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EQUINE VETERINARY EDUCATION

American Edition | August 2020

EQUINE VETERINARY EDUCATION/AMERICAN EDITION

VOLUME 32 NUMBER 8

AUGUST 2020



The official journal of the
American Association of
Equine Practitioners, produced
in partnership with BEVA.

IN THIS ISSUE:

- AAEP 66th Annual Convention & Trade Show Registration Kit
- Transnasal endoscopic treatment of equine sinus disease in 14 clinical cases
- Intervertebral disc disease of the cervical and cranial thoracic vertebrae in equidae: eight cases



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1 Data on file.

2 Adequan® i.m. Package Insert, Rev 1/19.

3 Burba DJ, Collier MA, DeBault LE, Hanson-Painton O, Thompson HC, Holder CL: In vivo kinetic study on uptake and distribution of intramuscular tritium-labeled polysulfated glycosaminoglycan in equine body fluid compartments and articular cartilage in an osteochondral defect model. *J Equine Vet Sci* 1993; 13: 696-703.

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AMERICAN EDITION

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66th Annual Convention & Trade Show
December 5-9, 2020 | Las Vegas, Nevada



SHINE: Bright Lights, Winning Ideas



Although COVID-19 has imposed inconceivable challenges on the practice of equine veterinary medicine, the crisis also has reinforced the timelessness and importance of sound medicine, disciplined management, collaboration, and personal wellbeing.

This December, amid the bright lights of the entertainment capital of the world, acquire winning ideas that will help you and your practice shine through economic crisis and recovery:

- Expand your clinical skill set with hands-on lab instruction in practical areas such as ultrasound, dentistry, podiatry, navicular bursa injection, and more.
- Raise your level of patient care in core areas with multiple sessions devoted to lameness, imaging, rehabilitation, sports medicine, and theriogenology/neonatology.
- Go from surviving to thriving with the business wisdom and proven methods employed by successful practice owners.

While relevant take-home knowledge is the cornerstone of its CE events, the AAEP also prioritizes the health and safety of attendees and is working with all convention vendors and host property Mandalay Bay to meet CDC guidance and industry best practices for disease prevention. The most current protocol status is available at **convention.aaep.org**.



Download the AAEP Convention App



Enhance your meeting experience with the AAEP Convention App. Browse sessions and speakers, create a personal itinerary and take notes; search, filter and contact exhibitors; create your own profile and message other attendees; swap ideas, photos and lessons learned with other attendees; view and post to the event stream on Twitter; and access *Proceedings* papers closer to the event. Search “AAEP Education” at your app store to download.

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Social Events

A complete list of the receptions and social events planned for the convention can be found at convention.aaep.org.

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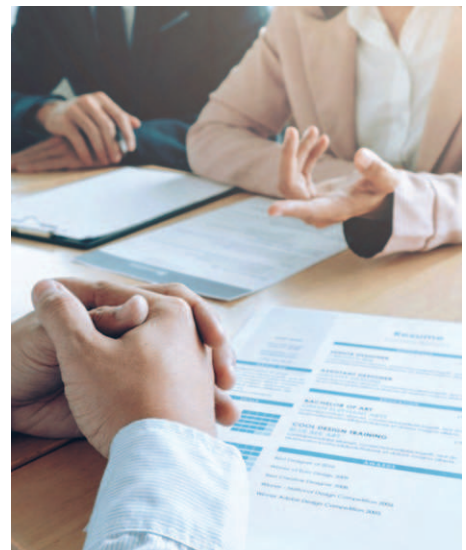
Are you in between jobs or looking for a new opportunity? Let AAEP help get your résumé in front of practices looking to hire at convention.

Meet with employers and recruiters to discuss your skill set and qualifications for their job openings. Here's how. Beginning Oct. 15:

1. Create or log in to your AAEP Career Center account at jobs.aaep.org.
2. Upload your résumé if you haven't already done so.
3. Indicate on your account page that you'll be attending the Career Fair at the convention, which will flag your résumé for participating employers to review and contact you (confidentially if you prefer).

You'll also be able to view a list of participating employers and create email job alerts to be notified of new Career Fair listings.

If you have questions about the Career Fair, contact Megan Gray, member concierge, at mgray@aaep.org.



EDUCATIONAL PROGRAM

Speakers, times, and topics are subject to change.

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SUNDAY, December 6

Morning

8:00 a.m. Opening Session

Moderator: Scott Hay

9:00-10:00 a.m. Keynote: Resiliency

Ronan Tynan (see next page)

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10:15 a.m. Kester News Hour

Enabled by a grant from the estate of Dr. Wayne O. Kester, the Kester News Hour highlights the latest scientific papers in specific areas of equine medicine. Presenters listed below and pictured from left.



Anchors: Regina M. Turner and Katherine S. Garrett
Forecaster: Amy L. Johnson; Sportscaster: Sherry Johnson;
Field Reporter: Eric Mueller

Afternoon

In-Depth: It's Not Black and White: The Relationship Between Imaging Findings and Lameness

Moderator: Myra F. Barrett

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- ✨ 1:30 p.m. Significance of Radiographic Findings in Racehorses – Sue Stover
- ✨ 2:25 p.m. Diagnostic Imaging Findings in English Sport Horses in Relation to Performance and Lameness – Sarah M. Puchalski
- ✨ 3:20 p.m. How Imaging Correlates to Prognosis, Rehabilitation, and Return to Work – Lauren V. Schnabel
- ✨ 4:15 p.m. How Imaging Findings in Western Sport Horses Relate to Performance and Lameness – Myra F. Barrett

How-to Session: Feeding for Fitness

Moderator: Kelly R. Vineyard

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- 1:30 p.m. How to Select Forages for Equine Athletes – Krishona Martinson
- 1:50 p.m. How to Select a Concentrate for Performance Horses – Stephen E. Duren
- ✨ 2:10 p.m. How to Feed the Overweight Performance Horse – Megan L. Shepherd
- 2:30 p.m. How to Feed Performance Horses for Optimal Digestive Health – Kelly R. Vineyard
- 2:50 p.m. Feeding Performance Horses with Myopathies – Joe D. Pagan
- 3:10 p.m. How to Support Immune Function Through Nutrition – Lori Warren
- 3:30 p.m. Effects of Low-Dust Forages on Racehorses' Airway Health – Laurent L. Couëtil
- 3:50 p.m. Role of Dietary Pro-Resolving Lipid Mediators in Resolution of Equine Asthma – Carla Olave
- 4:10 p.m. Effects of Supplements Containing Turmeric and Devil's Claw on Equine Gastric Ulcer Scores and Gastric Juice pH – Michael St. Blanc

Back to Basics: The Acute Abdomen in the Field

Moderator: Louise L. Southwood

Sponsored by IDEXX, the worldwide leader in veterinary diagnostics.

- ✨ 1:30 p.m. How to Interpret History and Physical Examination Findings of a Horse with an Acute Abdomen in the Field – Louise L. Southwood
- ✨ 2:00 p.m. How to Safely and Effectively Perform Abdominal Palpation per Rectum – Diana M. Hassel
- ✨ 2:30 p.m. How to Perform a Diagnostic FLASH – Cris Navas
- ✨ 3:00 p.m. How and When to Consider Advanced Diagnostic Procedures in the Field: Point-of-Care Lab Data and Abdominocentesis – Diana M. Hassel
- ✨ 3:30 p.m. How to Manage a Horse with Colic in the Field – Anthony Blikslager
- ✨ 4:00 p.m. How and When to Refer the Horse with Colic That is Not Responding to Medical Management – Louise L. Southwood
- ✨ 4:30 p.m. How to Help Your Client with Their Horse Following Colic Surgery: Expectations, Potential Complications, and Ongoing Care – Anthony Blikslager

Theriogenology

Moderator: *Juan Samper*

Sponsored by *Merck Animal Health, makers and manufacturers of Regumate®.*

- 1:30 p.m.** Stallion Semen Cooling Using Native Phosphocaseinate-Based Extender and Sodium Caseinate Cholesterol Loaded Cyclodextrin-Based Extender – *Igor F. Canisso*
- 1:50 p.m.** One-Hour Post-Breeding Lavage Does Not Affect Pregnancy in Mares Bred with Frozen Semen – *Juan Samper*
- 2:10 p.m.** Reproductive Outcomes of 71 Thoroughbred Mares Following Unilateral Ovariectomy of Granulosa Cell Tumor/Granulosa-Theca Cell Tumor – *Sheila G. Spacek*
- 2:30 p.m.** Use of Interleukin-6 (IL-6) as a Biomarker for Ascending Placentitis – *Carleigh E. Fedorka*
- 2:50 p.m.** Doppler Indices of the Fetal Carotid Artery Throughout Gestation – *Stefania Bucca*
- 3:10 p.m.** Intrauterine Administration of Platelet-Rich or -Poor Plasma Mitigates Persistent Breeding-Induced Endometritis in Mares – *Lorenzo G.T.M. Segabinazzi*
-  **3:30 p.m.** Review of Foal Heat Breeding Options – *Patrick M. McCue*
- 3:50 p.m.** Recumbency as a Risk Factor for Mare and Foal Survival Following In-Hospital Dystocia Management – *Heather Roe*
- 4:10 p.m.** Prediction of Gestational Age Based on Fetal Ultrasonographic Biometric Measurements in Quarter Horses – *Catherine D. Renaudin*

- 4:30 p.m.** Inflammatory Protein Biomarkers in the Low-Volume Lavage of Mares with Endometritis and Degenerative Endometrial Fibrosis – *Jennine M. Lection*

- 4:50 p.m.** Iodine Levels in Extensively Managed Broodmares and their Foals – *Maria F. Lopez-Rodriguez*



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Seating is limited so please arrive early.

1:30-3:00 p.m.

Dealing with Upset or Difficult Clients – *Alan Donnell and Barbara Dallap Schaer*

Diagnosing the Neurologic Horse in the Field – *Amy L. Johnson and Steve Reed*

Updates on Antimicrobial Therapy/Responsible Use and Stewardship – *Ben Buchanan*

Sole Proprietorship vs Corporation vs LLC – *Andy Clark and Martha Mallicote*

3:30-5:00 p.m.

Debt Management (Student) – *Amy L. Grice and Joe Pluhar*

How to Set Professional Service Fees – *Monty McInturff and Jim Zelff*

Ophthalmology – *Carol Clark and Leslie Easterwood*

Sports Medicine Diseases with Surgical Options – *Lane Easter and Ryland Edwards*

KEYNOTE ADDRESS: Resiliency

Ronan Tynan, MD



Few professions align passion and purpose like equine veterinary medicine. While knowledge and skill are essential to success, resiliency is critical to coping with the immense demands of the profession while meeting the demands of everyday life.

In a particularly timely and inspirational keynote address, modern-day Renaissance man Ronan Tynan will discuss resiliency through the lens of his own perseverance through numerous challenges, which he accomplished with enormous passion and determination. Introduced to international audiences as a member of the Irish Tenors, Tynan did not seriously consider formal voice study until age 33, while well into his residency as a physician.

Born with a lower limb disability, Tynan learned how to ride horses and began competing in point-to-point races by 16. An auto accident at 20 led to amputation of his legs below the knee. Within a year, he was winning international track and field competitions; he represented Ireland in the 1984 and 1988 Summer Paralympics, winning four gold medals, two silvers and one bronze.

The determination instilled by his parents soon propelled Tynan to conquer a whole new field. He became the first disabled person ever admitted to the National College of Physical Education and, later, became a full-fledged medical doctor specializing in orthopedic sports injuries, with a degree from prestigious Trinity College.

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EDUCATIONAL PROGRAM

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MONDAY, December 7

Morning

Frank J. Milne State-of-the-Art Lecture

7:30-10:15 a.m. Moving Equine Anesthesia from an Art Toward a Science

John A.E. Hubbell (see next page)

Moderator: Ryland Edwards

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The Business of Practice: Strengthening the Foundation of Your Practice

Moderator: Martha Mallicote

- 8:00 a.m. Business News Hour – Caitlyn Daly, Amy L. Grice, and Mike Pownall
- 9:00 a.m. Loan Repayment: Programs and Strategies for Equine Vets – Martha Mallicote
- 10:00 a.m. Why Veterinarians Are Leaving Equine Practice – Amy L. Grice
- 10:20 a.m. How to Employ the Four-Principles Approach for Resolving Ethical Dilemmas in Equine Practice – Barb Crabbe
- 10:40 a.m. Use of a Net Promoter Score Survey to Improve Business Growth, Profitability and Client Loyalty – Mike Pownall
- 11:00 a.m. Review of Equine Hospital Design Techniques for Controlling Infectious Disease – Heather E. Lewis and Lucas Pantaleon

Afternoon

In-Depth: Interactive Lameness Diagnosis

Moderator: Matt Brokken

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1:30-5:00 p.m.

Lameness cases beneficial for all equine practitioners will be presented, varying from common lameness to those with advanced diagnostics. The diverse backgrounds of the panelists will allow multiple perspectives on how to identify, diagnose, treat, and manage horses with performance-limiting lameness. Audience participation and feedback will guide discussions.

Panelists: Vern Dryden, Johanna Kremberg, and Michael Porter

In-Depth: Neonatology

Moderator: Nathan M. Slovis

- ✨ 1:30 p.m. Neurologic Examination in the Foal – Monica Aleman
- ✨ 2:20 p.m. Quality Control: Genetic Testing in Foals – Carrie J. Finno
- ✨ 3:10 p.m. Hormones in Critically Ill Foals: The Good, the Bad, and the Ugly – Ramiro E. Toribio
- ✨ 4:00 p.m. Diarrhea in the Neonate: Is There Anything Really New? – Nathan M. Slovis

Sports Medicine and Rehabilitation

Moderator: Meg Mullin

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- 1:30 p.m. Autologous Bone Marrow Mononuclear Cells Modulate Joint Homeostasis in an *in vivo* Model of Synovitis – Bruno C. Menarim
- 1:50 p.m. Bone Marrow Mononuclear Cell Therapy for Equine Joint Disease – James B. Everett
- 2:10 p.m. A Pooled Equine Platelet-Rich Plasma Lysate Biologic as a Novel Disease-Modifying Osteoarthritis Therapy – Lauren V. Schnabel
- 2:30 p.m. Platelet-Rich Plasma Lysate Improves Bacterial Load and Outcomes of *Staphylococcus aureus* Infectious Arthritis in Horses – Lauren V. Schnabel
- 2:50 p.m. How to Manage Back Pain in Horses – Erin Contino



- 3:10 p.m.** Objective Assessment of Pulsed Electromagnetic Field Therapy on Horses with Clinical Back Pain – *Melissa R. King*
- 3:30 p.m.** Identification of Genomic Loci Associated with Performance-Limiting Kissing Spines in Quarter Horses and Warmbloods – *Beau Whitaker*
- 3:50 p.m.** Relationship Between Postural Stability and Paraspinal Muscle Adaptation in Lamé Horses Undergoing Rehabilitation – *Katherine L. Ellis*
-  **4:10 p.m.** Review: Management of Pain Associated with Laminitis in the Horse—Evidence for Therapies – *Katherine L. Ellis*
- 4:30 p.m.** Effects of Horseshoe Characteristics and Surface Composition on Shear Forces on the Equine Digit – *Tara Doherty*
- 4:50 p.m.** Association of mRNA Biomarkers with Catastrophic Racing Injuries in Thoroughbreds – *Allen Page*



The Business of Practice: Navigating Important Corporate and Legal Matters

Moderator: Tom Timmons

- 1:30 p.m.** What You Should Know about Corporate Practice Sales – *Charlotte Lacroix*
-  **2:20 p.m.** Issues to Negotiate in Contracts Seen in Practice – *Charlotte Lacroix*
- 3:10 p.m.** Employee Performance Coaching and Setting Goals – *Charlotte Lacroix*
- 4:00 p.m.** Cannabis in Your Patients and Legal Conundrums – *Charlotte Lacroix*



Table Topics

Sponsored by Dechra Veterinary Products.

Seating is limited so please arrive early.

1:30-3:00 p.m.

Infectious Diseases at Large Competitions – *Nicola Pusterla and Ashley Whitehead*

Equine Biologic Therapies – *Ali Daniel and Kathryn A. Seabaugh*

Equine Gastric Ulcer Syndrome – *Frank Andrews and Ben Buchanan*

Tips and Tricks for Getting Good Ultrasound Images – *Myra F. Barrett*

3:30-5:00 p.m.

CEM – It's a Night-Mare: Responsibilities When Monitoring CEM at Equine Events – *Amber Headen and Iwona Popkowski*

Pain Management – *Lori Bidwell and Rachel Hector*

Pre-Purchase Exam: Improving Cervical Spine Imaging in the Field – *Kurt Selberg and Natasha Werpy*

Meet the Expert: Effects of Low-Dust Forages on Racehorses' Airway Health – *Laurent L. Couët*

Meet the Expert: Milne Lecture – *John A.E. Hubbell*

FRANK J. MILNE STATE-OF-THE-ART LECTURE:

Moving Equine Anesthesia from an Art Toward a Science



John A.E. Hubbell DVM, MS, DACVAA
Chief of Anesthesiology, Rood and Riddle Equine Hospital
Professor Emeritus, Veterinary Clinical Sciences, The Ohio State University College of Veterinary Medicine

Since dawn of the modern era of equine anesthesia and analgesia in the 1960s, significant advances have been driven by the development of complex surgical procedures and advanced imaging modalities that require extended periods of general anesthesia. Despite the many advances, however, anesthesia of the horse remains more perilous than anesthesia of the other domestic species.

During his lecture, acclaimed veterinary anesthesiologist Dr. John Hubbell will trace the development of modern anesthetic methods, identify current best practices and areas of needed improvement, and postulate pathways for enhancing the safety of equine anesthesia in the future.

Dr. Hubbell received his veterinary degree in 1977 from Ohio State, where he served on faculty from 1982 until 2015, when he joined Rood & Riddle. He is author of numerous articles on veterinary anesthesia and co-author of two textbooks: *Handbook of Veterinary Anesthesia* and *Equine Anesthesia Monitoring and Emergency Therapy*.

Sponsored by



EDUCATIONAL PROGRAM

☀ Denotes a core concept for new graduates.

TUESDAY, December 8

Morning

Early Riser Session Pre-Purchase Examinations: Ethical Dilemmas and Best Practices

Moderator: Kenton Morgan

Sponsored by Merck Animal Health. *The Science of Healthier Animals*; and Zoetis, "For Animals. For Health. For You."

6:30-8:00 a.m. Panel: How to Avoid Problems Before and After Pre-Purchase Examinations

Common issues with the pre-purchase examination will be discussed and best practices proposed during this ethics-focused panel. Topics will include the following:

- The right of full disclosure and full knowledge during the pre-purchase and pre-lease process (PLE)
- Types of conflicts and pre-purchase exams and PLEs
- Off-label use of drugs and pre-purchase examinations
- Best practices
- Exposure scenarios taken from real cases

Panelists: Avery Chapman, Ernie Martinez, Nina Mouledous, Phoebe Smith, and Ted Vlahos

Lower Limb Dissection

Moderator: Raul J. Bras

- ☀ **8:00 a.m.** Lower Limb Dissection: Live Demo – Mitch Taylor
- ☀ **9:30 a.m.** How to Evaluate Foot Conformation and Understand the Effect of Shoeing on Load Distribution – Renate Weller
- ☀ **10:15 a.m.** How to Understand Lameness: The Link between Force and Movement Asymmetry – Thilo Pfau
- ☀ **11:00 a.m.** How to Shoe for Quarter Cracks – Stuart Muir



Medicine: Non-Infectious Diseases

Moderator: Ashley Whitehead

Sponsored by Boehringer Ingelheim, the market leader in equine health.

- 8:00 a.m.** Inhaled Ciclesonide in Horses with Severe Equine Asthma: Results of a Large Prospective European Clinical Trial – R. Scott Pirie
- 8:20 a.m.** A Retrospective Study of Exercise-Induced Pulmonary Hemorrhage and Asthma in Barrel Racing Horses in Texas – Laszlo Hunyadi
- 8:40 a.m.** Neonatal Dysphagia and Racing Performance in Standardbreds Born Near Unconventional Natural Gas Development Activity – Kathleen R. Mullen
- ☀ **9:00 a.m.** Practical Clinical Research Results to Consider When Testing for PPID in Horses – John C. Haffner
- 9:20 a.m.** Review: Optimizing the Efficacy of Oral Omeprazole – Ben Sykes
- 9:40 a.m.** Ureterolithiasis in 15 Horses: Clinical and Ultrasonographic Findings – Linda Dillenbeck
- 10:00 a.m.** How to Perform Whole-Blood Transfusions in the Horse – Ashley Whitehead
- 10:20 a.m.** Serum and Cerebrospinal Fluid Phosphorylated Neurofilament Heavy Concentrations as a Biomarker of Equine Neurodegenerative Diseases – Lisa Edwards
- ☀ **10:40 a.m.** Impact of Concurrent Treatment with Omeprazole on Phenylbutazone-Induced Gastric Ulceration in Horses – Heidi Banse

Imaging and Rehabilitation

Moderator: Sarah Sampson

- ☀ **8:00 a.m.** Deep Digital Flexor Tendinopathy in the Pastern Is Associated with Additional Lesions Within the Foot – Elizabeth Acutt
- 8:20 a.m.** Factors Affecting Successful Ultrasound-Guided Injection of the Podotrochlear Bursa Using a Palmarolateral Approach – Pablo Espinosa-Mur
- 8:40 a.m.** External Transcutaneous Ultrasound Technique in the Equine Cricoarytenoideus Dorsalis Muscle: Assessment of Muscle Size and Echogenicity with Resting Endoscopy – Masato Satoh

- 9:00 a.m.** Comparison of Radiographic and Magnetic Resonance Imaging Findings in the Proximal Metatarsus in 35 Horses – *Frances Hinkle*
- 9:20 a.m.** How to Perform Plantar Non-Weight Bearing Ultrasonographic Evaluation of the Equine Hind Proximal Suspensory Ligament – *Kimberly D. Trolinger-Meadows*
- 9:40 a.m.** Review of Non-Weight Bearing Proximal Suspensory Ligament Ultrasound for Alterations in the Muscle/Fat Indicating Pathologic Change – *Natasha Werpy*
- 10:00 a.m.** Standing PET Imaging of the Racehorse Fetlock: System Validation and Early Descriptive Data – *Mathieu Spriet*
- 10:20 a.m.** How to Perform Digital Venography Including the Dorsal 60° Proximal-Palmarodistal Oblique Radiographic Projection for Evaluation of Equine Digit Pathology – *Kimberly D. Trolinger-Meadows*
- 10:40 a.m.** Racing Performance of Yearlings Identified with Subchondral Cystic Lesions on the Distal MC3/MT3 Condyle – *Mitja Miklavcic*
- 11:00 a.m.** Effects of Aquatic Conditioning on Cartilage and Bone Metabolism in Young Horses – *Brittany L. Silvers*
- 11:20 a.m.** How to Determine the Presence of Musculoskeletal Pain in Ridden Horses by Application of the Ridden Horse Pain Ethogram – *Sue Dyson*
- 11:40 a.m.** High-Power Laser Therapy Improves Healing of the Equine Suspensory Branch in a Standardized Lesion Model – *Mathilde Pluim*



The Business of Practice: Managing the Health of Your Practice and Personnel

Moderator: Mike Pownall

- 8:00 a.m.** “Healthy Practice” Measures for Solo- and Multi-Doctor Practices – *Marsha Heinke*
-  **9:00 a.m.** Strategies for Improving Financial Health Using Benchmarks – *Marsha Heinke*
- 10:00 a.m.** Staying Safe and Comfortable in Practice During Pregnancy – *Amy L. Grice*
- 10:20 a.m.** Veterinary-Specific Risks in Practice for Pregnant Women – *Amy L. Grice*
- 10:40 a.m.** Tips on Preventing Pre-Purchase Exam Malpractice Complaints – *Nina Mouledous*



Table Topics

Sponsored by Dechra Veterinary Products.
Seating is limited so please arrive early.

8:00-9:30 a.m.

- Dental and Sinus Complications – *Jack Easley*
- Managing the Mare with Abnormal Estrous Cycles – *Jenn Linton and Patrick M. McCue*
- Saddle Fit and Its Contribution to Lameness – *Erin Contino and Sue Dyson*
- USEF/FEI Updates – *Kent Allen and Stephen Schumacher*

10:00-11:30 a.m.

- Assisted Reproductive Techniques – *Jennifer Hatzel*
- Hind Limb Lameness – *Richard D. Mitchell and Cooper Williams*
- Pregnancy in Practice – *Sarah Cohen and Laura Javscas*
- Meet the Expert: How Imaging Findings in Western Sport Horses Relate to Performance and Lameness – *Myra F. Barrett*

Afternoon

In-Depth: Medication and Therapeutics for Racehorses

Moderator: Scott D. Stanley

- 1:30 p.m.** Overview on Racehorse Medications – *Heather Knych*
- 2:15 p.m.** Approaches for Equine Medication Control (Anti-Doping) – *Scott D. Stanley*
- 3:00 p.m.** Responsible Use of Medication in Performance/Racehorses – *Jeff A. Blea*
- 3:45 p.m.** Role of the Veterinarian in Thoroughbred Racing Safety – *George D. Mundy*
- 4:30 p.m.** Panel Discussion with the Speakers



EDUCATIONAL PROGRAM

 Denotes a core concept for new graduates.

How to Manage Hoof Lameness

Moderator: Raul J. Bras

Sponsored by Dechra Veterinary Products.

- 1:30 p.m.** Understanding the Principles of Using Radiographs for Pathological Trimming and Shoeing – Ric F. Redden
- 2:15 p.m.** Life After Deep Digital Flexor Tenotomies – Raul J. Bras
- 3:00 p.m.** Shoeing Around the Coffin Joint – Scott Morrison
-  **3:45 p.m.** How to Recognize Foot-Related Lameness – Renate Weller
- 4:30 p.m.** How to Plan the Strategy for Pathological Shoeing – Ric F. Redden

Medicine: Infectious Diseases

Moderator: Amy L. Johnson

Sponsored by KindredBio, Best Medicines for Our Best Friends.

- 1:30 p.m.** Hemagglutinin Inhibition Antibody Responses to Commercial Equine Influenza Vaccines in Primed Horses – Bruno Karam
- 1:50 p.m.** Anti-PNAG Titers Correlate with Protection Against Rhodococcal Foal Pneumonia – Susanne K. Kahn
- 2:10 p.m.** Transfusing 2 Liters of Hyperimmune Plasma is Superior to 1 Liter for Preventing Rhodococcal Pneumonia – Patricia Flores-Ahlschwede
- 2:30 p.m.** Comparative *in vitro* Susceptibility of Bacterial Isolates from Horses to Trimethoprim/Sulfadiazine and Trimethoprim/Sulfamethoxazole – W. David Wilson
- 2:50 p.m.** Validation of a Point-of-Care Polymerase Chain Reaction Assay for the Detection of *Streptococcus equi* subspecies *equi* in Nasal Secretions from Horses with Suspected Strangles – Nicola Pusterla
- 3:10 p.m.** Alterations in the Fecal Microbiome of Horses with Antimicrobial-Associated Diarrhea Compared with Antibiotic-Treated and Non-Treated Healthy Case Controls – Carolyn Arnold
- 3:30 p.m.** Evaluation of the Usefulness of Elevated Serum Amyloid A Alone or in Combination with Abnormal Neutrophil Count and Hyperfibrinogenemia in Differentiating between Infectious and Non-Infectious Diseases in Horses – Fiona Wensley



Lifestyle & Wellness: Physical Wellbeing

Moderator: Robert Franklin

Sponsored by Avanti Veterinary Partners. Together We Grow.

- 1:30 p.m.** Reducing Your Risk for Musculoskeletal Disorders with Ergonomics – Guy Fragala
- 2:20 p.m.** Applying Concepts of Ergonomics to Minimize High-Risk Activities – Guy Fragala
- 3:10 p.m.** Escape from Inflammation Nation: A Mindful Approach to Achieving Health and Wellness – Floyd 'Ski' Chilton
- 4:00 p.m.** Escape from Inflammation Nation: The Nuts and Bolts of Diet, Weight Loss, and Physical Activity – Floyd 'Ski' Chilton



Table Topics

Sponsored by Dechra Veterinary Products.

Seating is limited so please arrive early.

1:30-3:00 p.m.

- Bisphosphonates – Ryan S. Carpenter and Ashlee Watts
- Management of the Performance Mare – Bridget Heilsberg and Jenn Linton
- Mentoring New Grads and Introducing Them into a New Practice – Luke Bass and Kim Harmon
- Novel Approaches to Tendon Healing – Brent Hague and Lauren V. Schnabel

3:30-5:00 p.m.

-  Management of the Neonate in the Field – Jen Gold and Phoebe Smith
- Neurologic vs. Neck Pain/Lameness – Ryland Edwards and Steve Reed
- Rehabilitation after Tendon Injuries in the Sport Horse: Back to Work Schedules – Sherry Johnson and Carrie Schlachter
- What to Expect as a New Associate: Skill Sets for Day 1 – Liz Arbittier and Michelle Bessire
- Meet the Expert: How to Manage Back Pain in Horses – Erin Contino

WEDNESDAY, December 9

Current Concepts in the Endoscopic Evaluation of the Upper Airway

Moderator: John B. Madison

Sponsored by Endoscopy Support Services.

- 8:00 a.m.** Video Endoscopy at Public Auctions in the United States – *Scott A. Hay*
-  **8:20 a.m.** Endoscopic Evaluation of Nasal Discharge – *Eric J. Parente*
- 8:40 a.m.** New Concepts in the Management of Epiglottic Entrapment – *Eric J. Parente*
-  **9:00 a.m.** Clinical Indications for a Tie-Back Surgery – *Rolf M. Embertson*
- 9:20 a.m.** Varied Presentations of Arytenoid Chondropathy – *Rolf M. Embertson*
- 9:40 a.m.** Right-Sided Abnormalities in Laryngeal Function – *John B. Madison*
- 10:00 a.m.** Panel with the Speakers

Safety Issues and Efforts in Equine Sport: Past, Present, and Future

Moderator: Ryan S. Carpenter

Sponsored by the Dolly Green Research Foundation.

- 8:00 a.m.** Safety Efforts in Flat-Racing (Practitioner) – *Ryan S. Carpenter*
- 8:30 a.m.** Safety Efforts in Flat-Racing (Regulator) – *Tim Grande*
- 9:00 a.m.** Safety Efforts in Jump Racing – *R. Reynolds Cowles*
- 9:30 a.m.** Safety Efforts in Three-Day Eventing – *Erin Contino*
- 10:00 a.m.** Safety Efforts in Sport Horses – *Richard D. Mitchell*
- 10:30 a.m.** Safety Efforts in Rodeo – *Douglas G. Corey*
- 11:00 a.m.** Panel with the Speakers

New Innovations and Timely Considerations in Equine Lameness and Surgery

Moderator: Ryan Lee

Sponsored by Zoetis, "For Animals. For Health. For You."

- 8:00 a.m.** Examining the Effects of an Extract of *Biota Orientalis* in the Osteochondral Fragment-Exercise Model of Osteoarthritis – *Kathryn A. Seabaugh*
- 8:20 a.m.** Surgical Management of Subchondral Cystic Lesions of the Medial Femoral Condyle with an Absorbable Implant – *Cole Sandow*
- 8:40 a.m.** Evaluation of Long-Acting Ceftiofur Crystalline Free Acid as a Pre-Operative Antibiotic in Field Castrations – *Thomas Bergstrom*
- 9:00 a.m.** Investigation into Lumbosacral Vertebral Anatomy and Growth Plate Closure in Quarter Horses – *Elizabeth M. Collar*
- 9:20 a.m.** Characteristics of Complete Tibial Fractures in Racehorses – *Monika A. Samol*
- 9:40 a.m.** Detection and Residence Time of Bisphosphonates in Bone of Horses – *Heather Knych*
- 10:00 a.m.** How to Safely Restrain a Laterally Recumbent Horse – *Rebecca Husted*
- 10:20 a.m.** How to Treat Coronary Band Dystrophy – *Stephen E. O'Grady*
- 10:40 a.m.** How to Perform Standing Needle Arthroscopy Beyond the Stifle – *Alvaro G. Bonilla*
- 11:00 a.m.** Computed Tomographic (CT) Assessment of Brain Damage by Various Firearms to Determine Euthanasia Efficacy of Horses – *Jane Lund*
-  **11:20 a.m.** Evaluation of the Local and Systemic Inflammatory Response to Anthelmintic Therapy: Is Killing Encysted Parasites Better? – *Ashley E. Steuer*

Consent to Use Photos

Registration and attendance at, or participation in, AAEP meetings and related activities constitutes an agreement by the registrant to AAEP's use and distribution of the registrant or attendee's image or voice in photographs, videotapes, electronic reproductions and audio tapes of such events and activities.

TRAINING SESSIONS

Wet labs, dry labs, and emergency management

Expand your skill set with hands-on instruction during the slate of wet and dry labs. Each lab has an attendance cap for optimal learning. Registration is on a first-come basis at convention.aaep.org or by phone at (859) 233-0147.

Wet Labs

Wet labs will be held at the Viticus Center – Oquendo Campus, approximately five miles from Mandalay Bay.

1. Essential Techniques for the Ultrasound Exam of the Equine Back and Hind Proximal Suspensory

presented in conjunction with ISELP

Saturday, Dec. 5

Session 1: 8:00 a.m.-noon

Session 2: 12:30-4:30 p.m.

Cost: \$450 for AAEP/ISELP members; \$500 for non-members

Attendance cap: 50 per session

Explore the complex anatomy and ultrasound challenges of the equine back and hind proximal suspensory ligament. Clinical cases will be discussed and approaches to diagnosing injuries and treating the equine athlete investigated with leading clinicians in this field.



2. Advanced Treatment of Equine Periodontal Disease

Saturday, Dec. 5

8:00 a.m.-5:00 p.m.

Cost: \$900 (AAEP members only)

Attendance cap: 24

Acquire the knowledge and skills necessary to use specific odontoplasty burring techniques to treat various types of pathological diastema in periodontal disease. The morning session will consist of classroom instruction; the afternoon session will be a cadaver wet lab.

Clinical Skills Dry Labs

Sunday, Dec. 6, Mandalay Bay Convention Center

Session 1: 10:00 a.m.-noon

Session 2: 1:00-3:00 p.m.

Session 3: 3:30-5:30 p.m.

Cost: \$250 per session (AAEP members only)

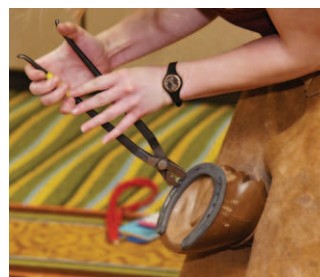
Attendance cap: 12 per lab session

Enhance patient care by learning a new clinical technique or refreshing your existing skill set. All labs will be offered during each of the three sessions; register for up to three of the following labs:

Lab A: Tendon Sparing Navicular Bursa Injection



Lab B: Tips on Collection, Processing and Interpretation of Endometrial Culture and Cytology



Lab C: Ultrasound-Guided Spinal Joint Injections

Lab D: Practical Skills in Podiatry

Veterinarians' Role in Emergency Management

Saturday, Dec. 5, 1:30-5:00 p.m.

Moderator: Bill Moyer

Sponsored by The Foundation for the Horse

Acquire the training and know-how to participate with local, regional, state, and national disaster management efforts. Topics will include the Incident Command System; training requirements; emergency planning structure and process; role of veterinarians in the planning process, evacuation, rescue, medical support, and sheltering; commonly encountered injuries and illnesses; and psychological impacts of being a first responder along with methods to prevent and deal with these issues.

This session is open to all attendees at no additional cost and with no advance registration necessary.

Presenters: Wesley Bissett, Leslie Easterwood, Jen Kleman, and Debra Zoran

PARTNER SUNRISE SESSIONS

Rise and Shine!

Explore a variety of topics related to equine healthcare and practice at the AAEP's Partner Sunrise Sessions, which will be held in the convention center prior to the start of educational sessions on Dec. 6-7. Arrive early and enjoy a complimentary breakfast while supplies last.



Sunday, Dec. 6

6:30-7:30 a.m.

Lameness and Osteoarthritis in the Horse: A New Management Plan
– Kent Allen, Philippe Benoit, Cricket Russillo, and Stuart Shoemaker.
Hosted by KindredBio.

Review of Human Medicine Bisphosphonate Therapy & Crossover to the Horse
– Larry Sulva and Ashlee Watts. Hosted by Dechra Veterinary Products.

What is the Lifespan of Passively Acquired Rabies Antibodies in Foals?
– TBA. Hosted by Zoetis.

Monday, Dec. 7

6:30-7:30 a.m.

Supporting Muscle Recovery Through Advanced Nutrition – Marty Adams and Abby Keegan. Hosted by Cargill.

Panel Discussion: Innovations in Equine Asthma – Sarah Reuss, Moderator.
Hosted by Boehringer Ingelheim.

New Studies on Equine Protozoal Myeloencephalitis That May Spark Your Interest – Nicola Pusterla. Hosted by Merck Animal Health.

The material presented in the Sunrise Sessions is done so at the discretion of the AAEP Educational Partner and has not undergone review by the AAEP Educational Programs Committee. The material presented does not reflect the opinions or views of, or an endorsement by, the AAEP. No CE credit is given for these sessions unless RACE approval has been previously obtained by the presenting company.



USDA Accreditation Training

Tuesday, Dec. 8

The USDA's National Veterinary Accreditation Program has assigned accreditation renewal dates to more than 20,000 equine veterinarians. These sessions will apply specifically toward the mandatory training requirements for accreditation renewal.

Although these courses do not have RACE approval for CE, state boards generally accept these courses when used for license renewal.

For complete descriptions of each session, visit convention.aaep.org and click the "Sessions" link.

Morning

8:00 a.m. Overview of the NVAP

9:00 a.m. Overview of Foreign Animal, Program, and Reportable Diseases

10:00 a.m. Preventing Disease Introduction and Spread

11:00 a.m. International Movement of Horses

Afternoon

1:00 p.m. Slaughter Horse Transport

2:00 p.m. Animals' Fitness to Travel

3:00 p.m. Animal Welfare: An Introduction

4:00 p.m. High-Impact Equine Diseases in the U.S.

TRADE SHOW



AAEP Trade Show

Sunday, Dec. 6 - Tuesday, Dec. 8

Dec. 6: 10:00 a.m.-6:00 p.m.

Dec. 7: 10:00 a.m.-6:00 p.m.

Dec. 8: 10:00 a.m.-4:00 p.m.

Finding the right solutions providers is essential to practice success. Discover the latest technologies, services and products to improve your practice inside the trade show. A complete list of exhibitors is available on the AAEP Convention App or at convention.aaep.org.

While in the trade show, grab a lunch included with your registration and stop by **AAEP Connect**, where you can chat with association and foundation staff, shop at the General Store, host a meeting, recharge your devices and get your shoes shined. Enjoy the following complimentary services within AAEP Connect:

Meeting Pods

Sponsored by EQUUS and EquiManagement: Your sources for horse health and veterinary business information.

Need to host a meeting during the convention? Three meeting pods are available for use during trade show hours. Reserve your meeting time at the *EQUUS/EquiManagement* booth. A charging station for your phone, tablet or laptop is available near the meeting pods.

Shoeshine Service

Sponsored by Dechra Veterinary Products.

Let the professionals with A Vegas Shoe Shine restore your shoes or boots to their original luster with a complimentary shoeshine. A charging station will be available for your mobile devices.

Portrait Hub

Monday, Dec. 7, 11:00 a.m.-1:00 p.m.

Tuesday, Dec. 8, 2:00-4:00 p.m.

Make your first impression count with a complimentary professional portrait for use on your practice website and social media channels.

AAEP General Store

Browse an assortment of AAEP products, including fleece-wear, jackets, shirts, hats and mugs, within the AAEP Connect area. Most merchandise is available for purchase on-site or can be ordered and delivered to your home.



Trade Show B-I-N-G-O!

Using the bingo card in your convention bag, travel through the trade show and collect stickers on every exhibitor name. Submit your completed card at the AAEP booth for a \$10 AAEP General Store gift certificate and to be entered in daily drawings for prizes, including Fitbits, VISA gift cards and more.

Council and Committee Meetings

Council and committee meetings are open to all AAEP members unless specified otherwise. These meetings will conclude with a brief “closed” business session for council/committee members only.

Saturday, Dec. 5

8:00-10:00 a.m.	Member Engagement Committee Performance Horse Committee Welfare & Public Policy Advisory Council
10:00 a.m.-Noon	Foundation Advisory Council Professional Conduct & Ethics Committee*
1:00-2:30 p.m.	Educational Programs Committee
1:00-3:00 p.m.	Infectious Disease Committee Racing Committee

Sunday, Dec. 6

4:00-5:30 p.m.	President's Advisory Council*
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**Open only to members of the council or committee*

Meeting days and times are subject to change. Please consult the convention program on-site in Las Vegas for the final schedule and the AAEP Convention App or convention.aaep.org for updates.

Rounds Meetings

Saturday, Dec. 5, 1:00-2:30 p.m.

The AAEP offers online Rounds discussions throughout the year on specific veterinary topics. Some of these Rounds will conduct face-to-face meetings open to all attendees during the annual convention. Rounds meetings will conclude with a session open only to AAEP members.

When finalized, the complete schedule of Rounds meetings will be available at convention.aaep.org, on the AAEP Convention App and in the convention program. To join a Rounds discussion, visit communities.aaep.org/home.

General Membership Meeting Monday, Dec. 7, 5:15-6:00 p.m.

Whether you're actively involved as a member volunteer or simply want to learn more about your association, attend this 45-minute annual business meeting and discover the AAEP's progress on issues important to the association, profession and industry during the past year.

Thanks to Convention Organizers

This meeting is brought to you by the combined efforts of the program chair, Educational Programs Committee and Scientific Review & Editorial Committee.



From left:

Scott Hay, DVM – Program Chair

Charlie Scoggin, DVM, MS, DACT – EPC & SREC Chair

Tracy Norman, VMD, DACVIM – EPC & SREC Vice Chair

The AAEP also thanks the following members of the EPC and/or SREC for their efforts organizing the 66th Annual Convention:

Liz Arbittier, Leea Arnold, Heidi Banse, Myra Barrett, Beth Biscoe, Raul Bras, Jim Bryant, Ben Buchanan, Teresa Burns, Erin Contino, Ty Corbiell, Ashley Craig, Josh Donnell, Jeremiah Easley, Lane Easter, Leslie Easterwood, Ryland Edwards, III, Ben Espy, Rob Foss, Bill Gilsenan, Nora Grenager, Casey Gruber, Kevin Haussler, Cody Johnson, Barbara Jones, Kelley Jones, Lisa Katz, Melissa King, Ryan Lee, Craig Lesser, Martha Mallicote, Valerie Moorman, Peter Morrese, Meg Mullin, Taylor Myers, Brittany Nehring-Lappin, Karen Nyrop, John Peloso, Mike Pownall, Alfredo Romero, Sarah Sampson, Carrie Schlachter, Maria Schnobrich, Debbie Spike-Pierce, Tom Timmons, Mike Tomlinson, Amanda Trimble, Claudia True, Beau Whitaker, Ashley Whitehead, Jeremy Whitman, Cara Wright, Kate Wulster, and Luke Bass (board liaison).

REGISTRATION

Register by Sept. 15 and save \$200

To help mitigate any concerns due to ongoing uncertainty with COVID-19, we are waiving the traditional \$75 cancellation fee. If you register for the convention and decide to cancel at any time prior to the event, you will receive a full refund. Cancellations must be submitted in writing to Kristin Walker at kwalker@aaep.org.

In the event the convention is canceled, a full refund of registration fees will be issued and hotel rooms booked through the housing bureau will be canceled free of charge. Reimbursement for other travel-related expenses such as airfare will likely be subject to your chosen airline so we recommend that you defer making non-refundable travel plans until 75 days prior to the scheduled start date of the convention.

Register Online

Register online at convention.aaep.org. Annual dues must be current to register at the member rate. Hotel reservations can also be made through the site. Your convention registration confirmation will be automatically emailed.

Register by Mail or Fax

Photocopy the registration form and send with your payment by Nov. 11. Your canceled check will serve as your receipt. By including your credit card number on the form, you may fax us your registration at (859) 233-1968. You may make extra photocopies to register additional people. Confirmation will be emailed when your registration is processed.

Register On-Site

Register at the Mandalay Bay Convention Center beginning Dec. 4 at 3:00 p.m.

Attendees registering at the student or resident/intern rate must present verification of enrollment in a veterinary school or a letter from an internship practice. New member registrants must present their DVM license or diploma.



Special Needs

If you require special accommodations to fully participate, attach a statement of needs to your registration form.

We Promise

We're so proud of the quality program that we promise to refund your registration fee if, for any reason, you are not satisfied with your convention education experience.

Contact Us

For more information, email Kristin Walker at kwalker@aaep.org; or call (800) 443-0177 (U.S. and Canada) or (859) 233-0147.

Book your hotel by Sept. 15 and save \$50 per night

Indulge in the dining and nightlife one can only find in Las Vegas—both on-site at the AAEP's group hotels listed below and just a short walk, tram or rideshare down the Strip. Nightly rates presented below are for single/double occupancy and exclude 13.38% hotel tax and \$15 daily resort fee.

The deadline to reserve a room at the AAEP rate, cancel a reservation or make changes is Nov. 11. Please book your hotel room online at convention.aaep.org. You must be registered for the convention to book a hotel room at the AAEP rate.

Headquarters	<i>Nightly Rate</i>	<i>Nightly Rate</i>
Mandalay Bay	<i>By Sept. 15</i>	<i>By Nov. 11</i>
Dec. 2–3	\$77	\$127
Dec. 4–5	\$137	\$187
Dec. 6–8	\$117	\$167
Dec. 9	\$77	\$127

Alternates

Delano	<i>Nightly Rate</i>	<i>Nightly Rate</i>
Dec. 2–3	\$107	\$157
Dec. 4–5	\$167	\$217
Dec. 6–8	\$147	\$197
Dec. 9	\$107	\$157

Luxor

Dec. 2–3	\$49	\$99
Dec. 4–5	\$97	\$147
Dec. 6–9	\$49	\$99



AAEP 66TH ANNUAL CONVENTION
Advance Registration Form
After Nov. 11, please register online or on-site at the convention.

Full name: _____
FIRST MIDDLE LAST

Credential (DVM,VMD, etc.): _____ Preferred first name on badge: _____

Address: _____ City: _____

State: _____ Postal Code or Zip: _____ Country: _____

Phone: _____ Cell Phone (optional): _____ Fax: _____

Do you want to receive a copy of the *Proceedings* book on-site? ☐ Yes ☐ No
If you choose to not receive a Proceedings copy, you will still have access to the digital edition.

Email: _____ ☐ Please remove me from all exhibitor mailing lists

Dietary requirements: ☐ Vegetarian ☐ Vegan ☐ Gluten Free ☐ Vegetarian & Gluten Free
☐ Vegan & Gluten Free ☐ Other, I will make other arrangements ☐ I do not have any meal requirements

Emergency contact name (required): _____

Phone: _____

Full name of guest (limit 2 per member): _____

Preferred first name on guest badge: _____

Address/City/State/Zip Code (guest): _____

Phone (guest): _____ Email (guest): _____

☐ **First-time convention attendee**

	Thru Sept. 15	Thru Dec. 3	On-site	Total
A. ☐ AAEP Member	\$499	\$599	\$699	_____
B. ☐ AAEP Honor Roll Member	300	300	400	_____
C. ☐ Guest Attending Sessions*	499	599	699	_____
D. ☐ Guest Pass**	30	30	50	_____
E. ☐ AAEP New Member Applicant	800	880	980	_____
F. ☐ Non-Member	995	995	1,095	_____
G. ☐ Current Resident or Intern	300	300	400	_____
H. ☐ International Members' Reception (Dec. 7; ticket required)				<u>Free</u>
I. ☐ President's Luncheon (per person) Qty ____ Dec. 8	60	60	60	_____
J. ☐ After Party (Dec. 8; ticket required)				<u>Free</u>
K. Wet & Dry Lab Experiences				
(Register online or by phone; see page 12)				
* Can be purchased only by AAEP members. Limit 2 per member.				Total: _____
** Can be purchased only by registered attendees. No access to sessions. Limit 2 per attendee.				

☐ I have read and agree to the disclosure statement on page 18

Payment Method: ☐ Visa ☐ MasterCard ☐ American Express ☐ Discover Card ☐ Check enclosed _____

Card #: _____ Expiration: _____ CVW Code: _____

Signature: _____ Date: _____

Return your registration and payment (if applicable) to AAEP, Attn: Meetings Registration, 4033 Iron Works Pkwy, Lexington, KY 40511; or fax with credit card information to (859) 233-1968. Last day to register by mail or fax is Wednesday, Nov. 11.

Health and Safety

Creating a healthy, safe meeting experience for convention attendees is our No. 1 focus. The AAEP is working with host hotel Mandalay Bay (an MGM Resorts property) and with conference partners to create a detailed plan for COVID-19 mitigation throughout all areas of the hotel and meeting space. Convention health and safety protocols will be updated frequently to reflect the most current recommendations.

At a minimum, the AAEP will follow the safety guidance provided by MGM Resorts and the state of Nevada. MGM Resorts has implemented at all its properties a “Seven Point Safety Plan,” a multi-layered approach to guest health and safety developed with guidance from public health experts. Following is a synopsis of the plan; view the full plan at <https://tinyurl.com/spspmgm>.



1. Screening, Temperature Checks, & Employee Training

Extensive employee screening measures and training programs have been implemented. Medical and trained security personnel on staff will be able to assist should a guest develop symptoms on-site.



2. Mandatory Masks & Personal Protective Equipment

Masks are required for all guests inside public spaces. Employees are required to wear an approved mask while working.



3. Physical Distancing

Six-foot physical distancing policies have been implemented throughout, with floor guides to assist and remind guests.



4. Handwashing & Enhanced Sanitation

Guests will have easy access to handwashing stations and hand sanitizer throughout. The amount of routine cleaning has been increased, with an emphasis on high-touch surfaces and common areas.



5. HVAC Controls & Air Quality

Rigorous measures have been taken to provide as much outside air circulation throughout buildings and guest rooms, with air filters that meet or exceed published standards.



6. Incident Response Protocols

Should a guest or employee test positive for the virus, protocols will be activated, and trained staff will respond quickly so that exposed areas are thoroughly sanitized.



7. Digital Innovations

Technology has transitioned current processes into contactless options. Guests can complete the entire check-in process themselves and will no longer need to wait in line if they choose. A digital room key will be available via a mobile app for those who prefer not to use a traditional key card.

Disclosure

I understand that my participation in the event involves a certain degree of risk of loss, harm or injury to my person or property, including, but not limited to, harm from contracting COVID-19 or other viruses, acts of God, theft, fire or accident. I also understand that participation in this event is entirely voluntary and that the AAEP requires attendees to abide by any applicable rules of conduct or local or state laws that may be announced at any time during the event, which may include wearing personal protective gear and engaging in social distancing. While AAEP is the sponsor of this event and takes commercially reasonable steps to require the event facility to maintain the venue in a safe and healthy condition, I understand and acknowledge that AAEP has no direct control over and is not responsible for the acts or omissions of the facility or others involved in producing this event. I have carefully considered the risk involved and waive and release AAEP and all its officers, directors, employees, staff, volunteers, faculty and affiliates from any and all claims, damages, injuries, or expenses that I may incur from my participation in this event.



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The AAEVT welcomes ALL veterinary technicians, assistants, students, and support staff to join our Association at the 16th Annual AAEVT Convention.

FEATURED SPEAKERS & TOPICS

KEYNOTE – Dr. Megan Green:
*How to Ignite Your Impact,
Influence and Income*

Dr. John Hubbell:
Neonatal Anesthesia

Dr. Margo Macpherson:
High Risk Pregnancy

Dr. Katie Garrett: *Use of CT*

Charlotte Lacroix, DVM, JD:
*Understanding your brand
and net worth*

Dr. Andy Clark:
Corporations in Vet Med

Dr. Mark Baus: *Telemedicine*

Dr. Doug Corey: *Rodeo Injuries
...and many more!*

SATURDAY, DEC. 5

7:00 a.m. - 12:30 p.m.

Wet Labs at Desert Pines Equine Clinic

Topics and Speakers: Joint blocks with cadaver legs – Dr. Winchell; Cytology with Zoetis/Abaxis Shockwave, Suture Patterns, Infectious Disease and BioSecurity

1:00 - 4:00 p.m. Disaster Preparedness and Management Training for Technicians - Mandalay Bay

*Conference registration opens at 3:00 p.m.
Mandalay Bay Convention Center*

SUNDAY, DEC. 6

7:00 a.m. - Noon Registration

10:30 a.m. - Noon Keynote:
Dr. Megan Green
*How to Ignite Your Impact,
Influence and Income*

Noon - 1:30 p.m. AAEVT Membership Meeting & Lunch

1:30 - 5:30 p.m. Lecture & Scientific Sessions
5:30 - 7:00 p.m. AAEVT Social & Scholarship Raffle

Exhibit Hall hours: 10:00 a.m. - 6:00 p.m.

MONDAY, DEC. 7

8:00 a.m. - Noon Lecture Sessions

Noon - 1:00 p.m. Lunch break

1:00 - 5:00 p.m. Lecture Sessions

Exhibit Hall hours: 10:00 a.m. - 6:00 p.m.

TUESDAY, DEC. 8

8:00 a.m. - Noon Lecture Sessions

Noon - 1:00 p.m. Lunch break

1:00 - 4:00 p.m. Lecture Sessions, Case Studies and Roundtables

Exhibit Hall hours: 10:00 a.m. - 4:00 p.m.

Thank you to ALL of our Sponsors!

AAEVT ADVANCE REGISTRATION FORM • PLEASE PRINT CLEARLY

Early registration closes **November 10**. Registrations must be received before this date. After Nov. 10, registration will only be available ON-SITE for an additional \$100. **Cancellation Policy:** If you cancel your registration within 7 days of the Conference start there will be a 50% penalty. If you cancel your registration once the Conference begins, you will forfeit your entire registration fee.
We will honor full cancellation refund if event is cancelled due to COVID-19.

Full Name: _____ Designation: _____
Address: _____ City: _____ State: _____
Country: _____ Postal Code/Zip: _____
Phone: _____ Email: _____ Practice: _____

Check if you are: ☐ AAEVT Online Certificate Program Participant ☐ AAEVT Student Member: School & Director Name: _____

PLEASE CHECK ALL APPROPRIATE TICKET BOXES AND SUBMIT TOTAL AMOUNT FOR REGISTRATION PAYMENT

*** Wet Labs limited to 50, only AAEVT Members will be allowed to attend ***

☐ AAEVT Member – Lectures Only \$250 ☐ Non-Member – Lectures Only \$650 **Become an AAEVT member at www.aaevt.org and SAVE \$400!!**
☐ AAEVT Member – Lectures & Wet Lab Combo \$500 ☐ AAEVT Guest – Membership lunch, Social ☐ AAEVT Student Member – Lectures Only \$150
☐ AAEVT Member – Wet Labs Only \$300 & Exhibit Hall Only \$75 *** All Students must be AAEVT Members ***

RSVP FOR THE FOLLOWING COMPLIMENTARY EVENTS:

☐ Wet Lab Bus ticket – please select if you will need a ride Desert Pines for Wet labs ☐ Sunday Membership Lunch ☐ Sunday Welcome Reception & Raffle

PAYMENT: AAEVT Member # _____ TOTAL \$ _____ Payment method: ☐ Visa ☐ MasterCard ☐ Enclosed check Check # _____

Card Number: _____ Expiration: _____ SSC: _____ PRINT name on card: _____

Card Billing Address: _____ Signature: _____

Return your registration and payment by secure fax with credit card information to (760) 301-0349 or by mail to: AAEVT, 336 36th St, Suite 735, Bellingham, WA 98225.
Last day for receipt of registration & payment is NOV 10. Full AAEVT Conference Program will be available online, along with registration form & information.

Hotel information can be found on the AAEP & AAEVT websites: www.aaevt.org

Highlights of recent clinically relevant papers

Wound healing

This randomised, blinded, controlled study by Peter Michanek and colleagues in Sweden investigated how pulsating visible red light ($\lambda \approx 637$ nm) and near-infrared (NIR) light ($\lambda \approx 956$ nm), affects swelling and wound healing in healthy horses.

Eight healthy adult Standardbred horses had a full-thickness skin wound created using a custom made, 2 cm diameter circular punch on both sides of their neck under sedation and local anaesthesia. The wounds were left uncovered to heal by secondary intention. One wound per horse was randomly allocated to receive light-emitting diode (LED) treatment on Days 0–4, 7–11, 14–18 and 21–25, with the wound on the opposite side of the neck acting as an untreated control. Treatment was conducted using a handheld device (BCD 650 Animal, Biolight AB) using a pre-set programme with a duration of 4 min and 40 s (red light was emitted for 95 s and NIR light for 185 s). The wounds were evaluated ultrasonographically for swelling and photographed daily. Wounds were considered to be healed when an epithelial layer covered the entire wound surface.

None of the wounds showed clinical signs of infection over the study period. Wound area and degree of swelling did not differ between the treated and control groups on any day. There was a significant difference in healing time between control and treated wounds, with LED light-treated wounds taking longer to heal than control wounds. No positive effect of LEDs on experimental wound healing was found.

Faecal sand clearance

In this randomised, placebo-controlled, blinded clinical trial Diana Hassel and colleagues from Colorado State University evaluated the efficacy of a product containing probiotics, prebiotics and psyllium in the clearance of colonic sand in horses with naturally acquired sand accumulation.

Sand accumulation, determined by both auscultation and abdominal radiography, was identified in 10 horses. Changes in colonic sand content was quantitatively assessed in response to management changes combined with treatment with the probiotic/psyllium product or no treatment. Faecal sand output was monitored in both groups via sand sedimentation analysis of faecal samples every 3 days for 35 days and with pre- and post-treatment abdominal radiography.

There was a significant reduction in sand accumulation in both treatment and control groups, but there were no significant differences between treatment and control groups in clearance of colonic sand as measured by both faecal sand sedimentation and quantitative radiography.

Care of geriatric horses

The aim of this study by Megan Ballou and colleagues in the USA was to understand the experience of caring for a geriatric horse with a chronic condition.

An anonymous, online questionnaire was distributed to investigate the burden of caregivers from the perspective of

owners of geriatric horses. Traumatic events and veterinary care decisions were also explored. Findings from the study supported the hypothesis that owners of geriatric horses with a chronic condition experienced higher levels of physical and emotional care burden, regardless of the age of the geriatric horse. Attachment levels reported by the 1448 participants were high, regardless of the health status of the horse. A chronic condition in their horse was reported by 68.8% ($n = 996$) of owners of geriatric horses.

This study provides the equine practitioner with a greater understanding of the care burden experienced by owners of geriatric horses, particularly horses with a chronic condition, who rely on their veterinarian to guide their management and health care decisions. Veterinarians can help prepare and support clients as they navigate the complexities of caring for an older horse with a chronic condition.

Cardiology

This study by Lisse Vera and colleagues in Belgium investigated whether arterial wall stiffness increases with age in horses, as it does with humans.

Cardiovascular ultrasound and non-invasive blood pressure measurement were performed simultaneously on 50 young (3–7 years) and 50 old (>18 years) healthy Warmblood horses. Arterial diameters, cross-sectional areas, and arterial wall thickness were measured. Arterial wall stiffness of the aorta and common carotid artery were assessed using pulse wave velocity. Lumen area/diameter change, strain, compliance, and distensibility were also calculated to assess local arterial wall stiffness.

No difference in blood pressure was found between age groups. All systolic and diastolic arterial diameters and the thickness of the common carotid artery were significantly greater in the old horses. The aorta and caudal common carotid artery local arterial wall stiffness and pulse wave velocities were significantly higher in the old horses. Arterial stiffness and wall thickness increase with age in horses.

Distal limb immobilisation

This study, by Holly Stewart and colleagues at Colorado State University, described the effects of distal limb immobilisation and remobilisation in the equine metacarpophalangeal joint.

One forelimb of each of eight healthy, skeletally mature horses was immobilised in a fibreglass cast for 8 weeks, followed by 12 weeks of treadmill-based training after the cast had been removed. Clinical examinations, radiography, computed tomography (CT), nuclear scintigraphy, MRI, and histomorphometry were used to examine the third metacarpal bone (McIII), proximal phalanx, proximal sesamoid bones, and associated soft tissues in each horse. Serum and synovial fluid were collected for biomarker analyses.

Distal limb immobilisation resulted in persistent lameness, effusion, and a decreased range of motion as well as radiographically visible fragments in the cast forelimb. Bone density was decreased in McIII according to CT, and trabecular bone fluid was increased according to MRI in the

cast forelimb. The cast forelimbs had a change in the appearance of the deep digital flexor tendon according to MRI immediately after removal of the cast. Numerous clinical, radiographic, CT, and MR abnormalities were visible at the end of the study period.

The authors concluded that 8 weeks of cast immobilisation induced changes in bone, cartilage, and periarticular soft tissues that were not reversed after 12 weeks of remobilisation. Cast application should be used judiciously in horses with musculoskeletal injuries, balancing appropriate stabilisation with potential morbidity secondary to cast placement.

New antifungal drugs for equine keratitis

This study by Darby Roberts and colleagues at North Carolina State University determined minimum inhibitory concentrations (MICs) of four fungal species isolated from horses with equine fungal keratitis to previously untested azole, echinocandin, and carboxamide antifungal drugs.

In vitro assays were performed to determine the susceptibility of *Aspergillus flavus*, *A. fumigatus*, *Fusarium falciforme*, and *F. keratoplasticum* to five antifungal drugs representing three modes of action.

Luliconazole exhibited increased growth inhibition against both *Aspergillus* and *Fusarium* compared to commonly used, standard antifungal drugs. MIC values for luliconazole at 0.001–0.002 µg/mL were at least 25-fold lower than all other antifungal drugs tested, including voriconazole.

The increased antifungal activity of luliconazole observed in this study warrants further investigation for its potential as an antifungal drug for equine fungal keratitis.

Liver fluke infection

In this study Aoife Quigley and colleagues in Ireland, Spain and the UK aimed to determine the susceptibility of horses to oral challenge infection with Fasciola hepatica metacercariae.

The authors attempted an experimental infection of 10 horses with *F. hepatica*. Four were given 1000 metacercariae, four 500 metacercariae and two were sham-infected. Blood and faecal samples were taken at intervals up to 18 weeks post-infection. ELISA assays were used to assess sero-conversion in the experimental horses and also in a panel of sera from horses of known fluke status. No flukes were recovered from any of the livers, and no lesions that could be attributed to *F. hepatica* infection were observed. Coproantigen ELISA was negative throughout for all horses. Three antibody detection ELISAs, used to diagnose fasciolosis in other species, had limitations as diagnostic aids as determined using a panel of sera from horses of known *F. hepatica* infection status.

Failure to establish infection after oral challenge raises fundamental questions on the pathophysiology and epidemiology of equine fasciolosis.

Medial condylar fracture repair

This study by Sophie Boorman and colleagues in the USA reports the performance of Thoroughbred racehorses after

surgical repair of a medial condylar fracture of the third metacarpal/metatarsal bone.

Forty-three horses surgically treated for medial condylar fractures, 30 with previous racing experience, 13 without previous racing experience (nonexperienced) were studied. Medical records were reviewed for signalment, radiographic fracture characteristics, repair technique, and post-operative morbidity and mortality. Each experienced horse was matched with two horses randomly selected from its most recent race to serve as healthy controls. Racing performance parameters (race rating, competitive level, speed rating, performance index) and career racing statistics were compared with multiple regression models between injured experienced horses and controls. The career racing statistics for nonexperienced horses were evaluated. Reasons for nonreturn to racing were obtained.

The median duration of follow-up was 6 years (minimum 2, maximum 10). Twenty-one of 43 (49%) horses raced again including 18/30 (60%) experienced horses and 3/13 (23%) nonexperienced horses. Higher preoperative racing performance parameters were associated with return to racing. Experienced horses were five times more likely to return to racing after medial condylar fracture repair, although their performance was generally lower than that of comparably uninjured horses.

S. WRIGHT

EVE Editorial Office

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Editorial

Keeping on top of the literature

Equine Veterinary Education's mission is to provide clinically relevant information and practical educational articles to equine veterinary clinicians around the globe. Veterinary practitioners need constant access to the published literature and current concepts of equine diseases to aid their problem-solving and clinical decision-making processes, particularly with the increasing emphasis on evidence-based veterinary medicine. Unfortunately, there is no single, freely available source of all current information for equine veterinarians, and with the ever-increasing volume of clinical research, it is becoming more and more challenging for journals such as EVE to meet the needs of all of our readers, even in the relatively small fields of equine medicine and surgery. Of course there are many other equine clinical and research journals being published, and these are important sources of new information. However, apart from the open-access journals, much of the published research has limited availability to practitioners in the field, who often have neither the time nor the ability to access multiple journals through personal or institutional libraries. Through EVE, we have therefore attempted to update practitioners with current, relevant research findings and evidence through the publication of Review Articles, Critically Appraised Topics, Clinical Commentaries and Highlights of articles published in other journals.

One of the major problems that our journal faces is the restriction on page numbers that we can regularly publish, and the resulting limits on the numbers and types of articles that can be accepted for publication. In 2018, we initiated a change in the way that the Case Reports are presented by publishing a one-page summary of the report in the print issue and having the full report available online. This change has allowed us to ease the backlog of Case Reports waiting

in Early View to be published in print and has freed up space in the print issue to allow us to commission and publish more of the other article types. Despite some veterinary journals moving completely onto digital platforms, surveys of our readers have consistently indicated their desire to have EVE available in both online and printed versions. For the foreseeable future, therefore, we will continue to publish the journal both online and in print format. Despite the changes that we have initiated with the publication of Case Reports (which we still consider to be an important element of EVE's mission), the pressure on space in the journal continues to mount. Whilst it is not our aim to be a primary research journal, Original Articles that contain novel information with direct clinical applicability to equine veterinarians are an appropriate and welcome component of the journal. In order to encourage the publication of these types of articles, whilst at the same time promoting the publication of other types of clinically relevant articles, we are now changing the way we publish Original Articles to a similar format to Case Reports – that is we will publish a one-page summary of the Original Article in the print version of the journal with the full manuscript published online. The one-page summary will include a structured abstract summarising the study aims, methodology and findings, and an explanation of the clinical relevance of the findings to equine practice. Full details of the new format for submitting authors can be found in EVE's Author Guidelines.

(<https://beva.onlinelibrary.wiley.com/hub/journal/20423292/homepage/forauthors.html>).

T. S. MAIR

Editor

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Editorial

From barn fires to hurricanes: Helping animals in times of crisis

My initial disaster response involved a two-barn fire at a racetrack just 4 years into my career in 1974. When I arrived as the only veterinarian on the scene, the local fire stations were heading in with sirens blaring as horsemen attempted to manage approximately 900 horses. Few horses were injured from the fire but the onrush of a well-meaning fire department led to serious injury of three frightened horses, two of which never raced again.

My baptism into large-scale disasters occurred in 2005 with Hurricane Katrina, which was predicted to make landfall in west Houston and Galveston Island, Texas. Texas A&M University College of Veterinary Medicine's Large Animal Hospital was selected to shelter/manage at-risk human evacuees. Despite being given just 48 h to prepare, we were able to move most hospitalised horses to other facilities. Dr P.K. Carlton and I were co-commanders in the Incident Command System (ICS) and, by the third day, we were thought to have received more human patients than any hospital in the country. We managed the first 3 days with two MDs, one registered nurse, veterinary clinicians and technicians, students and local volunteers before the US Public Health Service arrived with over 100 professionals. My learning curve regarding the essential ICS had begun.

Following that successful effort, our Large Animal Clinical Sciences Department began setting up and managing horse evacuations in subsequent disasters. This eventually led to creation of the Texas A&M University Veterinary Emergency Team (TAMU VET), which often responds with Texas Task Force 1 (search and rescue). My deployment with a small team from Texas A&M to Iraq in 2008 under military security to rebuild what had been an active agricultural entity further taught us how to perform daily amidst chaos.

Ultimately, TAMU VET convinced the College of Veterinary Medicine to create a required 2-week rotation in emergency medicine and management. Our team has responded to scores of disasters since.

My appreciation and concern for the complexity and difficulty of providing veterinary care has been renewed and reinforced with each experience. However, the provision of reasonably immediate assessment and care is still inadequate. Clearly, addressing human concerns like providing needed services (power, water, food, shelter, medical care, etc.) is a priority; animal welfare is secondary.

The AAEP and its charitable arm, recently rebranded as The Foundation for the Horse, have been helping such efforts since 2005. The Foundation, for example, provided the first

donation for a medically equipped trailer for the TAMU VET in 2010 and, ever since, has been organising a system to contact jurisdictions in harm's way for needs and resources. AAEP members should be proud of the Association's past, present and future endeavours to help horses, other animals and devastated owners.

Here is how you can help animals in future disasters:

- Acquire training and learn how to effectively get involved with local, regional, state and national efforts. **The 2020 AAEP Convention will provide unique and essential training. Sign up!**
- Contact local emergency services regarding your interest in aiding in their individual plans to protect, save and return horses/animals to owners. Such engagement is overwhelmingly welcomed and accepted.
- Understand that emergency medicine is one animal at a time whereas disaster medicine/management can easily be multiple animals. Therefore, it is important to know triage based on multiple factors such as safe access to those injured; availability of useful resources (medical supplies, shelters, transport, etc.); personnel security; and access to supporting veterinarians and technicians.
- Encourage your respective College of Veterinary Medicine to include disaster medicine/management into its curriculum.
- Realise that every disaster begins locally – you are the only expert in managing animal injury. You know what resources exist in your community; thus, you are awesome.

Being a first responder is not always possible as one's availability varies from day to day; however, knowing how such responses are constructed means that all of us can be involved. This might be as a responder, a resource provider, a place to stay for responders, a medical expert via cell phone, an expert on horse handling and transport, temporary shelter provider and financial contributor – the list goes on as each disaster has its own needs.

With training and understanding, we – the AAEP and the veterinary medical profession – can upscale our collective ability to help.

W. MOYER

Billings, Montana, USA

Dr Moyer, 2011 AAEP president, lives in Billings, Mont. He retired from Texas A&M University College of Veterinary Medicine in 2015 after 22 years with the university.

Case Report

Segmental ischaemic necrosis of the jejunum in a post-partum mare due to two mesenteric avulsions**L. Vilaregut*** , **C. O'Shea**, **M. Lores** , **G. Couto** and **M. Misheff**

Sharjah Equine Hospital, Sharjah, United Arab Emirates

*Corresponding author email: lvilaregut@hotmail.com**Keywords:** horse; post-partum; mesenteric avulsion; mesenteric rent; segmental ischaemic necrosis; peritonitis**Summary**

A 9-year-old Arabian maiden mare gave birth after 365 days of gestation. Parturition was assisted due to ventro-sacral presentation of the foal. After delivery the mare was referred to the hospital due to eversion of the bladder, which was corrected without complication. Flunixin meglumine and trimethoprim sulfadimidine were administered to reduce inflammation and prevent infection. For the first 24 h post-partum the mare was alert and vital signs were within normal limits. On the second day the heart rate and the haematocrit increased and the mare started to reflux. Transabdominal ultrasound revealed nonmotile small intestinal loops and an increased amount and echogenicity of the peritoneal fluid. Differential diagnoses at this time included haemoperitoneum due to arterial rupture, uroperitoneum due to bladder tear or peritonitis due to intestinal or uterine injury. Peritonitis was suspected but only confirmed on day 3 by abdominocentesis which yielded haemorrhagic peritoneal fluid (red blood cell count $5.76 \times 10^{12}/L$) with an increased WBC count ($1.9 \times 10^8/L$, 85% neutrophils). Unremarkable bladder cystoscopy ruled out leakage from the traumatised bladder. Due to the lack of behavioural signs of colic, a uterine tear was considered likely. Hysteroscopy could not confirm the tear and medical treatment was attempted. The mare was placed on maintenance i.v. fluids supplemented with calcium gluconate, dimethyl sulfoxide and lidocaine CRI. The antibiotic therapy was changed from trimethoprim sulfadimidine to potassium penicillin and gentamicin. On the morning of the fourth day post-partum, in view of worsening clinical parameters, but in spite of continued absence of behavioural signs of colic, an exploratory laparotomy was performed. A 2-m segment of necrotic jejunum with avulsion of the corresponding mesentery that completely transected the mesenteric vessels was resected. The line of demarcation between normal and devitalised bowel was consistent with ischaemic necrosis and no evidence of a previous strangulation could be identified. A second mesenteric avulsion transecting the mesenteric vasculature, and resulting in a 20-cm segment of necrotic jejunum, was located in the proximal jejunum adjacent to the duodenum (**Fig 1**). Due to the distance of several metres from the larger avulsion, a second resection and hand sewn end-to-end jejunojejunostomy were performed. Unfortunately, the mare collapsed and died in recovery after several coordinated attempts to stand. In hindsight, this mare would have had a higher chance of survival if abdominocentesis and exploratory laparotomy had been undertaken earlier in the



Fig 1: Segmental ischaemic necrosis of a distal portion of the jejunum, which was separated from its mesentery by a tear to the latter.

course of the treatment. Peritonitis in a post-partum mare is often associated with a uterine tear. However, as this case illustrates, this is not always the underlying cause. Hence, we present this report as a reminder of the important diagnostic value of exploratory laparotomy, and to highlight an unusual differential diagnosis of mesenteric avulsion of the jejunum in a post-partum mare.

Key points

- Mesenteric avulsion should be considered in cases of post-partum peritonitis even when there are no behavioural signs of colic.
- Exploratory laparotomy as a diagnostic procedure is recommended sooner rather than later in cases of peritonitis of an unknown origin.



Case Report

Transurethral intraluminal closure of a caudally located bladder neck tear in a standing mare

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Keywords: horse; surgery; urinary tract

Summary

This case report describes a minimally invasive transurethral approach to repair a caudally located, ventral tear in the neck of the bladder in a standing mare. The mare was diagnosed with a ruptured bladder 16 h post partum based on clinical signs, transabdominal ultrasonography, peritoneal fluid and serum biochemistry and cystoscopy.

Surgery was performed 19 h after admission. The mare was restrained in standing stocks and sedated with detomidine hydrochloride (Dormosedan, 40 mcg/kg bwt) i.v. and butorphanol tartrate (Torbugesic, 0.01 mg/kg bwt) i.v. Sedation was maintained with boluses of i.v. detomidine and i.v. butorphanol as required. Caudal epidural anaesthesia was performed with 1.5 mL xylazine (100 mg/mL), 0.3 mL mepivacaine hydrochloride (20 mg/mL) diluted to 9 mL with sterile water. Faeces were manually evacuated from the rectum and the mare's tail was restrained dorsally using a rope. The vulva, perineal region and anus were prepared preoperatively with iodine scrub solution (Betadine[®]).

The operating surgeon was positioned behind the mare. A sterile disposable foil large animal vaginal speculum (Henry Schein[®]) was introduced into the urethra. A 10 mm diameter, 31 cm in length laparoscope (Hopkins[®] forward-oblique telescope 30°) was introduced through the vaginal speculum and each positioned such that the defect in the region of the neck of the bladder could be visualised (**Fig 1**). A surgical assistant stood to the right and another to the left of the operating surgeon to aid in manipulation of the vaginal speculum and laparoscope. The operating surgeon introduced a Karl Storz Macro needle holder grasping a cutting needle with

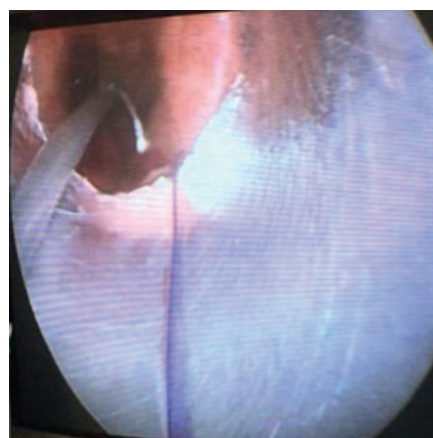


Fig 2: Karl Storz Macro needle holder grasping a cutting needle with 0 Polyglactin 910 (Vicryl[®]).

0 Polyglactin 910 (Vicryl[®]) (**Fig 2**). Beginning at the cranial aspect of the tear, the needle was passed through both wound edges and grasped with a second Karl Storz Macro needle holder. The needle was then passed through a small preformed loop in the opposite end of the suture. The edges of the wound were apposed in a cranial to caudal direction using 0 Polyglactin 910 (Vicryl[®]) in a simple continuous pattern. The Karl Storz Macro needle holders were removed and the wound closure evaluated. A 30 French Foley urinary catheter was placed transurethraly into the bladder immediately post-operatively.

The surgical time was 30 min and no complications were encountered. The mare has shown no signs of urine pooling, urine dribbling or cystitis since the operation. She is alive at the time of submission (130 days post-operatively).

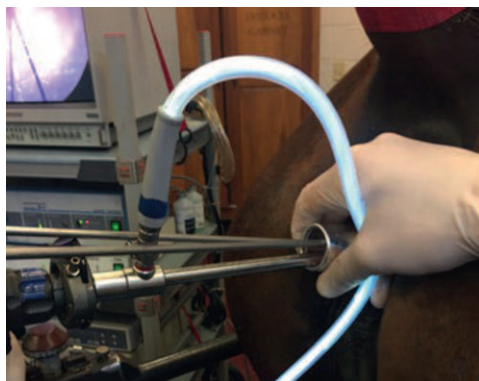


Fig 1: Introduction of the instruments through the vaginal speculum.



Key points

- Advantages of this technique include the avoidance of general anaesthesia, the absence of any incision into the peritoneal cavity, and excellent surgical access to bladder tears which may otherwise have been challenging to reach.
- For lesions in the caudal area of the bladder, this standing transurethral technique provides a viable surgical approach with excellent visualisation and accessibility in mares.

Case Report

Trans-nasal endoscopic treatment of equine sinus disease in 14 clinical cases

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^{*}Corresponding author email: kolosf@vfu.cz**Keywords:** horse; sinusitis; endoscopy; concha; fenestration

Summary

Trans-nasal endoscopic sinus treatment was used in four horses diagnosed with primary sinusitis and 10 horses with dental sinusitis. Pre-existing ($n = 5$) or surgically created ($n = 9$) sinonasal fistulae were used as portals for trans-nasal endoscopic exploration, debridement and lavage of the inflamed sinus cavities. Necrotic and purulent material adjacent to the pre-existing sinonasal fistulae (**Fig 1**) was debrided under endoscopic control to make them patent for the endoscope. Surgical endoscopic sinonasal fistulation (**Fig 2**) was performed using either a trans-endoscopic diode laser fibre (four cases) or an electrocautery instrument under endoscopic control (five cases). All procedures were performed on standing sedated horses with the use of local anaesthesia. In six cases, the ventral concha was fenestrated in order to enter the ventral conchal and rostral maxillary sinus. In

two cases, the dorsal concha was fenestrated to access the caudal group of the paranasal sinuses. One case required fenestration of the ventral conchal bulla due to its empyema. Post-operative bleeding was controlled with a nasal cavity tamponade for 24 h. Endoscopic lavage of the inflamed sinuses (via the working channel of the endoscope or using a separate rigid lavage catheter) was performed every 2–3 days. Medical treatment consisted of antibiotic and anti-inflammatory drugs. In cases of dental sinusitis, the underlying dental pathology was addressed. Median hospitalisation time was 10 days (range 5–25 days) and the median number of endoscopic procedures (including the initial procedure) was 4 (range 3–7). Cases were followed up by telephone consultations with the owners. Median follow-up time was 9.5 months (range 4–22 months). A complete resolution of clinical signs was reported in 7/10 cases of dental sinusitis (five with surgically created and two with pre-existing sinonasal fistulae); a clinical improvement (occasional nonpurulent nasal discharge) was reported in two cases with pre-existing sinonasal fistulae. Complete resolution of clinical signs was observed in 3/4 cases of primary sinusitis (all had surgically created fistulae). Two cases (one primary and one dental sinusitis) showed recurrence of the purulent nasal discharge. Recurrence of the primary sinusitis was caused by inspissated purulent exudate in the ventral conchal sinus, which was not noticed during the initial treatment of the caudal sinus group empyema. In the second case, recurrence was caused by inaccessible dental fragments in the rostral maxillary sinus with severely hyperplastic mucosal lining. Both cases underwent trephination of the affected sinuses and made a full recovery after removal of the remaining pathological sinus content.

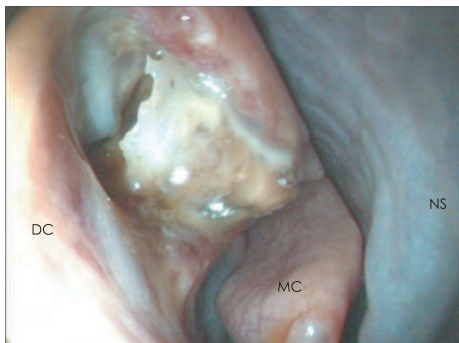


Fig 1: A pre-existing sinonasal fistula with an adjacent sequester of the conchal bone (Case number 5). DC, dorsal concha; MC, middle concha; NS, nasal septum.

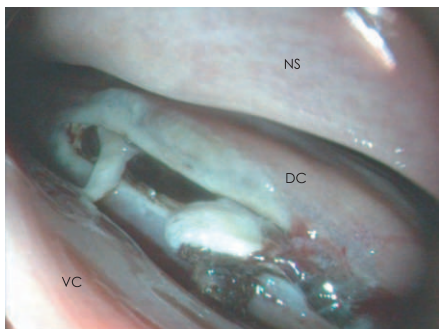


Fig 2: Surgically created (trans-endoscopic diode laser fibre) sinonasal fistula in the dorsal concha with inspissated purulent exudate protruding through the fenestration; DC, dorsal concha; VC, ventral concha; NS, nasal septum.

Key points

- Trans-nasal endoscopic paranasal sinus treatment using sinonasal fistulae can be successfully used in selected cases of primary and dental sinusitis.
- Effective surgical endoscopic sinonasal fistulation requires correct assessment of location, extent and character of the inflammatory process and adequate space in the nasal cavities.
- Effect of the trans-nasal endoscopic treatment is limited in cases of sinus disease with masses growing inside the sinus cavity; in cases showing severe chronic mucosal hyperplasia inside the sinus and in cases with severely distorted anatomy of nasal and paranasal cavities – presence of these factors makes sinusotomy preferable over the trans-nasal endoscopic approach.





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¹ American Association of Equine Practitioners. Parasite Control Guidelines. <https://aaep.org/guidelines/parasite-control-guidelines>. Accessed June 1, 2019.

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Case Report

Pine branch of *Araucaria angustifolia* in horse bronchi: A series of four cases

F. C. M. Barussi, F. Z. Bastos, L. Zenni, C. E. Camargo and P. V. Michelotto* 

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Keywords: horse; endoscopy; foreign body; lung; pulmonary

Summary

Four horses in the city of Curitiba located in the Paraná state of southern Brazil were examined for a history of chronic coughing. Case 1 was a male Thoroughbred yearling. Case 2 was a 10-year-old Appaloosa mare. Case 3 was another Appaloosa horse, a 20-year-old gelding and Case 4 was a 5-year-old male Crioulo horse.

All animals had free access to the native pasture and had a history of persistent coughing of several months duration. The animals also had a fetid nasal discharge and exercise intolerance. They were examined by different practitioners and had a history of treatment with antibiotics and anti-inflammatory drugs that did not resolve the clinical signs.

Airway endoscopic examinations were performed under sedation complemented with administration of topical tracheobronchial anaesthesia with 2% lidocaine diluted in saline (1:4). The endoscope was introduced into the right bronchus, and in each case a branch of *Araucaria angustifolia* was identified near the third to fifth division bronchi (**Fig 1**).

Treatment involved retrieval of the *A. angustifolia* branches from the airways to resolve the inflammation and infection. However, different results were obtained using wire polypectomy loops and biopsy forceps that were passed through the endoscope's working channel.

In Case 1, only a part of the pine branch could be removed, while in Case 2, there were two unsuccessful attempts, prior to the horse being lost to follow-up.

In Case 3, the branch was removed in two segments, with a total length of 30 cm. The animal was treated with penicillin (20,000 IU/kg bwt s.i.d. i.m.) and metronidazole (20 mg/kg bwt b.i.d. per os) for 10 days. After one year, the horse is clinically well and being used for pleasure rides, as before.

In Case 4, the pine branch was surrounded by thick pus, and was firmly lodged in the bronchus. This resulted in numerous unsuccessful attempts at removal of the branch during the 1-year period. It was decided to keep the horse resting under pasture management; however, occasional coughing persisted.

We suggest that other cases of aspiration of foreign bodies, caused by similar plant types in the tracheobronchial region of horses might be overlooked. Successful treatment necessitated more than one extraction attempt, and the use of appropriate equipment. However, the *A. angustifolia* branch can adhere to swollen mucosa, which can make the extraction difficult.

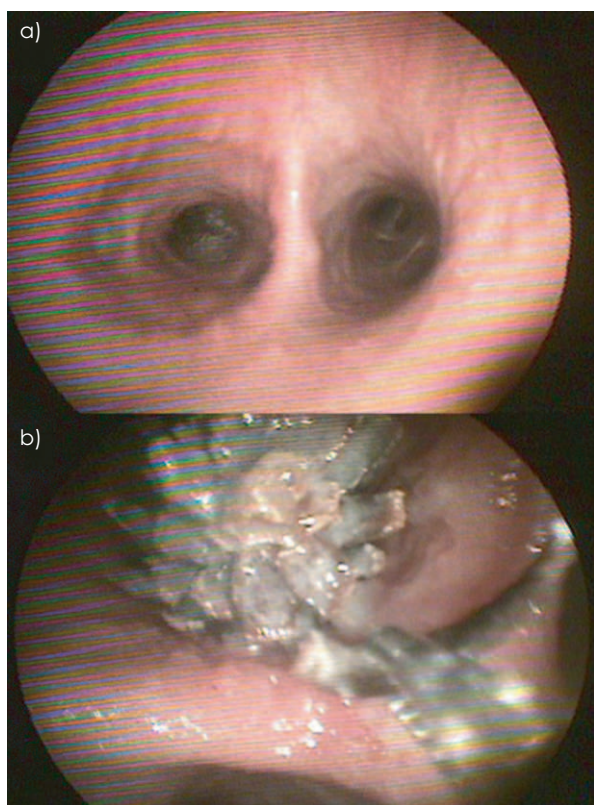


Fig 1: Bronchoscopic examination of horses. a) Carina region of a 5-year-old male Crioulo horse showing severe local inflammation; b) The foreign body in the same horse, as shown in 1a, distal to carina region.



Key points

- Foreign bodies must be included in the differential diagnoses of horses presenting with recurrent chronic cough and malodorous breath. Endoscopic examination must be performed distal to the tracheal bifurcation after instilling topical anaesthesia.
- The extraction of *A. angustifolia* branches is especially difficult due to their shape, which adheres them to the mucosa and creates resistance for their exit from the bronchus.
- Surgical access provides a possible treatment option, but it is influenced by the bronchial location, that is, the distance from the branch to the site of the tracheotomy. Moreover, it depends on the availability of suitable equipment and trained professionals.

Case Report

Cystic intra-abdominal testicles: Standing laparoscopic removal in two colts**A. B. M. Rijkenhuizen^{†*} , D. Lichtenberg[‡] and K. Weitkamp[§]**[†]Veterinary Clinic Wijk bij Duurstede, Wijk bij Duurstede, The Netherlands; [‡]Equine Clinic Hochmoor, Gescher; and[§]Equine Clinic Telgte, Telgte, Germany

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Keywords: horse; testicle; laparoscopy; cystic testicle; teratoma; cystic rete testis**Summary**

This case report describes the laparoscopic approach for removal of cystic intra-abdominal testicles in the standing colt. A 3-year-old Tobiano and a 2-year-old Warmblood colt were referred for abdominal cryptorchidectomy. The horses were clinically and ultrasonographically examined and a presumptive diagnosis of unilateral abdominal cryptorchidism was made. A laparoscopic approach via the flank was used to localise each abdominal testicle (**Fig 1**). In both colts the abdominal testicle was enlarged and cystic (**Fig 2**). Each spermatic cord was ligated and fluid was aspirated from the testicle. By reducing the size of the mass minimally invasive removal through an enlarged instrumental portal was possible. Histopathology revealed a cystic rete testis in the Tobiano and a teratoma in the Warmblood. Enlarged abdominal testicles can complicate routine castration, certainly when performed by conventional surgery. Laparoscopy offers the chance to localise the abdominal testicle and when the testicle is abnormal in size it can be physically reduced by aspiration of fluid in the case of a cystic lesion, using a morcellator in case of firm tissue or simply removed via an enlarged incision. In these cases the cystic enlarged testicles were nonpainful and were incidental findings. A cystic testicle might be developmental (Tobiano case) or arise due to neoplastic transformation (Warmblood case). The laparoscopic approach for enlarged cyst-like testicles in the standing horse offers a secure minimally invasive method for removal.

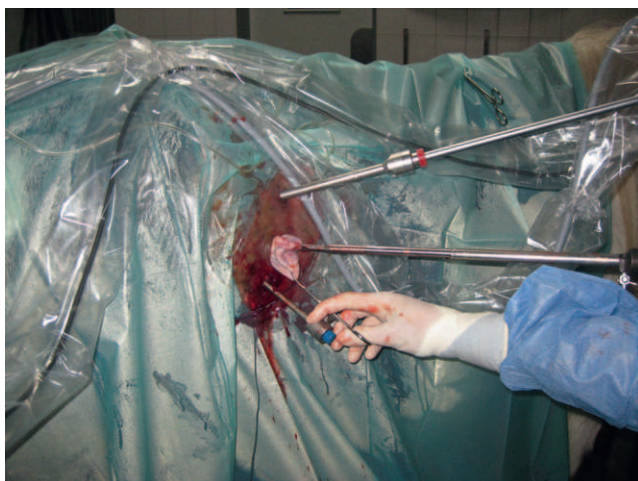


Fig 1: The emptied cystic testicle was removed intact by connecting the two instrument portals to a length of 5 cm using a modified grid technique.

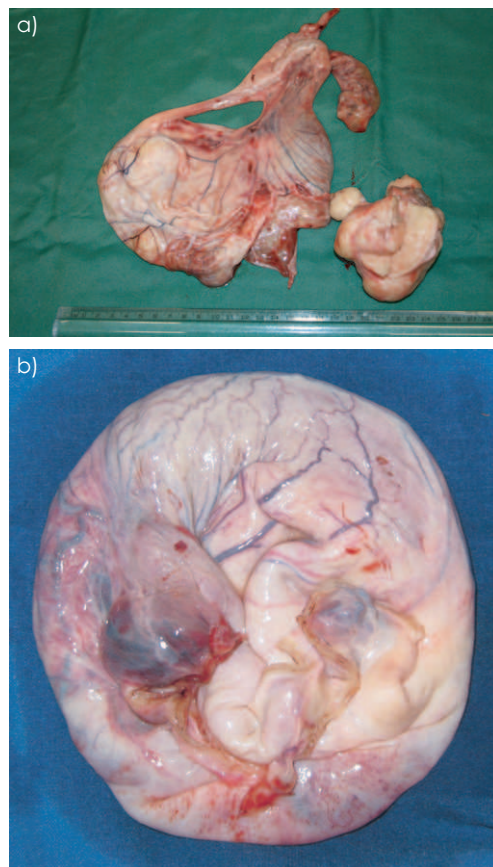


Fig 2: Macroscopic view of the retrieved mass. a) Warmblood horse. b) Tobiano horse.

Key points

- The laparoscopic approach for enlarged cystic testicles in the standing horse offers a secure minimally invasive method for removal.
- An abnormally sized testicle (developmental or pathological) itself might be the primary cause of the cryptorchism.
- A cystic testicle might be developmental or arise due to neoplastic transformation (**Figs 1 and 2**).



Clinical Commentary

Getting the rabbit out of the hat

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In the accompanying paper, Rijkenhuizen and co-workers (2020) describe the presentation and subsequent successful laparoscopic surgical castration of two unusual abdominal cryptorchid horses. Both horses had hormonally active unilateral enlarged cystic intra-abdominal testicles. Their article raises important discussion points with regards to occurrence and technique when dealing with enlarged abdominal testicles and teratomas in horses.

Abdominally retained testicles are infertile due to the higher temperatures, inhibiting the development of seminiferous tubules and hence limiting spermatogenesis (Bergin *et al.* 1970). It is generally accepted that abdominal testes are infertile, though spermatozoa can sometimes be identified (Hobday 1914). The testicular tissue in the Tobiano horse was inactive, but it is unclear whether it was possible to differentiate temperature- and pressure-related atrophy. In the other horse a cystic teratoma was present, with no grossly visible testicular tissue. The features of this horse follow a common pattern seen in monorchid horses, whereby most other secondary structures form normally, vis-à-vis vaginal process, ductus deferens, epididymis, proper ligament, testicular artery and vessels (e.g. Garlick 1952; Parks *et al.* 1989; Santschi *et al.* 1989; Strong *et al.* 1997; Brommer *et al.* 2011). It supports the theory that two gonads always form embryologically with subsequent loss or aberrant development occurring to the testis.

The previous hemicastration of the Warmblood teratoma horse warrants attention (Rijkenhuizen *et al.* 2020). The fallacious myth that castration of the descended testis in a cryptorchid horse would aid the descent of the missing testicle has no evidence to support it (Cox 1987). It probably gained traction from pony populations afflicted by delayed testicular descent, where the delayed gonad 'appeared' a few years after the previous one was removed, as it would have done anyway. A hormonal basis for testicular descent has been shown in man (Hagberg and Westphal 1982), leading to the recommendation for medication with hCG to stimulate descent in cryptorchid colts (Brendemuehl 2006). This may have some merit for inguinal retention and delayed descent, but the vaginal rings contract within the first few weeks, reducing the likelihood of descent of an abdominal testis (Bergin *et al.* 1970). A pathologically enlarged testicle would be even less likely to be able to pass the inguinal rings. Unilateral castration of a descended testicle in a cryptorchid horse could allow hormonally entire males to be mis-sold as geldings. For this reason, it could be legally construed as fraud and doing so a potential offence (Cox 1987). As well as the negative effects on the welfare of the horse, it may also increase the cost and morbidity of subsequent castration (Marshall *et al.* 2007), though more recent ultrasonographic methods offset this by allowing location to be determined before surgery (Schambourg *et al.* 2006; Coomer *et al.* 2016). When castrating a cryptorchid horse, the missing testicle should be removed first and if this is not possible, the

descended testicle should be left in place regardless. Cryptorchid horses undergoing hemicastration should not occur.

The authors of the accompanying article successfully removed comparatively large structures through small incisions by first decompressing the cystic cavities via needle aspiration. This technique has been around for a while, for example Hickes (1905) aspirated 39 fluid ounces (1.15 L) from a cystic abdominal testicle to facilitate its removal. The horse described by Rijkenhuizen *et al.* (2020) had close similarities with that described by Cribb and Bouré (2010), which also contained low viscosity liquid and was removed during standing laparoscopy. In managing decompression in this way, these authors were somewhat lucky in finding themselves presented with a liquid amenable to needle aspiration. Teratomas come in many forms and may be composed of any or all three germ layers: ectoderm, mesoderm and endoderm. Dermoid and epidermoid cysts are subtypes of benign teratoma; epidermoid cysts only contain skin, whilst dermoid cysts contain in addition, hair follicles, hair, sweat glands and their accumulated secretions. Other teratomas contain bone and cartilage (**Fig 1a,b, Supplementary item 1**) (Cox 1987). Teratomas in both mares and stallions are frequently cystic but because many are dermoid cysts, the contents may be of a viscous oily consistency and/or contain hair. Decompressing such cysts directly into the abdomen by tearing them open to allow the contents to drain into the peritoneum before removal was once practiced routinely with no ill effects (Hobday 1914). I recall one occasion when such a cyst wall tore during traction of what appeared, from pre-operative workup, to have been a moderately enlarged ovarian granulosa cell tumour. Liberal quantities of dark brown oily tenacious liquid admixed with hair spilled throughout the layers of the laparotomy incision (**Fig 2**). After lavage, no adverse effects occurred. Interested readers are directed to the beautifully illustrated descriptions of different types of testicular teratoma contained in Hobday (1914).

Removing enlarged retained testicles is not as well referenced as ovaries in horses, probably because they are encountered less frequently. The use of retrieval bags (e.g. Lloyd *et al.* 2007; Bont *et al.* 2010; Cribb and Bouré 2010) prevents seeding of the laparotomy surgical site, or abdomen, with tumour cells. This is a small problem because most are benign. A more tangible benefit to bags is that they provide a convenient way to provide traction without the need for hands that can slip or grasping instruments that can tear (**Fig 3**). Physical maceration may also be carried out inside the bag to further ease removal (Bont *et al.* 2010). Morcellators may reduce morbidity further by allowing removal via incisions no larger than the original laparoscopy ports (Kummer *et al.* 2010; Lund *et al.* 2014). It may be difficult to avoid peritoneal contamination if using a morcellator on a large cystic teratoma, or one containing bone. Huge testicular teratomas

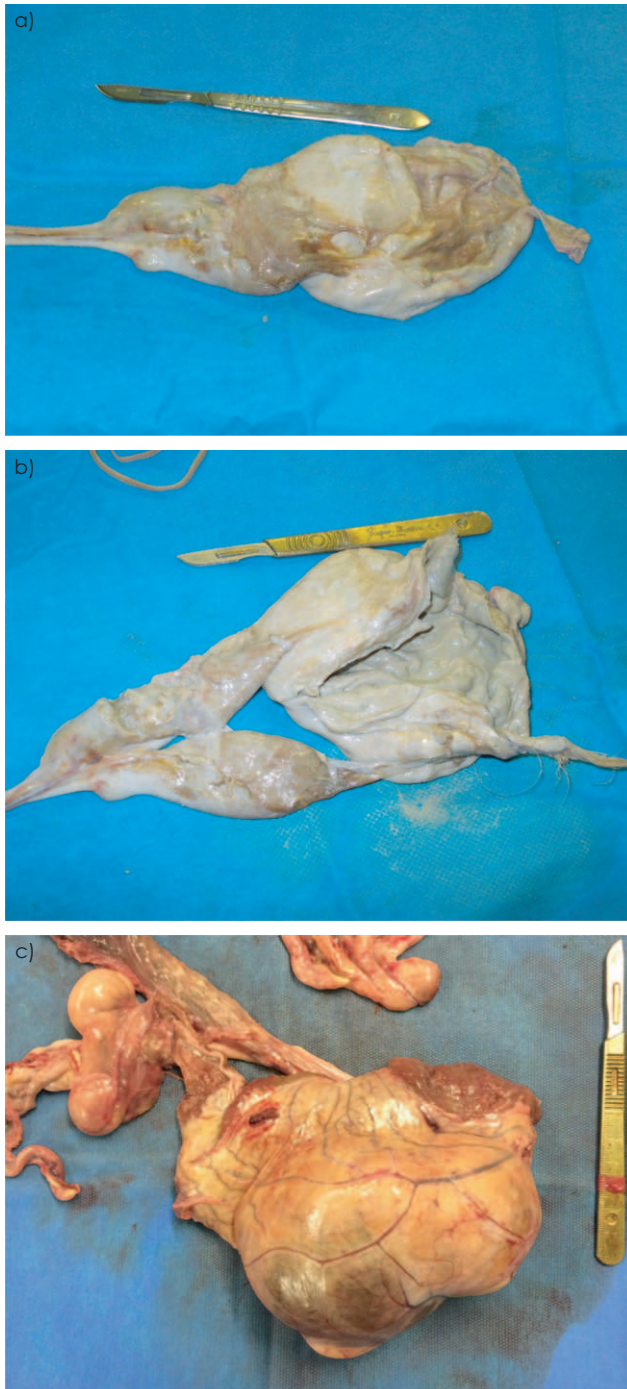


Fig 1: Testicular teratomas can contain many different types of tissue. a) and b) Show one that was dermoid cyst, containing viscous sebous liquid and hair. c) Also contained cartilage and bone (Supplementary item 1).

sometimes occur, with Dr Beeker of Cologne describing one such measuring 79 cm by 69 cm and weighing 45 kg (Hobday 1914). The teratoma depicted in **Figure 4** contained predominantly bone, weighing 22 kg and measuring 50 cm in diameter. The progressive inflammation, adhesions and damage caused by such a heavy mass eventually caused acute colic that proved inoperable.

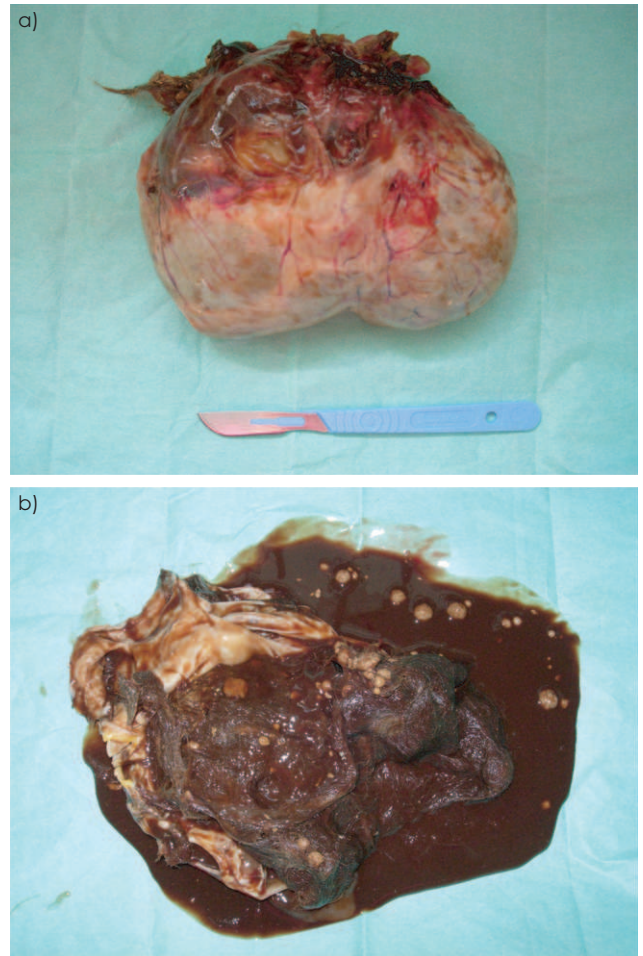


Fig 2: The contents of teratomas are frequently ill-suited to needle aspiration. The ovarian teratoma shown here was predominantly dermoid cyst (a). It ruptured during passage of the abdominal wall, spilling liberal quantities of brown viscous hairy fluid (b) throughout the laparotomy wound. No ill effects occurred for the horse.

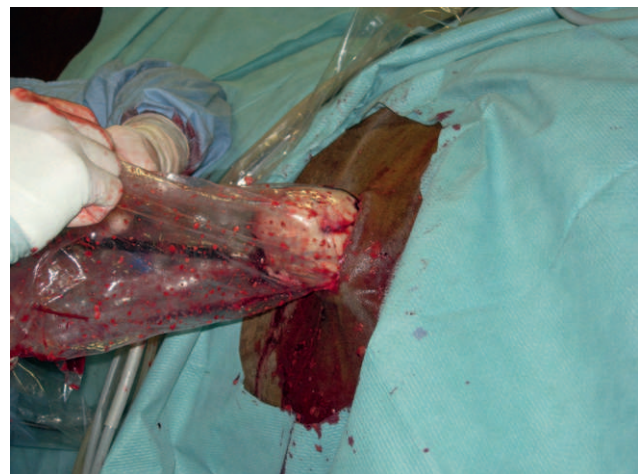


Fig 3: Placing an enlarged ovary in a bag before removal simplifies removal by allowing partial maceration and providing firm retraction. It also avoids the scenario outlined in Figure 2.

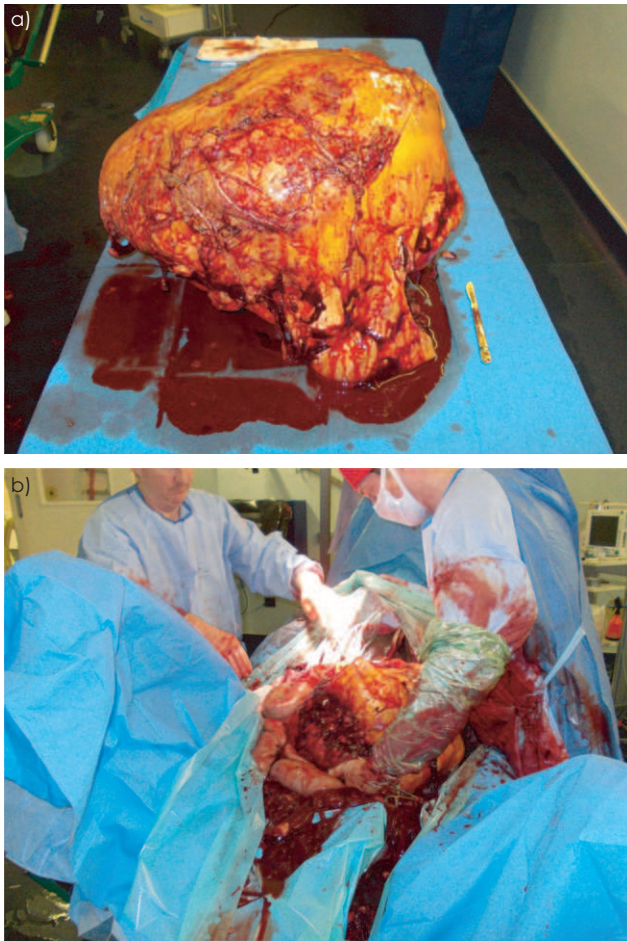


Fig 4: This teratoma was predominantly bone, weighing 22 kg and measuring 50 cm in diameter (a) by the time recurrent colic prompted exploratory laparotomy (b). Extensive and multiple adhesions had developed, including both large and small intestine. The size of the laparotomy wound and grave internal damage sustained in removing it proved fatal.

The use of insufflation during standing laparoscopy, as it was in both cryptorchid horses in the accompanying article, warrants discussion. Carbon dioxide is preferred over oxygen, nitrous oxide and room air thanks to not supporting combustion and its rapid blood solubility allowing clearance through the lungs (Safran and Orlando 1994). Peritoneal acidosis induced by CO₂ absorption also causes mild inflammatory peritonitis (Latimer *et al.* 2003) that may be associated with increased early post-operative pain. In a 2013 Cochrane review (Cheng *et al.* 2013) post-operative pain scores were higher in elective human laparoscopy patients undergoing insufflation with carbon dioxide compared to nitrous oxide. Many surgeons including the author do not use it routinely in standing horses for laparoscopy (e.g. Lloyd *et al.* 2007; Lund *et al.* 2014). With adequate starvation to reduce gut fill, the potential space achieved by passive aspiration of room air gives good visibility and working area, whilst the use of modern vessel sealing devices minimises the risk of combustion. The need for a 'sterile operating medium', as opposed to passive room air with its attendant dust particles, may be a concern for some, but carbon dioxide is made industrially and various studies

have shown it to be a source of bacteria and other undesirable contaminants. Using a filter method, Ott (1997) cultured multiple strains of bacteria including: *Staphylococcus* spp. from 12 of 60 gas tanks, *Streptococcus* spp. 9/60, *Listeria monocytogenes* 3/60, *Enterobacteria* spp. 6/60 and *Escherichia coli* 5/60. Numbers rose counting insufflators, inward and outward connectors and tubing, whilst similar results were obtained by Couper *et al.* (1997) who also found metallic dust in 100% of the 10 insufflators they tested. Frankel *et al.* (1998) was unable to replicate these results but were unable to conclude whether their negative results were because their filters failed to trap contaminants, or whether none were present to start. Whether or not there is a clinically relevant difference between the contamination obtained by passive air aspiration from a regular operating room, versus a commercial gas tank and insufflator, is debatable. Having the means to supply positive pressure insufflation with carbon dioxide is a wise precaution in case of limited working space. Routinely using it in standing horses is not a necessity.

The accompanying article illustrates well the need for quick thinking and improvisation of surgical technique, even when rigorous workup regimes are followed. Although testicular teratomas are rare, with sufficient volume they occur with regularity and little warning. Having a technique available to remove an abdominal cryptorchid testicle much larger than its descended counterpart should be available. The potential for viscous or solid contents ill-suited to needle aspiration or morcellation should be anticipated.

Author's declaration of interests

No conflicts of interest have been declared.

Ethical animal research

Not applicable.

Source of funding

None.

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Case Report

Colopexy dehiscence preceding an episode of large colon volvulus, followed by repeat colopexy, in three Thoroughbred broodmares

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Keywords: horse; surgery; gastrointestinal tract; colopexy

Summary

Three Thoroughbred mares ranging in age from 5 to 9 years, that had undergone previous colopexy following surgical correction of a large colon volvulus, presented for colic signs unresponsive to medical management. Exploratory laparotomy was elected and a midline celiotomy was performed in the caudal aspect of the ventral abdomen in each mare, due to the fact that a colopexy had been performed previously. Examination of the cranial abdomen revealed the large colon was not adhered to the ventral body wall, indicating dehiscence of the previous colopexy. Further examination of the abdomen in each mare revealed a 360-degree large colon volvulus. The previous colopexy site appeared as a linear haemorrhagic area of fibrosis in one mare (**Figs 1 and 2**) and a pale area of fibrosis in two other mares. The large colon volvulus was corrected and a second colopexy was then performed at the same site and using the same technique as the first colopexy – by incorporating 10–12 cm of the lateral free band of the left ventral colon into the midline linea alba closure using number 3 polyglactin 910 (Vicryl®). In this technique, the colopexy is placed in the cranial 10–15 cm of the incision, at a site on the lateral free band of the left ventral colon at least 40 cm from the Caecocolic ligament. The remainder of the linea alba incision is closed using the same suture pattern but without incorporating the tenia from the colon. The skin is then closed in a routine fashion.

The time elapsed between the first and second colopexy in each mare was 48, 1496 and 616 days. The mares each recovered uneventfully from anaesthesia and were discharged 2–10 days later. Two of the mares are still alive at the time of manuscript submission, 593 and 907 days post-operatively. The third mare survived 4 years post-operatively, following which she was lost to follow-up. Data available from our clinic indicate an incidence rate of 0.79% for colopexy dehiscence followed by a repeat episode of large colon volvulus. This phenomenon should be considered as a differential diagnosis when a mare that previously underwent a colopexy presents with severe signs of colic.

Key points

- If a colopexy has been performed previously by incorporating the left ventral colon into the midline linea alba closure, any future midline celiotomy should be performed in the caudal aspect of the ventral abdomen.
- In each case, the second colopexy was performed in the same location on the lateral free band of the left ventral colon as the first colopexy.
- Colopexy dehiscence followed by large colon volvulus should be considered as a differential diagnosis when a mare that previously underwent a colopexy presents with severe signs of colic.



Fig 1: (Case 1) The original colopexy site appearing as a linear haemorrhagic area of fibrosis along the lateral free band of the left ventral colon, 48 days post colopexy.

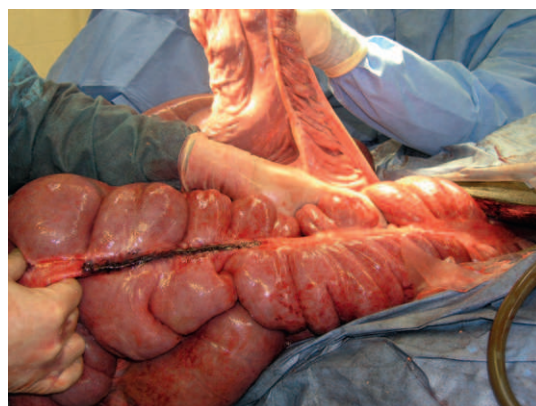


Fig 2: (Case 1) Image showing the position of the colopexy site on the left ventral colon.



Clinical Commentary

Is a standardised approach to colopexy justified?

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Keywords: horse; colopexy; colon volvulus; dehiscence**Summary**

Equine colopexy techniques vary according to surgeon preference and there is no clear evidence of the superiority of any one technique. Complications secondary to colopexy are varied, but dehiscence of the colopexy site is rare, with less than 1% of horses reported to have a repeat large colon volvulus after dehiscence of the colopexy. Considerations of how and when to perform a surgical fixation of the colon to the body wall include position of the colon, length of the colopexy, and suture material and pattern. Little evidence exists regarding best practice outside of experimental studies and retrospective studies of Thoroughbred broodmares. Therefore, more work must be done to standardise a colopexy technique to apply to a broad spectrum of horses suffering from large colon volvulus and displacement.

Several methods of colopexy have been described in the literature, including incorporation of the lateral free band of the colon in the ventral midline or left paramedian celiotomy closure, and left paramedian colopexy not incorporated into the celiotomy incision. Complications arising directly from colopexy include catastrophic rupture of the colon, enterocutaneous fistula, dehiscence of the colopexy without accompanying rupture of colon, and incisional hernia. In their recent publication, Hall and Rodgerson (2020) describe the complication of colopexy dehiscence with subsequent large colon volvulus and also provide an estimate of the overall risk of this complication in a population of Thoroughbred broodmares. This complication risk appears to be quite low, with less than 1% of horses reported to have a repeat large colon volvulus after dehiscence of the colopexy. However, there may be opportunities to optimise or standardise the colopexy technique to minimise complications and promote adhesion of the colon to the body wall. Hall and Rodgerson point out the likely factors that may contribute to colopexy dehiscence, including insufficient incorporation of the body wall, shallow suture bites of lateral band of the ventral colon, intestinal compromise and excessive weight of the colon. Whether to perform a colopexy and how to perform a colopexy have typically been questions of surgeon's preference within a framework of common-sense guidelines.

There are several technical and biomechanical factors to consider if a 'standard' colopexy technique were to be promoted. For example, does the position of the colopexy matter? Does the length of colopexy matter? Is the choice of suture material or suture pattern important? Based on the available literature, the post-volvulus broodmare has been the most likely candidate for colopexy; however, there may also be considerations specific to the sport horse when

decision-making after surgical correction of a large colon volvulus or displacement.

After some initial poor outcomes with experimental colopexy, there have been a number of successful techniques reported. Hance and Embertson (1992) described a technique of colopexy of both the right and left ventral colons to right and left body walls, respectively. This technique involved elevation of the body wall with suture placement at an angle to the internal rectus fibres to help prevent suture pullout. They reported a 4.5% rate of colon rupture (2/44) and a 6.8% rate of colopexy dehiscence (3/44), with two horses having recurrence of large colon volvulus or displacement. The authors described a modification of the colopexy technique, in which they abandoned the right colopexy and incorporated the external and internal rectus fascia in the left colopexy. The authors stated that the 'modifications to the colopexy technique used on mares subsequent to this study have seemingly prevented dehiscence of a colopexy site' (Hance and Embertson 1992). The left paramedian colopexy was recently described in a larger number of cases, with the technique of making an initial left paramedian celiotomy approach and incorporating the lateral free band of the ventral colon in part of the closure of the celiotomy (Broyles *et al.* 2018). There were no instances of colopexy dehiscence specifically described in any of the 156 Thoroughbred broodmares in this retrospective report, although they reported recurrence of large colon volvulus or displacement in 1.2% of cases and recurrent colic in 17%.

Incorporation of the lateral free band of the ventral colon in the ventral midline celiotomy closure was initially reported by Hunt and Spirito (1995), and this same technique was used in the cases reported by Hall and Rodgerson (2020). The position (midline vs. left paramedian) and length (10 cm vs. 20 cm) of the colopexy differ, and although the outcomes appear to be positive with either technique, the biomechanics of the position and length of the colopexy are unknown. Experimental colopexy constructs demonstrated that manual creation of a twist at the base of the colon was possible with a short colonic adhesion (8 cm) but not possible with a long adhesion (35 cm) (Markel *et al.* 1988a). Despite this experimental evidence, there have not been clinical cases of large colon volvulus at the base reported with an intact, short (10–15 cm) colopexy.

The authors of the accompanying case series point out potential disadvantages of incorporating the colopexy in the ventral midline celiotomy closure. Weakness in the closure could lead to incisional hernia or incisional dehiscence. However, the incision in the body wall may promote adhesion at the colopexy site, much in the way that the incisional gastropexy technique in dogs has been successful. The canine gastropexy technique involves an incision in the

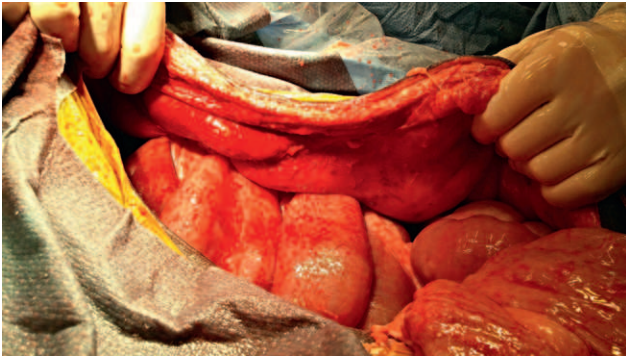


Fig 1: Interrupted horizontal mattress colopexy performed with elevation of left body wall.

seromuscular layer of the stomach and an incision through the peritoneum and transversus abdominus muscle. The incisions are then sutured together. An incision in the seromuscular layer of the equine colon appears to be unnecessary and would likely be risky in a compromised colon. Based on the success of laparoscopic colopexy in horses, in which the peritoneum is not incised, a body wall or peritoneal incision is not crucial to the success of the colopexy adhesion, although we are not aware of any clinical retrospective studies of laparoscopic colopexy (Trostle *et al.* 1998). The authors of this commentary do not routinely make a body wall incision or dissection of the subcutaneous space in their left paramedian colopexy procedures (Fig 1), which has not resulted in any instances of dehiscence, to our knowledge. This procedure has led to mature adhesions confirmed on necropsy in cases subjected to euthanasia for reasons unrelated to colopexy dehiscence (Fig 2).

A variety of suture materials and suture patterns have been described for equine colopexy. An experimental colopexy technique using surgical gut suture did not result in long-term adhesions between the right and left colons, whereas the technique using polypropylene suture resulted in colopexy adhesions that remained at one year (Markel *et al.* 1986). Polypropylene suture was also used in the report by Hance and Embertson (1992), and nylon suture has been

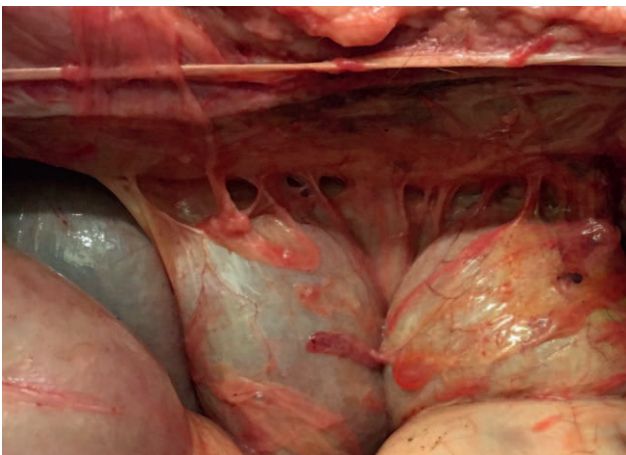


Fig 2: Post-mortem image of colon to body wall adhesions 24 months after colopexy.

described for use in laparoscopic colopexy, mainly due to the needle size which allows penetration through the body wall (Trostle *et al.* 1998; Wilson 2012). The use of braided absorbable suture (polyglycolic acid and polyglactin 910) has been described more recently with the technique of incorporating the lateral free band in the celiotomy incision closure (Hunt and Spirito 1995; Broyles *et al.* 2018). Absorbable and nonabsorbable suture have been reported for bovine omentopexy (Fubini *et al.* 1992; Baird *et al.* 2017). Incorporation of the visceral wall in the surgical fixation appears to mitigate risk of future left displaced abomasum (LDA) in cattle, with recurrence of LDA in 14% of cows with omentopexies versus 0% of cows with pyloro-omentopexies (Baird *et al.* 2017).

To the authors' knowledge, catastrophic incisional dehiscence of the celiotomy incision has not been reported with colopexy at either ventral midline or left paramedian sites. This lack of body wall failure may lend support to the theory that the most common cause of colopexy dehiscence is failure at the seromuscular layer of the colon, similar to the mode of failure of gastropexies in dogs. Ex vivo biomechanical analysis of gastropexy techniques has been performed in canine cadavers (Imhoff *et al.* 2015; Culp *et al.* 2016). The primary mode of failure with axial tension to failure was gastric seromuscular tissue tearing at the gastropexy site. Pilot data from our laboratory demonstrated that failure of an equine ex vivo colopexy construct occurred most commonly with pull-through at the colonic band, which lends support to the recommendation for adequate bites of the lateral band (Fig 3). The effect of suture pattern and needle/suture size on colopexy strength has not been evaluated but may play a role in the strength of the colopexy and quality of the adhesion.

Based on the large retrospective studies out of central Kentucky, a colopexy technique incorporating the ventral midline or left paramedian celiotomy incision is an effective prevention of large colon volvulus and displacement in Thoroughbred broodmares. There is limited information about outcomes in sport horses. Authors of retrospective studies of diverse populations of horses with large colon volvulus propose large colon resection to prevent future volvulus (Driscoll *et al.* 2008; Pezzanite and Hackett 2017), a procedure more technically difficult and requiring a lengthier surgical time than colopexy. A case report by Markel *et al.* (1988b) documents three horses that returned to athletic work after colopexy surgery without complications, and show horses having received colopexy at the authors' institution are currently in athletic work. Further work must be done to evaluate what restrictions, if any, should be safely recommended for return to performance following colopexy. An additional factor in the decision to perform colopexy versus resection is the duration of volvulus and severity of compromise to the colon, with colon resection preferred for compromised colons. Horses with frequent, chronic colic referable to the large colon may also benefit from large colon resection, although colic episodes have also been reported after large colon resection (Driscoll *et al.* 2008; Pezzanite and Hackett 2017).

Current published data are not sufficient to recommend a standardised colopexy technique. The authors in the accompanying case series chose to repeat the colopexy procedure in horses with repeat colon volvulus after dehiscence, with successful outcomes. The authors could



Fig 3: Failure of the colon wall at the suture site within the lateral band (a was predominant in samples harvested for ex vivo biomechanical testing of colopexy pullout strength b).

have chosen colon resection or a different colopexy technique, but incorporation of the colon into the ventral midline is almost certainly the fastest technique. Randomised clinical trials to compare colopexy techniques would be challenging due to surgeon preference, individual case considerations, and limited large colon volvulus cases at many hospitals. However, biomechanical analysis and retrospective data on colopexy in larger populations of non-broodmare horses would be valuable contributions to decision-making in equine large colon volvulus cases.

Authors' declaration of interests

No conflicts of interest have been declared.

Ethical animal research

Not applicable.

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Authorship

All authors contributed to preparation and final approval of the manuscript.

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Case Report

Mesenteric strangulation by pedunculated lipomas without involvement of associated intestine in four horses

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Keywords: horse; mesentery; colic; lipoma

Summary

This report describes the clinical signs, pathological findings and outcome in four horses with mesenteric strangulation by pedunculated lipomas. In each case, there was no intestinal strangulation. These horses were presented with no specific preoperative evidence of intestinal obstruction or a strangulating lesion other than degree of pain (no nasogastric reflux, no dilated loops of intestine on rectal examination/ultrasound). The small intestinal mesentery was involved in three horses and the small colon mesentery in the fourth horse but the associated intestine was not strangulated, haemorrhagic, nor obviously obstructed in any horse. In all horses, a patch of haemorrhagic mesentery of variable size was evident around the origin of a mesenteric

lipoma and a major mesenteric vessel (**Fig 1**). One horse was subjected to euthanasia for financial reasons and the remaining three had surgery from which they made a complete recovery after removal of the lipoma. Intestinal resection was not performed in any of the three horses undergoing surgery, although a mesenteric defect had to be closed in the small colon mesentery.

Traction on the mesenteric vessels as they were drawn into the mesenteric strangulation by the lipoma caused pain and mesenteric haemorrhage. The equine small intestine and small colon both have extensive collateral circulation so that arcuate blood vessels from major mesenteric branches outside the strangulated region could provide adequate blood flow to the intestine. Furthermore, the thick-walled arteries could remain patent and continue to perfuse the intestinal segment during this process so that intestinal viability was preserved. In the three cases that underwent surgery, the excellent post-operative outcome indicated that resection is not required in cases of mesenteric strangulation.

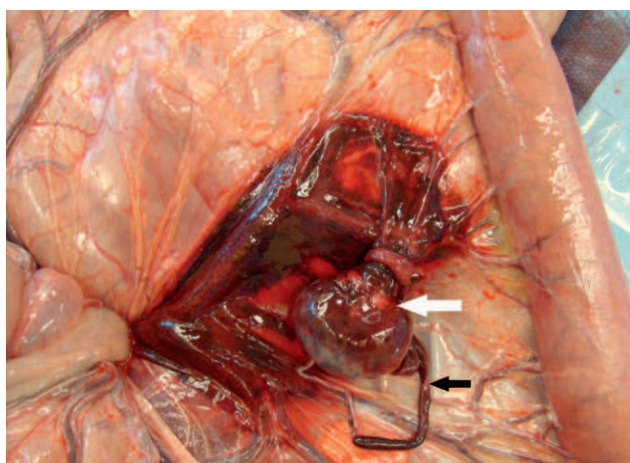


Fig 1: Intraoperative picture after correction with white arrow pointing to the lipoma and the small black arrow to its pedicle. The lipoma was detached from the mesentery at this stage to allow correction but is replaced on its point of origin. Note that haemorrhage follows the mesenteric vessels.

Key points

- This report describes management of an unusual but important form of colic caused by strangulation of the mesentery by a pedunculated lipoma, without intestinal strangulation.
- Surgical treatment involved removal of the lipoma and repair of any mesenteric defects, but not resection of the intestines.
- In the three horses that underwent surgery, all survived to discharge with no episodes of post-operative colic or reflux.



Clinical Commentary

Perplexing pedunculated lipomas

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Abdominal lipomas are benign smooth walled and encapsulated fat tumours that are formed by a hyperplastic growth of adipocytes originating from the mesenteric tissues of the small intestine and small colon in older horses (Archer 2007). Lipomas can occur as solitary masses, or alternatively multiple tumours can be found in the same horse. The small intestine has been reported to be involved in 89% and approximately 10% are associated with the small colon (Garcia-Seco *et al.* 2005).

These lesions may be discovered as an incidental finding at laparotomy or at necropsy examination, but often are implicated as a cause of colic due to their propensity to develop on a stalk associated with the intestinal mesentery of the small intestine or small colon. Strangulation of intestinal segments occurs when the stalk wraps around a segment of bowel resulting in luminal and vascular occlusion (**Fig 1**). Why some lipomas tend to lie dormant and some lead to severe intestinal incidents is not completely known or understood. Additionally, the length of the intestine that becomes entrapped by the lipoma can vary extensively. Factors such as the weight of the lipoma, length of the stalk and potential motility of the associated intestine could all be implicated (Edwards and Proudman 1994). Occasionally lipomas are found to be calcified or necrotic (**Fig 2**).

Intestinal strangulation by a mesenteric lipoma is a commonly encountered surgical lesion and it has been reported that pedunculated lipomas are responsible for up to 30% of all small intestinal strangulating lesions requiring surgery (Garcia-Seco *et al.* 2005). Lipomas are more commonly reported in older horses, with horses >15 years at increased risk (Edwards and Proudman 1994; Freeman and Schaeffer 2001; Garcia-Seco *et al.* 2005; Archer 2007). Garcia-Seco *et al.* (2005) reported a significant predisposition for Saddlebreds and Arabians to present with strangulating lipomas compared to other breeds. Other studies have reported Quarter Horses, Arabians, Morgans and ponies to be predisposed (Dart *et al.* 1992; Edwards and Proudman 1994). In the literature, it would appear that castrated males are over-represented compared to females or intact stallions (Blikslager *et al.* 1992; Garcia-Seco *et al.* 2005). It has been shown in small animals that neutering predisposes both dogs and cats to obesity and that this effect is due to behavioural changes such as reduced activity and increased food intake (Nguyen *et al.* 2004; German 2010). It is possible that a similar effect is seen in castrated male horses and it has been previously speculated that increased body weight may be a risk factor for the development of pedunculated lipomas (Edwards and Proudman 1994) in horses; however, to date this has not been confirmed. A recent study (Newkirk *et al.* 2014) looking at pituitary lesions, obesity and mesenteric

lipomas in insulin resistant horses did have significantly more lipomas and higher lipoma area compared to insulin sensitive horses, although there was no correlation between body condition score (BCS) and lipoma frequency or total lipoma area. It is interesting to note that similar breed predispositions (Arabians, Saddlebred, Morgan and pony breeds) are affiliated with equine metabolic syndrome (Frank *et al.* 2010) and those presenting with lipomas.

Although intestinal strangulation is the most common surgical consequence of a pedunculated lipoma, the case report by Bauck *et al.* (2020) in this issue describes another manifestation of how a lipoma can induce colic. In the four cases (all greater than 20 years of age) described in this report, the mesentery appeared to have been strangulated by a lipoma, with the associated intestinal segment

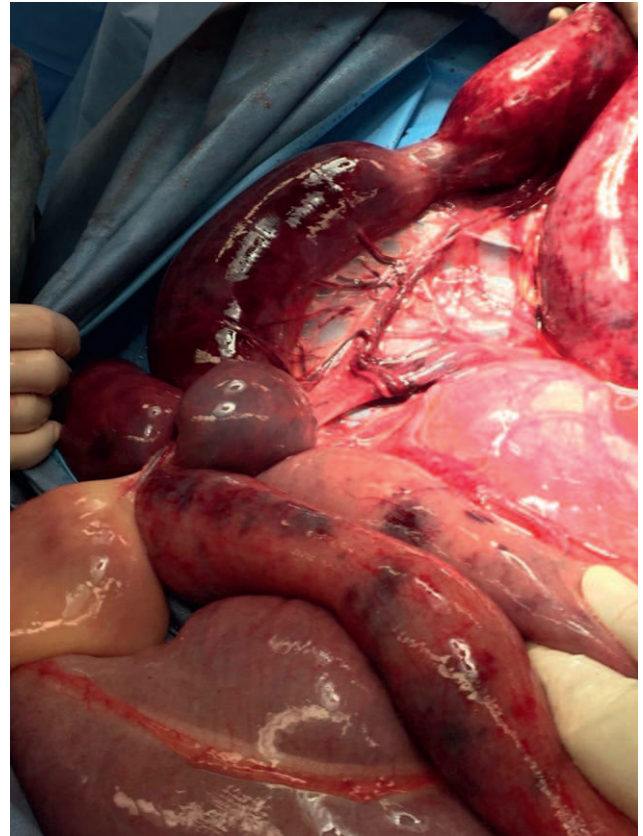


Fig 1: Strangulating lipoma of the distal jejunum resulting in vascular and luminal obstruction of a section of jejunum.



Fig 2: A large (10 × 4 × 6 cm) pedunculated yellow, fluid-filled mass arising from the mesentery with a twisted black stalk located 385 cm from the pylorus on the mesentery of the jejunum. The mass ruptured upon manipulation and contained yellow clear fluid and a yellow/black soft tissue core of 2.5 × 6.5 cm when cut (necrotic, cavitated, fluid-filled lipoma). Photo courtesy of Dr. Katherine Watson.

unaffected. All three cases that underwent surgery had a good outcome without the necessity of requiring a resection and anastomosis of the associated intestinal segment, which would indicate that although there was variable venous occlusion, the mesenteric arterial supply was patent to maintain perfusion and intestinal viability. The authors speculated that the small intestine supplied by the affected mesentery could also have had sufficient collateral circulation from adjacent vessels. Although an exact manner by which the lipoma had injured the mesentery could not be determined, sufficient damage to the affected mesentery and mesenteric vessels resulted in venous occlusion and/or congestion similar to that seen with mesenteric haematomas (Van Hoogmoed and Snyder 1996). Van Hoogmoed and Snyder (1996) described acute small intestinal injury associated with haematomas in the mesentery of four horses. In two of these horses, haematomas in the mesentery were secondary to tears that disrupted the integrity of the mesenteric vessels; the result of a pedunculated lipoma in one horse and as a complication of parturition in the other horse. In the other two horses, the predisposing cause of the mesenteric haematomas causing ischaemic necrosis of the small intestine could not be identified. All horses in this case series had evidence of intestinal ischaemia associated with the mesenteric haematomas necessitating resection.

Other unusual manifestations of lipomas include a case report (Verwilghen *et al.* 2013) that describes a very large (41 kg) mesenteric lipoma as a cause of recurrent colic in one horse. The author speculated the broad and short mesenteric base found in the massive lipoma was less likely to create strangulation as typically seen with pedunculated lipomas. However, due to the weight and size of the mass, partial occlusion of the adjacent intestine by compression or tension, was hypothesised to be the cause of recurrent colic. Other forms of adipocyte accumulation causing colic, such as lipomatosis (Archer 2007) have also been described. Lipomatosis, in contrast to lipoma, is a nonencapsulated benign form of fat accumulation that is not limited by tissue planes (Archer 2007). Histologically it appears benign but can cause massive tissue infiltration. Two cases of lipomatosis have been reported to cause recurrent colic in horses (Henry and Yamini 1995; Riley *et al.* 2007). One report (Riley *et al.* 2007) described a case of colonic lipomatosis that resulted in simple nonstrangulating obstruction of the small colon and a previous report (Henry and Yamini 1995) was the first to describe infiltrative lipomatosis which led to the development of colic in a horse due to compromise of the muscular and neural structures of the colonic wall. An additional case of atypical diffuse infiltrative lipomatosis of the mesojejunum was reported in a mare that had experienced episodes of recurrent colic (Linnenkohl *et al.* 2013).

In conclusion, intestinal strangulation by a mesenteric lipoma remains the most common cause of colic due to fatty accumulations in the abdomen, particularly in older horses. However, readers should be aware that other manifestations, such as mesenteric strangulation, as described in the current case report, chronic colic due to larger lipomas or lipomatosis can also be implicated and should be considered as potential causes of colic.

Authors' declaration of interests

No conflicts of interest have been declared.

Ethical animal research

Not applicable for this clinical commentary.

Authorship

I. Kilcoyne wrote the commentary and J. Nieto edited the commentary.

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Original Article

The proper application of the wooden shoe: An overview

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Keywords: horse; hoof; therapeutic farriery; lameness; laminitis

Summary

The wooden shoe provides the clinician with an alternative option to conventional farriery when treating a variety of foot problems such as acute/chronic laminitis, white line disease, distal phalanx fractures and poor-quality hoof capsules. The wooden shoe provides a simplified method to apply many of the principles of therapeutic farriery which include redistributing the load or forces on the foot, repositioning breakover and providing heel elevation when necessary. Understanding the biomechanics of the wooden shoe along with understanding good basic farriery which include the appropriate foot trim, proper size, fit and placement of the wooden shoe on the foot combined with the appropriate application are essential for consistent success. This paper outlines what is considered to be the proper application of the wooden shoe.

Introduction

There are many practical farriery options available to the clinician when an alternative to a horseshoe may be necessary or preferred. The wooden shoe has become a simple, practical and very effective farriery option for treating not only chronic laminitis but a variety of other foot problems (Steward 2003; O'Grady *et al.* 2007; O'Grady and Parks 2008; O'Grady and Steward 2009; Parks and O'Grady 2009, 2015; O'Grady 2010, 2011) (Fig 1). Among those problems that may benefit from the wooden shoe are acute/chronic laminitis, extensive white line disease, fractures of the distal phalanx/navicular bone and horses that have feet with thin deformable soles. The wooden shoe should only be used as a transitional device to stabilise the hoof capsule, promote hoof wall growth at the coronet and increase sole depth. Once the structures of the hoof capsule have improved with sufficient mass to achieve stability and realignment of the distal phalanx within the hoof capsule in the case of chronic laminitis, conventional farriery is used or the horse can be left barefoot. The wooden shoe is simple to apply but, as with any procedure, there is a learning curve such that it is essential to follow a procedural model. Understanding the biomechanics of the wooden shoe coupled with understanding good basic farriery which include the appropriate foot trim, proper size, fit and placement of the wooden shoe on the foot along with its proper application are essential. It must be stated from the onset, that the application of the wooden shoe must be combined with the appropriate foot trim for the clinician to achieve consistent effective results from this modality. Chronic laminitis is the disease most often treated with the wooden shoe, so its use here will be stressed when describing the overall procedure.

Advantages

The wooden shoe has all the mechanical aspects that can be incorporated in other farriery systems previously described yet it may possess some additional advantages over previous methods. A major advantage of the wooden shoe, coupled with the trim, is its ability to redistribute the load (weight) evenly over a specified section of the foot due to its flat solid construction (O'Grady and Steward 2009; Parks and O'Grady 2009; O'Grady 2010, 2011). Silastic material added to the solar surface of the foot further increases the surface area of the foot enhancing the effects of placing one flat surface against another (Parks and O'Grady 2015). Another advantage is its nontraumatic application that eliminates the necessity to use local anaesthesia in the case of chronic laminitis or other painful foot problems (O'Grady and Steward 2009; Parks and O'Grady 2015). The wooden shoe is constructed from readily accessible materials (wood) or can be purchased commercially.¹ Breakover and heel elevation can be fabricated into the shoe and the beveled perimeter of the shoe decreases the torque on the lamellae at breakover by moving the ground reaction force axially. The beveled perimeter of the shoe also appears to concentrate the load (weight) under the distal phalanx due to the solid base of the shoe. Heel elevation, when necessary, can be applied in a uniform manner by altering the shape of the wooden shoe or by attaching a degree pad to the foot surface of the shoe. The shoe can be easily adjusted using radiographic guidelines and the biomechanical or structural requirements of the individual foot conformation.

Mechanism

The wooden shoe addresses three of the principles used in applying therapeutic farriery. The first is to redistribute the load (weight of the horse) or unload the forces on a section of the ground surface of the foot. Secondly, to reposition breakover and lastly, to provide heel elevation when necessary to decrease the tension in the deep digital flexor tendon (DDFT) (O'Grady 2006, 2011; Parks 2011, 2012; Parks and O'Grady 2015). These three principles are especially relevant when treating chronic laminitis. To understand these principles, it is necessary to briefly consider foot biomechanics and the moments about the distal interphalangeal joint (Eliashar 2007; Parks 2011, 2012; Parks and O'Grady 2015). In a standing horse, the weight of the horse borne by the limb exerts a force on the ground which is opposed by an equal and opposite force, the ground reaction force (GRF). The GRF acts on any point of the foot touching the ground. The summation of these forces can be calculated to have a central point of action which is termed the centre of pressure

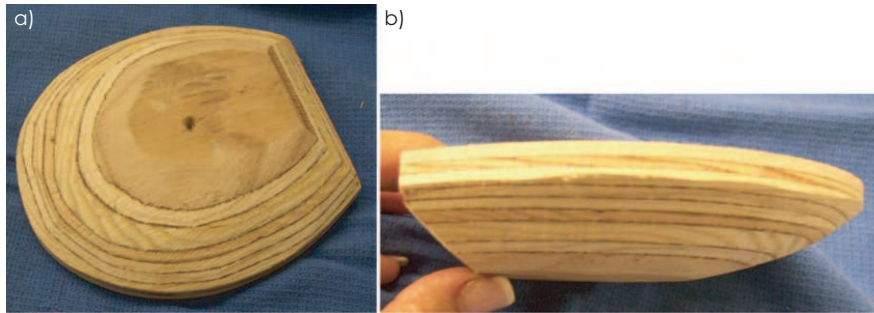


Fig 1: a) Ground surface and b) side view of the wooden shoe. Note the bevel around the perimeter of the shoe and the flat platform on the ground surface.

(COP). The position of the centre of pressure varies depending on foot conformation and trimming but will be located dorsal to the centre of rotation (COR) of the distal interphalangeal joint (DIPJ). The GRF being dorsal to the COR creates a moment about the distal interphalangeal joint termed the extensor moment. The extensor moment must be opposed by an equal and opposite moment, which is termed the flexor moment. A moment is the product of a force and its distance from a reference point to cause a body to rotate about an axis which in this case, is the centre of rotation of the distal interphalangeal joint. At rest, the extensor moment is the product of the weight borne by the limb (a force) and the horizontal distance from the point at which the ground reaction force acts on the foot (COP) and the centre of rotation of the distal interphalangeal joint. The flexor moment opposes the extensor moment and is the product of the force (tension) in the tendon and the shortest distance of the DDFT from the centre of rotation (**Fig 2a**). The GRF determines the subsequent compressive and tensile stresses that are placed on the dorsal section of the foot. If a horse is standing on its limb, the weight of the horse acts on the foot through the COR and is relatively constant, but the position of the GRF where it acts on the ground surface of the foot can be shifted away from the affected area or redistributed. At breakover, the flexor moment begins to exceed the extensor moment such that the GRF moves dorsally to the toe at which point the heels lift off the ground (**Fig 2b**). As the COP moves dorsally, it places greater force at the toe; a force that can potentially be disruptive. The thickness of the wooden shoe allows breakover to be placed in the shoe further palmarly than conventional shoes. This

reduces the extensor moment arm, brings the GRF closer to the centre of rotation and reduces tension in the DDFT (**Fig 3a**). This concept of changing the point of breakover can be clearly demonstrated by creating a bevel in two pieces of wood that are of different thickness (**Fig 3b**). Furthermore, the bevel created around the perimeter of the wooden shoe will reduce the moment which decreases the force required to breakover in a medial or lateral direction with less stress on the tissues (**Fig 4**). Finally, combined with the appropriate trim and impression material placed in the frog sulci, one firm flat surface (the foot) is created and now placed against the wooden shoe; the distribution of force becomes larger and more uniform because weight bearing is widely distributed across the palmar section of the foot.

Construction of the shoe

The author prefers wood due to its accessibility, light weight, the ease with which it can be constructed/shaped (both before and after application), malleability and its ability to dissipate energy at impact while remaining rigid (Reid 1994). There are shoes available commercially that have an ethyl vinyl acetate (EVA) pad substituted for the thicker $\frac{3}{4}$ inch section of plywood that is beveled. EVA is an extremely elastic material that can be sintered to form a porous material similar to rubber yet has resilience. The compressibility of this material distributes the load across the surface of the foot, however, it does wear and compress unevenly relative to the load placed on the limb causing the angle and the forces on the foot to change. Although more time consuming, the author prefers to use wood which can

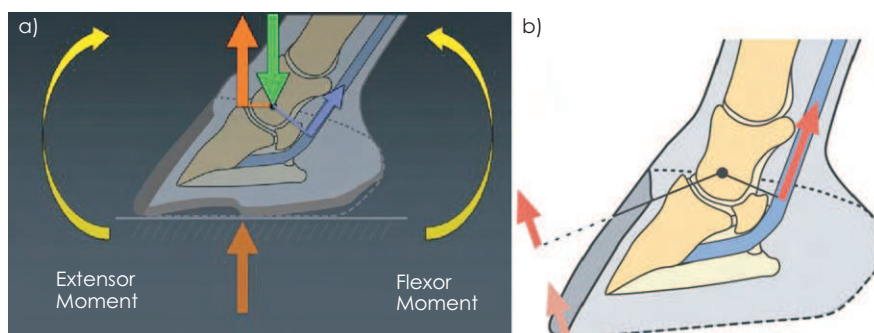


Fig 2: a) The biomechanical forces exerted on the foot and the moments about the DIPJ. b) The GRF moving dorsally in the toe during mid-stance and breakover (Image courtesy of Andrew Parks).

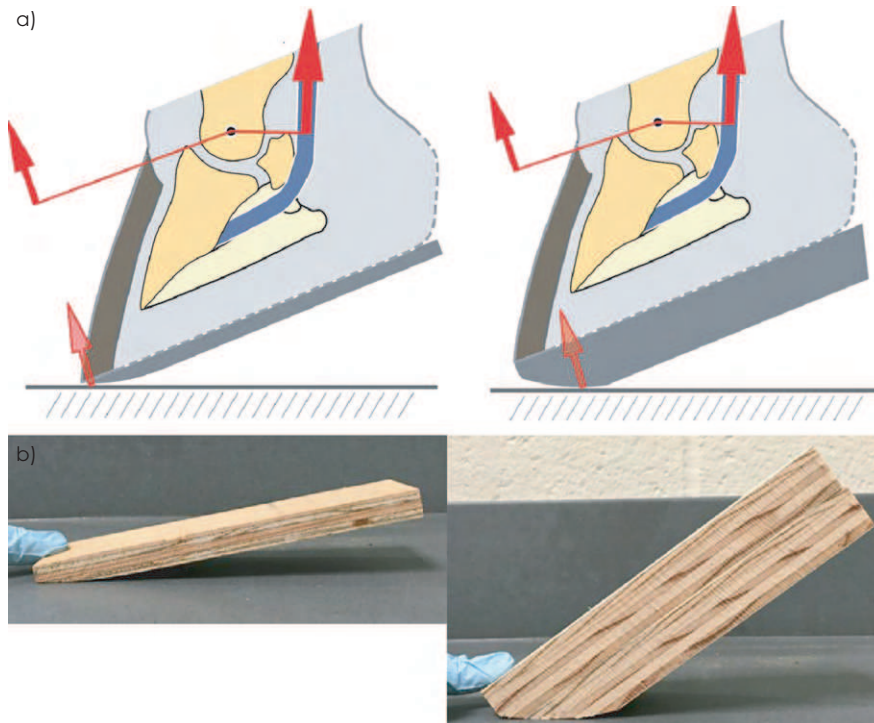


Fig 3: a) The extensor moment about the DIPJ can be moved further palmarly in a wooden shoe when compared with a conventional horseshoe (Image courtesy of Andrew Parks). b) This illustrates how the tilt (breakover) can be increased when a bevel is created in two pieces of wood of different thicknesses. Note the increased breakover in the thicker block.

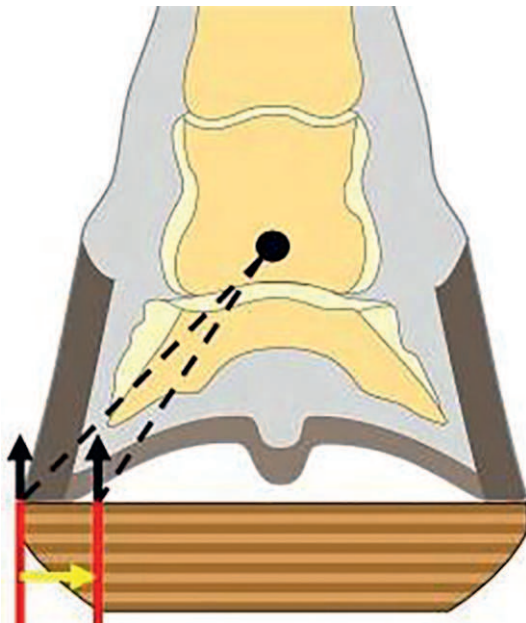


Fig 4: This illustrates the bevel in the wooden shoe that shifts the GRF axially which decreases the moment about the DIPJ and enhances breakover in a mediolateral direction (Image courtesy of Andrew Parks).

be fabricated according to the conformation of the foot, the integrity of the structures and the radiographs. The wooden shoe can be constructed using any steel or aluminum shoe

with a broad toe that is available in sizes 00–5 as a template.² The basic shoe is made from two pieces of plywood. One piece of plywood is 6.3–9.5 mm (1/4–3/8 in) thick (depending on the thickness of the shoe required) and the second piece is 19 mm (3/4 in) thick. Using the aluminum shoe as a template, the thinner piece of plywood is cut out with a vertical border while the thicker piece is cut out with the border straight or beveled at a 30-degree angle across the palmar or heel section and a 45-degree angle around the perimeter of the block using an angle saw³ (Fig 5a). The straight or decreased angle across the palmar section of the shoe prevents rocking backwards during landing. The two pieces of plywood are glued together with the thinner portion proximal and then two 1-inch drywall screws or wood screws are inserted on the ground surface of the shoe for additional security. A wood rasp or belt sander is used to blend the cut angles into a uniform smooth slope. Plywood can also be purchased in a solid 45 mm (1.8 in) thickness which eliminates the necessity to cut two pieces. Alternatively, the wooden shoe is available commercially and can be easily modified with a belt sander or a hoof rasp to match the wooden shoe that was described above³ (Fig 5b). Shoe height is dictated by the conformation of the hoof and the amount of displacement of the distal phalanx present, that is, the greater the rotation of the distal phalanx, the more shoe height is necessary in order to achieve the appropriate palmar placement of breakover. If the sole is prolapsed or the distal phalanx has penetrated the sole, a recess can be created in the dorsal foot surface of the shoe by cutting a half moon shape in the thinner piece of plywood using a router or a hand grinder to create a trough

in the shoe below the area of the sole or bone that has prolapsed. If it is determined that heel elevation is required, the heels can be raised accordingly by applying a wedge pad to the foot surface of the wooden shoe. The angle of the wedge is usually 2–3 degrees depending on the amount of heel horn removed. The wedge pad is attached to the shoe with 1-inch drywall screws or wood screws. An

alternative method to raise the heels is to cut the ground surface of the wooden shoe itself at an angle to the hoof surface.

Radiographs

Radiographs are essential when applying the wooden shoe. The lateral view evaluates the distal phalanx and related soft tissue structures of the foot in a sagittal plane while the dorsopalmar view evaluates these structures in a frontal plane. High quality radiographs are required to visualise the osseous structures, the hoof capsule and related soft tissue structures in order to evaluate any disease process, hoof conformation, the position of the distal phalanx within the hoof capsule, position of the DIPJ and especially the soft tissue structures. The radiographs are also used as a guideline for trimming the foot as well as positioning and applying the wooden shoe (**Fig 6**).

The lateral radiograph is used to identify dorsal rotation or displacement of the distal phalanx when evaluating chronic laminitis but it does not allow identification of asymmetrical medial or lateral distal displacement of the distal phalanx (O'Grady *et al.* 2007; O'Grady 2010; Parks and O'Grady 2015). Therefore, a dorsopalmar (0-degree dorsopalmar) radiographic projection should always be included as part of the radiographic study for either acute or chronic laminitis.

The radiographic features of chronic laminitis are well documented (Redden 2003; Sherlock and Parks 2013). The lateral radiograph will allow the clinician to assess the thickness of the dorsal hoof wall, the descent of the distal phalanx within the hoof capsule, the degree of dorsal rotation of the distal phalanx, the angle of the solar border of the distal phalanx relative to the ground, the distance between the dorsal limit of the solar margin of the distal phalanx and the ground and the thickness of the sole.

The dorsopalmar radiograph will reveal if asymmetrical distal displacement of the distal phalanx on either the lateral or medial side is present and whether the width of the hoof wall is thicker than normal on the affected side.

A useful template can be superimposed on the lateral radiograph and then transferred to the foot for use as a guideline for the appropriate trim and placement of the wooden shoe in cases of chronic laminitis (O'Grady and Steward 2009; Parks and O'Grady 2015) (**Fig 7**).

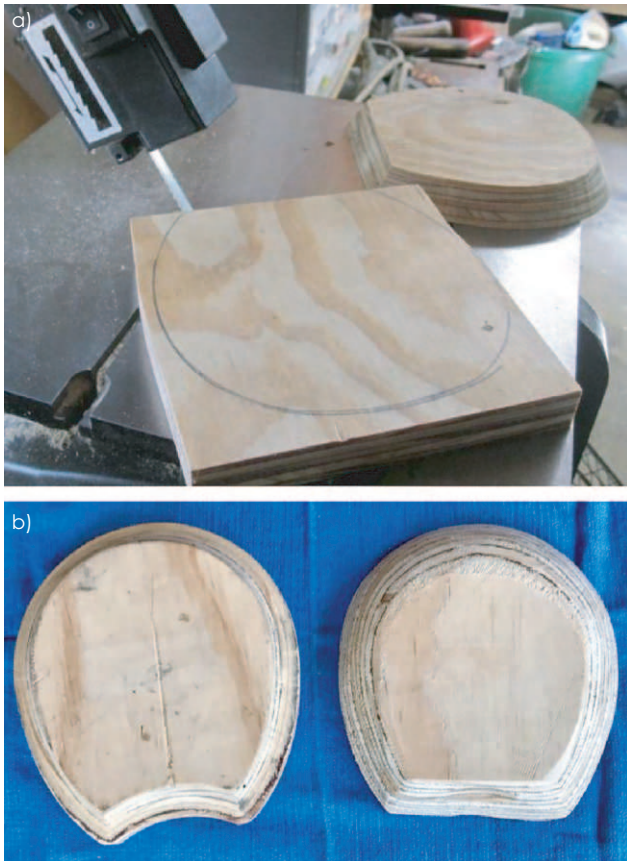


Fig 5: a) Using a template to cut a shoe from a wooden block with an angle saw. b) Commercially purchased wooden shoe that has been reshaped to create the appropriate bevels using a belt sander or a grinder.

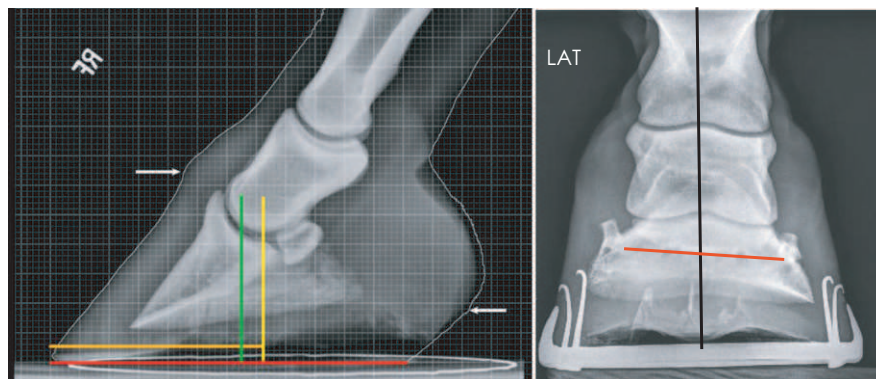


Fig 6: A lateral and dorsopalmar radiograph view. The lateral radiograph shows good foot conformation where the yellow line is the centre of rotation and the green line is the widest part of the foot. DP view shows the distal phalanx displaced medially.

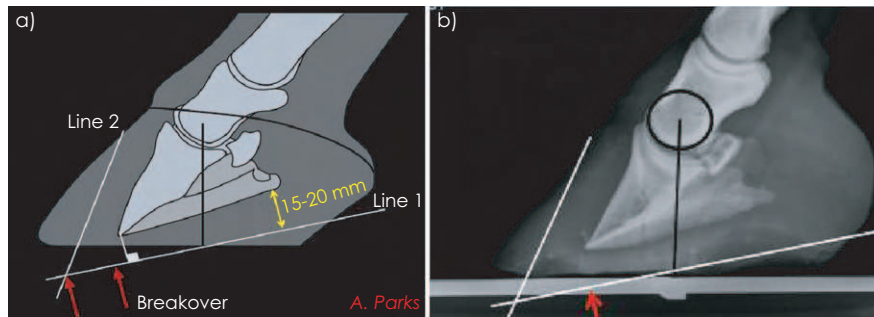


Fig 7: a) A schematic illustration of a radiograph with dorsal capsular rotation showing the lines drawn parallel to the solar surface of the distal phalanx and the line drawn parallel to the parietal surface of the distal phalanx (Image courtesy of Andrew Parks). b) The illustration applied to a radiograph with dorsal capsular rotation. Black line represents COR.

Application of the shoe

The trim

Before beginning the trim, the horse should be observed in motion, noting the degree of lameness, if present, on the straight and on turns. The strike pattern of the horse is determined whether the horse lands flat, markedly heel first, toe first or lands asymmetrically on one side of the hoof capsule. The initial step to trim the foot in all cases is to draw a line across the widest part of the foot. The widest part of the foot is 5–10 mm dorsal to the COR which makes it a good guideline to begin the trim. The frog is trimmed by removing any loose exfoliating horn and the hoof wall is rasped from the middle of the foot palmar to where the hoof wall at the heels and the frog are on the same plane. This creates additional ground surface from the middle of the foot to the heels which moves the load in a palmar direction. In most cases where the wooden shoe is used, the dorsal section of the foot will be compromised with limited sole thickness, so the toe length can be reduced using the nippers in a vertical direction according to the radiograph or by rasping the dorsal hoof wall (O'Grady 2010; Parks and O'Grady 2015).

A template superimposed on a radiograph can be used as a guide when trimming the case with chronic laminitis (O'Grady 2010; Parks and O'Grady 2015) (Fig 7). The quarters and heels of the hoof wall are trimmed from the widest part of the foot palmar to coincide with line 1 drawn distal and parallel to the solar margin of the distal phalanx on the radiograph. The solar surface of the foot dorsal to the widest

part of the foot is not trimmed. The toe length is reduced from the dorsal hoof wall according to line 2 drawn dorsal to the parietal surface of the distal phalanx. If possible, the ideal end product when trimmed according to the template, will have two different planes on the ground surface of the foot with the heels of the hoof capsule and the frog on the same plane (Fig 8a). This method of trimming redistributes the load to the palmar section of the foot and functionally unloads the toe.

Following the trim, the foot is placed on the ground and the horse is observed to see whether the heel of the foot is touching the ground at rest. In motion, the horse is observed for signs of lameness or increased lameness following the trim and whether it lands toe first in a straight line. If any of these signs are present, heel elevation will be necessary to compensate for the increase in tension in the deep digital flexor tendon caused by trimming the heels of the hoof capsule. Heel elevation is easily added to the wooden shoe using a wedge pad (O'Grady 2010; Parks and O'Grady 2015) (Fig 8b).

Fitting and applying the shoe

The foot surface of a wooden shoe is measured from dorsal to palmar drawing a line across the middle of the shoe. The correct size of the shoe is determined by superimposing the line drawn across the widest part of the foot and the line drawn across the shoe over each other; allowing the wooden shoe to extend marginally beyond the perimeter of the hoof capsule and 1–3 cm palmar to the trimmed heel.

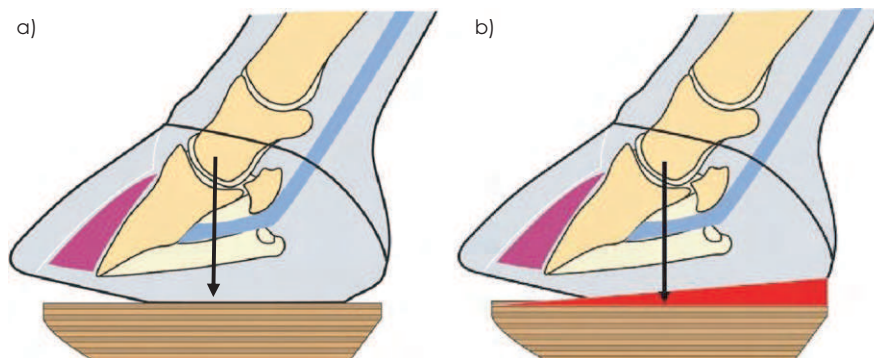


Fig 8: a) The two planes on the solar surface of the foot when trimming for realignment of the distal phalanx. Note the position of the block on the foot using the widest part of the foot as a guide. b) A wedge pad added to the wooden shoe for heel elevation (Image courtesy of Andrew Parks).



Fig 9: a) A rasp positioned vertically dorsal to the coronet to mark the position of breakover. b) Breakover being created in the wooden shoe with a rasp at the designated point.

Using a 2 mm diameter drill bit, multiple guide holes are drilled from the solar surface proximally through the lateral and medial side of the hoof wall on the abaxial side of the sole wall junction (white line) beginning at the widest part of the foot and continuing towards the heel. Screws placed palmar to the widest part of the foot will maintain the two planes created by the trim and help unload the toe. These holes are predrilled in the solar surface of the foot to ensure accurate screw placement in the wall. The author prefers drywall screws, although they tend to be brittle, they are thinner in diameter and have a coarser thread. A 3.9×38 mm course thread tapered drywall screw or 4.2×38 mm tapered wood screw is placed in each hole on the outer hoof wall directed distally towards the ground surface and screwed in until just visible on the ground surface. Any exfoliating horn is removed from the frog and the frog sulci and the adjacent area is cleaned with a wire brush. Copper sulfate crystals (powder) are often applied to the cleaned area for its antiseptic properties before applying the impression material. To recruit the sole, bars, frog and frog sulci for weight bearing, deformable impression material (IM)⁴ is applied to the palmar section of the foot being careful that the impression material just covers the intended

structures and does not extend beyond the bearing border of the foot surface to create pressure. With the foot off the ground, the shoe is now set in place, two or three screws are screwed into the shoe and the foot is placed on the ground to bear weight. This allows the impression material to conform between the palmar section of the foot and the shoe, thus creating two flat surfaces. After the remaining screws are inserted, additional screws can be placed in the wooden shoe against the outer surface of the hoof wall at the heels to act as struts to provide stability and act as an anchor for the casting tape. With the foot on the ground and using a rasp as a straight edge, a vertical line is viewed from the dorsal aspect of the coronary band to the ground, marked on the side of the wooden shoe and then a line is drawn across the ground surface of the shoe (**Fig 9a**). Setting the breakover to this point in the shoe is easily accomplished by extending the bevel to this line using a hoof rasp with the foot being held between the farrier's knees (so called farrier position) (**Fig 9b**). The line across the shoe is where the breakover point of the shoe should be positioned which will consistently be just dorsal to the solar margin of the distal phalanx when viewed on a radiograph (**Fig 10**).

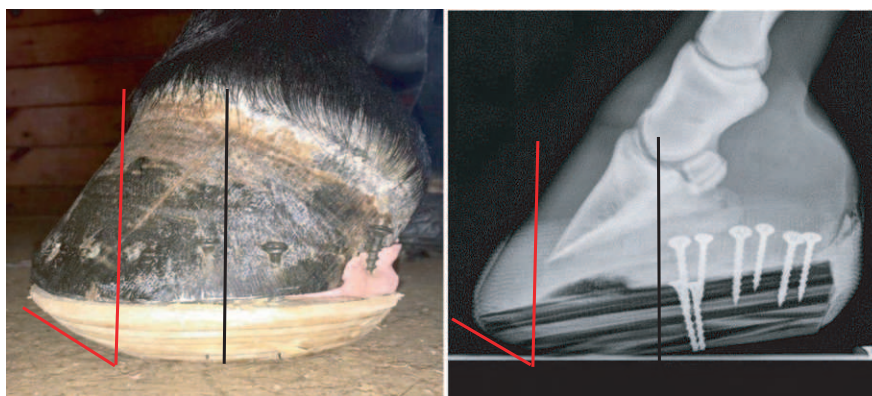


Fig 10: Wooden shoe applied to the foot with corresponding lateral radiograph. Black line is the COR that correlates with the widest part of the foot and red line is the position of breakover. Note the screw placed against the out side of the hoof wall at the heel termed a strut to anchor the casting tape.

Orthopaedic felt or impression material is placed across the bulbs of the heels and 2-inch casting tape⁵ is applied around the perimeter of the foot forming an attachment between the hoof wall, screws and wooden shoe. The casting tape provides circumferential stability that when attached to the screws not only adds security but may decrease flaring of the hoof wall during weight bearing that appears to pull the sole distally (Thomason 2007; O'Grady 2010; Parks and O'Grady 2015). Following application of the wooden shoes, horses are allowed brief periods of controlled exercise according to their comfort level. The exercise can be in the form of hand walking or turn out in a small paddock. Horses are radiographed at 4-5 weeks to assess improvement of the soft tissue structures and the wooden shoes left in place until the desired results are achieved, reset if necessary or transferred to conventional shoes (Fig 11).

Unilateral displacement of the distal phalanx

Unilateral displacement of the distal phalanx in a mediolateral direction commonly occurs because of overloading one side of the foot or from laminitis. Unilateral displacement can occur in two clinical scenarios. The first context is less recognised where one side of the foot is overloaded and the distal phalanx descends. Here, the limb conformation of the horse leads to an asymmetric landing which causes disproportionate loading on one side of the foot. Hoof characteristics would include an offset foot, a sheared heel, compressed growth rings and decreased growth at the coronet above the displaced heel (Fig 12a). In the second scenario, the horse will have clinical signs of laminitis, radiographic evidence of not only displacement or rotation in the dorsal section of the foot but also unilateral displacement of the distal phalanx as noted on the DP radiographic view. The hoof wall on the displaced side of the foot will be thickened compared with the contralateral side due to the diseased lamellae (Sherlock and Parks 2013; Parks and O'Grady 2015) (Fig 12b). Based on the apparent asymmetry of the distal phalanx within the hoof capsule visible on radiographs, a clinician's first response might intuitively be to try and restore the asymmetry of the distal interphalangeal joint and the position of the distal phalanx in relation to the ground. This would most readily be accomplished by raising the side of the hoof on which the distal phalanx is displaced. However, this practice will increase the weight bearing on the affected side and cause

the distal phalanx to displace further in relation to the hoof capsule, along with increased discomfort. Horses with unilateral displacement show an increased distance between the distal phalanx and the hoof wall on the affected side which indicates weight bearing by the wall on the displaced side would have increased leverage on the hoof capsule, thus potentially shifting the centre of pressure towards the affected side. Theoretically, the hoof capsule can be stabilised in relation to the distal phalanx by increasing weight bearing on the contralateral side and reducing weight bearing on the affected side. Biomechanically, the weight of the horse is opposed by the GRF which is exerted on the foot at every point of contact. The GRF acts on the foot through the COP, therefore, changing the placement of the shoe should effectively change the centre of pressure. The COP is important because it determines the distribution of stresses within the hoof; therefore, changing the position of the wooden shoe will cause an asymmetrical redistribution of pressure on the ground surface of the foot that will change the COP (Fig 13a). The author has been successful in controlling mediolateral displacement by setting the wooden shoe wide on the unaffected side (O'Grady *et al.* 2007; O'Grady 2010; Parks and O'Grady 2015).

The foot is trimmed as described above making sure the hoof wall and frog are on the same plane and that either the lateral or medial hoof wall is not lowered more than the other. Any significant flare on the affected side of the foot is reduced with a rasp from the outer hoof wall and impression material is placed in the palmar section of the foot to make it load sharing. The wooden shoe is fitted to the foot such that it is flush or tight on the affected side and then forms a 6.3–9.5 mm (1/4–3/8-in) extension beyond the perimeter of the wall on the unaffected side of the foot (O'Grady *et al.* 2007; O'Grady 2010; Parks and O'Grady 2015) (Fig 13b).

Conclusions

The wooden shoe provides an alternative farriery option when treating a variety of foot problems. Treating many of these foot problems is subjective due to the variations in each case such as chronicity, instability, integrity of the structures of the hoof capsule and hoof conformation. Results from the author's practice and consulting service during the last 5 years treating acute and chronic laminitis, white line

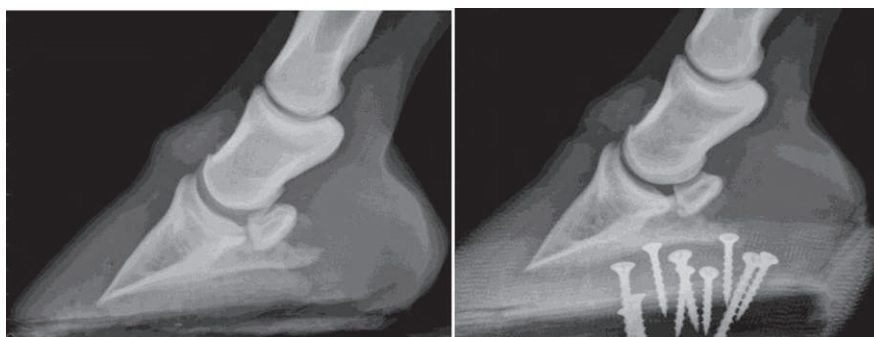


Fig 11: Radiographs show the conformation of the foot before application of the wooden shoe and the change in the soft tissue structures 4 weeks after application.

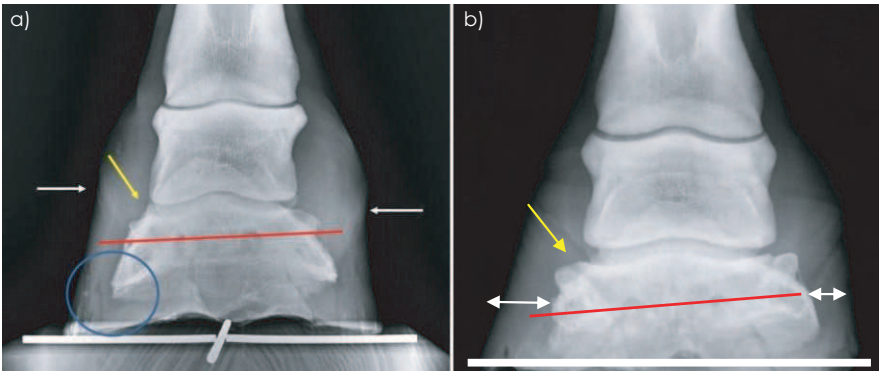


Fig 12: a) A radiograph of a foot with unilateral displacement without laminitis. Red line is the tilt of the bone, yellow arrow is widened joint space, circle is decreased sole thickness and white arrows are position of coronet noting proximally displaced heel on affected side. b) A radiograph of unilateral displacement with laminitis. Note the difference in hoof wall thickness with the affected side increased.

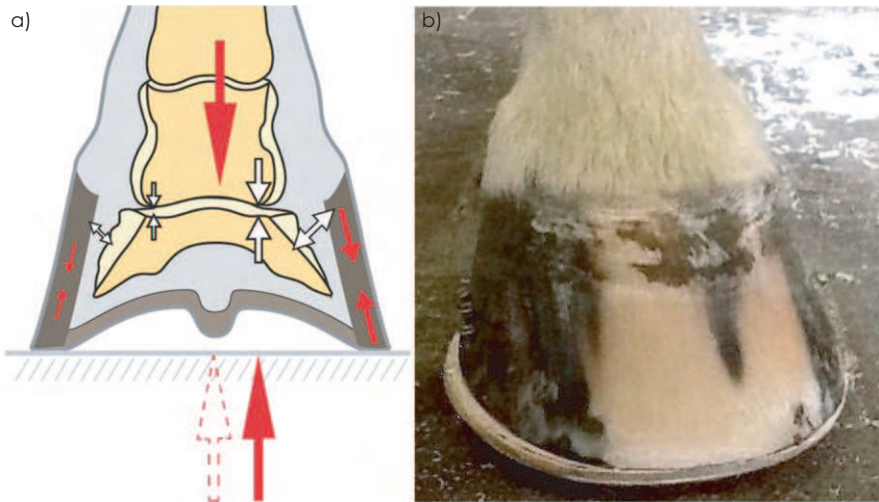


Fig 13: a) The biomechanical concept of moving the COP (Image courtesy of Andrew Parks). b) The extension of the wooden shoe on the unaffected side of the foot.

disease, distal phalanx fractures and improving the structures of the hoof capsule using the wooden shoe in a large number of cases showed consistent improvement which was considered a success (Table 1).

The magnitude of the bevel of the wooden shoe decreases the stress on the entire circumference of the lamellae and soft tissues at breakover, an effect which is often difficult to produce with traditional shoes. Cutting the perimeter of the wooden shoe at a 45-degree angle or bevel around the circumference of the shoe appears to decrease the dorsal/lateral/medial torque on the lamellae, especially when the horse turns. The flat firm plane of the wooden shoe, combined with the impression material in the palmar section of the foot, allows load sharing across the ground surface of the foot which further decreases the load borne by the dorsal hoof wall. This concept of load sharing is very helpful in a horse with compromised foot conformation that has limited viable hoof structures in a given section of the foot. Furthermore, therapeutic shoes are often deficient in providing sufficient breakover and heel elevation due to the

TABLE 1: Foot cases treated with a wooden shoe over 5 years	
Acute laminitis	>10 cases
Chronic laminitis	>200 cases
White line disease	>30 cases
Distal phalanx fractures	3 cases
Improvement of hoof capsule structures	>50 cases
±70% success rate	

physical limits of the particular shoe, whereas increasing the height of the wooden shoe allows the desired biomechanics to be fabricated into the shoe. For this author, the wooden shoe has been a very effective farriery option for treating a variety of conditions. Given that the principles behind the application of any shoeing technique are more important than the technique itself, clearly there is more than one way to accomplish many of the intended goals. The simplicity of construction, ease of adaptation, combined with the light weight in relation to height provides advantages that are often hard to match with a traditional steel or aluminum

shoe. Therefore, in the author's practice, it has become the method of choice for treating horses with acute and chronic laminitis, while line disease, distal phalanx fractures and certain distortions of the hoof capsule.

Author's declaration of interests

No conflicts of interest have been declared.

Ethical animal research

Not applicable.

Source of funding

None.

Manufacturers' addresses

¹Equicast, Inc. 575 SE Broad Street Southern Pines, North Carolina, USA.

²EDSS Inc, Penrose, Colorado, USA.

³Sears, Roebuck and Co., Hoffman Estates, Illinois, USA.

⁴Equilox, Inc. Pine Island, Minnesota, USA.

⁵3M Animal Care Products, St Paul, Minnesota, USA.

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Original Article

Surgical management of foreign body obstruction of the small and large colons in 29 equids (2004–2016)

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Keywords: horse; foreign body; colic

Summary

The objectives of the study were to describe the clinical presentation, surgical findings, complications and outcome of a case series of small and large colon obstruction by foreign bodies (FBs) in horses. The study is a retrospective case series which included 29 equids (28 horses and one donkey). Medical records of cases diagnosed with FB obstruction of the large or small colon between the years 2004 and 2016 that underwent surgery were reviewed. Data regarding signalment, clinical signs, surgical findings and post-operative variables were recorded. Short- (survival to hospital discharge) and long- (1 year after surgery) term survival rates were obtained. Cases had a mean age of 4.2 years, with both females and Arabian horses being overrepresented. Abdominal distention was the most common observation on presentation and the FB could be palpated in 20% of the cases during rectal examination. The most common reason to go into surgery was severe pain with abdominal distention. Significantly more FBs were found in the small colon during surgery ($P < 0.0001$) and most were removed by small colon enterotomy. Complications rate post-operatively was relatively high (41%) with fever and diarrhoea being most common. Twenty-three cases (79%) were released from the hospital and all cases that were available for long-term follow-up were alive and returned to previous activity. No correlation between the chosen method of surgical removal of the FB and survival or complications post-operatively was noted. These data reflect favourable prognosis for surgical removal of colonic FBs. Few techniques are available to improve the safety of removal and the preferred method depends on the FB location, appearance and mobility. As FB obstruction resembles 'noncomplicated' colonic impaction, it is essential to try and recognise FB cases since deterioration can be rapid and surgery is the only sufficient treatment.

Introduction

Small colon impaction is the most common disorder of the small colon in horses, accounting for 34–78% of all cases of small colon disease (Dart *et al.* 1992; Rhoads *et al.* 1999; de Bont *et al.* 2013). Most small colon impactions consist of feed material, however foreign body (FB) ingestion can also cause small colon impaction and may include nylon fibres, hay nets, twine, plastic material, cotton fibres and even metal (Boles and Kohn 1977; Gay *et al.* 1979; van Wuijckhuise-Sjouke 1984; de Oliveira Dearth *et al.* 2009). The

ingestion occurs most commonly in young horses probably because they are less discriminatory in their eating habits (Dart *et al.* 1992; Schumacher and Mair 2002), however it may also occur in adult horses kept under unsanitary conditions (de Oliveira Dearth *et al.* 2009). Once ingested by the horse, the foreign object serves as a nidus for deposition of mineral elements over it, which increases its size. As a result, an irregular intestinal concretion is formed, often containing projections which can generate intestinal wall pressure necrosis (Edwards 1997; Schumacher and Mair 2002). Affected horses typically remain unresponsive to medical treatment. Surgical intervention is therefore recommended prior to initiation of irreversible intestinal damage (Schumacher and Mair 2002; Pierce 2009). During surgery, the FB can be manipulated using fluid distention to move it to a safe area where enterotomy can be performed (Pierce 2009). If the obstructed segment cannot be exteriorised, an alternative approach, such as a paramedian celiotomy, can be performed to facilitate safe removal of the obstruction (de Oliveira Dearth *et al.* 2009). In some cases, a FB trapped in the small colon can be removed by a high enema and external massage of the intestine to break up the surrounding obstruction and evacuate it through the rectum (Pierce 2009). Resection and anastomosis of the small colon may be indicated in severe cases where the obstruction has resulted in intestinal necrosis, provided the segment of intestine can be exteriorised (Schumacher and Mair 2002; Pierce 2009).

There are few descriptions of the clinical presentation, short- and long-term prognosis due to the low frequency with which these cases have been recognised in horses. Short-term prognosis for FB obstruction mentioned in the literature varies considerably and ranges from 0% to 100% (Boles and Kohn 1977; Gay *et al.* 1979; van Wuijckhuise-Sjouke 1984; de Oliveira Dearth *et al.* 2009). Previous publications have described relatively low case numbers, thereby making data interpretation more challenging. The largest case series was reported by Boles and Kohn (1977) presenting 10 cases with a success rate of 50%.

The aim of the study was to describe the clinical presentation, surgical findings, complications and outcome of a case series of small and large colon obstruction by FBs in equids.

We hypothesised that surgical management of colonic FBs would be associated with good short- and long-term survival rates.

Materials and methods

Case selection

Medical records from January 2004 to December 2016 from the Koret School of Veterinary Medicine were searched for cases which were diagnosed with FB obstruction of the large or small colon. Equids were included in the study if a definitive diagnosis of FB was made during exploratory laparotomy or necropsy.

Keywords used during the search included colic, foreign body and twine.

Medical records review

Data obtained from the records included age, breed, sex, pregnancy status, duration of colic prior to admission and season of the year when the horse was admitted. Season was defined as follows: autumn (September–November), winter (December–February), spring (March–May) and summer (June–August). Additional information obtained included physical examination findings, haematological and serum biochemical analysis, nasogastric intubation and rectal palpation findings. Data regarding surgery included the interval from admission to surgery, location of the FB (large or small colon), composition of the FB, surgery technique used to remove the FB, additional pathologies identified in surgery, performance of a pelvic flexure enterotomy, duration of surgery and the surgeon performing the surgery. Additionally, information regarding post-operative complications, hospitalisation time and outcome was obtained.

Outcome

Short-term survival was defined as survival to the time of discharge and long-term survival was defined as alive 1 year after surgery. Long-term follow-up was obtained by telephone interview with the owner.

Procedure

Intravenous fluid therapy was initiated before surgical preparation and was continued during surgery. Flunixin meglumine (1.1 mg/kg bwt, i.v.), penicillin G sodium (22,000 U/kg bwt, i.v.) and gentamicin (6.6 mg/kg bwt, i.v.) were given before surgery. The surgical approach in the vast majority of the cases was a standard ventral midline incision under general anaesthesia, however, one case was operated under standing sedation through the left flank. Horses were sedated with xylazine hydrochloride (0.5 mg/kg bwt, i.v.) and butorphanol tartrate (0.01 mg/kg bwt, i.v.). Anaesthesia induction was achieved with administration of ketamine hydrochloride (2.2 mg/kg bwt, i.v.) and diazepam (0.05 mg/kg bwt, i.v.) and maintained with isoflurane in 100% oxygen. The horse operated under standing sedation was restrained in stocks and sedated with a constant rate infusion of 10 mg of butorphanol tartrate and 10 mg of detomidine HCl in 1 L isotonic saline solution. The rate of infusion was varied according to the horse's responses to the surgical stimuli. In addition, local anaesthesia using 2% lidocaine applied as a line block was administered at the intended incision site for the horse treated under sedation.

The techniques employed to facilitate removal of the FB depended on the location of the obstruction. For FBs lodged within the small colon, in areas that could be exteriorised, removal was achieved by means of: 1) high enema combined with external massage to break the impaction

around the FB and evacuate it via the anus; 2) enterotomy through the antimesenteric taenia. Closure of the enterotomy site was performed using 2-0 polydioxanone in a full thickness simple continuous pattern, followed by a Cushing continuous pattern. 3) small colon resection and anastomosis of the damaged segment including the FB. Anastomosis was performed using closed, one-stage, stapled, functional, end-to-end resection and anastomosis as described previously (Anderson *et al.* 2012).

Foreign bodies located in the large colon or oral small colon were removed using one of the following techniques: 1) fluid distention using high enema or pelvic flexure enterotomy to manipulate the FB so it could be extracted through a pelvic flexure enterotomy; 2) Enterotomy at the location of the FB. The latter was performed in cases where the FB was adhered to the mucosa and fluid distention failed to allow manipulation of the foreign body, or when the FB was too large to evacuate via a pelvic flexure enterotomy. Closure of enterotomy sites was achieved by suturing the wall of the intestine in two layers as described earlier. Prior to performing small colon or large colon enterotomy (excluding the pelvic flexure), the planned enterotomy site was isolated from the abdomen using saline-soaked sterile laparotomy sponges and a nylon drape was sutured around the incision site using a size 3-0 polydioxanone suture material (**Fig 1**).

Data analysis

Statistical analyses were performed by using analytic computerised software- Statistix 8¹ Student Edition. Descriptive statistics (mean; median; SEM; s.d.; 95% CI; proportions, etc., as applicable) were calculated for all relevant parameters. Comparison was done between survivors and nonsurvivors, and between horses with FB in the small colon and the large colon. Fisher exact test was used to compare proportional data, whereas continuous data were analysed with nonparametric tests; either Wilcoxon rank sum test (for two categories) or with Kruskal-Wallis One-Way ANOVA (for ≥ 3 categories). Differences were considered significant at a value of $P \leq 0.05$.

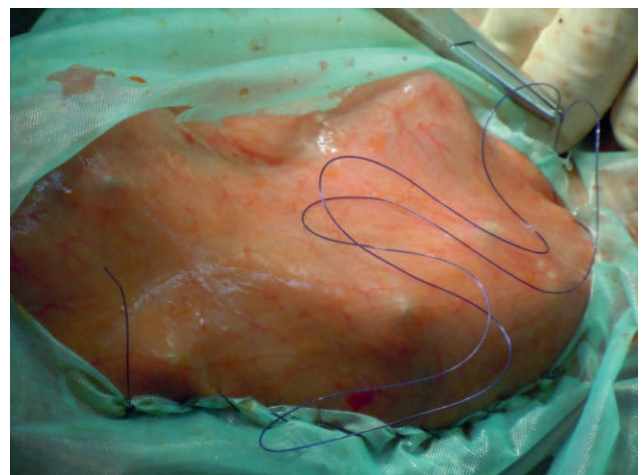


Fig 1: The enterotomy site chosen to remove the foreign body (excluding the pelvic flexure) was isolated from the abdomen and a nylon drape was sutured around the incision site using a USP 3-0 polydioxanone suture material.

Results

Twenty-nine cases (24 females, one gelding and four intact males) met the inclusion criteria and were enrolled in the study. Females were overrepresented compared to the surgical colic population in the hospital in which females represent 66% ($P = 0.003$). Nine mares were pregnant at the time of presentation, with a mean pregnancy duration of 7.6 months. The study population had a mean age of 4.2 years (median, 4 years; range, 4 months to 12 years). The predominant breed was Arabian ($n = 22$), followed by Quarter Horses ($n = 2$), mixed breed ($n = 2$) and one each of Paint Pony, Tennessee Walking Horse and a donkey. Arabians were overrepresented in the current study compared to the surgical colic population in which the Arabians represent 39% ($P < 0.001$). The age distribution for the study population reflected that for horses undergoing colic surgery at the hospital. Mean time between onset of clinical signs of colic and admission was 1.8 days (median, 1 day; range, 2 h–10 days). Most animals ($n = 20$) were admitted to the hospital with less than 48 h of colic signs. No significant difference was seen regarding season of referral which distributed as follows: Winter – eight cases, Spring – eight cases, Summer – five cases and Autumn – eight cases. Seventeen horses had a mention in the medical files regarding manure passage during the colic episode prior to referral and the majority of them had not passed any faeces ($n = 12$) or passed a very small amount of hard faecal balls ($n = 5$). Seven horses were housed in a small paddock or at pasture and were given free access to hay, six horses were housed solely in a stall with measured amounts of feed and the remaining horses had unknown housing and feeding habits due to missing data. Only two horses had known access to foreign material in the diet (baling twine).

On physical examination, most cases were tachycardic (mean, 62 beats/min; range, 40–96 beats/min) and afebrile (mean, 37.7°C; range, 37–39.2°C), however, six horses exhibited temperatures outside of the normal parameters, with those temperatures ranging from 38.5 to 39.2°C. Mucous membranes were discoloured in 13 cases, of which 10 cases had hyperaemic mucous membranes. Abdominal distention was present in 27 cases, of which 22 were subjectively considered to suffer from moderate-severe distention. On rectal palpation, 17 cases were diagnosed with a large colon distention, two horses were diagnosed with a large colon impaction and two cases did not undergo a rectal examination. The FB was felt in only six cases and in three horses no abnormalities were recognised during rectal palpation. Nasogastric intubation yielded gastric reflux in 11 cases with a mean reflux volume on arrival of 1.5 L (range 0–7 L).

Twenty-two cases underwent exploratory celiotomy on the day of admission. The reasons to go to surgery were as follows – insufficient response to medical treatment for at least 12 h hospitalisation ($n = 9$), severe pain on arrival combined with moderate or severe abdominal distention ($n = 13$), severe pain on arrival with signs of endotoxaemia (hyperaemic mucous membranes with or without a gingival toxic line, heart rate >60 beats/min, temperature $>38.5^\circ\text{C}$) ($n = 5$). Two cases were referred for surgery after intensive treatment at home for more than 2 days without success.

Overall, 33 FBs were discovered during surgery and found to be the cause for the colic. In surgery, 25 cases had a

single FB which was found in the small colon ($n = 15$), transverse colon ($n = 9$) or right dorsal colon ($n = 1$). Four cases were found to have two FBs located in both the small and large colons. Foreign bodies were significantly more common in the small colon in comparison to the large colon ($P < 0.0001$). There was no significant difference between cases suffering from a FB in the small colon compared with the large colon regarding the signalment, clinical signs, laboratory findings, post-operative complications and survival. In all the cases where the obstruction site of the FB was visible, the serosa appeared hyperaemic and oedematous to varying degrees. Removal of the FBs was accomplished mainly by small colon enterotomy ($n = 14$), followed by pelvic flexure enterotomy ($n = 8$), right dorsal colon enterotomy ($n = 5$), high enema ($n = 5$) and small colon resection and anastomosis ($n = 1$). The FBs consisted predominantly of pieces of twine in 22 cases ($P < 0.0001$). Fragments of nylon were seen in six cases and a hair pin was found in one horse. In 27 cases, the FB was embedded in an irregular, soft, partially mineralised mass surrounded with faecal material (**Fig 2**). Two horses had FBs which had undergone a uniform hardening with mineral deposition, which gave the FBs the appearance and texture of an irregular enterolith (**Fig 3**). Additional findings during surgery included large colon impaction ($n = 14$) and right dorsal displacement of the large colon ($n = 1$).

Pelvic flexure enterotomy was performed in 27 horses as a means to remove the FB or evacuate the large colon. Mean surgical time was 199 min (median: 180 min, range: 120–320 min). Time of surgery did not differ significantly between the different techniques used to remove the FBs.

Two mares were subjected to euthanasia during surgery. One was euthanised due to gross contamination of the abdomen during attempts to remove the FB from the aboral right dorsal colon. The second mare was subjected to euthanasia during surgery due to severe and extensive damage to the small colon as a result of the FB.

Post-operatively, horses were continued with i.v. fluid therapy for a mean duration of 2.5 days. Penicillin G sodium (22,000 U/kg bwt, i.v., every 6 h) and gentamicin (6.6 mg/kg bwt, i.v., once a day) were given for a mean duration of



Fig 2: Representative image of the foreign body found in most cases. The foreign body was embedded in an irregular, soft, partially mineralised mass surrounded by faecal material.



Fig 3: Representative image of the foreign body found in two cases. The mass was uniformly hardened with mineral deposition, giving it the appearance and the feel of an irregular enterolith. The mass was cut into two halves. The left side represents the outer surface and the right side the inner surface of the mass with the foreign body imbedded in the middle.

4 days and flunixin meglumine (1.1 mg/kg bwt, i.v., twice a day) for 24 h followed by 0.5 mg/kg for another 2 days. Additionally, 17 horses received metronidazole (15 mg/kg bwt, orally, every 8 h), 14 horses were treated with polymyxin B (6000 U/kg bwt, i.v., twice a day), 12 horses were treated with low-molecular weight heparin (0.3 mg/kg bwt, subcutaneously, once a day) and 10 horses were administered 2 L of fresh frozen plasma. Cryotherapy for the distal limbs was applied to all horses for 1–7 days and food was gradually introduced following surgery in all horses.

Post-operative complications were noted in 11/27 (41%) of animals recovered from surgery. Complications included: fever ($n = 6$), diarrhoea ($n = 5$), incisional infection ($n = 4$), laminitis ($n = 1$), abortion 1 week after the surgery ($n = 1$), peritonitis ($n = 1$) and pulmonary oedema ($n = 1$). Mean hospitalisation time was 9.4 days (median: 7 days, range: 5–30 days).

Twenty-three cases survived to discharge (79%). There was no significant difference between survivors and nonsurvivors (short or long term) regarding the signalment, clinical signs, laboratory findings, surgical findings, methods to remove the FB and post-operative variables.

Four horses were subjected to euthanasia during hospitalisation. The first case was an 8-month pregnant mare in which the FB was not discovered in surgery. The mare suffered from severe post-operative colic, peritonitis and endotoxaemia and was eventually euthanised. At necropsy examination, a FB was found in the transverse colon with necrotic intestinal wall surrounding it. Three cases were subjected to euthanasia 2, 3 and 17 days after surgery due to post-operative complications – two suffered from colitis and the third from peritonitis.

Twenty horses were available for long-term follow-up and were alive and had returned to their previous level of activity (time range for follow-up after surgery: 1–13 years). Three horses were lost to follow-up.

Discussion

The current study presents the clinical management of 29 cases diagnosed with intestinal FBs, which were treated

surgically and resulted in a favourable outcome. Previous literature gives wide ranging prognoses following surgical FB removal, making comparisons with our investigation difficult. In the present study, 79% of the horses were released from the hospital and all the horses which were available for long-term follow-up were still alive and back to their intended use. The prognosis in the current study resembles the outcome of most reports on surgical resolution of small colon impactions (Dart *et al.* 1992; Rhoads *et al.* 1999; Frederico *et al.* 2006; Prange *et al.* 2010; de Bont *et al.* 2013). It is ill-advised to make a direct statistical comparison between the studies due to innate differences between them, thus we cannot ascertain if our results are truly inferior to previous studies.

In previous studies it was evident that FB obstruction usually occurs in horses younger than 4 years of age, presumably due to their less selective eating behaviour (Boles and Kohn 1977; Dart *et al.* 1992; Pierce 2009). In the current study, the mean age of the horses was 4.2 years, however older animals were seen as well and four horses were over 8 years of age. This broad age distribution suggests that horses may be affected at any age if the environmental conditions are suitable. It is reasonable to assume that horses kept in a stall with a strict feeding regimen were less likely to be affected than horses in a pasture or paddock with unlimited exposure to hay and presumably with less sanitary conditions. However, due to missing data regarding the husbandry practices, such a prior statement could not be confirmed from our data. Only two horses in the current study, which were kept at pasture, had a known access to foreign material in the diet. In most horses, the FBs were comprised of twine made from plastic fibres. The twine seen in the FBs is used to bind hay bales, meaning it could be found in all environments as long as it is not removed from the hay before feeding. It has been mentioned in a previous publication that seasonality may have an effect on FB presentation with a higher incidence in warm climates (Gay *et al.* 1979). Another study showed a higher rate of small colon impactions in cold weather (Rhoads *et al.* 1999). However, in the present study, the cases were spread during the entire year with no evidence of preferred season.

Arabians and females were found to suffer from FB obstruction more commonly than males and other breeds in the current study. In previous studies, no breed or sex predisposition was found regarding FBs; however, females and Arabians, miniature horses and ponies were found to be affected more commonly by small colon impactions (Dart *et al.* 1992). Arabian horses may be predisposed to FB obstruction due to their small stature, and they were dominant in this study possibly since in Israel miniature horses and ponies do not represent a significant part of the population.

Mean time between onset of clinical signs of colic and admission was 1.8 days. This represents typical signs of small colon or aboral large colon obstruction with gradual progress of clinical signs (Dart *et al.* 1992; Schumacher and Mair 2002). It is interesting to note that in spite of the relatively elongated time for admission, most horses underwent surgery on the same day as arrival. Reasons to go to surgery were mainly related to severe pain and inadequate response to conservative treatment, however there were a few cases that showed signs of endotoxaemia development. Moreover, all the cases in which the obstruction was visible, suffered already from injured serosa. Although the clinical presentation of FB obstruction may appear at first as a 'non-complicated' impaction, the pressure of the FB on the intestine may result in necrosis and quick deterioration of the animal's health state. As such, it is our impression that any case suspected to suffer from FB obstruction should be considered as a surgical case more rapidly.

The main clinical sign upon presentation was abdominal distention seen in the majority of cases and decreased or no faecal passage. Moreover, detection of large colon distention was the most common finding during rectal palpation in the current study. The abdominal distention, produced by gas accumulation oral to the FB, is the probable cause for the gastric reflux evident in 38% of the horses. Abdominal distention and the presence of reflux are not an uncommon finding in small colon obstruction or previous reports of FB obstruction (Gay *et al.* 1979; Ruggles and Ross 1991; Rhoads *et al.* 1999; Frederico *et al.* 2006). Recognition of the FB during rectal palpation was evident in only six horses. There may be several reasons for the low FB detection rate during rectal palpation, seen in other studies as well (Boles and Kohn 1977; Gay *et al.* 1979). One reason is that the high incidence of gas distention could obscure the location of the FB and prevent its detection. The other reason is that the common location of the FB in the oral small colon or aboral large colon is difficult to reach during the examination.

The most common location of the FBs was the small colon followed by the aboral part of the large colon (mainly transverse colon), similar to previous studies (Boles and Kohn 1977; Gay *et al.* 1979; van Wuijckhuise-Sjouke 1984). The ingested foreign material may remain within the large colon for a significant period of time before obstructing the small colon or tunnel-like structure of the transverse colon (Schumacher and Mair 2002). The surgical inaccessibility of those intestinal segments complicates the removal process and therefore several techniques were developed to prevent contamination while removing the FB (Schumacher and Mair 2002; de Oliveira Dearo *et al.* 2009; Pierce 2009), as mentioned earlier. When feasible, our first choice of treatment for small colon FBs is high enema which is the least invasive technique since it does not

include enterotomy or resection. This technique was used in cases when the impacted mass around the foreign material could be dissolved to some extent, decreasing the size of the impaction, eliminating the sharp protrusions and enabling it to be massaged to the anus. High enema was not performed in cases where the FB was well adhered to the intestine wall, the intestine around the FB was compromised or the FB contained rigid projections which could potentially damage the intestine during the manipulation. In those cases, a small colon enterotomy was performed. Due to the less invasive nature of the technique, it will presumably involve less complications post-operatively. However, owing to the small number of horses, this statement could not be confirmed. It has been stated previously that a high enema during surgery may result in inflammation, vascular compromise, peritonitis, adhesions and intestinal rupture (Ruggles and Ross 1991). As such, it has been recommended that a high enema should be performed with extreme caution and an antimicrobial treatment post-operatively against anaerobic bacteria should be initiated (Ruggles and Ross 1991). A high enema can also be advantageous when the FB is located in the transverse colon or oral small colon. Here, the high enema is performed to distend the bowel with fluid and as a consequence the FB can detach from the intestine and move in a retrograde manner to a safe site for enterotomy in the large colon. When applicable, the FB was manipulated in that manner to the pelvic flexure and removed by pelvic flexure enterotomy. If the body was too large, a right dorsal colon enterotomy was performed. In the vast majority of the cases, a pelvic flexure enterotomy was performed as well, to evacuate the large colon. This process presumably enables healing of the segment involved with the FB post-operatively and minimises contamination at the forthcoming enterotomy site (Pierce 2009). An additional benefit of evacuating the large colon in that manner is the removal of smaller FBs, such as twine fragments, which could cause obstructions in the future.

Historically, complications following small colon surgeries are common with an incidence rate reaching up to 80% (Boles and Kohn 1977; Rhoads *et al.* 1999; Frederico *et al.* 2006). Diarrhoea and fever are the two most common complications associated with small colon surgery (Rhoads *et al.* 1999; Frederico *et al.* 2006; Prange *et al.* 2010). In the current study, the complication rate was 41% with fever, diarrhoea and incisional infection being most common. Incisional infection is a well-known complication following abdominal surgery and accounted typically for 20–40% of cases, however higher incidence such as 70% was reported in specific circumstances such as repeated surgery (Tnibar *et al.* 2013; Dunkel *et al.* 2015; Isgren *et al.* 2017). The prevalence of incisional site infection in the present study (15%) compares favourably with these studies, particularly when considering the high risk for faecal contamination in FB surgeries which is considered to be a risk factor for incisional infection (Darnaud *et al.* 2016). Diarrhoea and fever, in cases suffering from small colon pathologies, are common with an incidence of up to 80% (Rhoads *et al.* 1999; Frederico *et al.* 2006; de Bont *et al.* 2013). Some evidence suggests that high enema and pelvic flexure enterotomy may cause diarrhoea due to irritation of the mucosa, however the influence is usually transient (Pierce 2009). In our study, performing a high enema did not increase the incidence of post-operative diarrhoea.

One mare in the current study suffered from a FB located in the aboral right dorsal colon, firmly adhered to the intestine wall. As a result of the location, the FB could not be removed in a safe manner and the mare was eventually euthanised due to gross contamination. It was reported previously that cases with FB located in unreachable locations may be subjected to euthanasia during surgery, due to intestinal spillage or inability to safely perform enterotomy (Boles and Kohn 1977). Proper draping with suturing of a nylon drape to the enterotomy site can considerably aid in preventing faecal contamination during removal of the FB, especially in regions which cannot be safely exteriorised. Thus, the location of the FB, with the ability to mobilise it as necessary, is critical for the success of the surgery. Another mare suffered from a FB located in the transverse colon which was not detected during surgery. Due to the mare's advanced pregnancy, the transverse colon was not properly palpated during the exploration. As a result, the mare developed post-operative colic, peritonitis, endotoxaemia and eventually subjected to euthanasia. It is the author's impression that detection of FBs in the transverse colon can be difficult, as also shown in a previous report (Boles and Kohn 1977). Thus, special attention should be given during exploratory celiotomy to verify that the transverse colon is thoroughly palpated in order to avoid such a disappointing result.

One mare had surgery under standing sedation through the left paralumbar fossa. This approach has been previously described and has inherent benefits such as avoidance of anaesthesia and reduced costs (Graham and Freeman 2014; Krueger and Klohnen 2015; Coomer *et al.* 2016). In the current case, the decision to perform the surgery standing was based on the owner's financial limitations and the presumptive diagnosis of a FB in the small colon by rectal examination. The mare had no intra- or post-operative complications, and the case supports the notion that in certain suitable cases, performing standing colic surgery through the flank offers an appropriate alternative to the traditional ventral midline laparotomy under general anaesthesia.

In summary, FB obstruction occurs more frequently in Arabian horses and females and most commonly affects the small colon. The FB may be palpable on rectal examination however it is possible only in the minority of cases. The clinical signs are not specific and resemble other colon impactions, yet any suspicion of FB presence should be treated more cautiously since deterioration may be rapid. Few techniques are available for removal of the FB during surgery and the preferred method depends on the FB location, appearance and mobility. Surgical removal of colonic FBs in horses is recommended and carries fair to good prognosis for survival and return to function.

Authors' declaration of interests

No conflicts of interest have been declared.

Ethical animal research

Not applicable.

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Authorship

G. Oreff, R. Dahan, A. Tatz and G. Kelmer contributed to study design and study execution. T. Raz contributed to data analysis and interpretation. G. Oreff prepared the manuscript. All authors gave their final approval of the manuscript.

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Original Article

Clinical findings in 10 horses diagnosed with monorchidism following exploratory laparotomy or standing laparoscopic surgery

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Summary

Monorchidism describes the complete absence of one testis and is rare in horses. This study reports the clinical findings in 10 horses diagnosed as monorchids by standing laparoscopy or exploratory laparotomy. Hospital records for all horses undergoing cryptorchidectomy (2000–2016) in four centres were reviewed from which horses diagnosed with monorchidism were identified. Surgery was by either standing flank laparoscopy or an inguinal exploration and subsequent exploratory laparotomy under general anaesthesia. Ten horses were diagnosed as monorchids, five by laparoscopy (one bilateral laparoscopy) and five by laparotomy. Nine horses had a normally descended scrotal testicle, which was also removed at surgery. The right testicle was absent in three horses, and the left testicle was absent in seven horses. Anatomical findings were recorded in each case; the vaginal process was present in all horses, ductus deferens and epididymis were present in 80% of horses and the ligament of the tail of the epididymis and testicular vessels were present in 50% of horses. Laparoscopy allowed easy identification of spermatic structures enabling a prompt diagnosis of monorchidism. In conclusion, when monorchidism occurs, most other associated spermatic structures are likely to be present. A diagnosis of true monorchidism is reliant on hormonal testing and absence of testicular tissue on histopathology and so some of these horses may strictly be somewhere on the spectrum of testicular degeneration. This information is particularly useful in the surgical situation when it is not clear whether the testicle is present or not.

Introduction

Monorchidism is the term used to describe the complete absence of one testis and is rare in horses (Cox 1987). There are a limited number of previously published single case reports (Garlick 1952; Koppang 1957; Adams 1964; Johnson *et al.* 1976; Petrizzi *et al.* 2004) and small case series of horses diagnosed with monorchidism after exploratory surgery using various laparotomy approaches (Parks *et al.* 1989; Santschi *et al.* 1989). These studies however predate the use of laparoscopy. The advantages of laparoscopy have been well published in the literature over the last 20 years (Hendrickson 2001), which includes assisting in the diagnosis of a monorchid or an anomalous abdominal cryptorchid (Kelmer *et al.* 2006; Smith and Perkins 2009; Brommer *et al.* 2011). Monorchidism can be due to agenesis, but most are attributed to testicular degeneration (Parks *et al.* 1989; Santschi *et al.* 1989; Kelmer *et al.* 2006; Rakestraw 2006).

There is evidence that testicular ischaemia may accompany cryptorchidism in the horse (Gardner *et al.* 2017) and so progression of testicular ischaemia could lead to complete testicular necrosis and a monorchid appearance. The presence of remnants of testicular tissue has been given the term anomalous abdominal cryptorchid (Brommer *et al.* 2011).

A comprehensive recording of the presence or absence of spermatic structures from a series of monorchid horses is lacking. There are three attachments of the spermatic tissues: the testicular vessels from the aorta, the vas deferens leading to the bladder and the ligament of the tail of the epididymis running to the apex of the vaginal process. Understanding which spermatic structures are present in these horses would be useful clinically particularly during surgery when it may be unclear whether a testicle is present or not. Identification of anatomical structures also aids attempts to locate an undescended testicle if present (Ortved *et al.* 2014). The aim of this study was to report the clinical findings in 10 horses diagnosed as monorchids by laparoscopy or laparotomy.

Materials and methods

The hospital records for all horses undergoing cryptorchid castration between 2000 and 2016 in four centres were reviewed retrospectively, from which horses diagnosed with monorchidism were identified.

Inclusion criteria

Horses presenting as cryptorchids based on a known history of no previous surgery and surgical findings consistent with monorchidism were included in this study. During surgery, the three attachments of the spermatic tissues were identified as well as an absence of testicular tissue on the one side. Information obtained from the records included signalment, pre-surgery evaluation, surgical technique, structures identified at surgery, post-operative complications and results of hormone assays and histopathology.

Pre-surgical evaluation involved external palpation in all horses, with additional percutaneous inguinal ultrasonography in five, as described by Coomer *et al.* (2016). Rectal palpation was not performed in any horse. All horses received perioperative antibiotics (intramuscular procaine penicillin 22,000 iu/kg bwt) administered 60 min prior to the first skin incision.

Surgery was performed in each horse by one of four board-certified equine surgeons using two methods: either laparoscopy under standing sedation (Kummer 2012) or exploration via an inguinal approach made directly over the

superficial inguinal ring (Schumacher 2012) and subsequent laparotomy under general anaesthesia (GA) (Kummer 2012).

Laparoscopy

Horses were restrained in stocks and sedated with a combination of an α_2 -adrenoreceptor agonist and an opioid. Standard laparoscopic techniques were used to gain visualisation of the ipsilateral deep inguinal area (Kummer 2012), with additional instruments used to facilitate this by moving bowel and allowing traction on the mesorchium if needed (**Fig 1**). The mesorchium was infiltrated with local anaesthetic (2% mepivacaine) then divided with a vessel-sealing device (Ligasure™), before being removed via an ipsilateral flank laparotomy (Hendrickson 2007). Standing open castration was then performed on the contralateral side (Searle *et al.* 1999).

General anaesthetic technique

With horses anaesthetised in dorsal recumbency, the inguinal canal was explored using an inguinal approach first. When the vaginal process could not be identified in the inguinal canal, the surgeon converted to a laparotomy approach. The approach to laparotomy differed between surgeons (parainguinal, suprapubic paramedian or ventral midline (Kummer 2012)). Regardless of approach, the abdomen was explored manually and any spermatic tissue present was extracted and resected. The normally descended scrotal testicle was removed using a closed castration technique. Spermatic structures were resected at surgery to avoid the possibility of functional testicular tissue being left behind. The resected tissue was then examined grossly for the presence of testicular tissue and/or sent for histopathology.

Results

Ten horses were found to be monorchids during castration, one of which had a teratoma on the contralateral side (**Fig 2**). Age range was 1–12 years (median 3 years and mean 4.2 years). Breeds are listed in **Table 1**. It is clear from the detailed clinical records, that these horses had been in their owner's possession from birth. Five horses had standing laparoscopy (four unilateral and one bilateral), whilst five horses had laparotomy using suprapubic paramedian ($n = 2$), parainguinal ($n = 2$) and ventral midline approaches ($n = 1$). The right testicle was absent in three horses, and the left testicle was absent in seven horses. The surgical findings are summarised in **Table 1**. The vaginal process was present in all horses; the ductus deferens

and epididymis were present in eight horses (**Figs 3 and 4**) and the ligament of the tail of the epididymis and testicular vessels were identified in five. There were no significant post-operative complications recorded in any of the cases.

Hormone tests were performed in eight horses within 2–4 weeks of surgery. Post-hCG administration testosterone levels were <0.2 nmol/L (reference range: gelding <0.05 nmol/L), in four horses, with the results for two horses lost to follow-up. The serum oestrone sulphate concentration in one horse was 0.01 ng/mL (reference range: gelding <0.02 ng/mL). The serum AMH concentration in one horse was 0.1 pg/L, (reference range: gelding <0.14 pg/L). Post-operative hormone assays confirmed the lack of testosterone-producing tissue in six of ten horses consistent with them being geldings. There were no complaints from clients concerning persistent stallion-like behaviour post-surgery suggesting there was no residual functional testicular tissue having removed the normally descended testicle. Histopathology results were available for three horses (Horses 1, 8 and 9). Histology of tissue samples from Horse 1 revealed ciliated columnar epithelium associated with the vas deferens, a fibrotic nodule, but no testicular tissue (**Fig 5**). In Horse 8, a small nodule of dense fibrous tissue with pigment-laden macrophages representing the remnants of markedly atrophic testicular tissue, skeletal muscle assumed to be cremator muscle, and ciliated columnar epithelium of the epididymis were identified. In Horse 9, the proper ligament of the testis and aplastic testicular tissue were present.

Discussion

In these monorchid horses, associated accessory spermatic structures were always present despite the absence of true testicular tissue on the ipsilateral side. The vaginal process was identified in all horses, which is similar to previous reports (Parks *et al.* 1989; Strong *et al.* 1997; Kelmer *et al.* 2006; Brommer *et al.* 2011). The presence of the vaginal process implies that at some point, gubernacular, and probably testicular tissue, had been present (Parks *et al.* 1989), suggesting a degenerative process is more likely than testicular agenesis. The gubernaculum, a mesenchymal column of tissue, develops during testicular development and extends from the caudal pole of the mesonephros and testis to the inguinal region. An invagination of peritoneum, the vaginal process, grows into the extra-abdominal part of the gubernaculum in horses at 48 days (McGeady *et al.* 2006). The cause of acquired monorchidism has been proposed to be ischaemic injury of the developing testis in utero (Parks

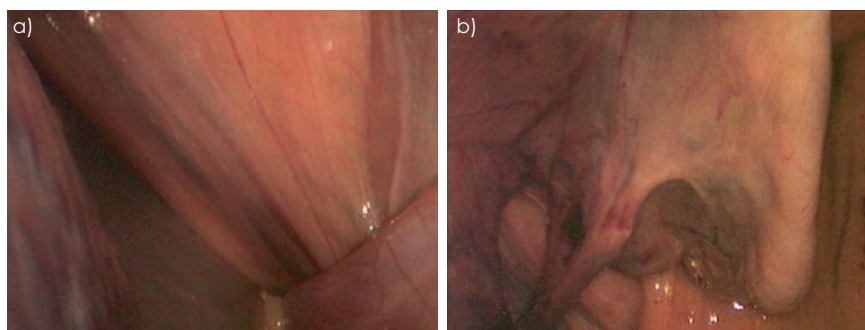


Fig 1: a) Laparoscopic view showing spermatic tissues entering the right internal inguinal ring. b) Gentle traction was applied on the mesorchium to bring it back into the abdomen but no testicular tissue was identifiable. The elongated mesorchium was subsequently resected and sent for histopathology confirming complete absence of testicular tissue.

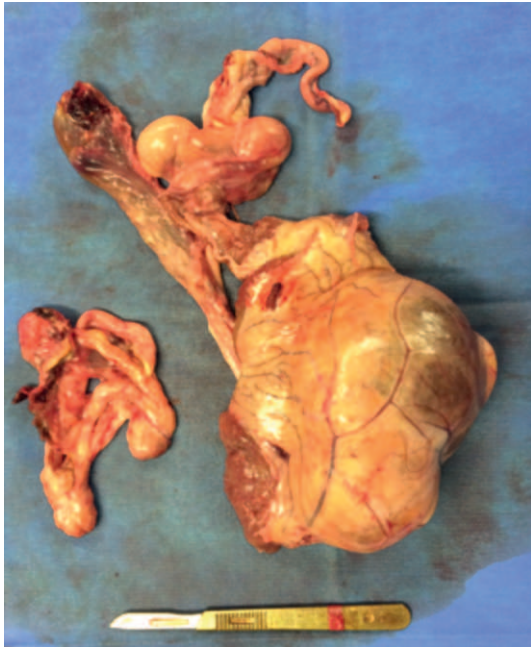


Fig 2: Horse 8. Presumed to be a bilateral abdominal cryptorchid was diagnosed with monorchidism after standing laparoscopy. A 15 cm teratoma was identified on the right side and all structures associated with spermatogenic tissue except for testicular tissue were identified on the left side.

et al. 1989; Santschi *et al.* 1989) or after birth in an abdominal testis (Parker and Rakestraw 1997), resulting in degeneration (Parks *et al.* 1989; Santschi *et al.* 1989) or complete testicular necrosis (Gardner *et al.* 2017).

The morphological changes of fibrous connective tissue, haemosiderophages and mineralisation of necrotic cells seen in the microscopic histopathology of Horse 8 are similar to those previously described in monorchid horses (Kelmer *et al.* 2006; Brommer *et al.* 2011; Gardner *et al.* 2017). This is very similar to the pathology of testicular regression in man (Lamesch 1994; Spire *et al.* 2000) where the vas deferens, epididymis, and calcification or haemosiderin pigmentation have been noted in almost 90% of cases, which is characteristic, if not specific, for atrophy resulting from ischaemia. Performing histopathology in more cases would have been beneficial for clarifying the nature of the abnormal tissue and for further implicating ischaemic injury as the cause of equine monorchidism (Fig 5). In light of the study by Brommer *et al.* (2011), one could argue that the cases, which relied on histopathology for identification of necrotic testicular tissue, should be more accurately described as 'anomalous cryptorchids'. It was decided to term them as monorchids for this study because of the absence of an obvious testicular structure during surgery. Their inclusion is clinically useful when trying to understand and explain how the surgical appearance of these horses can vary so much. As Brommer *et al.* (2011) suggests, it may be associated with the testicle being somewhere along the spectrum of ischaemic testicular degeneration.

In equine fetal development, the tail of the epididymis, proper ligament of the testis, vas deferens and ligament of the tail of the epididymis are in close proximity at the caudal aspect of the testicle (Noden and De Lahunta 1985). Brommer *et al.* (2011) hypothesised that varying degrees of

ischaemia can lead to these structures becoming disrupted and degenerative, and their ends can adhere together, end separately, or regress altogether. This theory would explain why the presence and gross appearance of the epididymis, vas deferens and testicular vessels varied amongst cases within this study and also between studies. The presence of a teratoma in Horse 5 was an anomaly. Although teratomas tend to occur in the gonads, they are nonfunctional and do not produce hormones so one could argue that this horse was actually an anorchid.

The most important weakness in our case selection is that the history since birth for each horse was taken on trust. Although owner assurances were given, there remains the possibility that the owners may not have declared the horse having undergone previous surgery and been incompletely hemicastrated whereby some residual epididymis or other spermatogenic tissue was left behind. This may be more likely to occur if carried out illegally by persons without using sufficient restraint or without veterinary qualification/expertise. Incomplete previous castration may complicate the diagnosis of monorchidism and should be considered a differential diagnosis, although arguably academic rather than clinically relevant. The signalment and history of these cases did not indicate any reason to suspect previous unilateral castration, due to trauma, inguinal herniation or for any other reason. It is important to recognise that in the cases of incomplete hemicastration however, the veterinarian would tend to inadvertently remove just the epididymis and part of the proper ligament, leaving the testis in the abdomen. As a result, it is unlikely that previous incomplete castration would result in a monorchid appearance.

Horses in this study were successfully castrated using either laparoscopy or laparotomy without complications. The choice of surgical approach was attributed to surgeon preference and also to the availability of laparoscopic equipment. The advantages of laparoscopy over traditional laparotomy techniques have been described (Searle *et al.* 1999; Kelmer *et al.* 2006; Joyce 2008). Laparoscopy enables good visualisation when searching for an intra-abdominal testis, which was evident in Horse 3 and Horse 4 which underwent previously unsuccessful laparotomy and inguinal exploration respectively. Laparoscopy can also help with identifying testicular remnants or adhesions from previous attempts at surgery, uses smaller and less invasive incisions, reduces manual tissue handling and does not disrupt the deep and superficial inguinal rings. This is in direct contrast to the complications associated with traditional laparotomy techniques, which include difficulty in identifying the testis, incisional infection and hernias, eventration, adhesions and peritonitis (French *et al.* 2002). Laparotomy also has the added risks associated with general anaesthesia (Wagner 2008) but standing open-flank laparotomy can be performed under sedation and local anaesthesia (Kelmer *et al.* 2013). As a result, surgical morbidity and post-operative complications are reduced and recovery is quicker with laparoscopy (Hendrickson 2006, 2007; Graham and Freeman 2014). Cribb *et al.* (2015) however, documented more post-operative complications with laparoscopy when compared to conventional inguinal and parainguinal approaches for cryptorchidectomy.

There must also be consideration given in these laparoscopy cases to the 20% prevalence of post-operative complications associated with standing castration of the

TABLE 1: Summary of findings in 10 equine monorchids

Spermatid structures identified at surgery												
Breed	Age/ years	Absent testicle	Inguinal ultrasound	Surgical approach	Vaginal process	Ligament of the tail of the epididymis	Epididymis		Ductus deferens	Testicular vessels	Post-op hormone test	Result
							Head	Tail				
1 Arab X	3	Right	Yes	Unilateral laparoscopy	+	–	–	–	+	–	Serum AMH	0.1 pg/L
2 Connemara	5	Left	Yes	Unilateral laparoscopy	+	+	+	+	+	+	hCG stim test	<0.05 nmol/L
3 Clydesdale	3	Right	No	Unilateral laparoscopy*	+	+	+	+	+	+	hCG stim test	Result lost to follow-up
4 Welsh pony	7	Left	Yes	Unilateral laparoscopy*	+	U	+	+	U	–	Not done	–
5 Cob X	3	Left	Yes	Bilateral laparoscopy	+	+	+	+	+	+	Not done	–
6 Shetland pony	2	Right	No	Paramedian laparoscopy	+	U	–	+	+	–	hCG stim test	<0.05 nmol/L
7 Unknown	1	Left	No	Paramedian laparoscopy	+	–	–	–	+	–	hCG stim test	<0.05 nmol/L
8 Warmblood	2	Left	Yes	Parainguinal laparoscopy	+	U	+	+	+	–	hCG stim test	<0.1 nmol/L
9 New Forest pony	12	Left	No	Parainguinal laparoscopy	+	+	+	+	+	+	Serum oestrone sulphate	0.01 ng/mL
10 Arab X	4	Left	No	Ventral midline laparoscopy	+	+	+	+	+	+	hCG stim test	Result lost to follow-up

*Exploratory surgery prior to standing laparoscopy.

–, absent; +, present; AMH, anti-Müllerian hormone; hCG, human chorionic gonadotrophin; U, unknown.

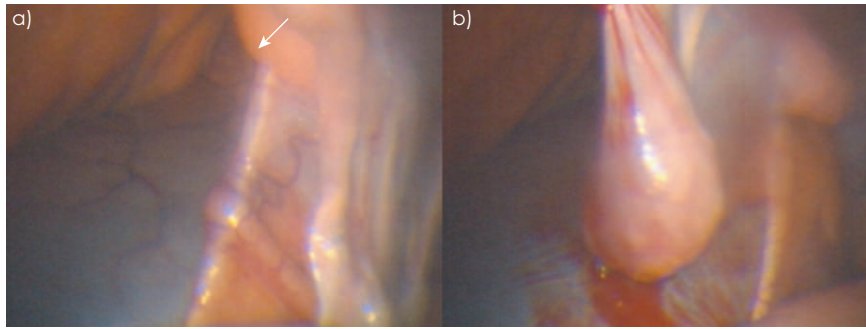


Fig 3: a) Laparoscopic view of the ductus deferens crossing the suspensory ligament of the bladder (arrow). b) The tail of the epididymis within the abdomen – this is significant because the tail of the epididymis descends before the testis.



Fig 4: Horse 4: This spermatic tissue was removed via unilateral standing laparoscopy. A large normal epididymis (E) in the region of the deep inguinal ring but no testicle was evident. Further gross examination of the resected tissue showed an oval nubbin of beige tissue around $5 \times 5 \times 8$ mm in the position a testicle should have been relative to the epididymis (*). This tissue was not sent for histopathology.

normal scrotal testicle (Mason *et al.* 2005). However, a reduction in surgical site infections has been shown when combining a laparoscopic and conventional castration technique to remove the descended testis in abdominal cryptorchids (Rijkenhuizen and van der Harst 2017).

Three different hormonal assays were used in this study, most commonly the hCG stimulation test. Historically both hCG stimulation tests and measurement of serum oestrone sulphate concentrations have been shown to be accurate (Cox *et al.* 1986) but there is more recent evidence to suggest preferred testing for functional testicular tissue in cryptorchids by measuring serum anti-Müllerian hormone (Ball *et al.* 2008; Claes *et al.* 2013; Parker 2016). An accurate diagnosis is important because of the behavioural differences between geldings and horses with functional testicular tissue. Hormone assays would have confirmed either the presence or absence of residual testicular tissue in the four horses for which results were not available.

It has been stated that a diagnosis of monorchidism can only be made after surgical exploration, removal of the normal testis and hormonal testing (Searle *et al.* 1999). The

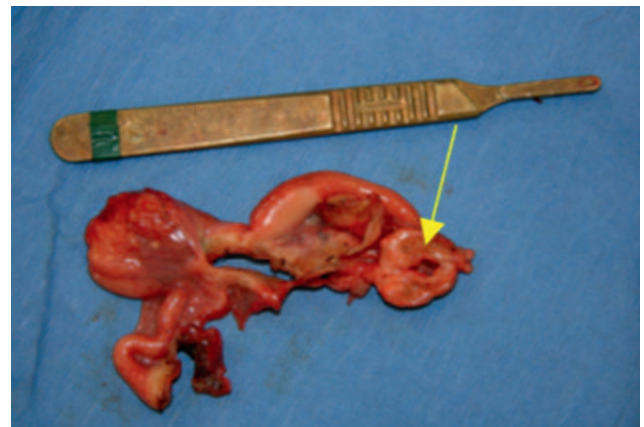


Fig 5: Horse 1: Spermatic tissue resected for histopathology. The presumed atrophic testis is marked with the arrow. Histopathology confirmed complete absence of testicular tissue.

retrospective collection of data for our study meant that it was not possible to follow the inclusion criteria set out by Searle *et al.* (1999) as post-operative hormone testing had not always been performed. The diagnosis in these horses was based primarily on surgical findings, but with additional information provided by inguinal percutaneous ultrasound, which has been shown to be an accurate diagnostic tool for locating inguinal cryptorchid testes (Coomer *et al.* 2016). Identifying the three spermatic tissue attachments (Parks *et al.* 1989), as well as an absence of testicular tissue at surgery supported the diagnosis of monorchidism.

In conclusion, systematic exploratory surgery requires good knowledge of anatomy to ensure that monorchidism is identified. Understanding the possible variations in appearance of the associated spermatic structures in monorchid horses is clinically useful particularly during surgery when a testicle cannot be found. Laparoscopy assists with the easy identification of the spermatic structures and the absence of testicle enabling a prompt diagnosis at surgery whilst hormonal assays and histopathology are useful post-operatively to confirm the complete absence of testicular tissue. Histopathology may also provide additional evidence for implicating ischaemic injury as the cause of acquired monorchidism in horses and may allow us to more accurately differentiate between true monorchids and anomalous abdominal cryptorchids.

Authors' declaration of interests

No conflicts of interest have been declared.

Ethical animal research

Ethical approval not required.

Source of funding

None.

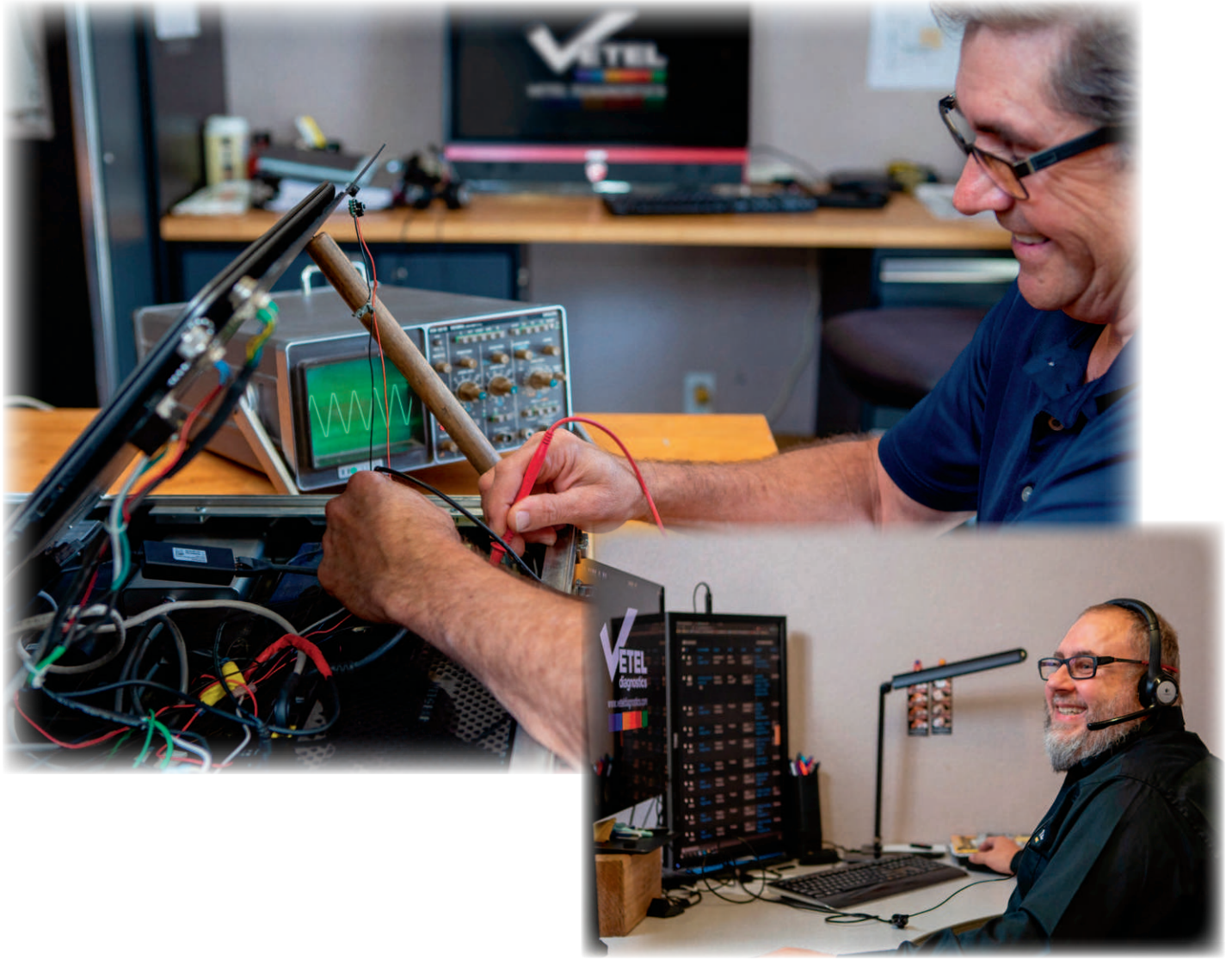
Authorship

All authors were responsible for providing the information on the cases in this paper, for study execution and helped prepare the manuscript. They all contributed to manuscript editing and have approved the final manuscript.

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Original Article

Intervertebral disc disease of the cervical and cranial thoracic vertebrae in equidae: eight cases

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Keywords: ataxia; discospondylitis; forelimb lameness; horse; neck locking; neck stiffness

Summary

Intervertebral disc disease in the cervical and cranial thoracic vertebrae is unusual in horses and the majority of documented cases have been associated with infection and resulted in ataxia. The current retrospective study documents the clinical and imaging features, and outcome in eight Equidae with neck stiffness $\pm$ forelimb lameness ($n = 3$) or ataxia ($n = 2$) assessed during a 10-year period at two clinics. The Equidae (one donkey and seven horses) ranged in age from 1.5 to 12 years (median 5.5 years). The duration of clinical signs ranged from 1 to 6 months (median 1.5 months). The donkey had a depressed demeanour. All Equidae had reduced range of neck movement. The donkey and one horse showed mild and severe ataxia respectively. Two horses showed a propensity to stumble on each forelimb, one of which exhibited forelimb lameness on the lunge or ridden. Two additional horses showed lameness in hand. One horse experienced 'neck locking' during grazing. Radiological abnormalities were identified involving the intervertebral symphysis between the sixth cervical vertebra (C6) and C7 in four Equidae; in two horses the articulation between C7 and the first thoracic vertebra (T1) was involved. One horse had abnormalities of the intervertebral symphyses of both C7 and T1, and T1 and T2. In one horse the articulation between C2 and 3 was affected. The donkey was treated with a prolonged course of doxycycline and improved. An advanced dressage horse returned to full-function after surgical fusion of the affected intervertebral symphysis. Intervertebral disc disease is a rare cause of neck stiffness $\pm$ lameness or ataxia.

Introduction

Discospondylitis is an inflammatory condition involving the vertebral bodies adjacent to the intervertebral symphysis (Nomina Anatomica Veterinaria 2005) and their associated intervertebral disc. Discospondylitis in the cervical and cranial thoracic vertebral column is an unusual condition, to which there is only limited reference in the equine literature (Adams *et al.* 1985; Hillyer *et al.* 1996; Speltz *et al.* 2006; Sweers and Carsten 2006; Alward *et al.* 2007; Garcia *et al.* 2015). Most reports describe the condition in adult horses and clinical signs have included neck stiffness, neck pain, a stiff or short-stepping forelimb gait and forelimb lameness. Ataxia is also reported as a clinical sign, associated with protrusion of disc material into the vertebral canal (Foss *et al.* 1983; Nixon *et al.* 1984; Adams *et al.* 1985; Stadler *et al.* 1988; Furr *et al.* 1991;

Hillyer *et al.* 1996; Colbourne *et al.* 1997; Sweers and Carsten 2006; Garcia *et al.* 2015). Infection has been recognised as the cause in the majority of horses (Foss *et al.* 1983; Nixon *et al.* 1984; Adams *et al.* 1985; Stadler *et al.* 1988; Furr *et al.* 1991; Hillyer *et al.* 1996; Colbourne *et al.* 1997; Sweers and Carsten 2006; Garcia *et al.* 2015) but attempts to identify the aetiological agent were largely unsuccessful. The aetiology of intervertebral disc disease in other reported cases remains unclear, although trauma has been reported (Adams *et al.* 1985; Speltz *et al.* 2006; Denoix 2007).

Previous surveys of 17 horses from 3 months to 19 years of age (Yovich *et al.* 1985) and 103 horses from birth to 23 years of age (Bollwein and Hanichen 1989), had indicated that the cervical intervertebral discs consist of fibrocartilage, with no nucleus pulposus. Age-related degenerative changes were identified, but even with severe disintegration of the discs, no related clinical signs had been recognised. However, a recent gross and histological study of the intervertebral discs of 33 Warmblood horses demonstrated that there was a nucleus pulposus and annulus fibrosus which were similar in structure to dogs and people, although the distinction between the regions was much less clear (Bergmann *et al.* 2018). Grade 4 and 5 degenerative changes (on a scale of 0–5) were found in 36% of horses in the segment between the fifth cervical (C5) and first thoracic (T1) vertebrae, which was a considerably higher frequency of occurrence than elsewhere in the vertebral column. It has been suggested that disc degeneration may increase intervertebral mobility, and associated dorsal bulging of the dorsal longitudinal ligament could potentially contribute to spinal nerve root compression at the entrance to the intervertebral foramen (K. Whitwell, personal communication, cited by Dyson 2011).

The purpose of this report was to describe the history, clinical and imaging features of intervertebral disc disease in eight Equidae, in six of which ataxia was not observed.

Materials and methods

Case records from the University of Liège and the Animal Health Trust (AHT) from 2008 to 2018 were interrogated to identify Equidae (D1 and H2–8, **Table 1**) with a diagnosis of cervical intervertebral disc disease. All animals underwent comprehensive static and dynamic physical examinations, repeated on several occasions. Horses 5–8 were evaluated moving on the lunge and ridden. Horse 6 underwent diagnostic analgesia of the lame forelimb (Bassage and Ross 2011). Ultrasound-guided (Nielsen *et al.* 2003) intra-articular

analgesia of the left articular process joint between the seventh cervical (C7) and T1 vertebrae was performed in Horse 7. Blood samples were collected for measurement of white blood cell count, fibrinogen and serum haptoglobin (D1), or serum amyloid A (H4) concentrations. Lateral-lateral radiographs of the cervical and cranial thoracic vertebrae were acquired (Butler *et al.* 2017). Images were interpreted by a Diplomat (V.B.) or an Associate (S.D.) of the European College of Veterinary Diagnostic Imaging.

Results

There were one donkey (D1, **Table 1**) and seven horses (H2–8), which ranged in age from 1.5 to 12 years (mean 6.3 years; median 5.5 years). There were five geldings, two stallions and one mare, used for general purpose riding ($n = 2$, including unaffiliated competition), dressage ($n = 2$), eventing (1), endurance (1) and driving (1); one horse was unbroken. Breeds included three Warmbloods and one each of Thoroughbred cross, Highland Pony, Akhal Téké and a pony. Height ranged from 142 to 167 cm ($n = 4$), Cases 5–8; mean 154.8 cm. Bodyweight ranged from 328 to 575 kg (median 480 kg, mean 455 kg).

Clinical features

The duration of clinical signs ranged from 1 to 6 months (mean 2.4 months, median 1.5 months). The donkey had a depressed demeanour and low head posture. All horses had a normal neck posture at rest, but when passive neck flexion was assessed using baited stretch exercises, flexion was limited. Neck muscle development was generally poor in five horses (H 3,4,5,7,8), but no focal muscle atrophy was observed. There was no patchy sweating, hyperaesthesia or allodynia, but Horse 5 showed a marked pain response when the caudal aspect of the left side of the neck was palpated when the horse exhibited neck 'locking'. All Equidae experienced difficulties in lowering the neck to graze, exhibiting a straddled stance with both forelimbs widely separated (D1, H2–4 and 6–8). Horse 3 would not eat from the ground and Horse 7 could not reach the ground to eat. Horse 5, after grazing for several minutes, developed neck 'locking': the neck became fixed in a lowered position, sometimes with the neck bent to the right (**Fig 1a**). He tended to cross the forelimbs while grazing, or had the left front fetlock knuckled forwards. The horse walked forwards

with the neck fixed in a low position. This persisted for up to 10 minutes and would then resolve spontaneously.

When evaluated moving in hand in straight lines, five horses (H 2,5,6,7,8) had a stiff neck posture. When turned in small circle these horses, in addition to Horse 4, had reduced range of motion of the neck. Two Equidae showed mild (D1, grade 1 – forelimbs) and severe (H2, grade 3 – hindlimbs > forelimbs) ataxia respectively (using a 0–4 ataxia-grading scale [Reed 2003; Olsen *et al.* 2014]). No other animal showed evidence of ataxia or weakness. However, Horses 2 and 6 had a propensity to stumble on each forelimb. For Horse 6 this was most evident when ridden. Horses 4, 6 and 7 exhibited forelimb lameness. Forelimb lameness was evident in hand for Horses 4 and 7, but was only apparent on the lunge or ridden in Horse 6. Horses 5 and 8 had reduced range of motion of the neck on the lunge. Horse 6 was consistently more reluctant to trot willingly on the right rein on the lunge, although paradoxically right forelimb lameness was more obvious on the left rein compared with the right rein. Hopping-type forelimb lameness was not observed. When ridden two horses (H 5,6) tilted the head and neck, with the nose to the right and to the left respectively. Horse 5 had unrelated bilateral hindlimb lameness.

The right forelimb lameness in Horse 6 was not improved by any local analgesic technique and showed deterioration after palmar metacarpal (subcarpal) nerve blocks. The left forelimb lameness in Horse 7 was improved after intra-articular analgesia of the left C6–T1 articular process joint, and the horse could then easily lower the head and neck to eat from the ground. Diagnostic analgesia was not performed in Horse 4.

Haematological and serum biochemistry results were within the normal range in all horses. The donkey had mild neutrophilia and an increased serum haptoglobin concentration, but the total blood leucocyte count and fibrinogen concentration were within the normal range.

Radiological findings

The radiological features are summarised in **Table 2** (**Figs 1–4b**). Three Equidae (D1 and H2,6) had intervertebral disc disease involving the intervertebral symphysis between C6 and 7; in three horses (H3,4,7) the articulation between C7 and T1 was involved. One horse (H5) had abnormalities of the intervertebral symphyses of both C7–T1 and T1–T2. In one horse (H8) the articulation between C2 and 3 was affected.

TABLE 1: Signalment, work discipline, duration of clinical signs (months) and summary of clinical features of eight Equidae with intervertebral disc disease of the cervical or cranial thoracic vertebrae

Identity	Age (years)	Breed	Work discipline	Duration of clinical signs	Depression	Forelimb lameness	Stumbling	Ataxia	Neck locking
D1	5	Donkey	Driving	1	+			+	
H2	1.5	WBL	Unbroken	6			+	+	
H3	12	WBL	Dr (PSG)	2					
H4	6	Akhal Téké	LDR	1.5		+			
H5	8	TB X	E	5					+
H6	5	Highland Pony	GP	2		+	+		
H7	5	Pony	GP	1		+			
H8	8	WBL	Dr (N)	1					

Dr, dressage (PSG = Prix St Georges; N = Novice); E, Eventing; GP, general purpose riding; LDR, long distance riding (20 km); TB x, Thoroughbred cross; WBL, warmblood.

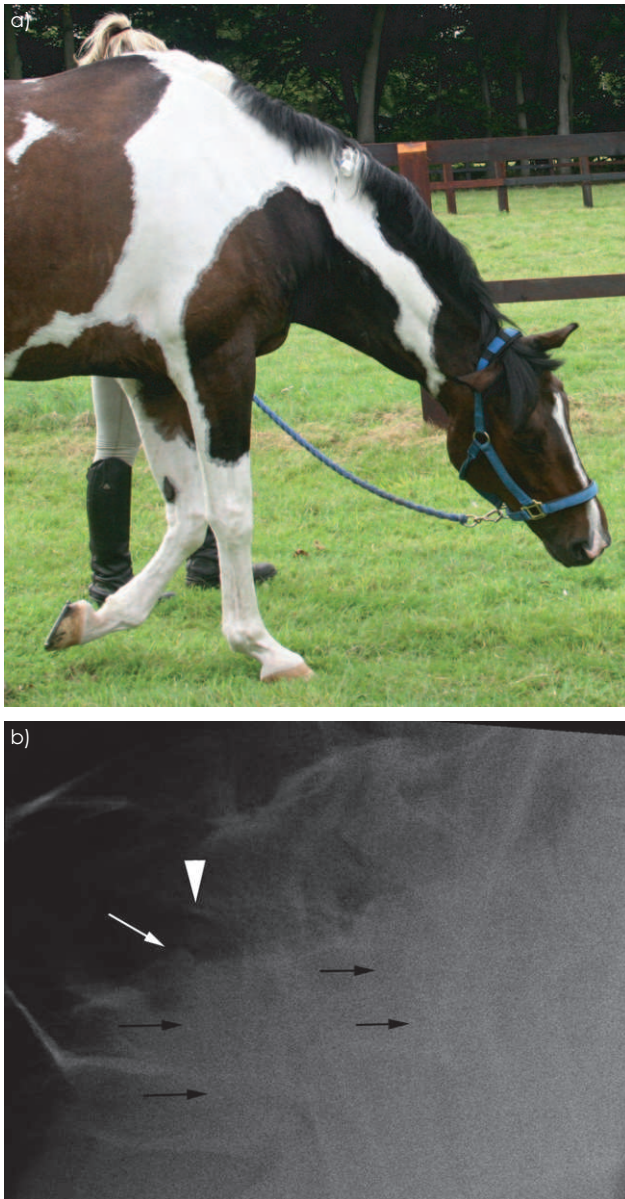


Fig 1: a) Horse 5 (see Table 1 and Fig 5) grazing with the neck in a 'locked', low position. The horse tended to knuckle forwards on the left metacarpophalangeal joint. The neck is turned to the right. The head is slightly tilted with the nose to the left. The right eye is partially closed. b) Lateral-lateral image of the seventh cervical (C7) and cranial thoracic vertebrae (T1–3). Cranial is to the left. There is complete loss of intervertebral disc space between C7-T1 and T1-2 (black arrows), with increased opacity of the caudal end plate of C7 and the cranial end plate of T1. There is new bone formation on the dorsal (white arrow) and ventral caudal aspects of C7. There is an ill-defined mineralised opacity dorsal to the intervertebral symphysis between C7 and T1 (white arrow head). There is asymmetrical enlargement of the articular process joints of T1–2, with marked decreased size of the intervertebral foramen.

Treatment and outcome

Donkey 1 was treated with doxycycline 10 mg/kg bwt per os b.i.d. for 5 months and showed progressive improvement,

TABLE 2: Summary of radiological features of eight Equidae with intervertebral disc disease in the cervical (C1–7) and cranial thoracic (T1–2) vertebrae

Equidae number	Radiological features
D1	Reduced and uneven intervertebral disc space C6–C7. Large semi-circular (about 3 cm × 1 cm) area of radiolucency with ill-defined, slightly irregular margins in the cranial end plate of C7 (osteolysis). Irregular and ill-defined caudal end plate of C6. Major surrounding increased opacity (in C6 and C7). Mild subluxation, with ventral displacement of C7. Enlarged APJs C5–6 and C6–7.
H2	Obliteration of the intervertebral disc space C6–C7. Large semi-circular (about 3 cm × 1.5 cm) areas of radiolucency with ill-defined, irregular margins in the caudal end plate of C6 and the cranial end plate of C7 with surrounding increased opacity. Subluxation, with marked ventral displacement of C7.
H3	Severe reduction of the intervertebral disc space at C7-T1. Ill-defined areas of radiolucency in the cranial end plate of T1. Minor surrounding increased opacity. Subluxation of C7-T1, with mild ventral displacement of T1. Enlarged APJs C6–7 and C7-T1 with narrowing of IVF. Transposition of ventral laminae from C6 to C7.
H4	Obliteration of the intervertebral disc space at C7-T1. Ill-defined focal areas of radiolucency in the cranial end plate of T1 and the caudal end plate of C7 (about 1 cm × 0.5 cm) facing each other. Extensive generalised increased opacity of caudal aspect of C7 and cranial aspect of T1. Irregular dorsal margin of the vertebral body of T1.
H5	Complete loss of intervertebral disc space C7-T1 and T1-2. Increased opacity of caudal end plate of C7 and the cranial end plate of T1. New bone formation on the dorsal and ventral caudal aspects of C7. Ill-defined mineralised opacity dorsal to intervertebral symphysis between C7 and T1. Asymmetrical enlargement of the APJs of T1–2, with marked decreased size of IVF.
H6	Complete obliteration of intervertebral disc space. Subluxation of C6–7 with dorsal displacement of C7, flattening of the cranial end plate of C7 and partial disruption of the dorsocranial aspect of the cranial end plate of C7 and the dorsal aspect of the caudal end plate of C6.
H7	Marked narrowing of intervertebral disc space C7-T1 with increased opacity of caudal end plate of C7 and cranial end plate of T1; concave depression in most cranial part of the cranial end plate of T1 and smoothly irregular contour of caudal end plate of C7. Dorsal and ventral modelling of the caudal end plate of C7. Ill-defined mineralised opacity traversing the dorsal aspect of intervertebral symphysis. Enlarged APJs C7-T1 with narrowing of IVF. Transposition of ventral laminae from C6 to C7.
H8	Marked narrowing of intervertebral disc space C2–3. Enlarged APJs C2–3.

APJs, articular process joints; D, donkey; H, horse; IVF, intervertebral foramen.

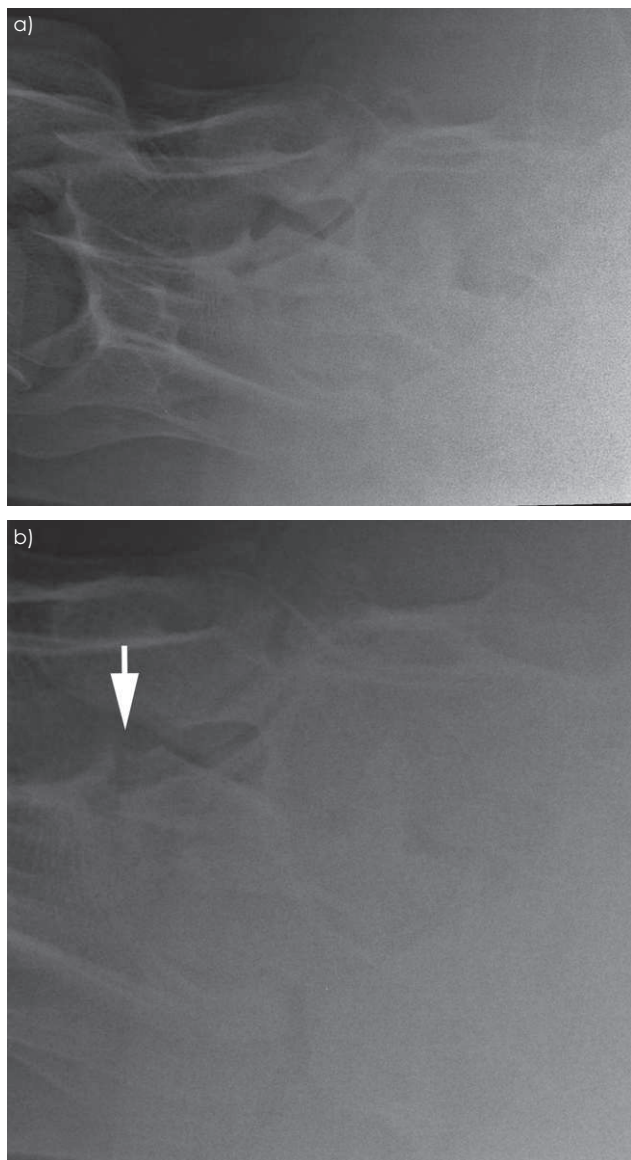


Fig 2: a) Slightly oblique lateral-lateral image of the sixth (C6) and seventh (C7) cervical vertebrae of Horse 6. Cranial is to the left. There is complete obliteration of the intervertebral disc space. There is subluxation of C6-7 with dorsal displacement of C7 and flattening of the cranial end plate of C7. b) Right 70° dorsal – left ventral oblique image of C6 to the first thoracic vertebra. There is irregular contour of the dorsocranial aspect of the cranial end plate of C7 and the dorsal aspect of the caudal end plate of C6 (arrow).

with resolution of clinical signs within 1 year. He remains clinically normal 5 years later, but was retired from driving. Horse 3 underwent surgical fusion of the C6-7 intervertebral symphysis at another clinic and has resumed work as an upper level dressage horse. Horse 4 underwent surgical fusion at another clinic, but was unable to stand after general anaesthesia, and was humanely destroyed after 3 days. Horse 7 showed transient improvement only after medication (methyl prednisolone acetate, 40 mg) of the left C6-7 articular process joints. Horses 6 and 8 were retired and Horses 2 and 5 were humanely destroyed, because of the severity of ataxia and

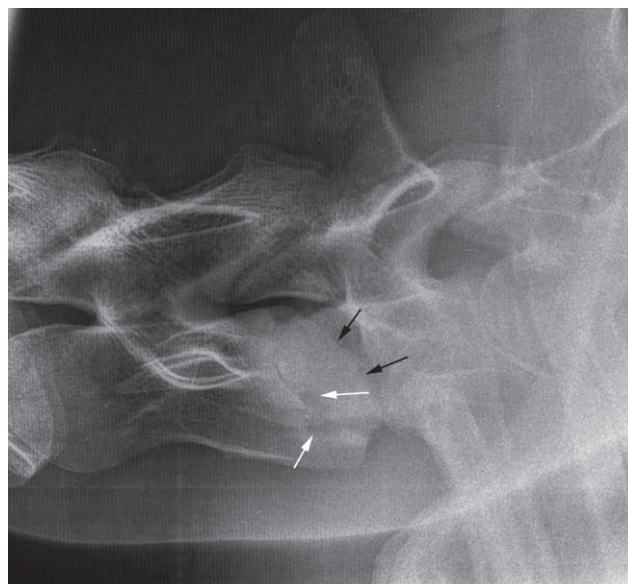


Fig 3: Lateral-lateral image of the seventh cervical (C7) to second thoracic (T2) vertebrae of Horse 4. Cranial is to the left. There is almost complete obliteration of the intervertebral disc space between C7 and T1. There are radiolucent areas in the subchondral bone of C7 and T1 (white arrows) surrounded by generalised increased opacity (black arrows). The articular process joints of C7-T1 have short pedicles.

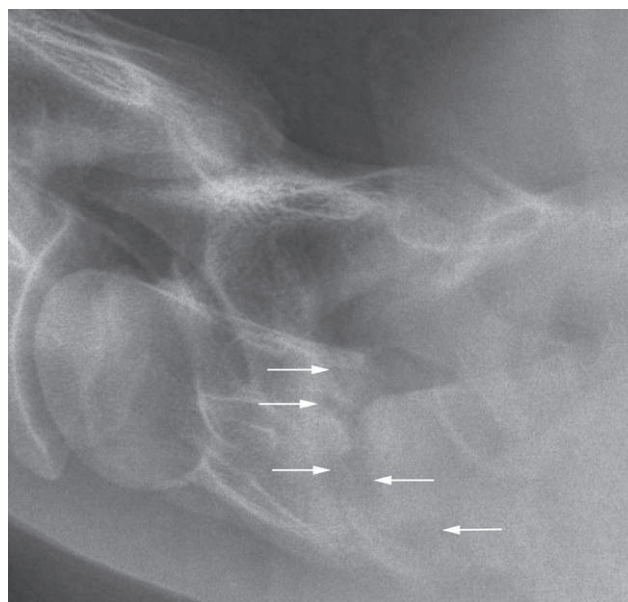


Fig 4: Lateral-lateral image of the seventh cervical (C7) to first thoracic (T1) vertebrae of Horse 2. Cranial is to the left. There are extensive areas of radiolucency in the caudal end plate of C7 and the cranial end plate of T1 (white arrows), with loss of the intervertebral disc space. There is marked ventral displacement of the cranial aspect of T1. This is a translational deformation, spondylolisthesis.

the presence of chronic pain respectively. Post-mortem inspection of the boiled-out vertebrae of Horse 5 revealed multiple pitted lesions in the caudal end plates of C7 and T1,

and the cranial end plates of T1 and T2; the bone was otherwise eburnated (**Fig 5**). There was a rim of new bone around the articular margins of the intervertebral symphyses and extensive new bone on the ventral aspects of the vertebral bodies of C7, T1 and T2, the extent of which had not been appreciated radiologically (**Fig 1b**). The facets for the articulations of the first and second ribs on both the left and right sides had periarticular modelling.

Discussion

In the majority of Equidae in the current report it seems likely that the underlying cause of intervertebral disc disease was not infection. However, in small animals discospondylitis is defined as bacterial, or less commonly fungal or algal, spinal infection, usually haematogenous, beginning as an infection of end plates of the vertebral bodies through the highly vascular and slow-flowing metaphyseal and epiphyseal capillary beds with secondary involvement of the intervertebral disc (Kerwin 2015; Ruoff *et al.* 2018). The mean and median ages of the Equidae in this case series was lower than the mean age of the majority of horses presented for lameness or poor performance to both clinics (Parkes *et al.* 2013). It is also lower than the reported age of horses with discospondylitis (Foss *et al.* 1983; Nixon *et al.* 1984; Adams *et al.* 1985; Stadler *et al.* 1988; Furr *et al.* 1991; Hillyer *et al.* 1996; Colbourne *et al.* 1997; Sweers and Carsten 2006; Garcia *et al.* 2015). The advanced nature of the radiological abnormalities at the time of diagnosis, despite clinical signs having been recognised in six Equidae for ≤ 2 months, suggests that radiological changes probably predated clinical signs. No horse had a history of known trauma. The cause of intervertebral disc disease therefore remains open to speculation. It was suggested that such radiological abnormalities may reflect the end-stage of cervical vertebral stenosis, based on a horse which presented with ataxia (Speltz *et al.* 2006). However, in the current series only three of the horses had concurrent enlargement of the articular process joints at the same level as the intervertebral disc disease and narrowing of the dorsoventral height of the vertebral canal was not a major feature. It is notable that in four cases there was subtle to severe subluxation of the affected vertebrae. Vertebral malalignment may be due to angular deformation, which is potentially reducible, although contributing to segmental instability, or a translational defect, more correctly referred to as spondylolisthesis, based on the human literature (Jiang *et al.* 2011). Spondylolisthesis is reported in humans as a consequence of trauma or disc degeneration in the cervical spine. In cervical degenerative spondylolisthesis in human patients, degeneration of the disc and the articular process joints occurs first, in association with neck pain, which is considered to be the initial symptom.

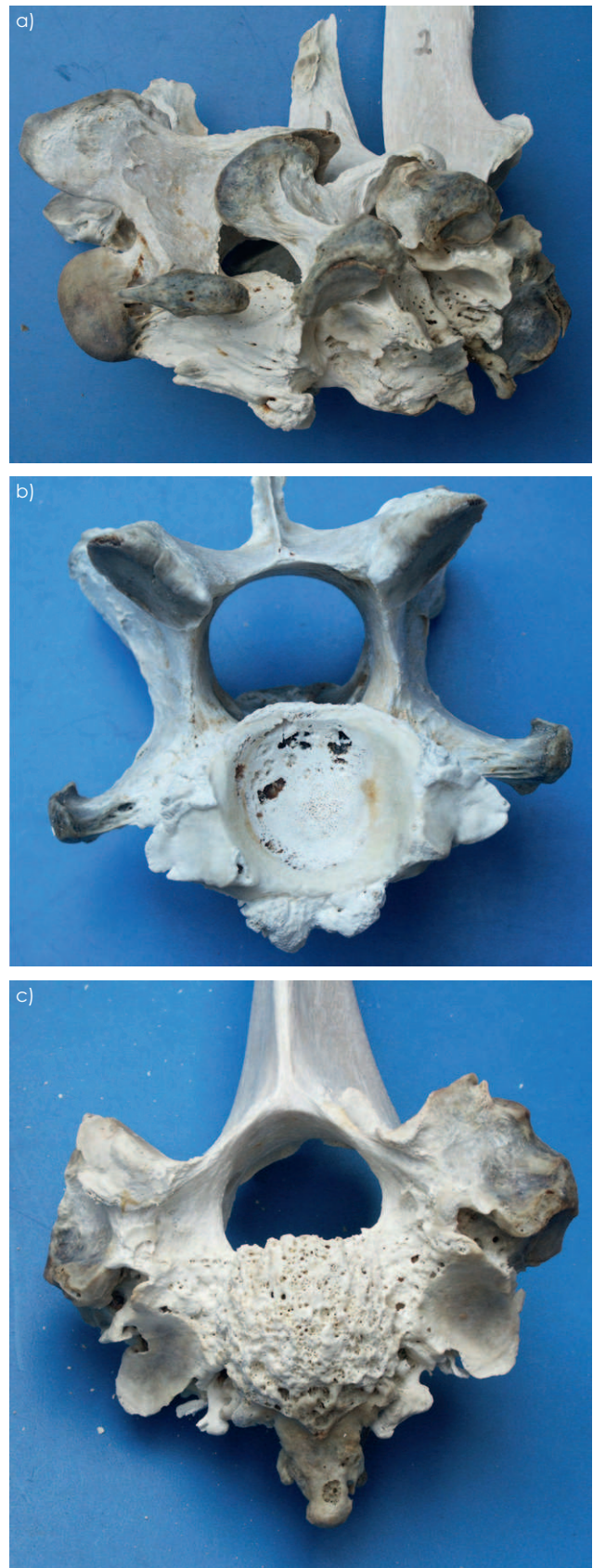


Fig 5: Osseous specimens from Horse 5 (see Fig 1). a) Lateral oblique image of the seventh cervical (C7) to second thoracic (T2) vertebrae. b) The caudal aspect of C7. c) The cranial aspect of T2. There is very extensive modelling on the ventral aspects of C7 to T2. There is major destruction of the caudal end plate of C7 and the cranial aspect of T2. There are severe bilateral costovertebral joint osteophytes of the first and second ribs.

Myelopathy and radiculopathy are also reported in association with spondylolisthesis. In the current case series, it is not known whether spondylolisthesis was primary, or developed secondarily to disc degeneration and joint instability. The high frequency of occurrence of degenerative changes in the intervertebral discs in the caudal cervical and cranial thoracic region (Bergmann *et al.* 2018) suggests that disc degeneration is primary.

Neck stiffness and an abnormal posture to graze were the most common clinical features. Difficulties in lowering the head to graze have been associated with congenital malformation of the occiput, atlas and axis (Dyson 2011) and with severe osteoarthritis of the articular process joints in the caudal neck region (Dyson 2011). One horse in the current series had concurrent osteoarthritis of the articular process joints of C7-T1 and both the ability to lower the head and forelimb lameness were markedly improved by intra-articular analgesia. To what extent intervertebral disc disease contributed to the clinical signs is difficult to determine. Lowering the neck to graze was a trigger for 'neck locking' in one horse (H5). It has previously been speculated that transient cervical nerve root compression may be a cause of 'neck locking' (Dyson 2011).

This horse (H5) showed a pain response on the caudal aspect of the left side of the neck only when the neck was 'locked'. In a previous study of horses with postulated nerve root compression, one horse with unexplained forelimb lameness showed focal hyperaesthesia ipsilateral to the lame limb, and a horse with episodic root signature posture had ipsilateral focal allodynia only when standing in this posture (Dyson 2020). Focal hyperaesthesia was reported in 48% of 91 horses with cervical vertebral compressive myelopathy (Levine *et al.* 2010). Hyperaesthesia may be related to compression of a nerve root, dura or dorsal horn lesions.

Two horses showed a propensity to stumble, which has been documented previously in association with lameness postulated to relate to cervical nerve root impingement (Dyson 2020). Three horses showed forelimb lameness, in one of which deterioration in lameness was seen after distal limb nerve blocks, a feature that has previously been recognised in horses with possible cervical radiculopathy (Dyson 2020). Head tilt was observed in two of the four horses assessed ridden, a clinical feature also observed in some horses with forelimb lameness, possibly related to cervical radiculopathy (Dyson 2020). One of these horses also exhibited a tilt of the neck and head when the horse walked with the neck 'locked'.

Post-mortem examination of Horse 5 revealed how radiography underestimated the degree of pathological abnormality of the affected vertebrae and rib articulations. The osseous changes of the vertebrae were similar to those described by Speltz *et al.* (2006).

In the majority of horses, the owners were reluctant to consider surgical fusion of the affected joints and for those with lesions caudal to C6-7 this would be logistically challenging. However, in one horse with lesions involving the C6-7 intervertebral symphysis surgical fusion was successful, allowing the horse to return to full athletic function as a dressage horse at Prix St Georges level. More horses require surgical treatment before the efficacy of this treatment could be assessed.

In conclusion, cervical intervertebral disc disease is an unusual cause of neck stiffness and an abnormal posture to graze and may be associated with forelimb lameness.

Authors' declaration of interests

No conflicts of interest have been declared.

Ethical animal research

The study was approved by the Clinical Ethical Review Committee of the Animal Health Trust (AHT 24 2018). Explicit owner consent for inclusion in this study was not sought, but all owners consented to the use of all case information and images for scientific publication.

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Authorship

S. Dyson contributed to study design, study execution, data analysis and interpretation, and preparation of the manuscript. A. Saliccia and V. Busoni contributed to study design, study execution and data analysis and interpretation. All authors gave their final approval of the manuscript.

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Review Article

A review of fungal endometritis in the mare

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Keywords: horse; mare; infertility; fungal; endometritis

Summary

Fungal endometritis is a relatively rare cause of infertility in the mare, accounting for only 1–5% of all cases of endometritis. However, it remains a challenge to the clinician due to difficulties in diagnosing and effectively treating affected mares, resulting in a high rate of recurrence and a guarded prognosis for ongoing fertility. Often occurring as an opportunistic infection, the most common causes of fungal endometritis in the mare are yeasts (*Candida* spp.) and moulds with septated hyphae (*Aspergillus* spp.). Early detection and identification of the causative agent are vital when choosing appropriate treatment as sensitivities to commonly used antifungals vary significantly. Assessing in vitro sensitivity for each isolate is accordingly recommended. Treatment of mares with fungal endometritis is multifaceted and includes; correction of any anatomical defects, uterine lavage and systemic and/or intrauterine infusion of antifungals. Concurrent bacterial infection is common so anticipation and subsequent treatment of bacterial endometritis is also often required.

Introduction

Endometritis is a leading cause of infertility in the mare and a major cause of economic loss to the equine breeding industry (Riddle *et al.* 2007). Whilst fungal infections only account for 1–5% of all cases of endometritis (Dascanio *et al.* 2001), due to difficulties in accurately identifying the causative agent and a lack of controlled studies and pharmacokinetic data on antifungals, effective treatment can be a challenge. In addition, with a high incidence of recurrence and a guarded prognosis for future fertility, fungal endometritis becomes an important consideration in the problem mare.

Fungal organisms consist of both yeasts, that are single-celled organisms, and moulds/hyphae, which are long, branching, filamentous structures. Certain fungal organisms such as *Candida* spp. are dimorphic and have the ability to exist in both forms under specific conditions. The most common causes of fungal endometritis following the culture of 102 fungal isolates, were yeast (69%, primarily *Candida* spp.), mould with septated hyphae (26%, primarily *Aspergillus* spp. [18%]) and mould with nonseptated hyphae (5%, primarily *Mucor* spp. [4%]) (Beltaire *et al.* 2012). Distinction between the different forms of fungal organisms is vital when considering treatment and assessing in vitro sensitivity for each isolate is recommended, as sensitivities to commonly used antifungals vary significantly.

Aetiology

Fungal endometritis in the mare is typically thought to occur as an opportunistic infection, with the primary reservoir being the caudal reproductive tract, including the vagina and

clitoral fossa. Risk factors for infection include; poor perineal conformation, compromised uterine defenses, necrotic foci (such as retained fetal membranes, abortion and trauma following dystocia) and endocrine/immune disorders resulting in immunosuppression. Fungal endometritis is often identified following the repeated use of intrauterine antimicrobials. Whilst the exact mechanisms are still unknown, the combination of a disrupted vaginal flora caused by the antimicrobial treatment and potential iatrogenic introduction of pathogens into the uterus has been suggested (Hinrichs *et al.* 1992). Progesterone supplementation may also increase the risk of mycotic infection due to decreased neutrophil function, reduced uterine contractility and increased cervical tone (Evans *et al.* 1986; Watson 1988).

In 152 mares presented to Utrecht University, the incidence of fungal endometritis was highest in barren (74%), followed by maiden (16%) and foaling (9%) mares. Risk factors in this study included previous intrauterine antibiotic treatment (87%), pneumovagina/urovagina (39%), excessive intrauterine fluid (33%) and a history of dystocia/retained fetal membranes (18%) (Stout 2008).

Concerns have been raised about the risk of venereal transmission as samples taken from the reproductive tract of healthy stallions have been shown to be positive for filamentous fungi and/or yeasts; however, there are no current studies to confirm semen as a source of infection in mares (Malmgren *et al.* 1998; Rota *et al.* 2011).

Diagnosis

Horses presenting with fungal endometritis are often older, multiparous mares with a history of chronic infertility. Clinical signs may include a purulent vaginal discharge and excessive amounts of flocculent fluid within the uterine lumen on palpation and ultrasound examination (**Fig 1**), whereas other cases may be subclinical.

A definitive diagnosis is made based on endometrial cytology, culture or quantitative polymerase chain reaction (qPCR). Endometrial cytology should be performed using a double-guarded uterine swab, cytobrush or following centrifugation of the effluent from a low volume uterine lavage (**Fig 2**). An endometrial brush will yield higher number of cells, whilst a low volume lavage is likely to produce a more representative sample of the entire uterus when compared with a standard swab technique (Cocchia *et al.* 2012). Positive smears provide a quick and reliable diagnosis and will often show evidence of inflammation in addition to fungal elements. Various stains can be used to identify fungal organisms including; trichrome, periodic acid-schiff (PAS), Gram stain, Romanovsky and modified Wright's (Diff-Quick®).¹ Yeast will be visualised on cytology as single-celled organisms, spherical/oval in shape and approximately 3–4 µm

TABLE 1: Intrauterine antifungal treatment (Brinsko *et al.* 2010, Hess *et al.* 2002)

Antifungal	Dose	Administration	Frequency
Polyene			
Amphotericin B	100–200 mg	Reconstituted in 50–100 ml sterile water for infusion	Q 24 h for 5–7 days
Nystatin	0.5–2.5 million units or 5 g	Reconstituted in 50–100 ml sterile water for infusion	Q 24 h for 5–7 days
Azole			
Clotrimazole	500–700 mg	Reconstituted in 50–100 ml sterile water for infusion	Q 24 h for 5–7 days
Fluconazole	100–500 mg	Reconstituted in 50–100 ml sterile water for infusion	Q 24 h for 5–7 days
Miconazole	1,200 mg insert	1,200 mg insert deposited into the uterus	Once
Chitin synthesis inhibitor			
Lufenuron (Program ^{®2})	540 mg	Reconstituted in 50–100 ml sterile saline for infusion	Once

in size, with a characteristic clear 'halo' around the organism due to the lack of stain uptake. Moulds in contrast are long, branching, filamentous organisms (**Fig 3**).

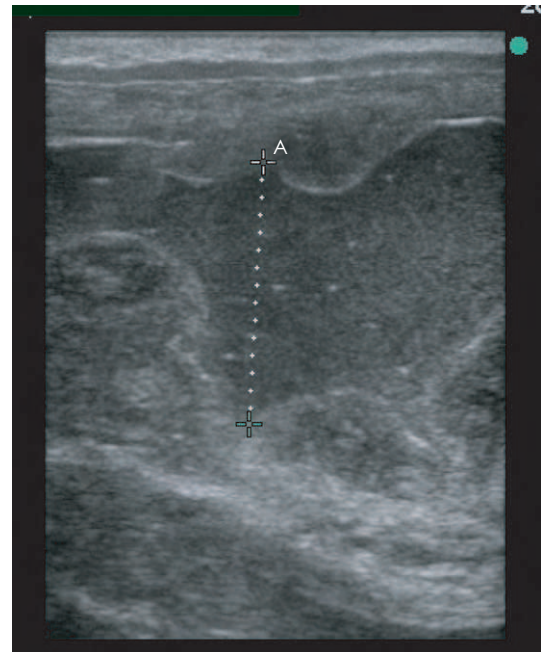
Endometrial culture requires prolonged incubation (up to 4 weeks) in a specialist medium (e.g. Sabouraud's dextrose agar) and a level of expertise for accurate identification. *Candida* spp. will typically grow as white to clear coloured colonies with a smooth appearance (**Fig 4**) and *Aspergillus* spp. as blue–green/grey–green colonies with white borders and a velvet-like texture (**Fig 5**). Beltaire *et al.* (2012) found 73% of samples positive for fungal growth on Sabouraud's dextrose agar to be negative on aerobic culture, highlighting the importance of specific fungal media for accurate diagnosis. Concurrent aerobic culture is however recommended as the same study revealed 51% of samples to have additional bacterial growth (*Streptococcus zooepidemicus* 32% and *E. coli* 21%). Obtaining an endometrial biopsy using an aseptic technique and subsequently smearing the tissue sample onto an appropriate agar plate has been shown to be more sensitive at detecting bacterial growth than a surface endometrial swab (Nielsen 2005). This method may aid in the diagnosis of fungal endometritis by detecting mycotic elements deeper within the endometrium. Concurrent culture of the vagina and external genitalia is also recommended to determine any reservoirs of infection.

TABLE 2: Systemic antifungals

Antifungal	Dose	Administration	Frequency
Fluconazole (200 mg tablets)	10 mg/kg loading dose, then 5 mg/kg	PO	Q 24 h for 2–3 weeks

Being a nonculture dependent test, quantitative PCR has the benefit of a potentially increased sensitivity and more rapid turn-around than that of standard culture but is not readily available in all areas and cannot provide antimicrobial sensitivity data (Ferris *et al.* 2013).

An endometrial biopsy stained with Gomori's methamine silver stain will reveal a black/grey colouration to fungal

**Fig 1: Intrauterine fluid accumulation on ultrasound examination of a mare with fungal endometritis.****TABLE 3: Nonspecific uterine lavage treatments**

Compound	Dose	Administration	Frequency
Acetic acid 2% (white vinegar)	20–100 ml	Diluted in 1 L sterile saline for infusion	Q 24 h for 5–7 days
Dimethylsulphoxide 20% (DMSO)	50 ml	Diluted in 1 L sterile saline for infusion followed by lavage with saline/LRS in 24 h	Q 24 h
Hydrogen peroxide 3%	60–120 ml	Infusion, followed by sterile saline/LRS lavage in 24 h	Q 24 h
Lactated Ringers's Solution (LRS)	1–4 L	Lavage	Q 24 h until effluent is clear
N-acetylcysteine 20% solution	6 g (30 ml)	30 ml diluted in 150 ml sterile saline for infusion, followed by sterile saline/LRS lavage in 24 h	Q 24 h until effluent is clear
Sterile saline 0.9%	1–4 L	Lavage	Q 24 h until effluent is clear
Tris-EDTA	250–500 ml	Infusion followed by lavage with LRS	Q 24 h for 5–7 days



Fig 2: Effluent from a uterine lavage of a mare diagnosed with fungal endometritis (*Aspergillus* spp.).

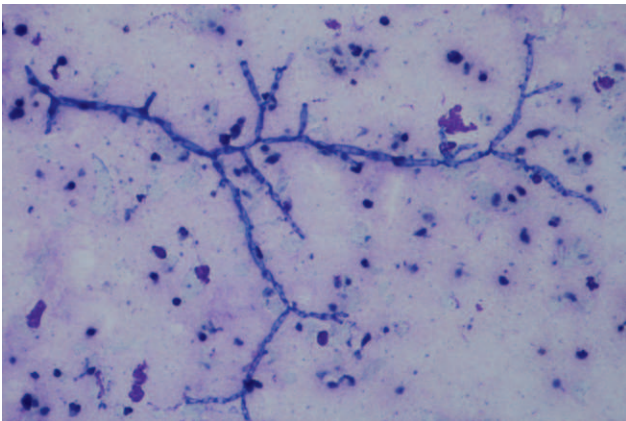


Fig 3: Endometrial cytology of *Mucor* spp. stained with Romanovsky stain.

elements, whereas PAS will stain the polysaccharide-laden walls of mycotic elements magenta (**Fig 6**). Fungal organisms are usually located either within the uterine lumen or within the superficial layers of the stratum compactum, however more invasive forms may be found embedded deep within the glandular lumina. In addition to the location of the fungal organisms, an endometrial biopsy will also determine the severity of inflammation and the extent of endometrial damage, and can be used to assess the response to treatment (Coutinho da Silva *et al.* 2000).

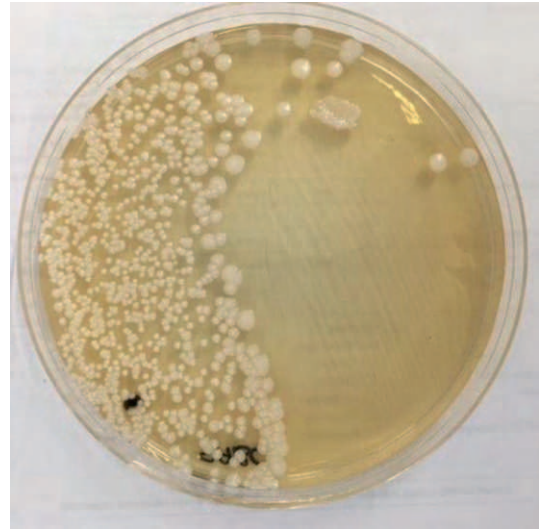


Fig 4: *Candida* spp. cultured on Sabouraud's dextrose agar.

Focal fungal infections may remain unidentified by standard diagnostic methods, in which case hysteroscopy may be useful to identify a nidus of infection.

Underlying endocrine disorders such as pituitary pars intermedia dysfunction and insulin resistance should be ruled out as potentiating causes of immune suppression, as altered neutrophil function and an inadequate cellular immune response may result in an increased incidence of secondary infections (McFarlane 2014; McFarlane *et al.* 2015).

Particular attention should be paid to the conformation of the vulva, perineum and anus. A recessed anus, deviation of the long axis of the vulva from vertical and compromise to the vulvar, vestibulovaginal or cervical seals will predispose to pneumovagina/pneumouterus, urine pooling and faecal contamination of the reproductive tract. These anatomical defects are known risk factors for the development of fungal endometritis and must be addressed.

Treatment

Treatment of mares with fungal endometritis is multifaceted and includes correction of any anatomical defects, uterine lavage and systemic and/or intrauterine infusion of antifungals. Topical antifungal treatment of the vagina and clitoris is also advisable since fungal colonisation of the vagina and clitoral fossa and sinuses is a potential reservoir of infection.

Uterine lavages should be performed to aid uterine clearance, decrease fungal load and to remove excessive mucus and potential biofilms. Suggested uterine lavage therapies include 20% N-Acetylcysteine solution, 20% DMSO (Pottz *et al.* 1967), 3% hydrogen peroxide, Tris-EDTA, 2% acetic acid in combination with 0.9% sterile saline/lactated Ringer's solution. Due to the risk of fibrosis and adhesion formation, dilute povidine-iodine should be used with great care. Anecdotally, nonspecific uterine lavage therapies have been shown to be very effective in treating cases of fungal endometritis in the mare and should be considered as a first-line treatment option whilst awaiting culture and sensitivity results (**Table 1**).

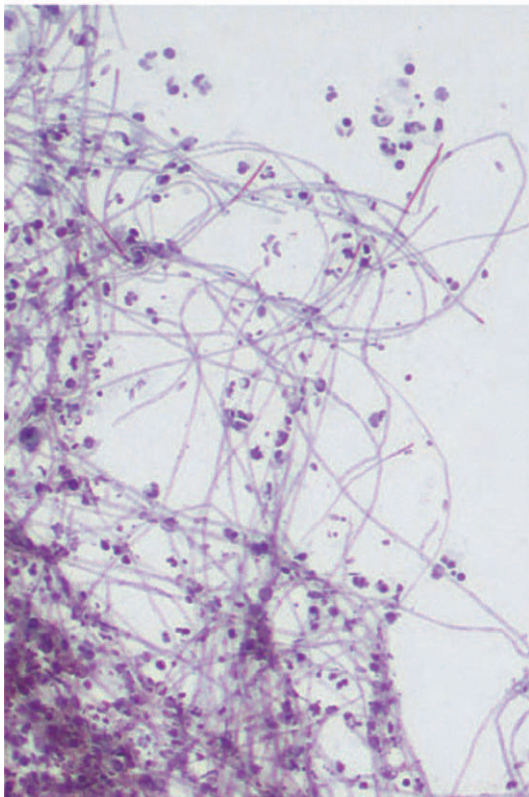


Fig 5: a) *Aspergillus* spp. cultured on Sabouraud's dextrose agar. b) Endometrial cytology of *Aspergillus* spp. and inflammatory cell debris stained with Trichrome stain.

Ideally specific antifungal sensitivity patterns should be determined prior to treatment, but due to limited availability and prolonged testing times, many cases are treated empirically whilst awaiting culture results. The two major classes of antifungals used are azoles and polyenes; their mechanism of action is to interfere with the cytoplasmic membrane of fungi. Polyenes bind to ergosterol and destabilise the membrane whereas azoles inhibit ergosterol biosynthesis. Polyenes are thought to be fungicidal and azoles fungistatic which may in part account for the increased resistance seen to azoles (Campoy and Adrio

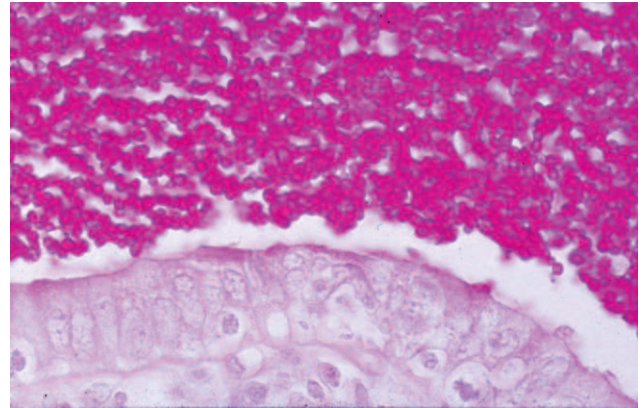


Fig 6: Endometrial biopsy stained with PAS showing *Candida* spp. spores within the uterine lumen over uterine epithelium.

2017). Unfortunately, there is a lack of controlled studies in the literature regarding appropriate dose and duration of therapy required to treat fungal endometritis in the mare (Table 2).

In an aim to improve treatment efficacy, Beltaire *et al.* (2012) cultured 102 fungal isolates, from 92 uterine samples taken from mares with reproductive problems and determined in vitro susceptibility to commonly used antifungals. Yeast isolates were 100% sensitive to polyenes, but susceptibility to azoles varied considerably: ketoconazole (90%), fluconazole (61%) and miconazole (48%). About 69–100% of moulds with septated hyphae were susceptible to polyenes, but the susceptibility to azoles was significantly lower compared with the yeast isolates, with 54% of moulds showing resistance or intermediate susceptibility to itraconazole and 100% showing resistance to fluconazole.

Hess *et al.* (2002) successfully treated four mares diagnosed with fungal endometritis caused by either *Candida* spp. or *Aspergillus* spp. with a single intrauterine administration of 540 mg Lufenuron (Program[®]2). Lufenuron is thought to inhibit fungal growth by interfering with chitin biosynthesis. However, since not all fungal organisms have chitin in their cell walls, Lufenuron may not be effective in all cases. Scotty *et al.* (2005) failed to demonstrate in vitro antifungal activity against *Aspergillus* spp. and Hector *et al.* (2005) tested in vitro antifungal properties of lufenuron against isolates of *Coccidioides immitis* and *Aspergillus fumigatus* and found no evidence of inhibition, under experimental conditions.

Weinstein *et al.* (2006) found the third-generation buffered chelator Tricide[™]3 to potentiate the antimicrobial effects in vitro of antifungal agents against isolates obtained from clinical cases of equine fungal keratitis. Whilst the use of chelating agents in fungal endometritis has not been studied to date, there is in vitro evidence to support their use in bacterial endometritis (Ferris *et al.* 2016).

Oral administration of fluconazole (15 mg/kg bwt per os loading dose followed by 5 mg/kg bwt per os q. 24 h) has been shown to achieve endometrial concentrations near or above MIC for *Candida albicans* (Scofield *et al.* 2011) and is well tolerated in the horse (Table 3). Systemic treatment is recommended based on sensitivity patterns and may help with invasive forms that are not exposed to luminal therapies and reduce the risk of iatrogenic infection associated with

intrauterine therapy. However, due to the widespread use of fluconazole, resistance is common and it is not recommended for treatment of fungal endometritis caused by moulds with septated hyphae, which have been shown to be 100% resistant (Beltaire *et al.* 2012).

Chronic or recurrent cases of fungal endometritis often require multi-modal and repeated treatment and since concurrent bacterial infection is common, anticipation and subsequent management of bacterial endometritis is often indicated.

Conclusion

The prognosis for future fertility following fungal endometritis is guarded. Stout (2008) reported a resolution rate of approximately 20% per treatment cycle.

Treatment failure and recurrence of the fungal organism are common, as is recontamination and concurrent bacterial endometritis. Unsuccessful treatment may result following inappropriate dose/duration and selection of antifungal agent, failure to treat reservoirs of infection and failure to correct predisposing conditions. Experience would suggest that early detection and treatment when the fungal organisms are still actively dividing increases the chance of treatment success.

Attempts should be made following the resolution of infection to correct any anatomical defects, instigate minimal contamination breeding techniques, to reduce the risk of iatrogenic infection and to limit pre/post-mating antibiotic treatment to prevent altering the normal vaginal flora.

In the event of treatment failure, a prolonged period of sexual rest may allow re-colonisation of the caudal reproductive tract with commensal flora and spontaneous resolution.

Author's declaration of interests

No conflicts of interest have been declared.

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Manufacturers' addresses

¹Baxter Healthcare, Miami, Florida, USA.

²Elanco Animal Health, Basingstoke, Hampshire, UK.

³Molecular Therapeutic LLC, Athens, Georgia, USA.

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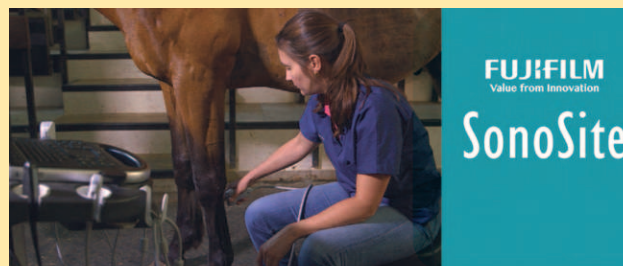
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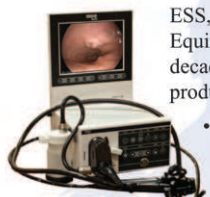
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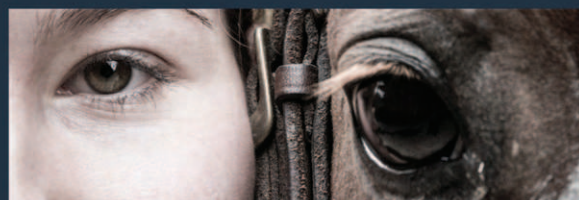

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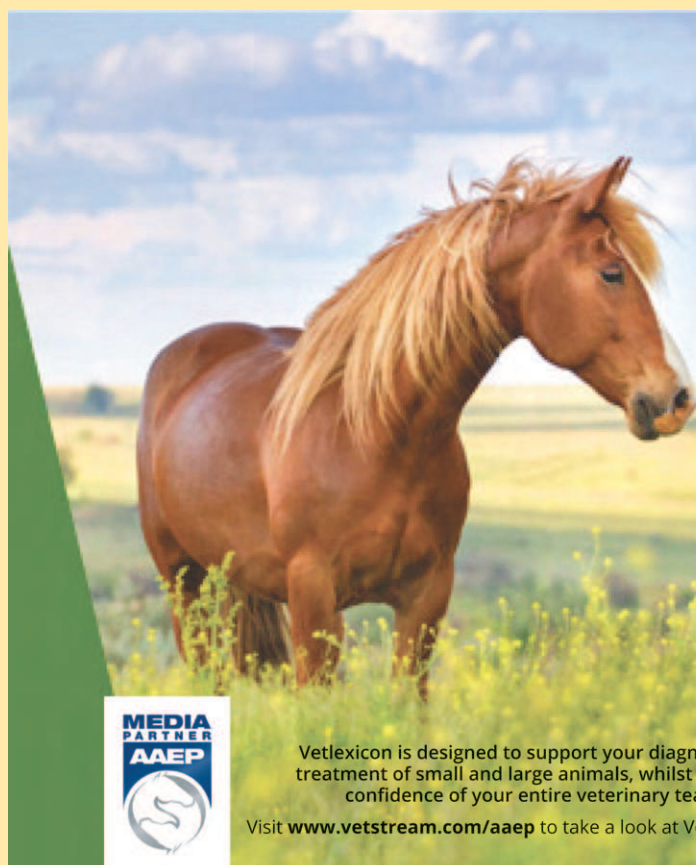
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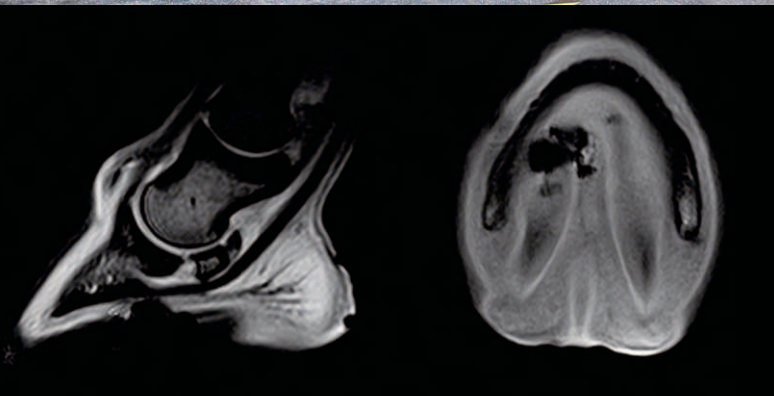
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