermal growth factor receptor) in canine mammary tumours.

Viral insertions:

Proto-oncogene function may be altered by insertion of viral genetic elements into the cellular genome. The best example of these acutely-transforming oncoviruses is the Rous sarcoma virus (RSV). These viruses arise as a result of a rare recombination event between a leukaemia virus infecting the animal and a cellular proto-oncogene, in which part of the viral genome is deleted and replaced with a cellular proto-oncogene. This new virus can now induce tumour rapidly because the cancer-causing oncogene is under the control of efficient viral transcription promoters. The virus infects a cell and the continuously-expressed oncogene is inserted into the normal cellular genome. This novel virus is likely to be deficient in replication, but may be spread throughout the animal with help from the normal leukaemia virus. The novel virus is not transmitted naturally and all these genetic events occur within the host.

Retroviruses can also activate cellular oncogenes by integrating genetic elements next to them, e.g. the myc gene in feline T-cell lymphoma, resulting in the oncogene coming under the influence of a promoter of transcription.

3.3. Tumour Suppressor Genes

Tumours may develop as a result of loss of function of tumour suppressor genes, i.e. genes that normally would prevent carcinogenesis. Cells with a mutation in one allele, with one wild-type allele, can usually produce enough of the normal protein to remain normal. Mutations in tumour suppressor genes are therefore normally recessive to the wild-type gene. This led to the development of Knudson's "two-hit" theory of carcinogenesis, i.e. both alleles must be "hit" by a genetic mutation.

For tumours that form as a result of this mechanism, e.g. retinoblastoma, the first (predisposing) genetic mutation could be inherited through the germ line (familial form) or it could arise *de novo* within somatic cells (sporadic form). The second event occurred in the somatic cells. In the sporadic form, both genetic mutation events must occur in the target cells, whereas in the familial form, the cells already contain one mutated gene and only require a one "hit" to cause the second mutation.

P53 is a gene whose product is of crucial importance in cell cycle control and has been called the guardian of the genome, as it directs cells with DNA damage into arrest or apoptosis. Thus the p53 tumour suppressor gene plays an important role in cell cycle progression, regulation of gene expression, and the cellular response mechanisms to DNA damage.

Normally, wild-type p53 will bind to specific DNA sequences and regulate a number of genes associated with the cell cycle and apoptotic pathways, including p21 and bax. These p53- pathways prevent the accumulation of potentially oncogenic mutations and genomic instability and therefore prevent oncogenesis. Failure of p53 to activate these functions may result in uncontrolled cell growth and malignant transformation.

P53 is the most frequently inactivated gene in human neoplasia and has a central role in a number of animal cancer. It may be inactivated either by genetic mutations, such as nonsense, missense or splice site mutations, allelic loss, rearrangements and deletions or by non-mutational mechanisms such as nuclear exclusion, complexing with viral proteins and overexpression of the oncogene MDM2.

3.4. Cancer Arises through Multiple Molecular Mechanisms

The transformation of a normal cell into a malignant cell requires relatively few molecular, biochemical and cellular changes to be acquired and these changes are common to a wide range of apparently different cancers. This is perhaps not surprising since all cells, irrespective of their origin have the same mechanisms to regulate proliferation, differentiation, ageing and cell death. Tumourigenesis is a multi-step process and each step reflects a genetic alteration that drives progression to a malignant phenotype. The vast array of different genetic abnormalities that may be found in cancer cells can be classified into a much smaller number of basic alterations in cellular physiology, called the "hallmarks of cancer", which are underpinned by two main themes; genomic instability and chronic inflammation. There is also another dimension of complexity, in that most tumours are comprised of tumour cells and normal cells, that contribute to the development and maintenance of these characteristics by creating the tumour micro-environment.

The eight acquired characteristics or hallmarks of cancer are:

- Self-sufficient growth
- Insensitivity to antigrowth signals
- Evasion of programmed cell death (apoptosis)
- Limitless replicative potential
- Sustained angiogenesis
- Reprogramming energy metabolism
- Evading immune destruction
- Tissue invasion and metastasis

4. The Hallmarks of Cancer

In one sense, cancer is a common disease in man and animals, with a high proportion of individuals suffering from some form of neoplastic disease at some point in their lives. In another sense, the development of cancer is a rare event. When the number of cells in an individual's body and the number of times that these replicate, the potential for mistakes to lead to malignant transformation is enormous. It is testament to the efficiency of cellular homeostatic mechanisms to recognize and repair DNA damage or cause apoptosis of irreparably damaged cells that malignant transformation of individual cells does not occur more frequently. Put simply, each of the characteristics or hallmarks of cancer reflects a breach in these normal homeostatic mechanisms. However, the cancer cell phenotype is more properly defined by the interactions between the cancer cell, the tumour microenvironment and the enabling effects of fundamental genomic instability and chronic inflammation.

4.1. Self-Sufficiency in Growth Signals

Normal cells require mitogenic stimuli for growth and proliferation. These signals are transmitted to the nucleus by:

- The binding of signalling molecules to specific receptors
- The diffusion of growth factors into the cell,
- Extracellular matrix components of the extracellular matrix
- Direct cell-to-cell adhesion or interaction

Many oncogenes act by mimicking normal growth signals, resulting in the development of a tumour cell that is not dependent on external mitogenic stimuli for proliferation and sustained growth. Probably the most fundamental trait of cancer cells, or at least the most easily understood, is their ability to sustain chronic proliferation. Deregulation of normal growth signals promotes signalling (typically through intracellular kinase domains) to promote progression through the cell cycle, increase in cell size, increase in cell survival, and changes in energy metabolism.

The cancer cell can acquire this capability in the following ways:

- They produce growth factor ligands themselves

- They induce stromal cells to produce such ligands
- There is an increase in receptor concentration on the cell surface that leads to receptor dimerisation, making the cell hyper-responsive to ligands.
- Structural alteration in the receptor that leads to ligand-independent signalling
- Constitutive activation of the signalling pathway, downstream of the receptor, e.g. constitutive activation of the PI3-AKT pathway, through mutations in the catalytic subunit of the PI3 kinase.
- Disruption in negative-feedback mechanisms that silence proliferative signalling, such as the following:
- Mutations in the Ras gene compromise the Ras GTPase activity, which acts as to ensure the effects of Ras are only transitory.
- PTEN is a tumour suppressor protein that counteracts PI3 signalling and its loss has a similar effect to constitutive PI3 activation and promotes tumourigenesis.

The acquisition of autonomy of growth signalling is intuitive, but perhaps too simple, as this tends to regard the cancer cell in isolation rather than interacting with the tumour stroma. In normal tissues, endocrine and paracrine stimuli contribute to growth and proliferation. Cell to cell growth signalling is also likely to occur in tumours and some growth signals for tumour proliferation may derive directly from the tumour stroma, e.g. cancer-associated fibroblasts. Hence, the recruitment or modulation of tumour stromal cells to provide growth signals may be just as important as apparent autonomy from normal signalling mechanisms.

4.2. Insensitivity to Antigrowth Signals or Evading Growth Suppressors

Cellular quiescence of normal tissue homeostasis is maintained by a balance between proliferative and anti-proliferative growth signals. Anti-proliferative signals may be mediated via soluble growth factors that interact with cell surface receptors and immobilized inhibitors embedded in the extracellular matrix and adjacent cells. Normal cells monitor their external environment during the progression through G1 and, on the basis of the external stimuli provided, decide whether to proliferate, become quiescent and enter into G0, or enter into a post-mitotic state (with the acquisition of differentiation-associated characteristics).

Cancer cells evade anti-growth signals via the following mechanisms:

- Mutation of tumour suppressor genes, such as Rb and p53. These molecules play a key role in integration of a diverse range of internal and external signals and control cell cycle progression.
- Evasion of contact inhibition. Cell-to-cell contact in most normal cells results in inhibition of further cell

proliferation to maintain tissue homeostasis. NF2 and LKB1 genes are tumour suppressor genes that are involved in this process and loss of these genes may promote loss of contact inhibition

- Corruption of the TGF- β pathway. TGF- β has anti-proliferative effects in cancer, but this pathway can be corrupted in the later stages of malignancy and can contribute to cancer progression. In this late effect, TGF- β is found to activate a cellular program termed epithelial-to-mesenchymal transition (EMT) that promotes invasion and metastasis (see later).

4.3. Evading Cell Death: The Roles of Apoptosis, Autophagy, and Necrosis

The net growth of any tumour depends on both the rate of cell division and also the rate of cell loss, mainly through apoptosis. Acquired resistance to death via apoptosis and other mechanisms is a hallmark of all cancer types.

One of the most common causes of resistance to cell death is loss of function of p53. This may occur through mutation, by sequestration or inactivation of the protein by viral proteins or by amplification of other oncogenes such as MDM2. Loss of p53 renders the cell less insensitive to DNA damage due to UV radiation, hypoxia, or exposure to DNA-damaging agents, and persistence of potentially oncogenic mutations.

Autophagy is a normal cellular response that operates at low levels in cells but can be induced by cellular stress, such as nutrient deficiency. In autophagy, there is controlled breakdown of cellular organelles to yield energy and cellular substrates for a variety of cellular functions. Autophagy may be involved in both tumour cell survival and, paradoxically, tumour cell death, depending on the cellular state. The link between apoptosis and autophagy suggests that autophagy may represent another barrier for cells to overcome before they can become malignant. However, irradiation or cytotoxic drug treatment in late-stage tumours may promote autophagy, leading to cells attaining a state of reversible dormancy. Thus, autophagy is a barrier to tumour development in early disease but, in late stage disease, may allow cancer cells to survive severe cellular stress.

In both autophagy and apoptosis, the process does not lead to the release of any proinflammatory signals. In contrast, the process of necrosis, observed in larger tumours, causes release of signals that support an influx of inflammatory cells. This may be a positive event, helping to expose the immune system to tumour antigens and promote an immune response. However, some phenotypes of inflammatory macrophages can actually support tumour growth through encouraging angiogenesis, cancer cell proliferation, and invasion.

4.4. Limitless Replicative Capacity

When normal human or animal cells are grown in culture, they have a finite replicative lifespan, i.e. they are capable of a finite number of cell divisions, after which they undergo replicative senescence and are incapable of any further cell division. This mechanism must be overcome to establish the immortal phenotype that is characteristic of the cancer cell.

In mammalian cells, the DNA is organized into chromosomes within the nucleus and these are capped by specialised DNA-protein structures known as telomeres. The major function of these structures is protection, but they are progressively eroded at each cell division because of the inability of DNA to completely replicate itself to the end of the strand. This results in progressive attrition of the telomere as cells proliferate. After approximately 50 cell divisions, cells enter an irreversible (and prolonged) state of cellular senescence (sometimes referred to as mortality stage 1 [M1]), which is characterised by arrest of proliferation without loss of biochemical function or viability. At the end of this period, cells have altered morphology and chromosomal instability, a state often referred to as crisis (mortality stage 2 [M2]).

Telomere maintenance is a feature of virtually all cancer types and is achieved by the expression of the enzyme telomerase, resulting in stabilized telomere length. Telomerase is a ribonucleoprotein enzyme that maintains the protective structures at the ends of eukaryotic chromosomes, at the telomeres. The telomerase complex comprises an RNA subunit containing a domain complementary to the telomeric repeat sequence TTAGGG and a catalytic protein component. The catalytic protein component acts as a reverse transcriptase and catalyses the addition of telomeric repeats onto the ends of chromosomes, using the RNA subunit as a template.

The level of telomerase in malignant tissue compared to normal tissue is much higher, and this differential expression is greater than that for classic enzymatic targets such as thymidylate synthase, dihydrofolate reductase, or topoisomerase II. Expression of telomerase has emerged as a central unifying mechanism underlying the immortal phenotype of cancer cells and has thus become the most common marker of malignant cells.

4.5. Reprogramming Energy Metabolism

Sustained growth and proliferation of cancer cells needs alterations in energy metabolism to ensure that this growth can be fuelled appropriately.

Under normal conditions, normal cells undergo aerobic respiration and metabolise glucose to pyruvate with a net gain in energy as ATP. Cancer cells can undergo a metabolic switch, referred to as the Warburg effect, so that glucose is metabolized to lactate, in the presence

or absence of oxygen, causing a net energy deficit. There is a corresponding upregulation of glucose transporters (e.g., GLUT-1), which increases uptake of glucose into the cytoplasm. This process is exploited in positron-emission tomography (PET) imaging as tumours will preferentially uptake a radiolabeled analog of glucose (^{18}F -fluorodeoxyglucose [FDG]).

The survival advantage of this mechanism is not clear. The metabolic switch may allow diversion of glycolytic intermediates into other biosynthetic pathways that support the production of new cells. Cancer cells may gain an advantage by being flexible in their ability to derive ATP from a number of metabolic pathways that derive ATP from glucose metabolism under aerobic and anaerobic conditions, but may also include efficiencies in metabolizing amino acids and lipids toward ATP and other biomolecule synthesis. This metabolic flexibility may be necessary during primary tumour development but even more so during metastatic progression.

4.6. Sustained angiogenesis

The development of new blood vessels from endothelial progenitors (vasculogenesis) or from existing blood vessels (angiogenesis) is required for cancer progression and metastasis. Endothelial cells or endothelial progenitors are activated by tumour-derived growth factors and result in new capillaries. In normal tissues, endothelial cell proliferation is controlled by a balance between factors that activate endothelial cells and those that antagonise activation. Malignant tumours provide signals that result in endothelial cell survival, motility, invasion, differentiation, and organization.

In many ways, these endothelial processes share parallel features with the processes required for the success of a metastatic tumour cell itself. The creation of new blood vessels requires the tumours to recruit circulating endothelial cells to their site, presumably through the release of growth factors such as vascular endothelial growth factor (VEGF). Circulating endothelial cells must survive at their new site with the help of survival signals (e.g., thrombospondin-1 [TSP-1]) and form vascular tubes that organise to sustain blood flow. Tumour vasculature is typically poorly organized with chaotic, leaky vascular structures with limited adventitial development and excessive branching.

Once developed, this angiogenic switch is associated with the development of a complex and diverse pattern of angiogenesis and neovascularization, which involves a wide variety of tumour and microenvironment-derived growth factors and signalling molecules. Superimposed on this, certain phases of cancer progression are associated with and require periods of anti-angiogenesis and

hypovascularised states may directly contribute to the progression of certain tumours.

Angiogenesis is important in the development of metastasis. The vascularity of a primary tumour (e.g. microvessel density) has been correlated with metastatic behaviour for many tumours. The expression of angiogenesis-associated growth or survival factors and their receptors (i.e., VEGFR) in serum and in tumours, respectively, has also been correlated with outcome. Functional imaging studies correlate vascularity with poor outcome. These findings have supported the development of a number of novel therapeutic agents with anti-angiogenic activities.

4.7. Evading immune destruction

At all stages of progression, tumour cells must evade detection and destruction by the immune system. The ability of the host immune system to recognize and destroy tumour cells (immunosurveillance) was first proposed by Paul Ehrlich in 1909. Molecular support of the mechanisms underlying the theory of immunosurveillance has come with studies of mice deficient in immunomodulatory and pro-inflammatory molecules such as interferon- γ (IFN γ), interleukin-12 (IL-12), and perforin, which develop tumours more readily than wild-type mice.

Clinical evidence for immunosurveillance against cancer was first reported by Coley over 100 years ago. Through the administration of bacteria (Coley's toxin), even and tumour regression was induced in patients with cancer, which mirrors the association between wound infection and improved survival after tumour surgery in some cases. In immunocompetent hosts, immunosurveillance may remove a large number of cancer cells from the primary tumour, from the circulation, and at distant metastatic sites. Cancer cells employ a wide variety of mechanisms to effect this evasion.

Modification of the immune system to treat cancer has been and continues to be an attractive therapeutic strategy. Clinical trials based on this concept have been reported throughout the veterinary literature in dogs with melanoma, soft tissue sarcoma, haemangiosarcoma, osteosarcoma, and others, using a variety of immune-based therapies. This principle has been the basis for the development and approval of a therapeutic vaccine directed against a melanoma antigen in dogs with melanoma.

4.8 Tissue invasion and metastasis

Metastasis is the dissemination of neoplastic cells to secondary sites, where they proliferate to form a macroscopic mass. Metastases are not a direct extension of the primary tumour and are not dependent on the route of spread. The process of metastasis is believed to occur through the completion of a series of step-wise events.

This is a complex topic and will not be discussed as part of this topic.

6. The Enabling Characteristics

The hallmarks of cancer are defined as functional capabilities that allow cancer cells to survive, proliferate and disseminate. The fact that these critical hallmarks can be attained within a single tumour is explained by two key enabling characteristics of cancer: genomic instability and tumour-promoting inflammation.

6.1. Genomic Instability

Most of the hallmarks of cancer require genetic changes through mutation, amplification, or chromosomal translocation. However, random mutation is an inefficient cause of sustainable genetic changes because of the complex and fastidious maintenance mechanisms of the normal cell that monitor DNA damage and regulate repair enzymes. Thus cellular genomes must attain increased mutability or genome instability in order to overcome the various homeostatic mechanisms that ordinarily prevent the emergence of a cancer cell.

The following mechanisms may support the development of genomic instability:

- Defects affecting various components of the DNA-maintenance machinery (caretakers of the genome), which may involve mutations in caretaker genes
- Loss of telomeric DNA, which may cause karyotypic instability and chromosomal changes (amplification/deletion)
- Inactivation of tumour suppressor genes through genetic (mutation) or epigenetic (DNA methylation/histone modifications) mechanisms

6.2. Tumour-Promoting Inflammation

Tumours contain infiltrates of inflammatory cells and other cells of the immune system that have generally been considered to be evidence of activation of the immune system to eradicate the tumour. However, tumour-associated inflammation may paradoxically have a tumour-promoting effect.

Inflammation can contribute to tumourigenesis through the following various mechanisms

- Supply of growth factors and growth signals to the microenvironment that promote angiogenesis, cell proliferation, and invasion
- Provision of induction signals that support epithelial to mesenchymal transition
- Encouraging the progression of premalignant lesions to cancer
- Production of mutagenic reactive oxygen species

Many of the cells that contribute to this are components of the innate immune system, particularly macrophages with a specific, cancer-promoting phenotype. Tumour-associated macrophages form part of the tumour microenvironment that supports the maintenance of the cancer phenotype.

6.3. The Pathway to Cancer

The eight acquired capabilities of tumour cells and the two overarching enabling characteristics of genome instability and tumour inflammation have been outlined.

However, the pathways by which cells become malignant are highly variable. Mutations in certain oncogenes may occur early in the progression of some tumours and late in others. Therefore, the acquisition of the essential cancer characteristics may appear at different times in the progression of different cancers. Furthermore, in certain tumours, a specific genetic event may contribute only partially to the acquisition of a single capability, while in other tumours it may contribute to the simultaneous acquisition of multiple capabilities. However, irrespective of the path taken, the acquired capabilities of cancer are the same for multiple cancer types and will help clarify mechanisms, prognosis, and allow the development of new treatments.

7. The Tumour Microenvironment

Tumours are now regarded as an organ system similar to the tissues from which they derive, in contrast to the reductionist view of a tumour as a mass of abnormal cells.

A tumour is a complex system of tumour cells and supporting or stromal cells which all contribute to the maintenance of the malignant population and support invasion and metastasis. The importance of the various cell types that make up the tumour microenvironment cannot be overstated.

The major cell types involved in this cancer organ system are:

- Cancer cells and cancer stem cells (CSCs)
- Endothelial cells
- Pericytes
- Immune cells
- Tumour-associated fibroblasts

7.1. Cancer Cells and Cancer Stem Cells

The concept that a cancer can arise from any cell in the body, along with the stochastic model of tumourigenesis, has recently been challenged. The stem cell theory of cancer states that tumours contain a hierarchical structure of cells, similar to normal tissues. Thus cancer stem cells (CSCs) (or tumour-initiating cells) are the founder cell population for a tumour and only these cells are tumourigenic and capable of extensive proliferation.

Although this is controversial, CSCs may be a common constituent of many, if not all, cancers. The CSC model also explains the development of metastasis in which only a small number of cells within a tumour have the ability and plasticity to endure the stresses of metastatic progression, survive during a dormant period, and then progress, proliferate, and differentiate into a complex heterogeneous metastatic lesion.

If tumour growth and metastasis are driven by a small population of CSCs, then the failure to develop therapies that are consistently able to eradicate solid tumours may be explained. Although chemotherapy can result in a partial remission in metastatic tumours, this is usually transient and may not improve overall survival. One explanation for this treatment failure is the development of drug resistance by the cancer cells as they evolve, but another explanation is that the treatment does not kill CSCs, which therefore persist and allow the tumour to remain.

Stem cell populations in human cancers have been identified in breast, bone, brain, colon, pancreas, liver, ovary, and skin. The origin of CSCs within solid tumours is not clear and may vary between tumour types. The tumour-initiating cell may be the resident adult or somatic stem cell or the resident progenitor or transit-amplifying cell. A characteristic of the CSCs is that they undergo asymmetric division and self-renew, like haematopoietic stem cells, providing a continual resident population of highly resistant cancer cells.

Existing cancer therapies have generally been developed against the bulk population of tumour cells because they are often identified by their ability to shrink tumours. Because most cells with a cancer have limited proliferative potential, the ability to shrink a tumour mainly reflects an ability to kill these cells. Normal stem cells from various tissues tend to be more resistant to chemotherapy than mature cell types from the same tissues. If the same is true of cancer stem cells, then CSCs would be more resistant to chemotherapy than tumour cells with limited proliferative potential. Even therapies that cause complete regression of tumours might spare enough CSCs to allow tumour regrowth. Therapies specifically directed against CSCs might therefore result in more durable responses and potentially even cures of metastatic tumours. In veterinary oncology, putative stem cell populations have been identified for breast, bone, brain, and liver. Interestingly, stem cell populations appear to have altered DNA repair pathways, which may explain their resistance to conventional drugs.

The acquisition of CSC characteristics may be linked to the process of epithelial to mesenchymal transition (EMT). Cells that undergo EMT also take on characteristics reminiscent of a CSC phenotype. For example, they have

the ability to self-renew and may support the ability of cells to colonise outside of the primary tumour. The signalling processes that support EMT may also serve to maintain the CSC population within a tumour and may also suggest plasticity in CSC populations.

7.2. Endothelial Cells

Tumours are heterogeneous collections of cells and much of this heterogeneity is found in the stromal compartment, particularly the endothelial cells that form the tumour-associated vasculature. VEGF and fibroblast growth factor are important signalling pathways in the formation of these vessels. New pathways that are signalling systems for neoangiogenesis may represent therapeutic targets, e.g. Notch signalling.

7.3. Pericytes

Pericytes are mesenchymal cells that ensheath the blood vessel endothelium and are a major cell type supporting the tumour vasculature.

7.4. Immune Inflammatory Cells

An environment of chronic inflammation is an important enabling characteristic that supports the acquisition of cancer-related capabilities and traits. Cells of the innate immune system are particularly important for the maintenance of the tumour environment and, in particular, tumour-associated macrophages with a specific pro-tumour phenotype can enhance cellular proliferation, invasion and neoangiogenesis.

7.5. Cancer-Associated Fibroblasts

Cancer-associated fibroblasts comprise a passive supporting structure for many tumours but can also play a more active role in promoting invasion, cell proliferation, and neoangiogenesis. Within any tumour, there is a complex signalling network between and within cancer cells that maintains the cancer phenotype and, superimposed on this, are complex signalling networks between stromal components and stromal cells and cancer cells.

Just as there is an effective evolution of cancer cells as the disease progresses from early stage to late stage disease, there may be a similar evolution in the tumour stroma that is driven by the cancer cells themselves. Cancer pathogenesis is a complex process that is highly dynamic and context dependent.

8. Summary

A simplified view of the complex process of carcinogenesis is that genomic instability and an environment of chronic inflammation support and provide a basis for the acquisition of the eight fundamental cancer characteristics. The identification of these characteristics guides an understanding of the underlying mechanisms in cancer

and the identification of potential biomarkers of disease or prognosis and therapeutic targets.

However, despite the ability to design specific therapies against key targets in cancer pathogenesis, a cure is still a long way away. There are many reasons for this, including inherent tumour heterogeneity (due in part to tumour stem cells), continuous tumour evolution, and contribution of the tumour microenvironment. Maximising the benefit of new therapeutic strategies will require more than one approach and more than one target.

Rules of Surgical Oncology: Any Evidence?

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The principles of surgical oncology are well known: biopsy for diagnosis and prognosis; clinical staging to determine the extent of disease; and surgical excision in a manner that maximizes the chances of a successful outcome. But are these principles based on scientifically proven facts or unproven theories and practices?

Clinical staging is the diagnostic workup of a patient to determine the size of the local tumor, whether there is regional lymph node metastasis, and the presence of distant metastasis. The size of skin tumors can often be measured with calipers, but caliper measurements frequently underestimate the size of the tumor when compared to ultrasound or advanced imaging of the tumor; yet we rarely perform imaging on skin tumors to determine the true extent of these tumors and hence plan the surgical approach. The same is true for bone tumors with various imaging modalities either underestimating or overestimating the true extent of the tumor. For limb-sparing candidates, this results in either over-treatment, which can potentially increase the risk of construct failure, or under-treatment, which increases the risk of incomplete tumor excision, local recurrence and poorer survival times.

The determination of regional lymph node status has traditionally been based on palpation of the nearest anatomical lymph node. However, palpation of the regional lymph node is an unreliable method for the determination of nodal metastasis because metastatic lymph nodes are not necessarily firm, fixed or painful. Furthermore, normal lymphatic drainage patterns are quite variable and hence the nearest draining anatomical lymph node may not be the sentinel lymph node for that tumor. For instance, thyroid carcinomas will metastasize cranially to the submandibular lymph node bed; oral tumors metastasize to any of the submandibular, medial retropharyngeal or parotid lymph nodes; oral tumors metastasize to the contralateral lymph nodes; and mammary tumors can metastasize to the inguinal or axillary lymph nodes regardless of the location of the mammary tumor. For this reason, sentinel lymph node mapping with blue dyes, nuclear scintigraphy and/or intraoperative gamma probes is used in human

oncology to identify the sentinel lymph node, or the first lymph node draining the tumor. The sentinel lymph node is representative of the entire lymph node bed and helps determine prognosis and the need for adjuvant therapy. Yet sentinel lymph node mapping is rarely used in veterinary surgical oncology. Furthermore, determining nodal metastasis can be difficult, especially in canine mast cell tumors.

Imaging modalities used to identify pulmonary metastatic disease vary in their sensitivity for detecting pulmonary nodules. In general, pulmonary nodules as small as 7-9mm can be detected using high detail screens whereas lesions as small as 1-2mm can be seen using breath-holding helical CT scans of the thoracic cavity. However, the routine use of CT scans for pulmonary metastasis checks are not cost effective. Furthermore, dogs with appendicular osteosarcoma with pulmonary nodules detected on CT scan but not radiography have the same prognosis when treated with limb amputation and chemotherapy as dogs with no pulmonary metastasis on either CT scan or radiographs. So we do not yet know the relevance of pulmonary metastasis in cats and dogs detected on CT scans but not radiographs.

The principal aim of surgical oncology is the complete resection of the local tumor to minimize the risk of local tumor recurrence and the need for re-excision. Surgical margins are usually determined as a metric measurement depending on the tumor type. However, except for grade I and II mast cell tumors, metric measurements are based on information passed down over the years with no scientific studies to support these recommendations. In human surgical oncology, margins are often assessed intraoperatively using gross assessment, imaging, frozen sections, or touch imprint cytology. Some of these techniques are either impractical or expensive in veterinary medicine, but others are readily available and cost-effective yet are not routinely used. The future of margin assessment in humans is the intraoperative use of fluorescent spectroscopy, and hopefully this technology will be available for use in veterinary medicine.

In cats and dogs, as in people, there is no consensus regarding what surgical margins should be used for tumor resection and what constitutes adequate surgical margins. In humans, adequate margins depends on the cancer type (for instance, breast carcinoma versus musculoskeletal soft tissue sarcoma), but margins can be assessed as adequate if there is no histologic evidence of cancer cells on the edge of the resected specimen (yes/no), cancer cells are > 2mm away from the edge of the specimen, or cancer cells are > 10mm away from the edge of the specimen. Another disadvantage of the histologic assessment of margins, other than not being able to assess all margins, is that the assessment of margins is completed after surgical resection which means that the completeness of surgical resection and the need for adjunctive therapy is not known until well after surgery. This harks back to the need for intraoperative assessment of surgical margins using techniques that have a high correlation with histologic margins.

A further problem is what do we do following incomplete excision? Previously, incomplete excision was associated with local tumor recurrence and the need for adjuvant therapy. However, the recurrence rate for incompletely excised mast cell tumors and soft tissue sarcomas in dogs is approximately 25%. This means that up to 75% of dogs with these tumor types were never going to recur and were over-treated with either radiation therapy and/or chemotherapy. The challenge is to identify cats and dogs at risk of local tumor recurrence, most likely with immunohistochemical markers or genetic mutations, and treat appropriately, while observing and not treating animals who do not express these markers or mutations.

As clinicians, we either do what we know or know what we do. For a long time, surgical oncologists have been doing what we know, but we really should be developing a better understanding of what we do on a day-to-day basis with well designed prospective studies investigating preoperative staging, surgical margins, and postoperative management of cats and dogs with cancer.

The scalpel and the beam: Radiotherapy for the surgeon

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Treating cancer is very often best done through a multimodal approach and the (oncologic) surgeon must strive to become a (surgical) oncologist. As radiotherapy becomes more widely available, it is increasingly important for all surgeons to be aware of its principles, indications and limitations to understand how to integrate radiotherapy in the range of therapeutic options. To provide the best treatments available, the surgical, medical and radiation oncologists must work in close cooperation, each having a deep understanding of the others' specialties in order to determine what their role will be in the optimal treatment plan.

The precise indications for a combination of surgery and radiotherapy in veterinary oncology are too many to be listed here, and more information on the application to particular tumour types is available elsewhere¹⁻³.

What surgeons need to know about radiotherapy

In its most common indications, radiotherapy is similar to surgery in that it is a local treatment used to treat solid tumours. It uses ionising radiation to cause cell death through damage to critical molecules such as DNA. This damage to critical cellular molecules is either caused by direct effect or through the formation of free radicals near them. Oxygen is therefore important in the cellular response to radiation and well oxygenated cells are more radiosensitive than hypoxic ones. As DNA is a major target of radiation-induced cellular damage, much of the resulting cell death occurs at the time of the next cell division (reproductive death). Consequently, the effects of radiotherapy are not readily apparent but are variably delayed depending on the cellular turnover rate of the irradiated tissues. Tissues with a rapid cellular turnover are therefore called "acutely-responding" and those with a slower turnover "late-responding". Although radiotherapy takes advantage of the differences in cellular biology (repair capacities, cellular turnover, etc.) between normal and neoplastic tissues to preferentially be detrimental to tumour cells, it is non-selective and normal tissues in the radiation field will also be affected. As it is not yet possible to strictly limit the administration of radiotherapy to neoplastic tissues, the tolerance to radiation of the normal tissues included in the radiation field is the limiting factor of the maximal dose of radiation which can be administered for treatment of a tumour.

Radiation therapy is most commonly applied as an external beam (teletherapy), but it can also be applied directly in contact with tissues (brachytherapy) or systematically (radioisotopes). Brachytherapy and radioisotopes will not be discussed here. Different types of radiation therapies can be used, depending on the source of radiation and resulting energy delivered to tissues. Currently, orthovoltage and cobalt-60 radiotherapy machines are being abandoned in favour of high-energy megavoltage linear accelerators. Different modalities of application of external beam radiotherapy exist (e.g. stereotactic, imaged-guided, intensity-modulated). Briefly, through different strategies, these modalities all aim at more selectively administering radiotherapy to the tumour and not to surrounding normal tissues. This is achieved through coordination between imaging and radiation units to multiply the incidences of treatment and/or more precisely collimate the radiotherapy field.

The Gray (Gy) is the unit of measurement used in radiation therapy. Although the total dose administered for treatment of a tumour is important, the fractionation protocol and overall duration of the course of radiation therapy are equally important. Indeed, the maximal dose which can be administered depends on the dose per treatment: the more fractionated the treatment (i.e. the smaller the dose per administration), the higher the total dose which can be given without unacceptable risks of side-effects. Similarly, the period of time over which the entire course of radiotherapy is dispensed is critical and, as a rule, the shorter the treatment, the more efficacious it is. The design of the radiotherapy protocol is therefore based on the type of tumour to be treated, the aim of the treatment (palliative vs curative intent) and practical considerations which include owner availability and financial resources. Currently, a standard course of radiation consists of 3 to 5 administrations a week, delivering 2.7 to 4 Gy per administration to a total dose of 42 to 57 Gy. However, in a palliative setting, hypofractionated protocols (e.g. 4 weekly treatments of 7 to 9 Gy) can be considered, since the risk of late adverse effects is rendered somewhat irrelevant by the short life expectancy of the patient. Conversely, more fractionated protocols involving several treatments a day are also commonly used.

Radiotherapy and surgery can be synergistic^{4,5}. When surgery fails in the treatment of solid tumours, it is most

commonly at the margins and the disease remaining is typically microscopic. The bulk of the tumour is typically excised. Conversely, radiotherapy is most efficacious against microscopic disease but will fail on bulky tumours, mainly as a result of their hypoxic centre. Combining surgery and radiotherapy therefore aims at compensating for the inherent limitations of each.

When to consider and administer radiotherapy

The wrong way for a surgeon to see radiotherapy is to consider it a safety net to think about when surgery was retrospectively found to be insufficient (e.g. incomplete margins). For surgery and radiotherapy to be synergistic, they need to be coordinated well, which requires collaboration of the surgeon and radiation oncologist early on in the management of the cancer patient^{2,6}. Whenever the surgeon is not extremely confident that a solid tumour can be excised entirely with sufficient margins, consultation with a radiation oncologist is indicated at the time of tumour staging. It may appear that neoadjuvant radiation therapy is the best course of action or that a particular positioning during advanced imaging would be helpful for the radiation oncologist. Conversely, if surgery is still thought to be the most appropriate first step of the treatment, preoperative consultation with a radiation oncologist will allow the surgeon to discuss the surgery plan to make sure it will not compromise the adjuvant radiotherapy (orientation of the wound, potential drains, etc.). The aggressiveness of the surgical excision can also be adapted according to the radiosensitivity of the tumour to be excised: the more confident the radiation therapist is that long-term tumour control can be achieved through radiation, the less aggressive the surgery needs to be. The surgeon can also discuss the usefulness and the modalities of making the limits of the surgical field easily recognisable for the radiation oncologist (cf. infra).

When combined with surgery, radiotherapy can be administered preoperatively (neoadjuvant radiotherapy), during surgery (intraoperative) or after surgery (adjuvant radiotherapy). Intraoperative radiation therapy is reported⁷⁻¹⁰ but rarely used in veterinary medicine and will not be discussed here.

The main advantage of neoadjuvant radiotherapy is that the radiation therapy is much easier to plan when the tumour is intact and the radiation field is then smaller, which makes radiotherapy more precise and more efficacious. In addition, before surgery, the tissues around the tumour are normoxic and therefore more radiosensitive than after surgery, as the scar tissues tend to be hypoxic. Neoadjuvant radiotherapy also potentially decreases the risk of tumour recurrence following intraoperative seeding by sterilising the tumour cells before they are seeded. Lastly, neoadjuvant radiotherapy eliminates the delay in starting the course of radiation, which can potentially be long when surgery is performed first and postoperative complications occur. One disadvantage of neoadjuvant radiotherapy is to allow

more time for the tumour to metastasise by delaying surgery: a period of 7 to 15 days is usually left between the last radiotherapy fraction and surgery. It increases the risk of postoperative wound complications¹¹, more than adjuvant radiotherapy¹². However, in our experience, when the course of radiation is properly planned in view of being followed by surgery (e.g. lower total dose, sufficient fractionation), the risk of surgical wound complication is not high, except for oral tumours. In a study of 26 dogs which had skin flaps to cover wounds before or after radiation therapy, neoadjuvant therapy did not appear to result in more frequent wound healing complications¹³. This study also confirmed that increased fractionation was associated with fewer complications. Similarly, when neoadjuvant radiotherapy is designed well, the aspect and physical characteristics of the irradiated tissues are not profoundly modified and this does not complicate surgery significantly. After hypofractionated protocols, the adverse effects on normal surrounding tissues are greater and tissues can become fibrous and abnormal-looking, which can make surgical dissections more difficult and may be the reason why many surgeons prefer to avoid operating on irradiated tissues.

A common misconception is that neoadjuvant radiotherapy allows a more conservative surgery with the same efficacy of the overall treatment. Neoadjuvant radiotherapy aims at killing tumour cells beyond the achievable surgical margins, where it is the most efficacious. Closer to the tumour, macroscopic (and therefore more radioresistant) disease is more likely to be present and radiotherapy is less likely to completely sterilise the tissues from tumour cells. Therefore, wide margins are still required when surgical excision is performed. The only exceptions are very radiosensitive tumours which can effectively be "down-staged" and rendered more easily operable (e.g. mast cell tumours, thyroid carcinomas)¹⁴. In other words, for the vast majority of tumours, and feline injection-site sarcomas in particular, the surgeon should still seek for wide margins after neoadjuvant radiotherapy. The only tumours which can be more marginally excised after neoadjuvant radiotherapy are especially radiosensitive tumours.

The main advantage of planning radiotherapy after surgery (adjuvant radiotherapy) is that it may not be needed at all if surgery achieves sufficient margins. However, when needed, radiotherapy is then less efficacious as a result of the larger and less well-defined treatment field (especially if the radiation oncologist was not consulted before tumour resection), and of the relative hypoxic state of cells within the wound. Consequently, higher radiotherapy doses are required compared to that used for neoadjuvant radiotherapy¹⁵ and, in general, larger radiotherapy fields are associated with greater toxicity to normal tissues⁵. In this setting, all macroscopic disease should be resected for radiotherapy to be most efficacious. "Debulking" surgeries leaving macroscopic disease in the wound are seldom indicated.

There is yet no evidence supporting the superiority of administering radiotherapy either preoperatively or postoperatively¹⁵ and the choice must be made on a case-per-case basis, considering the theoretical pros and cons of each approach.

How to operate around radiotherapy

Operating after radiotherapy

When performing surgery after neoadjuvant therapy, little changes are required compared to standard surgical technique. Careful manipulation of tissues to keep surgical trauma to a minimum is critical as irradiated tissues will be less resilient than normal tissues. Good communication with the radiation oncologist is, again, essential to limit postoperative complications, as the radiation oncologist must have planned his treatment assuming that the surgeon will excise a given portion of the radiation field. Therefore, neoadjuvant radiotherapy was probably tailored to the peripheral margins, and the bulk of the tumour and its immediate surroundings may have received insufficient or excessive radiation doses. Consequently, these tissues are more prone to complications or tumour recurrence, and should be excised en-bloc. This is another rationale for avoiding marginal resections following neoadjuvant radiotherapy. One exception may be oral tumours. Although one study on dogs did not find differences in complication rates between cutaneous and mucosal flaps placed in a radiation field, the mucosal flaps were smaller which may have masked differences¹³. In our experience, the risk of postoperative complications is increased when performing oral surgery on irradiated tissues and neoadjuvant radiotherapy should be carefully considered when dealing with oral tumours.

Operating before radiotherapy

When performing surgery before radiotherapy, it is essential for the surgeon to have discussed the anticipated radiotherapy plan with the radiation oncologist so that the radiation field is kept as small as possible. For instance, when excising a tumour on the extremities, avoiding circumferential or near-circumferential scars helps the radiation oncologist to keep a band of skin out of the radiation field, which will decrease the risk of distal oedema from radiation-induced damage to the lymphatic vessels. Such mistakes can be avoided by understanding the radiotherapy considerations at play in each single case. In most instances, the placement of drains is avoided. If drains are required, it is important to place their exit point so that they will not require extension of the previously planned radiation field to be included in it. Active drains are therefore preferred as their efficacy does not rely on the position of their exit point. This consideration applies to wound soaking catheters placed for postoperative analgesia. It is crucial to minimise the risk of delaying adjuvant radiotherapy because of any wound healing complication.

Ideally, the surgical wound should be completely healed 2 weeks after surgery and radiation therapy started 2 to 4 weeks after surgery. Primary closure or immediate reconstruction of the surgical wound is therefore sought. When using skin flaps, it is essential to avoid contamination of the donor site with tumour cells so that the radiation oncologist can leave it out of the radiation field. To this purpose, the author commonly elevates the chosen skin flap and closes the donor site, including the skin, in a first surgical step, prior to beginning the surgical resection of the tumour. This ensures the absence of contamination of the donor bed and the radiation oncologist is made aware that it can be considered as disease-free. Wound complications can also be limited by decreasing the risk of postoperative infection. In particular, attention should be paid to minimising the amount of foreign material left in the wound (sutures, prosthetic material, etc.). Another way in which the surgeon can assist the radiation oncologist is by documenting as well as possible the position of the tumour before excision and the limits of the surgical field. This can be achieved by taking intraoperative measures and pictures. Placement of vascular clips at the margins of the surgical field is a common way of rendering the limits of the tissues to consider as contaminated visible for the radiation oncologist. This is particularly true in areas of the body where tissues are loose and move easily (e.g. trunk, neck) or where the position of organs varies (e.g. pelvis). This is less crucial in areas where the skin and underlying tissues are more cohesive (e.g. nose, extremities). One study comparing the radiation fields based on the surgical scar and on the position of vascular clips placed in the wound showed that vascular clips would be out of the radiation field based on the surgical scar for 79% of tumours on the trunk and 11% of tumours on the extremities¹⁶. Failure to indicate precisely the limits of the surgical field to the radiation oncologist exposes to tumour recurrence as a result of improper positioning of the radiation field.

Surgery and radiotherapy complications

Reactions of normal tissues to irradiation are classified as early (acute) or late^{1,4,11}.

Early effects are common and involve tissues with a high cellular turnover, mainly epithelial tissues. These effects are observed during or immediately after the course of radiotherapy and are usually self-resolving or only require symptomatic treatments.

Late effects involve tissues with lower cellular turnover, mainly mesenchymal tissues. These effects are therefore delayed and, as a rule, more difficult to treat. Surgeons can be involved in treating complications associated with these effects. Osteoradionecrosis and radiation-induced bone tumours are uncommon, but severe such complications. In veterinary medicine, their combined incidences at 3, 5 and 8 years after a course of orthovoltage radiotherapy have been reported to be 4.8%, 11.7% and 14.9%, respectively¹⁷.

The humerus appeared to have a predisposition for both complications¹⁷. Interestingly, this study did not report any cases of mandibular or maxillary osteoradionecrosis, whereas they are very common locations in human medicine and, anecdotally, are among the locations in which we have most commonly encountered such a complication. Prognosis for oral osteoradionecrosis is considered guarded with a high tendency of recurrence¹⁸ (extension to surrounding remaining bone). Currently, amputation or wide resection and bone debridement is the recommended route of treatment for osteoradionecrosis. Unfortunately, this usually negates the efforts made previously to spare the body portion which was treated. For this reason, we have found that owners are often reluctant to pursue aggressive treatment (amputation, mandibulectomy, maxillectomy) of these complications. Efforts made at achieving healing of the soft tissues located over the necrotic portion of bone without resecting it are usually doomed to failure. Similarly, most cases of chronic open wound on irradiated areas find their cause in necrosis of deep underlying tissues and are extremely difficult, if at all possible, to treat without deep debridement, which is a high-risk procedure in an irradiated environment.

Chronic open wounds without obvious underlying bone necrosis can also be frustrating to treat. Skin flaps have been evaluated for closing such radiotherapy complications and it appeared that the risk for flap failure is high (8 of 9 cases, 50% of which had severe complications)¹³. To our knowledge, advanced wound management strategies (e.g. vacuum-assisted wound closure, low-laser, ultrasound, hyperbaric oxygen) have not been reported for treatment of chronic radiation wounds in small animals.

Radiation-induced bone tumours must be addressed like other bone tumours, although limb-sparing procedures are not recommended.

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Surgical margins

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Classical margin evaluation with a metric radial margin and a fascial plane deep to the tumor must be adjusted in the assessment of margins for solid carcinomas such as thyroid carcinoma, anal sac adenocarcinoma and thymic carcinoma. If these tumors are marked with tissue ink and submitted for histopathology, it is possible that a pathologist may report a metric margin and that this margin, if 0-2mm, may be interpreted as a dirty margin. More work in the reporting of the margins of these tissues is required, with very little information available in the veterinary literature. In human evaluation of thyroid carcinoma, the focus is on whether or not there is extracapsular extension of the tumor. This is a more appropriate way to evaluate the completeness of excision in solid carcinomas. For any of the solid carcinomas listed above, an en bloc excision with 3cm margins and/or a true fascial plane surrounding the tumor is not feasible. However, without extracapsular extension, the rate of recurrence in these tumor types is low, with failure more commonly due to metastatic disease.

Another question that arises in the surgical planning for complete margins of excision is whether or not neoadjuvant therapy is worthwhile pursuing prior to excision. The most common tumor type in veterinary medicine where neoadjuvant therapy has been attempted for local downstaging is mast cell tumors. The use of neoadjuvant therapies remains somewhat controversial and the use of preoperative therapies may depend to some extent on the goals of surgical therapy. The use of corticosteroids will likely shrink the tumor and may facilitate excision. However, the primary effect of corticosteroids is most likely to be anti-inflammatory, rather than cytotoxic. This may result in a decrease in tumor size, but the continued presence of tumor cells in the tumor periphery. This approach is warranted if the goal is cytoreduction and primary closure, followed by radiation therapy. It may, however, give the surgeon a false sense of security if a curative intent excision is part of the treatment plan. Chemotherapy such as vinblastine or palladia, may be effective as a tool to downstage mast cell tumors prior to wide surgical excision because of their cytotoxic effects. However, this remains to be reported in the veterinary literature. In general, if a mast cell can be

removed with clean margins with a wide excision, it is recommended by the author to excise the tumor without downstaging first, with downstaging reserved for cases where a curative excision is not possible or not possible without unacceptable morbidity to the patient. In these cases, adjuvant radiation therapy may also be a necessary part of treatment.

In the human literature, the most classic use of neoadjuvant chemotherapy is for downstaging prior to limb salvage surgery. Historically, this was done to allow therapy to be initiated while custom-made prostheses were developed for limb salvage. It has also allowed for evaluation of the efficacy of the neoadjuvant chemotherapy through the assessment of the percentage necrosis of the tumor. With newer implants being used, the wait for a custom prosthesis is not as long and is not generally a reason for neoadjuvant chemotherapy to be pursued. There is also an emerging theory that the use of neoadjuvant chemotherapy may actually contribute to chemoresistance. It may be that this convention in human orthopedic oncology is now based on the belief that limb salvage is facilitated by down staging with chemotherapy, rather than evidence that it is beneficial. This area requires further evaluation in both human and veterinary surgical oncology. It is, however, a difficult area to study and definitively prove whether or not there is a clinical benefit.

In people, as in cats and dogs, there is no consensus regarding what surgical margins should be used for tumor resection and what constitutes adequate margins for specific cancer types. In humans, adequate margins depends on the cancer type (for instance, breast carcinoma versus musculoskeletal soft tissue sarcoma), but margins can be assessed as adequate if there is no histologic evidence of cancer cells on the edge of the resected specimen (yes/no), cancer cells are > 2mm away from the edge of the specimen, or cancer cells are > 10mm away from the edge of the specimen. In regards to breast cancer, 46% of North American surgeons are satisfied with a yes/no assessment of surgical margins compared to 28% of European breast cancer surgeons, while 22%

and 9% of North American and European surgeons, respectively, required margins > 2mm for resection to be considered complete. Because of this lack of agreement, the re-excision rates for various types of cancer can vary widely (e.g., from 0% to 70% for breast cancer in North America). The disadvantage of the histologic assessment of margins, other than not being able to assess all margins, is that the assessment of margins is completed after surgical resection which means that the completeness of surgical resection and the need for adjunctive therapy is not known until well after surgery.

Intraoperative assessment of surgical margins is obviously desirable, preferably with a technique that has a high degree of correlation with histologic margins.

There are various techniques to assess surgical margins intraoperatively in people, including gross examination of the margins, frozen sections, cytology from touch imprints, and radiography. Intraoperative assessment of the tumor and resected margins is not considered reliable or accurate this does not correlate with the final margin status in 25% of patients. Frozen sections are commonly used for the intraoperative assessment of surgical margins in people, but not in veterinary medicine. The diagnostic accuracy of frozen sections is approximately 90% and the use of intraoperative frozen sections reduces the rates of local recurrence and re-excision in women with breast cancer. However, this is a time-consuming process, adding up to an hour of anesthesia and surgical time per frozen section, and requires special training and skills from the pathologist. There are other drawbacks, including the presence of fat at the margins which can result in an erroneous interpretation of the completeness of tumor excision. Touch imprint cytology can be a very effective technique to evaluate margins intraoperatively with a sensitivity of 97%, specificity of 99%, with positive predictive value of 84%, and negative predictive value of 99% in breast cancer patients. Furthermore, using touch imprint cytology to guide surgical resection results in a significant reduction of 5-year local recurrence rates from 8.8% to 2.8%. While the intraoperative assessment of margins is more widely available and used in human surgical oncology, the principal disadvantage of all of the aforementioned techniques is the subjective assessment of areas of concern by the surgeon.

The future direction for the assessment of surgical margins is the intraoperative evaluation of the entire surgical specimen and resultant tumor bed. This is primarily being done with various spectroscopy techniques: fluorescence spectroscopy, electrical impedance spectroscopy, diffuse reflectance spectroscopy, and radiofrequency spectroscopy. Other techniques include molecular probes using antibodies specific to cancer markers, such as Tn-antigen in breast cancer. This field continues to evolve and more research in both veterinary and human surgical oncology are needed to ensure that the appropriate dose of surgery is delivered.

Small animals - VSSO

**Urogenital and colo-rectal neoplasia;
What's new?**

**Friday July 5
11.00 – 12.30**

Colorectal tumors: from transanal pull-through approach to bilateral pelvic osteotomy. A critical review.

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Colorectal resection should only be reserved to really aggressive tumors (high grade/ infiltrative adenocarcinoma and leiomyosarcoma). A minimum of 4-5 cm of macroscopically healthy tissue should be given in case of aggressive tumors and only after that the tumor extent has been carefully determined by endoscopy and CT scan (1). In case of less aggressive tumors (carcinoma *in situ*, polypoid adenocarcinoma) a not full thickness rectal excision (sparing the muscular layer) and a strict further monitoring (periodical rectal digital exploration, colonoscopy and abdomen ultrasound) may be an alternative. Conservative resection may be accomplished manually or with stapler after "pull out", i.e. rectal prolapse through traction of full thickness stay sutures applied to distal rectum (2). However, the author strongly recommends this procedure only for distal/middle rectal lesions since an excessive traction to exteriorize more proximal lesions may result in an "uncontrolled" full thickness intrapelvic tear of the rectal wall requiring opening of the pelvis to correct it.

Amputation of different tracts of colo-rectum may be performed according to different techniques depending on tumor location, extent and complete staging (2) but major complications may develop. In general, complications may arise because of several reasons but, apart from an incorrect surgical technique, they are mainly related to impaired vascularization and tension. Rectal vascularization is provided by the cranial (from caudal mesenteric artery), middle and caudal (from internal pudendal a.) arteries. The cranial rectal a. is the most important and, if ligated, all rectum and distal colon should be eliminated (3). An impaired vascularization +/- tension may lead to potential complications such as anastomosis dehiscence (3-5 days from surgery) or permanent fibrotic stenosis resulting in protracted tenesmus, mainly in small dogs. Intrapelvic anastomotic dehiscence is a dramatic event, often leading to death or euthanasia. During healing a transient stenosis is likely to occur in all the anastomotic intestinal sites but the development of an annular and persistent fibrous ring in an anastomotic intrapelvic location is likely to result in either obstruction or protracted tenesmus requiring surgical revision or, as a minimum, balloon dilation (bougienage) (2).

Pull-through rectal amputation starting from the skin: it is indicated for very distal rectal tumors. The external sphincter muscle is tentatively spared, the paired rectococcygeal muscle is transected to allow exteriorization and amputation of up to half of the rectum; excessive traction should be avoided in order not to cause a tear of the cranial rectal artery. Then, the proximal rectal stump is sutured to the skin. Critical points: 1) in the author's experience, isolated tumors in this location are rarely aggressive (that means that this procedure is rarely indicated and more conservative techniques should be chosen); 2) the dog is likely incontinent as the distal 2-3 cm of rectum are eliminated (1). This procedure may be indicated for tumors involving the perianal region extending proximally in the pelvic canal.

Trans-anal pull-through rectal amputation: it is indicated for aggressive tumors of the middle rectum, i.e. still intrapelvic and without extension beyond the rectal wall. The distal 1.5-2 cm of rectum is preserved and this allows the external sphincter muscle to be left intact and functional. Critical points: 1) a transient (1-4 weeks) fecal incontinence and tenesmus should be anticipated during the healing process; 2) to prevent more serious complications, it should be avoided the amputation of the intestine beyond the caudal peritoneal reflection / cranial pubic edge (i.e. reaching the colon) as tension (and vascularization too) may be a concern in this case; fecal continence may be not a problem as the distal rectum is spared (1).

For aggressive colorectal tumors localized in the proximal rectum with/without extension to descending colon, the previous two procedures are absolutely unfeasible because traction applied to the proximal stump is always excessive, vascularization of the two intestinal stumps is not under control and excision margins may be not enough. For these lesions an abdominal approach combined with an intrapelvic one is necessary to: 1) determine the entity of resection but, at the same time, avoid tension at the anastomotic site, 2) ligate only vessels that really need to be ligated (for example, not the caudal mesenteric artery but only the vasa recta that are needed), and 3) excise the potentially metastatic regional lymph nodes (sublumbar,

colic). The procedure may be accomplished through the modified Swenson's rectal pull through, that requires both an intra-abdominal phase and then a trans-anal approach with change of the decubitus during surgery (1), or the sagittal pelvic symphyseal separation or bilateral osteotomy (4-6). These are all complex and relatively long procedures, with a higher risk of perioperative and potentially fatal complications (1). Besides, regarding the simpler pelvic symphysiotomy, an excessive distraction exerted by the Finocchietto retractor that may be needed to widen the operative space, may result in subluxation/luxation of the sacro-iliac joint. This does not require any stabilization, but it may lead to both post-operative discomfort/pain and prolonged recovery time (7). Still, when a bilateral ischio-pubic osteotomy is performed, the reconstruction (involving also the prepubic tendon) requires time which adds to that dedicated to tumor excision and anastomosis; potential post-operative complications that may be observed are reluctance to walk during the first 1-3 days and skin dehiscence as a result of hindlimb abduction (to avoid this, it may be useful to tie together the rearlegs at the level of the hocks for some days).

All the complications described should compel the surgeon to 1) make any diagnostic effort to evaluate if an aggressive surgery is really necessary, 2) have a patient free of concomitant disorders as much as possible, 3) plan beforehand as much as possible what has to be performed during surgery, 4) be aware of all the potential complications that may occur, and 5) have the owner absolutely aware of all these aspects. In many cases a more conservative surgery, palliation and/or a medical treatment (anti-Cox2 drugs) may be preferred (8,9).

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Bladder and urethral neoplasia: What's new?

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Introduction

In dogs, the most common site for neoplasia in the urinary tract is the bladder although it comprises less 1% of all canine tumours.

Aged female animals (mean 10 years) are usually affected with the exception of embryonal rhabdomyosarcoma that occurs mainly in young dogs and particularly those of large breeds.

Bladder cancer is much rarer in the cat than in the dog, accounting for less than 0.5% of all tumours.

The majority of tumours in both the dog (97% of cases) and cat (80% of cases) are epithelial, the most common being transitional cell carcinoma and they may be solitary or multiple and can appear as papillary or non-papillary mass, with an infiltrating or non-infiltrating growth.

Tumours most commonly arise at the trigonal region of the bladder.

Transitional cell carcinoma is usually locally invasive and, infiltrating through the bladder wall, it can extend into adjacent tissues and regional organs such as the pelvic fat, prostate or uterus, vagina or rectum. Peritoneal seeding may also occur as well as metastatic spread to internal iliac and lumbar lymph nodes, lungs, liver, spleen and pelvic bones. Nearly 50% of the cases had regional lymph node involvement at time of diagnosis.

Mesenchymal bladder tumours are mainly derived from fibrous tissue or smooth muscle and these include leiomyoma, haemangioma and fibroma along with their malignant counterparts. Rhabdomyosarcoma (botryoid or embryonal sarcoma) is a rare embryonal myoblast tumour which sometimes occurs in the bladder wall. It usually arises in the trigonal region, is often multi-lobulated and may occlude the ureteric orifices. While most mesenchymal bladder tumours are locally invasive and less likely to metastasise than transitional cell carcinoma, however, embryonal rhabdomyosarcoma has a tendency for both local recurrence after surgery and distant metastasis. Lymphoma has also been reported.

Clinical signs and diagnosis

Dogs with bladder tumours are often presented with signs similar to those of chronic cystitis including haematuria, dysuria and pollakiuria. Urinalysis may help to distinguish between cystitis and neoplasia if pleomorphic

tumour cells are seen on cytological examination but it is diagnostic in less than 50% of the cases.

Contrast radiography may indicate the presence of a bladder mass but ultrasonography of the bladder is often more useful to visualise a mass or a localised, irregular, bladder thickening and also gives information on the depth of invasion of the bladder wall.

CT scanning is invaluable in detecting lumbar lymph node enlargement and chest metastasis. Biopsy may be performed using cystoscopy, or by applying negative pressure with a syringe to a catheter inserted in to the bladder to suck in some tissue. Ultrasound-guided fine needle aspiration is easily performed for large bladder masses but carries the risk of seeding tumour cells along the tract of the needle and therefore it is usually not recommended.

Surgical therapy

Traditionally, surgery has had a limited role in the treatment of canine and feline bladder tumors. In fact due to their invasiveness and capacity infiltrating the musculature, the use of a cystoscopic superficial resection followed by a topical therapy is not feasible in our animals, while it is the treatment of choice in humans with non invasive urinary cancer.

In human medicine, invasive bladder tumors are treated by means of a complete cystectomy followed by the reconstruction of the lower urinary tract with an ileal neobladder.

In dogs and cats, even if technically feasible, this method is limited by the necessity of mechanically "squeezing" the bladder.

Despite this, a number of techniques have been developed with the aim of removing the bladder and obtaining a functional lower urinary tract.

Partial cystectomy

Partial cystectomy is indicated for tumors located in the bladder apex, lateral wall or small based.

For apical neoplasia, a non crushing forceps is applied on the body, the apex is resected and bladder wall is sutured over the balloon of a Foley catheter that is maintained for 4-6 days. For lateral or ventral wall tumors, the bladder is simply cut out and sutured. In male dogs may be necessary to resect also a part of the prostate.

If needed the ureter must be cut and reimplanted in a different site.

Care must be paid in not occluding or ligating both of the caudal vesical arteries.

Initially dogs need to urinate frequently but complete continence is regained in 4-6 weeks.

Internal cystectomy

This technique is especially important for benign or low grade malignant tumors and rhabdomyosarcoma. The bladder is incised along its major axis and opened. The wall is cut partial thickness around the base of the neoplasia taking care to not damage important vessels on the serosal side and sutured.

Trigonal cystectomy

This technique is based on the paper of Saulnier Troff and co-workers. Briefly, a complete circumferential resection of the trigonal area is performed paying attention to preserve the branches of the caudal vesical artery nourishing the apex by means of a serosal stripping. Then, an end to end anastomosis between the remaining part of the bladder and the urethra is performed and the two ureters are reimplanted.

There are only two cases reported but they both regained continence after a transient pollakiuria.

Radical (prostate)cystectomy and colonic reimplantation

With this technique the colon acts as a reservoir for urines, Bladder, and prostate if necessary, are removed and an end to side anastomosis between ureters and colon is performed.

Many complications are reported including urinary tract infection, colitis and metabolic disturbances. For these reasons, this type of surgery is no longer used

Radical (Prostate)cystourethrectomy and urethrobiureteral/ colobipureteral anastomosis

This technique is indicated for dogs that are not amenable to a conservative cystectomy, preferably of small size and of good nature as they must wear a diaper for the rest of their life.

Bladder, and prostate if necessary, is removed and an end to end anastomosis is performed between the two ureters and the remaining urethra.

In female dogs, anastomosis is realized with the uterine stump.

In male dogs, removing bladder and prostate can leave a too short urethra to accomplish a tension free suture.

In these cases, a segment of small bowel is interposed between the urethra and the ureters.

Two ureteral catheters are positioned and removed after 6-8 days.

Cysto-colpo anastomosis

This approach is indicated in female dogs with urethral tumors and a free bladder. The urethra is resected in proximity of the vagina (a pubic osteotomy can be necessary), the vagina is sutured and an end to end anastomosis is done between the bladder neck and the uterus.

A Foley catheter is left in place for 6-8 days

Conclusions

Many possibilities exist to excise bladder, prostate and urethra but no large series of cases are reported and available data are too limited in order to assess on the results in terms of efficacy and survival.

Our experience with complete cystectomy is good in terms of clinical results and owner acceptance but most of the patients die because of metastasis.

Unfortunately, the role of adjuvant chemotherapy in these cases is still unknown.

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Management of intra-pelvic masses

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Intra-pelvic masses are rare in dogs and cats and in the literature there are only few case reports. According to Spector et al. (2010), a mass is defined as intra-pelvic if >50 % of its long axis is caudal to the pubis and/or cranial to the caudal margin of the obturator foramen.

Clinical signs are variable and may depend on the dimension of the mass. The presence of a space-occupying lesion in the pelvic cavity may lead to deviation or compression of adjacent anatomical structures with secondary symptoms such as dischezia, fecal tenesmus, haematochezia, dysuria, stranguria, haematuria vaginal bleeding, perineal swelling, or in some cases lameness and oedema of the hind limbs.

Rectal palpation turns out to be of great aid in pre-operative evaluation as it allows identifying abnormal structures which can be more or less consistent in texture, smooth or lobulated, dorsal or ventral to the rectum and potentially rectal stricture or deviations. However, not all intra-pelvic masses are palpable at rectal examination. During digital rectal examination the sublumbal lymph nodes are palpated. These include all lymph centres present in the sublumbal region: the medial iliac, hypogastric, and sacral lymph nodes which drain the anus, rectum and colon.

Caudal abdominal radiographs generally detect the presence of intra-pelvic masses clinically suspected even though do not identify the tissue they originate from. CT and MRI scans help to properly recognize the organ of origin and can therefore provide information important in the surgical planning (Murgia, 2011).

CT and MRI scans reveal characteristics that point us toward the correct treatment plan to pursue. Information gained with cross-sectional imaging include the size, consistency (solid or cystic mass), homogeneity/heterogeneity, the appearance of the margins (regular or irregular), contrast uptake, calcification and invasiveness into the surrounding tissues.

In people, the CT features and histologic findings of intra-pelvic masses have been compared. While benign parauterine masses were more likely to be homogeneously cystic, malignant parauterine tumors were more likely to contain both cystic and solid regions (Miyao et al. 1992). CT features in 234 women with uterine adnexal masses that were predictive of malignancy included heterogeneity, multilocularity and irregular, thickened cystic septations

(Zhang et al. 2008). CT characteristics of colonic carcinoma in people include an asymmetric, lobulated configuration, narrowing of the lumen and circumferential wall thickening, while homogeneity of colonic masses did not correlate with tumour type (Balthazar et al. 1988). There is only one study in veterinary medicine which reports that the heterogeneous internal architecture of the mass identified on CT scans with contrast was the only feature that could be associated with malignant biological behaviour (Spector et al. 2010).

Possible tissues of origin of intra-pelvic masses include colorectal, uro-genital, lymphoid (sub lumbar lymph nodes), neuro-vascular, osseous or even adipose tissue. However, occasionally some soft tissue sarcomas can also develop within the pelvic cavity. These are generally managed with surgical marginal resection requiring the subsequent use of adjuvant therapies such chemo- or radiotherapy.

Among colorectal masses only adenocarcinomas require en bloc excision with an adequate margin of healthy tissue (minimum 4 cm both proximally and distally). The metastatic rate of adenocarcinomas is high in the annular stenosing form since the involvement of the entire wall thickness facilitates the dissemination (Buracco, 2012).

Uro-genital masses include prostatic adenocarcinoma, transitional cell carcinoma and, more rarely, urethral leiomyoma, leiomyosarcoma, transitional cell carcinoma, and carcinoma, leiomyoma, leiomyosarcoma, fibroma of the uterus/vagina/cervix.

Metastasis to the sub lumbar lymph nodes as well as tumours of the myelin sheath and lipomas can also result in large intra-pelvic masses.

The same cancer that can affect the appendicular skeleton (osteosarcoma, chondrosarcoma, hemangiosarcoma, etc.) can also affect the axial skeleton, including the pelvis.

The choice of the most suitable surgical approach to intra-pelvic masses can be difficult and varies depending on the case. In some cases a caudal abdominal or a perineal approach allow adequate exposure of the mass and its excision. Obtaining adequate exposure of the pelvic cavity is crucial to surgical removal of lesions involving the rectum,

proximal portion of the urethra, vagina and prostate. Options include pelvic symphysiotomy, pubic osteotomy and bilateral pubic and ischial osteotomy (Allen, 1991 and Yoon et al. 2008). However in the author experience, pelvic symphysiotomy and pubic osteotomy provide only restrict access to the pelvic canal compared to bilateral pubic and ischial osteotomy.

Pelvic symphysiotomy consists of sagittal osteotomy of the pubic symphysis performed with oscillating saw. The symphysis is then gently and gradually distracted using a Finocchietto retractor.

Excessive distraction to increase the exposure may result in sacro-iliac dis articulation. A distraction of the symphysis equal to 25% of the width of the sacrum results in bilateral sacroiliac subluxation, whereas a distraction equal to 100% results in substantial dislocation. Although in these cases sacro-iliac stabilization is not required, this can lead to greater post-operative pain, reluctance to ambulate and a more prolonged recovery (Buracco & Romanelli, 2012).

During symphysiotomy it is necessary to take care not to injure the anatomical structures directly below the

symphysis, such as the urethra. The urethra can be protected passing a finger or a blunt periosteal elevator underneath the symphysis. Placement of a urinary catheter to make the urethra recognizable can be a valuable help.

Pubic osteotomy, unlike the symphysiotomy, allows only limited access to the more cranial pelvic cavity (Yoon et al. 2008). There are also cases in which the required exposure must be greater than that afforded by the two techniques described above.

Some surgeons may be reluctant to perform bilateral pubic and ischial osteotomy because of a lack of information about the clinical outcome and complications such as inability to ambulate, extended recovery time and level of difficulty associated with the approach. This approach requires some anatomic considerations which may increase the likelihood of success. The division between the right and the left adductor muscle should be sharply incised, taking care to stay exactly on the midline to minimize haemorrhage. The internal obturator nerves which are on the cranial margin of the obturator foramen should be protected with a malleable retractor during osteotomy, and the prepubic tendon must be incised to obtain wide exposure. The ischio-pubic bilateral osteotomy is certainly a more invasive approach compared to other techniques. However, it has been seen that patients undergoing this type of

intervention are able to ambulate already a couple of days after surgery with different manifestations of pain (Yoon et al. 2008).

To stabilise the osteotomized pubic and ischial osteotomy orthopaedic stainless-steel wire is normally passed in holes which should be pre-drilled before performing the osteotomy. Orthopaedic stainless-steel wire provides

great stability to the osteotomy. However, Yoon et al. (2008) reported that also the use of polydioxanone provides equally good results. In facts, because the pubis and ischium are non-weight-bearing segments of the pelvis, stabilisation might not require the strong stability afforded by wire. Body weight could influence the choice between wire and suture; therefore, large breed dogs can definitely benefit from a fixation with wire, while in smaller patients fixation with polydioxanone suture may be sufficient.

Osteotomies of the floor of the pelvis usually heal in 2-3 months if properly stable. Delays in the consolidation bone may occur in case the patient has not been sufficiently rested. A potential concern with bilateral pubic and ischial osteotomy is that the avascular bone segment that is created may be susceptible to infection and sequestration. Preserving soft tissue attachments (right or left internal obturator) to the bone flap can avoid such complication.

Pelvic masses involving the colon and rectum require amputation of the involved intestinal segment. Amputation can be performed via enterectomy and anastomosis following pelvic symphysiotomy or bilateral pubic and ischial osteotomy or by transanal rectal pull-through or even through a combination of caudal abdominal approach and transanal pull-through. Transanal rectal pull-through allows amputation of a consistent portion of colon and rectum with preservation of 1.5-2 cm of the distal rectum and sphincter. Therefore, patients undergoing this procedure are usually faecal continent (Buracco, 2012).

Combination of transanal pull-through and caudal abdominal approach would replace the pubic symphysiotomy/pubic and ischial osteotomy and can be used when the mass affects the middle cranial portion of the rectum extending to the descending colon (Morello et al. 2008). The intestinal segment is first isolated via the abdominal approach and subsequently amputated by transanal pull-through.

Colorectal amputations are characterised by a high post-surgical complication rate. Complications happen mainly after amputations of long segments and when the colo-rectal junction is involved. This is due to the particular rectal blood supply. Rectum is supplied by the cranial rectal artery (originating from the caudal mesenteric artery), middle and caudal rectal arteries (originating from the internal pudendal artery). The cranial rectal artery is the most important artery for the blood supply of this intestinal portion. The traction and/or amputation of excessive long colo-rectal segments may lead to lesions of the cranial rectal artery with subsequent wound healing impairment of the performed anastomosis, intestinal wall necrosis and wound dehiscence. This usually happens 3-5 days after surgery. In order to obtain a proper healing of such intestinal anastomosis, selective ligation of involved blood vessels is recommended. This is not possible when a transanal pull-through approach is chosen. Therefore, it is preferable to amputate colo-rectal masses either opening the pelvic

cavity or using the combined approach (caudal laparotomy/transanal pull-through)(Buracco & Romanelli, 2012).

Also removal of intra-pelvic lesions involving the urogenital structures may require pubic symphysiotomy or bilateral pubic and ischial osteotomy. However, some vaginal lesions (usually benign fibromas or leiomyomas) can be easily approached via episiotomy. Vaginectomy may be required in case of malignant vaginal tumours.

The surgical approach to metastatic sublumbar lymph nodes, usually does not require pelvic osteotomy since caudal abdominal exploration permits also excision of the lymph nodes located within the pelvic cavity.

Hoelzler *et al.* (2001) reported a case of omentalization of cystic sublumbar lymph node metastases for long long-term palliation of tenesmus and dysuria in a dog with anal sac adenocarcinoma. Omentalization permitted continuous drainage of the cystic lesion by means of the insertion and fixation inside them a portion of the omentum, which thus reduced the dimensions.

Conclusion

There are different surgical approaches for treatment of pelvic masses. The preference accorded to one or the other technique depends in first instance on the degree of the personal confidence with the approach. However, the histological nature of the lesion as well as the information regarding the characteristics of the mass provided by cross-sectional imaging must not be neglected.

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Small animals

Short communication: Oncologic surgery

Friday July 5
14.30 – 15.30

Subtotal vaginectomy for management of extensive vaginal disease in 11 bitches

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Introduction

Vaginal disorders are uncommon in bitches and include benign or malignant neoplasms, vaginitis, vaginal prolapse and congenital abnormalities. Leiomyomas are the most common neoplasms, they appear to be sex hormone dependent and occur most frequently in nulliparous, intact animals. Most benign tumors are amenable to management by local resection via episiotomy. Unlike benign tumors, malignant vaginal masses tend to be broad based and infiltrative and require more extensive surgical resection. This report describes 11 cases of extensive intramural vaginal disease not amenable to local resection via simple episiotomy and necessitated subtotal vaginectomy which was performed via a combined ventral midline celiotomy and episiotomy approach.

Materials and methods

A ventral midline celiotomy to free the cranial vagina was performed. Intact bitches underwent ovariohysterectomy. The peri-vaginal tissues were subsequently bluntly dissected as far caudally as possible ensuring that no residual vascular supply or fascial attachment remained intact. A transfixing stay suture with a large loop was anchored through all layers of the cranial opening of the vagina; the loop of the suture was passed into the vaginal lumen. The abdomen was closed. An episiotomy was subsequently performed and the loop of the transfixing stay suture was identified in the vaginal lumen and retracted caudally, withdrawing and inverting the cranial vagina to the episiotomy site. A full thickness circumferential incision of the vaginal wall was made at the junction of the vagina with the vestibule immediately cranial to the urethral orifice. The vagina was then freed from the remaining pelvic attachments. If the urethral orifice and distal urethra were involved in the disease process, diseased tissue was resected with the vagina and an urethroplasty was performed. The perivaginal tissues were apposed closing dead space. The episiotomy was closed.

Results

Seven bitches had a wide based intramural vaginal mass cranial to the urethral orifice, which were not amenable to

local resection. Two bitches had an annular vaginal mass with invasion of the distal urethra and urethral orifice. One bitch underwent resection of a prolapsed necrotic vaginal mass. One bitch with suspected vaginitis had a severe inflammatory reaction at the level of the cervix with inflammation and scar tissue involving the distal ureters and severe inflammation and extensive adhesions between the vagina and the rectum. In two bitches surgery was complicated by significant intra-operative hemorrhage during resection of the caudal vagina. No other significant complications were encountered intra- or postoperatively and presenting clinical signs had resolved four weeks postoperatively. One bitch with malignant neoplasia was euthanized three months later for metastatic disease and one bitch developed postoperative urinary incontinence. All other bitches had no local recurrence or metastases throughout the follow up period.

Conclusion:

The combined abdominal and vestibular approach, was consistently used to achieve subtotal vaginectomy for resection of extensive intramural vaginal lesions. The technique was associated with a low incidence of significant intra-operative or postoperative complications. The prognosis following resection of benign vaginal disease is very favorable and survival times for those bitches with malignant vaginal tumors were in excess of one year.

Analysis of factors influencing wound healing complications following wide excision of feline injection site sarcomas

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Introduction

Wide surgical resection is the main therapy for injection site sarcomas in cats. The aim of this study was to analyse factors influencing the development of wound healing complications in cats undergoing wide surgical resection of injection site sarcomas. The relationship between clinical dimension and computed tomographic (CT) dimension was also investigated.

Materials and methods

Medical records of client owned cats with injection site sarcomas located on the trunk were reviewed. Cats were enrolled in the study if they underwent wide excision planned with contrast-enhanced computed tomography. Cats receiving neoadjuvant treatment were not included. The relationship between clinical dimensions and CT dimensions was evaluated by linear regression. Wound healing complications were divided into major (when further surgery and/or general anaesthesia were required) and minor. The prognostic effect of covariates (sex, age, weight, body condition score, site, clinical dimension, CT dimensions, histological type, duration of surgery, surgical margin status, local anaesthesia) on major and minor wound healing complications was evaluated by a Cox model. Bivariate analysis of tumour dimension adjusted for duration of surgery and a multiple regression linear model was used to evaluate the relationship between duration of surgery and clinical variables (site, CT width, excision and reconstruction pattern).

Results

Forty-nine cats were enrolled in the study. The risk of developing major wound healing complications significantly increased with a body condition score of 5/5, with increasing weight, duration of surgery and CT dimensions and when non-linear reconstruction was adopted. On bivariate analysis the duration of surgery

remained associated with the risk of major complication whereas tumour size no longer had a significant impact. In the multiple regression model the duration of surgery was influenced by the excision pattern and tumour CT width. The clinical dimensions underestimated CT dimensions, especially in small injection site sarcomas.

Conclusion

An increased duration of surgery, caused by a larger tumour and non-linear reconstruction, is associated with a significantly increased risk of developing major wound healing complications following injection site sarcoma resection. The clinical dimensions underestimates true tumour size and pre-surgical CT examination is advisable for both large and small masses.

Bone cementation of appendicular osteosarcoma with a calcium phosphate cement releasing bisphosphonates. A preliminary case series in dogs and cats

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Bone cementation usually refers to the bone filling of osteoporotic vertebral bodies during vertebroplasty or kyphoplasty procedures or to the filling of bone cysts, benign bone tumors or metastatic vertebrae with an acrylic cement. In human surgery, calcium phosphate (CaP) bone cements have become the gold standard treatment in different orthopedic applications. The use of bisphosphonates (BP) as anti-osteoclastic agents in the management of osteolytic bone conditions is now well established. The aim of our study was to investigate the use of a CaP bone cement loaded with BP for bone cementation of appendicular bone tumors in dogs and cats. We hypothesised that bone cementation associated with chemotherapy could be a palliative option that would allow limb preservation and delay amputation or euthanasia.

Three large-breed dogs and one cat with histopathologically confirmed appendicular osteosarcoma (OSA) and no identified metastases were enrolled in this prospective study: one cat with a distal ulna OSA, one dog with a distal femur OSA and 2 dogs with distal radius OSA. A CaP cement loaded with alendronate was used for cementation. The cement formulation had been optimised so that the alendronate molecule was chemically bounded to the apatite crystals of the cement to ensure local release of the BP along with progressive cement resorption. Surgical treatment included minimally invasive approach of the bone tumor under fluoroscopic guidance, curettage of the tumoral cavity and injection of the bone cement. Follow-up consisted in a physical examination once a week during chemotherapy treatment, and once a month thereafter with XRay examination to detect any metastasis.

Post-operative X-rays showed a satisfactory filling of the curetted bone cavity with no cement leakage into the adjacent joint or within the surrounding soft tissues. During follow-up, weight-bearing conditions markedly

improved and remained quite stable, analgesic effects of the cement injection were obvious and allowed the reduction of the dose of analgesic drugs. At the time of submission, the 2 dogs with distal radius OSA remained alive, 90 and 270 days after cementation respectively, with preservation of the radiocarpal joint in both cases. The cat had the limb amputated 6 weeks after cementation at the owners' request, despite favorable function and comfort. Histological examination of the lesion confirmed the bioactivity of the CaP cement that exhibited slight resorption but also osteointegration with bone bonding osteoconductive properties.

Cementation with such an original cement appeared quite a simple procedure that did not prevent tumor progression but provided a sustainable clinical improvement with very satisfactory limb function and quality of life.

Small animals

Short communication: Soft tissue surgery

Friday July 5
16.00 – 18.00

The role of lipopolysaccharide in the hepatic response to the attenuation of congenital portosystemic shunts in dogs

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Introduction

Dogs with congenital portosystemic shunts (CPSS) have liver hypoplasia and hepatic insufficiency. Surgical CPSS attenuation results in liver growth and clinical improvement. This hepatic response is thought to be due to liver regeneration. The precise trigger for this response is unclear, although lipopolysaccharide (LPS) via the portal vein is a possibility. The aim of this study was to investigate the role of portal LPS as the trigger for the hepatic response to CPSS attenuation.

Methods

Dogs surgically treated with CPSS attenuation were prospectively recruited. Residual blood was taken peri-operatively from the jugular vein and mesenteric vein for LPS measurement with the Limulus Amebocyte Lysate assay.

A liver biopsy was taken for routine diagnostics and residual tissue was placed in RNA later. Repeat surgery was performed in dogs treated with partial attenuation to achieve complete attenuation and another biopsy was taken. Relative expression of IL-1 β , IL-6, TNF β , TLR2 and TLR4 was measured using quantitative polymerase chain reaction.

Residual blood was collected before, 24 and 48 hours after surgery. IL-6 concentration was measured using a canine specific ELISA.

Control liver tissue and blood samples from were taken from healthy beagle dogs.

Differences in LPS concentration and gene expression were assessed using independent or paired T tests and differences in IL-6 concentration were assessed using Friedman's test. Statistical significance was set at the 5% level ($p=0.05$).

Results

Paired plasma samples were available from 13 CPSS dogs and 9 controls. For both CPSS ($p=0.046$) and control dogs ($p=0.002$) the median LPS concentration in portal blood was significantly greater than that that in peripheral

blood. LPS concentration in the peripheral ($p=0.012$) and portal ($p=0.005$) blood of CPSS dogs were both significantly greater than controls.

Liver biopsies were collected from 24 CPSS dogs that tolerated complete attenuation and 25 that tolerated partial attenuation. There were significant increases in TLR4 expression following partial attenuation ($p=0.020$). Complete attenuation dogs ($p=0.011$) and those with good portal blood flow on pre- ($p=0.004$) and post-attenuation ($p=0.015$) portovenography had significantly greater TLR4 expression.

Serum samples were collected from 22 CPSS dogs. There was a significant increase in IL-6 concentration at 24 hours following CPSS attenuation ($p<0.001$).

Conclusion

The results of this study suggest that portal LPS delivery to the liver is critical for the hepatic response to surgery and that LPS binding capacity via TLR4 is linked to blood flow and degree of hepatic development. This supports the hypothesis that LPS triggers liver regeneration via Kupffer cell binding and signalling following CPSS attenuation.

Computed tomography-based anatomical classification of an extrahepatic portosystemic shunt in dogs.

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Introduction

Recently, multislice helical computed tomography (CT) angiography has been reported to be useful for the definitive diagnosis of portosystemic shunt (PSS) in dogs. We hypothesised that CT angiography-based anatomical information would be useful for surgical treatment of canine extrahepatic PSS. The purposes of this study were to demonstrate the detailed morphology of canine extrahepatic PSS based on CT angiography and to clarify the anatomical classification as a result of the comparison between CT angiography and intraoperative findings.

Materials and Methods

One hundred and six dogs with an extrahepatic PSS diagnosed by CT angiography were included in this study. The type of the extrahepatic PSS was classified based on the CT angiographic findings. Surgery or percutaneous transvenous coil embolisation was performed for the treatment of the extrahepatic PSS. The CT angiographic findings were compared with the intra-operative findings on gross inspection or percutaneous transvenous portography.

Results

The 106 dogs were classified into 14 different shunt types as follows: left gastric – phrenic shunt in 27 dogs (25.5%); left gastric – azygos shunt in 24 dogs (22.6%); right gastric – caval shunt in 18 dogs (17.0%); left gastric – caval shunt in 15 dogs (14.2%); right gastric/splenic – caval shunt in 8 dogs (7.5%); right gastric – phrenic shunt and splenic – caval shunt in each 3 dogs (2.8%); left gastric – left hepatic shunt in 2 dogs (1.9%); splenic – azygos shunt, left colic – left renal shunt, left colic – right common iliac shunt; right gastric – azygos shunt; right gastric/left gastric – caval shunt; and right gastric/splenic – azygos shunt in each 1 dog (0.9%). In addition, left gastric – phrenic shunt was divided into 2 different types: one was that the shunt vessel traveled the dorsal side of stomach, and another was that the shunt vessel ran along the small curvature of stomach and across the ventral aspect of cardia. Of 106 dogs, 26 dogs were more than 5 years old. Left gastric – phrenic shunt was observed in 11 dogs (42.3%), and accounted for a large percentage of the dogs.

Discussion

Our study demonstrated that a detailed classification (14 different types) of canine extrahepatic PSS was feasible by CT angiography. Left gastric – phrenic shunt was detected in most dogs, especially those more than 5 years old. This shunt type might have a tendency to late detection compared with the other types. The attenuation site should be carefully decided in right gastric – caval shunt and right gastric/splenic – caval shunt due to the merging of the original left gastric venous branches. In conclusion, the CT-based anatomical classification demonstrated in our study is suggested to be useful for the diagnosis and treatment of canine extrahepatic PSS.

The use of contrast-enhanced computerized tomography (ct) for presurgical planning in dogs and cats with recurrent draining tracts (rdt) in the thoracic and abdominal wall: 37 cases.

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Objectives

To evaluate the use of CT for pre-surgical planning in dogs and cats with RDT

tissues was not possible, debridement of draining tracts inconsistently provided a successful outcome.

Design

Retrospective study.

Materials and methods

36 clients-owned dogs and one cat with RDT in which pre-operative CT and subsequent surgical treatment were performed between 1995 and 2011 were reviewed. Signalment, history, clinical signs, CT data, surgical approaches and findings as well as final clinical outcome exceeding 12 months were recorded.

Results and discussion

CT identified the source of infection (SOI) in 8 cases (21.6%; group 1) and in these animals, surgery was limited to the removal of a foreign body in 7 cases and of a bone sequestrum in one case. A SOI was suspected at CT in 17 cases (45.9%; group 2) and debridement of the DT and/or drainage of abscesses were performed allowing the removal of a foreign body in 8 cases. No SOI was either identified or suspected at CT in 12 cases (32.4%; group 3) and en bloc resection of all abnormal inflammatory tissues was performed allowing removal of a foreign body in 3 cases. The clinical signs resolved in 35/37 of cases (94.4%). DT recurred in one dog in group 2 and in one dog in group 3 in which no foreign body were found at surgery.

Conclusions

CT was useful for presurgical planning in animals with RDT allowing removal of a foreign body with minimized surgical trauma in 46% of cases. A favourable outcome was observed in 94.4% of cases. The outcome was good in cases in which the SOI was identified and removed but also in cases in which, although no foreign body could be identified by CT or at surgery, all diseased tissues could be debrided, drained or excised. In the latter cases, all animals healed uneventfully. In contrast, when the SOI was not found at surgery, and when complete excision of diseased

Autologous platelet gel to treat chronic decubital ulcers: a randomized blind controlled clinical trial in dogs

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¹School of Veterinary Medical Sciences, University of Camerino, Matelica, Italy, ²Department for Clinical Sciences, Clinic for Small Animal Surgery, Veterinary Medicine University Vienna, Vienna, Austria.

Introduction

The objective of this prospective randomised blind controlled clinical trial was to appraise the effectiveness of topical application of autologous platelet gel (PG) in canine chronic non-healing wounds.

Material and Methods

Dogs with bilateral chronic wounds caused by protracted decubitus ulcers (n = 18) were considered in the study. For each dog, the wound side was randomised to receive either platelet gel (group G) every 5 days for 5 dressing changes, or paraffin gauze dressings (group C), as a negative control. Wound healing and wound surfaces were compared at admission and then evaluated every 5th day, until the 25th day. The following outcome variables were measured: open wound area, reduction of open wound area compared to admission and to each preceding dressing change and time to complete epithelialisation.

Results

Significant differences in the healing process were observed at day 5 and throughout the entire study period ($P < 0.0001$). The final mean percentage value of surface reduction was 93.5% in group G and 13.2% in group C ($P < 0.0001$).

Discussion and Conclusion

Appropriately prepared autologous PG is an inexpensive and easily available blood derivative that can be applied locally to enhance wound healing of decubital ulcers in the dog. Chronic non-healing decubital ulcers treated with PG heal significantly quicker than those treated with paraffin-impregnated gauzes.

Modified axial pattern flap for the repair of caudal defects of the hard palate. A cadaveric study in dogs.

Milgram J, Epstein T, Zemmer O.*

Koret School of Veterinary Medicine, Rehovot, Israel.

Introduction

Oronasal fistulae of the caudal hard palate may be congenital or acquired and are challenging to repair surgically. An axillary pattern flap based on the major palatine artery is useful in the repair of many of these defects. However, the medial translation of the flap is limited by the location of the major palatine artery within the palatine canal. The aim of this study was to describe the release of the major palatine artery from the palatine canal in order to mobilise the axial pattern flap based on this artery sufficiently to allow medial transposition of the flap.

Materials and Methods

The mucoperiosteum of the hard palate was incised on the midline from a line between the second molar teeth, caudally, to the incisors, cranially. A second incision in the mucoperiosteum was made along the entire length of the lingual aspect of the teeth. The two mucoperiosteal flaps created were raised with a periosteal elevator, preserving the major palatine artery. A mucosal defect was then created by excision of an ellipse of mucosa in the midline between the maxillary fourth premolar teeth. A defect in the hard palate was created by removing a rectangular piece of bone. The bony defect extended from the second molar tooth, caudally, to the second premolar tooth, cranially. On the lateral aspects the bony defect did not extend beyond the foramina of the major palatine arteries. The edges of the defect in the mucoperiosteum were grasped with thumb forceps and an attempt was made to appose the edges. Once it was determined that the edges of the wound could not be apposed a burr and fine rongers were used to free the major palatine artery from the palatine canal, bilaterally.

Results

Prior to the release of the major palatine artery none of the defects could be closed. However, the mucosal defect could be closed without tension after release of the major palatine artery in all cases. The defect created in the mucoperiosteum was $28\% \pm 6\%$ (mean $\pm$ sd) of the distance between the fourth maxillary premolar teeth. The

palatine canal was opened $7.3 \text{ mm} \pm 2.4 \text{ mm}$ (mean $\pm$ sd) on the left and $8.3 \text{ mm} \pm 1.9 \text{ mm}$ (mean $\pm$ sd) on the right.

Discussion

In clinical cases presenting with an oronasal fistula located in the caudal hard palate, there is already a significant bony defect. The use of an axial pattern flap based on the palatine artery is limited as the palatine artery is enclosed within the palatine canal preventing medial translation of the flap. Minimal enlargement of the bony defect is required to release the major palatine artery from the palatine canal. Release of the palatine artery will allow medial transposition of the flap and tension-free closure of the mucosal defect.

Diagnostic value of echolaryngography to assess laryngeal paralysis in dogs: evaluation of a new examination protocol.

*Arnault F^{*1}, Sonet J², Finck C², Carozzo C^{*2}, Gallois-Bridge H³.*

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Objective

Diagnosis of laryngeal paralysis with echolaryngography was previously described. Echographic laryngeal examination is not well standardized and submitted to imager subjectivity and experience. We recently described a new standardised examination of the larynx with transverse ventral scans (TVS) associated with transverse lateral scans (TLS). This study was designed to evaluate this new standardised echographic examination of the larynx for the diagnosis of idiopathic laryngeal paralysis

Study design

Prospective clinical study

Method

14 dogs with laryngeal paralysis underwent a standardised echolaryngography performed without sedation. Transverse ventral, transverse left lateral and transverse right lateral scans were performed as previously described. Quality of visualisation and movements of each laryngeal structure were evaluated separately and results were computed on to pre-designed evaluation forms. Videotapes of echolaryngographic examinations of 24 healthy dogs and 9 dogs with laryngeal paralysis were randomised and re-evaluated blindly to determine the accuracy of ultrasonography for the diagnosis of laryngeal paralysis

Results

Adding TLS improves the quality of visualisation of laryngeal structures in dogs with laryngeal paralysis. Absence of movement of the rima glottis (8/14), absence of movement of vocal cords (12/28), dorso ventral movement of cuneiform (21/28) and corniculate processes (7/28) and dorso ventral movement of vocal cords (7/28) were the most frequent echographic laryngeal movement abnormalities reported in this study. All dogs with laryngeal paralysis had at least 1 abnormality of movement (paradoxical movement or absence of movement or abnormal ventrodorsal movement) on 2 different laryngeal structures (rima glottis, cuneiform process, corniculate process, vocal cord) on one side of the larynx. By using this criteria to diagnose

laryngeal paralysis on randomised and blindly evaluated videotapes of echolaryngographies, the sensitivity and specificity of echolaryngography for the diagnosis of laryngeal paralysis was 100% and 96% respectively.

Conclusions

Echolaryngography can be performed on unsedated dogs and therefore prevent artefacts and risks associated with anesthesia. With the use of this new standardized examination protocol, echolaryngography is accurate to diagnose laryngeal paralysis.

Outcomes and complications associated with a dual chamber pacemaker implantation in 25 dogs (2008-2012)

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Introduction: The aim of the present prospective study was to describe the technique, feasibility and complications of transvenous dual chamber pacemaker implantation in dogs.

Material and Methods: Dual chamber pacemaker implantation was performed between January 2008 and March 2012 in 25 dogs with symptomatic second or third degree AV block. Median age was 85.9 months (range 31.5 – 159.4 months) and mean body weight was 29.2 ± 16.3 kg. The most common breeds were Labrador Retrievers (n = 5), Border Collies (n = 2), Dogue de Bordeaux (n = 2) and mixed breed dogs (n = 4). Pacemaker implantation was performed in left lateral recumbency under general anesthesia. Two leads were introduced by a right sided jugular vein venotomy, and placed into the right ventricular apex and the right auricle under fluoroscopic guidance. Closure of the venotomy and jugular vein lead fixation was achieved with double-purse string and Chinese finger trap sutures. Lead fixation to the myocardium was achieved passively. With a pacing system analyzer the pacing threshold and the sensed voltage of the P- and R-wave were measured. The pulse generator was placed into a subcutaneous pocket at the cranio-dorsal aspect of the scapula. Postoperative care included antibiotic treatment for 10 days with amoxicillin/clavulanic acid (20 mg/kg twice a day) and neck bandaging. The dogs were hospitalised for 10 days and a telemetric analysis was performed in the first three days and immediately before discharge.

Results: Dual chamber pacemaker implantation was successfully performed in all 25 dogs (100%) without intraoperative surgical complications. Resynchronization of atrium and ventricle was achieved by programming the system in all dogs in a DDD mode. Implantation procedure time was 146 ± 31 minutes. The aimed position of both leads could be achieved in all 25 dogs with a pacing threshold of $\leq 0.8V$ in the ventricle and $\leq 1.0V$ in the atrium. One dog developed ventricular fibrillation immediately after

inducing anesthesia and was successfully defibrillated. The same dog developed atrial fibrillation during the procedure, which was successfully converted. Early complications in the first ten days included seroma formation in 7 dogs (mild 6; moderate 1), coagulation disturbance of unknown origin with a hematoma formation around the pulse generator and the entrance of the leads into the jugular vein (n = 1), mild wound exudation (n = 1), atrial lead dislodgement (n = 1), ventricular lead dislodgement (n = 1) and mild thrombus formation on the leads (n = 2).

Conclusion: Transvenous dual chamber pacemaker implantation in dogs with symptomatic AV block is feasible with a low intraoperative complication rate and effective resynchronization. Short term complications are mostly minor.

Decision making for caesarean operation in primary uterine inertia: use of vaginal endoscopy and measurement of plasma progesterone

England G.

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Introduction

The endocrinological duration of pregnancy has a consistent length of 63 +/- 1 days from ovulation to parturition, and yet pregnancy length can vary from 58 to 72 days measured from mating to the onset of parturition. This study investigated the pre-partum decline in plasma progesterone and the endoscopic appearance of the cervix in normal bitches compared with bitches suffering primary uterine inertia.

Materials and methods

Plasma progesterone concentration was measured by ELISA and the endoscopic appearance of the cervix was subjectively assessed daily throughout the last 10 days of pregnancy in 25 healthy previously parous control bitches, and 10 bitches considered to be at risk of primary uterine inertia because a single pup had been identified using ultrasound.

Results

In control bitches progesterone concentration at 10, 5, 2 and 1 day prior to parturition was a mean of 10.3 + 1.2 (SEM), 4.7 + 0.7, 2.4 + 0.5 and 1.4 + 0.2 ng/ml respectively. For individuals there was an abrupt decrease in progesterone between 12 and 48 hours before the onset of parturition and progesterone was basal (mean 0.4 + 0.3 ng/ml) after parturition. From 7 days prior to parturition the cervix appeared oedematous and had increased vascularisation, but this appearance did not substantially change and was not useful for the prediction of parturition, except in 3 bitches examined within 6 hours of parturition where there was opening of the cervix and a colourless discharge.

Four bitches at risk of primary inertia had normal parturition with progesterone and endoscopic appearances indistinguishable from control bitches. Six bitches had primary inertia, and in each, progesterone declined similarly to control bitches, although basal values were slightly higher (0.7 + 0.4 ng/ml) but were basal for two consecutive days with no signs of imminent parturition. On the second day of basal progesterone there was no vulval discharge

but vaginal endoscopy demonstrated green/red coloured fluid at the cervix. Caesarean was performed 2 or 3 days after basal progesterone and in each case a single viable pup was delivered.

Discussion/Conclusion

Decision making for presumed overdue pregnancy should include endoscopic examination of the cervix and measurement of plasma progesterone. An open cervix with a small volume of green/red-coloured discharge combined with basal plasma progesterone concentration (< 1.0 ng/ml) are criteria indicating that parturition is overdue, potentially necessitating caesarean operation.

Small animals - Soft tissue

In depth – Endocrine surgery

Saturday July 6

08.30 – 10.15

Thyroid carcinoma in dogs

S. Boston

University of Florida, USA

Thyroid carcinoma is commonly reported in older dogs, with a median reported age of 9 to 11 years. Golden retriever, beagles, boxers and Siberian huskies are reportedly predisposed. Most commonly, this disease is diagnosed because of the detection of a cervical mass by the owner or the referring veterinarian. This highlights the importance of neck palpation as part of every physical examination. Early detection and treatment of this cancer will result in a more favorable outcome.

Thyroid carcinoma is usually diagnosed by ultrasound-guided or palpation guided fine needle aspirate. This procedure is reportedly painful in humans and sedation for our canine patients is encouraged. Cytology may not be able to differentiate between an adenoma or adenocarcinoma. However, masses that present clinically are overwhelmingly malignant and a mass in the thyroid gland that is palpable should be treated as malignant, even in the face of a more bland cytology. An incisional biopsy by a Tru-cut biopsy is not recommended due to the high vascularity of these tumors and the high risk of uncontrolled bleeding or the potential for hematoma formation that might result in contamination of the area with carcinoma cells. Similarly, an open incisional biopsy is not recommended because of the high chance of hemorrhage and contamination of the biopsy tract. Technically, the removal of an entire lobe of the thyroid via a midline cervical approach is more straightforward than attempts at incisional biopsy over the mass laterally and this approach is not recommended.

Further staging of a thyroid mass is somewhat clinician dependent. Staging should include local staging to evaluate whether or not the mass will be amenable to surgical resection, evaluation of lymph nodes and evaluation of the lungs for evidence of metastatic disease. This can be done through a combination of palpation of the submandibular lymph nodes and mass, cervical ultrasound, thoracic radiographs and CT of the head, neck and thorax. CT is favored by the author because of the ability to evaluate the retropharyngeal lymph nodes and the increased sensitivity in assessing for pulmonary metastasis.

Surgery is the mainstay of treatment of thyroid carcinoma for noninvasive, mobile masses. Generally speaking, a unilateral thyroidectomy is performed and is a technically

simple surgery. Care must be taken not to damage the recurrent laryngeal nerve. Bilateral thyroid carcinoma has been reported and successfully treated. Consideration must be given for the potential for transient or permanent hypoparathyroidism after bilateral thyroidectomy.

For cases of invasive thyroid carcinoma, treatment with external beam irradiation (palliative or curative intent) or radioactive iodine ablation have both been reported. Radioactive iodine has the potential to treat local and metastatic lesions, but is not currently widely used, primarily due to the need for isolation of these patients.

Chemotherapy has been used with some success in cases of thyroid carcinoma. However, there is not a consensus on the efficacy of chemotherapy or which chemotherapeutic is recommended. Histological characteristics of malignancy and tumor size will help to guide these recommendations. Carboplatin is commonly used. Palladia may also play a role in the management of metastatic thyroid carcinoma, with some reports of clinical efficacy in dogs with metastatic thyroid carcinoma.

Although there are similarities in the presentation and management of thyroid carcinoma in humans and dogs, there are also major differences. Thyroid carcinoma is a disease of young and middle-aged adults in humans. Although differentiated thyroid carcinoma has a similar indolent course in humans, the lifespan of the patients and the age of onset requires a more aggressive approach to treatment and management. Papillary or differentiated thyroid carcinoma is the most commonly diagnosed thyroid cancer in humans. Unlike in dogs, there are many other differentials that are common when presented with a solitary thyroid mass or nodule, including goiterous thyroiditis, benign cyst or adenoma. Human patients with thyroid carcinoma are treated with complete resection of the entire thyroid gland. This is partly because of the high chance of developing a second carcinoma and partly to ease management of thyroid carcinoma. After complete thyroidectomy, radioactive iodine is recommended in all cases with metastasis to lymph nodes, aggressive characteristics on histopathology or carcinomas that are >4cm. For nodules that are <1cm without metastasis or characteristics of malignancy, radioactive iodine is not

recommended. For patients with nodules that are 1-4cm, there is a grey area for radioactive iodine ablative therapy (RAI) and this is currently somewhat institutionally based. The advantages of RAI are that it will treat undetected metastasis and it will ablate all remaining normal thyroid tissue. This makes monitoring for recurrence more straightforward. Patients will be monitored for thyroglobulin levels, which should remain undetectable after complete thyroidectomy and RAI. Without RAI, low levels of thyroglobulin from remnant normal thyroid or carcinoma may be present, making monitoring somewhat equivocal.

Parathyroidectomy

E. Monnet

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After the diagnosis of primary hyperparathyroidism with elevated ionized calcium, normal to high level of parathyroid hormones (PTH) and PTH related protein being undetectable, the abnormal parathyroid gland needs to be removed. Usually primary hyperparathyroidism is due to an adenoma from one of the four parathyroid glands normally present in dogs and cats. Keeshounds may have several nodules present.

There are two external and two internal parathyroid glands in dogs and cats. They are located, respectively, at the cranial pole of the thyroid gland and within the parenchyma of the thyroid gland toward the caudal pole. Parathyroid nodules are well visualized on ultrasounds. Absence of a nodule on ultrasounds does not rule out the diagnosis of primary hyperthyroidism.

Parathyroid gland can be ablated with ethanol injection or heat under ultrasound guidance. This technique does not allow tissue collection for histology and requires several injection to completely eliminate the abnormal parathyroid gland. Surgical resection of the nodule is the technique of choice for the treatment of primary hyperparathyroidism. It provides tissue sample for histological diagnosis and it allows a complete evaluation of the other parathyroid glands. The recurrence rate at the ablation site is as high as 7%.

After a midline incision on the ventral part of the neck caudal to the larynx, both thyroid glands are exposed. The parathyroid gland that is responsible for the hyperparathyroidism is nodular and usually red tinge. The other parathyroid glands are not visible because they have been suppressed by the hyper-functional gland. If the nodule is coming from an external parathyroid gland it can be dissected away from the thyroid gland. Since most of the nodules are benign hypertrophy they are peeling off the thyroid gland very easily. If they are not peeling off the thyroid gland a thyroidectomy should be performed because the tumor can be a carcinoma. If the nodule is coming from one of the internal parathyroid gland a thyroidectomy is performed. If none of the parathyroid glands looks abnormal it is then important to explore the entire cervical area for

an ectopic parathyroid gland. Ectopic parathyroid glands can be located anywhere from the base of the tongue to the base of the heart. MRI might be helpful to localize an ectopic parathyroid gland.

Post-operatively, the patient should be closely monitored for hypocalcemia. Hypocalcemia can occur within the first 6 days. Calcium gluconate will be used to treat an acute hypocalcemia and the patient will be placed on oral calcium and calcitriol orally. Supplementation is usually needed for 2 to 3 weeks after surgery. We conducted a retrospective study to evaluate the risk of hypocalcemia after parathyroidectomy and determine predictor of hypocalcemia in the post-operative period.

Objective—To determine whether preoperative ionized calcium (iCa) or parathyroid hormone (PTH) concentrations help predict postoperative hypocalcemia following parathyroidectomy in dogs with primary hyperparathyroidism.

Design—Retrospective case series.

Animals—17 dogs with primary hyperparathyroidism treated with parathyroidectomy.

Procedures—Medical records were evaluated from years 2001 to 2009. Data evaluated included age, breed, sex, clinical signs, diagnostic tests performed, preoperative and postoperative iCa concentrations, preoperative PTH concentrations, and whether calcium supplementation was provided following surgery. Two groups were identified on the basis of whether dogs became hypocalcemic (iCa < 1.2 mmol/L) following parathyroidectomy.

Results—12 dogs developed hypocalcemia after surgery. Preoperative (within 24 hours after surgery) iCa concentrations for the hypocalcemic group (1.82 ± 0.22 mmol/L) and the nonhypocalcemic group (1.83 ± 0.29 mmol/L) were not significantly different. Calcium concentrations decreased in a linear fashion during the 24 hours following parathyroidectomy, and the slopes of

the decrease over that time were not significantly different between the 2 groups. Preoperative PTH concentrations were not significantly different between the hypocalcemic and nonhypocalcemic groups.

Conclusions and Clinical Relevance—Preoperative iCa or PTH concentrations are not predictive of postoperative hypocalcemia in dogs undergoing parathyroidectomy for primary hyperparathyroidism. Future studies to evaluate whether calcium supplementation should be provided on an individual basis with perhaps more emphasis on clinical signs than iCa concentrations after surgery may be warranted.

Pheochromocytoma: Surgery

E. Monnet

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Adrenal tumors represent a challenge for the anesthetist, the surgeon, and the criticalist during the post-operative period. Adrenal tumors can be adenoma, carcinoma, or pheochromocytoma. Rare cases of aldosteronoma have been described in dogs and cats. Adenoma and carcinoma are secreting tumors that induce a Cushing's syndrome with its effect on metabolism, electrolytes and coagulation. Pheochromocytoma are tumors secreting vasoactive mediators that have a profound effects on the cardiac and hemodynamic functions of the patients. Pheochromocytomas are tumors that have a tendency to invade the caudal vena cava that makes the surgery more complicated.

Treatment of dogs with phenoxybenzamine has been strongly recommended for two weeks before surgery. This treatment helps lowering the arterial blood pressure and helps stabilize the patient during surgery while manipulating the adrenal tumor. Beta-blockers can also be added to the medical treatment after the phenoxybenzamine has been lowering the blood pressure. Usually this is necessary since ultra short acting beta blockers (esmolol) can be used intra-operatively to control the heart rate. Prazosine can also be used as an alpha antagonist to control the blood pressure before surgery.

If the tumor is a pheochromocytoma, heparin is not required during the surgery unless the tumor is invading the vena cava. It is recommended to heparinize the dogs if vascular surgery is performed to minimize the risk of thrombus formation on the suture line. If there is some doubt on the nature of the tumor then heparin is recommended to minimize the risk of pulmonary thromboembolism associated with Cushing's disease. When heparin is used PTT is measured to document the efficacy of the treatment. The goal is to increase the baseline PTT time by 50%. Supplementation with steroids during the surgery and the post operative period is not necessary for pheochromocytoma however it will be recommended if there is any doubt on the nature of the tumor.

Ultrasound has been used to document invasion of the vena cava. However, CT angiogram or MRI angiogram are more valuable because they can give more information on the extent of the tumor thrombus in the vena cava.

Surgical resection of a pheochromocytoma can be performed with laparotomy or laparoscopy. Laparoscopic resection can be achieved with small adrenal tumor not invading the vena cava. For laparoscopy, the patient is placed in lateral recumbency and three or four portals are required to remove the adrenal tumor. Electrocautery, ultrasound dissection and vessel sealant device are used to dissect the adrenal gland. Renal artery, renal vein, caudal vena cava, aorta and phrenico-abdominal vein need to be located during the surgery. It is important to notice where the caudal attachment of the diaphragm is. It can be performed for right and left adrenal masses. If the tumor is invading the vena cava then a laparotomy is required. The tumor thrombus extends in the caudal vena cava through the phrenico-abdominal vein. Then the adrenal tumor is dissected to a pedicle including the phrenico-abdominal vein. Tourniquets are then placed around the caudal vena cava cranial and caudal to the venotomy site. After interrupting the blood flow the vena cava is open and an elliptical incision is made to resect the tumor thrombus with the phrenico-abdominal vein. The vena cava is then closed with a 6-0 simple continuous suture pattern. The vena cava needs to be de-air before completing the closure of the venotomy. The blood flow is reestablished and the vein is checked for bleeding. Gentle pressure with gelfoam can be applied to the venotomy to control bleeding from the suture holes.

Postoperatively it is important to monitor, heart rate, blood pressure and electrolytes.

We completed a study looking at 86 dogs with adrenal tumors and evaluating outcome with or without vena cava invasion. (Barrera et al, JAVMA 2013 In Press)

Objective—To evaluate risk factors for outcome for adrenal gland tumors with or without invasion of the caudal vena cava and treated via adrenalectomy in dogs.

Design—Retrospective study.

Animals—86 dogs treated via adrenalectomy for adrenal gland tumors.

Procedures—Medical records of dogs that underwent adrenalectomy for an adrenal gland tumor from 1993 to 2009 were reviewed; data collected including signalment, clinical signs, diagnostic test findings, treatments prior to surgery, findings at surgery including additional procedures performed and extent of caudal vena cava invasion (local

invasion [caudal to the hepatic portion of the vena cava] or extensive invasion [cranial to the hepatic portion of the vena cava]), procedures performed during surgery, histopathologic diagnosis, perioperative complications, follow-up data, and necropsy findings.

Results—Of the 86 dogs, 14 had adenomas, 45 had adrenocortical carcinomas, and 27 had pheochromocytomas. Fourteen dogs had invasion of the caudal vena cava; of these tumors, 7 were locally invasive and 7 were extensively invasive. Risk factors for poor short-term survival were vena caval invasion, extent of invasion, pheochromocytoma, intraoperative transfusion, and postoperative disseminated intravascular coagulation, pancreatitis, hypotension, hypoxemia, and renal failure. Multivariate analysis of short-term risk factors revealed that extensive invasion was the most important factor. Regardless of extent of invasion or tumor type, long-term survival was possible.

Conclusions and Clinical Relevance—Invasion of the caudal vena cava, particularly tumor thrombus extension beyond the hepatic hilus, was associated with a higher postoperative mortality rate, but did not affect long-term prognosis in dogs after adrenalectomy.

PROTOCOL ADRENAL TUMORS

Prior to Surgery all the cases with an adrenal tumor should have a standard work up either by the internal medicine or at least approved by an internist. The work-up should include adrenal function testing (ACTH stim and/or LDDST, endogenous ACTH, CBC, chem., UA, urine culture, UP:C, thoracic radiographs, abdominal ultrasound, blood pressure)

PHEOCHROMOCYTOMA

Prior to surgery:

Minimum 2 weeks of Phenoxybenzamine – dose range is wide, but start low (0.25 mg/kg BID) and titrate to effect (signs of hypotension) – do not exceed 2.5 mg/kg

CUSHING'S DISEASE

Day of surgery: Get a coagulation profile with ATIII and blood type (PTT will be used as the baseline) from Clin path but also from CCU because during the night only CCU PTT will be available.

Intra-op:

- Dexamethasone: 0.05 to 01 mg/kg IV over 6 hours
- Heparin: 10 UI/kg/hr

Post op:

- Heparin: 10 UI/kg/hr
- Measure PTT 2 hours after dog admitted in CCU
- Increase the dose of heparin by 5 UI/Kg/hr to reach 1.5xPTTbaseline
- Get a platelet count daily to monitor for heparin toxicity
- Dexamethasone 0.05 mg/kg SQ immediately post-op and 8 hours later

- Measure electrolytes and blood glucose QID
- ACTH stim within 24 or 48 hours after surgery
- Prednisone (0.25-0.5 mg/kg) PO: 2 to 3 times a day; taper dose every 2 days

Going home:

- Heparin 100UI/Kg SQ three times a day until suture removal
- Prednisone (0.25-0.5 mg/kg) PO: 2 to 3 times a day; taper dose every 2 days: depending on ACTH stim test results.

UNKNOWN (assuming a full medicine work-up)

Prior to surgery:

- 2 weeks of Phenoxybenzamine: adjust dose to effect

Day of surgery: Get a coagulation profile (PTT baseline)

Intra-op:

- Dexamethasone: 0.05 to 01 mg/kg over 6 hours
- Heparin: 10 UI/kg/hr

Post op:

- Heparin: 10 UI/kg/hr
 - Measure PTT 2 hours after dog admitted in CCU
 - increase the dose of heparin by 5 UI/Kg/hr to reach 1.5xPTTbaseline
 - Get a platelet count daily to monitor for heparin toxicity
 - Dexamethasone 0.05 mg/kg SQ immediately post-op and 8 hours later
 - Measure electrolytes and blood glucose QID
 - ACTH stim within 24 hours after surgery
 - Prednisone (0.25-0.5 mg/kg) PO: 2 to 3 times a day; taper dose every 2 days: duration and dose depends on results of ACTH stim test
- Going home:**
- Heparin 100UI/Kg SQ three times a day until suture removal if the histology confirmed an adrenocortical adenoma or an adenocarcinoma.
 - Prednisone (0.25-0.5 mg/kg) PO: 2 to 3 times a day; taper dose every 2 days: duration and dose depends on results of ACTH stim test

Short-term outcome after laparoscopic adrenalectomy for resection of adrenal masses in 20 dogs and 3 cats.

Mayhew PD, Hunt GB, Culp WTN, Steffey MS, Mayhew KN, Della Maggiore A, Nelson RW.

University of California-Davis, School of Veterinary Medicine, Davis, United States.

This case series describes the short-term outcome in twenty dogs and three cats that underwent laparoscopic adrenalectomy (LA) for management of adrenal masses.

Dogs weighed a median of 14.4kg (range 6.8-43.6kg). Cats weighed a median of 6.2kg (range 4.7-7.3kg). Ultrasound was used for pre-operative imaging in all cases. Computed tomography scans were used in 17 dogs and 2 cats. Thirteen dogs had left-sided lesions and 7 were right-sided. Two cats had left-sided lesions and one was right-sided. Nine dogs were suspected to have adrenal-dependent hyperadrenocorticism and two had diabetes mellitus. The remaining dogs were either suspected to have non-functional masses or pheochromocytomas. Two cats had aldosterone-secreting masses and one was progesterone-secreting. In four dogs and one cat a 4-port technique was used whereas in 16 dogs and 2 cats a 3-port technique was used. In one cat conversion to an open approach was necessary due to extreme friability of the abdominal wall causing chronic leakage of insufflated CO₂. No other cases required conversion to an open technique and no other major complications occurred.

Histopathology confirmed adrenocortical carcinomas in 9 dogs, adenomas in 6 dogs, phaeochromocytoma in four dogs and an embryonal duct remnant in one dog. Two cats had adrenocortical carcinoma and one had an adenoma. All patients were discharged from the hospital and all survived to at least one month post-operatively.

LA is a viable option for resection of selected adrenal masses in dogs and cats and can be associated with low perioperative morbidity and mortality.

Evaluation of short-term outcome after video-assisted thoracoscopic lung lobectomy for resection of primary lung tumors in medium to large breed dogs.

Mayhew PD, Hunt GB, Steffey MA, Culp WTN, Mayhew KN, Fuller M, Johnson LR, Pascoe PJ.

From the Department of Surgical and Radiological Sciences, Medicine and Epidemiology, University of California-Davis, CA.

A video-assisted thoracoscopic (VATS) approach for lung lobectomy is a standard of care procedure for resection of many primary lung tumors in humans and has been described in a small number of canine patients.¹

The aims of this study were to describe the clinicopathological features of dogs undergoing VATS lobectomy for resection of primary lung tumors and to compare short-term outcome of VATS lobectomy with open thoracotomy (OT).

Medium to large-breed dogs undergoing either VATS (n=22) or open thoracotomy (n=24) were included. A 3-port technique was used in 12 dogs and 4 ports were used in 10 dogs. One-lung ventilation was employed in all VATS cases. Tumor volumes were calculated from pre-operative computed tomography scans where available.

Two of 22 dogs (9%) were converted from a VATS to an OT approach. All dogs were discharged from the hospital. There was no significant difference between VATS and open lobectomy with regard to major complication rate, time to discharge, time in intensive care, or in completeness of resection. Surgery time was significantly longer for VATS lobectomy (median 120 minutes, range 70-170 minutes) than OT lobectomy (median 95 minutes, range 60-135 minutes).

VATS lobectomy has a low conversion and complication rate in medium to large breed dogs. Short-term morbidity of VATS lobectomy was comparable to OT for resection of primary lung tumors in dogs.

1. Lansdowne JL, Monnet E, Twedt DC et al. Thoracoscopic lung lobectomy for treatment of lung tumors in dogs. *Vet Surg* 2005;34:530-535.

Pancreas: A multidisciplinary approach to canine insulinoma

Kirpensteijn J and Buishand F.O.*

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Introduction

The most common pancreatic surgery is the removal of pancreatic tumors and this lecture will focus on the treatment of insulinoma (INS). Insulinoma are insulin-secreting tumors and originate from endocrine b-cells from the islets of Langerhans in the pancreas. INS are uncommon in dogs and very rare in cats. Primary canine INS are commonly solitary tumors and their diameter is usually smaller than 2.5 cm. Most INS are located in the left or right pancreatic lobe. In general canine INS are considered to be malignant in more than 95% of cases, because they almost always tend to metastasize, even though they may lack histological criteria of malignancy. INS hypersecrete insulin and cause an increased insulin concentration in the blood. Normally when blood glucose concentrations decrease, insulin secretion is inhibited. Neoplastic b-cells are less sensitive to the negative feedback of low blood glucose concentrations and secrete inappropriately high amounts of insulin despite declining blood glucose concentrations resulting in a profound hypoglycemia. Clinical signs of canine INS often occur intermittently. In the initial stages hypoglycemic episodes are preceded by fasting, exercise, excitement or stress, because those situations lead to increased glucose utilization. Between hypoglycemic attacks affected dogs usually do not have clinical signs. The mean duration of clinical signs prior to diagnosis is 3.6 months (range, 1 day – 3.5 years).

Diagnosis

Physical examination findings are usually unremarkable in dogs with INS. The presumptive diagnosis of canine INS is not defined by hypoglycemia alone, but commonly based on signalment and history, combined with the fulfillment of Whipple's triad: Presence of clinical signs, hypoglycemia and relief of clinical signs after glucose administration or feeding.

The plasma insulin concentration should be determined and with INS circulating insulin concentrations are typically within the reference range or higher despite hypoglycemia.

Diagnostic imaging techniques, like transabdominal ultrasonography (US), computed tomography (CT),

single-photon emission computed tomography (SPECT) and somatostatin receptor scintigraphy (SRS) can be of great help for the identification and preoperative staging of INS. More recently dual-phase CT angiography (CTA) techniques have been developed and the use of dynamic CTA for the presurgical localization has been reported to be successful. To date the gold standard, however, remains exploratory laparotomy. Careful inspection and palpation of the pancreas and adjacent structures reveals most INS and metastases.

Therapy

INS therapy can be divided into medical management and surgical treatment. Surgery, if needed combined with postoperative medical management, is the treatment of choice for long-term management, because this treatment strategy results in longest survival times. Dogs with INS should be fed four to six small meals a day of a high-protein, high-fat and high-complex-carbohydrate diet. This type of diet decreases postprandial hyperglycemia, thereby preventing a marked insulin surge. Restricting exercise to brief walks on a leash might also help to reduce clinical hypoglycemia. Diazoxide is the preferred drug for treatment of INS-induced hypoglycemia. Diazoxide raises blood glucose concentrations mainly through direct inhibition of pancreatic insulin release, but also through stimulation of hepatic gluconeogenesis and glycogenolysis and inhibition of glucose uptake by tissues. Possible side effects of diazoxide treatment are anorexia, vomiting and ptialismus. An alternative to diazoxide therapy is glucocorticoid therapy. Glucocorticoids, such as prednisolone, antagonize the effects of insulin at the cellular level and increase gluconeogenesis. In addition to the commonly used drugs described above, treatment with somatostatin (analogs) and cytotoxic treatment with streptozocin have been described.

Depending on the pancreatic localization, INS can be removed by local enucleation or partial pancreatectomy. Partial pancreatectomy is the preferred method, because it results in longer survival times than local enucleation. Therefore, local enucleation should only be considered

if the INS is located in the body of the pancreas. Partial pancreatectomy is commonly performed using either the suture-fracture technique, the dissection-ligation technique or using the LigaSure Vessel Sealing System. LigaSure pancreatectomy is fast, caused no intraoperative complications and annihilates the use of suture materials or clips.

The presence of metastatic disease is evaluated in 2 ways: (1) gross inspection of common target organs including lymph nodes and liver, and (2) on the basis of the blood glucose concentrations after the glucose infusion has stopped. All macroscopically enlarged lymph nodes should be excised and submitted for histologic examination. In case of liver metastases, our approach is aggressive: a tumor debulking approach is warranted to decrease tumor mass and increases the effects of medical therapy after surgery.

Prognosis

Canine INS has a reserved prognosis, because metastasis, tumor regrowth and return of clinical signs are almost inevitable.

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Hypophysis

B. Meij

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Introduction

Transsphenoidal selective adenectomy is the primary therapy for Cushing's disease in humans. The most common approach in humans is by the standard microsurgical submucosal transseptal transsphenoidal procedure using a neurosurgical operating microscope. There are many virtues of the midline transsphenoidal approach. Most importantly, it is the least traumatic route of surgical access to the sella. The lack of visual scars, lower morbidity and mortality as compared with transcranial procedures, the necessity of only a brief hospital stay, the relatively brief recuperative period add to the procedure's appeal. More and more human pituitary surgeons employ the pure endoscopic endonasal transsphenoidal surgical approach for pituitary tumor removal using rigid endoscopes. The pure endoscopic approach is facilitated by the air-filled sphenoid sinus that is only separated by a thin bony floor from the pituitary fossa.

In dogs the most common method of treatment for Cushing's disease or pituitary-dependent hypercortisolism (PDH) remains medical treatment with mitotane (o,p'-DDD) or trilostane. However, medical therapy leaves the pituitary adenoma untreated. Also, it may be hypothesised that the removal of the chronic negative feedback exerted by the glucocorticoid excess at the pituitary level, may actually stimulate pituitary tumor proliferation and expansion.

At the Utrecht University transsphenoidal hypophysectomy was re-started in 1993 and has become an important addition in the management of Cushing's disease in the Netherlands (and occasionally for patients coming from other European countries). Until now 300 dogs and 20 cats have undergone pituitary surgery. Surprisingly, pituitary surgery in dogs and cats is, besides the Netherlands, only advocated in a few other institutions (Japan and only very recently the USA, UK, and Italy). In dogs the indications for pituitary surgery include pituitary corticotroph adenomas (causing Cushing's disease), debulking of clinically non-functioning pituitary macroadenomas (causing diabetes insipidus or central neurological signs by the tumor mass effect) and occasionally sellar meningiomas.

Pituitary Imaging

Computed tomography (CT) and magnetic resonance imaging (MRI) visualize the pituitary size and the surgical landmarks that are a prerequisite for pituitary surgery. Since the surgical landmarks are bone structures, they are more difficult to discern on MR images than on CT images. CT has proven to be practical, fast and accurate for detection of pituitary abnormalities. Surgical localisation of the pituitary gland in the various canine and feline skull types is dependent on the continuous visual assessment of typical bone features during the transsphenoidal approach and relating those, real-time, to the CT images in the operating room. The enhancement pattern of the neurohypophysis during dynamic contrast enhanced CT has been called the 'pituitary flush'. The displacement, distortion, or disappearance of the pituitary 'flush sign' in dynamic CT examinations can be used to confirm left or right-sided lateralization of (micro)adenomas.

Surgical Technique

Pituitary surgical techniques include selective removal of the pituitary adenoma (adenectomy), removal of the adeno-hypophysis (adenohypophysectomy), removal of a significant part of pituitary tumor mass in the case of a macroadenoma (pituitary debulking), or complete removal of the pituitary gland including the tumor (hypophysectomy). Hypophysectomy in the dog and cat is performed by the midline transoral, transnasopharyngeal, transsphenoidal, microsurgical approach with the animal in sternal recumbency. Access to the pituitary fossa is obtained with a burr. An operating loupe or videoscope is used to provide magnification. Bone punches are used to enlarge the opening created in the inner cortical lamina of the sphenoid bone. Following incision of the dura mater, the pituitary adenoma is extracted through the dural opening using fine neurosurgical grasping forceps and suction. In most cases the complete adeno-hypophysis is usually affected by the tumor and there is no sharp definition between adenoma and normal pituitary tissue. Unlike humans with Cushing's disease, well-defined pituitary (micro)adenomas are rare in dogs and cats. The hypophysectomy is considered complete when 1) there is an unobstructed view of the

ventral hypothalamic surface and the opening to the third ventricle, and 2) there are no pituitary remnants upon exploration of the extensions of the hypophyseal fossa. The pituitary fossa can also be inspected for pituitary tumor remnants using rigid endoscopes, e.g., and endoscope with a diameter of 2.7 mm and a 30 degree viewing angle. In dogs with giant (>2 cm) pituitary adenomas, the aim is to remove as much of the tumor tissue as possible to reduce the mass effect (debulking).

Postoperative intensive care includes close monitoring of vital functions, plasma electrolytes (sodium and potassium), plasma osmolality, and central venous pressure. Oral water intake is encouraged as soon as possible. Postoperative medication includes antibiotics and analgesics. Hormone replacement consists of hydrocortisone (1 mg/kg IV every 6 hours) and desmopressin, a vasopressin analogue (4 mg administered as a drop into the conjunctival sac every 8 hours for 2 weeks). When the dog has resumed eating and drinking, oral replacement therapy is started: cortisone acetate (1 mg/kg every 12 hours) and thyroxine (15 µg/kg every 12 hours). Over a period of 4 weeks the dose of cortisone acetate is gradually tapered to 0.25 mg/kg every 12 hours. Desmopressin (0.01%) is administered for 2 weeks, 1 drop into the conjunctival sac every 8 hours.

Results and Complications

The efficacy of transsphenoidal hypophysectomy in the treatment of dogs with PDH has been investigated in a prospective study in 181 dogs with a median age of 9 years. The 1-, 2-, 3-, and 4- year estimated survival rates were 86%, 83%, 80%, and 79%, respectively. Treatment failures included postoperative mortalities (= death within 4 weeks after surgery irrespective of the cause of death, 14 dogs), and incomplete hypophysectomies (12 dogs). The 1-, 2-, 3-, 4-year estimated relapse-free fractions were 90%, 77%, 72%, and 62%, respectively. Survival and disease-free fractions after hypophysectomy were markedly higher in dogs with nonenlarged pituitaries than in dogs with enlarged pituitaries. The main postoperative complications after hypophysectomy are reduction in tear production (31%) and prolonged diabetes insipidus (53%). Tear production restored to normal values in 79% of the affected dogs over a median period of 9 weeks. Diabetes insipidus occurred more frequently in dogs with enlarged pituitaries than in dogs with nonenlarged pituitaries and was permanent in 22% of the dogs. The results compare favourably with those of 129 dogs treated with o,p'-DDD in the same institution in another time frame. With longer follow-up time, hypophysectomy leads to better results than o,p'-DDD treatment.

Adrenocortical Function after Hypophysectomy

Adrenocortical function after hypophysectomy can easily be measured using the basal urinary cortisol/creatinine ratio (UCCR) in samples collected at home. When the patient leaves the hospital, usually 3 days after surgery,

owners receive tubes for urine collection at 2 weeks, 8 weeks, 6 months, and 1 year after surgery. Thereafter yearly assessment of adrenocortical function is advised. Urine samples are collected at home when the dog is 24 hours free of cortisone medication. The early (<8 weeks) UCCR has prognostic value when considering long term survival and disease free fractions. In dogs with early postoperative UCCR < 5 x 10⁻⁶, the survival and disease free fractions are greater than in dogs with early postoperative values between 5 and 10 x 10⁻⁶.

Pituitary Surgery in Cats

The indications for transsphenoidal hypophysectomy in cats are: Cushing's disease caused by an ACTH-cell pituitary adenoma or acromegaly caused by a GH-cell pituitary adenoma. Both conditions in cats are usually accompanied by diabetes mellitus requiring insulin administration. Transsphenoidal hypophysectomy has a higher morbidity and mortality in cats with PDH than in dogs. In cats with acromegaly with concurrent diabetes mellitus, hypophysectomy has an excellent prognosis resulting in disappearance of diabetes mellitus, discontinuation of insulin administration within 1 to 4 weeks after surgery, and normalisation of GH and IGF-1 levels.

Further Reading

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Figure 1. Transverse contrast-enhanced computed tomography of the skull of a dog with Cushing's disease due to a pituitary adenoma, before (A) and 8 weeks after transsphenoidal hypophysectomy (B).



Perioperative complications of endocrine diseases

A. deLaforcade

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Post-operative care represents an important aspect of critical care medicine. In multi-specialty practices, a team approach is often used to optimize the care of critical and post operative patients. Endocrine surgery is routinely performed and may be accompanied by unique post-operative concerns. Especially as it relates to surgery involving the pancreas and the adrenal gland, anticipation of potentially life threatening complications is required for a successful outcome.

Surgery related to the pancreas

Surgical manipulation of the pancreas is generally approached with caution due to the potential of compromising the blood supply, and inducing post-operative pancreatitis. Pancreatic surgery is most commonly performed in dogs with pancreatic masses. Restrospective studies of dogs with insulinomas have shown a survival benefit to surgical resection over medical management, as well as confirmation of diagnosis, staging, and overall reduction of gross disease. Preoperatively glucose control can be challenging, with the major goal of stabilizing glucose concentration in a range that does not cause clinical signs of hypoglycemia. In severe cases, glucagon may be used to raise blood glucose and avoid clinical signs of hypoglycemia. Glucose supplementation may precipitate hypoglycemic crisis. Despite gentle manipulation, intra-operative manipulation of the pancreas may trigger insulin release and worsening hypoglycemia. For this reason, blood glucose should be monitored frequently throughout surgery and at regular intervals post-operatively. Dextrose is administered in those patients with worsening hypoglycemia and maintained during the post operative period until the dog is eating. Techniques used to raise blood glucose in those dogs showing clinical signs of hypoglycemia that are refractory to glucose supplementation include the following:

- Glucagon infusion (5-40ng/kg/min)
- Glucocorticoids (dexamethasone 0.3mg/kg IV)
- Diazoxide (6.6-40mg/kg/day divided)

It is important to note that seizures due to hypoglycemia may continue after correction of hypoglycemia and anticonvulants can be added. In severe cases where seizures cannot be controlled, general anesthesia may be required.

Although hypoglycemia from incomplete tumor removal is the most frequently reported post-operative concern, hyperglycemia is also a common post operative finding. Due to chronically elevated circulating insulin concentration, function of normal beta cells may be suppressed leading to hyperglycemia following tumor resection. This transient diabetic state resolves once function of the normal beta cells is restored, typically lasting 2-3 days. In very few cases where hyperglycemia is severe and persistent, insulin therapy may be initiated. In these cases, urine glucose monitoring should be performed frequently to avoid a hypoglycemic crisis.

Despite gentle manipulation of the pancreas, post-operative pancreatitis remains a common complication of partial pancreatectomy and may require intensive care. Cardiovascular support in the form of intravenous fluids is encouraged in the post operative period, as is feeding of frequent small meals consisting of a low fat, low carbohydrate high fiber diet to prevent spikes of insulin release. Fasting dogs with pancreatitis is no longer recommended and enteral feeding should be begin post-operatively as soon as the dog is alert enough to eat. Since most insulinomas are not completely excised, prolonged fasting is typically avoided and small frequent feedings are encouraged to maintain euglycemia.

Surgery related to the adrenal gland

In our facility, the surgical approach to adrenal masses is commonly preceded by a discussion between specialists in anesthesia, surgery, and critical care in order to establish a plan for anesthesia, blood product availability, and intraoperative as well as post operative management of any complications. Adrenal masses may be secretory or non-secretory, and can be due to adenoma, carcinoma, or pheochromocytoma. Whether or

not to pursue surgery can be difficult to determine, due to the high incidence of intra operative and post-operative complications. Tumor invasion into surrounding structures and tumor size are highly suggestive of malignancy. Post-operative complications of adrenocortical tumors are generally related to long term excessive circulating cortisol and include immunosuppression, impaired wound healing, hypertension, hypercoagulability and pancreatitis. Medical control of hyperadrenocorticism and hypertension may reduce the likelihood of postoperative complications. In dogs with adrenocortical adenomas or adenocarcinomas, atrophy of the contralateral adrenal gland and limited adrenocortical reserve should be expected and corticosteroids may be required for a period of time after surgery.

Pheochromocytoma – Surgical removal of these catecholamine producing tumors of the adrenal medulla may be accompanied by cardiovascular collapse due to massive catecholamine release during surgical resection. Complications associated with pheochromocytomas include the following:

- Tachycardia
- Arrhythmias
- Hypertension
- Hypotension
- Hemorrhage
- Thrombosis, thromboembolism
- Cardiac arrest

ECG monitoring is typically initiated during the pre operative period and continued post-operatively due to the high risk of ventricular arrhythmias. Pre operative control of tachycardia using beta blockers (propranolol, atenolol) may be helpful. Pre-operative administration of an alpha adrenergic receptor blocker such as phenoxybenzamine (0.5mg/kg q12 hours started 2-3 weeks pre operatively) has been shown to reduce post operative mortality in dogs with pheochromocytoma. All drugs that are pro-arrhythmogenic or that potentiate the effects of catecholamines are generally avoided. Cardiovascular support and blood pressure monitoring is performed throughout the induction and surgical period due to the concern for both arrhythmias and hypertension during induction, and acute reduction in vascular tone following tumor removal.

During surgery, hemorrhage is a significant concern due to proximity of the adrenal gland to great vessels and the extensive blood supply to the tumor itself. Availability of blood products should be confirmed prior to induction. Hypercoagulability secondary to excessive cortisol secretion and systemic inflammation associated with surgery puts these dogs at risk for thrombotic complications in the peri-operative period, and perioperative anticoagulation is controversial. In dogs suspected of post operative pulmonary thromboembolism, anticoagulation can be

initiated (unfractionated or low molecular weight heparin) and supportive care with oxygen supplementation should be initiated.

Finally, special consideration must be given to endocrine disease as a co-morbidity in any dog or cat undergoing surgery. Animals with diabetes mellitus or chronic renal failure are susceptible to rapid development of hypovolemia and special consideration must be given to their perioperative intravenous fluid therapy. A carefully considered plan for fasting and insulin therapy is required prior to surgery in the diabetic. Glucose monitoring perioperatively will help with decisions relative to feeding and insulin therapy during this post-operative period. In those animals experiencing volume related issues post operatively, the reason is most often attributed to inadequate rate of IV fluid administration and failure to supply a bowl of water. The maintenance needs of these animals is altered, and frequent re-assessment of volume status with adjustments of fluid rates is needed to tailor fluid therapy to each patient.

Small animals

Resident presentation

Friday July 5
18.10 – 19.10

Understanding Hemostasis

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Understanding hemostasis is a critical need for the veterinary surgeon. The last decade has been characterized by significant changes in our understanding of hemostasis, and the role of hemostatic disorders in disease processes. This session will discuss the following:

- The cell based model of coagulation
- Disseminated intravascular coagulation
- Hypercoagulability in naturally occurring canine diseases
- Fibrinolysis: an emerging focus

Cell based model of coagulation

The traditional 'y shaped' coagulation cascade including the sequential activation of serine proteases and the clear division of secondary hemostasis into the intrinsic and extrinsic pathway can be helpful in understanding our traditional coagulation tests but is poorly reflective of in vivo hemostasis. Rather, the cell based model of coagulation provides insight as to the role of the cell surface in promoting coagulation, and highlights the role of tissue factor in initiating pathologic clot formation.

According to the cell based model of coagulation, hemostasis occurs in three overlapping phases:

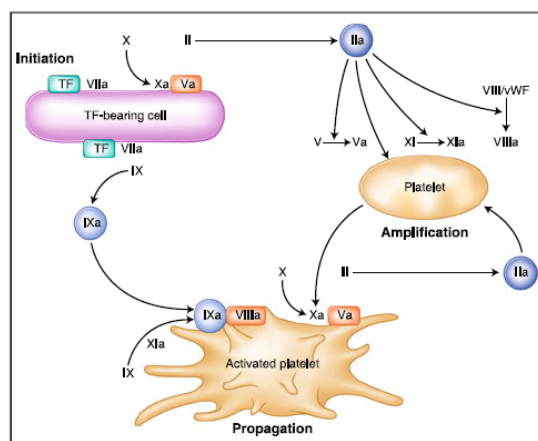
Initiation – takes place on tissue factor bearing cells, and leads to the formation of a small amount of factor IX, X, and thrombin. Tissue factor expression resulting from endothelial damage or cytokine-induced activation of inflammatory cells is the major initiator of coagulation. Once it leaves the cell surface, the Tissue factor:VIIa complex is rapidly inhibited by endogenous inhibitors (TFPI and AT), however a small amount of thrombin is generated contributing to platelet and factors V and VIII activation.

Amplification – Platelet adhesion and activation as well as continuing influence of thrombin generation leads to accumulation of activated V and VII bound to the platelet surface. This sets the stage for assembly of the procoagulant complexes which will ultimately trigger large scale thrombin generation.

Propagation – During this phase the tenase (factor VIIIa:IXa) and prothrombinase complexes (Xa:Va) are assembled on the platelet surface and large scale thrombin generation ('thrombin burst') leads to formation of a fibrin clot.

The cell-based model of coagulation highlights the importance of the platelet in both physiologic and pathologic activation of coagulation, and the interplay between coagulation and inflammation. Thrombin acts as a powerful pro-coagulant and pro-inflammatory molecule, supporting the development of hypercoagulability in states of systemic inflammation.

Disseminated intravascular coagulation (DIC)



From the surgery perspective, the notion of coagulopathy brings to mind the complicated syndrome DIC, characterized by a combination of sometimes concurrent bleeding and thrombosis. DIC is best thought of as a consumptive coagulopathy and is always secondary to an underlying disease process. Some insult (with some inflammatory component likely), triggers coagulation and results in the formation of microthrombi once endogenous anticoagulant systems are either overwhelmed or suppressed. Impaired fibrinolysis may also play a role. Thus DIC should always be thought of as an **acquired** syndrome characterized by **systemic intravascular coagulation**. Systemic intravascular coagulation causes thrombosis of small and midsize vessels, leading to organ failure and ultimately death. Coagulation factor and platelet depletion ultimately leads to a bleeding diathesis which can also lead to death. Hemorrhage and thrombosis may occur concurrently. Several diagnostic criteria have been suggested for

diagnosis of DIC in people and generally focus on evidence of the following:

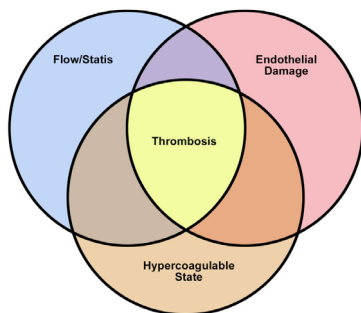
- Procoagulant activation
- Fibrinolytic activation
- Inhibitor consumption: antithrombin, proteins C or S
- Biochemical evidence of end organ damage

In general a tentative diagnosis of DIC is made in animals if abnormalities in 3 or more of the following are noted: D-dimer (or FDP), antithrombin, platelet count, fibrinogen, PT, or aPTT. Thromboelastography has been evaluated as an adjunctive tool to characterize hemostatic derangements in DIC. In one study of 50 dogs with DIC, 22% of dogs were found to be hypocoagulable (and were most likely to die); 34% were normocoagulable, and 44% were hypercoagulable.

Treatment for DIC is mainly supportive in nature, with treatment of the underlying disease (and thus removal of the trigger) imperative to a successful outcome. Supportive intensive care and administration of blood products (for replenishment of factors, platelets, and fibrinogen, and to maintain oxygen delivery) is frequently required. Historically anticoagulation has been recommended, however anticoagulants would need to be administered prior to the onset of bleeding, when DIC is typically clinically unrecognized. For this reason, treatment tends to focus on control of bleeding.

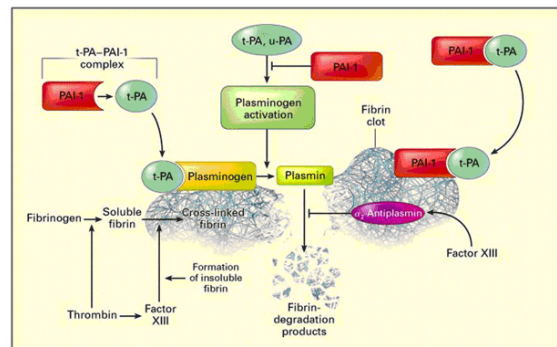
Hypercoagulability

Thrombotic complications of naturally-occurring disease processes are being recognized with increasing frequency in veterinary medicine. Although initially meant to describe the *consequences* of a pulmonary embolus, the elements of Virchow's triad are now accepted as predisposing factors to thrombosis. It is believed that 2 of the 3 elements of Virchow's triad, namely hypercoagulability, endothelial damage, and blood stasis, are required to increase a patient's risk of developing a thrombus. Viscoelastic testing has raised awareness of hypercoagulable states in veterinary medicine, especially as it relates to systemic inflammation and protein losing states. However, the therapeutic implication remains to be determined. It will likely become more common for surgeons to encounter cases at risk for clot formation, animals with thrombotic complications, and those in need of surgery chronically treated with anticoagulants.



Fibrinolysis

The growing use of viscoelastic testing has not only provided a means for assessing hypercoagulability, but has also identified certain states affected by disorders of fibrinolysis. Traditionally difficult to assess, the fibrinolysis plays a crucial role in limiting vascular occlusion, and upregulation or suppression of fibrinolysis can lead to clinically evident bleeding or thrombosis, respectively. Fibrinolysis describes the mechanism by which fibrin monomers are cleaved into soluble fibrin degradation products through the action of plasmin. Tissue plasminogen activator (tPA)-mediated plasmin production from plasminogen can be altered in disease states through up or down regulation of plasminogen activator inhibitor (PAI-1) which has an inhibitory effect on tPA. The presence of fibrin degradation products (FDPs) can be evaluated clinically through quantification of FDPs themselves, or more specifically D-dimers. Viscoelastic testing of various disease states, however, has provided telling evidence of accelerated fibrinolysis that could play a significant role in clinical bleeding. Most notably in dogs with DIC, acute liver failure and in some dogs following severe trauma, documentation of hyperfibrinolysis may provide a window for therapeutic intervention in dogs with clinical evidence of bleeding.



Small animals – Short communications

Neuro, orthopaedic and soft tissue

Saturday July 6

15.30 – 17.15

An innovative acellular bi-phasic scaffold for articular cartilage reconstruction

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Introduction

Articular chondral defects are a relevant problem in the human and veterinary orthopedic practice. The osteo-cartilaginous lesion is challenging to cure, because tissue damage extends to the sub-chondral bone. Reconstructing an osteochondral lesion involves two different tissues characterized by different intrinsic healing abilities. The optimal scaffold should allow bone repair in the subchondral area and migration of mesenchymal stem cells into the superficial cartilaginous layers, with the goal of hyaline cartilage repair at the articular surface. The current study was designed to assess the ability of a bi-phasic cell-free scaffold to support regeneration of bone and hyaline cartilage. The results of a twelve month pre-clinical study are presented.

Methods

The study was approved by the Ethical Committee of the Experimental Center at Asaf Hrofe Medical center, and it was performed under the Animal Welfare Law. The study was conducted on twenty-four Saanen goats. A critical sized focal cartilage defect measuring 6mm diameter by 10mm depth was created in the medial femoral condyle. In sixteen of the goats, a bi-phasic implant was inserted into the defect. In eight goats, an empty defect was created as a control. The goats were followed for periods of six and twelve months, after which they were sacrificed.

Results

In the Agili-C (CartiHeal (2009) Ltd.) implanted goats, there was evidence of both hyaline cartilage and bone regeneration.

Discussion

Agili-C is an acellular bi-phasic implant capable of reconstructing hyaline cartilage in an acute focal defect in a caprine model. Histology and MRI confirms that the cartilage formed is hyaline containing type II collagen and does not contain type I collagen. Furthermore, the cartilage undergoes zonation indicating maturation of the

tissue. This phenomenon has not been observed using alternative approaches. Repair of focal cartilage defects is often difficult or impossible due to formation of a mixture of fibrous and cartilaginous tissue. This Agili-C scaffold appears to prevent fibrous tissue invasion from the bone marrow and enables the formation of purely hyaline cartilage as demonstrated by collagen type II formation. Currently, a clinical evaluation in human patients is ongoing in Europe as the scaffold is a CE approved device.

Conclusion

An acellular bi-phasic scaffold appears to be capable of supporting hyaline cartilage formation in a caprine model and humans. This model may open a window of opportunity for the treatment of focal cartilage defects using a simple single-step implant.

Tightrope® versus percutaneous lateral fabellar suture: technical errors and biomechanical properties

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Introduction

The Tightrope® (TR) repair has been proposed as a technique that is biomechanically superior to the lateral fabellar suture for the management of cranial cruciate ligament insufficiency. The objectives of this study were to identify the incidence and type of technical deviations during training on the Tightrope® and the percutaneous lateral fabellar suture (pLFS), and to compare the ability of each technique to control cranial draw.

equal in the ability to eliminate CTT and both repairs were weaker than the intact CCL.

Methods

Sixteen 3rd year veterinary students, 6 small animal surgical residents and a Diplomate of the American College of Veterinary Surgeons performed the TR and pLFS techniques on 64 paired limbs. The perceived level of difficulty, duration of surgery and technical deviations were assessed via questionnaire, radiographs and dissection. Limbs appropriately repaired were biomechanically tested by eliciting cranial tibial thrust and measuring the resulting force. Results were compared with a paired t-test and McNemar's Test.

Results

The TR procedure was perceived as more technically demanding than the pLFS by veterinary students and residents. Technical deviations were overall more common after TR than pLFS, and in limbs repaired by students, regardless of the procedure. The most difficult aspect of the TR consisted of the bone tunnels. The most difficult step of the pLFS consisted of passing the suture around the fabella. The sensitivity of radiographs for detection of technical deviations was 39% after TR and 50% after pLFS. All stifles were able to withstand 12mm of displacement without breakage of the implant. At 1, 2, 3, 5, 10 and 12 mm there was no significant difference between the TR and the pLFS. Comparing the TR and pLFS to the intact CCL, all loads were significantly smaller.

Conclusion and Clinical Relevance

Technical deviations are more common during the training phase of the TR than the pLFS, and the sensitivity of radiographs to detect those is low. The TR and pLFS were

The association between meniscal injury and the degree of lameness in dogs with cranial cruciate ligament rupture

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Introduction

Dogma suggests that meniscal injuries cause pain and should be surgically treated, but objective evidence for this is lacking. Recently, the need for meniscal surgery has been questioned by some surgeons. The purpose of the study was to investigate if dogs with cranial cruciate ligament (CCL) rupture and concurrent meniscal injury are more lame than dogs with CCL rupture alone. The null hypothesis was that dogs with meniscal injury are no more lame than those with no meniscal injury.

Material and methods

Recent clinical records of dogs that presented for suspected CCL rupture were reviewed. Meniscal injury was defined as an injury to the medial meniscus that was surgically treated at the time of stifle surgery. Kinetic gait analysis was performed using a Kistler force platform and proprietary software (Bioware). All dogs were analysed before surgery at a walking gait (velocity 1.0-1.3 m/s, acceleration $\pm 0.5\text{m/s}^2$) within 24 hours of surgery. The primary measure was PVF while VI, FS and PVF AI were secondary measures. A P-value ≤ 0.05 was considered significant.

Results

Eighteen dogs fulfilled the inclusion criteria. Of the 18 cases, nine had meniscal injury and nine did not have meniscal injury. There were significant differences between the two groups in terms of age, weight and gender. Mean duration of clinical signs in the 'meniscal injury' group was 21 days (range 9-180 days) and 180 days (range 14-365 days) in the 'no meniscal injury' group. This difference was significant ($p = 0.05$) with dogs with meniscal injury presenting earlier than those without. The mean PVF (N as %BW) in the index limb in dogs that had meniscal injury was 26 ± 8 (range 9-36) and 33 ± 6 (range 26-41) in dogs without meniscal injury. This difference was significant ($p = 0.03$) where dogs with a meniscal injury put significantly less force in the vertical plane through the index limb compared to dogs without meniscal injury. None of the secondary outcome measures (VI, $p = 0.10$; FS, $p = 0.65$,

PVF AI = 0.07) were significant between the meniscal injury group and the no meniscal injury group.

Discussion/conclusion

The null hypothesis of this study was rejected and our data provides objective evidence that dogs with meniscal injury at the time of presentation are significantly more lame when compared to dogs without meniscal injury. This provides some proof that meniscal injury is a significant component of the overall pain dogs with CCL rupture and concurrent meniscal injury experience and that surgeons should aim to treat meniscal injuries at the time of stifle surgery in order to provide some relief discomfort to these dogs.

Comparison of the detection of meniscal tears by arthroscopy and arthrotomy in dogs with cranial cruciate ligament ruptures: a retrospective, cohort study

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²Western College of Veterinary Medicine, Department of Large Animal Clinical Sciences, Saskatoon, Canada.

Introduction and Hypothesis

Arthroscopy and arthrotomy have been used for evaluation of cranial cruciate ligament deficient stifles in dogs. Arthroscopy has been shown to be more sensitive for detection of meniscal tears in a cadaver model. The objective of this retrospective study was to evaluate and compare detection of meniscal tears in clinical cases by either arthroscopy or arthrotomy. We hypothesized that arthroscopy would detect more meniscal injuries than arthrotomy.

Methods and Materials

A retrospective, cohort study was performed on 430 dogs (n= 531 stifles) with naturally occurring cranial cruciate ligament ruptures. A medial parapatellar arthrotomy or an arthroscopic procedure was performed to evaluate intra-articular structures and each group (arthrotomy or arthroscopy) was compared for significant differences in meniscal tears detected, time injury to diagnosis, from injury to surgery and signalment using logistic regression analysis.

Results

In total 531 stifles were included (n =430 dogs). The mean weight + SD was 33.6 + 13.8 and mean age + SD was 5.5 + 2.7 years. Fifty-one breeds were represented, with mixed breed (n = 142), Labrador retriever (n=122), Rottweiler (n=44), and Golden Retriever (n=30) being most common.

Arthroscopy was performed on 58.8% and arthrotomy on 41.2% of stifles. Overall, 44.4% of the stifles examined had meniscal tears, of the total meniscal tears, 36.0% were present in stifles examined by arthrotomy and 64.0% were present in stifles examined by arthroscopy. In stifles examined by arthrotomy 38.8% had meniscal tears and 48.4% of those examined by arthroscopy had meniscal tears. Detection of a meniscal tear was significantly different ($P = 0.019$) between the groups and meniscal tears were observed more frequently by arthroscopy than

by arthrotomy (odds ratio 1.54; 95% confidence interval 1.07 – 2.22).

Discussion/Conclusions

These results suggest that the association between arthroscopy and detection of meniscal pathology is greater than that of arthrotomy and meniscal pathology in clinical cases with naturally occurring cranial cruciate ligament deficiency, suggesting arthroscopy may miss fewer meniscal injuries than arthroscopy.

Use of the kyon revision cup for treatment of acetabular cup loosening: surgical technique and clinical application in 30 cases

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Clinica Veterinaria Vezzoni, Cremona, Italy.

Introduction

The purpose of our study was to report surgical technique for the use of Kyon cementless revision cup with screw fixation, and its clinical application in cases of cup loosening.

Materials and methods

Records were reviewed for dogs treated for cup loosening using the Kyon revision cup between April 2010 and April 2012, with a minimum follow-up of 6 months.

Implant design: Each cup is composed of two parts: a perforated titanium outer shell with holes for 2.4mm screws and an inner plain titanium cup with a polyethylene insert. The number of screw holes changed from 13 to 6 from 1st to 2nd generation cups.

Surgical technique: After removing the loose cup, the acetabulum was prepared using a reamer of the same size as the loose cup, or in cases with severe bone loss, with a larger reamer. The outer shell was impacted into the acetabulum. Next, a variable number of screws were inserted drilling holes with a 1.6 mm K wire. The inner cup was then impacted in a coaxial direction with respect to the outer shell. A head-neck unit was assembled to the stem, the prosthesis was reduced, and routine closure was performed.

Follow-up: Clinical and radiographic follow-ups were performed at 2, 6 and 12 months post-surgery, and then annually.

Results

30 cases met the inclusion criteria; 15 cases of aseptic loosening and 15 related to infections. The mean age of the dogs was 59.8 months (10.5-157) and the mean bodyweight was 30 Kg (15-48.5). In 12 cases, the size of revision cup was the same as the loose cup, in 18 cases, the revision cup was larger. A mean of 5 screws was used for fixation of each cup, with a minimum of 2, and a maximum

of 7. No intra-operative complications were recorded. At final follow up, 29 dogs had complete limb function with osteointegration of the revised cup. Postoperative complications were recorded in 2 cases: one case of luxation 3 weeks post-surgery and one case of secondary cup loosening 7 months after surgery.

Discussion

Two postoperative complications were recorded. The first was a case of cranio-dorsal luxation secondary to a fall, which is not directly related to the revision cup. The second was a case of secondary cup loosening after revision for septic loosening. For proper insertion of the inner cup the direction of the impactor must be coaxial with respect to the shell. Tightening the screws can create a slight deformation of the shell's rim and thus make insertion of the inner cup difficult. To avoid angular eccentricity and subsequent interference of the screw heads with the inner cup, screw holes were drilled with a K wire, allowing for inclination and bending of the wire without risk of breakage which may occur with a drill bit.

Conclusion

Use of Kyon revision cup seems to provide promising results in treatment of cases of loosening.

Cyclic testing in torsion of 2 standard and 5 locking plate constructs using the staircase method

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Introduction

The principles of biological osteosynthesis have gained popularity in the management of small animal fractures and led to the development of numerous locking plates known as internal fixators. Acute biomechanical testing to failure of these implants tested as constructs has been reported but these results should be supplemented by a more clinically relevant fatigue analysis. The fatigue behavior in torsion of conventional vs. locking plate designs was compared in this study. Our null hypothesis was that no difference in the fatigue failure strength was present between angle-stable (locking) and standard plates; furthermore, failure mechanisms would not differ.

subsequently considered in modifying the applied fixation methods of these different implants.

Material and methods

DCP®, LC-DCP®, LCP®, ALPS10 and 11, SOP™ and Fixin plates were fixed to a validated bone model simulating a comminuted fracture. The study design was a staircase fatigue test at an estimated fatigue life of 15,000 cycles. Sixteen constructs per group were tested. Differences in mean failure level among different constructs were tested using the Dixon and Mood estimates in pairwise, unequal variance, unequal sample size t-tests ($P < 0.05$). Holm's method was used for type I error adjustment.

Results

The DCP®, LC-DCP® and ALPS11 plate constructs had higher fatigue strengths compared to most other constructs. Bone model failure was observed in these constructs at the screw/bone model interface. Screw failure was observed with all other locking constructs (except the ALPS 10: plate failure). Differences between the other constructs were not consistently ordered between standard vs. locking implant design.

Discussion

Our null hypothesis was rejected. Increased construct stability was present in the standard and ALPS constructs, as compared to the remaining locking constructs, as plate contour perfectly matched that of the straight tube it was compressed against. Stress concentration in the remaining locking constructs at the screws resulted in screw failure. The different biomechanical properties must be noted and

Effect of monocortical vs. Mixed monocortical-bicortical fixation on the torsional stability of 3.5Mm string of pearls locking plate constructs

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¹Michigan State University College of Veterinary Medicine, East Lansing, United States, ²Croft Vet Hospital, Cramlington, United Kingdom.

Introduction

Limited data is available on the torsional properties of locking constructs using monocortical (M) versus bicortical (B) screw fixation. Our objectives were to evaluate the effect of screw type, number and position on the torsional stability of String of Pearls (SOP) plate constructs. We hypothesized that torsional compliance (TC) and angular deformation (AD) would decrease with 1) increasing number of bicortical screws per fragment and 2) bicortical screws positioned closer to the fracture gap.

Materials and Methods

Thirty-two SOP plates were assigned to eight groups (n=4/group), named according to screw type and position relative to the fracture gap. Specimens were tested in torsion; data (TC and AD) was statistically compared (p<0.05).

Results

The MMM (negative control) group was the most compliant (p<0.001). Compliance decreased in groups with a single bicortical screw (p<0.001). Compared to a centrally positioned bicortical screw, constructs with a bicortical screw in either the outer or inner most position were 15% and 23% less compliant, respectively (p<0.001). Addition of a second bicortical screw per fragment further decreased compliance (p<0.001). The positive control, BBB, was the least compliant construct (p<0.001). Maximum AD followed an identical pattern of significance to that of TC.

Discussion/Conclusion

Our results suggest that a minimum of one bicortical screw per fragment should be used to provide adequate torsional stability of 3.5 mm SOP constructs. Should further stability be desired, using two bicortical screws in the "far-near" positions or three bicortical screws per segment is recommended.

Combined small and large animal

In depth – Infection control in surgical practice

Friday July 5

08.30 – 10.20

Strategies to prevent and interrupt contagious diseases in my surgical practice

G. van Galen, K. Gommeren, D. Verwilghen

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Introduction

Contagious diseases are feared in veterinary hospitals and can be brought in by admittance of an animal suffering from a contagious disease, but probably the most common are hospital-acquired or hospital-associated infections (HAI). The group of contagious diseases concerned contains very different viral, bacterial, parasitic and fungal diseases and some of them are emerging or re-emerging, whereas some are old well established and endemic. They vary tremendously in clinical spectrum and contagiousness. Nevertheless, since hospitalized patients are often debilitated, contagious diseases can more easily spread through a hospital population with a possible bigger clinical impact than on healthy individuals. They can compromise the well being and health of the patient, cause longer hospitalization duration, increased medical costs, higher mortality, economic losses, fear and concern amongst owners, and in some cases temporary closure of the hospital ¹⁻⁹. Moreover, due to close patient contact some diseases with zoonotic potential can even affect their caretakers.

Why should the veterinary world be much more focused on preventing instead of treating contagious diseases?

First of all, the contagion risk has substantially increased over the last decade mainly together with the exponential growth of international and intercontinental transportation of companion animals, horses and food animals ¹⁰. The intensification and scale increase of sport, sales, and breeding events, allows a more intense interaction between transported animals and contagious diseases: travelling animals can spread contagious diseases but they can also come in contact with foreign infectious diseases and attract them due to absence of or poorer protective immunity. In addition, veterinary hospital structures have grown bigger and house larger numbers of patients, meaning increased risk and susceptibility for infectious diseases and their spread. Even though outbreaks in veterinary hospital settings are undoubtedly underreported, there seems to be an emerge and/or re-emerge of pathogens within veterinary hospitals ¹¹. A survey amongst American veterinary teaching hospitals showed that 82% had identified at least one outbreak of hospital associated disease in the last 5 years, and that 32% of them even demanded closure of the hospital ¹².

Secondly, veterinarians have responsibility and need to protect their hospital, their patients and all people involved. There seems to be an increasing recognition of the need for veterinary hospitals to be accountable for HAI ¹¹. At the same time, there is a demand from the community that we as veterinarians perform veterinary care that is of better and higher level, not allowing for contagious complications and outbreaks anymore if they can be prevented ¹³. Nosocomial infections have been listed in the top 10 reasons for malpractice claims against human hospitals ¹⁴ and it is likely that the veterinary community will face the same in the future.

Thirdly, with better diagnostic methods and improved worldwide communication, increased awareness and increased visibility of outbreaks of contagious diseases has developed.

Last but not least, the possibility for zoonotic infections and the emergence of antimicrobial resistance also demands for more strict infection control.

Due to all these changes, the "we have done so for the last 30 years without problems"-culture is no longer acceptable.

This talk will focus on the different transmission routes for infectious diseases and how to interrupt them in a veterinary hospital, with a main focus on surgical patients. For surgical patients, time in the hospital can be divided in a pre-surgical, surgical and post-surgical period; all three of interest regarding spread and/or contamination of infectious diseases. This talk will focus on mainly the pre- and post-surgical period, not the surgical period. Also the subject of multi-resistant bacteria, although integral part of infection control measures, will be more extensively discussed in a later talk.

Transmission routes and transmission-based precautions

Transmission requires 3 elements: a susceptible host with a portal of entry, a source of the infectious agents, and a mode of transmission for the infectious agent. The possible transmission routes with examples and transmission-based precautions are as follows ^{15,16}:

Direct contact: from one individual to another.

Example: FIV, FeLV, rabies, influenza

Precautions include: limit number of staff with patient contact, cleaning and disinfection of stalls and cages, barrier protection, cover all wounds or draining tracks, promptly clean up any body secretions, use disposable items,

Indirect contact: by fomites, by the environment, airborne, fecal-oral, waterborne. This is mainly applicable to pathogens that remain quite stable outside the host.

Airborne or inhalation: infectious droplets of bacterial or viral particles, either by direct or indirect contact. This route is of interest for surgical patients since they have undergone general anesthesia with inhalation of anesthetics and ventilation.

Example: Influenza, EHV, FHV, feline calici virus

Precautions include: avoid overcrowding, increase distance between patients, isolate with separate ventilation system, management of temperature, relative humidity and ventilation, schedule infectious patients at end of day, limit stress and excitement, avoid high pressure washers and dry mopping or sweeping, use wet mopping or filtered vacuum cleaners.

Fecal-oral: ingestion of pathogens shed in feces, either by direct or indirect contact. Environmental contamination plays an important role.

Example: Salmonella, E. coli, rotavirus, canine parvovirus

Precautions include: thorough cleaning of all animal-contact items and surfaces, food storage in closed containers with first-in first-out principle, food storage clean and free of pests, avoid common water supply, barrier protection, promptly clean up feces from areas of patient traffic.

Fomites: transmission via contaminated equipment, clothing, vehicles, etc

Examples: enteric pathogens, strangles

Precautions include: hand hygiene, hand free sinks and towel dispensers, change clothes when dirty or contaminated, cleaning equipment, foot hygiene, dedicated work shoes.

Iatrogenic: transmission during medical procedures, especially for surgical patients of importance

Example: any pathogen via inadequately sterilized equipment and contaminated blood products or medication

Vector borne: mechanical or biological transmission via vectors

Example: West Nile Fever, blue tongue virus, Equine Infectious Anemia, African Horse Sickness

Precautions include: fly and mosquito control, flea control, pest control

Water-borne: indirect transmission via contact with infected water (drinking, swimming, washing)

Giardia, leptospirosis, pseudomonas

Sexual transmission: via sexual contact or contaminated equipment for reproductive procedures

Example: contagious equine metritis, equine arteritis virus

Vertical: from mother to offspring

Example: BVD, EHV, parvovirus

Although not limited, the most important routes for surgical patients are airborne, fecal-oral, fomites, and iatrogenic transmission. Common entry and exit sites for pathogens are the respiratory tract, the skin and the gastro-intestinal tract.

Strategies to interrupt transmission and prevent contagious disease

Most strategies will have their effect upon multiple ways of transmission. Whereas it is sometimes difficult to identify the effectiveness of one single measure on transmission in a clinical setting, different studies have shown that with combinations of infection control measures transmission can be stopped^{3,4,7,9,17}.

Infection control measures need to allow for a reasonable flow and function of the hospital. Institutes need to make up their own balance on infection control measures with regards to feasibility, costs, effectiveness, practicality and risks (or accepting certain risks)¹⁸, all dependent on the geographical area, the population of clients and patients and the level of veterinary care offered. The benefit for infection control measures (or the costs of HAI or other contagious diseases) should be weighed against the costs of the implementation of these measures. Even though the costs of some outbreaks can be very high^{4,7,13}, it remains difficult to estimate the true cost of the impact of infectious diseases in a hospital, especially when it concerns single cases or smaller outbreaks.

Grouping patients with different risks

Not all infectious diseases have the same clinical impact or risk to be transmitted. Therefore classification systems have been developed where each class can have its own specific rules or measures¹⁸. Different levels of separation can be set up ranging from complete isolation to barrier nursing to a simple door closing practice. The levels of clothe and shoe changing, hand and foot hygiene, disinfection and separation from other patients (distance, separate entrance, ventilation system, management of disposals, allowed to go into surgery) depends entirely on the hospital and the type of medical problem.

With regards to contagious patients, it is important to keep in mind that as long as there is a suspicion of a contagious disease, the patient should be treated as contagious until proven otherwise! Therefore one should know how to interpret laboratory findings. It may also be that the best interest for the hospital is in conflict with the best interest for the individual patient.

Not only groups for contagious patients need consideration about separation, but also non-contagious patients can be considered to have separation levels^{13,18}. The bigger the hospital, the easier it is to allocate specific rooms or barns for a specific type of patient or age group.

Different species

Different species should be separated from each other to reduce inter-species spread

Research animals

Healthy research animals should not be housed together with sick patients

Patients coming for consultations

Patients that are coming for consultation only should ideally be separated from hospitalized patients in order to avoid exchange of pathogens and reduce the amount of passage in the hospitalization ward.

Surgical patients, elective surgery

Separate patients that are booked for elective surgeries from those that come for other medical reasons. Patients with for example skin conditions or respiratory diseases can potentially spread their disease and increase the risk of anesthetic or surgical complications for elective surgery patients when hospitalized closely together.

Neonates

Neonates and mother animals have specific needs concerning infection control. Neonates are more at risk for infectious diseases than adults due to their physiologically immature immune system that may be even further dysfunctional due to disease and therefore need infection control for protection. Moreover, a calm environment to deliver and to nurse their newborn is recommended. On the other hand, neonates, broodmares and septicemic calves have been shown to excrete more often *Salmonella*, even without showing clinical signs such as fever or diarrhea^{11,19}, and admittance to a equine neonatal intensive care unit was identified as a risk factor for MRSA colonization²⁰.

Colic horses

Also colic horses have specific needs. Regardless if they are medical or surgical cases, they are more at risk to excrete *Salmonella* and this can be with or without showing clinical signs such as fever or diarrhea²¹. Moreover, especially postoperative cases frequently are immunosuppressed, receive antimicrobial therapy, are fasted, have an IV catheter and can therefore be suggested to be at higher risk for infectious complications such as diarrhea, wound infections, viral infections, thrombophlebitis, etc.

General cleanliness and hygiene of the patient, environment and instrumentation

General cleanliness and hygiene are the basis of good veterinary practice and it will help creating a good image

towards your clients. These principles account for all patients, regardless of their infectious status.

Basic rules regarding cleaning and disinfection

Cleaning is necessary before disinfection! Disinfectants are often deactivated by organic material¹³.

Work from clean to dirty or from uncontaminated to contaminated.

Use the optimal conditions for the disinfectant: good dilution and appropriate contact time according to type of disinfectant and manufacturers instructions. The efficacy of disinfectants can be questioned when products are used with low concentration or with low bactericidal activity, and this might select for less susceptible bacteria^{22,23}. True resistance to high concentrations has been described in health care facilities but remains uncommon²³. Concentrations of disinfectants should not be based on minimum inhibitory concentrations (MIC), but on biocidal activity²⁴.

Each disinfectant has its own characteristics and spectrum and therefore a disinfectant must be chosen depending on the agent and the circumstances. For example with regards to *Salmonella* organisms, bleach was found to be the most effective disinfectant on the largest number of surfaces tested²⁵, but another study showed peroxygen disinfection to be highly efficacious in a clinical setting². Parvovirus and rotavirus are difficult to kill pathogens¹³.

The patients

It speaks for itself that good patient hygiene will contribute to the overall well being of the patient. Dirt, secretions, excretions, urine and feces all can compromise skin health and possibly contain infectious agents. Therefore they should be cleaned off the animal.

Waste from the patient

In order to reduce spread of wound infection causing bacteria, the patient's wound dressings should be put directly into waste disposal bags without touching any surface⁷. All dirt, secretions, excretions, urine and feces from the animal expelled in the environment as well as medical waste should be cleaned up and/or disposed. Enough bins for waste disposal should be available throughout a hospital and at strategic places.

The patients stable or cage

The stable/cage, the bedding and even the surroundings are frequently touched surfaces by the patient and caregivers and should be clean and regularly disinfected. Special attention should be paid to drinking and eating equipment since they can be an easy vector of infectious diseases, including MRSA⁷, and a source of fungal or bacterial growth. In general, eating and drinking should be

optimized in order to provide optimal immunity defense to infectious complications¹⁵.

Environmental surfaces including examination rooms, induction/recovery room, surgical theater and isolation facilities

Although several studies have shown decreasing bacterial loads after cleaning and disinfection in human and veterinary settings^{7,26}, no study has been able to demonstrate lower infection rates in human hospital settings associated with routine disinfection of surfaces versus cleaning with detergent only²⁷. As far as the authors are aware, no data is currently available for veterinary settings about its clinical effects.

Nevertheless, it is generally accepted that all rooms used for patient handling and their non medical equipment such as stretchers, chairs, washbowls²⁸, door handles^{7,29} and drains should be cleaned and disinfected regularly²⁶, because some pathogens, including *Salmonella* and MRSA can extensively contaminate a hospital setting^{7,29}. Cleaning efficacy of environmental sites differs greatly, and especially computer keyboards and mice seem more challenging to clean³⁰.

Faucets need particular attention since they can easily become colonized with *Pseudomonas aeruginosa* and have been identified as sources of HAI in human hospitals^{31,32}.

Whenever possible, wooden, porous, textured, cracked or pitted materials or surfaces, and rubber mats should be avoided for medical settings since they cannot be disinfected properly^{7,13,15,28}. Roughened floors can, however, be necessary for safety when dealing with large animals.

Directed mist application of a 4% peroxymonosulfate solution and cold fogging with Virkon S have been demonstrated to be an effective and efficient manner to perform environmental decontamination from *Staphylococcus aureus* and *Salmonella* spp in veterinary settings. These methods are also suggested to be less disruptive than traditional approaches and to potentially minimize microbial contamination in the hard to reach areas^{33,34}. This approach can be a useful adjunct, not a replacement, to traditional cleaning and disinfection¹³. In experimental and clinical human hospital settings, a new disinfectant product with persistent effect, Appeartex, has shown promising results in reducing bacterial loads even one day after application³⁵.

Separate ventilation systems in surgical theatres and isolation facilities are recommended to avoid airborne spread of pathogens, as described for an EHV outbreak in a veterinary hospital⁵.

Instrumentation or animal contact items

All medical and non-medical instrumentation should regularly be cleaned and disinfected. Scissors, stethoscopes³⁶, thermometers (ref), twitches, blood pressure cuffs³⁷, computer keyboards in treatment areas^{7,38} and anesthetic inhalation machines, pulse oximeter probes²² have all been

reported in literature to be associated with contamination or the spread of pathogens in hospitals and should therefore not be forgotten. When alcohol is used for disinfection it should be applied for the appropriate contact time (15-20min) and allowed to evaporate completely before reuse²².

Twitches can have changeable twitch ropes and be of material easy to clean and disinfect⁷.

Stethoscopes can be considered as an extension of the hands and cleaning can therefore be suggested at the same frequency as hands³⁹. Cleaning was found highly effective at removing bacteria and can be done with ethanol based cleansers and isopropyl alcohol^{36,39}, but in a day those cleaned stethoscopes were contaminated back up to a similar level of bacterial load as never-cleaned stethoscopes in a small animal hospital setting³⁶. Antimicrobial diaphragm stethoscope covers have been developed but their practical utility can be questioned since stethoscopes with these covers were found to even have higher bacterial loads while used in human hospital than those without these covers⁴⁰.

The replacement of rectal thermometers by tympanic ones in human settings has shown important reductions of infections with vancomycin-resistant *Enterococcus* and *Clostridium difficile*⁴¹. In the veterinary world, thermometers have been recognized to be a potential concern with regards to transmission of multi-resistant enterococci^{42,43} and therefore specific thermometer-cleaning protocols can be suggested.

Some non-surgical instrumentation, such as endoscopes and dental equipment, will need cleaning or cleaning and disinfection after each use.

Sterilization of surgical equipment is beyond the scope of this presentation.

Staff hygiene

Eating and drinking

For their own protection, staff members should not be allowed to eat or drink while in clinical rooms or when handling patients, samples, detergents and disinfectants, chemicals and/or medication. Eating and drinking should only be allowed in dedicated rooms.

Clothing

Since uniform contamination may be an important factor in the spread of infections, it is advised that staff wears hospital clothing while in the hospital and specific surgical clothing for use in the surgical theatre⁷.

There is currently discussion whether home-laundering of soiled, but non-contaminated surgical scrubs from human operating room personnel should be allowed. Although logic sense speaks for an increased transmission risk of infectious diseases and that significant higher bacterial counts have been found on home-laundered versus hospital-laundered scrubs⁴⁴, home-laundering policies have

not been linked with higher surgical site infections or by harmful effects on home environment^{45,46}. No statistical difference on bacterial counts was found between hospital-laundried scrubs and unused new and disposable scrubs⁴⁴. The situation in veterinary surgical theatres is probably different from human settings, and no scientific evidence is currently available about home-laundering of surgical scrubs. When home-laundering is done it is advised to wash surgical attire separately from other laundry and as last and to use bleach, high washing temperatures and a hot air dryer^{22,47}.

Silver-impregnation of surgical scrubs appeared to be ineffective in reducing bacterial contamination in veterinary settings⁴⁸.

Mobile phones

Mobile phones of veterinary teaching hospital staff have been found to harbor pathogens, although in a low contamination rate⁴⁹. Also in human medicine cell phones are recognized to be a possible transmission route for pathogens in hospital settings and opposite to the veterinary mobile phones have high pathogen contamination rates^{50,51}, and interestingly higher with smart phones than non-smart phones⁵¹. A disinfection protocol for cell phones can be considered.

Hand hygiene (not for surgical preparation)

Hand hygiene measures are leading measures to personal hygiene and to interrupt transmission cycles. There is convincing evidence that they reduce nosocomial infections in human hospitals as part of multimodal implementation of infection control strategies⁵². When their effect is evaluated alone without considering other measures they have only been proved efficacious in a limited amount of studies^{53,54}, possibly because of lack of appropriate adherence with hand hygiene recommendations⁵². Factors for poor compliance or adherence in human settings were amongst others: being a male, doctor status (rather than nurse)⁵⁵, working in surgical care unit, working in anesthesiology, wearing gloves⁵². Failure to perform and comply with appropriate hand hygiene measures is now considered the leading cause of HAI and outbreaks of multi-resistant organisms⁵⁶.

Hand washing (water and antibacterial soaps or water and plain soap), hand rubbing (alcohol based rubs) and glove wearing can protect patient handlers and patients and are recommended in between patients or different procedures. The effect of hand asepsis protocols on HAI rates and removal of pathogens from hands was superior from hand washing with plain water and soap⁵⁷. Of the hand asepsis protocols, alcohol-based hand rubs appear to be the most effective at reducing pathogen loads on the hands of health care workers, but hand washing is needed when hands are visibly soiled^{13,15,22,52}. The use of gloves, although easier to monitor, can provide a false idea of safety and glove removal should be followed by hand

washing or disinfection^{22,52}. Short nails and a healthy skin are suggested to be an integral part of hand hygiene, and therefore provision of hand lotions can be suggested^{7,13,15,52}.

Hand hygiene facilities should be easily accessible for staff and available at multiple strategic points and beside all doors and sinks^{7,13}, since accessibility of hand hygiene facilities affects the frequency and compliance of hand disinfection by personnel^{52,58,59}.

Jewelry, including watches, should not be worn not only during surgeries but also normal clinical work^{7,52}. Extra clocks can be placed and watches to pin on working clothes can be used⁷.

Hand hygiene measures amongst veterinarians and their staff are currently poor^{60,61}, but more and more hand hygiene educational campaigns and protocols are currently instituted^{7,61}.

Foot hygiene

Foot baths and mattresses should not be expected to sterilize footwear, but can reduce the amount of germs on shoes and therefore the spread of infections^{62,63}. They can be used at sites where infectious status changes. Disinfectants containing peroxygen compounds have showed good effectiveness for footbaths and foot mats in reducing bacterial loads on boots or shoes used in large animal veterinary settings⁶²⁻⁶⁴, whereas quaternary compounds have performed very poorly in footbaths⁶². Nevertheless, the disinfectant used should be effective against the specific pathogen, stable in solution and have a short contact time¹⁵. Their success depends on the used disinfectant, the amount of organic debris, the amount of passage, their cleaning frequency and the will of the involved people to step in or on them¹⁵. However, if not correctly used or without regular hygienic monitoring footbaths or foot mats may also act as contamination source⁶⁵. Removing organic debris from footwear before the use of a foot bath or foot mat with for example a brush and water will minimize the buildup of debris in the foot bath or mat and will increase effectiveness of the disinfectant¹⁵. Although footwear hygiene protocols are generally accepted to be an important aid in reducing risk of transmission, and reduce significantly bacterial loads on boots or shoes⁶²⁻⁶⁴, some questions can be raised on their efficacy, since total bacterial counts and *Salmonella enterica* isolates recovered from floor surfaces in veterinary hospitals appear not to be affected by them^{66,67}. In other settings, however, such as an animal research facility, a significantly lower bacterial load obtained from floors was demonstrated after use of disinfectant foot mats or shoe covers, compared to no foot hygiene measures⁶⁸.

Plastic overshoes can be used in addition or as alternative in isolation or surgical facilities. Nonetheless, occupational contamination risk during attire and removal is evident⁶⁹.

Unfortunately, no studies relate the use of foot hygiene directly to contamination or infection of surgical sites or patients⁶⁹.

Limiting passage

Another main principle is to limit passage through the hospital or the hospitalization barns/wards at several levels: visitors, owners or clients, patients, accompanying animals, insects and vermin. This will limit incoming infectious diseases, and spread of infectious diseases.

Whether a clinic cat should be allowed in a large animal hospital is up for discussion because they can be the only means to keep the rodent population under control. In small animal hospitals, however, it is not recommended to have resident cats since they have been shown to carry multidrug-resistant enterococci and are likely to contaminate the hospital environment⁴³.

Communication and education

Everybody involved should be aware of and cooperate with the implemented rules, because a single person committing critical errors can undermine all the efforts of the others¹¹. Unfortunately, the highest educated medical staff (doctors themselves) has shown to be the least compliant with hygienic measures in hospital surveys⁵⁵, and not showing the good example. Therefore education and training about the pathogens, their transmission and the implemented infection control measures at all levels is a must^{7,18,22,52,61}. It can also be extremely helpful to have written protocols^{4,7,18}. Although more and more veterinary hospitals are aware of this need and are actively working on it, still few have a formal infection control program⁷⁰. Veterinary infection control is unfortunately still often reactive instead of proactive¹¹.

Also good communication about the infectious status of patients is necessary. It is recommended to use signage and messages on the stable/cage including the measures that need to be taken.

In addition, tracking and documentation of patient movements is crucial to back track the origin of outbreaks of infectious diseases⁷.

Surveillance and control systems

Surveillance and controls systems are necessary to establish baseline rates for infection rates, for subsequent assessment of efficacy of infection control protocols, and for rapid identification, intervention and cessation of disease transmission^{3,11}. Surveillance and control systems require reliable and standardized diagnostic tests¹¹.

Regular testing, prospective investigations: active surveillance 18

Patients, environment (stables, treatment rooms, surgical theatre), and equipment can be regularly tested for presence of contagious agents. Patients can be systematically sampled on admission in a clinic to monitor for MRSA or Salmonella (standard surveillance or screening)^{2,17,25}. Sampling of environment and equipment can be performed standardly every so many months to determine if a high bacterial load is present and if sterilization and/or cleaning/disinfection procedures are efficacious².

Of course, extra testing of patients, environment and equipment is warranted after contact with a suspected contagious agent (syndromic surveillance)^{3,7}. Environmental tagging with fluorescent dye may be of use to establish baseline cleaning rates, identify deficiencies in protocols, and help with staff education³⁰.

Opting not to perform standard surveillance but only syndromic surveillance has previously lead to late identification of infectious problems and subsequent outbreaks⁴, but standard surveillance is expensive and its need is debatable for low prevalence countries or patient groups^{7,19}. Moreover, standard surveillance might provide a sense of false security with staff handling negative-tested horses with less care⁷. Basic precautions and good cleaning routines should be implemented for every patient irrespective of culture results.

Retrospective investigations: passive surveillance

It can be helpful to retrospectively investigate hospital-specific viral and bacterial diagnoses, nosocomial diseases and resistance patterns. Every hospital has their own "in-house" problems and they are important to be recognized¹⁸.

Evaluation of infection control protocols

Developing and maintaining effective infection control programs is a dynamic process^{11,18}. Therefore, infection control protocols need to be evaluated and weaknesses identified and dealt with in order for them to be efficacious in interruption of transmission routes and occurrence of contagious diseases^{4,5}.

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Multi-resistant infections: Current knowledge and strategies

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The introduction of penicillin for clinical use in the 1940s has led to great improvements in the management of bacterial infections and to significant advances in surgical procedures both in human and in veterinary medicine. Before effective antimicrobial drugs became available, many *S. aureus* infections in people were fatal with over 80% mortality reported for bacteraemia cases. However, bacteria continuously evolve and can adapt rapidly and they have been able to develop resistance mechanisms to virtually all antimicrobials used.

Infections due to multidrug-resistant (MDR) bacteria can have major implications on the patient's recovery as treatment may be prolonged, associated with more frequent and more serious side effects (as less commonly used antimicrobial drugs are needed) and may lead to substantially increased cost compared to infection with susceptible pathogens. Furthermore, many MDR pathogens can infect animals and humans and zoonotic transmission is often documented in both directions between hosts. This has implications for public health and may require comprehensive infection control strategies and owner education.

The most important MDR pathogens involved in wound infections in animals include methicillin-resistant *Staphylococcus aureus* (MRSA) and methicillin-resistant *S. pseudintermedius* (MRSP) but *Pseudomonas aeruginosa* (particularly through formation of biofilm in wounds), *E. coli* and *Acinetobacter* spp. may also present as challenging pathogens.

MRSA

MRSA in animals has a varied epidemiology depending on host species. If identified in small animals, MRSA is typically associated with human healthcare contact and likely to represent a spill-over of hospital strains into the community and to pets; this occurs more frequently in countries with a high MRSA burden in human healthcare facilities. In horses, most MRSA infections are due to *S. aureus* lineages that are commonly found in horses but rarely in people and the spread of equine-adapted MRSA following the presence of certain, still incompletely understood risk factors has been proposed. In farm animals, particularly in pigs, new MRSA lineages (e.g. CC398, CC9) have shown the ability to spread rapidly amongst

healthy animals colonising skin and mucosae. Disease in livestock is extremely rare but transmission to in-contact people (farmers, vets) is frequently documented and human infections with LA-MRSA are reported.

The relevance of MRSA infections in animals lies primarily in its zoonotic potential. Clinically, most infections in small animals and horses can be treated successfully with antibacterial agents authorised for use in animals. While MRSA are by definition resistant to all β -lactam antibiotics and often to fluoroquinolones, effective therapy can most often be achieved with potentiated sulphonamides, tetracyclines or in approximately 50% with clindamycin where systemic treatment is indicated. Since most animal MRSA infections have involved surgical site and skin infections, good wound management, suture or implant removal and topical antibacterial therapy alone may be sufficient for many infections. The prognosis for resolution of MRSA infection has typically depended on the prognosis of underlying factors. However, since MRSA is a primarily a human pathogen, can be spread into the environment via skin squames and hair and can survive on dry surfaces for up to one year, owner education and first-class hygiene measures are critical to appropriate case management.

MRSP

A much greater clinical challenge presents the emergence of highly drug-resistant MRSP in canine and feline patients and to a lesser extent in horses. In contrast to MRSA, MRSP is typically resistant to all antimicrobial agents authorized for systemic use in pets. MRSP has been reported from the USA, Europe and from Asia and has accounted for up to 30% of clinical *S. pseudintermedius* submissions in some countries in recent years. Clinically and cytologically, MRSP wound infections resemble other staphylococcal diseases. They are often identified after empirically chosen β -lactam therapy has failed. Since the vast majority of MRSP are also resistant to third-generation cephalosporins and fluoroquinolones, bacterial culture and antimicrobial susceptibility testing should be initiated early to allow targeted therapy and avoid delayed healing due to inappropriate empirical therapy. Treatment of MRSP infections may rely on good wound management, suture and implant removal and topical antibacterial therapy for infections that are amenable to topical therapy alone. For

deeper infections where systemic treatment is indicated amikacin, chloramphenicol rifampicin based on extended *in vitro* testing may be effective. Vancomycin should be avoided as this aminoglycoside is currently one of the very few agents still effective in serious MRSA infections (e.g. bacteremia, endocarditis) in humans.

Other multidrug-resistant bacteria

Other multidrug-resistant bacteria that may involve wounds include *Pseudomonas* species, particularly those producing biofilms on wounds, or enteric commensals such as *Escherichia coli* or enterococci. Of concern are strains of *E. coli* with extended-spectrum beta-lactamases (ESBLs) and vancomycin-resistant enterococci (VRE) as those are currently causing problematic infections in humans. In addition, multidrug-resistant *Salmonella typhimurium* and *Acinetobacter baumannii* infections have been reported in cats and dogs from several countries and animals have been implicated as a reservoir for human infection. Treatment tends to be very challenging and with only little information published to date, recommendations for management and treatment of such cases will have to rely on general strategies of addressing underlying causes until infection can be resolved.

Prevention of MDR infections

Since surgical site infections due to MDR pathogens are currently still infrequent in most animal species, awareness, implementation of rigorous infection control measures and a conscientious use of antimicrobial drugs are key to minimise the threat from MDR infections in veterinary practice. A potential carrier status of animal patients should be considered once infection has resolved to limit spread and address the zoonotic implications. Within a veterinary practice or hospital setting, it is important to recognise clusters of MDR infections early in order to initiate a comprehensive approach for eradication and to reduce the risk of repeated outbreaks.

Evidence based hand hygiene in veterinary surgery: what is holding us back?

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Step by step we have adapted our medical decision-making to the light of new scientific evidence. As much as possible, recommended medical protocols should now be evidence-based¹, which may result in changes in diagnostic methods and treatments in veterinary medicine² as in human medicine. Despite, in the field of hand hygiene, things have evolved slowly. Surely, the field has advanced since 1800's, when Semmelweis and Lister were making seminal (yet controversial) discoveries of the benefits of hand hygiene and laid foundations for the concepts of asepsis and vigorously fought the disbelief they were facing. Yet, are we open-heartedly embracing evidence today?

According to a survey performed in 2009 amongst ECVS and ACVS diplomates, 6.7% of respondents were following World Health Organisation's (WHO) guidelines for pre-surgical hand asepsis³. Unfortunately, in a survey performed in 2013, still 66% of the 218 respondents⁴ did not follow the current WHO guidelines based on the scientific evidence available today in this field. So what do current guidelines and evidence say? Additionally, what is right; current guidelines or current practices?

A variety of methods for surgical hand preparation are available. Aqueous solutions containing either povidone-iodine (PVP) or chlorhexidine gluconate (CHX) have been standard for many decades, but alcohol-based hand rubs (AHR) have been described for surgical hand-preparation for more than a century⁵. Although, no randomized controlled trials have been conducted showing any significant differences in surgical site infection (SSI) rates between above mentioned methods, the AHR method is considered superior for a number of reasons^{6,7}. The antibacterial efficacy of products containing high concentrations of alcohol was shown to surpass significantly that of any medicated soap currently available⁸. The initial reduction of the resident skin flora (microbiota) is so rapid and effective with AHR that bacterial regrowth to baseline values on the gloved hand takes more than 6 hours⁹. These observations

also were confirmed in a veterinary trial that compared the activity of a AHR solution to CHX and PVP soap¹⁰. In that study, a 1.5min application of an AHR solution was performed, the 3h residual effect on CFU reduction of AHR was in particular shown to be significantly better than for traditional hand scrubbing with PVP and CHX. It should be noted that when choosing a AHR solution, the product should meet the EN12791 or equivalent standard required for pre-surgical hand-rub formulations¹¹. Many available hygienic gels will for instance not meet the surgical standards and are therefore not recommended.

The purpose of both a surgical scrub with medicated soaps and that of a surgical rub is to remove and/or kill transient skin organisms and to reduce resident microbiota for the duration of a surgical procedure in order to reduce the risk of SSI, while minimizing damage to the skin that might promote rebound bacterial overgrowth or compromise future hand antisepsis attempts. The transient microbiota is acquired by contact with people, animals and contaminated surfaces. It colonises the superficial layers of the skin and is the most common cause for inducing SSI. The resident microbiota is a more established, deeper component of the microbiota that is regarded as less pathogenic on intact skin. Amongst its functions, microbial interference as a mean of defence against bacterial infection is one of the most important. Techniques involving aggressive cleaning of the skin with alkaline medicated soaps, like CHX scrubs will have deleterious effects on the skins local defence mechanisms¹². Moreover, besides not having shown additional effect on bacterial reduction¹³, techniques involving brushes and scrubbing cause small excoriations and therefore damage to the skin; which in turn increases the risk of skin colonization by pathogenic species¹⁴. Yet, 44% of the respondents to our survey state they always use brushes for their preparation. Current recommendations are to use soft sponges, if any, for hands and forearms, only if visibly soiled and brushes for fingertips¹⁵.

About 17% of survey respondents⁴ used a medicated scrub technique combined with an AHR, in clear contradiction to published evidence and recommendations. Medicated soaps are either less effective or have a similar efficacy to hand rubs. A first scrub with medicated soaps instead of a first rub will not result in increased reduction of microbiota¹⁰. On the contrary, long-term use of medicated soaps increases the risk of dermatitis, making the skin more difficult to decontaminate, and combination of medicated soaps and AHR likely increase the risk of skin damage while providing no demonstrable positive effect. Further, prior hand-washing can alter the effectiveness of AHR solutions¹⁶, particularly if hands are not completely dried before AHR application. Hand washing also increases preparation time, cost, increases carbon footprint and water usage^{17,18}. It is estimated that 20L of water is used per hand when preparing with medicated soaps. Faucets are also common sources of *Pseudomonas* spp. and other Gram-negative bacteria; the rinsing phase of traditional soap method can therefore result in a recontamination of the hands prior to gloving¹⁵. Considering the above, it has been suggested there is no reason to include a hand wash before AHR solutions are applied^{16,19} and that hands should only be washed if they are visibly soiled. However, compared with human hospitals, the bacterial burden in veterinary settings may be higher, especially for large animal surgeons. Until further objective data are available, it is our opinion that a short hand-wash with a gentle soap (pH neutral) should precede the AHR application. In this way, bacterial spores mostly carried in organic material on hands can be eliminated.

A new and more worrying aspect supporting reduced use of medicated soaps is the emergence of increased acquired resistance towards antiseptics^{20,21}. Particularly the prevalence of *Staphylococcus aureus* carrying chlorhexidine resistance gene *qacA/B* has been shown to increase in the hospital environment²². The overuse of CHX scrubbing soaps, which results in spreading of large quantities of diluted active substance, which is more likely to be bacteriostatic than bactericidal, could be a creeping problem comparable to antibiotic resistance. Due to the fast killing activity of alcohol and the lack of any known (or plausible) genetic mechanisms that would allow for transmission of inherent alcohol resistance, acquired resistance to AHR has not been shown to date nor is it likely to be encountered, providing another major reason to move towards these products.

Also, outside the closed environment of the surgery theatre, transmission of microbial pathogens by the hands of healthcare workers during patient care plays a crucial role in the occurrence of SSI and other hospital acquired infections (HAI's). Hand hygiene is therefore regarded as one of the most effective measures to contain these. Several reports have shown temporal association

between interventions to improve hand-hygiene measures, compliance rates and/or reduced infection rates. A recent British report evaluating the "Clean your hand"-campaign showed that in the 4-year study period, the AHR use per bed day raised more than a twofold simultaneously with a twofold decrease in MRSA (methicillin resistant *Staphylococcus aureus*)/bacteremia and *Clostridium difficile* infections²³, strongly emphasising the importance of these measures. In order to achieve these results, compliance with hand hygiene measures should be improved. The weakest link here seems to be the surgeons and physicians since compliance of these reveals to be more difficult to obtain than from the nursing staff^{24,25}. Even worse, health care workers in surgical units have been shown to be less compliant and adherent to hand hygiene policies¹⁵. The introduction of AHR's and improving the accessibility of materials, has been identified as associated with higher hand hygiene compliance rates²⁶. New technologies are underway to monitor electronically the compliance in human health care, with financial incentives for health care staff. Ultimately, however, increased awareness and personal responsibility by all personnel is critical for improving hand hygiene rates.

It is clear that the veterinary occupation also has a real impact on the health of our skin. Not only is medical staff known to acquire more pathogenic resident microbiota over time²⁷, a high proportion of healthcare workers develop occupational dermatitis mostly related to repeated washing with chlorhexidine soaps^{28,29}. Conflictingly, one of the most important determinants of healthcare workers resistance to change to AHR is the belief that AHR's are more harmful to their skin than soap and water^{30,31}. Each hand wash detrimentally alters the lipid layer of the superficial skin creating loss of protective agents such as amino acids and natural antimicrobial factors. Prolonged and repeated washing leads to damaged barrier function of the *stratum corneum* resulting in the skin becoming more permeable for toxic agents and bacteria. On the other hand, AHR solutions have shown greater skin tolerance than soaps³², including in veterinary settings¹⁰. This corroborates the results from the above mentioned survey⁴ in which preliminary results show that surgeons using antimicrobial soaps as pre-surgical hand-preparation methods have poorer overall hand health scores as monitored by WHO guidelines. Particularly in the evaluation of moisture content, surgeon using antimicrobial soaps report significantly dryer hands than those using AHR solutions (Table 1). This is mainly due to the absence of the above mentioned deleterious effects of soap washing combined with the fact that AHR products contain humectants and need shorter application times³⁰. Further, although lipid layers are also dissolved with AHR, they are not washed away but rather reincorporated by the action of rubbing. As mentioned before, unnecessary washing should be avoided, particularly with hot water²⁸.

In our latest survey⁴, 89 respondents stated they believe AHR are superior than traditional hand scrubbing techniques for obtaining hand asepsis. Nevertheless, over 42% of these respondents report the use antimicrobial soaps in their protocol, clearly indicating lack of compliance with their own beliefs. Potentially, the fact that many surgeons consider the act of scrubbing as an “ancestral ritual” towards preparation to surgery may prevent them from shifting to more efficient protocols²⁵. In addition, this may highlight the fact that involvement of the hospital management in setting up changes in hand hygiene policies is essential³³. The use of campaigns and internal training sessions has shown great benefit^{24,25} in increasing hand hygiene compliance amongst staff in human medicine. Similar initiatives should be made in veterinary medicine in order to obtain better compliance with the application of current knowledge on hand hygiene. Considering the application technique of AHR is important and the use of hand scrubs is probably less prone to errors as all parts of the hands and arms get wet under the tap, good education is mandatory when introducing AHR.

As a conclusion, in order to comply with current medical standards the veterinary community should aim at introducing AHR solutions in both the pre-surgical and hygienic surgical hand disinfection protocols.

It is in our hands !

Protocol	Appearance					
	Intactness	Moisture Content	Sensation	Overall Score		
A	Antimicrobial scrub (n=91)	7	6	5	7	6.25
B	Antimicrobial scrub followed with AHR (n=45)	7	6¥	5	7	5.75
C	Neutral soap followed by AHR (n=35)	7	6	6∞	7	6.75*
D	AHR only (n=15)	7	7	7∞	7	6.75*
E	Alcohol Chlorhexidine combination (n=24)	7	6	5	7	6

Table 1: Hand health scores from 2013 surgical preparation survey⁴, based on “hand and skin self-assessment tool” WHO guidelines appendix 315. 7 point based scale with 1 being abnormal and 7 normal. The overall score is based on the mean of the 4 individual assessments. Scores are reported as medians. Overall Scores: * significantly different from A, B and E. Intactness: ¥ significantly different from C and D. Moisture content: ∞ C and D significantly different from A,B and E but not from each other.

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Small animals

In depth – Infection in small animal surgery

Friday July 5
14.30 – 18.00

Surgical site infection: Where are we at in small animal surgery?

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Surgical site infections (SSI) continue to increase morbidity, to delay patient recovery, to increase cost to owners and they often add to the problem of rising antimicrobial resistance. New challenges in the management of SSIs over recent years have been the emergence of multidrug-resistant bacteria in veterinary medicine and infections associated with biofilm-producing bacteria. In addition, increasing concern over antimicrobial resistance and even resistance to biocides amongst important pathogens has heightened pressure to review and reduce antimicrobial prophylaxis. In parallel, substantial advances in small animal surgical procedures over recent decades may have led to longer, more complicated surgery and potentially a wider use of implant devices with an associated increased risk of SSIs.

Bacteria involved in SSIs are often those associated with the animal's skin microflora such as staphylococci (and occasionally oral microflora organisms) and can therefore not be eradicated. In addition, exogenous sources such as environmental contaminants (airborne or adherent to surfaces) or organisms transmitted by veterinary staff or owners may also become involved (e.g. enterococci, *E. coli*, *Pseudomonas spp.*, streptococci). In humans, it has been shown that up to 80% of post-surgical infections were caused by the patient's own, nasally carried *Staphylococcus aureus* strains with *S. aureus* carriage widely recognised as the major risk factor for *S. aureus* SSI. In dogs, 80% of *S. pseudintermedius* isolates from pyoderma lesions were genetically identical to isolates carried on skin and mucosae by the patient. This suggests that microflora strains are well adapted to their hosts and thus in an ideal position to cause disease should the opportunity arise (such as during surgery) and a similar predisposition for endogenous SSI as in people may be proposed for dogs.

A low frequency of SSIs (average around 5%, depending on the NRC classification of wounds) has been shown to be unavoidable despite high level of asepsis, surgical experience, facilities and wound management. However, since aseptic technique often relies on good human compliance, a microbiologically trained mindset and awareness amongst staff will be critical to prevention of SSIs. Knowledge of risk factors for SSIs may also aid in

the reduction of infection cases and risk factors have been widely studied in humans and animals.

While most SSIs can still be treated successfully using topical and/or systemic antibacterial therapy (combined with good wound care and/or removal of implants), responsible use of these agents is becoming critical in order to preserve their efficacy for the treatment of serious infections in humans and animal in the future. Surface wound infections in particular offer the opportunity to confirm a bacterial component prior to antimicrobial therapy through simple impression smear or tape strip cytology which will rapidly confirm the presence of high numbers of bacteria in combination with inflammatory cells. In addition, empirical choice of antimicrobial agents should be limited to first-time infections in animals with no history of repeated antimicrobial therapy. Bacterial culture and antimicrobial susceptibility testing, often not performed due to a perceived time and cost effort, may ultimately be cost-effective by allowing targeted therapy early. However, it is vital to sample relevant tissue. While sampling of surface wounds will be easy and quick, deep infection may require another invasive procedure to obtain subcutaneous tissue for macerated tissue culture.

All wounds should initially be covered until the first seal provides protection against environmental bacteria. In addition, there is an array of antimicrobial dressings that may help in the prevention and treatment of SSIs in combination with other measures. Since SSIs arise in practice or hospital settings (within 30 days or within 1 year for implants of hospital exposure) where selective pressure from antimicrobial use may predispose to acquisition of multidrug-resistant bacteria, early recognition, surveillance and isolation of suspected cases are indicated. Lastly, staff should be aware of an occupation risk documented for MRSA carriage amongst veterinary surgeons and nurses in order to minimise the risk of wound contamination from human sources.

Infection's biology: Biofilms

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Biofilms are conglomerations of bacteria (or certain fungi) within a 'slime' of polysaccharides, proteins and DNA. This extracellular matrix assists bacteria in adhering to surfaces and can be formed by some bacterial strains when they change from a free-living 'planktonic' form to a sessile form for example on the surfaces of teeth, heart valves, lungs but also on implants, in skin wounds or when floating on moist surfaces such as sewage or even disinfectant footbaths. In nature, biofilms are ubiquitous and although biofilm-associated bacteria grow slower than their planktonic counterparts, biofilms help bacteria to thrive in difficult or even extreme conditions such as hot springs or on glaciers. However, over the past 20 years, biofilms have become recognized as a serious problem for public health as they facilitate many important microbial infections in humans and animals, including wound and implant-related infections, and substantially complicate their treatment.

The impact of biofilms on microbial infection stems from their ability to protect pathogens from antimicrobial drugs and disinfectants (intrinsic resistance), to help to retain nutrients and to protect microbes from host-immune responses (antibodies can penetrate biofilms and phagocytes engulf them but the resulting immune reactions are reduced). In addition, the formation of phagocyte agglomerations around biofilms can lead to capsule formation and interfere with wound healing. The microenvironment within biofilms includes signaling channels which facilitate bacterial communication and possibly exchange of resistance genes (acquired resistance) and lead to a change in gene expression and production of virulence factors that are not typically expressed by planktonic forms. Detachment and expulsion of aggregates of biofilm allows spread of infection and may facilitate thromboembolic disease.

For biofilm formation to start, bacteria first need to be deposited and proliferate on a substrate layer, e.g. an intravenous catheter coated naturally by a protein film of fibronectin, fibrinogen, albumin and immunoglobulins. Bacteria capable of producing biofilm will start to form and secrete extracellular proteins and polysaccharides once sufficient numbers of bacteria are present. This regulation through bacterial communication called quorum sensing (*quorum*: minimum number that must be present in e.g. a meeting to make a valid decision) allows a delayed production of extracellular proteins and of virulence factors

leading to a greater likelihood of bacterial success. Biofilms can form on rough and smooth surfaces and on both hydrophobic and hydrophilic material although generally rougher and more hydrophobic materials predispose to biofilm formation. In addition, bacteria that possess flagella, pili or fimbriae find initial attachment easier.

Important human diseases often associated with biofilm infections are gingivitis, endocarditis, cystic fibrosis, urinary tract diseases and Legionnaires' disease in addition to various types of implant-related infections (catheters, prostheses, heart valves). Veterinary examples of quorum sensing and biofilm producing bacteria are *Staphylococcus aureus*, *S. pseudintermedius*, *S. epidermidis*, *Pseudomonas aeruginosa*, *E.coli* and certain streptococci. Chronic cutaneous wounds in particular are vulnerable to the formation of biofilm following the loss of the skin's innate barrier function and there is good evidence that biofilms in wounds contribute to infection and delayed wound healing.

Since conditions in biofilm infections differ substantially from non-biofilm disease, results from standard bacterial culture and antimicrobial susceptibility tests cannot be directly extrapolated to biofilm infections. For diagnostic purposes, implant devices may still be submitted to the laboratory and roll-over cultures may still yield relevant bacterial species (biofilms can occur in pure culture or as mixed microbial growth). However, biofilms are often difficult to remove from devices, particularly from the inside of catheters. Treatment based on standard susceptibility test results may lead to treatment failure in biofilm-associated infections and special biofilm-assays may be required if systemic treatment is critical. Susceptibility to antimicrobials has been shown to be reduced by more than 500x in biofilm-associated *E.coli* compared to free-living strains and treatment may have to focus on removal of devices combined with topical antimicrobial treatment where possible.

Over recent years, biofilm properties have been harnessed for used-water treatment in sewage plants, in the clean up of oil spills in oceans and in the generation of energy from organic biofilm material. Beneficial medical applications may arise from properties of extracellular proteins produced by certain biofilms, with potential in antibacterial or anticancer therapy in the future but current prevention methods focus on materials with biofilm-resistant surfaces.

Sepsis: New strategies/biomarkers

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Sepsis, defined as the systemic response to infection, occurs commonly in dogs and cats; it can be a challenge to diagnose, expensive to treat, and it is associated with significant morbidity and mortality. Despite advances in critical care, morbidity and mortality from sepsis remains high.

It has been determined in people that delay in treatment of sepsis is associated with a worse outcome. Early identification of sepsis can be difficult as clinical signs associated with sepsis often mimic those of other disease processes making sepsis difficult to diagnose in its early stages. Clinical signs of systemic inflammation including tachycardia, tachypnea, fever or hypothermia, leukocytosis or leukopenia, are also common findings in animals with non-infectious causes of systemic inflammation such as immune-mediated diseases or pancreatitis. Documentation of a septic, suppurative exudate (a highly neutrophilic effusion containing intracellular bacteria) in some animals can be straightforward, however in practice this documentation may be difficult to obtain in dogs experiencing severe hypoperfusion. In some dogs the index of suspicion for sepsis results from sampling of a highly neutrophilic effusion with clinical signs supporting infection, but clear indication of a septic process (intracellular bacteria) may not be visible. Techniques such as comparing the glucose or lactate of the effusion to the peripheral glucose or lactate concentrations have been found to be highly sensitive and specific for the diagnosis of a septic effusion. However, how these can be applied to those animals developing sepsis post operatively has not been determined.

Despite difficulties in diagnosis of sepsis, delay in institution of therapy has also been shown to negatively affect outcome. The 2012 Surviving Sepsis Guidelines state "The early identification of sepsis and implementation of early evidence-based therapies have been documented to improve outcome and reduce sepsis-related mortality". For this reason, these guidelines recommend routine screening of patients at risk of critically ill people for signs of severe sepsis, and administration of intravenous antibiotics within one hour of recognition of severe sepsis or septic shock. With growing awareness of the importance of early institution of therapy, screening protocols have

been developed and validated to improve recognition of severe sepsis and earlier implementation of what are called 'sepsis bundles', with the goal of reducing sepsis-induced mortality. As an example, a study published in the J of Trauma in 2009 investigated a three-step process that included screening for SIRS, then having a midlevel provider search for infection in any patient with a SIRS score of at least 4. In those patients where an infection was identified, an intensivist would evaluate the patient for possible implementation of a sepsis protocol. In this study, the screening process was highly sensitive and specific for the diagnosis of sepsis, and led to a significant reduction in sepsis-related mortality.

Our experience with a sepsis protocol for dogs presenting to the emergency service at TCSVM will be discussed.

In addition to screening tools, biomarkers are constantly being evaluated for their ability to reliably differentiate sepsis from severe inflammation. Nearly 200 potential biomarkers have been evaluated for the diagnosis of sepsis states or for determination of prognosis. These include acute phase proteins, cytokines, cell markers, and biomarkers of organ dysfunction, vasodilation, vascular endothelial damage, and coagulation. As this list is exhaustive, a select few will be discussed here.

Hematological variables: Leukocytosis, leukopenia, or the documentation of a left shift is often considered a potential early indicator of a septic process. However, these changes are non-specific and can occur as a result of any systemic inflammatory insult. Eosinopenia has been suggested in people as potentially having value for distinguishing between the presence and absence of infection, but this has not been evaluated in veterinary medicine.

C-reactive protein (CRP): Synthesized by hepatocytes in response to inflammatory cytokines, CRP has been used as a marker of the acute phase response in human and veterinary studies. Increased CRP has been documented in dogs with diseases marked by systemic inflammation including pancreatitis, immune-mediated diseases, sepsis, and secondary to surgery. One study found that CRP seems to be generally higher in critically ill dogs compared to normal dogs. Sensitivity for the diagnosis of sepsis in people has varied, but is higher when combined with body temperature. While not particularly useful for

differentiating systemic inflammation from infection, trends in CRP concentration may be valuable for predicting prognosis and disease severity. Lack of specificity is a major limitation of CRP evaluation, as concentrations are generally increased in severe inflammatory states and may be influenced by corticosteroid therapy.

Procalcitonin (PCT): Tight regulation of procalcitonin production (the prohormone of calcitonin) by the thyroid gland is lost in the presence of microbial infection leading to extrathyroidal production of PCT. Increased PCT concentration has gained widespread attention in people for its ability to identify sepsis, and for its potential as a tool to guide antibiotic therapy. PCT has been shown to be superior to CRP as far as diagnostic accuracy of sepsis in people, but may have greater sensitivity and specificity when combined with other variables. As a prognostic marker, both absolute measurements and trends of PCT concentrations are considered helpful in predicting mortality, and this biomarker continues to be studied for its potential to guide decisions related to institution or de-escalation of antimicrobial therapy. Unfortunately the assay for PCT does not recognize canine or feline PCT making it unavailable for veterinary use at this time.

Endotoxin activity (EA): As an important trigger of inflammatory cytokine release, endotoxin activity was thought to have promise as a marker for sepsis states. However, studies in people have had mixed results due to variable incidence of circulating endotoxemia in people with sepsis, and known endotoxemia in disease states other than sepsis. However, some studies suggest that higher EA may be helpful in identifying people at higher risk of dying from severe sepsis. A few studies have evaluated the use of the EA assay in veterinary medicine, with mixed results. One study documented higher EA in dogs with sepsis compared to SIRS, while another did not find that EA correlated to clinical infection in dogs.

Tumor necrosis factor (TNF): This well studied pro-inflammatory cytokine has been measured in several veterinary studies. Its early release in sepsis is followed by an acute drop in production, limiting its potential utility in naturally occurring disease states where the actual onset of sepsis is not known. Circulating TNF was documented in one study of dogs with parvoviral enteritis. Another study documented measurable TNF in dogs with both sepsis and SIRS compared to healthy controls, but did not find that it was useful in differentiating SIRS from sepsis. Several additional inflammatory cytokines will be discussed.

Natriuretic peptides (NP): The natriuretic peptides consist of atrial natriuretic peptide (ANP), B-type natriuretic peptide (BNP), and C-type natriuretic peptide (CNP). Natriuretic peptides are produced as prepropeptides and following a series of reactions are converted to an inactive N-terminal

(NT) peptide and a biologically active C-terminal peptide. As ANP and BNP both function to regulate circulating blood volume, they have been investigated as potential biomarkers for disease states including cardiovascular disease in cats. NT-pro-CNP in particular (the inactive N terminal of CNP) has been evaluated as a potential sepsis biomarker in dogs, and results have been encouraging. Dogs with sepsis had significantly increased NT-pCNP concentrations compared to dogs with SIRS and to healthy controls.

The ultimate biomarker for sepsis would be available as a point of care test to screen patients at risk for sepsis. In differentiating sepsis from systemic inflammatory states that are not accompanied by infection, the ideal biomarker will allow for early recognition of sepsis and institution of antibiotic therapy (which may improve survival). In addition, a biomarker that accurately identifies severe sepsis may provide a means to guide antibiotic therapy, thus potentially reducing the use of antibiotics in general and the incidence of superinfections in veterinary medicine.

Animal models of implant related infection

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Increasing antibiotic resistance amongst bacteria within the hospital and community environments will ensure that musculoskeletal infection continues to pose a major challenge to clinicians. At the same time, it is clear that current infection rates and treatment algorithms could benefit from new technologies such as antimicrobial activated coatings. Safe and expedient implementation of this technology relies on well-designed and clinically relevant *in vivo* simulation using animal models.

Many animal models of musculoskeletal infection have been described in the literature; however, there remains a dearth of fully standardised or universally accepted reference models hindering advancement in the field. The design variables involved in creating a model are manifold and inevitably demand compromise. An inherent limitation of animal models is the difficulty in extrapolating results not only to humans, but also to other animals or to the same model in another laboratory.

In the orthopaedic and trauma field, standardisation and refinement of fixation methods would also improve existing models. Rabbits, rats and mice, for example have been frequently used in the field but the nature of implant or fixation and the anatomical location used vary. Stable, repeatable fixation systems, which mirror clinical practice and reliably heal fractures without complication, should be the starting point for clinically relevant research and development into anti-infective strategies in the field.

Recent advances in some of these areas have been made and the burgeoning availability of tools for longitudinal *in vivo* monitoring of infection via the use of bioluminescent bacteria is another exciting development in the field. These refinements and others should enable the creation of robust, controlled and consistent models, which allow strong scientific conclusions with a minimum of harm to animals.

Can we influence the risk of infection by implant design?

The use of implanted orthopaedic devices has greatly improved the quality of life for an increasing number of patients, by facilitating the rapid and effective healing of

bone after traumatic fractures, and restoring mobility after joint replacement. However, the presence of an implanted device results in an increased susceptibility to infection for the patient, owing to the creation of an immunologically compromised zone adjacent to the implant. Within this zone, the ability of the host to clear contaminating bacteria may be compromised, and this can lead to biofilm formation on the surface of the biomaterial. Currently, there are only limited data on the mechanisms behind this increased risk of infection and the role of material or implant choice.

The development of an infection after implantation of a fracture fixation device is known to be influenced by design aspects of the implant such as the surface area available for colonisation, whether or not it creates dead space, bone contact area, compression, periosteal necrosis and the stability provided by the implant. *In vivo* studies using implants of identical dimensions and only differing in material have shown that the implant material is also a factor that can affect infection rate for intramedullary nails and dynamic compression plates. Of the commonly used orthopaedic implant materials stainless steel and titanium; stainless steel is associated with an increased infection rate in comparison with titanium for intramedullary nails and dynamic compression plates in experimental studies. Aside from bulk material differences, these implants also differ in surface topography, from the smooth electropolished surface of stainless steel implants to the non-polished microrough surface of titanium implants.

Polishing the surface of titanium and titanium alloy internal fixation plates can minimise unwanted soft-tissue adhesion and ease removal of screws and intramedullary nails in comparison with standard equivalents, with significant clinical benefit in certain situations. The effect surface polishing has on *in vitro* bacterial adhesion and *in vivo* infection rate has been uncertain to date, and recent data has emerged for locking compression plates and intramedullary nails in a non-fracture rabbit model, indicating that surface topography is not a significant factor in risk of infection, at least in a non-loaded model.

Can we influence the risk of infection by implant design?

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Current strategies for treating pleural and peritoneal infections

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Pyothorax and septic peritonitis are a life threatening condition in dogs and cats that causes serious metabolic alterations and organ dysfunction. They result from contamination of the pleural or peritoneal space by microorganisms. Pyothorax and septic peritonitis will result in septic shock and death of the patient if not treated appropriately.

Treatments of pyothorax and peritonitis have 3 goals: administer appropriate supportive medical treatment (antibiotics, fluid therapy, shock therapy), lavage thoroughly the pleural and the peritoneal cavity with sterile warm saline to flush bacteria or debris, and surgical correction of the primary problem if possible.

MEDICAL TREATMENT

Antibiotic therapy is initiated as soon as the diagnosis is established and samples are collected for culture and sensitivity. Cytology of the pleural fluid may show presence of filamentous organisms indicative of *Actinomyces* or *Nocardia*. Combination of Ampicillin (20 mg/kg three times a day) and Enrofloxacin (5 mg/kg 2 times a day) is appropriate while waiting for result of a culture and sensitivity. Cefoxitin (22 mg/kg IV three times a day) is also a good choice. If filamentous organisms are visible Clindamycin is then indicated. Presence of filamentous organisms is an indication that plant material is present.

Since the goal of medical treatment is to optimize oxygen delivery it is paramount to measure lactate level. Elevate lactate level is an indication of anaerobic metabolism, and poor oxygen delivery. Since oxygen delivery is a function of cardiac output and oxygen content, it is important to optimize cardiac function, pulmonary function and hemoglobin level.

First, fluid therapy with crystalloid, colloids should be initiated first with a shock dose since the patients are in hypovolemic shock. Colloids such as Dextran 70, Hetastrach or plasma are highly recommended for patients with septic shock and endotoxemia. Plasma can also be used especially if albumin is getting low or if the patient is in need of coagulation factors. Oncotic pressure can be measured to decide if plasma is needed to maintain oncotic

pressure. Hypoglycemia and electrolyte imbalance should be corrected when recognized.

Second, hemoglobin level has to be maintained to optimize oxygen carrying capacity. The PCV should not be allowed to drop below 30%. Blood transfusions are then required.

Third, monitoring heart rate and rhythm, and blood pressure are a requirement for the management of pyothorax and septic peritonitis. Inotropes are required to maintain mean blood pressure above 60 mm Hg. Urine production (at least 1 ml/kg/hr) is also an important parameter because it is good indicator of kidney perfusion and cardiac output.

SURGICAL TREATMENT

Surgery is necessary to halt ongoing contamination, remove foreign material and adjuvant substances, and provide drainage.

Peritonitis:

At the time of closure of the abdominal cavity there are four options for the surgeon: close the abdomen completely, closed the abdomen and perform a second surgery 24 hours after to have a second look, place a closed suction drain, or leave the abdomen open with an heavy bandage to contain the abdominal organs. If the contamination was mild and the source of the peritonitis well controlled then the abdomen can be closed. If the contamination was mild and the source of the peritonitis controlled but it was difficult to flush the abdominal cavity well or there is some questionable segment of intestine than a second look is indicated. At the second surgery, 24 hour later, the initial repair can be evaluated and reinforced if needed. The abdominal cavity will be flushed again. If the peritonitis is mild but has a tendency to be very exudative (bile peritonitis) or the source not well controlled then a drain can be placed. A second look is also possible. If the contamination of the abdominal cavity is severe or if the source of the contamination is not controlled or if lot of foreign materials are present the abdomen should be left open to drain. Colon trauma, intestinal necrosis after incarceration, strangulation of a loop of bowel, rupture of

a pyometra with generalized peritonitis, and necrotico-hemorrhagic pancreatitis are amenable to open abdominal drainage.

Second look surgery: Twenty-four hours after surgery the patient is anesthetized and brought to the operating room. The abdominal cavity is open again. A fluid sample is collected for cytology. A full exploration is performed to evaluate the surgical site and also break down adhesion to eliminate pockets of fluid. Foreign materials are eliminated mechanically during the exploration. If the surgical site is showing signs of leakage it is then repaired. The abdominal cavity is then flushed aggressively with 3 to 4 liters of warm sterile isotonic solution. A drain can then be placed if needed. The abdomen is then closed. This operation can be repeated 24 hours later if needed.

Surgical technique for placement of drains: Jackson Pratt drained should be placed in the cranial part of the abdominal cavity. The drain should extend between the liver and the diaphragm. The drain then exit in the lateral side of the cavity and connected to a closed suction device that generate between 5 to 10 mm Hg. The drains are maintained for several days until the daily cytology of the abdominal fluid shows significant improvement. The tip of the drain should be cultured at the time of removal. This technique does not allow flushing of the abdominal cavity. The drain allows collection of fluid that can be evaluated daily. Vacuum assisted peritoneal drainage has also been reported as an option to treat peritonitis. It might improve efficiency of the classic Jackson Pratt drain. It can be an intermediate situation between Jackson Pratt drain and a treatment with an open abdomen.

Surgical technique for open abdomen: At the end of the surgical procedure, a loose lace of heavy suture material (#2 monofilament non-absorbable suture) is placed on the edge of the abdominal incision to maintain the abdominal organs inside the abdomen. The two edges of the abdominal incision are not brought close together. Subcutaneous tissue and skin are not sutured. A layer of 2 or 3 sterile laparotomy sponges is placed on the loose lace. Loops of 2-0 nylon are placed every 2 to 3 cm on the skin 5 to 6 cm away from the edge of the incision and umbilical tape is laced through those loops to maintain the laparotomy sponges. Sterile surgical towels are applied and maintained in place with an adhesive incise surgical drape. If the patient is a male dog, a urinary catheter is placed and the penis can be incorporated under the adhesive incise surgical drape. Under heavy sedation and analgesia or general anesthesia, bandages are changed every 12 to 24 hours. At each bandage change, the abdomen is flushed with warm sterile saline. Cytology of the fluid present in the abdominal cavity is performed. When the cytology shows healthy neutrophils and decreased number of bacteria per high power field, the abdomen can be closed. During the open abdomen treatment the patient

is kept under appropriated intravenous antibiotherapy. Usually, a combination of ampicillin and enrofloxacin is used until the results from the culture and sensitivity are known. With an open abdomen patients are losing a great amount of proteins which placed them very quickly in severe hypoproteinemia. Fresh frozen plasma transfusions should then be administered to maintain their preload and oncotic pressures. To limit the severity of the hypoproteinemia a jejunostomy tube is placed at the first surgery to try to supplement the patient in high catabolic stage. Also the plasma transfusions bring coagulation factors that very important for these patients since they are at high risk of disseminated intravenous coagulation (DIC). Since these patients are septic or are at high risk to become septic heart rate, arterial blood pressures, central venous pressure, activated coagulation time, and blood glucose should be monitored closely. The major complications from open abdominal drainage are hypoproteinemia, DIC, and nosocomial infection.

Feeding tube placement

A combination of gastrostomy and jejunostomy tube are used for the management of patients with peritonitis.

Prognosis is worse for young and very old animals, or in the presence of delayed diagnosis, greater or more virulent contamination or poor nutrition. Mortality rate is high if organ failure is present. Poor prognosis is associated with refractory hypotension, cardiovascular collapse and development of DIC. Mortality could be as high as 68% for peritonitis. Mortality rate with open abdomen has been reported as high as 48%.

Pyothorax

Lack of significant clinical improvement within 48 to 72 hours of medical treatment or radiographic demonstration of undrained encapsulated fluid are indications to surgically explore the thoracic cavity. Radiographic evidence of lung lobe consolidation and pneumothorax suggest the possibility of a ruptured pulmonary abscess and is a relative indication for surgery. Diagnosis of a mass in a lung or in the mediastinum is an indication for surgical treatment. Presence of *Actinomyces* or *Nocardia* is also another indications for surgical treatment. Thoracoscopy has been used also to explore the pleural spaces, collect samples for histopathological analysis and culture, and debride the pleural space. Foreign bodies have been retrieved from the pleural space with thoracoscopy.

Exploratory thoracotomy should be undertaken by medium sternotomy which gives access to both hemithoraces. Adhesions and loculated pockets of fluid should be broken down carefully during surgery. Mediastinectomy often is necessary since the ventral mediastinum is invariably thickened and filled with small abscesses.

The pericardium also may require excision if it is thickened and abscessed. Consolidated lung lobes which

cannot be inflated should be excised by partial or complete lobectomy. Large lung lacerations created by adhesion breakdown must be repaired or the damaged tissue excised. Before closure, the thoracic cavity is vigorously lavaged with copious amounts of warm isotonic crystalloid solution. Closed pleural lavage should be continued postoperatively for at least two to three days. The probability of success with surgical management of refractory pyothorax is better for dogs than for cats.

Small animals - Vet endoscopic society session

In depth – Thoracoscopy

Saturday July 6

08.30 – 12.30

Anesthesia for thoracoscopy

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General anesthesia for thoracoscopy requires adequate analgesia and a balanced plan including local anesthetic. Ventilation is required, either by hand or with a ventilator because the thorax will be open just as with a traditional thoracotomy. Thoracoscopy alone affects blood gasses in normal dogs.¹ Even with bilateral ventilation, PaO₂ decreases and PaCO₂ increases likely due to V/Q mismatch. Total peripheral vascular resistance decreases, but the affect in normal dogs is not clinically problematic. The changes result in alteration of ventilation based on the patient's response and blood gas measurements (either direct or indirect measures); however, it is important to remember that research has been reported in normal dogs. Typically, ventilation is altered to allow a viewing space to form. The rigid thorax provides an adequate "room" in which to view, but the lungs and their motion interfere with visualization. A starting guideline to decrease lung volume within the thoracic cavity is to decrease the tidal volume by ½ and to double the ventilator rate. Monitoring blood gasses or their indirect measures guide further changes required for maintaining adequate ventilation during the procedure.

Rarely is one-lung ventilation required (OLV). OLV increases the working space via atelectasis of the right or left lungs. OLV must be obtained by either selective intubation of one bronchus or bronchial blockade of the desired side. The lung that is not ventilated should be the side undergoing the operative procedure. A flexible endoscope is required to achieve proper OLV, and OLV should be established within the operative suite when the patient is in the position desired for surgery to avoid inadvertent loss of OLV. If OLV is established during thoracoscopy, proper OLV can be verified rather quickly. For selective bronchial intubation, the endotracheal tube is placed over the bronchoscope, which is directed into the desired bronchus under endoscopic visualization. The endotracheal tube is then fed off of the bronchoscope much like catheterization using the Seldinger technique. If bronchial blockade done, the bronchial blocker (an ovoid balloon) is "loaded" on the bronchoscope using its suture loop. The bronchoscope is passed into the bronchus to be blocked (the operative side), and the

balloon advanced, inflated, and positioning verified under endoscopic visualization. Specialized endotracheal tubes have a cuff that can be inflated in the trachea and an extension, or bronchial, tube that has a cuff for inflation in a bronchus. Depending on which port is connected to the ventilator system, the tracheal site may be ventilated or the bronchial tube may be used. This allows for alternate OLV, shifting between sides as desired. OLV in normal dogs with closed chest ventilation showed similar changes in PaO₂ and PaCO₂ as dogs undergoing thoracoscopy, likely the alterations were somewhat blunted due to the use of normal dogs and normal hypoxemic vasoconstriction, which minimized V/Q mismatch.² If alterations in ventilator parameters are significant, PEEP at as little as 5 cmH₂O can be used to improve the V/Q mismatch with out significant effects on cardiac output or oxygen delivery.³

Since significant changes may occur with thoracoscopy or OLV, aggressive anesthetic monitoring is required. Blood gas measurements should be possible just as they may be needed with open thoracotomy. Indirect measures can be used to trend and adjust ventilation more acutely and should include pulse oximetry, capnography, ECG, and indirect blood pressure. Ideally an arterial catheter would be placed to allow for direct blood pressure measurement and for blood gas sampling on an as needed basis. Known changes are expected during thoracoscopy, and the ability to further decrease lung volume when OLV is not being done can be guided based on indirect monitoring. Changes can be more significant in patients with pulmonary pathology and alterations in vascular volume, perfusion, and vascular tone.

A commonly suggested protocol for anesthesia includes the following:

Premedication – opioid and a sedative

Induction with propofol, diazepam and ketamine, or diazepam and etomidate followed by endotracheal intubation and maintenance of anesthesia with isoflurane or sevoflurane in oxygen. Intercostal nerve block should be done either prior to or upon completion of the procedure

prior to closure and may be utilized intrapleurally after recovery.

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Creating working space for thoracoscopic surgery

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For certain thoracoscopic interventions such as pericardial window, thoracic duct ligation and lung biopsy, a pneumothorax that forms within the chest when the first cannula is placed and air is allowed to enter the pleural cavity, will provide adequate working space for the procedure to be completed safely. For these procedures anesthesia concerns are similar to those for any "open" thoracotomy. Intravenous access should be established along with an indwelling arterial catheter for direct measurement of arterial blood pressure if possible. Variables monitored during the procedure will include heart rate and rhythm (on an ECG), oxygen saturation by pulse oximetry, end-tidal capnography and/or intermittent blood gas analysis and continuous arterial pressure. Positive pressure ventilation preferably with a mechanical ventilator will be mandatory for anesthetic maintenance as it is for open thoracic surgery.

To increase the working space in the thoracic cavity during more advanced thoracoscopic procedures there are several techniques that can be used. Intermittent ventilation can be used for shorter procedures and is variably tolerated by animals under anesthesia. Animals with normal pulmonary parenchyma may tolerate long breaks between ventilation, however those with cardiorespiratory disease may be less tolerant. Intermittent ventilation is generally frustrating for more complex procedures where intermittent inflation of lung fields obscures visualization making iatrogenic trauma to pulmonary parenchyma during instrument exchanges more likely and generally prolongs the procedure.

Thoracic insufflation with a closed chest can be performed if thoracic cannulae with one-way valves are used, as is done for laparoscopic surgery. Carbon dioxide is used for thoracic insufflation just as it is for creation of a pneumoperitoneum. The big advantage of thoracic insufflation is that it is very easy to institute and can significantly increase the volume of working space. The big disadvantage is that the thoracic cavity is poorly tolerant of positive pressure insufflation due principally, to the many thin-walled low pressure vascular compartments within it which include the right side of the heart, cranial and caudal vena cava and pulmonary veins. Even at low insufflation pressures (3mmHg), significant cardiopulmonary depression has been shown to occur.¹ However, thoracic insufflation is an area that may merit further evaluation and the author has found it helpful in select thoracoscopic cases where

working space may be marginal or patient characteristics are unfavorable (dogs with low thoracic depth-to-width ratios and cats).

One-lung ventilation (OLV) is generally the preferred method for increasing the working space during more advanced thoracoscopic interventions. Improved visualization can help avoid iatrogenic trauma to tissues that can occur when visibility is impaired by repeated lung inflation. Whenever OLV is used, significant physiological changes must be anticipated as a significant ventilation-to-perfusion mismatch occurs as a result of non-ventilated lung remaining perfused. However, studies have shown that no large effect on oxygen delivery in healthy dogs occurs during one-lung ventilation.² It should be remembered that tidal volume must be reduced usually by a factor of 30-50% to avoid barotrauma and to compensate, the respiratory rate is usually increased by approximately 20%. The use of OLV has been reported for formation of pericardial windows, subphrenic pericardectomy, lung lobectomy, and thymoma excision.³⁻⁶ In most dogs without significant cardiopulmonary disease, OLV is very well tolerated in the author's experience. Positive end-expiratory pressure (PEEP) of 5cm H₂O can be helpful during OLV and has been shown to increase PaO₂ and decrease shunt fraction without having a detrimental effect on cardiac output.⁷ Subjectively, the author has noted that PEEP can, however, significantly impair visualization in the chest of smaller or flat-chested dogs where even small amounts of residual inflation during ventilatory cycles can decrease visualization of organs.

Various techniques can be used to create OLV including use of endobronchial blockers (EBB), selective intubation, or double lumen endobronchial intubation (DLT).⁸ All usually require bronchoscopic-assisted placement although blind thoracoscopic-assisted placement of DLTs has been described and is feasible in certain breeds of dog.⁹

Selective intubation involves the placement of a smaller diameter long endotracheal tube into one mainstem bronchus. A bronchoscope is placed down the lumen of the tube and guided into either the left or right mainstem bronchus depending on which side requires ventilating (contralateral lungfield to the side of the lesion). Selective intubation is used principally in the author's institution for very large dogs in which DLT's are usually too short and in which the balloon on the tip of the EBB is sometimes not large enough to completely occlude the lumen of the

mainstem bronchus. In these very large dogs we often use foal endotracheal tubes to achieve selective intubation. The principal limitation of the use of selective intubation in smaller dogs is the availability of long enough tubes.

EBBs are relatively easy to place and consist of an endotracheal tube with either a small diameter balloon-tipped catheter attached to the end of the tube or running within the lumen of the tube. In the most common model used (Arndt Endobronchial Blockerä, Cook Medical Inc.) the bronchoscope is passed through a suture loop on the tip of the EBB as it is passed down the lumen of the endotracheal tube. This allows the balloon-tipped catheter to be guided by the bronchoscope into one or other mainstem bronchus so that when the balloon is inflated, fresh gas inflow is prevented from entering the now obstructed right or left mainstem bronchus. They are available in 5,7 and 9 Fr sizes with either spherical or round balloons. These work well although in very large dogs the balloons on even the largest blocker sizes may not inflate to a large enough diameter to completely occlude a mainstem bronchial lumen. The 5Fr EBB is probably the best option for induction of OLV in the smaller patients as DLT cannot be used in dogs smaller than about 10kg.

Double-lumen endobronchial tubes (DLT) are slightly more challenging to place but have the advantage of allowing alternating one-lung ventilation that can be useful in situations in which both sides of the thoracic cavity need to be examined or in which the precise location of the lesion is unknown, such as occurs sometimes in cases of spontaneous pneumothorax caused by pulmonary bullae or blebs.¹⁰ It is also the only method, in theory, for which intra-operative bronchoscopic-assisted manipulation of the tube is not necessary if alternating left and right ventilation is required. Ventilation can be alternated between the right and left lungfields by swapping the fresh gas inflow from the tracheal to the bronchial side using DLT's. Dogs with right cranial lobe lesions can also benefit from using a left-sided DLT as the tube can be placed into the left mainstem bronchus and ventilation through the bronchial lumen will prevent inflation of the right cranial lung lobe which is difficult to achieve with either EBBs or selective intubation due to the very cranially located entrance of the right cranial lobar bronchus.

In all cases, whether selective intubation, endobronchial blockade or DLT's are used, great care needs to be taken monitoring anesthesia. The most significant clinical problem is tube displacement intra-operatively. Most commonly this results in loss of OLV intraoperatively, impairing the surgeon's ability to proceed with the procedure. Less commonly if a bronchial blocker or DLT slips cranially out of the mainstem bronchus into the trachea it is possible for an acute airway obstruction to occur resulting in total cessation of ventilation. This must be noticed immediately and will necessitate tube repositioning. Placing the OLV tube in the operating room rather than in the anesthesia preparation area will minimize movement of the patient and minimize risk of initial displacement. After placement, every effort should be made by both surgeon and anesthetist to minimize movement of the patient.

Table 1. Selection of device for creation of OLV ventilation in dogs and cats

Device	Dog <10kg	Dog 10-30kg	Dog >35kg	Cats
Selective intubation	Yes	Yes	Yes*	Yes
Double-lumen endobronchial blocker	No	Yes*	No	No
Bronchial blocker	Yes*	Yes	No	Yes*

*author's personal preference

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Pericardectomy

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Pericardectomy was the first procedure commonly performed thoracoscopically and is now nearly the standard of care in veterinary medicine. Indications include idiopathic pericardial effusion, neoplastic effusion, and constrictive pericarditis. Many techniques exist including pericardial window, pericardial fenestration, and subphrenic subtotal pericardectomy. Most dogs requiring pericardectomy have clinical signs associated with compromise of right heart filling and most have lethargy, tachypnea, and decreased appetite, and may show signs of labored breathing, abdominal distention or fluid, and weak femoral pulses with muffled heart sounds.

The procedure has been described via lateral thoracoscopic or paraxiphoid approaches, mimicking the lateral thoracotomy and median sternotomy, respectively. A left or right lateral approach may be done, with ports in the mid-third, dorsal 5th, and ventral third of the 9th intercostal spaces. Some surgeons prefer a right-sided approach with ports in the 4th, 6th, and 8th intercostal spaces. Alternatively, the heart may be identified ultrasonographically and ports may be placed in 3 intercostal spaces triangulated with the central port most dorsal in the appropriate intercostal spaces. The paraxiphoid approach is more commonly done and provides exposure to the majority of the pericardium. A port is placed adjacent to the base of the xiphoid process directed into the ipsilateral hemithorax. Subsequent ports are placed on either side of the chest in the 9th intercostal spaces or 2 ports can be placed on one side of the chest directed at the pericardium. Slight tilt (10-15 degrees) to one side facilitates exposure. Ports should be placed ventral enough to avoid pulmonary excursions. The mediastinum must be divided to provide exposure to both hemithoraces.

Pericardial window is typically defined by resection of a 4x4 cm segment of the pericardium. The size is not adequate for all conformations and sizes of dog, but should be large enough to avoid closure and adhesion to the epicardium and not large enough but so small as to allow cardiac herniation with entrapment of the atria in the remaining pericardium, which can affect function dramatically. The window is typically made on the cranio-ventral surface of the heart taking care to avoid atrial appendage trauma. Aggressive graspers should maintain

traction on the pericardium, which should initially be grasped with babcock forceps to avoid cardiac trauma. Metzenbaum scissors connected to cautery, bipolar cautery, or a vessel-sealing device is used to excise a portion of the pericardium. The pericardium should be lifted away from the heart and contact with it or other structures, including the thoracic wall, should be avoided to decrease the risk of collateral damage.

Subtotal pericardectomy ventral to the phrenic nerves can be done with the patient in dorsal recumbency using the port sites described for pericardial window via a paraxiphoid approach. The mediastinum must be dissected from the sternum, and the pericardium grasped as with pericardial window creation. Alternate one-lung ventilation may be used to increase exposure of the pericardium if required, which is excised while leaving a 1 cm cuff of pericardium ventral to the phrenic nerves. Energy is used per that described above.

A thoracostomy tube should be placed under endoscopic visualization, and port sites should be avoided as points of entry for the tube. Intercostal nerve blocks should be done, and intrapleural local anesthetic can be done via the thoracostomy tube after recovery. Analgesia should be continued and tailored to meet the patient's needs, as should oxygen supplementation.

Samples of the pericardium should be submitted for histopathological examination, and a sample of tissue submitted for aerobic, anaerobic, and fungal culture. Significant improvement in clinical status is expected regardless of the etiology of the effusion. Further discussion of the expected outcomes will be included.

The role of thoracoscopy for chylothorax

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Typical therapy for chylothorax includes an initial course of medical management; however, prolonged medical management beyond 1 or 2 months may allow significant fibrosing pleuritis to occur. If surgery is an option, prolonged medical management should be avoided. The diagnostic plan for chylothorax is exhaustive and is not altered for thoracoscopy. The typical workup includes CBC, biochemical profile, urinalysis, thoracic radiography following thoracocentesis, pleural fluid analysis, pleural fluid triglyceride level, serum triglyceride level, pleural fluid culture, thoracic ultrasound, abdominal radiographs and ultrasound, cardiac ultrasound, and heartworm testing. Many clinicians include CT or MRI of the thorax prior to surgery or thoracoscopy.

Surgical options for chylothorax include thoracic duct ligation (TDL), pericardectomy, cisterna chyli ablation (CCA), and omentalization. Minimally invasive approaches have been described for TDL, pericardectomy, and CCA and any can be done to treat chylothorax. Thoracoscopic TDL and pericardectomy have been described in clinical patients; however, the author currently performs TDL, pericardectomy, and CCA as an initial treatment for chylothorax. Lateral or sternal recumbency can be used for the procedures; however, only sternal recumbency has been described for endoscopic CCA.

TDL followed by CCA can be done with the patient in sternal recumbency; one-lung ventilation is not required; however, no pressure should be placed on the abdomen. This includes pressure from the weight of the dog against the table. Support the patient under its pubis, not caudal abdomen, and thoracic limbs/sternum as necessary. The right side of the chest and left side of the abdomen in dogs and the entire left side in cats must be prepared for surgery. Also prepare the popliteal fossae bilaterally for surgery. TDL is done first. The first port is placed at the middle of the 10th intercostal space, and the chest is examined using a 30-degree endoscope. Make a longitudinal incision in the mediastinum at the ventro-lateral aspect of the aorta. Dissect along the aorta under the adventitia until the dorsal border of the aorta is reached. AVOID angling across the aorta to avoid intercostal arterial trauma; make sure that the dissection is perpendicular to the long axis of the patient. Significant ventral retraction of the aorta is

used to continue the dissection into the left hemithorax, ideally at the ventro-lateral aspect of the left side of the aorta. The left hemithorax must be entered and confirmed visually to minimize the risk of missed branches of the thoracic duct. Release aortic retraction, and incise the mediastinum longitudinally ventral to the sympathetic trunk. Dissect across the mediastinum until visualization confirms entry into the left hemithorax. Place endoscopic clips across any obvious branch(es) of the thoracic duct. Ligation may be possible with suture using either intra- or extra-corporeal knot tying.

Once all branches are ligated, expose the convex surface of one popliteal lymph node and stabilize it with a hemostatic forceps on the distal pole. Dilute methylene blue 1:60 or 1:100 in saline appropriate for injection. Insert a butterfly catheter into the medulla of the lymph node. Inject methylene blue slowly, stopping when the lymph node is distended and refill upon nodal relaxation. Many cc's of methylene blue can be injected. Visualize the thoracic duct during methylene blue infusion. If the duct becomes large and distended and no blue color is noted cranial to the ligation site, the ligation should be complete. Distention and blue coloration should also facilitate CCA, which is done next.

Place a port in the transdiaphragmatic position during diaphragmatic retraction or place a port in the mid-abdomen using a modified Hasson technique. Initially insufflate the abdomen for visualization and placement of a port in the pericostal region percutaneously. The left kidney will gravitate ventrally and its position varies greatly depending on the conformation of the patient. Follow the left renal artery to the aorta – at that point dissect dorsal to the aorta and cranial to the renal vein in an attempt to obtain a complete CCA. The blue color and distention of the cisterna chyli due to infusion of dye against the TDL site should help. Curved dissection forceps will allow for an adequate CCA to be done. Make sure that insufflation is discontinued and CO₂ is removed from the abdomen if possible. Verification can be done with repeat injection of the popliteal lymph node – blue fluid should flow freely from the CCA site into the abdomen.

The author then closes the port sites and places the dog in dorsal recumbency for pericardectomy and pericardial fenestration followed by thoracostomy tube placement.

Outcome for dogs with idiopathic chylothorax was successful in 6/7 dogs and 2/5 of dogs with secondary chylothorax had complete resolution of the fluid following thoracoscopic TDL and pericardectomy in one study¹, which is comparable to that of the open approach. Another report of 6 dogs showed complete resolution in 5 with only a mild amount of effusion present in the 6th dog after thoracoscopic TDL and pericardectomy.² The results of endoscopic TDL, CCA, and pericardectomy for chylothorax have not yet been reported, but will be in the near future!! Further refinements of the procedure will also be presented.

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Use of thoracoscopy in the management of pyothorax in dogs and cats

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Inflammatory conditions of the pleura may be dry, serofibrinous, pyogranulomatous, or purulent. *Purulent pleuritis*, also referred to as *pyothorax* or *empyema*, is invariably the result of bacterial or fungal sepsis of the pleural space.

Sources of bacterial contamination include penetrating thoracic wounds, extension of bacterial pneumonia, migrating foreign bodies, esophageal perforations, extension of cervical, lumbar or mediastinal infections, and hematogenous spread. Thoracic bite wounds are frequently implicated in feline pyothorax. Inhalation and migration of a grass awn often is suspected in field dogs with pyothorax. Anaerobic bacteria and *Nocardia asteroides* are isolated most often from dogs with pyothorax. *Nocardia* and *Actinomyces* are very commonly associated to a foreign body. Pleural infections are almost always polymicrobial in nature. *Pasteurella multocida* and anaerobes are the most prevalent isolates in cats.

Pleuritis and pyothorax frequently have an insidious course and presentation may be delayed. Pyothorax occurs most commonly in young adult, male, non purebred cats and adult large breed dogs. Clinical signs result from restrictive disease, including increased respiratory rate, and shallow respiration, dyspnea. Other clinical signs include exercise intolerance, lethargy, anorexia, and fever. Physical examination reveals muffled heart sounds, decreased lung sounds, and dull percussion sounds, especially over the ventral portions of the thorax. Chronic or severe infection result in a patient in septic shock with dehydration debilitation or hypothermia.

A diagnosis of pyothorax is confirmed by hematology, thoracic radiography and thoracocentesis with cytologic evaluation and culture of the pleural fluid. After the diagnosis has been established treatment has to be decided between medical or surgical treatment.

Treatment of pyothorax must be prompt and aggressive. The prognosis is guarded. Supportive care with intravenous fluids is necessary to correct dehydration, acid-base and electrolyte imbalance.

The initial goals of therapy are to relieve respiratory embarrassment by thoracocentesis, preferably under minimal restraint with the patient sternal or standing and to administer antibiotics. Thoracostomy tube placement, thoracic lavage, and antibiotherapy are the major components of the medical treatment. Dogs more likely will require surgery while cats usually respond better to medical treatment. The standard recommendation is to attempt medical treatment for three days and then switch to surgical treatment if the clinical situation is not improving. However, if actinomyces is identified on cytology, or a mass is present on thoracic radiographs surgical treatment with a median sternotomy is recommended as a first choice.

Thoracoscopy could be used to help in the diagnosis, and the decision making for the management of the case and avoid the three days of medical treatment. It is now recommended by the American College of Thoracic Surgeon to use thoracoscopy as a diagnostic tool in the management of cases of pyothorax and a treatment modality for acute and chronic pyothorax. It is difficult to differentiate an acute from a chronic case of pyothorax in dogs or cats with clinical signs and different imaging technology. Thoracoscopy can then be performed as a diagnostic modality to visualize the pleural space, and collect tissue samples for histology and culture. Thoracoscopy can also be used to debride the necrotic mediastinum which will then reduce the bacterial load and get a better response to antibiotherapy and allow a more efficient lavage of the pleural space.

An acute pyothorax will more likely only require debridement of the mediastinum and collection of samples for diagnosis. A thorough lavage of the pleural space can also be performed. Thoracostomy tubes can then be placed under direct visualization. If the pyothorax is more organized and chronic, several procedures may be required to further debride the pleural space. Partial or complete lung lobectomy, subtotal pericardectomy, and foreign body removal can then be required.

For the evaluation of a pyothorax, a transdiaphragmatic subxyphoid approach is used to access both sides of the thoracic cavity. With this approach it is difficult to resect a caudal lung lobe. An intercostal approach would be more

appropriate for a lung lobectomy but this would not allow a good evaluation of both sides of the thoracic cavity. A subtotal pericardectomy can be performed without one lung ventilation with a transdiaphragmatic approach.

If the pyothorax is very chronic with severe adhesions exploration of the pleural space would not be possible with thoracoscopy. Then a median sternotomy will be required. More likely medical treatment will be a failure for those patients. Therefore thoracoscopy might help initiate the surgical treatment sooner since standard and advanced imaging techniques does not allow for differentiation between acute and chronic pyothorax with severe adhesions.

Thoracoscopy has been shown to reduce the length of stay in the critical unit and the hospital for human patients with pyothorax. It has also been shown to reduce the number of days ventilation and a thoracostomy tube were needed.

Thoracoscopy persistent right aortic arch and pda

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Thoracoscopy is being more and more frequently in veterinary surgery to treat several conditions. Thoracoscopy has been used to transect the ligamentum arteriosum during the persistence of the 4th right aortic arch or ligate a patent ductus arteriosus.

PERSISTENT RIGHT AORTIC ARCH APPROACH

To perform minimally invasive PRAA correction the patient is placed in right lateral recumbency. Four portals will be required. Three portals are placed in the 7 or 8th intercostal space and the fourth cannula is placed in the one intercostal cranial in the ventral third of the space. A retractor or a palpation probe used as a retractor will be introduced in that portal.

EQUIPMENT USED

Five millimeters equipment can be used for the procedure. However, since most of the dogs are very young and less than 8 kg a pediatric set of equipment is more appropriate. Pediatric equipment is usually 2.7 mm in diameter. Five millimeter diameter cannulas are difficult to place in the intercostal space. One 5 mm cannula will still be need for introduction of vascular clip or vessel sealant device.

SURGICAL TECHNIQUE

The left cranial lung lobe is retracted ventrally to expose the cranial mediastinum and the heart base. The first step of the procedure is to localize the ligamentum arteriosum. Usually the esophagus is fairly dilated and a narrowing can be noticed at the level of the base of the heart. A stomach tube can be placed in the esophagus to improve visualization of the ligamentum arteriosum. A palpation probe is used to further localize the ligamentum arteriosum.

After identification of the ligamentum arteriosum, the vagus nerve needs to be identified. In a normal dog the vagus nerve travels in the mediastinum at the level of the ligamentum arteriosum. The vagus nerve will have to be preserved during the dissection.

The ligamentum arteriosum is dissected with sharp and blunt dissection to isolate it from the pleura and esophagus. Identification of the esophagus during dissection is facilitated by passing a stomach tube or an endoscope.

After complete dissection of the ligamentum arteriosum, it is important to ligate it because residual blood flow can be present. Endoscopic 5mm vascular clips are placed on the isolated ligamentum arteriosum and it is transected between the clips. A vessel sealant device can also be used to seal the ligamentum arteriosum before transection.

Any remaining fibers are dissected off of the esophagus and divided and the esophagus is dilated by passage of a balloon dilation catheter or esophageal bougies. A chest tube is placed and the portals are closed. Postoperative dietary management is the same as for open surgical PRAA correction.

We have performed a retrospective analysis of the cases of PRAA treated with thoracoscopy.

Objective

To present the surgical technique used to correct PRAA under thoracoscopy in dogs.

Study Design

Retrospective study.

Animals

Nine dogs.

Materials and Methods

Medical records of dogs presented for the surgical treatment of vascular ring anomaly were reviewed. Entry criteria was correction of a persistent right aortic arch under thoracoscopy. Surgical technique and complications were recorded

Results

Thirteen dogs were identified with a vascular ring anomaly. Two dogs were excluded because they had a double aortic arch diagnosed during thoracoscopy and two dogs because they were treated with thoracotomy. Nine dogs met the entry criteria. Age and weight at the time of surgery were 4.90 ± 1.90 months and 8.60 ± 2.10 kg, respectively. Each dog had an esophageogram and esophagoscopy prior to surgery. The thoracoscopy was performed with three or four cannulas with the patient in right lateral recumbency (150 tilt). The ligamentum arteriosum

was identified after introduction of a large stomach tube in the esophagus. Ligation of the PRAA under thoracoscopy was performed with clips in two dogs, an ultrasound dissector in one dog, and the Ligasure in three dogs. One-lung ventilation was instituted in only two dogs. Five dogs had their PRAA completely dissected and ligated under thoracoscopy. Thoracoscopy had to be converted into a thoracotomy for four dogs. The reasons for conversion were: perfused PRAA, bleeding during sealing of the PRAA with an ultrasound dissector, persistent left cranial vena cava, and bleeding after placement of chest tube. One dog treated with thoracoscopy died four days after surgery because of aspiration pneumonia.

Conclusion

Thoracoscopic treatment of PRAA is possible in dogs. One-lung ventilation is not required.

PATENT DUCTUS ARTERIOSUS

Ligation of patent ductus arteriosus has been attempted with thoracoscopic assisted or thoracoscopic technique.

APPROACH

Dogs are placed on right lateral recumbency and an intercostal approach will be used. For the thoracoscopically assisted procedure, the incisions are made at the level of the 4th and 5th intercostal space midway between the dorsal spinal process and the sternum.

For the thoracoscopic approach, portals are placed in the 3rd, 4th, and 5th intercostal space. For both approaches, a retractor is used to retract ventrally the left cranial lung lobe.

SURGICAL TECHNIQUE

For both approaches, the surgeon is staying on the dorsal side of the dog and an angle telescope is used to improve visualization. For the thoracoscopic approach regular surgical instruments can be used while for the thoracoscopic approach only minimally invasive surgical instrument have to be used.

After identification of the vagus nerve the patent ductus arteriosus is dissected cranial and caudal to the ductus. The medial dissection is not attempted. Then large hemoclips are used to occlude the patent ductus arteriosus. Large endoscopic clips have to be used to occlude completely the ductus. If the ductus is not completely occluded residual flow will persist. Intraoperative trans-esophageal echocardiography can be used to confirm complete closure of the ductus.

The most important benefit from thoracoscopy in small animal surgery is the fast recovery. Since there is no rib retraction during thoracoscopy, the amount of pain post operatively is significantly reduced when compared to

thoracotomy. When performing a thoracoscopy the surgeon has to be ready to convert to a thoracotomy at any time.

Complications of video-assisted thoracoscopic surgery

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Video-assisted thoracoscopic surgery (VATS) is gaining in popularity greatly in the human field and has begun to become commonplace in a relatively small numbers of veterinary centers. As with any new surgical intervention or approach the “early adopter” phase of development, which veterinary medicine arguably still finds itself in, can be plagued by challenges and complications that may in many cases be unforeseen. It is therefore imperative to tread carefully with regard to case selection and ensure that high quality equipment is available and further training is sought in order to ensure success. These strategies will help to minimize perioperative morbidity and the need to convert to an open approach.

In order to perform VATS approaches in dogs and cats it is necessary to create a working space. While some techniques can be performed under a pneumothorax alone, many more advanced procedures require the use of one-lung ventilation or thoracic insufflation in order to be completed successfully. This requires an indepth knowledge and familiarity with special anesthetic techniques and monitoring. An important potential source of perioperative morbidity in these cases results from inappropriate anesthetic management or patient comorbidities and this should be considered in detail prior to surgery. A detailed discussion of anesthesia for VATS approaches is beyond the scope of this lecture and some aspects of the challenges of anesthetic management for VATS have been discussed elsewhere in this session.

Complications associated with thoracoscopic access

The first step in any VATS procedure is safe access into the pleural cavity. When thoracic entry is being attempted, iatrogenic damage to intracavitary structures during initial port placement must be avoided. Entry is usually performed by intercostal or paraxiphoid insertion of a blunt-tipped trocar-cannula assembly to induce a pneumothorax. A veress needle can be used as the initial entry device but this is less common. Blind insertion of the cannula is commonly performed and is relatively safe if care is taken and the trocar tip is blunt. The technique of optical entry is very useful in the thoracic cavity and is the standard approach used by the author. Using either a human disposable trocar-cannula assembly designed for

optical entry that incorporates a translucent cannula (e.g. Ki Fios First Entry, Applied Medical Inc.) or a trocarless threaded non-disposable cannula (e.g. EndoTip, Karl Storz Endoscopy), the telescope can be placed into the cannula, allowing the surgeon to watch the tissue layers as they are penetrated during insertion. In this fashion recognition of entry into the pleural space can easily be detected by immediate visualization of intrathoracic structures (usually the lung).

In humans, thoracic access injury, unlike laparoscopic access-related morbidity, appears to be a rare complication as most studies evaluating complications of VATS procedures either do not discuss access-related morbidity or have found it to be rare.^{1,2} Even less information is available with regard to the incidence of access injury during thoracoscopic interventions in small animals. Injuries during paraxiphoid port placement have not been reported in small animals, possibly because of the lack of large vascular structures close to this entry site. When the first cannula is inserted in an intercostal location or indeed when further instrument ports are placed intercostally after placement of the telescope portal, incising in the middle of the intercostal space is imperative to avoid iatrogenic damage to the intercostal artery and vein which run parallel and caudal to each rib. Bleeding from intercostal vessels can be profuse and will generally not cease spontaneously. In these cases placement of a circumcostal suture proximal and distal to the bleeding vessel is usually necessary. During intercostal cannula placement contact with lung tissue is unlikely to cause iatrogenic damage as the blunt tip is usually atraumatic enough push the lobe away rather penetrate it. However, in cases where unknown adhesions of the lung lobes to the thoracic wall exist, the author has witnessed iatrogenic lung damage even in cases where blunt trocars were used. For intercostal trocar insertion, the use of blunt dissection through the thoracic wall prior to insertion of the trocar-cannula assembly may help to reduce iatrogenic damage to blood vessels and lung parenchyma during entry.

Complications associated with specific thoracoscopic procedures

Pericardial window (PW) formation was one of the first described thoracoscopic techniques used in veterinary

medicine and can easily be performed in most breeds without OLV. Complications of this technique can include lung laceration, phrenic nerve transection and hemorrhage although all are uncommon. Iatrogenic damage to the underlying epicardium or coronary vessels during dissection is a possibility and care needs to be taken especially if a vessel-sealing device is used for tissue transection. These devices are very helpful to minimize hemorrhage but all have some degree of lateral thermal spread and so elevation of the device above the level of the epicardium is important to avoid thermal damage to underlying structures. Recurrence of pericardial effusion due to stenosis of the window or adhesion of the pericardium back onto the epicardium appears to be uncommon after this procedure.^{3,4} Thoracoscopic subphrenic pericardectomy has now also been described in dogs both with and without OLV.^{4,5} This technique is similar to the PW although an effort is made to remove all pericardial tissue ventral to the phrenic nerve. In addition to phrenic nerve damage, iatrogenic damage to the atrial appendages must also be avoided during this procedure especially on the left side. A thoracoscopic technique for right atrial mass resection after pericardectomy was recently documented using the EndoGIA stapler in a dog.⁶ Small well-circumscribed masses involving the right atrial appendage may be resected in this fashion, but just as in open surgery, it may be challenging to achieve a complete margin of resection.⁶

VATS lung lobectomy has been described for management of primary and metastatic lung masses as well as resection of pulmonary blebs/bullae associated with spontaneous pneumothorax. In humans, advantages of the VATS technique include a reduced volume of thoracic drainage, decreased post-operative pain, shorter hospital stays and a more rapid return to normal function.^{7,8} One study reporting early experience with this technique in a canine clinical population with lung tumors, reported successful thoracoscopic resection in 5/9 dogs, while conversion to an open technique was required in 4 dogs.⁹ Conversion was required in these dogs due to loss of visibility secondary to bleeding from an intercostal artery in one dog, loss of intraoperative OLV in two dogs and difficulty accessing the right middle lung lobe in one dog.⁹ The author has recently completed data collection on a group of 22 dogs with primary lung tumors resected using a VATS technique and compared them to a population of previous cases operated by standard open thoracotomy. Non-pain related morbidities were similar between groups and conversion was necessary in 2 of 22 cases for similar reasons to those seen in the Lansdowne study. Iatrogenic penetrative injury of a lung lobe was seen in one of these patients and two suffered iatrogenic intercostal artery bleeding.

Thoracoscopic management of chylothorax has now been reported in small numbers of canine clinical cases.^{10,11} A significant complication of this technique may be the failure to ligate all branches of the thoracic duct, although this problem can equally occur after open thoracic duct ligation.

No studies have directly compared the efficacy of thoracic duct ligation/pericardectomy after thoracoscopic surgery to that obtained using open techniques. Early data suggests that success, as defined by resolution of pleural effusion and clinical signs may be similar between techniques, although a controlled prospective clinical study will be required to confirm this.

Several other thoracoscopic techniques have been described in very small numbers of animals including ligation of persistent ductus arteriosus and vascular ring anomalies as well as thymoma resection. All of these advanced techniques require careful case selection and experience in minimally invasive surgery. Further studies are required to evaluate the level of morbidity and mortality involved to be able to accurately assess whether they offer a significant advantage over traditional "open" techniques.

Post-operative complications

The most commonly observed complication after VATS surgery in humans is prolonged air leak followed by bleeding and wound infection.^{1,2} All occur in <5% of patients in almost all published reports.^{1,2} Air leak can arise from staple lines placed across pulmonary tissue or from iatrogenic damage to the surface of the pulmonary parenchyma by instrumentation, cannulae or thoracic drains. While this complication is not commonly described in the veterinary literature, the author has witnessed this on several occasions. Defining the origin of the cause is challenging although we have never had a to reoperate a pulmonary resection for a stapleline leakage and it is suspected that these air leaks are the result of minor damage to the surface of the lung that occurs during the procedure or from overzealous chest tube aspiration in the post-operative period.

Port-site complications after VATS procedures are generally associated either with seroma formation, surgical site infection (SSI) or subcutaneous emphysema. In the authors experience seroma formation is relatively common with intercostal portals as it is challenging to closely appose the deeper layers of the thoracic wall without causing iatrogenic damage to the lungs during needle passage. These seromas almost always seem to resolve spontaneously, however, and rarely require drainage. One veterinary study of SSI rates after open and minimally invasive surgery, a proportion of which were VATS cases, documented a lower SSI rate compared to open surgery in dogs and cats.¹² Herniation of thoracic contents through incompletely closed port incisions is probably much less likely than in the abdomen due to the less mobile nature of most thoracic viscera. Although not impossible this complication has not been reported to date in veterinary patients.

Port-site metastasis can occur when neoplastic lesions are resected and withdrawn through small portal incisions. Metastasis of a pericardial mesothelioma to a port site after thoracoscopic PW has been described in

the veterinary literature¹³ and this author has witnessed a similar occurrence with a malignant thymoma that was resected using a VATS approach. This process was initially considered to be a result of direct inoculation of neoplastic cells during traumatic extirpation of tissue through small port incisions. However, it was found that the use of specimen retrieval bags to remove neoplastic or infected tissue, although highly recommended, does not completely prevent port-site metastasis. There is now general recognition that a more complex interplay of factors such as the local immune response, pneumoperitoneum and surgical technique may all play a role in the etiopathogenesis of port site metastasis.¹⁴

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Small animals – Short communications

**Endoscopic and interventional
radiology**

**Saturday July 6
15.30 – 17.30**

Thoracoscopic resection of right auricular masses in 9 dogs

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Objective

To show the feasibility thoracoscopic resection of masses located on the right auricle in dogs.

Study Design

Retrospective case series.

Animals

Dogs (n = 9) with a mass on the right auricle.

Procedures

Hospital records from 2003 to 2011 were reviewed. Dogs that underwent thoracoscopic resection of a mass on the right auricle were selected. Data collected included history, clinicopathological findings, surgical technique, and outcome.

Results

All dogs with pericardial effusion were examined with echocardiography. Cardiac masses were identified in 5 dogs on the right auricle. Eight dogs had clinical signs of cardiac tamponade and right-sided heart failure. All dogs underwent thoracoscopic resection of a mass on the right atrium. Eight hemangiosarcomas and 1 pyogranulomatous lesion were resected. One dog with a mass located at the base of the right auricle died during surgery. No postoperative complications were noticed.

Conclusions and Clinical Relevance

Right auricular masses were successfully removed in nine dogs. Masses close to the base of the right atrial appendage may not be amenable to resection with thoracoscopy. Resection of small masses at the tip of the right auricular appendage can be performed thoracoscopically.

Cardiac tumor stenting

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Central venous obstruction can have profound systemic effects. Interventional radiology techniques have been used to palliate both malignant and non-malignant causes of vascular obstruction for both intrinsic and extrinsic lesions. The author has been presented with a number of dramatic cases of venous obstruction in dogs due to naturally occurring large cardiac masses not amenable to traditional veterinary therapies. To the author's knowledge, placement of transatrial stents or pulmonary artery stents for long-term decompression of cardiac tumor venous obstruction has not been previously reported. Transatrial stents may be a safer alternative to stent free ends within the atrium or the stent migrating into the ventricle.

Three dogs recently reported in abstract form¹ presented with large, non-resectable cardiac masses obstructing venous return to the right atrium. Venous return to the heart was severely obstructed leading to congestion with subsequent ascites (2) or head swelling and pleural effusion (1). Due to the extensive nature of the disease, an interventional palliative approach was pursued. Transatrial self-expanding metallic nitinol stents were placed from the CdVC to the CrVC in order to restore venous return to the heart via blood flow through the stent interstices. One example of cranial vena cava and one example of caudal vena cava obstruction are presented below for demonstration purposes.

Caudal vena cava obstruction: A 9 year-old male castrated Petite Bassett Griffon Vendene (PBGV) dog was evaluated for a 3 week history of progressive abdominal distension and lethargy. On physical examination a palpable abdominal fluid wave was present as well as a grade 2-3/6 heart murmur and generalized muscle wasting.

Subsequent medical work-up confirmed the presence of ascites (modified transudate), an anterior mediastinal mass, and a large vascular mass filling the right atrium, involving the atrial septum, and extending into the left atrium. There was no jugular vein distension. The dog was diagnosed with a cardiac tumor resulting in subsequent inferior vena cava obstruction and subsequent Budd-Chiari-like syndrome.

A 14mm x 100mm self-expanding, mesh, nitinol stent was placed transatrially from the IVC to the superior vena cava (SVC) in order to relieve the venous obstruction. During stent placement across the mass, the dog developed tachyarrhythmias and hypertension that responded to esmolol; the mass was suspected to be of neuroendocrine origin. The pressure gradient was relieved and the ascites resolved but returned approximately 14 months later. Repeat angiography confirmed tumor ingrowth and restenting relieved the obstruction once again. Approximately 21 months following the first stent procedure, the dog was euthanized for progressive lethargy, anorexia, and coughing. A metastatic chemodectoma was ultimately diagnosed via post mortem and the stent remained patent but tumor ingrowth had occurred.

Cranial vena cava obstruction: A 9 year old male castrated Beagle was examined for head and neck swelling/edema with pleural effusion consistent with cranial vena cava syndrome. Echocardiography revealed a mass obstructing the cranial vena cava and right atrium. No chest metastases or ascites was present.

A 14mm x 85mm SEMS was placed across the lesion, the pressure gradient resolved, and the head swelling and pleural effusion resolved over the next few days. The dog was only treated with Palladia and died of undetermined causes 5.5 months post-stenting. No ascites or head swelling was present at the time of death and the stent was patent upon post-mortem examination.

In both cases here and a third in the abstract¹, stent placement was successful and resolution of ascites or head swelling/pleural effusion was achieved. Two dogs required additional stent placement for partial stent occlusion likely due to tumor ingrowth. In both cases, restenting resulted in ascites resolution or substantial reduction suggesting overlapping of open stents did not prevent bloodflow through the interstices.

Thrombosis or tumor embolism was not a substantial problem in any case; none of which received anticoagulant therapy. Cardiac venous return across the stent interstices appeared to be adequate in these three dogs but cardiac

output was not challenged. Neointimal formation across the stents interstices did not appear to be a major problem. Substantial contact with the SVC (and possibly IVC) should be the goal to prevent migration into the atrium as stent expansion is difficult to anticipate during stent deployment. Ascites recurrence suggests progressive mass ingrowth through the interstices of the stent. For tumors in which survival is expected to be longer than 3-6 months, potential restenting should be anticipated.

Transatrial stenting from the IVC to the SVC has been described for short-term management of ascites in two humans for intracardiac HCC extension.² To the authors' knowledge, the abstract described above¹ is the first report of long-term palliative transatrial stenting for non-HCC tumors affecting venous return to the heart (cardiac tumors). The stents were well tolerated in these canine patients for whom surgical options were not possible. Stent free ends within the atrium can result in cardiac perforation or migration into the ventricle.³ In addition, this report demonstrates that longer-term palliation (>3months) is possible using this technique.

Transatrial stenting may be considered in the future for similar patients in which traditional options are declined, not indicated, or may be associated with excessive morbidity or mortality, however potential stent shortening should be anticipated (so stent length should be longer than necessary) and careful monitoring is necessary to evaluate for stent occlusion.

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Laparoscopic ovariectomy versus ovariectomy via midline coeliotomy or flank laparotomy in cats: effects on postoperative pain

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The purpose of this prospective clinical study was to compare three methods of ovariectomy in cats. We hypothesised that laparoscopic ovariectomy would cause less postoperative pain than open midline and flank approaches and that other studied parameters would be similar.

Sixty-eight ASA1 client-owned female cats were initially enrolled. Eight cats were excluded (pregnancy, uterine abnormalities, aggressiveness). The cats were randomly assigned to one of three groups: Midline group (n=20), Flank group (n=20), Lap group (n=20). All open and laparoscopic procedures were performed by 2 different senior surgeons. Surgical assistants were veterinary students in all cases. The animals were premedicated with IM medetomidine and morphine hydrochloride. General anaesthesia was induced with propofol and maintained with isoflurane. For laparoscopic ovariectomy, a transabdominal suspension ligature was used and haemostasis was achieved with an endoscopic bipolar vessel-sealing device. The patients were evaluated 1h, 2h, 4h, 6h, and 12h after extubation. Postoperative pain was scored using the 4A-vet pain scale. This compound pain scale combines a subjective numerical pain rating and the objective scoring of physiological and behavioural parameters, including the response to stimulation of the surgical site. Additional postoperative analgesia was provided as required according to the Pain Score by IV administration of morphine. Recorded parameters were age, body weight, duration of anaesthesia, duration of surgery, duration of recovery, dose of propofol required for anaesthetic induction, number of perioperative morphine injections, quality of the recovery, level of postoperative consciousness, preoperative and postoperative heart rate, respiratory rate, body temperature, and pain score at each of the different examinations. For quantitative parameters, statistical analysis was performed using one-way ANOVA with a post-hoc Tukey test. Qualitative parameters were compared using a Fisher exact test. Significance was set at $P < 0.05$

Mean surgical time was significantly higher in the Laparoscopy Group (41 ± 6 min) compared to the Midline (35 ± 9 min) and Flank groups (24 ± 9 min). Pain scores were significantly lower in the Laparoscopy group compared to both Midline and Flank groups from 2h to 12h postoperatively. Pain scores did not differ significantly between the Midline and Flank groups but revealed moderate postoperative pain in both groups.

Laparoscopic ovariectomy in cats is a safe procedure that necessitates specialized equipment and training. Although a slower technique, it resulted in less postoperative pain than open approaches, as observed previously in dogs.

Minimally invasive unilateral arytenoid lateralization in dogs - a cadaveric study.

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Introduction

Laryngeal paralysis is a condition in which there is partial or complete loss of the ability to abduct the arytenoid cartilages and vocal folds during inspiration. Although many procedures have been described, the method of choice is generally considered to be unilateral arytenoid lateralisation. The superficial location of the larynx, the location of the arytenoid cartilage medial to the thyroid cartilage and the ability to see into the larynx via an endoscope placed into the mouth provide all the necessary requirements for the development of a minimally invasive technique for unilateral arytenoid lateralisation. The aims of this study were to develop a percutaneous thyroarytenoid lateralisation (PTAL) technique, and to evaluate the effectiveness and safety of this technique on canine cadavers.

Materials and Methods

Eleven canine cadavers, weighing 15 kg to 37 kg, were used. The dogs were placed in ventral recumbency with the neck extended and the mouth open. A rigid endoscope was used to visualize the rima glottidis. The larynx was palpated and 2 hypodermic needles were passed through the skin into the lumen of the larynx, penetrating both the thyroid and arytenoid cartilages. Nylon suture material was passed through the needles to hold and retract the arytenoid cartilage. A key-hole approach to the larynx was performed and the suture material was knotted adjacent to the thyroid cartilage. The procedure was performed bilaterally and the change in the rima glottidis area after each procedure was recorded as were the duration of the procedure and complications encountered.

Results

The landmarks for needle insertion were easily palpated in all dogs. The time required to place the suture material (measured in 17 unilateral procedures) ranged from 4:30-20:19 minutes. The time required to perform a unilateral PTAL (measured in 9 unilateral procedures) ranged from 9:30-16:00 minutes. A 1.4-16.2 fold increase in the area of the rima glottidis was documented after performing a unilateral PTAL.

Discussion

Canine cadavers have frequently been used to show the effectiveness of various techniques of unilateral arytenoid lateralisation. We have shown that unilateral PTAL significantly increases the area of the rima glottidis. However, the effect of this procedure in a clinical patient is beyond the scope of this study. The advantages of PTAL is that it is minimally invasive, quick and relatively simple to perform. An added theoretical advantage is that it can be performed as a planned surgery or in an emergency setting. In an emergency the suture material can be placed around the arytenoid cartilage and tied on the skin. This will temporarily abduct the arytenoid cartilages and allow the dog to be managed without intubation.

Thrombolysis and thrombectomy

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Advanced imaging techniques, the management of extremely debilitated patients with a host of hypercoagulable risk factors, and the growing use of indwelling catheters and medical devices will likely increase the number veterinary patients identified with clinically detectable thrombosis. While many of these patients will not require intervention for these problems, a growing proportion will as the underlying disease processes are now being better managed. The most common underlying diseases to investigate in a complete evaluation include cardiac, endocrine, inflammatory, hepatic, renal, and neoplastic processes. In addition, idiopathic thrombosis can also occur when an underlying condition is not identified. The complete diagnostic work-up for a patient with thrombosis is beyond the scope of this lecture, which will focus primarily on interventional management options when the clinician feels they are indicated. Standards-of-care have not yet been determined or evaluated in veterinary patients with symptomatic thrombosis so the procedures discussed are based solely on the author's experience.

Differentiating Thrombus Type and Guiding Therapy

This lecture will be divided into three separate parts based upon anatomical location and thrombus type, including arterial, venous and pulmonary thrombi. Arterial thrombi form under high shear forces and are therefore comprised mostly of platelets with fibrin strands binding them together. Alternatively, venous thrombi form under much lower shear forces and therefore are composed mostly of fibrin and red blood cells. Pulmonary thrombi are generally an intermediate form or mixed thrombi. The development of pulmonary thrombi are likely very different from those encountered in humans and therefore the treatment options will likely vary.

Understanding the nature of the thrombi, as well as the age or chronicity, will help the clinician determine the appropriate therapy and likelihood of success with treatment. For instance, it is generally recognized that anti-platelet drugs are generally not necessary for low-platelet venous thrombi, although veterinarians often prescribe these drugs. In addition, the location of the thrombus, and completeness of vascular obstruction, will also play an important role in determining the role of interventions. For instance, an arterial thrombus leading

to impaired bloodflow to an organ or anatomical location is an emergency whereas a venous obstruction of the caudal vena cava or jugular vein may be either subclinical or only result in swelling and edema. On the other hand a jugular thrombus may grow down to the cranial vena cava and result in pleural effusion, chylothorax, and severe head swelling with respiratory compromise or a portal vein thrombus may result in severe portal hypertension, ascites, and a compromised gastrointestinal tract requiring urgent intervention.

Lastly, the patient's physical status, underlying comorbidities, prognosis, and the client's financial concerns will likely all be important considerations in the care provided to the individual. Often, even when the thrombus can be safely and effectively addressed, if the underlying condition is not treatable (ie cannot be permanently resolved), then the patient will remain at risk for future thrombosis. In addition, these patients may even be at higher risk for recurrence if medical devices such as intravascular stents are placed.

Interventional Radiology Treatment Options

The failure of medical therapies to be effective alone, combined with the overall high morbidity associated with surgical thrombectomy in hypercoagulable, sometimes post-surgical patients soon to be receiving anti-coagulation, makes minimally-invasive treatment options a reasonable consideration in many of these patients. The excitement associated with performing these procedures must not overshadow the most important part of the therapy; The underlying condition must be addressed and the hypercoagulable state must be resolved or any intervention is likely to fail. Any intervention meant to treat these problems must be associated with a comprehensive medical plan to manage the underlying disease process and hypercoagulable state prior (if possible) to the intervention. This means aggressive anticoagulation and antiplatelet therapy if indicated. Recently available human oral anticoagulation (Rivaroxaban) may facilitate this process in animals as well.

Arterial Thromboembolism

Arterial obstructions often present with more severe clinical signs depending upon the amount of tissue risking

devitalization. Peripheral arterial thrombi are less commonly diagnosed in veterinary patients, likely due to the vast and abundant collateral perfusion throughout much of the body. The classic arterial thromboembolism scenario in veterinary medicine is the saddle thrombus occluding unilaterally or bilaterally the pelvic limbs. In severely affected animals the attending clinician often does not have the luxury of time to see if systemic anticoagulation and/or lytic therapy will be effective. Historically, surgical thrombectomy has been performed and rheolytic thrombectomy has been described. Both techniques are effective but unfortunately the underlying cardiac disease and fragile systemic condition of the patient often results in poor longer term outcomes in approximately 50% of the patients. In addition, acute reperfusion of both pelvic limbs would be associated with malpractice litigation if performed in humans due to the anticipated risk of death from reperfusion injury. Before performing such a procedure the attending clinician should have a long conversation with the pet owner about such a sequela. It has been the author's experience that dogs (and likely cats) can likely tolerate occlusion of both the internal iliac arteries without clinical signs. Once the thrombus grows and extends beyond this bifurcation, clot begins travelling down the external iliacs arteries and into the femoral arteries. This is the point of clinical presentation. As long as both external iliac arteries can remain patent the animal can recover. The use of infusion thrombolysis with vascular stenting has been successful in a small number of these patients treated by the author. This technique appears to provide a more delayed reperfusion than the hyperacute reperfusion encountered during complete clot removal.

Interestingly, the author has recognized more chronic distal aorta thrombi in dogs between the renal and external iliac arteries; the chronicity is identified by collateral circulation and the clinical signs associated with claudication rather than acute hindlimb ischemia. These patients should not be "lumped in" with saddle thrombi patients. These patients can respond to vascular therapy very well as the risk of acute reperfusion injury is not expected. Aggressive and early physical therapy should be performed as the author has seen muscle contracture following arterial ischemia the pelvic limb in a dog.

Venous Thromboembolism (VTE)¹

Treatment of venous thrombi must be based upon consideration of the overall clot burden and extent, the resulting clinical signs associated with the venous obstruction, and the ability to control the underlying cause of the clot if it is known. In addition, one of the most problematic complications in humans with venous obstruction is "Post Thrombotic Syndrome (PTS)", a group of conditions including swelling, pain, skin ulceration and discoloration resulting from chronic untreated DVTs. The cause is unclear but likely associated with chronic inflammation and damaged venous valves. We are unclear

if this occurs in animals. The major goals of VTE treatment include resolution of clinical signs, avoidance of PTS, and reduction in risk of PTE. While anticoagulation and systemic thrombolysis continues to play a predominate role in VTE, catheter-based techniques may help improve outcomes when considering the goals stated above. These techniques are generally divided into three categories including (1) Passive infusion of thrombolytics into the clot through infusion catheters called "catheter directed thrombolysis (CDT)", (2) "Percutaneous mechanical thrombectomy (PMT)" involving mechanisms of clot aspiration and maceration, and (3) Lytic-assisted devices providing pharmacomechanical and sonically enhanced thrombolysis techniques.

CDT is technically easy and relatively inexpensive to perform however improved outcomes have not yet been documented and prolonged infusion times and increased risk of bleeding are the problems. PMT provides an elegant approach and have been demonstrated to work well with hyperacute thrombi, however they tend to fall short in more chronic thrombi that are 2-3 weeks old. The lytic-assisted devices are the new frontier and work well in smaller vessels, however larger vessels may also require adjunctive CDT or vascular stenting.

Venous stenting is often employed in processes in which the large veins may be externally compressed leading to recurrent thrombosis however stent are often avoided at the confluence of veins or in the limbs where stent fracture and other complications can occur. Stenting has been employed more often at the author's institution due to the relative ease and rapidity of placement, immediate resolution of clinical signs, and general chronicity of most of the clots encountered in our practice.

Pulmonary Thromboembolism (PTE)²

As mentioned above, the cause of PTE in veterinary patients is likely different from those in humans who often suffer from migration of deep vein thrombosis (DVTs); As such the treatments are likely to be different. In people, PTE carries an approximate 30% mortality rate if left untreated compared to ~8% when treated. Not all PTEs are the same, however, so careful risk stratification must be pursued in order to determine which patients will benefit from such an intervention and which patients may be harmed. As such, the terms "massive PE" and "submassive PE" have been used. In massive PE, hemodynamic instability (systemic hypotension and circulatory collapse) is likely an absolute indication for intervention (thrombolysis for instance). In submassive PE, right ventricular dysfunction (RV:LV ratio greater than or equal to 1 in humans), high clot burden, or concomitant DVTs may raise the consideration for intervention.

The presence of DVTs (highly uncommon in veterinary patients) makes the use of vena cava filters a rare consideration in our patients while it is a very common, rapid, minimally-invasive and safe procedure in humans. These implantable basket-like devices allow bloodflow to persist through the vena cava but catch any blood clots launching up the vena cava, preventing further PTE. In addition, the clot is trapped in an area of high bloodflow, facilitating lysis.

Systemically administered thrombolysis is contraindicated in patients with recent surgery, known or recent hemorrhage, intracranial disease (bleeding, tumor, trauma, or stroke). While this treatment is appealing, in humans there has been statistically significant clinical evidence that systemic thrombolysis is associated with improved mortality over anticoagulation therapy alone. There is growing evidence that shorter infusion times (<2hrs) may be preferred over the historically longer infusion times (~12hrs for instance) in terms of more rapid clot lysis and fewer bleeding sequelae. For PTEs, there is evidence that systemic thrombolysis does not provide sufficient clot exposure to the compound and more localized therapy is therefore warranted (consider an open bottle of wine "breathing" without a dacanter).

Surgical embolectomy is associated with high morbidity and mortality in human hospitals without substantial experience and multi-disciplinary approaches. As such, the risks associated with the procedures performed in veterinary patients is like to be at least as high but may be considered in those patients with massive PE and contraindications to thrombolysis. Catheter-based techniques delivering localized tPA through infusion catheters, pigtail fragmentation catheters, thrombectomy devices, etc. offer a more elegant and theoretically improved clot removal approach but little evidence exists supporting an advantage at this time.

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Thoracoscopic cranial mediastinal mass resection

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Cranial mediastinal masses in dogs are most frequently diagnosed as either thymoma or lymphoma with ectopic thyroid carcinoma, branchial cysts and chemodectomas being much less common. If a cytological or histopathological confirmation of a thymoma is made, surgical resection is usually recommended. Thymoma is a tumor arising from the thymus gland and is a rare disease in dogs. In humans it is often detected incidentally during a chest radiograph or as part of a work-up for myasthenia gravis, but in dogs it is often clinically silent for long periods and therefore presents at a more advanced stage.¹⁻³ Canine thymoma has been described as benign or malignant, but this is based more upon phenotypic behavior than histologic appearance.⁴ Typically benign or "non-invasive" tumors remain within the thymic capsule and do not invade vascular or other structures in the region. Malignant or "invasive" thymomas are locally aggressive and may also metastasize.^{1,5} In both humans and dogs, surgery is the treatment of choice for non-invasive thymomas and complete excision, without violation of the capsule, is the critical technical element that correlates with a good prognosis.^{5,6}

Dogs with thymoma usually present with symptoms attributable to compression or invasion of surrounding structures or paraneoplastic syndromes. Signs include coughing, dyspnea or symptoms of venous congestion secondary to occlusion of the cranial vena cava. The most common paraneoplastic syndrome associated with thymoma, in both dogs and humans, is myasthenia gravis. Thymomas can be asymptomatic and diagnosed as an incidental finding on thoracic radiographs performed as part of the diagnostic evaluation for another condition.

Many thymomas will be too large to be amenable to thoracoscopic approach although those that are up to 5-6cm in diameter in middle to large breed dogs and that do not invade surrounding organs may be amenable to a thoracoscopic resection.^{7,8}

Surgical anatomy of these masses is quite variable and so preoperatively a CT scan can be very helpful in clinical decision making. The CT can be used to rule out vascular invasion and aid in planning port placement depending on the location of the mass.

One-lung ventilation (OLV) may also be very helpful during the procedure to maximize visualization and potentially reduce iatrogenic damage to pulmonary parenchyma during dissection. The smaller thymomas that have been resected in the authors practice have generally been located from midline towards the left cranial quadrant of the thoracic cavity but their anatomy can vary widely. OLV can be achieved using a double-lumen endobronchial tube or endobronchial blocker. If a double lumen endobronchial tube is used, OLV can be alternated between the left and right side depending on which side of the tumor is being dissected at any given time.⁷

It may be possible to resect cranial mediastinal masses from a lateral or dorsal approach but the author favors dorsal recumbency. Dorsal recumbency often results in the mass being "suspended" within the cranial mediastinal root and often provides good visualization of its relationship to surrounding structures (especially the internal thoracic arteries). A telescope portal is established in a subxiphoid location. A 3cm incision is then made at the left 4th intercostal space at the level of the dorsal third of the thorax in an area adjacent to the mass (if the mass is more right sided, which is less common, this incision can be made on the right side). This incision can be used to place a finger into the thoracic cavity to aid in manipulation of the mass during dissection and also to remove the mass at the termination of the surgery. A second port will usually be placed on the right side at the 6-9th IC space in the ventral third of the thoracic cavity. Once all ports are in place, a blunt grasping instrument, blunt probe or gloved finger are used for manipulation of the mass and a vessel-sealing device is used to initiate the dissection of the mass from the surrounding tissue planes. In some cases the mass can be attached to the internal thoracic artery and careful dissection is required to dissect these two structures from one another. Every effort should be made to resect the mass without penetrating the tumor capsule. Once completely dissected the mass is placed into a specimen retrieval bag and removed through the cranial left-sided portal.

A number of possible complications can arise during thoracoscopic cranial mediastinal mass resection. These include inadequate visualization to proceed with dissection. This is usually due to inability to achieve OLV, intraoperative

loss of OLV or inadequate room for dissection if the mass is too large or the patient too small. Conversion to an open approach is always a reasonable approach in these situations if the problem cannot be resolved. Major hemorrhage can occur and needs to be controlled either using a vessel-sealing device or hemostatic clips. Port site metastases has been noted by the author in one dog with a thymoma where capsular penetration of the mass occurred during dissection. An inability to dissect the tumor free without capsular disruption is probably in itself a reasonable criteria for conversion to an open approach. Preservation of the capsule along with careful use of a specimen retrieval bag might help to minimize the occurrence of port site metastases in these patients.

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Learning curve and initial experience with laparo-endoscopic single site (less) ovariectomy using a multitrocar port , angled telescopes and articulating instruments in the dog

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Objective

To define the learning curve, describe the technique and evaluate the outcome for dogs that had a Laparo-Endoscopic Single Site (LESS) Ovariectomy using a commercially available multitrocar port with articulating instruments and an angled telescope.

Design

Retrospective case series.

Animals

25 client-owned dogs.

Procedures

The SILSTM commercially available multitrocar port was inserted into the abdomen through a 15-20 mm incision at the umbilicus. A LESS ovariectomy was performed bilaterally using the SILS TM multitrocar port, articulating grasper, bipolar vessel sealing device and a 30o telescope. The excised ovarian tissue was removed through the multitrocar port incision between ovaries.

Results

25 dogs had a LESS ovariectomy. Median body weight was 20.3 kg (range, 3.5-41 kg). Median surgical time was 30 minutes (range, 15-90 minutes). Median patient age was 334 days (Range, 184-2913 days). For a single surgeon, a Chomsky learning curve revealed that after the 12th procedure a surgeon reaches 90% of the fastest time expected ($p=0.046$) with a 95 % confidence interval. Complications included minor haemorrhage due to a splenic laceration for dog #13 and an incisional infection occurred postoperatively in dog #14.

Conclusions and Clinical Relevance

The learning curve for the LESS ovariectomy is short and definable. The LESS ovariectomy is a safe procedure that can be utilized as a minimally invasive laparoscopic sterilisation technique. Caution should be taken to avoid splenic injury during multitrocar port insertion.

Evaluation of short-term outcome after video-assisted thoracoscopic lung lobectomy for resection of primary lung tumors in medium to large breed dogs.

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A video-assisted thoracoscopic (VATS) approach for lung lobectomy is a standard of care procedure for resection of many primary lung tumors in humans and has been described in a small number of canine patients.¹

The aims of this study were to describe the clinicopathological features of dogs undergoing VATS lobectomy for resection of primary lung tumors and to compare short-term outcome of VATS lobectomy with open thoracotomy (OT).

Medium to large-breed dogs undergoing either VATS (n=22) or open thoracotomy (n=24) were included. A 3-port technique was used in 12 dogs and 4 ports were used in 10 dogs. One-lung ventilation was employed in all VATS cases. Tumor volumes were calculated from pre-operative computed tomography scans where available.

Two of 22 dogs (9%) were converted from a VATS to an OT approach. All dogs were discharged from the hospital. There was no significant difference between VATS and open lobectomy with regard to major complication rate, time to discharge, time in intensive care, or in completeness of resection. Surgery time was significantly longer for VATS lobectomy (median 120 minutes, range 70-170 minutes) than OT lobectomy (median 95 minutes, range 60-135 minutes).

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VATS lobectomy has a low conversion and complication rate in medium to large breed dogs. Short-term morbidity of VATS lobectomy was comparable to OT for resection of primary lung tumors in dogs.

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Small animals – Neuro- and Orthopaedic surgery

**In depth – Lumbo-sacral disease in
dogs and cats: diagnostic and surgical
treatments**

Friday July 5

08.30 – 13.00

Clinical signs: is it Degenerative lumbosacral stenosis (DLSS)?

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Degenerative lumbosacral stenosis (DLSS) is the most common disease affecting the peripheral nervous system to be found in aged medium-sized and large dogs. The intervertebral disc space of L7 and S1, including the associated ligaments, is usually affected. Because the spinal cord segments are shorter than their respective vertebrae, the spinal cord ends at the level of L6 in most of dogs. DLSS occurs due to stenosis of the lumbosacral vertebral canal leading to compression of the blood vessels and nerves which form the cauda equina. As a consequence a lesion localized at L7-S1 will induce **lower motor neuron signs**.

Anatomically following nerves might be affected by the disease:

- The sciatic nerve (L6–L7–S1) provides motor innervation to the semimembranosus, semitendinosus and biceps femoris muscles. More distally, it branches into the tibial nerve (which controls the gastrocnemius, popliteal, and the superficial and deep digital flexor muscles) and the peroneal nerve (which innervates the tibialis cranialis, fibularis longus and the long digital extensor muscles). This nerve complex is also responsible for the sensory innervation of the whole of the hindlimbs distal to the knee with exception of a shallow medial strip innervated by the saphenous branch of the femoral nerve.
- The pudendal nerve (S1–S2–S3) provides motor innervation to the external anal sphincter and the caudal rectus muscle. It provides sensory innervation to the prepuce, peritoneum, vulva and scrotum.
- The pelvic nerve (S1–S2–S3) innervates the smooth muscles of the bladder and rectum.
- The caudal nerves (Cd1–Cd5) are responsible for the motor and sensory innervation of the tail.

A constant and central clinical factor is **lumbosacral pain**. The origin of pain can easily be explained by irritation/compression of the lumbosacral nerves and innervated surrounding structures (dorsal longitudinal ligament, ligamentum flavum) but also by degenerative changes affecting the vertebral joints (arthrosis) and intervertebral disc (annulus fibrosus, vertebral endplates).

In the early phase of disease, pain is not recognised by the owner and a reluctance to exercise is noticed. The dog typically does not want to walk upstairs or jump into the car, etc.

Pain can be elicited during the neurological examination with the following manipulations:

- Energetic pressing down on the L7–S1 joint, resulting in the animal sitting down or showing pain in other ways.
- Overextension of the tail with or without concomitant pressure on the lumbosacral region.
- And at least overextension of the hindlegs. The expression of pain with this manipulation occurs not only with DLSS, but it may also be due to orthopaedic disease (coxarthrosis...) making this test less sensitive.

A slight muscular weakness is another clinical signs seen during the course of DLSS. The joints are slightly more flexed than normal making it difficult for the animal to stand up. The paresis can also manifest in the tail muscles. A low tail carriage and reduced tail tonus can be observed more frequently than a severe hindleg paresis. **Pain and weakness are early signs of DLSS and are very often the only ones present.**

In the later stages of this disease, the following clinical signs can develop:

- Atrophy of the muscle groups innervated by the sciatic nerve. The whole of the hindlimb musculature can be affected but the atrophy is more frequently detected in the tibial cranial muscle and less frequently in the hamstring muscle group. The quadriceps muscles are generally less affected (only disuse atrophy) because they are innervated by the femoral nerve. Sensation remains normal.
- Proprioception deficits.
- The flexor reflex is reduced, but only rarely is it completely absent. In the majority of cases, it appears normal when examined superficially. A normal response to this reflex is a strong retraction of the hindlimbs. In cases of DLSS, the flexion of the coxo-femoral joint is not affected as the femoral nerve is not involved in this disease process. In

contrast, flexion of the knee and the tarsal joints is reduced or lacking. The tibialis cranialis reflex is often normal or reduced, the patella reflex is normal or appears to be increased (pseudohyperreflexia). The perineal reflex can be reduced and the anus dilated, although this is not a consistent finding. Incontinence occurs more in the later stages

Clinical relevance: DLSS only elicits mild neurological locomotory deficits and cannot be responsible for severe ataxia or paresis. In cases of lumbosacral pain associated with severe ataxia, a DLSS might be present but the main pathology might be located T3-L3. Degenerative myelopathy and chronic disc herniation are both pathologies which are not painful on palpation and that should be taken in consideration as further differentials in such cases.

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Diagnostic imaging of lumbosacral disease

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Diagnostic imaging of degenerative lumbosacral stenosis (DLSS) has been challenging until the introduction of computed tomography (CT) and magnetic resonance imaging (MRI).

Former methods included survey radiography, stress radiography, myelography, epidurography, transosseous and intravenous venography, discography, scintigraphy and linear tomography¹.

Survey radiography gives an overview of the anatomic situation (eg. presence or absence of transitional vertebrae) and allows the evaluation of signs of degenerative disease. Its main disadvantages include poor soft tissue contrast, superimposition and positional artifacts. Stress radiography can demonstrate movement or instability, but is affected by the same limitations.

Myelography can only be used if the dural sac is reaching into the sacrum which may end anywhere between L6 and the sacral vertebrae. Furthermore it will not demonstrate compressions originating in the dorsal, lateral or foraminal compartments.

Epidurography outlines the epidural spaces at the lumbosacral junction. Sensitivity is low for lesions obstructing less than 50% of the vertebral canal.

Discography of the lumbosacral disk could help delineating the borders of the disk and demonstrate herniations. In combination with epidurography it has been proposed as a rather accurate method for demonstrating cauda equine compression². However it is an invasive method and fails to demonstrate lateral and foraminal compressions.

Osseous and intravenous venography could be used to demonstrate space occupying lesions at the lumbosacral junction. They are rather difficult to perform and can be false positive due to incomplete venous sinus filling and variations in sinus configuration.

All these methods have in common that they were used to diagnose cauda equine compression by evaluating indirect signs such as space occupying effects or demonstration of disk herniation or spondyloarthritis. It was not possible to directly visualize the nerves of the cauda equina.

This limitation was finally overcome by the introduction of CT and MRI. Both are cross sectional imaging methods finally enabling direct visualization of nearly all relevant anatomic structures³⁻⁶.

CT is an excellent method for evaluation of bone and to some extent soft tissues. It allows visualization of nerves – as long as they are surrounded by fat. Direct evaluation of the intervertebral disk is possible and absence or presence of herniation and the resulting degree of cauda equine compression can be determined. Common bony pathologies such as spondyloses, hypertrophic/osteoarthritic facet joints and foraminal stenosis can be easily evaluated. Intravenous application of iodinated contrast media allows identification of vasculature, aids in the differentiation between inflammatory, degenerative or neoplastic disease and can help delineating nerves in case of compression. Since the introduction of multislice helical CT soft tissue contrast has improved and with the acquisition of very thin slices (1 mm and below) high quality multiple planar reconstructions became possible and allow to adapt slice orientation for optimal visualization of the desired structure (eg. along the nerves). 3D reconstructions can further help understanding the situation and aid in planning of surgical treatment. The main disadvantage of CT is still the rather poor soft tissue contrast. Especially in presence of compressive material delineation of neural structures can become difficult to impossible.

MRI instead provides excellent soft tissue contrast. It allows to evaluate and grade disk degeneration and disk herniation. The nerves of the cauda equina can be easily identified and followed along all their course. MRI is sensitive for detecting changes in fluid content of tissues, so apart from anatomic information it can show to some extent pathophysiologic changes such as nerve swelling, edema and neuritis. Usually T1 weighted, T2 weighted and a fat suppressed sequence in different planes are recommended to examine the lumbosacral junction. 3D sequences allow multiplanar reconstructions to adapt slice orientation to the structures of interest. Intravenous application of gadolinium based contrast media can improve nerve delineation and help characterizing pathology.

Whereas High Field MRI (field strength of 1 Tesla and more) usually provides better signal to noise ratio, the diagnostic accuracy of Low Field MRI (up to 0.5 T) appears to be similar⁷.

Main disadvantage of MRI is the limited capability to delineate bony surfaces. In cases of irregular spondylosis differentiation between intervertebral disk, spondylosis

or just fibrous tissue can be difficult. Also osteochondrotic lesions of the sacrum can more easily be evaluated with CT.

The decision whether MRI or CT should be the method of choice in evaluation of lumbosacral disease in dogs and cats still needs to be answered. When compared with each other there was good correlation between MRI and CT and only moderate correlation with surgery⁸.

Modern multislice helical CT scanners are much faster than MRI and provide sufficient soft tissue contrast to visualize most relevant structures. Mainly pathologies affecting the nerve roots – such as primary or secondary neuritis – can still be better evaluated with MRI. MRI is also considered superior in detecting not degenerative disease like inflammation or neoplasia.

Interestingly in human medicine there are not that many studies comparing the diagnostic accuracy of MRI and CT for lumbosacral stenosis. However actual recommendations prefer MRI over CT due to its better soft tissue contrast and the lack of ionizing radiation^{9,10}.

In veterinary practice the most important criterium for choosing one of these modalities will be its availability.

It should be kept in mind that results of both CT or MRI imaging studies of lumbosacral disease do not have a high correlation with clinical signs or prognosis^{11,12}. Rather severe nerve compressions can give rather low symptoms and small compressions can lead to severe clinical signs.

The results of all imaging exams have always to be evaluated in the light of the clinical signs.

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Lumbosacral stenosis: static or dynamic problem?

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Introduction

Degenerative lumbosacral stenosis (DLSS) is a dynamic disease in many aspects. The controversies surrounding this disease syndrome are numerous and different views how to diagnose and treat DLSS make the discussion of this disease among veterinary colleagues a dynamic event!

Clinical signs

DLSS can present in a number of different ways and because of this patients suffering from DLSS can sometimes be misdiagnosed. DLSS patients are typically neuro-orthopedic patients, the disorder is per definition a spinal disease but the presentation is more that of an orthopedic disorder. As DLSS mainly affects middle-aged and older dogs they can often have other concurrent degenerative orthopedic or neurologic disorders such as, respectively, osteoarthritis or degenerative myelopathy. Hence it is helpful if these patients are subjected to both orthopedic and neurologic examinations.

Findings during orthopedic examination are directly related to the compression of the cauda equina, and the most consistent finding is lumbosacral pain on palpation. LS pain can be evoked by the lordosis test and hyperextension of the tail base with simultaneous pressure at the LS region. Hyperextension of the hip joints (one at a time) with the dog standing or in lateral recumbence should not cause pain unless the dog has pain derived from the hip. However, many dogs with DLSS and hip dysplasia allow gradual extension of the hip joints but start to show a pain reaction when hyperextending the lumbosacral junction. Especially in these cases the experienced clinician will note the difference between a mild response to extension of the dysplastic hip joint and the overt pain response due to added compression to the cauda equina. This is proof of the dynamic nature of the compression and stenosis which worsens in motions of extension (Fig. 1). Other common findings are uni- or bilateral hind limb lameness, atrophy of the hind limb musculature (innervated by the sciatic nerve) and a weight shift from hind limbs to the fore limbs. Unilateral entrapment of the L7 and/or S1 nerves (Fig. 1C) causes radiating nerve root pain (the so-called nerve root signature).

Overt neurological deficits are extremely rare in DLSS patients. Textbooks often state that urinary incontinence is part of the clinical syndrome but it is more likely to be a

separate concurrent problem than the direct result of cauda equina compression. The reason for this is that the spinal nerves comprising the cauda equina are much more resilient to compression than the spinal cord itself, and experimental studies have shown that the cauda equina in dogs can withstand considerable compression without suffering nerve fiber damage. Hence it is important that dogs with DLSS showing spinal ataxia and/or proprioceptive deficits are thoroughly investigated to exclude other conditions, such as degenerative myelopathy, thoracolumbar IVD herniation, discospondylitis, or neoplasia.

Lumbosacral imaging

The usefulness of myelography in DLSS is debated since it depends on the extension of the dural sac (containing subarachnoid space) over the lumbosacral junction. Myelography has been reported as a diagnostic method of DLSS but as a normal myelogram cannot exclude DLSS, myelography is not advocated as a reliable diagnostic technique for DLSS. Epidurography is technically easier and diagnostically superior to myelography and it is also associated with less side-effects. Contrast medium is injected into the epidural space at the lumbosacral or sacrococcygeal junction. An epidurogram in dogs with DLSS may show narrowing, elevation, deviation or obstruction of the epidural contrast-medium lines. Dynamic radiographic studies such as flexion/extension studies may increase the diagnostic sensitivity and specificity. Epidurography can nicely demonstrate the dynamic nature of the disc protrusion. Discography is now considered an outdated technique and is controversial because disc puncture itself causes degeneration in healthy IVDs.

Computed tomography (CT) provides significantly better soft tissue contrast resolution than conventional radiography. The great advantage with CT over conventional radiography is that transverse CT images can be reconstructed to view structures in any plan (sagittal, dorsal or oblique) and even three-dimensional reconstructions are possible. The CT findings in DLSS are the same as for radiography but in addition CT can also show soft tissue structures such as cauda equina nerves and thickening of individual roots (like L7 or S1), Hansen type II disc herniation, hypertrophy of ligaments (ligamentum flavum or dorsal longitudinal ligament), and joint capsules of the

facet joints. Transverse views can also be used to evaluate the intervertebral foramina and may show entrapment of the exiting spinal nerve, especially when CT is performed in a dynamic way, i.e. when CT is performed with the low back in two different positions (e.g., extension and flexion). CT is superior to MRI in detecting calcified tissue such as osteophytes and spondylotic bridging between vertebrae as well as calcified nucleus pulposus material in the spinal canal, but CT is less sensitive than magnetic resonance imaging (MRI) for discriminating soft tissues within the spinal canal. MRI provides more detailed information on soft tissue structures, in and around the spinal canal as well as detailed information regarding intervertebral disc degeneration. IVD herniation, both Hansen type I and type II, as well as proliferation of the ligamentum flavum, facet joint capsules or the dorsal longitudinal ligament can be imaged with considerable accuracy using MRI. MRI is also superior to CT for the evaluation of nerve root displacement or entrapment as well as loss of epidural fat. On T1-weighted images fat tissue has a high signal intensity and appears bright white. The intervertebral disc is of uniform medium signal intensity, slightly greater than that of the spinal cord, nerve roots, and bone marrow. On sagittal T2-weighted images water has a high signal intensity and appears bright white. As the NP of normal intervertebral discs have a high water content they will be bright white on T2-weighted MRI. IVD degeneration is characterized by a decreased T2 signal intensity within the NP. Parasagittal and transverse MR-images provide valuable information on stenosis of the L7-S1 intervertebral foramina, especially when observing the changes in the fat signal. Because of long scanning times with low-field MRI, extensive dynamic MRI studies with the low back in different positions are usually not performed.

Treatment

It is very likely that selected patients with low back pain can be managed by conservative treatment successfully, similar to humans with low back pain. Conservative treatment consists of medical treatment using non-steroidal anti-inflammatory drugs (NSAIDs) and body weight reduction in combination with altered and more balanced activity level where high impact physical activities should be avoided. The use of systemic corticosteroid treatment or repeated epidural infiltrations with methylprednisolone is controversial since the anti-inflammatory action of corticosteroids is similar to that of NSAIDs, whereas they have significantly more side effects than NSAIDs.

The indications for surgical treatment of DLSS are dogs with moderate to severe lumbosacral and nerve root pain unresponsive to conservative treatment. The primary aims of surgery are to decompress the cauda equina and free entrapped nerve roots. The standard surgical procedure is a dorsal laminectomy of the L7 and S1 vertebrae which is often sufficient in relieving all clinical signs of DLSS. The dorsal laminectomy can be supplemented with additional

procedures if further decompression is required such as: 1) partial discectomy consisting of dorsal fenestration (or dorsal annulectomy) and nuclear pulpectomy (or nucleotomy); 2) foraminotomy, and rarely 3) facetectomy. Stabilization by fixation and fusion is indicated when ventral subluxation of S1 is present or in severely deranged lumbosacral junctions (like chronic discospondylitis), or to prevent further development of lumbosacral instability. Pedicle screw rod fixation has proven to be an adequate stabilization technique in large breed dogs and the ultimate goal of this technique is spinal fusion. The decision to undertake surgical treatment and decide which surgical technique to use should be directed by the clinical signs of the patient, supported by diagnostic imaging findings. This way treatment is tailored best to suit the patient's needs.

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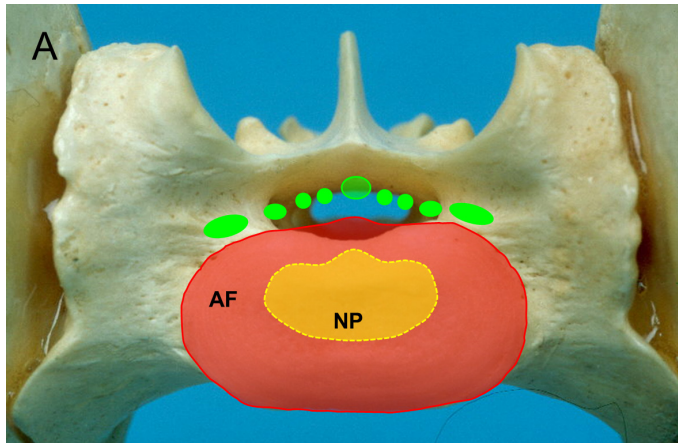
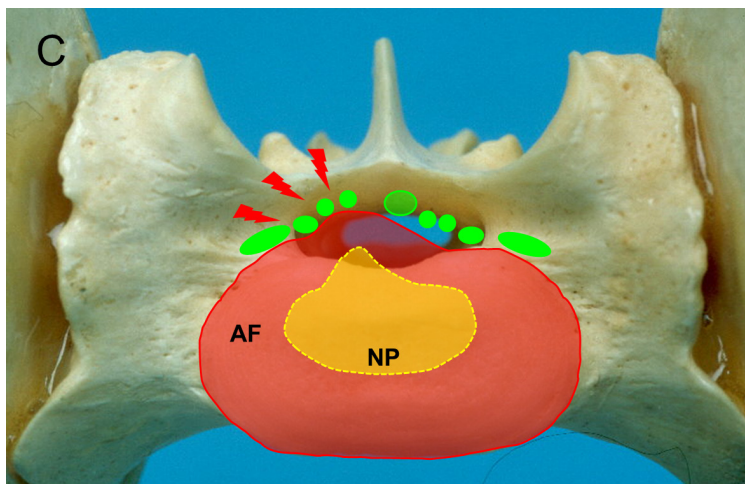
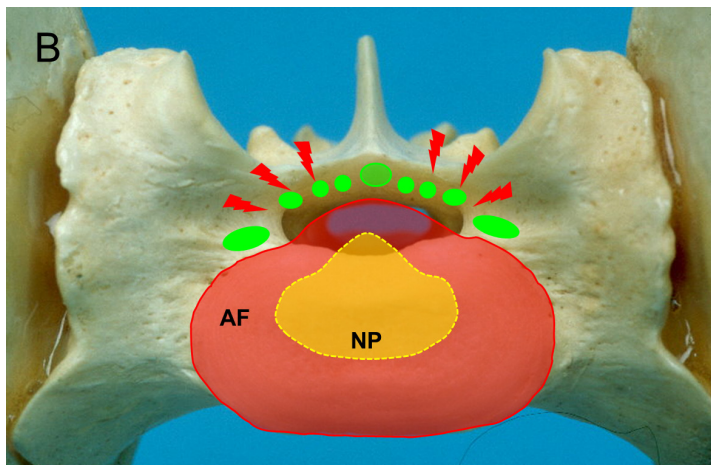


Figure 1. Schematic transverse drawing of the lumbar disc showing the dynamic changes during rest (A), central compression (B) and lateralized compression (C) of type 2 intervertebral disc herniation in degenerative lumbar stenosis. AF = annulus fibrosus; NP = nucleus pulposus



Decompression and pitfalls

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Foraminotomy and pitfalls

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Introduction

Lumbosacral foraminotomy is performed for decompression of the 7th lumbar nerve roots within the L7-S1 neuroforamina. Nerve root compression can occur unilaterally or bilaterally and is usually caused by extruded disc material, reactive bone formation, hypertrophic ligament development, thickening of the facet joint capsule, or scar tissue caused by previous operations.

Clinical signs of foraminal nerve root compression may include rear limb lameness, hyperaesthesia, a poor withdrawal reflex occasionally combined with patellar hyperreflexia, and pain elicited by hind limb extension or lumbosacral palpation.

Proprioceptive deficits or even hind limb ataxia may be observed in cases of marked compression. Lameness caused by unilateral foraminal stenosis can be confused with similar features in posture and gait caused by cranial cruciate ligament pathology. Lameness may show a tendency to increase during activity. A reduced perineal reflex, tail flaccidity, and urinary and fecal incontinence occur only in the presence of concurrent severe nerve root compression in the central region of the lumbosacral spinal canal.

Prior to the availability of computed tomography (CT) and magnetic resonance imaging (MRI) the adequacy of the opening of the spinal foramina and the status of the 7th lumbar nerves travelling through them could not be effectively visualized. With the availability of MRT, the lumbosacral neuroforamina and the 7th lumbar nerve's path out of the spinal canal could now be assessed. As lesions in this area were clearly identified, surgeons began investigating possible techniques to relieve nerve root compression.

The surgical procedure to relieve nerve root compression requires removal of the offending bone and soft tissue. An early technique involved the removal of the articular facets to free compressed nerve roots and was at one time a commonly performed procedure. However, because it may lead to severe instability it is no longer recommended and should be avoided (Danielsson and Sjöström, 2002).

For direct foraminotomy visualisation of the neuroforamen through a standard L7-S1 laminectomy is extremely limited. An experimental study utilizing endoscopically assisted foraminotomy via this approach found that only the

entrance but not the important middle and exit zone of the neuroforamen could be visualized or surgically widened (Wood et al., 2004). No data of clinical patients treated by this method have been published, but marked new bone formation at the site of removed bone was observed in the described group of experimental animals.

In 2007, Goedde and Steffen published a novel dorso-lateral approach to the L7-S1 neuroforamen. After diagnosing foraminal stenosis by MRI, the authors decompressed L7-S1 nerve roots in 20 dogs. The procedure was performed unilaterally or bilaterally, and with and without concurrent laminectomy to also decompress the central region of the spinal canal. The results in this series were encouraging with 19 dogs showing good or excellent results and only one dog having an unfavourable outcome.

Archer et al (2010) described the successful use of lateral foraminotomy in combination with laminectomy to treat nerve root impingement in a case of lumbosacral transitional vertebra.

Carozzo *et al.* (2008) described a transileal approach to visualize the lumbosacral neuroforamen and disc space. Clinical application and case series have not yet been presented.

Material and Methods

This series from our clinic describes results in 63 lumbosacral foraminotomies performed in 54 dogs. All the procedures were performed by ECVS board certified surgeons. The sex distribution was: 20 intact and 8 neutered males, and 8 intact and 18 spayed females. The age of the patients ranged from 1 to 12 years, and weights were between 8 and 51 kilograms. After suspecting foraminal stenosis on the basis of clinical and neurologic examination, diagnosis was established by CT in 27 cases, and by MRI in 37 cases. Seven dogs underwent MRI as well as CT pre-operatively. Occasionally patients were re-examined post-operatively by CT to assess the extent of bone removal. Bilateral foraminotomy was performed during the same procedure on two dogs, one of whom also had an L7-S1 laminectomy. Two dogs underwent unilateral foraminotomy in combination with a dorsal laminectomy. Seven dogs received foraminotomy in staged procedures, after clinical signs were observed on the unoperated contralateral side. Surgeries were performed using the procedure described by Göttsche and Steffen with minor modifications.

Primary differences in our series were parasagittal skin and superficial fascia incisions in unilateral cases, as well as in most cases not transecting the muscular attachments to the articular processes. An operating microscope was used in the majority of our operations. We found that asymmetric Gelpi retractors were helpful in retracting the separated multifidus and sacrocaudalis muscles. Occasional haemorrhage from para-spinal vessels was controlled by bipolar coagulation. In cases of persisting minor haemorrhage the insertion of gelatin sponges was preferred over excessive use of electro-surgery to avoid nerve root damage. Autogenous fat transplants were used to cover the foraminotomy sites and decompressed nerve roots. Most patients were released from the hospital on the day after surgery. The typical postoperative protocol included perioperative antibiotics and non-steroidal anti-inflammatory agents for 10 days. Patients returned for re-evaluation and suture removal by either the referring practices or in our clinic.

Results

All operations were performed without significant intra-operative problems. Follow-up information to determine outcome was obtained in all but four patients. Follow-up was either by direct clinical re-evaluation or by interview of the referring veterinarians or owners.

In four patients, diagnosis was definitively incorrect and had to be corrected later in the course of their diseases. Three of these animals had been diagnosed by CT-examination. Of these four patients, one dog suffered from a tarsal joint problem not detected at the time of neurologic and orthopaedic work-up. One patient developed evidence of a soft tissue sarcoma that was compressing the ipsilateral sciatic nerve. One dog that had previously received THR on the affected limb did not improve after foraminotomy and eventually developed radiographic signs of hip implant loosening which was not evident radiographically at the time of foraminotomy. The fourth patient, a 3 years old female Malinois with a unilateral hind limb lameness and moderate signs of foraminal stenosis on MRI, developed a generalized hind limb weakness several weeks after surgery. A repeat MRI revealed a subdural mass at the T4-5 level. Exploration and removal of the mass was performed. Histopathology reported a vascular hamartoma, most probably a result of an accident months before the onset of neurologic deficits. The patient made a nearly complete recovery after the mass was removed.

Two dogs were euthanized soon after treatment: one dog developed prostate cancer, and one dog developed bilateral fractures of the caudal articular processes of L7 and was euthanized at the owners request.

Of the remaining group of 44 dogs with 52 foraminotomies, the outcome was considered as excellent in 37 cases (no further lameness or need for restriction of activity or medical treatment), good in 7 cases (moderate lameness or

reduced activity, no or very occasional need for medication), fair in 4 cases (frequent medication necessary), and poor in 4 cases (no improvement). All cases with poor long-term outcome developed obvious signs of degenerative myelopathy and eventually required euthanasia.

Long term followup information was obtained on 14 patients that were two or more years post surgery and had good or excellent short-term outcomes. Information was obtained either by clinical evaluation or by telephone interview. None of the patients in this group reported recurrent signs of foraminal stenosis during the followup period, but some were restricted in their activity by prudent owners or because of their advancing age.

One of the dogs with a long term excellent outcome, a 10 years old male Giant Schnauzer, had developed a painful episode with neurologic deficits on the non-decompressed side 3 days after surgery. A marked lumbo-sacral subluxation with a fractured facet joint on the decompressed side was diagnosed by radiographs and CT. Immediate recovery was achieved by L7-S1 surgical stabilization using pedicle screws and PMMA in a more flexed lumbosacral position to widen the still intact neuroforamen.

Discussion

As stated by Gödde and Steffen, accurate diagnostic work-up is the cornerstone of successful treatment of degenerative lumbosacral disease and especially of foraminal stenosis. Our experiences using both CT and MRI-based diagnoses showed clearly the advantages of MRI. In contrast to the authors mentioned above, we had no access to electro-diagnostics in our patients. Even with the help of the latter, a definitive distinction of the clinical relevance of central spinal canal narrowing and foraminal stenosis could not be established (Gödde and Steffen, 2007). In contrast to the published cases, we typically preferred to treat only the foraminal stenosis of the side presenting with clinical signs. Great emphasis was put on re-evaluation of the compressed but untreated side during the follow-up period. Exceptions were patients clearly showing marked signs of bilateral or unilateral and central compressions. As lumbosacral problems are encountered in larger breed dogs also prone to degenerative myelopathy, super-imposition of foraminal stenosis in patients with degenerative myelopathy may lead to unsuccessful outcomes (Gödde und Steffen, 2007). We experienced this in four of our cases.

We found lumbosacral foraminotomy to be a challenging but feasible procedure in our hands. The dorso-lateral approach is complicated by reduced visibility of the L7 pedicle caused by proximity of the iliac wing, the pelvic musculature and, in some cases subcutaneous fat. The well planned insertion of retractors and the resection of small concealing parts of musculature is necessary to determine the precise starting point of the pediclectomy. The dorso-caudal edge of the L7 transverse process provides the best landmark for starting bone removal in dorso-ventral

as well in cranio-caudal orientation. Three-dimensional reconstruction of a CT-scan can be helpful for the novice in this technique to gain confidence in exposing the spinal canal without unnecessary bone loss. Too much bone resection may weaken the articular facet and lead to post-operative fractures (Moens et al, 2002). Direct visualization is reduced when the drill burr protrudes towards the inner laminar cortex. Extreme caution has to be applied when this cortex is finally perforated and the opening is extended caudally until the nerve root is reached. Once visible, the spinal nerve is isolated more safely by Kerrison rongeurs than by a rotating burr. Soft tissue impacting the neural tissue is frequently encountered and can also be removed using Kerrison rongeurs. The removal of soft tissues occasionally may cause haemorrhage. If bleeding is not controlled by bipolar cautery or apposition of haemostyptic gelatine sponges, vision is heavily impaired and prevents safe further decompression. The long-term relief of clinical signs and no re-occurrence of neurogenic pain in the long-term followup patients supports the belief that meticulous apposition of autogenous fat over the decompressed nerve root and the widened neuroforamen are effective in preventing post surgical compression of the nerve root by scar formation.

In our group of patients were two dogs with post-operative fractures of articular processes and subsequent painful instability. Both were 10 year old male large breed dogs: one White Shepherd Dog weighing 41 kg, and a Giant Schnauzer weighing 50 kg. One patient was treated with dorsal stabilization and recovered, and one was euthanized due to the wishes of the owner. In retrospect we believe owners should be educated before the original foraminotomy procedure about the possible management of this uncommon complication. To minimize chances of this problem, surgeons should strictly follow the recommendation to only remove the lamina of the first sacral segment and the interarcuate ligament and to preserve the caudal border of the L7-lamina when laminectomy is performed during the same procedure as unilateral or bilateral foraminotomy (Kinzl *et al.* 2004).

Conclusion

Lumbosacral foraminotomy is an effective therapy to relieve neurogenic pain and restore nerve function in compressed L7-S1 nerve roots. The anatomy of the lateral region of the L7-S1 junction creates a challenge for the performing surgeon. Precise diagnosis is the key to successful surgical treatment of lumbo-sacral nerve root pain and deficits.

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Pitfalls of lumbosacral fixation

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- Arthrodesis of the lumbosacral junction means immobilizing vertebrae L7 and S1 with the sole goal of accomplishing their fusion.
- It's a complicated procedure, which should only be attempted as a last resort.
- It is appropriate in 3 situations: lumbosacral luxation, as an adjunct to a destabilizing decompression surgery, or in cases of mechanical sacral pain which is unresponsive to medical management.
- In the dog, there is no consensus on how best to accomplish lumbosacral arthrodesis. The various surgical techniques proposed result in highly varied stability. None of the proposed techniques has been the subject of a large-scale or long-term study.
- In cases of lumbosacral arthrodesis, lacking an evidence-based surgical technique, it is important at least to avoid the most common pitfalls, in order to avoid their complications. These can be catastrophic.

Pitfall 1: Operating too soon on patients which are only painful!

Most patients with L7S1 joint problems have pain as their only symptom.

This pain may have a mechanical (lumbosacral) or neurological (radiculopathy) cause. In the absence of motor deficit (limping, lack of weight-bearing...) or sphincter deficit (incontinence), and no matter the significance of the neurological structures compressed or the lumbosacral degeneration at work, only after medical management has been exhausted (rest, physiotherapy and anti-inflammatory drugs for at least 3 months) should a surgical solution be entertained.

Vertebral fixation might then be necessary either as an adjunct to surgery to free the nerve root when such surgery is too destabilizing, or as a treatment for pain of mechanical origin, whose physiopathology is poorly understood: arthropathy, painful degeneration of the disc, "micro" mobility

Pitfall 2 : Not having a sectional imaging study and analysis

It is unreasonable to undertake a lumbosacral arthrodesis without a sectional imaging study in hand (MRI or CT scan).

This examination is indispensable to the operation. It will confirm either central or/and foraminal stenosis, it allows identification of neural structures which may be compressed and examination of the nature of that compression. It will give information on the best site for screw implantation in the pedicles. It may reveal the presence of signs of instability.

Furnished with this information, it will be easy to plan decompression surgery, making it as efficient as possible and minimizing any destabilization, and if necessary anticipating a vertebral fixation procedure.

At the end of the imaging study, 3 questions should be asked:

- Is instability the cause of the lesion, which would justify fixation?
- Will the bone resection necessary for decompression lead to postoperative destabilization, necessitating fixation?
- If fixation is elected, do bones and ligaments at the level of L6L7 present signs of degeneration, so this space should be bridged.

Pitfall 3: Arthrodesis without graft

The goal of lumbosacral fixation is vertebral fusion. As with carpal arthrodesis, it is unacceptable to perform an arthrodesis without graft, with the risk of loosening and even fracture of the plate. Thus no lumbosacral fixation without graft. Studies performed and our own experience shows that achieving fusion in the dog is rare. This is not a sufficient argument for not trying. Cancellous bone may be placed around the facet joints. When a graft is placed in the intervertebral space, it exposes the nerve roots, which are fine and fragile, to stretching and post-op fibrosis.

Pitfall 4: Poorly-positioned fixations

A poorly-positioned arthrodesis may lead to perioperative complications (hemorrhage caused by abdominal compression) and a poor functional outcome. For example, a position with hindquarters in hyperflexion has the advantage of opening the interarcuate space, and thus with facilitating procedures inside the canal, but causes a kyphosing arthrodesis which runs the risk of being painful.

Pitfall 5: Using a fixation technique which provides insufficient stability

Some techniques give limited stability: a single facet screw or a single transilial pin does not seem to us sufficient, since it does not provide the required stability in the various planes caused by a major instability. Although no consensus has been reached, we believe that interventions involving the implantation of screws in the pedicles of L7 and S1 are more rigid. These screws are connected by cement or by rods, in the case of tulip-headed screws (human pedicle screws). The stability of the fixation may be augmented by facet screws, transilial pins, iliac screws...

Pitfall 6: Not fully understanding the principles of pedicle screw implantation

Pedicle screw implantation is a procedure which requires a certain technical proficiency. The most common pitfalls are:

- Poor placement*: a screw which is angled medially may damage the root of L7, resulting in a postoperative neurological deficit

- A screw of insufficient diameter*, which may result in implant failure

- Implantation in the sacrum*: the consistency of the sacrum is unsuited to the implantation of screws, and pullouts are possible. Placing screws in the pedicles of both S1 and S2 or implanting sacroiliac or iliac screws in the pelvis are two interesting alternative solutions.

Pitfall 7: Too short a fixation

If there is any narrowing of the canal at L6/L7 or signs of degeneration (arthrosis, discoligamentous changes), arthrodesis at L7/S1 runs the risk of aggravating the consequences (stenosis and low back pain) by the increase in mobility that it will engender at this level. For this reason it is preferable to include it in the arthrodesis.

Small animals – Short communication

Neuro and orthopaedic

Friday July 6
16.30 – 17.30

Minimally invasive approach to the thoracolumbar spinal canal in dogs

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Introduction

The objective of this study was to develop two minimally invasive approaches to the spinal canal for treatment of intervertebral disc disease and compare their efficacy to that of standard hemilaminectomy.

Methods

Barium-impregnated agarose gel (BA-gel) was injected into the spinal canal at three intervertebral spaces of the thoracolumbar spine in each of ten canine cadavers (5 < 13 kg, 5 > 13 kg). Sites were randomly assigned to one of three approaches: standard hemilaminectomy (SH), endoscopic foraminotomy (EF), or foraminotomy via an illuminated port (FP). Computed tomographic scans were performed before and after the procedures. Procedures were compared for duration, bone window size, incision length, complications and percentage of BA-gel removed via repeated measures ANOVA.

Results

The incisions created during EF and FP were similar and smaller to that of a SH. The duration of EF was prolonged compared to FP and SH. The size of the vertebral window created was greater after SH in large dogs, while no difference was found between procedures in small dogs. The amount of simulated disc material removed from the spinal canal did not differ between procedures, regardless of the size of the dog.

Conclusions

The two minimally invasive approaches were feasible in small and large dogs. Both techniques allowed similar removal of simulated disc material and may decrease soft tissue morbidity compared to SH. Minimally invasive foraminotomy and discectomy may be effective alternatives to standard hemilaminectomy in the thoracolumbar spine of dogs.

Evaluation of the effect of a dynamic proximal ulnar osteotomy on radio-ulnar congruence in 26 elbows

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Introduction

Our objective was to investigate resultant radio-ulnar joint modification using computed tomography (CT) after a Bi-Oblique Dynamic Proximal Ulnar Osteotomy (BODPUO) had been performed for the treatment of perceived elbow incongruence.

Materials and methods

Dogs operated by a single surgeon, with a BODPUO and for which a CT-scan study was available, preoperatively (PreO) and after completion of the osteotomy healing process, were included. Radio-ulnar space measurements were taken on transverse, frontal and sagittal CT projections (as defined by Holsworth et al.), preoperatively, 6 weeks postoperatively (PostO) and after radiographically determined healing of the osteotomy (12 weeks PostO). Additional transverse measurements were taken at the cranio-distal extent of the ulnar osteotomy line between the caudal radial cortex and the cranial ulnar cortex.

Results

Twenty-six elbows were included into the study. In addition to elbow incongruence, 21 elbows were affected by an MCP lesion in isolation, 2 by an ununited anconeal process (UAP) coupled with an MCP lesion and 3 by an osteochondritis dissecans (OCD) coupled with an MCP lesion. All osteotomies (26/26) were radiographically healed at the last CT examination. The mean elbow extension angle PreO, at 6 and 12 weeks PostO were $119 \pm 13^\circ$, $119 \pm 8^\circ$ and $121 \pm 10^\circ$ respectively, which were not statistically different from one another. (ANOVA; p -value = 0.678). LCP (.165cm vs. .270cm), Tr3 (.114cm vs. .230cm), Tr2 (.087cm vs. .129cm) measurements were statistically greater at twelve weeks post operatively than pre-operatively. None of the other measurements taken at the level of the elbow were statistically different.

Radio-ulnar distance measurements taken at the cranio-distal extent of the osteotomy in a transverse plane significantly increased (paired t-test; p -value=0.001) after healing of the osteotomy (mean $\pm$ SD: 0.642 ± 0.25 cm) by comparison with pre-operatively (0.351 ± 0.08 cm)

Discussion

CT measurements documented a significant increase in radio-ulnar joint space at the mid-coronoid level, at the level of the base of the coronoid process and at the level of the lateral coronoid process. This corresponds to a cranially directed rotation of the medial coronoid process around the proximal radial epiphysis. In sagittal and frontal planes, a slight proximal displacement of the base of the medial coronoid process was noted and there was a trend for increased negative displacement of the coronoid tip, but without statistical significance. The statistically significant caudal displacement of the distal aspect of the proximal ulnar segment however confirms that this motion does actually occur. Further studies are required to investigate the effect of BODPUO on humero-ulnar congruence in three dimensions.

Correlation between histopathology, arthroscopic and mri findings in medial coronoid disease in dogs

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Introduction

Despite recent advances in our understanding of medial coronoid disease (MCD), detailed descriptions of MRI findings in MCD are scarce. The long-term goal of our research is to develop an objective scoring scheme for diagnosing and staging MCD using MRI. As a first step towards this goal, we undertook a systematic comparison of the MRI, arthroscopic and histopathologic findings in dogs with MCD of differing severities.

Materials and Methods

Osteochondral specimens from 25 affected dogs and 5 unaffected controls were evaluated by MRI (using a novel grading scheme), arthroscopy (using a modified Outerbridge scheme) and histopathology.

Results

Modified Outerbridge scores of II and III were observed most commonly. MRI findings and Outerbridge scoring were consistent. On MRI, bone marrow lesions were described as focal in 68% of the cases, with 3 different patterns observed. The most common histopathologic findings were subchondral microfractures, subchondral microfractures continuous with cartilaginous fissures, moderate to severe hypercellularity of the marrow space, trabecular bone necrosis and degenerate articular cartilage. When compared to the controls, there was a reduction in subchondral bone density in affected dogs.

Discussion/Conclusions

Although qualitative at this stage, the findings from this study highlight the potential divergence between cartilage lesion score, MRI findings and histopathology. Objective quantitative assessment of subchondral bone quality and quantity may be needed to more completely describe the extent and severity of MCD disease in dogs.

Effect of intramedullary rod diameter on the bending behavior of sop-rod constructs

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Introduction

While conventional plate-rod constructs (PRC) are often used to spare a plate from deleterious bending stresses, the effect of an IMR on PRCs using locking plates (e.g. String of Pearls – SOP), is unknown. Our objective was to evaluate the effect of IMR diameter on bending compliance (BC) and angular deformation (AD) of SOP-rod constructs. We hypothesized BC and AD would decrease with increasing IMR diameter.

Materials and Methods

SOP groups with an IMR 24%, 32%, or 40% the medullary cavity (MC) diameter were compared to an SOP with bicortical fixation and conventional PRC. Specimens were tested in mediolateral bending; BC and AD were statistically compared ($p < 0.05$).

Results

Construct BC and AD decreased with increasing IMR diameter ($p < 0.001$). The SOP-24 and bicortical SOP control were statistically similar. The SOP-32 was statistically similar to the conventional PRC control. The SOP-40 was the least compliant construct ($p < 0.001$). AD followed an identical pattern of significance.

Discussion/Conclusion

Biological osteosynthesis relies on more compliant constructs to promote beneficial micromotion at the fracture site. This study suggests an SOP plate and thinner IMR, 32% the MC diameter, is comparable to a conventional PRC. Should a more compliant construct be desired (e.g. immature patients), a yet thinner IMR with a locking SOP is as compliant, and as stable as an accepted bridging construct with bicortical screws only. Previous studies have shown the SOP to be less compliant than conventional plates. Therefore, SOP constructs augmented with an IMR 40% the MC diameter may be unnecessary.

Small animals – Orthopaedic

**In depth – Osteotomies for elbow
incongruencies**

Saturday July 6

08.30 – 12.00

Current understanding of medial compartment disease of the canine elbow

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Introduction

Medial compartment disease is a complex and challenging condition which remains incompletely understood despite extensive bench top and clinical research over the past few decades. The condition was originally described as fragmented coronoid process (FCP), and it was proposed that surgical retrieval of osteochondral fragments would carry a good prognosis. However, longer term clinical studies have shown that outcomes were often suboptimal and osteoarthritis frequently appeared to progress irrespective of treatment. FCP was initially thought to be a form of osteochondrosis, but this has not been supported by histological studies. The improved visualization of the joint with arthroscopy has allowed the condition to be better defined, and it is now clear that a spectrum of changes can be seen affecting the entire medial compartment of the elbow rather than just the medial coronoid process (MCP). This has led to the condition being redefined as 'medial coronoid process disease' or 'medial compartment disease' (MCD).

Arthroscopic observations

The changes affecting the elbow include various patterns of fissuring and fragmentation of the MCP, cartilage lesions of variable severity affecting the medial aspect of the humeral condyle and the distal extent of the trochlear notch, and occasionally linear erosion of subchondral bone. True osteochondrosis of the medial humeral condyle can occasionally be seen, either alone or more frequently in combination with other lesions affecting the medial aspect of the elbow joint, but this is much less common. Osteochondrosis appears to be histologically and genetically distinct from MCD and can be classified as a separate condition.

Different patterns of MCP fissuring and fragmentation have been observed, and it has been suggested that these can be categorized into tip fragmentation and radial incisure fragmentation. Whilst this discrete categorization is appealing, our own observations have been suggestive of a more continuous spectrum of fissuring and fragmentation affecting the radial incisure and cranial aspect of the MCP. Fragmentation is not seen in every case; indeed we have

observed non-displaced fissures more commonly than discrete fragmentation.

A range of cartilage lesions has been described affecting the medial aspect of the humeral condyle and the distal extent of the trochlear notch, either with or without concurrent bony MCP fragmentation. The cartilage lesions often appear to be linear in nature, running circumferentially around the joint, suggestive of mechanical overload of the medial compartment of the elbow. Severity ranges from mild chondromalacia through to full thickness cartilage loss which can be accompanied by linear erosion of the subchondral bone. Extensive full thickness cartilage loss appears to be more common in older patients, suggesting progressive erosion of cartilage and even medial compartment collapse can occur in clinical cases.

Aetiology

It is clear from several studies that MCD is overwhelmingly more common in certain breeds of dog, strongly suggesting a genetic component to the condition. The precise genetic basis has not been defined, but it is thought that MCD is a complex polygenetic trait with estimates of heritability ranging from 0.1 to 0.7. MCD appears to be inherited independently from other manifestations of elbow dysplasia such as un-united anconeal process and osteochondrosis. In addition the genetic mechanism may be different in different breeds. In most studies, MCD has been reported to be more common in male dogs. Environmental factors such as high energy diets, rapid growth rates and joint trauma during exercise may also play a role in the development of pathological lesions in the elbows and subsequent osteoarthritis.

Diagnosis

Confirmation of the presence of MCD based on radiographs is challenging and historically diagnosis has been based on observation of secondary degenerative changes in susceptible dogs. However the severity of osteophytosis correlates relatively poorly with arthroscopic findings. Recently subcoronoid sclerosis has been shown to be strongly associated with MCD; identification of this feature allows more accurate radiographic diagnosis of MCD. CT has been used extensively to investigate the

elbow joint both experimentally and clinically. CT allows detailed assessment of the coronoid process and can also be used to assess joint congruency and subchondral bone architecture. Arthroscopy allows excellent assessment of intra-articular lesions, and is complementary to CT. The use of other non-invasive modalities such as MRI, ultrasound and scintigraphy has also been described, but their use is less widespread.

Pathogenesis

The pathogenesis of MCD has been the focus of extensive research but remains poorly characterized. Histological studies have consistently demonstrated subchondral microfractures and other changes consistent with fatigue fracture of the MCP. These microfractures appear to affect the entire MCP rather than just displaced fragments. The arthroscopic and histological changes can all be explained by mechanical overload of the medial compartment of the joint, possibly secondary to joint incongruency. Using conventional CT, we have noted increased subchondral bone density affecting both the MCP and the adjacent humeral condyle, suggestive of chronically increased mechanical loading of these regions. Based on pathological studies, two forms of incongruency were initially proposed. Firstly, it was suggested that a radioulnar step secondary to longitudinal undergrowth of the radius with respect to the ulna could lead to increased load on the MCP. An alternative suggestion was the possibility of a radius of curvature mismatch between the humeral condyle and the trochlear notch, leading to humeroulnar incongruency; however it has been observed that this form of incongruency can be seen in normal elbows. Nonetheless, at least theoretically either of these proposed mechanisms could lead to increased loading of the medial compartment of the joint and subsequently to fatigue fracture of the MCP and cartilage erosions.

Diagnosis and more detailed assessment of incongruency can be challenging. Radiography can be employed to determine the presence of incongruency, but is relatively insensitive and does not allow characterization of incongruency in detail. CT allows much more accurate assessment of the bony anatomy of the elbow and has been used to investigate incongruency in a series of studies. Standard transverse sections, reconstructed images and 3D volume rendered models have all been employed. These studies have shown that the nature of incongruency is far more complex than initially proposed. Radioulnar steps, humeroulnar radius of curvature mismatch, cranial humeral subluxation and radioulnar incisure incongruency have all been described. In addition, it appears that in many cases the detailed surface contours of different areas of the elbow are grossly abnormal, possibly as a result of joint surfaces developing in the presence of abnormal transarticular forces. This implies that it may be impossible to restore perfectly normal congruency in affected dogs.

Arthroscopy has also been used to assess incongruency. Despite being inherently invasive, arthroscopy has the obvious advantages that detailed assessment of cartilage lesions can be performed and additional information can be collected that may not have been apparent on radiography or CT. Focal treatment of intra-articular lesions can also be performed. With regards to incongruency, arthroscopy has been shown to be highly accurate in measuring incongruency in experimental models, but its use to characterize the more complex incongruency seen in clinical cases is less well reported.

A strong association between MCD and the presence of incongruency has been identified in several studies. However measurable static incongruency is not been identified in every case at the time of diagnosis. Coupled with pathological and arthroscopic observations of variable patterns of intra-articular lesions, this observation has led to various dynamic forms of incongruency being proposed. It has been shown that the MCP is loaded axially by compression from the humeral condyle, but also lateromedially along its craniolateral articulation with the radial head. This lateromedial compression could be caused by pronation of the radial head during weight bearing, or could be due to supination of the ulna secondary to the pull of the biceps brachii muscle which inserts in part on the medial aspect of the proximal ulna. Crushing of the MCP between the medial humeral condyle and the radial head has also been suggested. If lateromedial loading on the MCP were excessive, fissuring and fragmentation in the region of the radial incisure could result. Alternatively, other forms of dynamic incongruency at certain phases of the gait cycle could lead to increased transarticular pressure across the medial joint compartment. This could subsequently lead to subchondral microfractures and cartilage erosions, even in the absence of measurable incongruency.

Implications for treatment

It is clear from pathological, arthroscopic and CT studies that a range of patterns of MCP pathology, cartilage erosion and incongruency can be encountered in clinical cases. Given this spectrum of disease, more accurate staging of cases using a range of modalities would seem logical as dogs with different forms of MCD may respond differently to treatment. Indeed, entirely different treatments may be indicated for different cases. Ideally treatment should be aimed at management of intra-articular lesions, addressing any underlying causes, and preventing ongoing progression of disease. However it should be borne in mind that our understanding of how different dogs can be allocated to different treatment groups is incomplete, and we should be wary of over-complicating the decision making process in the absence of robust outcome data.

It has been shown that although focal intra-articular treatments alone can be effective, they are not appropriate

for every case and indeed in some cases may be no better than conservative management. In older dogs, progressive cartilage loss, subchondral bone erosion and collapse of the medial joint compartment appear to be relatively common; this progression of disease is likely to be secondary to ongoing mechanical overload. Given the complex and possibly dynamic nature of any incongruity, it seems unlikely that any osteotomy can restore perfect congruency in every case. However, it may be possible to perform osteotomies or other techniques such as bicipital tenotomy to shift loading away from diseased portions of the joint. These procedures could be performed as salvage operations in older dogs once cartilage erosions have occurred, or could be performed in younger patients in an attempt to reduce ongoing cartilage loss. Alternatively, in the future it may be shown that cartilage loss, osteoarthritis and associated clinical signs progress irrespective of these interventions, and partial or total joint replacement may represent a more satisfactory therapeutic avenue.

Given our incomplete understanding of MCD, it is clear that extensive further research is needed into pathogenesis, development of treatment possibilities and especially into clinical outcomes. Although many procedures may be theoretically appealing, any clinical benefits must be defined in controlled clinical studies and should be balanced against morbidity and potential complications.

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Traditional proximal ulnar osteotomy

U. Krotscheck

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This presentation will focus on a prospective study evaluating the long-term effects of surgical intervention for FCP, both with and without ulnar ostectomy with IM pin. Gait analysis, CT osteoabsorptiometry and CT-aided joint space width determination were evaluated prospectively over 12 months in a population of dogs with fragmented coronoid processes. All dogs received arthroscopic debridement and were randomized to treatment groups (ostectomy or not). Outerbridge scoring was used to record the severity of cartilage pathology. CT scans were performed pre-operatively and 6 months post operatively, force plate gait analysis was performed at regular intervals for a 12 month period. Data collected was compared to a normal control group and correlations were determined for lameness scores, Outerbridge scores, radiographic and CT osteoarthritis scores and gait analysis.

Dynamic Proximal Ulnar Osteotomy [DPUO]

M. Olivieri

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Introduction

Medial Compartment Disease (MCD) is a pathology which is part of elbow dysplasia, sometimes isolated, sometimes associated to other conditions (FCP, OCD).

In a preliminary study (1) the author showed that in dogs affected by MCD, simulating weightbearing under arthroscopic vision, the erosion of the medial humeral condyle and of the underlying ulna interfere during joint flexion and extension. The author described this condition as a humero-ulnar conflict (1) and hypothesized that performing a Dynamic Proximal Ulnar Osteotomy (DPUO) the two articular surfaces would have found a proper congruence, allowing the erosions to be repaired by fibrocartilage.

This study presents the author's experience about 94 dogs with MCD treated with DPUO. In the first 18 cases a second-look arthroscopy was carried out 2.5 months after the osteotomy.

Materials and Methods

The elbow arthroscopies performed between January 2001 and January 2009 were reviewed and all the cases with MCD were selected. The criterion for inclusion in this study was treatment of MCD only by means of DPUO. If there were FCP or OCD fragments, these were removed. The criterion for exclusion were sclerosis of the subchondral bone, cartilage lesion of the lateral compartment and the presence of other orthopedic conditions.

In all the dogs a Robert Jones bandage was applied for the first 4 to 7 days, until bone dynamization was obtained; soon after a splint was implemented until consolidation of the osteotomy was reached. At the beginning of the study some cases had a second look arthroscopy after 2.5 months following initial surgery.

After osteotomy consolidation, clinical follow ups were performed at 1, 2 and 12 months.

Results

94 cases were selected. Arthroscopic inspection showed erosion of the medial articular surfaces in all patients. The localization and extension of the erosion differed in some cases, suggesting that the forces generating erosion may have different force vectors. With flexion and extension of the joint, simulating weightbearing (1), it was always demonstrated that the pathologic joint cartilages of the medial humeral condyle and of the underlying ulna interfere during normal joint movements, creating a "conflict area" (humero-ulnar conflict).

Consolidation of the osteotomy was obtained in a range of time between 30 and 120 days.

18 dogs did a second look arthroscopy; in 16 cases good fibrocartilage regeneration was present where the subchondral bone was originally exposed. In 2 cases the resurfacing was associated to fibrillation.

Clinical follow ups showed normal function and pain free in 86 out of 94 dogs at 30, 60 and 365 days after consolidation of the osteotomy while 8 cases remained lame. 2 out of these 8 cases were the ones with fibrillation at the second look. A third look arthroscopy was done in these 2 dogs during the follow up 365 days later. In some areas of the medial compartment the fibrocartilage had disappeared or was irregular.

The same clinical results obtained after 2 months were confirmed in all the dogs of this study after 1 year.

Discussion

In this study 94 dogs with MCD were treated by means of DPUO. The author believes that the ulnar osteotomy solves the problem of conflict, optimizing the joint of the medial humeral condyle with the corresponding ulnar one. Two important data support this hypothesis: the first is represented by the fibrocartilage regeneration in 16 out of the 18 dogs with a second look, the second by the clinical outcome.

The great advantage of this technique is to allow the best possible joint congruity in many directions. In fact, the cartilage erosions are not always in the same position. This would confirm that the lines of force that generate the disease are not always the same. At the same time MCD can be isolated or associated to other lines of force generating FCP and/or OCD. So maybe a non "dynamic" correction doesn't correct the malarticulation of the medial compartment in a complete way. Further investigations are needed to fully clarify this important point.

Regarding the 8 lame cases it is important to observe that they all had consolidation of the osteotomy before 60 days and were hyperactive. The author hypothesizes that this could lead to the destruction of most of the regenerated and initially delicate fibrocartilage.

References

1. Olivieri M. et al : "Preliminary results of arthroscopic diagnosis and treatment of elbow humero-ulnar conflict (cartilage erosion) through proximal ulnar osteotomy". ESVOT Munich 2006

Proximal abducting ulnar osteotomy (paul)

A. Vezzoni

Clinica Veterinaria Vezzoni srl, Cremona, Italy

Elbow dysplasia is a major cause of front limb lameness in medium to large dog breeds. In the majority of cases, it starts in, or is limited to, the medial compartment, with fragmentation of the medial coronoid process (FCP) and/or osteochondritis dissecans of the medial humeral condyle (OCD), usually associated with different degrees of joint incongruity.

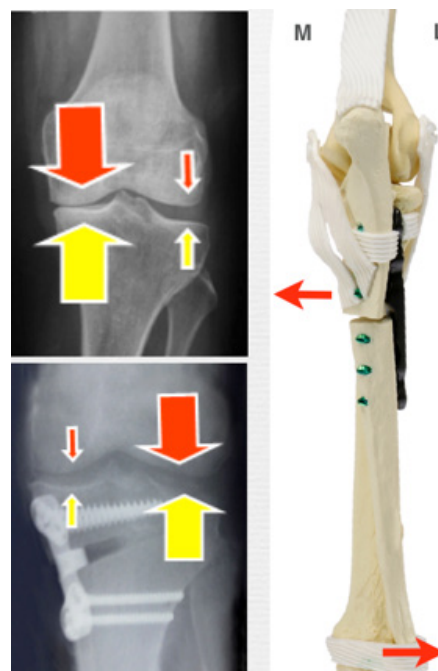
Conventional surgical treatment with joint debridement and removal of loose osteo-cartilaginous bodies is not rewarding if joint incongruity persists; the result is overloading and subchondral bone exposure with erosion of the cartilage of the medial humeral condyle and medial coronoid area of the ulna. Medial collapse of the joint attributable to friction and resultant loss of the osteocartilaginous layer is intensified leading to a vicious circle. Consequently, the paw moves medially during weight bearing, which increases the load on the medial compartment. Friction from bone-on-bone contact produces heat and necrotic debris, exacerbating the biochemical cascade in osteoarthritis (OA).

Rationale for PAUL osteotomy

A number of different osteotomies have been proposed and implemented for the treatment of medial compartment syndrome, mostly based on the assessment of incongruities within the joint, or more recently, on the forces exerted by the muscles proximal to the joint. Consideration of the overall loading of the limb offers another viewpoint and may identify the actual cause of the condition and thus generate a more rational treatment approach.

As a rule, when a dog is walking, the paws should be under the shoulders, but the ground reaction vector runs medial to the elbow in the frontal plane. In medial compartment syndrome with collapse of the medial joint space, a larger medial offset will generate a larger moment in the frontal plane. The unavoidable consequence of this is further compression of the medial compartment and tension in the lateral collateral ligament. Muscle forces play a minor role in this balance once the paw hits the ground. Consideration of elbow incongruity alone, which is typically described as a short or long ulna compared with the radius, may lead to inappropriate intervention because the end result is a medial shift. Ingo Pfeil and Slobodan Tepic in 2010 suggested proximal osteotomy of the ulna fixed by a special plate as well as shifting, abducting and incidentally

rotating the ulna, which would lead to lateralization of the paw and thus to unloading of the medial compartment. The biomechanics of proximal abducting ulnar osteotomy (PAUL) are similar to high tibial osteotomy for treatment of varus deformity of the knee and medial compartment syndrome in humans as an alternative to unicompartmental knee joint replacement, which may be carried out later on in cases with progressive OA. The procedure in people consists of medial open wedge osteotomy of the tibial plateau and elevation of the tibial plateau medially to allow the distal limb to move laterally. This loads the lateral knee compartment and unloads the medial compartment. The PAUL plate is a straight plate with a step of 2 to 3 mm and is applied to the lateral surface of the proximal ulna. This raises the ulna on the medial humeral condyle and results in a lateral shift of the distal limb with increased load on the lateral compartment and decreased load on the medial compartment. The amount of achieved abduction is about 4° with the 2mm step plate and 6° with the 3mm plate, plus 4° to 5° attributable to the natural curvature of the ulna, which is straightened by the plate. The final lateral shift is about 8° with the 2mm step plate and 11° with the 3mm step plate.



Case Selection for PAUL

Dogs aged 9 months to 9 years with medial compartment syndrome, which was confirmed by arthroscopy, and a lack of response to conservative management were included. Arthroscopic confirmation was done immediately before PAUL surgery or at a previous operation when conventional joint debridement was carried out. PAUL was offered to dog owners as a palliative treatment. In younger dogs, dynamic ulnar osteotomy was carried out distally in dogs up to 6 months of age and proximally in dogs that were 7 to 8 months of age. Dogs were excluded from the study when arthroscopy showed fragmented coronoid process without medial compartment syndrome or there was ununited anconeal process or narrowing of the lateral compartment in addition to advanced terminal OA.

Surgical planning

The cranio-caudal radiographic view was used to evaluate the mechanical medial elbow angle (mMEA), which has a normal range of $81.5 \pm 2.5^\circ$. In cases with an $mMEA \leq 80^\circ$, a 3 mm step PAUL plate was used, and in cases with an $mMEA > 80^\circ$, a 2 mm step PAUL plate was used.

The degree of adduction of the paw was assessed using still frames from video recordings taken while the dog was walking toward the camera. The goal of the operation was to create a 4° to 5° lateral abduction of the paw. In older dogs with severe OA, a 2 mm step plate was used because stiffening of the interosseus ligament was expected. Advanced Locking Plate System (ALPS) PAUL plates are available in 4 different sizes: #8 for small dogs, #9 for medium dogs, #10 for large dogs and #11 for giant dogs.

Surgical technique

A caudolateral approach to the ulna was used to expose the lateral side of the ulna, where the plate was to be fixed. The medial side was exposed for a distance of only 1-2 cm in the location for the osteotomy; preservation of muscle attachments and periosteum was of paramount importance to promote bone healing. The ulnar osteotomy line was marked and measured 4 cm from the radial head, which was easily palpated. Before the osteotomy, the plate was placed on the ulna to ensure that there was adequate space for its fixation. Ulnar osteotomy was carried out perpendicular to the bone with a straight thin saw blade, from lateral to medial, after protecting the medial muscles with wet sponges and the radius cranially with a thin periosteal elevator. After temporary fixation of the PAUL plate with reduction forceps and ensuring that the plate was centred with its step distal to the osteotomy, it was fixed with temporary compression screws then replaced by definitive locking screws according to the plate manufacturer's recommendations. Before final fixation, the proximal ulnar segment was shifted 1-2 mm caudally to eliminate contact with the tip of the diseased coronoid process. The gap created by the osteotomy was filled

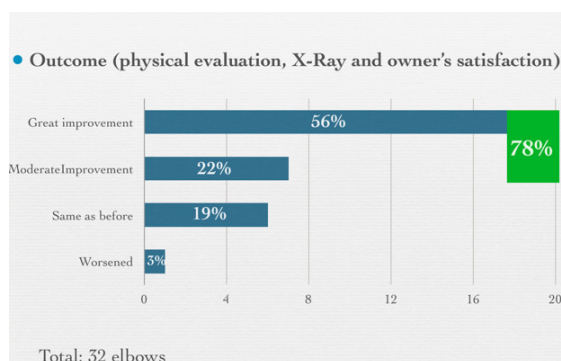
with osteoconductive/osteoinductive material to promote bone healing. The surgery was completed by suturing the antebrachial fascia, the subcutis and the skin. A soft padded bandage was applied for 2-3 day to help prevent seroma formation.



Outcome

In this preliminary study, PAUL was carried out in 32 elbows of 29 dogs (3 dogs had bilateral operations in two different times). The dogs ranged in age from 9 months to 9 years and weighed 26 kg to 48 kg. Of the 29 dogs, 53% were ≤ 2 years old, 18% were 3 to 5 years old, another 18% were 6 to 8 years old and 1% were 9 years old. Breeds included Labrador retriever (18), golden retriever (5), German Shepherd dogs (5), Rottweiler (2), Bernese mountain dog (1) and Staffordshire terrier (1). A 2 mm step was used in 54% of the cases and a 3 mm step in the remaining 46%. Follow-up physical and radiographic evaluations were carried out in all dogs 2 months after surgery. Sixty-four percent underwent a follow-up examination 6 months after surgery and 52% one or more years postoperatively. Bone healing of the osteotomy was complete from 3 to 4 months after surgery, except two cases requiring 6 months. All the owners were contacted by phone by an independent interviewer for a final evaluation of the outcome a minimum of 6 months postoperatively. The outcome based on the owner interview was classified as:

- **Great improvement:** When the owner stated that the dog was more active without tiring and no longer required an NSAID.
- **Moderate improvement:** When the owner stated that the dog was more active, but required intermittent medication with an NSAID, but considerably less often than before surgery.
- **No improvement:** When the owner stated that there was no observable improvement in the dog's activity level and the dose and frequency of NSAID administration had not changed compared with before surgery.
- **Worse:** When the owner stated that the dog showed worsening of the clinical signs and required a more frequent dose of an NSAID.



The table shows that the majority of the dogs (78%) improved (great or moderate improvement) postoperatively, while 19% did not improve and one case deteriorated (8-year-old Labrador retriever with very severe OA and plate breakage two months after surgery).

Complications

Nine (28%) cases had minor complications that did not require surgical revision: one case had broken screws, three cases had delayed union (more than four months required for union) and five cases had seroma formation. Complications requiring surgical revision occurred in four (12.5%) dogs and included two broken plates (the prototype plate was weaker than the final PAUL plate), which were replaced with new plates, and in two dogs, the plate was removed after bone healing. After the introduction of the new PAUL plate, no plate loosening or breakage was observed. The complications, even those requiring surgical revision, did not result in severe morbidity, and only mild lameness was observed, even after a plate broke.

Discussion

Although operated dogs had advanced OA, improvement was seen in 78%, which is encouraging for a preliminary study of PAUL. The dogs in this study had been unresponsive to conventional treatment via arthroscopy or to conservative management before PAUL. Therefore, the improvement seen after the procedure can be attributed to a shifting of weight bearing laterally after abduction of the lower limb via ulnar osteotomy. In dogs with chronic OA of the elbow, client satisfaction after PAUL is considered to be a meaningful parameter because radiography cannot show changes indicative of improvement, whereas behaviour of the dog can. This procedure is a palliative treatment with improvement expected in approximately two thirds of cases. Owners should be informed that OA and degenerative joint disease are not affected by PAUL, although the procedure may limit their progression. The risk of complications after PAUL in terms of severity and frequency of surgical revision was small. The surgical technique was straightforward, quick and with quite limited post-operative morbidity. A limitation of this study is the lack of a second arthroscopy look to evaluate the joint surface. However, Pfeil observed the formation of fibrocartilage in the medial compartment one month after PAUL in a Rottweiler and 7 months after PAUL in a Bernese Mountain Dog, where full erosion was present before surgery. The follow-up period in the present study was only two years. Therefore, further longer term evaluations are needed to determine whether lateral compartment overload attributable to abduction of the lower limb has detrimental effects. Similar to the situation in human medicine in relation to varus knee corrective osteotomy, PAUL does not stand in the way of total elbow replacement should this become necessary.

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Sliding Humeral Osteotomy SHO

M. Hamilton

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Introduction

Elbow dysplasia is an important cause of thoracic limb lameness in dogs. Most frequent pathological changes are associated with the medial aspect of the coronoid process of the ulna and medial aspect of the humeral condyle. Cartilage erosion in the region defined by the medial aspect of the coronoid process and medial aspect of the humeral condyle has been referred to as medial compartment disease (MCD).

In light of the typically unicompartamental nature of elbow dysplasia, force redistribution within a joint from an area with profound cartilage and subchondral pathology to a more normal area may have benefit in the treatment of dogs with elbow dysplasia. Sliding humeral osteotomy (SHO) involves a mid-diaphyseal humeral osteotomy and stabilization with a custom, locking, stepped plate to the medial aspect of the humerus, medially translating the distal segment relative to the proximal segment. Our purpose is to document ongoing clinical experiences and outcomes with the SHO procedure and report on various modifications of technique from our previous case series^{1,2}. Mid-term complication rate and clinical outcomes were compared with or without focal treatment (FT) of the coronoid process.

Materials and Methods

Medical records of dogs that underwent SHO between February 2009 and October 2011 were evaluated. Signalment, lameness, pain score and preoperative radiographic findings were recorded and modified Outerbridge score and fissure/fragmentation were recorded arthroscopically. SHO was performed with technical modifications and outcome measures included lameness score, elbow pain score, owner function assessment and force-plate preoperatively, at 6 and 12 weeks and 6-25 months. Major complications were defined as those that needed subsequent surgical intervention including major infections, whereas minor complications implied no further surgical treatment.

Statistical analysis

Lameness and pain upon elbow manipulation were stated as categorical dependent variables. Lameness, pain, ASI, age and owner VAS scores were compared

using a Mann-Whitney test between the groups with and without coronoid FT. Weight was compared between the treatment groups by a one-way ANOVA. Owner-assessed VAS function scores were compared using a Mann-Whitney Test. Statistical analysis was performed for the unilateral cases and the first elbow operated in cases treated bilaterally. Force plate data was statistically analyzed comparing preoperative values of the percentage of body weight between affected and non-affected limbs using a t-test. A non-parametric related-samples Wilcoxon test was used to compare the difference between symmetry indexes from before and after the surgery.

Surgical technique

Dogs were positioned in dorsal recumbency and the limb prepared for surgery in a freely moveable position. In the cases operated earlier in this series, focal coronoid treatment by fragment removal and subtotal coronoid ostectomy was performed and in the later cases in this series, no focal treatment was performed. All plates and screws were manufactured by New Generation Devices (Glen Rock, NJ, USA). A medial approach was made to the diaphysis of the humerus and the soft tissues retracted using four Hohmann retractors. Plate step size (7.5mm or 10mm) was selected depending on the width of the humerus measured on the cranio-caudal radiographic projection. A minimum bone overlap of 1/3 was deemed a prerequisite. The operative technique steps were identical in every case and no bone grafting was performed for any case. Particular emphasis was placed on centering the distal screw in the proximal segment (hole number 4) over the cranial to caudal center of the mid-humeral diaphysis and to ensuring that the plate did not drift off the cranial edge of the proximal humerus or the caudal edge of the distal humerus. The major modification of technique was that at the completion of the procedure, 4.0mm locking screws were present in every screw hole. Plate movement was prevented during screw insertion by leaving multiple drill bits in situ within their corresponding locking drill guides to act as multiple fixation points as the screws were placed.

Results

60 limbs were operated by SHO; 22 also had FT of the medial coronoid process. Age was 44.17±33.0 months, body

weight 17.4-49.8 Kg. Preoperative duration of lameness was 2.16 ± 0.69 months. All dogs included in this study had full-thickness (modified Outerbridge grade IV or V) cartilage erosion of the medial compartment. Lameness improved for all limbs by 12 weeks, resolving in 49/60. Significant improvements in postoperative pain scores and most owner function assessments occurred. There was no significant difference with or without FT. Complication rate was 0.00% major and 4.17% minor complications. Force-plate data was available for 18 of 46 dogs operated unilaterally preoperatively and at last follow-up. There was significant improvement in ground reaction force and reduction of asymmetry index (t-test; $P < 0.05$).

Discussion

Our results support our hypothesis regarding amelioration of pain and lameness in both juvenile and mature dogs after SHO, with or without focal treatment of the diseased medial aspect of the coronoid process. Further investigation is necessary to determine effect on long-term disease progression and to confirm recommended case selection criteria. SHO is a valid treatment for MCD and warrants consideration in cases affected by intractable pain of the medial compartment of the elbow. Demonstration of de novo fibrocartilage generation on the medial aspect of the humeral condyle via histopathology without application of exogenous factors acts as proof of principle regarding medial compartment unloading and supports clinical use of this technique.

Conclusions

SHO with or without focal treatment of the medial aspect of the coronoid process ameliorates lameness and pain associated with MCD at medium-term follow-up. Application technique is critical to minimize morbidity with reduced complication rates noted as compared to a previous case series with the modifications in technique.

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Effects of humeral rotational osteotomy on contact mechanism of the canine elbow joint. An ex vivo study.

A. Gutbrod, T. Guerrero

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Introduction

Elbow joint disease is a common cause of front limb lameness in the dog, with usually the medial part of this joint being affected. Although this syndrome is well known, the outcome, especially long term, is unsatisfactory since patients develop osteoarthritis regardless of treatment. In an attempt to improve outcome, new options of treatment aiming to relieve pressure in the medial part of this joint have recently been published. It has been suggested that, an external rotational osteotomy of the distal humerus would result in lateral translation of the paw, and this translation would cause a lateral shift of the weight-bearing axis and a lateral shift of the transarticular forces in the elbow joint. The purpose of this ex-vivo study was to investigate the effects of the humeral rotational osteotomy on the forces acting in the canine elbow joint. Our hypothesis was that external humeral rotation of 15° would shift the peak pressure location and the center of pressure towards lateral.

Materials and Methods

Eight forelimbs of 5 adult dogs were harvested by forequarter amputation. Computer tomography was performed to ensure that the elbows were free of orthopedic disease and to plan for the rotation. An approach by osteotomy of the lateral humeral epicondyle was performed. The epicondyle was reflected distally, and a second osteotomy (used later on to position a pressure sensor into it) was performed parallel to the articular surface of the radius and ulna, proximal to the insertion of the lateral collateral ligament in the radius, including the ventral part of the articular surface of the ulnar notch, and the entire radial head. The semilunar notch and the anconeal process were mobilized by a third subchondral osteotomy perpendicular to the second osteotomy. This osteotomy allowed the articular part of the separated ulna and radial head to slide proximo-distally and load the sensor placed in the horizontal osteotomy site. A digital pressure sensor (Pliance® - S2070 Germany) was positioned into the subchondral osteotomy site at the radial head and proximal ulna. The leg was mounted in the testing apparatus and measurements were taken in the

following sequence: (1) neutral, and (2) after 15° of external rotation. To rotate the distal humerus a mid-diaphyseal humerus osteotomy was performed and stabilized with a locking plate.

For each condition contact area, peak and mean contact pressure, location of peak pressure, center of pressure, and total force were acquired. The localization of the peak pressure and center of pressure were expressed as a relation to the entire area of the loaded sensor.

CT images were reconstructed at the level of the subchondral osteotomy in the radius and ulna and true to scale images of the force map were superimposed. Based on these overlay images the pressure was calculated for the subchondral compartment of the radius and the ulna.

Contact mechanics data was analyzed using paired T-tests. For all statistical analyses performed, $p \leq 0.05$ was considered statistically significant.

Results The study was performed in 8 elbows of 5 dogs with a mean $\pm$ SD body weight of $33.6 \text{ kg} \pm 3.8$. After 15° of external rotation the peak pressure location was found $37.56 \pm 15.9\%$ ($p < 0.001$) further lateral. The mean $\pm$ SD shift of the center of pressure towards lateral was of $21.5 \pm 6.8\%$ ($p < 0.001$). Both differences were statistically significant. Pressure measured in the ulnar part of the osteotomy was reduced from $58.7 \pm 9.1\%$ to 27.1% after ERHO ($p < 0.001$). No statistically significant differences were found between conditions for the contact area ($p=0.086$), peak contact pressure ($p=0.229$), mean pressure ($p=0.078$), and total force ($p=0.584$).

Discussion

According to our results, an external rotation of the distal humerus contributes to shift the pressure from the damaged medial compartment of the joint towards lateral reducing the pressure acting on the ulna. This lateral shift may be beneficial in dogs with medial compartment disease. Being an ex vivo study, performed in a few specimens, and under a single load condition, care must be taken before extrapolating this results onto a population of affected patients. Further studies are needed to evaluate clinical effects.

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Small animals – Orthopaedic

In depth – Elbow replacements

Saturday July 6

15.30 – 17.00

Development of TATE and clinical cases

L. Déjardin

Michigan State University, East Lansing, USA

The Canine Unicompartmental Elbow (CUE) arthroplasty system

J. L. Cook¹, K. S. Schulz², P. Böttcher^{*3}

¹Comparative Orthopaedic Laboratory, University of Missouri, Columbia, Missouri, USA, ²Peak Veterinary Referral Center, Williston, Vermont, USA, ³Department of Small Animal Medicine, University of Leipzig, Leipzig, Germany

Medial compartment disease (MCD) of the elbow is the typical end-stage situation of many elbow disorders, such as fragmented medial coronoid process (FCP). But it might also be a primary disease, inducing accelerated medial joint arthritis, probably as a consequent of elbow mechanical axis deviation. Predominant characteristics of MCD are loss of cartilage at the medial coronoid process and the opposing humeral trochlea resulting into bone-on-bone contact, together with collapse of the medial joint compartment. At arthroscopy the situation is red and white, with a clearly visible sagittal demarcation line from no cartilage at the medial compartment to visible normal cartilage at the lateral joint compartment (see fig. 1).

The Canine Unicompartmental Elbow (CUE) Arthroplasty System (Athrex Vet Systems, Naples, Fla.) is thought as an alternative to other treatment modalities dealing with severe degenerative joint disease, such as total elbow replacement or osteotomies of the humerus or the ulna. Designed as a resurfacing procedure with the aim to eliminate bone-on-bone contact at the medial joint compartment, the principle is similar to unicompartmental knee arthroplasty in humans (see fig. 2). The technique consists of the completion of an open arthrotomy of the elbow, most typically via osteotomy of the medial epicondyle (alternatively by tenotomy) (see fig. 3). Fragments at the medial coronoid process are removed and a high molecular weight polyethylene domed cylinder of 4-6 mm in diameter is implanted in the centre of the eburnated coronoid. The corresponding lesion at the humeral trochlea is resurfaced with a double-cylinder metallic implant. The technique of implantation is similar to osteochondral transplantation, in which the transplants are press-fitted into place. While the implantation is straight forward, osteotomy of the medial epicondyle with reflection of the flexor muscles and the medial collateral ligament has turned out to be the most challenging part of the procedure. Complications associated with the operative technique are mostly related to the osteotomy rather than to the implantation, but it is the preferred approach, as carpal hyperflexion was relatively common with the tenotomy.

Today 78 cases have completed all assessments at > 6 months after surgery. Intraoperative complications occurred in 4 cases (5%): malpositioning of the humeral implant and over-reaming of the ulnar implant as well as twice anconeal fracture. Short to mid-term complications occurred in 30 cases (38%): Catastrophic = 1 (1%): one patient was euthanatized at the client's request for nonspecified reasons associated with continued lameness Major = 9 (12%), e.g. infection of the fiberwire tenotomy repair or ulnar implant loosening with concomitant lameness. Minor = 20 (26%) e.g. cases of mild carpal hyperextension and/or lameness which resolved by 6 months postop (cases in which tenotomy was used instead of osteotomy), epicondyle displacement or fracture of epicondyle, which were not associated with outcome. No implant problems have been noted on radiographic evaluations through 1 year after surgery. In terms of level of function at > 6 months after surgery as assessed by the attending clinician and the client, 65 (83%) of these cases have been judged a success (full (34) or acceptable (31) level of function). Lameness grade improved significantly ($p < 0.01$). It is important to note, that full function does not necessarily mean without any detectable lameness. Full function is defined as a dog returning to its previous level of function without the need of pain medication, e.g. a hunting dog which can go hunting again. Second-look arthroscopies done 3 to 7 months postoperatively showed stable implants with new fibrocartilage tissue formation adjacent to both implants and no evidence of inappropriate wear. Lateral compartment cartilage surfaces were unchanged compared to preop assessments with no evidence for abnormal wear or visible lesions.

Based on the initial results of the CUE Multicenter Clinical Trial, this procedure appears to be safe for treatment of medial compartment disease in the canine elbow and warrants continued clinical evaluation.

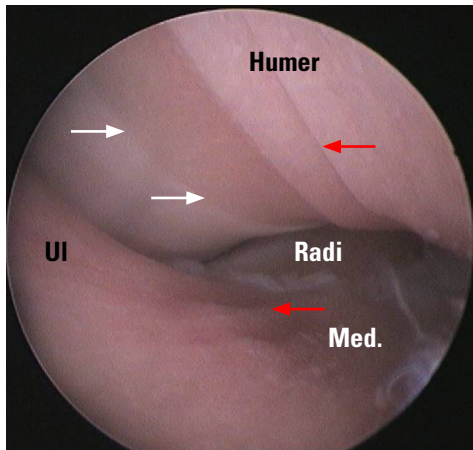


Figure 1: Typical appearance of an end-stage elbow with extensive medial compartment disease (MCD). Note the demarcation line from no cartilage at the medial aspect to normal locking cartilage at the lateral joint compartment (white arrows). Sagittal ridges within the subchondral bone medially illustrate the significant mechanical humero-ulnar conflict of MCD (red arrows).

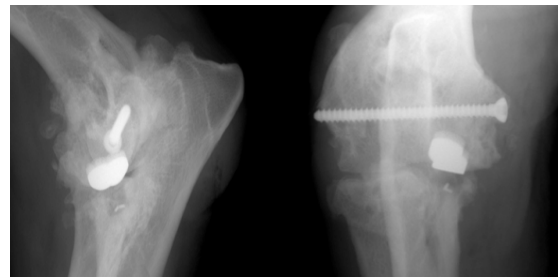
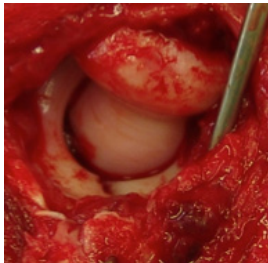


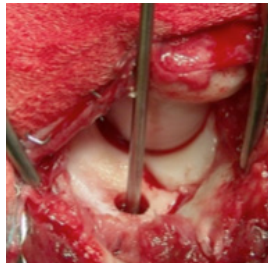
Figure 2: Typical post-op appearance of CUA arthroplasty, resurfacing the medial joint compartment. Note the metallic wire at the base of the ulnar implant, indicating proper positioning. The osteotomy of the medial epicondyle has been fixed with a screw.

Implant

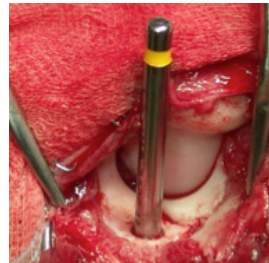
Medial arthrotomy with osteotomy of the medial epicondyle



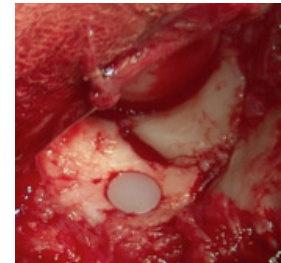
Drilling for the ulnar



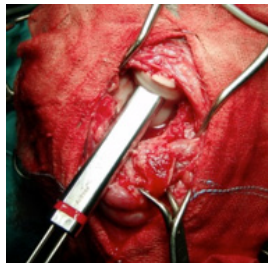
Trial



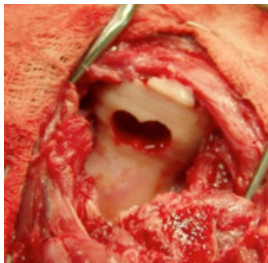
Implant in position



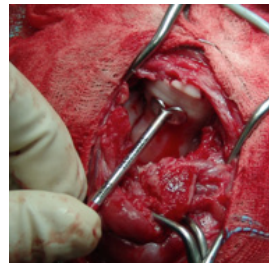
Drilling for humeral implant



Socket for humeral implant



Trial



Implant in position

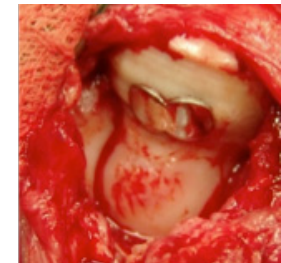


Figure 3: Different operative steps during CUE of a left elbow (medial approach, cranial to the right)

Disclosure: Drs. Schulz & Cook are patent holders on the CUE and will receive royalties associated with sales of the CUE.

Small animals

Poster session

Saturday July 7
14.15 – 16.00

Structural characteristics of the soft palate and meatus nasopharyngeus in brachycephalic and non-brachycephalic dogs analysed by ct.

Grand JG, Bureau S*.*

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Introduction

The goal of this study was to compare the dimensions of the soft palate and cross-sectional area of the meatus nasopharyngeus in non-brachycephalic dogs and brachycephalic dogs with different degrees of severity of brachycephalic airway syndrome (BAS) using computed tomography.

Material and Methods

A total of 26 brachycephalic dogs that had at least one of four major symptoms of snoring, inspiratory effort, stress or exercise intolerance, and syncope were included in this prospective study. The dogs were grouped by the frequency of different clinical signs into absent/minimal brachycephalic airway syndrome and severe brachycephalic airway syndrome groups. Five non-brachycephalic dogs were studied as control animals. All dogs underwent pharyngeal area computed tomography. Seven measurements were made on the transverse and midsagittal reconstructions. All parameters were compared between controls, absent/minimal and severe brachycephalic airway syndrome groups.

Results

The dogs with severe brachycephalic airway syndrome had significantly thicker soft palates compared to those with absent/minimal brachycephalic airway syndrome and control dogs ($P < 0.05$). There were no significant differences among groups with regard to the length of the soft palate or the cross-sectional area of the airway at the level of the meatus nasopharyngeus. There were no significant differences in the skull index between the absent/minimal BAS and severe BAS groups. We observed positive significant associations between the skull index and the thickness of the soft palate ($P < 0.05$).

Conclusion and Clinical relevance

The increased thickness of the soft palate is the most relevant pharyngeal CT parameter identified in severe BAS dogs, suggesting that this abnormality should be considered as a component of BAS. However, more basic research on brachycephalia is required to investigate the

relationship between the thickening of the soft palate and functional impairment before recommendations for specific surgical procedures can be made. Additionally, the lack of significant differences in the size of the meatus nasopharyngeus between BAS brachycephalic dogs and non-brachycephalic dogs suggests that this area cannot be considered to be the primary location where brachycephalic airway problems arise.

Intranasal epidermoid cyst in three brachycephalic dogs: preliminary considerations

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Introduction

The typical cause of respiratory distress in Brachycephalic Obstructive Airway Syndrome (BOAS) is threefold: stenotic nares, elongated and hyperplastic soft palate and laryngoceles. The aim of this study is to report diagnosis and surgical treatment of intranasal epidermoid cysts in three brachycephalic dogs.

Material and methods

A 9-year-old male neutered Pug, a 4-year-old male English Bulldog and a 3-year-old male Pug were presented for BOAS related respiratory signs that worsened recently associated with haemorrhagic and purulent nasal discharge. An MRI scan of the head was performed and revealed the presence of a unilateral or bilateral intranasal cystic structures. Surgical enucleation of the cyst was suggested to the owners. Bacteriological culture of the cystic contents and histology of the cyst wall were also carried out.

Results

The MRI scans showed a thin-walled cystic structure filling one or both nasal chambers which was surgically removed via lateral rhinotomy of the affected nasal cavity. Aerobic and anaerobic culture of the cystic contents was negative and histology of the removed cystic tissue was consistent with intranasal epidermoid cysts.

Discussion

New studies have shown that BOAS is caused by far more numerous constrictions in the upper airways than was previously thought including severe intranasal deformities. To the author's knowledge, there are no published reports of intranasal epidermoid cysts in brachycephalic dogs. The newly detected intranasal cysts in three dogs suggests that MRI or CT of the upper airways should be considered as part of the diagnostic work-up in these breeds. This would also permit better surgical planning. Surgery was performed to remove the cyst, restore the patency of the nasal cavities and to relieve the upper airway obstruction. Surgical approach via lateral rhinotomy was less invasive compared to a dorsal or ventral rhinotomy and also permitted good exposure of the cysts which could be easily removed in their entirety with an unevenful recovery. Histology

clearly identified the lesions as benign epidermoid cysts. These findings are very similar to dentigerous, radicular and canine odontogenic parakeratinized (COPC) cysts. However, dentigerous and radicular cysts typically surround respectively the crown of an unerupted tooth and the apex of a non vital tooth and COPCs are mainly identified in the maxilla, surround the roots of fully erupted, normally developed teeth and are characterised by locally infiltrative growth. Clinical presentation of the intranasal epidermoid cysts mirrors the behaviour of space occupying and slowly expanding, painless fluid-filled cysts. This may lead to the suspect that lesions in the reported three cases could be identified as COPCs with expansile growth into the nasal chambers. However, the aetiopathogenesis of the epidermoid cysts is still unclear. It is author's opinion that the described findings may contribute to a more complex pathogenesis of BOAS although further clinical cases are still needed to support this theory.

Splenic neoplasia: does the dog's size play a role?

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Introduction

Breed predisposition to splenic neoplasia indicates that large breed dogs are more commonly affected with splenic haemangiosarcoma. This retrospective study was undertaken to evaluate differences in splenic neoplastic disease between small and large breed dogs. The hypothesis was that small breed dogs would have significantly more benign splenic lesions than large breed dogs, and hence a longer survival time after splenectomy.

Study design

Retrospective clinical study of 146 dogs.

Material and Methods

Medical records of dogs splenectomised due to neoplastic disease between January 2002 and December 2011 were evaluated. Data collected comprised: signalment, history, preoperative condition, additional surgeries, hospital stay, pathohistology, long term outcome. Dogs were divided into two groups: body weight smaller than 20 kg (group 1) and body weight larger than 20 kg (group 2). Survival was defined as time from surgery until death related to splenic disease. Complete data including long term survival were retrieved from 105 dogs. Differences in frequency distribution were analyzed using the Chi Squared test. Median survival time was analysed using the Kaplan Meier method.

Results

Splenic neoplasia was found in 85 dogs (58.2%, 85/146). Group 1 and group 2 had 23 (54.8%, 23/42) and 62 (59.6 %, 62/104) affected dogs respectively. Neoplasia was found to be malignant in 77.6% (66/85) and benign in 22.4% (19/85). Group 1 had 69.6%(16/23) malignancy and group 2 had 80.6% (50/66) malignancy. No significant association between body weight and type of neoplasm was found. Haemangiosarcoma was seen in 60% (51/85) of affected dogs and was the most common malignant neoplasm (77.2%; 51/66). Group 1 had 87.5%(14/16), group 2 had 75.5% (37/50) haemangiosarcoma. Survival time was significantly longer in dogs with benign neoplasia than in dogs with malignant neoplasia. No significant difference was found in the occurrence of haemangiosarcoma and body weight. Survival time of small dogs having haemangiosarcoma was significantly

longer than in large dogs having haemangiosarcoma ($P=0.017$).

Discussion/Conclusion

This study found a longer survival time for small dogs with haemangiosarcoma in contrast to large dogs. This result needs to be interpreted cautiously due to a statistical outlier in group 1 dogs. Reported breed predisposition regarding splenic haemangiosarcoma in the German shepherd, Golden retriever and Labrador retriever might drive the clinician to overemphasize the occurrence of this disease in large breed dogs. This study found no difference in occurrence of splenic hemangiosarcoma in small and large dogs.

Successful treatment of an extrahepatic portosystemic shunt with an azygos continuation of caudal vena cava in dogs.

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Introduction

The purpose of this report was to describe the diagnostic imaging, abdominal vascularity, and surgical treatment of 5 different types of an extrahepatic portosystemic shunt (PSS) with azygos continuation of caudal vena cava (CVC) in 6 dogs.

Materials and Methods

Six dogs (Dog #1 – 6) were diagnosed with an extrahepatic PSS and an azygos continuation of CVC based on diagnostic imaging techniques including ultrasonography, computed tomography (CT) and intraoperative mesenteric portography, and underwent the surgical treatment. Signalment, diagnostic imaging findings, portal pressure measurements, intraoperative findings, and prognosis were reviewed.

Results

Dog #1 was an intact female Shih Tzu (11-month-old, BW 5.0kg) with an azygos continuation of CVC and an extrahepatic porto – caval shunt, and underwent surgical attenuation by sterile nylon wire banding. Dog #2 was an intact male Papillon (7-month-old, BW 2.5kg) with an azygos continuation of CVC and an extrahepatic left gastric – azygos shunt and underwent surgical attenuation with an ameroid constrictor (AC) of 4 mm in diameter. Dog #3 was an intact male Shih Tzu (4-month-old, BW 2.25kg) with an azygos continuation of CVC, an extrahepatic left gastric – left hepatic shunt and left azygos vein, and underwent surgical attenuation with an AC of 5 mm in diameter. Dog #4 was an intact female cross-breed (2-year-old, BW 3.65kg) with an azygos continuation of CVC and an extrahepatic left gastric – azygos shunt similar to Dog #2, and underwent surgical attenuation with an AC of 5 mm in diameter. Dog #5 was an intact male Toy Poodle (7-month-old, BW 2.8kg) with an azygos continuation of CVC and an extrahepatic umbilical – internal thoracic shunt, and 2 stage surgical ligations were done for complete occlusion. Dog #6 was an intact female Shiba (3-month-old, BW 5.4kg) with an azygos continuation of CVC and an extrahepatic splenic – caval shunt, and 2 stage surgical ligations were done for

complete occlusion. All dogs had no clinical signs more than 1 month to 8 years after the complete occlusion.

Discussion

In our report, 6 dogs had 5 different types of an extrahepatic PSS with an azygos continuation of CVC. The previous reports have described the other types of congenital malformations of portal vein and CVC associated with PSS in dogs. We strongly believe that there are unknown different types of atypical PSS in dogs. CT angiography is clinically useful for detecting canine vascular abnormalities such as PSS and an azygos continuation of CVC, and has the potential for establishing new classification of these vascular abnormalities. This report might be of clinical value from the viewpoint of the diagnosis and treatment of canine PSS with an azygos continuation of CVC.

Use of cone-shaped polypropylene mesh for perineal herniorrhaphy in 39 dogs

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Introduction

Unilateral or bilateral perineal hernia results from failure of the muscular pelvic diaphragm to support the rectal wall, which stretches and deviates and occasionally abdominal contents protrude into the perineal area. This study aimed to investigate the outcome of herniorrhaphy technique with the cone-shaped polypropylene mesh in dogs with perineal hernia.

Materials and Methods

The medical records of all dogs underwent herniorrhaphy with polypropylene mesh (PROLENE mesh® Johnson & Johnson) formed in the shape of a cone between October 2008 and July 2012 were reviewed. Data including signalment, short and long-term complications (within and over 15 days after surgery, respectively), additional procedures, and previous treatment were evaluated. The sheet mesh was formed in the shape of a cone and adjusted to the size of hernia. The apex of cone-shaped mesh was inserted into the hernia region. The bottom of the mesh was sutured to the sacrotuberous ligament, internal obturator muscle, external anal sphincter, and residual coccygeal muscle. When it was difficult to suture the internal obturator muscle that was extremely atrophied or already used at the previous surgery, 3 or 4 holes were drilled in the ischial edge and the mesh was sutured using those holes.

Results

Thirty-nine dogs with a total of 71 perineal hernias were included in this study. Of these dogs, 19 Miniature Dachshunds, 6 Pembroke Welsh Corgis, and 6 cross-breeds were most commonly observed. Median age was 9 year-old, median body weight was 6.3 kg, and median follow-up period after the surgery was 4 months. Five dogs had herniorrhaphy previously. Cystopexy was performed in 11 dogs with bladder retroflexion. Colopexy was performed in 2 dogs. Instead of internal obturator muscle, the ischial edges were drilled and sutured to the mesh in 4 dogs with 4 hernias. There were no intraoperative complications in any dog. In the short-term, complications comprising exudation/swelling (14/39, 36%), minor wound dehiscence (2/39, 5%), wound infection (4/39, 10%), and a temporary

urinary incontinence (4/39, 10%) occurred. In the long-term, complications comprising tenesmus (3/39, 8%), urinary incontinence (2/39, 5%), and wound infection (1/39, 3%) occurred. Foreign body reaction to the artificial mesh was not observed. The recurrence rate and mortality were 3% (1 dog) and 0%, respectively.

Discussion

Herniorrhaphy with cone-shaped polypropylene mesh resulted in good outcomes and less postoperative complications compared with the other herniorrhaphy procedures. In addition, this technique can be performed in the recurrent cases with an internal obturator muscle. This technique with the cone-shaped polypropylene mesh can be one of the surgical options in dogs with perineal hernias.

Sublumbar abscesses in 46 dogs: a review of clinical findings, diagnosis and treatment

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Introduction

A sublumbar abscess is an uncommon condition characterized by abscessation and inflammatory changes within the hypaxial musculature. Various diagnostic imaging techniques have been used for diagnosis prior to surgical debridement and prognosis is often considered guarded. The purpose of this study was to examine the success of surgical treatment for this condition and whether prognosis should be re-evaluated.

Materials and Methods

The medical records of 46 cases of sublumbar abscesses diagnosed at DVS between December 2000 and February 2011 were reviewed to determine pre-operative clinical findings, intra-operative techniques and post-operative treatment. Follow-up period (minimum 6 months) was determined by contacting the referring veterinary surgeons.

Results

The highest ranking breed was the springer spaniel 12/46. Duration of clinical signs ranged 1 to 96 weeks. In 41/46 cases surgical exploration and debridement was performed with subsequent antibiotic administration. Five cases did not undergo surgery for various reasons including: clinical deterioration before surgery necessitating euthanasia, owner concerns and financial constraints. A midline coeliotomy alone or combined with other approaches was used in 32/41 cases. A lateral approach was used in 9/41 cases. A foreign body was found in 9/41 dogs. Omentisation was performed in 24/41 cases and surgical drains placed in 22/41. Bacteriologic culture and sensitivity was performed in 28 cases (13 yielding positive bacterial growth). Common respiratory bacteria were cultured. Broad spectrum antibiotics were given for 2-12 weeks (mean 5 weeks). Follow-up was obtained for all cases except 2 where records were lost. Four cases recurred, 1 of which were euthanased. One dog died suddenly 10 days after the initial surgery. One dog was euthanised due to clinical deterioration before surgery could be performed. Surgery was successful in 34/39 cases with a recorded recurrence-free interval post-surgery ranging from 8-111 months (mean 33 months).

Discussion/Conclusion

This study challenges the previously held opinion that the prognosis in dogs with sublumbar abscesses was guarded as 34/39 (87%) of dogs were successfully treated surgically. The authors found advanced imaging very useful in the diagnosis and planning of these cases prior to surgery. The success rate was still high even though foreign material was not found in the majority of cases. Duration of clinical signs did not influence outcome.

Outcome and prognostic factors for dogs with a histopathological diagnosis of splenic hematoma following splenectomy: 35 cases (1992-2012)

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Introduction

Splenic haematoma and haemangiosarcoma are grossly indistinguishable from each other. Haemangiosarcoma is the most common neoplasm of the spleen. The study objective was to retrospectively determine outcomes and prognostic factors associated with dogs given a histopathological diagnosis splenic haematoma following splenectomy.

Methods

Medical records were reviewed for dogs with a histopathological diagnosis of splenic haematoma following splenectomy during the period 1992-2012 (n=35). Signalment, clinical data, and surgical findings were evaluated for associations with outcome. Outcome was determined through follow up with referring veterinarians as well as patient owners. A Cox Proportional Hazard Model was employed to compare variables with survival data. Statistical significance was defined as a P-value ≤ 0.05 .

Results

The overall median survival time (MST) was 674 days, with a range of 0-3287 days. Clinical evidence of metastatic disease was reported at the time of euthanasia for 3/35 (8.5%). The mean DFI for these dogs was 315 days (102, 322 and 522 days). The remainder of the study population died of causes unrelated to splenic haematoma. Survival was not influenced by signalment, presenting signs, or clinicopathological features.

Conclusion

The overall MST for splenic haematoma in this study was 674 days, which is significantly higher than previously reported for either splenic haematoma or HSA.

A diagnosis of splenic hematoma may not indicate need for adjunctive chemotherapy in most cases. A small percentage (8.5%) of histopathologically diagnosed splenic haematomas died of metastatic disease. It could not be confirmed if this was due to HSA or a second neoplasia.

Ovary visualisation during laparoscopic ovariectomy in dogs: comparison of dorsal, semi-lateral and lateral recumbency

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Introduction

To describe the optimal recumbency for laparoscopic ovariectomy (LapOVE) in the dog. Ovary visibility without organ manipulation was compared between 3 body side declinations (0°, 45°, 90°).

Materials and Methods

In a prospective clinical trial, 16 healthy client-owned female dogs undergoing routine one-hole laparoscopic ovariectomy were included. Anaesthetised dogs were placed in dorsal recumbency on a tiltable operation table with fixed declination points at 45° and 90°. The starting side of declination was randomly assigned. After introduction of an 11-mm trocar 1 cm sub-umbilically and insertion of a 0° 10-mm operative laparoscope in a 0° position, a pneumoperitoneum was created and the abdomen completely explored. The operating laparoscope was then directed towards the respective ovary. The table was tilted to 45° and 90°, for each position a video recording of 15' was taken. Ovariectomy was performed using the one-hole-technique. The table was returned to 0° and rested in this position for 1 min. Subsequently the contralateral side was treated accordingly.

A digital video recording was started on insertion of the laparoscope and continued until the end of the procedure. Fifteen second cut scenes were evaluated by blinded observers for ovary/ovarian bursa visibility and presence of other organs in case the ovary/ovarian bursa was not visible. Ovary visualisation differences between positioning angles were determined using the chi-square-test. Interobserver agreement (IOA) was expressed by the statistical coefficient kappa (k). Correlation between ovary visibility and body condition score as well as body weight was determined using the Pearson's correlation coefficient r.

Results

One video was excluded by observer A because of poor image quality, so 95 videos were available for evaluation. In 0° positioning, the ovary was visualized in 2/31 (6.5%) and 0/32 cases by observer A and B, in 45° declination in

6/32 (19%) cases by both observers and in 90° declination in 21/32 (66%) and 29/32 (91%) cases by observer A and B, respectively. There was no significant difference in ovary visibility comparing the 0° and 45° declination for observer A ($P=0.143$), but a significant difference for observer B ($P=0.01$). The difference between 45° and 90° ($P<0.001$) and 0° and 90° was significant for both observers ($p<0.001$). There was no significance for body side declination (A: $P=0.877$, B: $P=0.832$).

Conclusion

The best ovary visibility was identified in lateral recumbency regardless of body side or observer experience. This information is particularly relevant for less experienced surgeons and for those performing single-port LapOVE since no instruments are inserted into the abdominal cavity to manipulate the organs extensively.

Effects of variable pressure pneumoperitoneum on cardiorespiratory parameters and working space during laparoscopy in cats.

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The effect of pneumoperitoneum on cardiorespiratory function has been studied in dogs and other species but not in cats.

The aims of this prospective randomized study were to evaluate the effect of pneumoperitoneum on cardiorespiratory variables and working space using three different intra-abdominal pressures (IAP) in cats.

Six healthy adult cats were anesthetized using a standardised protocol. A right femoral arterial catheter was placed for blood pressure and blood gas monitoring. A thermodilution catheter was placed via the right jugular vein using fluoroscopic guidance. A single subumbilical 6mm cannula was placed into the peritoneal cavity. Cardiopulmonary variables were recorded at baseline, 2 and 30 minutes after initiation of a pneumoperitoneum at IAPs of 4, 8 and 15mmHg, created using a mechanical insufflator. At each different IAP abdominal dimensions (height, width and circumference) were measured at a standardized location.

At 4mmHg and 8mmHg IAP there were no clinically significant changes in cardiorespiratory parameters. Heart rate and cardiac index remained unchanged at all IAPs. MABP was significantly elevated at both time points at 15mmHg. At 15mmHg PaCO₂ was significantly increased and cats were more acidotic compared to baseline. Working space was significantly greater at 8mmHg compared to 4mmHg but no clinically significant enlargement was seen between 8 and 15mmHg.

Cardiopulmonary variables were largely unchanged by pneumoperitoneum up to 8mmHg IAP. No clinically significant increases in working space occurred between 8 and 15mmHg. There is little justification for use of IAPs >8mmHg in cats undergoing laparoscopic procedures.

Risk factors for gastric spirochaete infection in dogs

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Introduction

Gastric spirochaetes have been implicated in diseases affecting many body systems in people. In dogs, the role of gastric spirochaetes in disease remains controversial but significant evidence exists to show that appropriate treatment of gastric spirochaetes can alleviate gastric signs in affected individuals. Gastrointestinal signs have been correlated with respiratory symptoms in brachycephalic breeds but a potential role for spirochaetes has not been previously considered. This study aims to identify conformational and clinopathophysiological factors related to gastric spirochaete infection.

Methods

Records of dogs undergoing endoscopic gastric biopsy in 2011 and 2012 were examined. Details of signalment, conformation (brachycephalic or mesocephalic), presenting signs, diagnosis, gastric mucosal pathology and presence or absence of spirochaetes were collated. Only patients with full records available were considered for admission. Fisher's exact tests and Mann-Whitney U tests were used to compare groups. ANOVA was used to compare groups with respect to degree of gastritis and numbers of spirochetes identified.

Results

39 dogs were admitted to the study of which 14 were brachycephalic (36%) and 25 mesocephalic (64%). Thirteen of the 14 brachycephalic dogs and 11 of the 25 mesocephalic dogs had gastric spirochaete infection. Brachycephalic breeds were significantly more likely to have gastric spirochaete infection than mesocephalic breeds ($P=0.005$). Dogs in which respiratory obstruction was a presenting sign (both brachycephalic dogs and those with other obstructive respiratory disease such as laryngeal paralysis) were significantly more likely to have gastric spirochaete infection than those with other presenting signs ($P=0.025$). There was no difference in the presence or severity of gastritis between groups ($P=0.13$) or in numbers of spirochaetes identified ($P=0.61$). There was no association between gastritis and spirochete infection ($p=0.93$).

Discussion

Brachycephalic dogs and dogs in which respiratory obstruction was a presenting sign were significantly more likely to have gastric spirochaete infection. We suggest that gastric spirochaete infection may exacerbate clinical disease in these patients. Improved outcome with treatment for gastritis (antacids and prokinetics) following surgery for brachycephalic obstructive airway syndrome (BOAS) has been reported previously. The results of our study suggest that targeted therapy for spirochaetes should be considered in the management of brachycephalic obstructive airway disease and other obstructive upper airway disease. Gastric endoscopic mucosal biopsy should be considered as part of diagnostic investigations in all brachycephalic dogs and dogs in which respiratory obstruction is a presenting symptom.

Validation of the use of a uniaxial extensometer to study the biomechanical properties of the dog skin.

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Introduction

To validate on cadavers the use of a uniaxial extensometer to analyse the viscoelastic properties of the dog skin for future clinical applications.

Material and methods

Forty-one skin sites (82 tests) were investigated in situ and after isolation of the skin tested from the surrounding skin in 11 dogs. The test for each site is constituted of two series of either 5 cycles of extension-relaxation to 5N or 10N, either 3 cycles to 5N then 3 cycles to 10N, either 8 cycles to 5N or 10N. The 2 principal hypotheses used were that the width of the tested skin in between the two pads can be assimilated to the width of the pads and the thickness of the tested skin is insignificant in front of the width of the skin tested. To characterize the skin's elastic properties of the dog, a parameter named 'Rigidity' was defined and to characterize the dog skin viscosity and a 'Fraction of dissipated energy' was calculated.

Results

Whatever the type of test realised, the curves obtained correspond to a hysteresis phenomenon. Reproducible values were obtained after at least 3 cycles (preconditioning). A relation of polynomial type was found to link the Rigidity ($Rev = 0.1203Riv^2 + 0.8022Riv$) and the Fraction of dissipated energy ($Fev = 0.043Fiv^2 + 0.9051Fiv$) obtained for skin in situ and isolated (R: Rigidity; F: Fraction of dissipated energy; ev : results on isolated skin and iv: results on in situ skin). The ratio between the values for 5N and 10N is not equal to 1 with a median significantly different from 1 ($P < 0.05$). The ratio between the values of Fraction of dissipated energy tends to become 1 with a median not significantly different from 1 ($p > 0.05$). Finally, as soon as the skin was cut, it retracted among the skin site. Because of the important difference between the cadavers used, we were not able to determine precisely if there is a variation of the Rigidity or the Fraction of dissipated energy from one site to another or from one dog to another.

Discussion

The analysis of those 2 parameters allowed us to conclude that the dog skin has to be preconditioned and is a pretensioned viscoelastic material with an anisotropic behavior, a non linear elastic behavior, and a linear viscous behavior. We also were able to find a link between the Rigidity and the Fraction of dissipated energy on skin in situ and on isolated skin, meaning that this extensometer can now be used in vivo without the need of isolating the skin tested. This study describes the use of a uniaxial extensometer on canine cadaver skin for an application on living dogs (experimental or clinical application) to study the healing process, the tension lines and the characterization of skin grafts or flaps.

Is open or closed castration technique associated with a higher complication rate in dogs?

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Introduction

Surgical sterilisation of dogs is a common procedure undertaken in first opinion companion animal practice. The literature in this area reveals varying opinions on the best technique but this is based on opinion rather than objective clinical evidence. The aim of the study was to determine, on the basis of the rate of adverse outcomes, if it was preferable to use an open or closed technique for the routine neutering of dogs by castration.

Material and Methods

A randomised controlled blinded prospective clinical study of 73 cases was undertaken involving the recording of all complications during and in the 10 days following castration of dogs fulfilling the standardised inclusion criteria. The active variable being the surgical technique of either open or closed castration as defined by Fossum's surgical textbook. Patients were assessed for complications at set follow-up appointments by one of four dedicated surgical nurses (blinded to the treatment). Veterinary surgeons were consulted when complications were identified. Complications were classified as either minor requiring no treatment, or major requiring either surgical and/or medical intervention. The nature of the complication and the time at which it was identified were recorded for each dog.

Results

Ages of dogs ranged from 5 to 120 months. Weights of dogs ranged from 3.0 to 52.7kg. Toy, small, medium, and large breeds were represented. There were no significant differences by age or weight between the open and closed group. Dogs undergoing open castration experienced significantly more complication events (independent of their minor/major classification) than the dogs undergoing closed castration (24/34, 70% vs 18/39, 46%, $P=0.04$). Within the major complication subset, frequency of complications did not differ between surgery method (6/34 vs 2/39) ($P=0.1$). Dogs undergoing open castration were three times more likely to result in scrotal complications (21/34, 61%) than dogs undergoing closed castration (13/39, 33%) ($P=0.03$).

Discussion/Conclusion

Open castration is associated with a higher complication rate in the first 10 days post surgery than closed castration. Interestingly open castration is also associated with increased complications of a scrotal nature including scrotal swelling, bruising and pain compared to the dogs undergoing closed castration. Additional dissection/tissue trauma with the open technique may be responsible for this finding. Closed castration should be preferred particularly in dogs which may be predisposed to scrotal complications due to a pendulous scrotum or their boisterous nature.

Post-operative complications after small intestine surgeries: a retrospective study in 111 cats

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Introduction

Intestinal leakage is one of the most important complications following intestinal surgery and is associated with a high mortality rate from septic peritonitis. The veterinary literature has little data concerning the outcome and complications following intestinal surgery in cats. No intestinal leakage was reported in 2 studies including 25 and 70 lymphosarcoma cases, respectively. In contrast, leakage after intestinal surgery is reported to occur in 15-20% of dogs. Our objectives were to determine the complication rate after intestinal surgery in cats for various intestinal disease and to identify perioperative risk factors.

Our results support previous findings that postoperative leakage is rare in cats after small intestinal surgery compared to the data published in dogs. Although septic peritonitis prior to surgery tended to be associated with a higher risk of leakage and failure to survive, this finding was not statistically significant and no relevant conclusions could be drawn with respect to risk factors.

Materials and methods

Cats admitted in our institution between 1993 and June 2012 for either a full-thickness intestinal biopsy, an enterotomy or an intestinal resection and anastomosis were included in the study. The following data were recorded from the medical records: signalment and medical history, surgical data and outcome.

Results

111 cats met the criteria for inclusion, comprising 40 intestinal resections and 71 enterotomies. In 13 cats with resection and 2 cats with enterotomy, septic peritonitis was present prior to surgery. Hypoproteinemia was reported in 3.6% of cases. Leakage occurred in 1.8% of cases, in 2 cats with resection (both had septic peritonitis prior to surgery and died after surgery). The overall mortality rate was 13.5%, comprising 20% for the resection group and 10% for the enterotomy group, but only 4.5% of cases died from complications of the intestinal surgical procedure. In cases that died, indications were foreign body removal in 27% and tumor biopsy or resection in 47%. In the surviving cases, these indications were: 72% and 16.5%, respectively. The mortality rate for septic peritonitis was 38.5%.

Discussion and conclusions

This is the first large-scale study evaluating postoperative complications in cats undergoing enterotomy or intestinal resection and anastomosis for various intestinal diseases.

Survival, functional and cosmetic outcome of free skin graft standard procedure in dogs and cats: 25 cases.

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Introduction

Few clinical studies are available in the veterinary literature reporting skin grafts in dogs and cats. Free skin grafts are reported to be 90 to 100% successful based essentially on the personal experience of some authors. The purpose in this clinical prospective study was to report the outcome (survival, functional and cosmetic appearance) of the use of a free skin graft standard procedure in dogs and cats.

reconstructive procedures. Compared to other techniques available, this skin grafting technique appeared to be a useful option and did not require multiple procedures or expensive surgical equipment.

Materials and methods

Patients enrolled had either a shearing injury or a surgical excision on the extremities and a skin graft was considered as the best reconstructive option. All animals underwent routine care of the wound. A thick split-thickness skin grafting technique was used on a healthy granulation tissue bed. Clinical evaluation combined with photographs was made at each bandage change in order to follow the progression of the graft for at least 6 months post-operatively.

Results

Twenty-five skin grafting cases in 23 animals (12 dogs and 11 cats) were included. Skin grafts achieved 100% success for 12/13 cats and for 7/12 dogs and the remainder had at least 70% take. Two dogs had a revision of the graft associated with further articular immobilisation. Minimal failures were allowed to heal by second intention healing. Hair growth and a good to excellent functional outcome were achieved in all patients even for the grafts applied over an articular area.

Discussion/conclusion

All dogs and cats achieved a good to excellent functional outcome for wounds affecting limbs and tails with survival rate of 90% to 100% with few complications by following this procedure. Good immobilisation of the area is important for the survival of the graft.

Skin grafting has the advantage of being repeatable in the case of necrosis and can be used in association with other techniques or be used after the failure of other

Intraoperative bacterial contamination in veterinary medicine

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Surgical wound infection is a problem and the surgical team is a potential source. The purpose of this study was to determine the prevalence of and risk factors for intra-operative surgical glove puncture and contamination (IOGP and C, respectively), to identify the organisms involved, and to relate IOGC to post-operative wound infection.

Surgical gloves were collected from the operative team immediately after surgery. IOGP was determined with a water pressure test. After some surgeries, but prior to degloving, the primary surgeon's gloves were cultured using a modified Gaschen bag technique. Type of procedure, duration of the surgery and anesthesia, type of gloves and years of experience of primary surgeon were recorded. Bacteria recovered were characterized and cases were followed for 2 weeks. 562 gloves were tested for perforations of which 10.3% had IOGP, and 82% of the time the individuals were unaware. Gloves were cultured after 21 clean procedures. No contamination was seen in 38%, low contamination in 23.8%, moderate contamination in 19% and high contamination in 19% of the cases. Orthopaedic procedures had a higher IOGC percentage than soft tissue procedures. 81% of the recovered bacteria showed high pathogenic potential with most common bacterial isolates being Gram positive cocci and Gram negative rods. The post-operative incisional infection rate was 15%. No significant association was found between IOGP and IOGC and between IOGC and wound infection. The vast majority of IOGP occur without staff awareness. Orthopaedic surgeries have more IOGC. A larger study is needed to confirm the true association between IOGP, IOGC and infection.

Learning curve and initial experience with laparo-endoscopic single site (less) ovariectomy using a multitrocar port , angled telescopes and articulating instruments in the dog

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Objective

To define the learning curve, describe the technique and evaluate the outcome for dogs that had a Laparo-Endoscopic Single Site (LESS) Ovariectomy using a commercially available multitrocar port with articulating instruments and an angled telescope.

Design

Retrospective case series.

Animal

25 client-owned dogs.

Procedures

The SILSTM commercially available multitrocar port was inserted into the abdomen through a 15-20 mm incision at the umbilicus. A LESS ovariectomy was performed bilaterally using the SILS TM multitrocar port, articulating grasper, bipolar vessel sealing device and a 30o telescope. The excised ovarian tissue was removed through the multitrocar port incision between ovaries.

Results

25 dogs had a LESS ovariectomy. Median body weight was 20.3 kg (range, 3.5-41 kg). Median surgical time was 30 minutes (range, 15-90 minutes). Median patient age was 334 days (Range, 184-2913 days). For a single surgeon, a Chomsky learning curve revealed that after the 12th procedure a surgeon reaches 90% of the fastest time expected ($p=0.046$) with a 95 % confidence interval. Complications included minor haemorrhage due to a splenic laceration for dog #13 and an incisional infection occurred postoperatively in dog #14.

Conclusions and Clinical Relevance

The learning curve for the LESS ovariectomy is short and definable. The LESS ovariectomy is a safe procedure that can be utilized as a minimally invasive laparoscopic sterilisation technique. Caution should be taken to avoid splenic injury during multitrocar port insertion.

Medial shoulder instability in 5 small breed dogs

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Medial shoulder instability (MSI) in small breed dogs has not previously been reported in the veterinary literature. MSI typically involves pathology affecting one or more of the subscapularis tendon of insertion, medial glenohumeral ligament and the joint capsule and often diagnosed with shoulder stability testing followed by arthroscopy in large breed dogs. Five small breed dogs with an average bodyweight of 6.0 kg presented with a history of a chronic insidious, consistent, severe weight bearing unilateral lameness of a thoracic limb which was poorly responsive to rest and NSAIDs. The diagnosis of MSI in these cases was made by evidence of severe shoulder pain particularly on flexion and when fully extended with stress abduction. Radiographs of both shoulders were made with one dog having a smaller glenoid cavity on the affected limb but no evidence of subluxation. The rest of the studies were unremarkable. The dogs were sedated to allow shoulder stability testing. Both abduction angles, craniocaudal and mediolateral stability tests were performed as per previously described techniques. Increased angles of abduction of at least 6 degrees on the affected limb compared to the contralateral limb were present. Three of the 5 dogs had mild medial translation with crepitus on manipulation. Arthroscopy was not offered due to patient size. Exploratory surgery to further evaluate the pathology and imbricate the affected tissues individually was performed. Three of 5 dogs had subscapularis tendon of insertion tearing and 2 of those had concomitant tearing of the coracobrachialis tendon of origin. All dogs had fraying of the medial labrum of the glenoid. The medial joint capsule and affected tissues were imbricated using a novel technique. A non weight bearing sling was not applied postoperatively. All dogs were followed for at least 6 months. All dogs were weight bearing on the first postoperative day. Restriction in activity was maintained for 6 weeks with all dogs resuming normal activity following that time. 4 of 5 dogs had complete resolution of the lameness that did not recur. The dog with congenital shoulder dysplasia was much improved but still had mild stiffness after activity. Owner satisfaction was extremely high in all cases. MSI in small breed dogs occurs and should be considered when presented with a chronic thoracic limb lameness and is typically more debilitating than in larger dogs. Assessment was made using the previously scrutinized shoulder stability tests however the criteria

for diagnosis may need to be changed for small breeds of dog. Surgical treatment is relatively straightforward and leads to excellent outcomes and unlike the larger breeds does not require extensive postoperative rehabilitation.

Comparison of two crimping devices for use in extracapsular stabilization of the canine stifle

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Introduction

To compare the tensile strength and stiffness of non-absorbable suture loops created with two different crimping devices.

Methods

Loops of monofilament nylon leader line (MN) of 18kg, 36kg, and 45kg, multifilament polyethylene (MP) with a crimp (MP-C) and MP with a crimp and knot (MP-CK) were mechanically tested to failure in quasistatic tensile loading after being created with either a wave pattern crimp device or three applications of a single crimp device. Each testing group consisted of five samples. Tensile loading to failure at a rate of 9.5mm/s was used. Failure was defined as a sudden drop in the recorded force.

Results

All suture materials failed by breaking near the crimp tube with both crimp devices with exception to the MP without knot, which slipped through the crimp tube using both devices. Sutures secured with the wave pattern crimping device were significantly stronger with a higher load yield, maximum load, displacement yield, failure displacement and maximum displacement than the single crimp device. Loops of MP suture crimped by either device with subsequent addition of a surgeon's knot are significantly stronger constructs than unknotted crimped MP constructs. Crimped MP combined with knot were significantly stiffer than crimped 45kg MN.

Conclusion

Performing extracapsular repair for ruptured cranial cruciate ligaments with the wave pattern crimp system may result in lower failure rates due to the construct being significantly stronger than the single crimp system.

Quasi-isometric points for the application of the lateral suture technique in cats

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Objective

To evaluate the quasi-isometric points between the distal femur and proximal tibia for the placement of a lateral suture that will most accurately mimic the action of the cranial cruciate ligament in the cat.

Sample population

Cadaveric cat stifles (7 cats, 14 stifles)

Methods

Specimens were prepared and placed in a mounting set in which rigid fixation of the femur was maintained while allowing free range of motion of the stifle joint and tibia. Radiopaque spheres were placed at predefined landmarks in the distal femur (F1 and F2: caudal aspect of the lateral femoral condyle and cranio-distal and cranio-proximal to the lateral fabella respectively) and in the proximal tibia (T1- caudal to the proximal aspect of the extensor groove; T2- cranial to the proximal aspect of the extensor groove; T3-two millimeters proximal and caudal to the insertion of the patellar tibial tendon and T4- three millimeters caudal to the insertion of the patellar tibial tendon). A sequence of 4 radiographs was performed with each stifle being held in extension (166°), flexion (45°), and two intermediate stance phases (90° and 130°). Measurements between femoro-tibial points were obtained independently by two authors and the range and total amount of movement between pairs of points calculated.

Results

The pair F2-T1 produced the smallest range of distance over all the different tested angles, but this was not statistically significantly different from F1-T1 and both these positions had significantly lower ranges of distance compared to all other paired points (all $p < 0.05$).

The lowest total amount of movement for all the tested angles was achieved with the combined points F1 and T1 (F1-T1). The difference in the total amount of movement for F1-T1 was not statistically significantly different from the pair F1-T2 but both these paired points were significantly less than all other positions (all $p < 0.05$).

Conclusion and Clinical relevance

F1-T1 represented the most quasi-isometric points for the placement of lateral sutures in cats. Further assessments with biomechanical studies and application of bone anchors would be needed to evaluate the reproducibility of achieving implant insertion at these landmarks for the stabilization of the cranial cruciate ligament rupture in cats.

Effects of rotation and osteotomy angulation on patellar tendon insertion position during circular tibial tuberosity osteotomy

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Objective

To evaluate the influence of rotation of the tibial tuberosity (TT) in the sagittal plane and angulation of osteotomy in the frontal plane (FPA) on the displacement of patellar tendon (PT) insertion.

Study Design

Ex vivo biomechanical study.

Sample population

Thirty-six canine tibiae.

Methods

Nine groups of four tibiae each underwent a circular osteotomy of the TT at a FPA from -20° to +20° with increments of 5° for each group. The osteotomised TT was rotated by angles of rotation (AOR) of 10°, 20° or 30° in the sagittal plane. The craniocaudal (CCD), distoproximal (DPD) and mediolateral (MLD) displacements of a marker located at the PT insertion on the TT were evaluated radiographically. Differences between groups were analysed by Mann-Whitney U test and Friedman two-way ANOVA.

Results

There was a significant correlation between the AOR and CCD. A positive FPA resulted in a high CCD and lateral shift of the TT at every AOR. Performing an osteotomy at a FPA of 0° produced the maximum amount of DPD.

Conclusions

FPA and AOR during circular osteotomy of the TT influence the final displacement of the PT insertion in all three planes.

Clinical Relevance

Circular osteotomy of the TT may have the potential to treat conditions such as patellar luxation and cranial cruciate ligament rupture; however, further studies are required before the procedure can be implemented clinically.

Peri-operative administration of antimicrobials during tibial plateau levelling osteotomy in dogs: 224 cases (2008-2010)

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Tibial plateau leveling osteotomy (TPLO) is commonly performed to stabilize a cranial cruciate insufficient stifle in dogs. Numerous studies have indicated a high risk for surgical site infection (SSI), despite TPLO being classified a clean surgical procedure. Peri-operative antimicrobials may be important for prevention of SSI but there has been limited scrutiny of current practices. The objective of this study was to evaluate peri-operative antimicrobial use during TPLO at the Ontario Veterinary College Health Sciences Center (OVCHSC).

224 dogs undergoing TPLO from 2008-2010 were included in this study. Medical records were reviewed and data collected included timing of pre- and intra-operative antimicrobial administration and whether post operative antimicrobials were prescribed. SSI and implant removal rate were also documented. Descriptive statistics and logistic regression analysis were performed. A p value of <0.05 was considered significant.

223/224 (99.6%) dogs received peri-operative antimicrobials, and cefazolin was used in 223/223 (100%) dogs. 95/224 (42.4%) dogs received "appropriate" peri-operative antimicrobials defined as pre-operative administration of antimicrobials within 60 min of incision and every 90 min intra-operatively. The mean time from first dose to incision was 42.5 min +/- 23.6 min (range 0-135 min). 128/224 (57%) dogs received pre-operative antimicrobials within 60 min of incision. 15/223 (6.7%) dogs had first dose after incision (mean 19 min +/-26 min, range 5-105 min).

Intraoperative dosing was indicated in 194/223 (86.9%) dogs with 195/223 (87.4%) dogs receiving intra-operative antimicrobials. The mean interval for the first dose of intra-operative antimicrobials was 95.1 min +/- 15 min (range 45-165 min). A mean of 1.2 +/- .41 intra-operative doses were administered to a maximum of 3 doses. Intra-operative antimicrobials were administered late (>90 minutes) following the initial dose in 57/195 (29.2%) dogs. Post operative antimicrobials were prescribed to 55/224 (25%) dogs. SSI was documented in 27/224 (12.1%) dogs

and implant removal occurred in 25/224 (11.2%) dogs. Post operative administration of antimicrobials was protective for development of SSI (OR: 5.07, 95% CI 1.42, 32.32, p=0.01).

Variable administration of perioperative antimicrobials was noted in the dogs of this study, indicating room for improvement in standard practices. The high SSI rate for TPLO is consistent with other studies, and indicates a need for better preventive measures. Further investigation into the apparent protective effects of post operative administration of antibiotics to TPLO patients is warranted.

Comparison of post operative infection rates in tibial tuberosity advancement in 197 stifles: post operative antibiotic treatment versus no post operative antibiotic.

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To evaluate the association between post operative antibiotic administration and post operative infection after tibial tuberosity advancement (TTA) in 197 stifles.

A retrospective study evaluating 202 consecutive TTA surgeries performed in 174 dogs in a single institution for the surgical management of cranial cruciate ligament deficiency and rupture. One hundred and ninety seven stifles met the criteria for inclusion. Clinical records from the institution where the surgeries were performed and from referring veterinarians were analysed.

Following 197 TTA surgeries, 7 stifles (3.55%) developed post operative infection. One hundred and sixty seven stifles received post operative antibiotics (group AB) and 30 stifles did not receive post operative antibiotic (group non-AB). Six stifles in the group AB developed infection; 1 stifle in the group non-AB developed infection. There was no statistical significant relationship between post operative infection rate and post operative antibiotic administration. Surgical and general anaesthesia time were significantly longer in the stifles that developed post operative infection. The choice of amoxycillin and clavulanic acid, cefuroxiome and cephalexin as peri operative prophylactic antibiotics did not have significant association with post operative infection rate.

There was no significant association between post TTA infection rate and post operative antibiotic administration. Long surgical and general anaesthesia duration were significantly associated with higher post TTA infection rate.

Non-invasive measure of bone density to predict mechanical properties of the vertebral endplate in the canine cervical spine

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Presented: A. Caron

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Introduction

Implant subsidence is a clinically significant problem in humans and dogs with cervical interbody cages, grafts or disc replacements. A reliable and predictive method of endplate fracture risk is required to further minimize postoperative complications. We hypothesized that the structural properties (stiffness and peak load) of the endplate would correlate to the endplate bone mineral density (BMD) measured on computed tomography (CT) and dual-energy x-ray absorptiometry (DEXA).

Materials and Methods

Ten skeletally mature cervical spines (C3-C6) underwent quantitative CT scan (QCT), DEXA and indentation testing of the cranial endplate. Linear regression analysis was used to determine the relationship between endplate stiffness, peak load, trabecular or endplate BMD, and endplate area.

Results

No correlation was found between trabecular BMD measured by DEXA and QCT. Mean ($\pm$ SD) initial stiffness and peak load of the endplate were 776.85 ± 32.2 N/mm and 537.4 ± 47.94 N, respectively. Mean ($\pm$ SD) area of the endplate was 157.2 ± 4.5 mm². No significant difference was found across the cervical levels for any variable. Endplate BMD was weakly but significantly correlated to initial stiffness ($r^2=0.14$, $p=0.027$). A stronger relationship was identified between endplate BMD and peak load ($r^2=0.65$, $p=0.0001$). There was no association between initial stiffness ($p=0.57$) and peak load ($p=0.71$) when compared to endplate area.

Discussion

The results from this study demonstrate that endplate BMD measured by QCT predicts the mechanical properties of the endplate. These findings suggest that pre-operative assessment of BMD may be useful as a guide to patient and surgical technique selection in dogs that are being evaluated as candidates for interbody fusion or total disc replacement.

Trochlear block transposition in treating concomitant medial and lateral patellar luxation in dogs; an experimental study.

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Introduction

Treating concomitant medial and lateral patellar luxation is an orthopaedic challenge. This situation is typically encountered in dogs with whose conformation includes hyperextension of the stifle joint with a very proximal position of the patella in the trochlear groove. The aim of this study was to evaluate proximal trochlear block transposition (TBT) and fixation and to determine the effects on stifle function and osteoarthritis formation. In this experimental study, TBT was compared with the more conventional trochlear osteochondrosulcoplasty (TSP).

Material and methods

The study included 4 intact beagle dogs without patellar luxation. Dogs were treated bilaterally with a TBT on one side and a TSP contralaterally. For the TBT, the entire femoral trochlea was osteotomized, transposed proximally for 4 mm, and stabilized. The TSP was performed extending the recession as much proximally as possible. Bone healing and osteoarthritis formation were evaluated and scored radiographically. Force plate analysis (FPA) of locomotion was performed prior to and at the conclusion of the study at 6 months. Patellar and trochlear cartilage and osteoarthritis were assessed visually. Statistical analysis of the FPA was conducted with a Student t-test. Non-parametric data were analysed with a Wilcoxon test. A p-value of <0.05 was considered significant.

Results

Postoperative healing was uneventful in both TBT and TSP stifles. At 6 months, all TBT stifles showed significantly increased radiographic osteophyte formation in comparison with the TSP stifles. In the TBT and TSP stifles, Fzmax, Fymax, and Fymin were 4.11 ± 0.56 and 4.46 ± 0.38 , 0.61 ± 0.16 and 0.64 ± 0.17 , and 0.72 ± 0.04 and 0.73 ± 0.11 , respectively, but these differences were not significant. Visual assessment revealed full thickness cartilage erosions of the central part of the patellar joint surface in all TBT joints with intact cartilage in the TSP joints. Osteoarthritis was significantly more prominent in the TBT stifles.

Discussion and Conclusion

The most important findings were increased osteoarthritis and the full thickness patellar cartilage erosion in the TBT stifles. Patellar cartilage erosions were attributed to contact lesions during full flexion of the TBT stifles. Although TBT joints seemed to function without any problems, degenerative joint disease was clearly present on radiographs visual assessment. Force plate analysis did not show significant differences which may be related, in part, to the small number of dogs incorporated in this pilot study.

In conclusion

TBT was technically feasible but resulted in severe patellar cartilage damage and increased signs of degenerative joint disease. The described technique of TBT is not recommended in treating concomitant medial and lateral patellar luxation in dogs.

Guided bone regeneration (gbr) membrane used for management of non-union in small animals

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Complications of fracture healing include mal-union, non-union, and large segmental bone defects. These complications may be caused and affected by, amongst others, infection, loss of blood supply to the bone fragments, periosteal and muscle stripping, unstable fixation, poor nutrition, neoplasia, and genetic disease (e.g. osteogenesis imperfecta). In difficult and complicated fractures distraction osteogenesis, bone transport, and bone grafting are employed to accelerate fracture healing.

BoneCure Membrane, composed of ammonio methacrylate copolymer type A (AMCA) and polyethylene glycol (PEG) 400, was developed in a 10 mm critical gap model in rabbits (Grin. A. 2009, J Drug Del Sci. Tech 19, 241) and in a similar 35 mm model in mature ewes.

The membrane functions as a scaffold barrier that prevents soft tissue invasion into the defect and forms a "biological chamber" to guide osteoprogenitor (mesenchymal stem) cells in the process of bone regeneration (GBR). BoneCure Membrane has passed the biocompatibility and toxicology tests required by the FDA and the CE for human clinical use. We have used the membrane in more than 35 clinical cases so far in a multi-center study. Of these cases, seven fractures did not unite; with the period of non union ranging from three to six months. Two cases were operated upon twice: once with intra medullary pins, and subsequently with DCP and screws. The fracture did not heal following before the incorporation of the BoneCure membrane.

We have also used the BoneCure membrane in cases that carry a higher risk of and are prone to non union (e.g. radius-ulna fractures in small and miniature dogs, distal tibiae in cats), and those that are known to be genetically prone to non union, (e.g. lateral humeral condyle in spaniels). Clinical and radiological follow up reports are available for at least three months post operation for the majority of cases.

Our results show conclusively that dogs and cats suffering from long term non-unions healed both

radiographically as well as clinically following treatment with BoneCure membrane. It must be emphasized that no autograft or synthetic bone substitutes were employed. One spaniel with a lateral humeral condyle that had not healed radiographically, nevertheless improved clinically and is able to use its leg.

BoneCure Membrane was shown to be a safe and effective implant for management of non-union fractures in small animals. BoneCure is easy to use and reduces surgical procedure time and cost, as well as patient risk and morbidity.

Mechanical torsional properties of tibiae following modified maquet technique or tibial tuberosity advancement

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Introduction

The purposes of this study were to quantify the variations in biomechanical torsional properties of the tibia following Modified Maquet Technique (MMT) or Tibial Tuberosity Advancement (TTA), and compare MMT versus TTA.

Materials and methods

Twenty dogs were randomly assigned to MMT (n=10) or TTA (n=10) group. For each dog, one tibia was assigned for MMT or TTA and the contralateral tibia was used as a control. Tibiae were embedded in a polyester resin and tested up to failure at a constant 1°/s rate of internal rotation. Torsional strength, twist angle, rotational stiffness and energy absorbed at failure were calculated.

Result

When compared to the control leg, torsional strength and energy absorbed at failure were decreased for MMT and TTA ($p < 0.01$). There was no difference between MMT and TTA for these 2 parameters. Rotational stiffness was decreased for TTA $p = 0.02$, but not for MMT. The difference between MMT and TTA was significant.

Discussion/Conclusion

Both techniques decrease the biomechanical torsional properties of the tibia. Extending the osteotomy of MMT in the proximal diaphysis does not result in a higher decreased torsional strength and energy absorbed when compared to drilling 2 holes in the proximal diaphysis with TTA. Decreased rotational stiffness with TTA may be due to the diaphyseal screw holes. Considering that clinically TTA is not commonly associated with tibial fracture, tibiae with MMT are likely to withstand physiological torsional loading *in vivo*.

Treatment of thoracolumbar leptomenigeal adhesions and subarachnoid cysts associated with chronic disc herniation in 5 dogs

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Objective

To describe 5 cases of treatment of subarachnoid cysts associated with a chronic herniated disc by lateral corpectomy and dissection and removal of leptomenigeal adhesions

Study design

Animals: Dogs (n=5) with neurological symptoms consistent with a T3-L3 lesion and diagnosis of a subarachnoid cyst associated with a herniated disc.

Methods

Diagnosis of the lesions was made by myelography or computed tomography scanning. The same surgical procedure was performed for all dogs i.e. hemilaminectomy and lateral corpectomy, dissection and removal of the leptomenigeal adhesions.

Results

Myelography (2/5 dogs) and CT scanning (3/5 dogs) provided images consistent with a subarachnoid cyst. An associated herniated disc was visible on 3/5 dogs. A hemilaminectomy was performed. A protruded herniated disc was consistently observed during the surgery and treated by lateral corpectomy. Then, a dissection and a removal of the ventral adhesions present was performed in all dogs. Histopathology performed on ventral adhesions (2 dogs) indicated connective tissue proliferation with fibrosis. The mean hospitalization time was 3.8 days (3-4 days) with no or mild degradation (i.e. less than 1 grade) of the neurologic status at time of discharge. Follow-up studies (8 months to 4 years for surviving dogs) revealed an improvement of the neurological status in all dogs with a good outcome in 4/5 dogs (1 dog died from an unrelated cause 2 months post operatively) and there was no recurrence of spinal cord dysfunction.

Conclusions

Leptomenigeal adhesions resulting from combination of microtraumas and chronic inflammatory processes, created by a chronic herniated disc, may induce an enlargement of the subarachnoid space and may be a

significant causative factor in spinal cord compression and dysfunction. Treatment should focus on removing the adhesions rather than on draining the subarachnoid cyst only. The origin of the adhesive arachnoiditis should be explored, particularly in adult chondrodystrophic dogs, in which chronic herniated discs are frequent and effectively treated by lateral corpectomy.

Clinical relevance: Dissection and removal of the leptomenigeal adhesions is technically demanding but appears to provide good results. As a potential causative factor of adhesive arachnoiditis, chronic disc herniation should be investigated. The condition may effectively be treated by lateral corpectomy.

Intra-articular botulinum toxin a for treatment of osteoarthritic pain in dogs: a randomized, double-blinded, placebo-controlled clinical trial.

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Introduction

Treatment of advanced osteoarthritis (OA) poses a challenge to veterinarians. Recently, intra-articular botulinum neurotoxin A (IA BoNT A) has been proven effective in relieving joint pain in human patients. Our objective was to investigate the efficacy of IA BoNT A in osteoarthritic pain in dogs. The hypothesis was that IA BoNT A would provide significant pain relief compared to placebo.

Material and methods

The study was a placebo-controlled, randomized, double-blinded clinical trial with parallel group design and 12-week follow-up. Thirty-six dogs with chronic lameness due to OA were randomized to receive an IA injection of 30IU of BoNT A (Botox®; Allergan Pharmaceuticals Ireland) or placebo. The primary outcome variables were vertical impulse (VI) and peak vertical force (PVF) measured by a force platform, and Helsinki Chronic Pain Index (HCPI). Subjective lameness score was a secondary variable.

Results

VI and PVF improved from baseline to the end of study in the treatment group, but not in the placebo group. The change in VI was statistically significant. It was greatest at week 12 (1.1 100×Ns/N, SD4.6, P<.001). The change in PVF was statistically significant at week 12 (4.9 100×N/N, SD25.5, P=.05). The difference between the groups in PVF and VI change was not statistically significant. There were no significant changes in HCPI or subjective lameness score in either group.

Conclusion

The results indicate that IA BoNT A has some efficacy in reducing osteoarthritic pain in dogs. Therefore, IA BoNT A might have a role in the treatment of canine OA.

Total shoulder arthroplasty in two dogs for the treatment of severe glenohumeral arthrosis.

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Introduction

Total shoulder arthroplasty is well established in humans for treatment of proximal humeral fractures and glenohumeral arthrosis. Shoulder arthroplasty has not been previously reported in the veterinary literature.

Objectives

The aim of this case series is to describe a novel ball and socket prosthesis for treatment of severe shoulder joint pathology in two dogs.

Case 1: A 10 month old Hungarian Vizsla had suffered a fall at 5 weeks of age causing fracture of the proximal humeral physis and subsequent haematogenous septic arthritis. Subsequently, there was marked medial shoulder instability.

Case 2: An 8 year old, neutered female German shepherd dog with severe left thoracic limb lameness. The original injury was unknown, however historical osteochondrosis dissecans lesion was suspected. Both dogs demonstrated severe lameness and muscle atrophy of the left thoracic limb, with pain on shoulder manipulation. Radiographically, the shoulders were affected by severe osseous deformities.

Materials and Methods

Implants were designed using data from CT images. The implants consisted of a scapular-glenoid component with two plates and a prosthetic glenoid. In Case 1, the scapular-glenoid implant was 316L stainless steel and in Case 2 it was titanium. Both were coated with hydroxyapatite. An ultra-high molecular weight polyethylene (UHMW-PE) (Case 1) or poly-ether-ether ketone (PEEK) meniscus was cemented into the articular surface of the glenoid component. The humeral component was cobalt chrome and consisted of an intramedullary stem with a polished spherical head. The humeral components were cemented into the medullary canal with a contoured stem in case 1. In case 2, the stem was un-cemented (press-fit).

Results

In both dogs, force plate analysis demonstrated an initial reduction in ground reaction forces at 6 weeks followed by improvement over 6 months. Post operative radiography and CT at 3 and 6 months did not reveal any evidence of implant-related complications. The glenohumeral joints were non-painful in all phases of motion at all checks after 3 months. Case 1 demonstrated a low-grade mechanical lameness.

Conclusions

Semi-constrained shoulder prostheses were effective in the management of severe shoulder lameness which was non-responsive to medical treatment in these cases. The procedure has potential value as an alternative to shoulder arthrodesis in selected cases.

Comparison of two natural resorbable scaffolds containing autologous mesenchymal stem cells for bone regeneration in a sheep model

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Introduction

The use of resorbable tissue constructs containing mesenchymal stem cells (MSCs) is an appealing strategy for repairing massive segmental bone defects. However, their therapeutic effectiveness does not match that of autologous bone grafts because they do not allow consistent bone healing. Early and important scaffold resorption has been identified as a cause of failure to achieve bone union. In the present study, the osteogenic potentials of 2 constructs made of fully-resorbable granular scaffolds of similar chemical composition but of different resorption rates (Acropora and Porites coral scaffolds) loaded with autologous bone marrow-derived MSCs were compared. Our hypothesis was that the use of a scaffold with a slower resorption rate would allow more consistent bone healing.

Materials and methods

15 sheep underwent a 25 mm long metatarsal osteotomy stabilized with a 3.5 narrow DCP plate. Bone defects were replaced with either MSCs-Acropora constructs (n=7) MSCs-Porites constructs (n=6), or a morcellized autograft (n=2). Animals were sacrificed 4 months later and bone formation and coral resorption were documented by radiographic, histologic and microCT studies.

Results and discussion

Results were highly variable amongst animals in both scaffold groups: non-union occurred in half of cases of each group; in the other half, abundant new bone formation within the defect was observed allowing full bone regeneration in 2 animals from the Acropora group and 1 from the Porites group. MicroCT analysis confirmed great variations in the amount of newly formed bone in defects (1437±1089 mm³ and 782±507 mm³ for the Acropora and the Porites scaffold groups, respectively) with no statistical significance between both groups. In two Acropora-filled defects, volumes of newly formed bone were equivalent to the autograft-filled defects.

The resorption rate was slower and its magnitudes lower in Acropora compared to Porites scaffolds. Although

bone formation was not statistically correlated with coral resorption, 2 Acropora-filled defects with the highest rate of resorption showed the least amount of bone formation.

Our results provided evidence that bone regeneration, which matches the efficacy of autograft, is achievable using only MSCs and a granular, resorbable, osteoconductive scaffold. The capacity of the 2 scaffolds used in the study is statistically similar, despite their different resorption rates. This finding suggests that improving the ultimate performance of cell-containing constructs cannot be limited to the decreased rate of scaffold resorption.

Efficacy of ultrasonography for the investigation of canine orthopedic disorders: comparison with other diagnostic imaging tools and an investigation of its diagnostic validity

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Introduction

In this study, we investigated the detectability articular structures of healthy dogs by ultrasonography (US) and its examination time and compared the data with those obtained using other diagnostic imaging tools. We also studied the diagnostic validity of US and its measurement accuracy using the joints of dogs affected with hind limb orthopedic disorders.

Materials and Methods

Healthy beagles (n=3) without orthopedic disorders were used to determine the detectability of their joints by US and the respective time taken for US examination for each joint. The NA-US group underwent US with the dogs in restraints only, and the A-US group underwent US with the dogs under general anesthesia. Some joints of these dogs were also examined using CT (CT group) and MRI (MRI group). The detectability and the examination times were compared among the groups. Eighteen dogs that were diagnosed orthopaedic conditions including Legg-Calvé-Perthes disease (LCPD group), rupture of cranial cruciate ligament (RCCL group), and medial patella luxation (MPL group) were used to investigate the diagnostic validity and measurement accuracy of joint US. In each group, we investigated how the abnormal findings detected by US corresponded to the results of orthopedic examinations. The measurement data by US were additionally compared with those obtained using other diagnostic imaging tools.

Results

The examination times for the US groups were significantly shorter than those for the MRI group but longer than those for the CT group. No differences were found in the examination times and detected structures between the NA-US and A-US groups. In the LCPD group, US showed the highest sensitivity and could diagnose irregularity of the femoral head earlier in the progression of disease than radiography or CT. In the RCCL group, US detected irregularity of the CCL in all cases, and the results were the same as those obtained by orthopedic

examinations. Comparison of measurement accuracy among the diagnostic imaging tools showed that there were no significant differences detected in determination of the size of the patella and in the height of the femoral trochlear ridge.

Discussion

We could identify precise structures that were important for the diagnosis of canine orthopedic disorders using high-frequency linear US probe. The examination times were not significantly different between the NA-US group and A-US group, and the structures detected in the 2 groups were similar. These results suggest that US of the joints can be performed without general anesthesia. In this study, canine joint US showed many of the typical abnormal findings that have been reported in human beings with joint disease. US of the joints showed the highest detection rate of abnormal findings among the diagnostic imaging tools studied and the findings of US examination corresponded to the results of orthopedic examinations. Joint US may be a valuable diagnostic imaging tool for dogs with orthopedic disorders.

Biomaterial wedge for modified tibial tuberosity advancement technique in dogs

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Introduction

Tibial plateau is considered to be a predisposing factor for rupture of the cranial cruciate ligament (CCL) and, as a result, surgical techniques have emerged to alter the biomechanics of the stifle joint. These techniques do not restore the function of the CCL but provide functional stability during weight bearing. The modified Maquet procedure and tibial tuberosity advancement are osteotomy techniques for treatment of CCL rupture. These procedures are accomplished by performing an osteotomy of the tibial tuberosity with advancement of this bone segment in order to change the angle between the patellar ligament and the tibial plateau. The purpose of this experimental study was to evaluate a modified osteotomy technique for tibial tuberosity advancement in dogs using a biomaterial composed of ceramic and high molecular weight polymer in place of the routinely used titanium cage.

Material and Methods

Four male mongrel adult dogs, weighing between 18 and 25 kg, underwent a unilateral resection of the CCL and subsequently, the stifle joint was functionally stabilized using a modified tibial osteotomy technique. After a bicortical osteotomy, the tibial tuberosity was advanced cranially and a biomaterial wedge was inserted into the osteotomy gap in order to maintain the patellar ligament perpendicular to the tibial plateau. The tibial tuberosity and biomaterial wedge were fixed with two cortical screws and a tension band wire. Orthopaedic, radiographic, and ultrasound examinations were performed monthly until 180 days after surgery to evaluate the effectiveness of the modified technique and the biomaterial wedge. Tissue samples were obtained for histological analysis by biopsy of the caudal bone-biomaterial interface from all animals at 120 postoperative days.

Results

All animals showed partial recovery of weight bearing at 48 hours after surgery, and after 60 days of observation the animals had no lameness at walk or trot. Radiographic observation demonstrated progressive bone formation at the proximal surface of the biomaterial with correct

positioning of the implants, and in all four dogs there was complete bone formation at the distal osteotomy site at 180 days postoperatively. There was no sign of degenerative joint disease in any animal upon ultrasonographic and upon radiographic evaluation. Histological evaluation showed formation of connective tissue around the biomaterial and absence of bone integration. The biomaterial had not triggered inflammatory reaction or bone necrosis in adjacent tissues and it was osteoconductive.

Conclusion

The wedge implant used as spacer was biofunctional and biocompatible and was able to support the forces of normal activity during the post operative period. This modified osteotomy technique offers a new variant for this method of treatment of CCL rupture, allowing functional recovery of the limb.

Omini procedure, a modified over-the-top approach for the replacment of the cranial cruciate ligament in the dog using an artificial implant: a cadaveric study

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Objective

to describe and evaluate a new intra-articular approach for the treatment of cranial cruciate ligament insufficiency in dogs using an artificial ligament and new bone anchors.

Study design

ex vivo study.

Animals

twelve canine cadavers weighting between 26 and 45 kg.

Methods

a cranio-lateral approach was made to the stifle joint. An 8 mm hole was drilled in the tibia in the center of the insertion area of the cranial cruciate ligament. A helicoil with a modified tibial screw connected to an artificial ligament were inserted in the hole and the ligament was passed through the stifle in accordance with the "over-the-top" procedure. A second 8 mm tunnel was drilled in the distal femur and a helicoil and a modified femoral screw was inserted. The artificial ligament was inserted in the eyelet of the femoral screw, tensioned and fixed in place. After apposing the soft tissues, the cranial draw sign and the cranial tibial thrust were tested and medio-lateral and a cranio-caudal projection radiographs were performed.

Results

post-operative assessment showed a negative cranial draw test and a negative cranial tibial thrust, with good limb alignment and a normal ROM of the stifle joint. The radiographic control showed correct insertion of both tibial and femoral implants in all cases.

ConclusionS

this novel technique did not require a long learning curve and these initial mechanical tests of the new implant are encouraging. Further studies are necessary to investigate the effectiveness of this procedure "*in vivo*".

Radiographic measurement of the angle formed by the tibial plateau slope and the ground during stance in dogs

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Introduction

Cranial cruciate ligament (CCL) rupture is a common clinical problem in dogs, with a steep tibial plateau slope (TPS) thought to be one of the predisposing factors in the disease. Traditionally, the steepness of the TPS is approximated by the tibial plateau angle (TPA). Defined as the angle between the TPS and the perpendicular to the tibial functional axis, it is measured from a radiograph of the patient that is typically in lateral recumbency. The TPS: ground angle may add to our understanding of CCL rupture, but since the present method of measuring it (the "standing TPA") is difficult to perform, we evaluated a simplified method.

Materials and methods

In 15 adult beagles with no orthopedic disease, each hind limb was radiographed in lateral recumbency. Aided by radiopaque markers, the crus axis was identified by a line connecting the proximal and most cranial aspect of the tibial tuberosity and the center of the talus. A line was also drawn along the slope of the medial tibial plateau. Each limb was then photographed standing, and the crus axis:ground angle was calculated. Finally, for each hind limb, each radiograph was placed over the corresponding hind limb photograph so the crus axes coincided, making it possible to approximate the ground line in the radiograph and thus to determine the TPS:ground angle.

Results

The crus axis:ground angles ranged from 31.3° to 57.7° (median: 44.0°), with a mean of $44.1^\circ \pm 1.0^\circ$. There was no significant difference between the right and left limbs ($p=0.21$). The TPS:ground angle ranged from -10.3° to +5.3° (mean of $-6.1^\circ \pm 1.0^\circ$) when calculated with data from each individual dog and from -10.8° to +3.8° when calculated with the mean of the individual angles (overall mean of $-4.8^\circ \pm 0.7^\circ$). No significant difference between right and left limbs was found, but each mean differed statistically from a plane parallel to the ground ($p<0.001$ for each).

Discussion/conclusion

In CCL-deficient dogs, plateau-leveling osteotomy can restore hind limb function by eliminating cranial tibial thrust. While measuring the TPA is essential to this procedure, knowing the TPS:ground angle may add to our understanding of how the surgery achieves its effect. The negative TPS:ground angle that we observed in the beagle may be a new finding that warrants consideration by surgeons when determining the tibial plateau rotation angle. Moreover, the lack of inter individual variation in the crus axis:ground angles suggests that breed-specific standards can be developed, eliminating the need to photograph each dog. And while the standing TPA cannot be determined reliably in CCL-deficient dogs because their stance is affected, the TPA:ground angle may be measurable with our method.

Intra-articular hyaluronic acid administration to dogs with osteoarthrosis of the elbow joint: clinical results

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Introduction

Osteoarthritis (OA) is a common cause of lameness in dogs. Hyaluronic acid (HA) is a form of viscosupplementation, which has been shown to slow the progression of OA and decrease inflammation within the joint. Several clinical studies in humans have demonstrated relief of joint pain associated with OA following intra-articular injections of hyaluronic acid. The aim of our study was to determine change of the intensity of lameness in dogs with arthritic elbow joints after intraarticular HA application.

Materials and Methods

In a sample of 24 dogs with forelimb lameness and radiographically proven osteoarthritic pathology in the elbow joint, we injected into affected joints 1 ml of a product containing 10mg/1ml hyaluronic acid each week for 3 weeks. The degree of lameness was recorded before intra-articular administration of hyaluronic acid, during the treatment period, and at one month and at six months after the treatment period. Lameness was classified into a 5 level grading scale. Radiological changes in the elbow were assessed based on the grading system for OA and elbow dysplasia according to the International Elbow Working Group protocol. We compared the change of lameness within observation periods and the results were recorded as Lameness Improved (including dogs with no lameness), No Change and Lameness Worse.

Results

The sample (n = 24) comprised different breeds of dogs aged 6.1 ± 2.2 years, weight 37.6 ± 9.9 kg with a history of lameness ranging from two weeks to six months. Eleven dogs had lameness of 1st grade, nine dogs had 2nd grade lameness and four dogs had 3rd grade lameness before administration of hyaluronic acid. Six months after HA application 15 (62,5%) dogs showed improved lameness (including 4 dogs with no lameness) and 9 (37,5%) dogs had no change of lameness. We did not record dogs with worsened lameness. In dogs with grade 1 elbow OA, lameness improved in half of the dogs. For dogs with grade 2 OA, 8 dogs had improved lameness and 3 showed no change. For dogs with grade 3 OA, there was improvement in lameness in two dogs and there was no change in one dog.

Discussion / Conclusion

Intra-articular administration of HA in dogs with elbow OA can improve limb use and reduce lameness, but it has limited abilities to completely resolve lameness.

Plasma concentrations of transforming growth factor beta 1 in dogs with stifle osteoarthritis secondary to cranial cruciate ligament rupture

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Introduction

Osteoarthritis (OA) is the most common form of arthritis, involving cartilage, synovium and bone. Transforming growth factor beta 1 (TGF- β 1) is a potent inducer of cartilage extra cellular matrix synthesis and also it is a counteracting agent against interleukin-1 catabolic cartilage actions.

Materials/methods

Whole blood was collected from 24 entire male dogs, in tubes with k3 EDTA and ACD-A anticoagulants. From these dogs, an OA group was formed comprising 12 dogs which presented radiological signs of OA in stifle joint and cranial cruciate ligament rupture (confirmed by arthroscopy). The other 12 dogs formed the Control group. These were clinically healthy and radiologically normal. Plasma was obtained from the whole blood by centrifugation at 1500 g for 10 min. Concentration of TGF- β 1 (ng/mL) was determined by ELISA sandwich, specifically developed with antibodies against canine TGF- β 1 (Mouse/ Rat/Porcine/ Canine TGF- β 1, MB100B, R&D Systems, Minneapolis, USA). Reading (Biochrom, Anthos 2010, Cam-bridge, UK) was performed at 450 nm.

Results

The TGF- β 1 protein had a detection sensitivity of 4.6 pg/mL. ELISA was performed by duplicate for each sample according to the manufacturers instructions. The data did not show normal distribution, but responded to logarithmic transformation. Statistical analysis for comparing the TGF- β 1 concentrations between the two groups was performed by a t test for unrelated samples. Comparisons between anticoagulants were performed by a t test for related samples. When EDTA samples were analyzed, TGF- β 1 concentrations in dogs with OA (30.93 ± 25.30 ng/mL) were significantly higher ($P < 0.05$) than plasma concentrations of the dogs of the Control group (5.18 ± 4.32 ng/mL). In plasma samples with ACD-A results obtained were similar to those obtained in EDTA treated plasma. The TGF- β 1 levels were 28.32 ± 27.00 ng/mL in ACD-A plasma

of dogs with OA and 9.32 ± 8.55 ng/mL for the Control group respectively. No difference was found between the anticoagulants used.

Conclusions: TGF- β 1 is a potent inducer of cartilage extra cellular matrix synthesis. May be, the increase in plasma TGF- β 1 concentrations in canine OA, indicates articular anabolism as a joint repair effort. Possibly, TGF- β 1 could be helpful as a biomarker of OA in dogs.

Evaluation of glycerin conserved patellar ligament allograft, secured with interference screws as a substitute of the cranial cruciate ligament in dogs.

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Introduction

Our purpose was to evaluate the use of patellar ligament allograft conserved in glycerin and fixed with interference screws as a substitute of the cranial cruciate ligament (CrCL) in dogs. We observed the feasibility and efficiency of this technique using the graft and screws, followed over 120 days, based on clinical, radiographic and arthroscopic findings, including suggestive signs of chondropathy and degenerative joint disease (DJD).

Materials/methods

Eight cross breed dogs ($22,3 \pm 3,18$ kg) were enrolled into the study. The grafts used consisted of the intermediate third of the patella, patellar ligament and the cranial portion of the tibial crest, harvested from canine cadavers and preserved in 98% glycerin. For each of the eight cross breed dogs, the surgical procedure was performed on the right knee. Clinically, the evaluations performed included: degree of lameness, thigh girth measurement and presence of cranial draw. Evaluations were performed preoperatively, and weekly, until 120 days post operatively.

Results

In "stance", all the dogs demonstrated equal weight-bearing on both hind limbs 4 weeks postoperatively, showing a mean score that was not significantly different from the preoperative evaluation ($P > 0,05$). This fact was also observed with the "walk" variable after 5 weeks post operative. At the 120 post operative evaluation, 3 dogs showed slight lameness while "trotting" and the remaining 5 dogs had normal lameness scores. There was a significant decrease in thigh girth ($P < 0,05$) 10 days post operatively when the compressive bandages were withdrawn and this recovered by the 13th week post operatively. The cranial draw test scores (performed in flexion and in extension) became significantly different ($P < 0,05$) from the preoperative between the 5th and 15th weeks post operative. Four dogs presented at the final evaluation point with no articular instability indistinguishable from the preoperative evaluation, and the other four dogs had slight craniocaudal instability. Radiographically, signs of DJD were significantly higher

($P < 0,05$) than the preoperative assessment only at the 90 and 120 day evaluations. Percental increase in osteophytes was observed between the 30th and 60th post operative days and there was no statistical significance in DJD score in the subsequent evaluations. Post operative arthroscopic evaluations were performed for 4 dogs at 60 days following surgery and at 120 days post operative for 4 dogs. The patella was the only structure which appearance showed significant variation ($P < 0,05$) between group A and B. In the other articular cartilages, the changes observed were fibrillation and softening, but with no statistical significance ($P > 0,05$) between groups. All the grafts showed neovascularization and the interference screws were well fixed in the femoral tunnel.

Conclusion

The use of this technique appears to be a viable alternative to currently available treatments for partial or complete CrCL rupture in dogs. Further studies are necessary to evaluate for any situations for which this procedure could offer a superior prognosis compared with other surgical techniques.

The effect of configuration on the biomechanical performance of three different suture materials when used in combination with a metallic bone anchor.

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Introduction

Metallic bone anchors (MBA) are orthopaedic implants designed to facilitate the reattachment of soft tissues to bone. They have many useful applications in the field of veterinary surgery, but can be associated with a high risk of abrasive damage/premature failure of suture materials. Such failures can occur at the bone-MBA interface, suture-MBA interface (eyelet) or soft tissue-suture interface. For suture-MBA constructs, the most common mode of failure is suture breakage at the level of the eyelet due to an "unfriendly edge". The objective of this study was to determine whether alterations in suture material configuration could enhance the biomechanical performance of these constructs. We hypothesized that the likelihood of sutures to fail at the level of the eyelet would be reduced, and that loads to suture failure would be increased by protecting the suture at this location with a plastic tubing insert, or by using a double stranded suture configuration.

Materials and Methods

Suture-MBA constructs were evaluated via a materials testing unit. Strands of 60lb Nylon leader line (LL), #2 polyblend composite suture (PCS) and 150lb ultra-high molecular weight spun polyethylene (UHMWSP) were passed through the eyelet of a 3.5mm MBA in three different configurations: single strand (SS) [n=10], single strand plus plastic insert through the eyelet of the MBA (SSP) [n=10], double strand (DS) [n=10]. A uni-axial force was applied to each construct at a force/displacement rate of 60mm/second, until the point of suture failure. Force at failure (N), extension at failure (mm), force at 3mm extension (N), stiffness (N/mm), and mode of failure of the suture were recorded for each test.

Results

For all sutures, the DS configuration yielded significantly higher forces at failure and forces to generate 3mm of extension; it was also the stiffest configuration. The SS configuration demonstrated the lowest force at failure. The SSP configuration yielded greater forces at failure for all suture materials when compared to the SS configuration,

with comparable stiffness. All sutures failed at the eyelet in the SS and DS stranded configurations. In the SSP configuration, LL and UHMWSP had a reduced tendency to fail at the level of eyelet.

Conclusion

A DS suture configuration should be used clinically in combination with MBAs to improve the biomechanical performance of this construct. Protection of "unfriendly" edges in MBAs with softer materials could improve abrasion resistance and prevent premature suture failure.

Parasagittal partial patellectomy, a novel method for augmenting surgical correction of patellar luxation in 4 cats.

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This communication describes a novel surgical technique used to correct feline patellar luxation where abnormal patellar tracking persists despite conventional corrective surgery. There is little published information specific to feline patellar luxation (PL). As in dogs, a combination of femoral trochlear sulcoplasty, tibial tuberosity transposition, soft tissue imbrication and or release are performed to achieve stable patellar tracking in the trochlear sulcus. It was noticed that in some feline cases, PL persisted intra-operatively despite performing the standard surgical corrective procedures. An anatomic difference between feline and canine stifles is that the feline patella is wider and more shallow relative to the trochlear sulcus. This results in less constrained patellar tracking in the cat. Therefore the feline patella is more lax than the dog and patellar subluxation is common in normal cats. We report a novel surgical technique i.e. parasagittal partial patellectomy that is used for cases of persistent patellar luxation to address the wide shape of the feline patella relative to the trochlear groove and thus control patellar luxation. This technique has been successfully performed in four cats with good outcome and without complication in each case. However, the risk and mechanical effect of parasagittal partial patellectomy has not been fully investigated and consequently, in the authors' hands, the technique is currently reserved for surgical cases in which patellar luxation cannot be controlled by conventional means.

The effect of contouring a tibial plateau leveling osteotomy plate on the magnitude of osteotomy compression.

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Introduction

TPLO plates often need significant contouring to conform to the medial aspect of the proximal tibia. Guidelines suggest that screws are inserted parallel to or away from the joint surface to ensure that inadvertent penetration of the stifle joint does not occur.

Some TPLO plates have the dynamic compression unit (DCU) in their proximal portion. Both angulation of the DCU to the long axis of the bone and angulation of the screw to the DCU have the potential to affect the magnitude of osteotomy compression. We hypothesize that the compression generated by the DCU will decrease at plate angles above 30°.

Materials and methods

The distal portion of a Slocum TPLO plate was attached to a horizontally positioned polyoxymethylene rod that was attached to a load cell. A segment of synthetic cortical bone substitute was attached to the end mount of the testing frame and adjusted to conform to the angle of the proximal portion of the TPLO plate. A universal drill guide in compression mode was positioned in the proximal DCU. A 2.5mm hole was drilled across the bone substitute perpendicular to the horizontal axis. A 3.5mm self-tapping screw was partially inserted, the load cell "zeroed" and then the screw tightened to 1.5Nm. The peak load (N) was recorded. Screw insertion and data collection was repeated for proximal plate angles of 0°, 5°, 10°, 15°, 20°, 25°, 30°, 35° and 40° on 9 brand new Slocum TPLO plates. A repeated measures ANOVA and post hoc multiple comparisons Bonferroni test was performed. Statistical significance was set at $p < 0.05$.

Results

A significant increase in the compression generated was observed as the plate angle was increased from 0° to 10°. The compression ceased to increase significantly until the plate was bent more than 20° after which a significant decrease in compression was noted. A marked reduction in the compression generated occurred at plate angles greater than 30°. The "osteotomy" would have

been distracted (rather than compressed) in a third of the plates bent to 40°.

Discussion

Contouring a TPLO plate that has the DCU in the proximal portion can markedly affect the degree of inter-fragmentary compression generated. In the current model an effort was made to ensure that the proximal screw placement was perpendicular to the horizontal axis of the bone model. However, it should be noted that in clinical cases screws are often angled away from the stifle joint to ensure that the joint is not penetrated. This will result in an exaggeration of the effect on compression at any given angle. Angulation of the DCU and screw insertion angle can have deleterious effects on the magnitude of osteotomy compression if the proximally placed screws are used to create compression. Surgeons intending to use the proximal screws to compress the tibial osteotomy in TPLO should be aware of the effective angle of insertion of screws when applying contoured TPLO plates, and when choosing to angle screws in regular plate application.

Influence of tibial rotation on cage size measurement for TTA

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Introduction

Tibial tuberosity advancement (TTA) alters the direction of the patellar tendon so that the Patellar Tendon Angle (PTA) becomes 90°. The size of the implanted cage is the main determinant of the advancement. To allow accurate identification of the anatomical landmarks for precise cage size estimation, a true medio-lateral projection of the stifle joint is required. Correct positioning is confirmed when the femoral condyles are superimposed. No reported studies to date have investigated the effect of rotation of the tibia on cage size selection. We hypothesized that internal rotation as well as external rotation of the tibia from a true lateral projection would result in underestimation of the cage size required to achieve a PTA of a 90° as a result of artefactual caudal 'relocation' of the tibial tuberosity.

Materials and methods

Three left and 3 right stifle joints of 6 medium to large breed skeletally mature dogs were investigated. Standard medio-lateral radiographs of each stifle were obtained, confirmed by superimposition of both femoral condyles. At a joint angle of $\geq 135^\circ$, 9 radiographic projections were acquired, with the tibia fixed at different degrees of internal and external rotation: 0°, 5°, 10°, 15° and 20°. Measured advancement, using the common tangent method, was converted into cage size.

Results

Twenty degree of internal rotation of the tibia significantly reduced the estimated amount of advancement, while all other states of rotation did not change the measured advancement significantly when compared to the neutral position. Moreover only internal rotation of the tibia of 15 and 20° significantly reduced the estimated cage size required to achieve a PTA of 90° ($P=0.001$). Even though only internal rotation of 15° and 20° produced a significant change in estimated cage size, external rotation of 5° and internal rotation of 10° tended to decrease the estimated advancement cage required by 1 size.

Discussion

Tibial rotation does significantly affect estimation of cage size. An internal rotation of 15° and more will significantly decrease the estimated cage size required for TTA, by 1.5 cage sizes, on average. Therefore under correction might be the result. Generally, internal rotation affects the measurement more than external rotation. Even though we expected a change in cage size when rotating the tibia, we anticipated a false increase in cage size. The potential reason for this contradictory observation might be the fact that the measurement of required cage size does not only depend on the position of the tibial tuberosity but also on the ability of the surgeon to reliably determine the tibial centre point when using the common tangent method. In case of an unexpectedly large cage size, tibial rotation identified on the x-ray should not lead to downscaling of the cage size, as tibial rotation would result in underestimation rather than in overestimation of cage size.

Kinematic gait analysis of the thoracic limb of normal dogs and patients with confirmed medial compartment disease using a six-degrees of freedom marker set

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Introduction

The dual objectives of this study were first to document thoracic limb gait patterns encompassing all three planes of motion in normal dogs and then to compare these with dogs affected by disease of the medial coronoid process (MCD) using a six degrees of freedom (6DOF) marker set.

Material and methods

Two groups of 13 Labrador retrievers (n=26 thoracic limbs) were selected, which represented the normal canine population and dogs with confirmed MCD respectively. All normal dogs used in this study were classified as having normal hip and elbow scores according to the International Elbow Working Group and the British Veterinary Association guidelines. MCD was confirmed using radiographs, CT-scan and arthroscopy after kinematic gait analysis was completed.

Dogs were walked on a canine specific treadmill at 0.7 ± 0.06 m/s. Kinematic gait analysis using a 6 DOF marker set was used to track the movement of the thoracic limbs during locomotion.

From an average of 74 and 68 cycles per dog in the Normal and in the MCD group respectively, the average gait pattern for each dog was produced for the humerus, the antebrachium and the elbow ranges of motion in all three planes. This data was used to create the average gait pattern for each group. The standard deviation at each percentage point of the gait cycle was then joined to create a confidence band (CB) across the gait cycle.

The average gait pattern and CB from both groups were overlaid for each plane of motion, which allowed for objective cohort comparison. Differences were deemed significant if the average gait pattern of one group was outside the CB of the other. Reliability of the gait patterns was calculated using the intra-class correlation coefficient (ICC) with results ≥ 0.75 showing good reliability.

Results

For both cohorts, good reliability was shown in all planes for the motion patterns of the antebrachium and of the elbow. The results from the humeral motion pattern showed good reliability in the sagittal plane only. Four significant differences were identified in the gait cycle; the elbow being 9 degrees more extended between 43%-55% of the gait cycle and 18° more externally rotated prior to, during and after foot strike (33%-56% of the gait cycle) and the antebrachium being 3° more abducted during early stance (50%-79% of the gait cycle) and 8° more supinated at foot strike.

Conclusions

Using a 6DOF marker set has allowed gait patterns to be compared, in all three planes of motion, between normal dogs and dogs with MCD. The higher degree of supination found in dogs affected by MCD could be an attempt to unload the most cranial part of the MCP and therefore to reduce elbow pain. It is however impossible to conclude whether our findings are consequences of MCD or intrinsic to aetiopathogenesis.

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