EQUINE VETERINARY EDUCATION/AMERICAN EDITION

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MARCH 2020

EQUINE VETERINARY EDUCATION

American Edition | March 2020

BEVA

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

IN THIS ISSUE:

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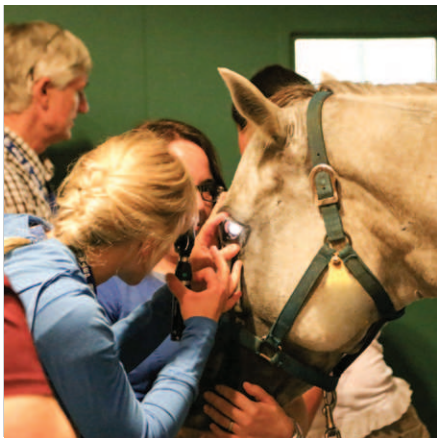

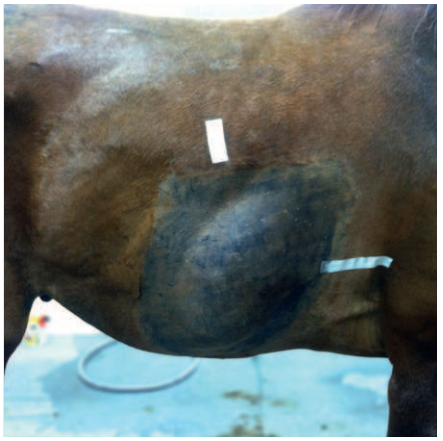

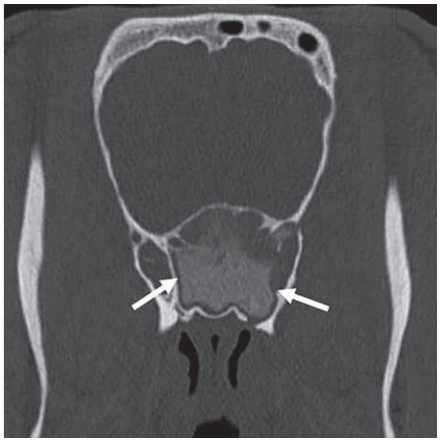

AAEP NEWS In this issue

Cover photo by Dr. Ruth Sobeck.

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AAEP Mission Statement: To improve the health and welfare of the horse, to further the professional development of its members, and to provide resources and leadership for the benefit of the equine industry.

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Equine Veterinary Education is a refereed educational journal designed to keep the practicing veterinarian up to date with developments in equine medicine and surgery. Submitted case reports are accompanied by invited reviews of the subject (satellite articles) and clinical quizzes. Tutorial articles, both invited and submitted, provide in-depth coverage of issues in equine practice.

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From the president: Understanding and validating value to our stakeholders

By David Frisbie, DVM, Ph.D., DACVS, DACVSMR

Dr. David Frisbie

Taking the AAEP reins in Denver was truly an honor, especially during a convention that saw the highest overall satisfaction rating in recent years based on member feedback. The Educational Programs Committee deserves a shout-out for all their hard work!

I am excited about this upcoming year and want to highlight a few key initiatives.

In 2019, the AAEP completed its 3-year review and update of its strategic plan, which includes focus areas on the profession, education and, of course, the horse. Retention of veterinarians in the equine profession was identified as a priority. In past years, about 5% of new veterinary graduates entered equine practice; however, a recent AVMA survey estimated this number currently closer to 2%, with about half of graduates leaving equine practice within five years.

During recent discussions among the board of directors, a multifaceted and multiyear approach to improve retention became a focal point of the AAEP's strategic priorities. In reflecting on the association's past successes, the leadership workshop—last held in 2011—bubbled to the top. These workshops not only helped member participants in their daily lives but returned great dividends in terms of grooming future leaders for the AAEP and the veterinary profession. The AAEP, in collaboration with educators and industry, is proud to announce the revival of our leadership program this fall.

Also being initiated in 2020 is a comprehensive project to better understand the needs and desires of early-career veterinarians with equine interest as well as the needs of the equine industry. This multiyear discovery program is being modeled after the well-known business/mission model canvas developed and validated in part by folks from Stanford University to bring wanted and needed value to stakeholders. The mission of this program is to understand the needs, wants and successful strategies centric to equine veterinarians, with one goal being to improve the retention of equine practitioners and personnel.

A task force is being assembled to work with experts in this area to understand the current state of our industry based on information already gathered. The next step will be to figure out what is missing and gather data from the equine industry to fill in the gaps. Once these data are assimilated, various solutions or models will be constructed and reviewed by stakeholders to make sure they are meeting the desired touch points. Once validated, the outcomes and suggested remedies will be published for consideration and adaptation by the industry.

Individuals involved in the review process will represent a broad spectrum of those affected by the outcomes, including veterinary students, veterinary institutions, recent graduates, mid-career equine veterinarians, practice owners, industry partners, equine owners/professionals, etc. This undertaking is not a quick fix, but the AAEP feels it will return significant dividends to our industry.

2019 was a busy year for the racing industry, especially in the media, and the AAEP was proud to have numerous Racing Committee members addressing topics being raised. Responding to the events of last year, the AAEP will convene an additional face-to-face meeting of the committee early this year to develop an action plan for the AAEP's ongoing role in the racing industry.

The mission of this program is to understand the needs, wants and successful strategies centric to equine veterinarians, with one goal being to improve the retention of equine practitioners and personnel.

With my own roots in the Western performance world, I am happy to report that the relatively new Performance Horse Committee has taken a page from the longstanding Racing Committee by providing guidelines for their sector. The Performance Horse Committee has also commissioned creation of a white paper on the use of intra-articular medications as well as a survey of the membership on current practices; please keep an eye out and participate in this upcoming survey.

Finally, if you haven't already done so, I encourage you to check out the series of YouTube videos highlighting some of the recently identified topics to be addressed in the performance industry. Visit https://tinyurl.com/aaepphv to see the contributions of committee members Drs. Sherry Johnson and Rick Mitchell.

AAEP board focuses on strategic priorities for the year ahead

By David Foley, AAEP Executive Director

David Foley

The AAEP board convened for its winter meeting Jan. 23 with all directors present. The meeting began with a discussion of tactics relative to the new Strategic Plan (accessible at aaep.org/sites/default/files/Documents/AAEP2020StrategicPlan.pdf) in an effort to develop the association's operational plan for 2020. The plan's three primary pillars are The Profession, Education and The Horse.

The Profession Goal – This goal has two distinct areas: retention of equine practitioners in the profession, and then recruitment of more. Initial focus will be retention of veterinarians doing equine practice. Fewer graduating students are choosing equine practice, and many who do transition to small animal work within the first five years. This could pose long-term problems for the welfare of the horse, the health of the association/equine veterinary profession, and the ability of practice owners to obtain associates and future partners. Some initial plans for 2020 include (1) continuation of the Practice Life and VetCoach sessions that debuted at the 2019 convention, (2) development and launch of a Leadership Training Program in the fall, and (3) a more aggressive approach to increase the effectiveness of the new mentorship program, Outrider. This issue is much bigger than the addition of a few programs; therefore, a longer-term initiative is also in development to get to the root of some of these challenges and develop implementable solutions.

Education Goal – Member surveys tell us that continuing education is the AAEP's most valuable attribute, which is why CE is a component of every strategic plan. The periodic CE Needs Assessment survey, which ensures that our CE is member-driven, is now in the field, and we strongly encourage you to take the time to express your views. In addition, we will roll out an array of digital education this year in the form of webinars, expanded podcast learning opportunities and RACE-approved educational modules; and expand the popular dry labs at the convention.

The Horse Goal – Many of the topics around the goal of The Horse are ongoing and related to work being done by the Performance Horse and Racing committees, as well as the Medication Task Force. These topics largely focus on welfare-related concerns surrounding medication of competition horses. Additionally, in response to member survey results indicating a desire for more development of owner educational materials, we will be developing a plan to create fresh content.

Following discussion of the strategic plan, the board addressed work group recommendations. Specific actions taken included:

Approval of a Welfare and Public Policy Advisory Council (WPPAC) recommendation to take a legislative position of "active pursuit of passage" for the Employer Participation in Repayment Act of 2019 (HR 1043 and S.46), which deals with student loan repayment.

Discussion of the WPPAC's concern over a growing lack of support by USDA on equine issues. As a result, we will work with both AVMA and the American Horse Council to see if improvements can be made.

Approval of an Educational Programs Committee recommendation to purchase additional models to be used for dry labs, as well as fund a grant process to encourage the development of new models.

Scrutiny of an Infectious Disease Committee recommendation to approve Serology Guidelines. The board sent the document back to the committee with feedback for changes. A revised version will be presented to the board at a later date.

Approval of Performance Horse Committee recommendations to (1) approve the recently developed "Commitment of the Performance Horse Veterinarian" and (2) approve the revised "Veterinarian's Guide to Equestrian Competition – Official Duties."

Approval of Racing Committee recommendations to (1) have AAEP officially endorse and join the newly formed Thoroughbred Safety Coalition and (2) fund an in-person meeting of the committee in the first half of 2020 to further map out its direction for the next few years.

Tabling of an additional Racing Committee recommendation to approve the revised position on therapeutic medications until the document is finalized in concert with final recommendations of the Medication Task Force.

Discussion of The Horse Racing Integrity Act (HR 1754), an active bill being debated in the current congressional session. AAEP's position on the bill is one of "monitor" or neutral; however, a task force has been discussing possible amendments to the bill that, if made, *could* lead us to a position of "support." The AAEP maintains its longstanding support of furosemide as the only medication allowable on race day.

Approval of Wellness Task Force recommendations to (1) transition from a task force to an official standing committee and (2) fund an in-person meeting of this new committee early in 2020. The work of this committee will play a key role in two of our strategic plan goals.

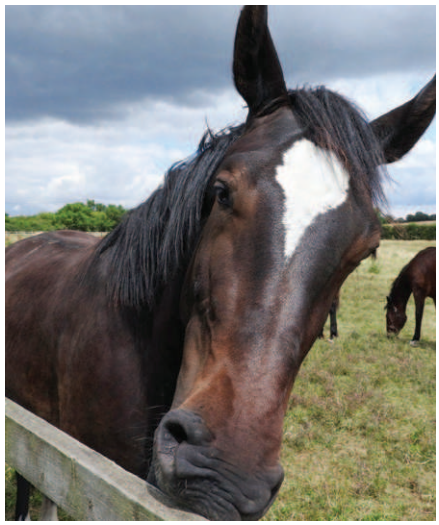
The meeting concluded with regular board business. The next meeting will occur in conjunction with the Summer Focus Conference & Labs in July.

5 things to know about AAEP this month

1. The AAEP is among the newest members of the Thoroughbred Safety Coalition, the industry-led effort aimed at meaningful safety reforms.
2. If you are a young practitioner wanting a mentor or a veteran with experience and advice to share, sign up for AAEP's Outrider mentorship program at jobs.aaep.org/ementor.
3. Expand your ophthalmic skill set at the AAEP's 360° Ophthalmology, June 24–27 in Gainesville, Fla. Register at aaep.org/meetings.
4. Read the AAEP's revised position on the use of hog rings to prevent cribbing at https://tinyurl.com/aaepewg.
5. The Wellness Task Force has transitioned into an official committee whose efforts are focused on improving quality of practice and life for AAEP members.

AAEP updates position statement on use of hog rings

At the recommendation of the Welfare and Public Policy Advisory Council, the AAEP board of directors recently approved a revised position statement on the use of hog rings to prevent cribbing. The complete text of the statement follows. It is also available at https://tinyurl.com/aaepewg.



AAEP Position on the Use of Hog Rings

Cribbing (also known as crib biting or windsucking) is one of many repetitive behaviors known as stereotypies which are sometimes demonstrated by horses. A variety of devices have been utilized to prevent horses from cribbing, including hog rings.

The AAEP opposes the use of hog rings placed around the maxillary incisors to prevent cribbing in horses. These devices are detrimental to the welfare of the horse due to the potential to cause persistent pain, damage to the gingiva, periodontal disease and abrasive wear to adjacent teeth. Hog rings should not be used as an anti-cribbing device.

New 'Practice Life' podcasts offer mentorship, student debt advice

"As young veterinarians go through that horrible phase of impostor syndrome, it's a hard time where they do need a lot of reassurance (from a mentor), and then they bounce back, and then they're on fire and they've got all these great ideas," said Dr. Caitlin Daly on one of two new episodes of the AAEP Practice Life podcast.

The 39-minute episode, entitled "Developing Young Veterinarians," dispenses advice for new veterinary graduates looking for their best career as well as suggestions for practice owners who would hire them.

Hosted by Dr. Mike Pownall, the episode features conversations with Dr. Daly, a solo practitioner and founder of Mid Coast Equine in Waldoboro, Maine; Dr. Elizabeth Arbittier of the University of Pennsylvania's New Bolton Center; and Dr. Luke Bass of Colorado State University.

If you are a younger veterinarian seeking a mentor or a veteran practitioner interested in providing mentorship, sign up to participate in Outrider, the AAEP's new mentorship program, at jobs.aaep.org/eMentor.

The other new episode is a 43-minute installment entitled "Myths and Misconceptions about Veterinary Student Debt."

Podcast host Dr. Mike Pownall investigates how a veterinarian can afford to be an equine practitioner with guest veterinarians Dr. Robyn Ellerbrock of the University of Georgia; Dr. Mary Kovach of Lap of Love Veterinary Hospice in Indianapolis, Ind.; and Dr. Tony Bartels of the VIN Foundation.

Download or listen to the AAEP Practice Life podcasts at podcast.aaep.org.

Nominate a difference-maker for an AAEP award

Recognize the excellence of a colleague by nominating that individual for a 2020 AAEP award. The nomination deadline is June 1, and winners will be announced and recognized during the President's Luncheon at the AAEP's 66th Annual Convention in Las Vegas, Nev., Dec. 5–9.

Nominations are being accepted in the following categories:

AAEP Research Award
Distinguished Educator – Academic Award
Distinguished Educator – Mentor Award
Distinguished Life Member Award
Distinguished Service Award
George Stubbs Award
Sage Kester Beyond the Call Award
The Lavin Cup (The Equine Welfare Award)

Visit aaep.org/about-aaep/annual-awards for nomination forms as well as additional information about each award and the selection process. You may also request a nomination form from Sue Stivers at sstivers@aaep.org or (859) 233-0147.

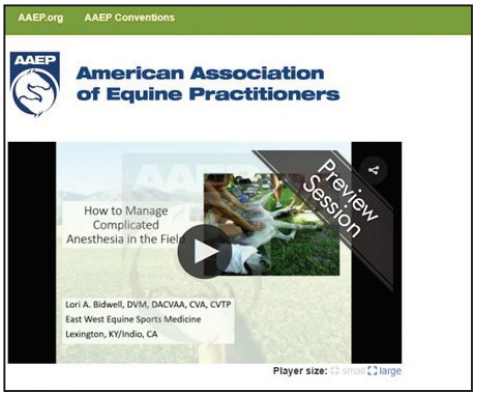
Dr. Terry Swanson, left, receives the 2019 Distinguished Educator – Mentor Award from Dr. Jeff Berk during the 65th Annual Convention in Denver, Colo.

Play it again: Access convention session recordings

If you couldn't make it to the AAEP's 65th Annual Convention in Denver or were unable to attend a session due to a schedule conflict, you can download archived recordings of all educational sessions except Table Topics at aaep.digitellinc.com/aaep.

Click the "On Demand" button and then select "AAEP Annual Convention 2019" to choose the session(s) you are interested in. There is a fee to download videos and audio; convention attendees received complimentary access to all recordings until March 7.

Additional information about this service is available by contacting the AAEP at (859) 233-0147. Tech support questions should be directed to Digitell at (877) 796-1325.



Convention keynote video available free for a limited time

Tammy Hughes' keynote address, "GenderSpeak: Working Together Successfully," is available for viewing by AAEP members through July at aaep.org/resources/2019-convention-keynote-address.

During the humorous, enlightening and research-based presentation, Hughes emphasizes that successful companies create a culture where the unique work and communication styles of each gender are understood and honored: "When both are allowed to work out of their strengths, productivity goes up."

Tammy Hughes

Expand your service offerings with hands-on ophthalmology training at AAEP's summer 360° meeting

Size and prominence make a horse's eyes susceptible to potential traumas and a variety of infections and diseases, many of which can present similarly and threaten vision and utility. Prompt, accurate diagnosis and treatment is imperative and a challenge to many practitioners, especially those with basic ocular knowledge or experience.

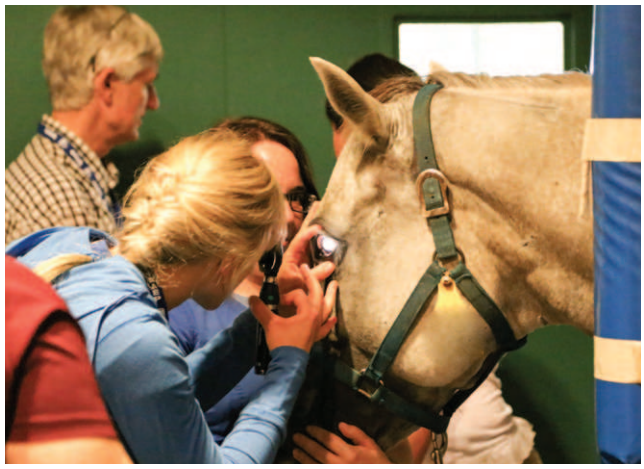
At the AAEP's 360° Ophthalmology, you'll take your eye examination to the next level by acquiring core concepts and subtleties of ocular diagnosis, treatment and prognostication from renowned specialists in equine ophthalmology.

"Eye Boot Camp" will begin with an overview of the ophthalmic exam and tips used by pros to evaluate cases. Subsequent lectures and labs will address the most common and some of the more unique conditions that may affect each of the structures of the eye and adnexa, instilling in you the knowledge and skills to recognize disease, disorders and the need for intervention; and the confidence to make informed and judicious decisions about ophthalmic disease in your equine patients, even with difficult cases.

Hands-on Training

Wet labs utilizing live animals and cadavers will equip you to understand and perform:

- the ophthalmic examination, including anterior and posterior segments, ultrasonography of the eye and orbit, and ophthalmic photography techniques
- ophthalmic blocks for diagnostic and treatment purposes
- surgical approaches to the adnexa and placement of SPLs and enucleation
- corneal surgery, including corneal suturing, keratectomy and conjunctival grafts



Dr. Amanda House

If you're ready to improve your ophthalmic skills and offer a higher level of service to patients and clients, take advantage of this exceptional, small-group learning opportunity being held June 24–27 at the University of Florida. The course is limited to 30 participants and offers extensive hands-on experience and one-on-one instruction with board-certified equine ophthalmologists. Lunches and evening social events provide additional opportunities to engage and develop professional relationships with instructors and participants.

360° Ophthalmology registration is open at aaep.org/meetings. Early registration is strongly encouraged due to the meeting's limited attendance. The syllabus and additional meeting information is available on the site.

Instructors:

Dr. Dennis Brooks
Dr. Ann Dwyer
Dr. Michala Henriksen
Dr. Luisito Pablo
Dr. Caryn Plummer
Dr. Chris Sanchez

CE hours: 28

Nearly 100 merge science with sunshine at Resort Symposium

A total of 95 practitioners escaped to the sun-kissed, sugar-white beaches of Aruba for tropical CE at the AAEP's 22nd Annual Resort Symposium, Jan. 23–25.

Three half-day educational sessions boosted attendees' ability to administer effective sedation and restraint; triage, treat and manage field emergencies; provide preventative care for neonates and geriatric horses; and protect client horses from the threat of infectious and contagious disease.

If the idea of a midwinter getaway for practical CE in a destination setting sounds appealing, dig out your Hawaiian shirt and make plans to join us Jan. 27–29, 2021, on the Big Island of Hawaii for the 23rd Annual Resort Symposium. Additional information about the meeting will be announced later this year.

Attendees enjoy the oceanfront Welcome Reception.

The AAEP thanks Boehringer Ingelheim and IDEXX for their sponsorship of the 22nd Annual Resort Symposium and ongoing support of equine continuing education.

AAEP mourns the loss of Drs. Dave Hanlon and John Peters

Dr. Dave Hanlon

Dr. Dave Hanlon, associate professor of theriogenology in the Colorado State University College of Veterinary Medicine & Biomedical Sciences, died in a car accident Jan. 20 when a motor vehicle swerved into the wrong lane and hit the Hanlon's vehicle head on. He was 50. His wife, Dr. Fiona Hanlon, also an associate professor of theriogenology at Colorado State, suffered a significant injury and is now recovering at home with their three children who received minor injuries.

The Hanlons joined the faculty at Colorado State in 2019 after relocating from Matamata, New Zealand, where they enjoyed long careers with Matamata Veterinary Services, one of the largest mixed-species veterinary practices in the Southern Hemisphere. Dave joined the practice in 1996 and served as shareholder, partner and director.

He received his veterinary degree in 1992 from Murdoch University in Western Australia. He completed a clinical residency and master's in large animal reproduction at Massey University in New Zealand, from which he also received a Ph.D. in 2012. He became a diplomate of the American College of Theriogenologists in 2001.

Dr. John Peters

Dr. John Peters, an Air Force veteran and longtime racing veterinarian in the Mid-Atlantic region, died Feb. 11 at age 88.

Dr. Peters received his veterinary degree from Cornell University in 1962 following a tour of duty in Korea and Japan as a 2nd Lieutenant in the U.S. Air Force. His long and distinguished career in private practice focused on racehorses at tracks in Delaware, Maryland, New Jersey, New York and Pennsylvania. He also served as a veterinarian for the state of Delaware and as chief veterinarian for the Delaware Thoroughbred Racing Commission.

Named Veterinarian of the Year by the Delaware Veterinary Medical Association in 2002, Dr. Peters was highly respected by both Thoroughbred and Standardbred horsemen, and he served as a mentor to countless veterinary students and peers until his retirement in 2017. In addition, Dr. Peters served on the AAEP's Racing Committee in the early 1980s and was co-founder of a partnership that bred Albatross, one of the greatest and most influential Standardbreds of all time.

Member in the News

Dr. Michael Odian named Maryland state veterinarian

The Maryland Secretary of Agriculture has appointed Dr. Michael Odian as the new state veterinarian. He will lead the department's Animal Health Program, which works to prevent and control infectious and contagious diseases in Maryland livestock and poultry.

A graduate of the Atlantic Veterinary College at the University of Prince Edward Island, Dr. Odian practiced for nearly a quarter-century, first at Thistledown and Northfields Park in Ohio until moving to Maryland in 2003 and opening a general equine practice focused on sport horse medicine.

Dr. Michael Odian

Welcome new members, and congratulations recent graduates

New Members:

Jorge Adarraga, DVM, Ithaca, NY
Melanie W. Burnley, DVM, Dresden, TN
Lauren Charnock, DVM, Auburn, AL
Danielle Jennine Fritz, DVM, Cowichan Bay, BC, Canada
Laura Dunbar Hostnik, DVM, MS, DACVIM, Columbus, OH
Atsutoshi Kuwano, PhD, DVM, Shimotuke-shi, Tochigi-ken, Japan
David Love, DVM, Punta Gorda, FL
Juan Carlos Pineros, DVM, Etobicoke, ON, Canada
James D. Robertson, DVM, Brookville, PA

Recent Graduates:

Luke de Freitas, DVM, Aldergrove, BC, Canada
Laci Schmidt, DVM, Assiniboia, SK, Canada
Mackenzie V. Walkenhorst, DVM, Richland, WA
Linnea M. Warlick, DVM, Lambertville, NJ

MEMBERSHIP

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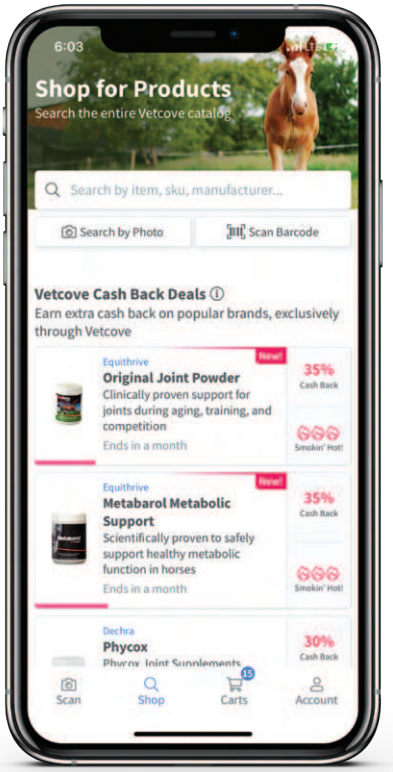

Are you taking advantage of your free AAEP Inner Circle benefits on Vetcove? This member benefit allows you to compare and buy from every veterinary vendor from one website. Vetcove supports your existing vendors and negotiated pricing, plus your billing, shipping and vendor relationships all stay the same. You'll save time and money purchasing supplies for your practice and earn extra cash back on top equine products. Best of all, AAEP members receive equine-specific content and exclusive features through the AAEP Inner Circle.

New for 2020: Vetcove's mobile app, built with the equine practitioner in mind, enables you to easily check prices, build shopping lists and place vendor orders while you're on the road. New features available exclusively in the app include the ability to find any product in the catalog simply by snapping a photo or scanning its barcode. Download the app on your mobile device at the iOS or Android app store, and then sign into the app just as you would from your computer.

"Vetcove has become an essential key to ordering in our practice," said Mandy Sawin, office manager at Conley & Koontz Equine Hospital in Columbia City, Ind. "Not only does this site save time, it saves money and valuable resources. I will never use another site, and anyone who has ever ordered 'the old-fashioned way' will surely appreciate the new features!"

Take control of your inventory by creating your AAEP Inner Circle account on Vetcove at aaep.org/dashboard/vetcove. If you have questions about Vetcove or other benefits of your AAEP membership, contact Megan Gray, member concierge, at mgray@aaep.org. You may also contact Vetcove directly at support@vetcove.com.

FOUNDATION

Foundation awards $25,000 in support of Australia wildfire relief

A koala rescued from the wildfires receives treatment for its injuries.

The Foundation for the Horse, which in mid-January issued a call for contributions through its Disaster Relief Fund to support veterinarians working with wildlife, horses and other livestock affected by the Australia wildfires, distributed $25,000 in late February to the Australia Veterinary Association's Benevolent Fund.

The total, comprised of $15,000 in contributions and a Foundation match on the first $10,000 raised, is supporting the many veterinarians impacted by the fires or providing charitable care to affected animals.

"Thank you to The Foundation and the AAEP membership for the incredibly generous support," said Jeffrey Wilkinson, national manager of special interest groups for the Australian Veterinary Association. "This is $38,000 Aussie Dollars and will make an enormous difference! Every penny will go to veterinarians and clinics who engaged in bushfire relief, which in turn strengthens fire-ravaged communities here in Australia."

The devastating wildfires consumed more than 38,000 square miles and killed 33 humans and millions of mammals, including a significant portion of the nation's koala population.

AVMA issues updated Guidelines for the Euthanasia of Animals

AVMA™ Our Passion. Our Profession.

The AVMA Panel on Euthanasia has released updated Guidelines for the Euthanasia of Animals. The recommendations are intended to guide veterinarians, who must then use professional judgment in applying them to the various settings where animals are to be euthanized.

The guidelines include an Equids section that begins on page 78 and contains information about adjunctive methods. View or download the guidelines at https://tinyurl.com/avmagea.

AAEP Educational Partner Profile: Cargill

Cargill Feed & Nutrition, an Educational Partner of the AAEP since 2001, is committed to translating nutrition research into feed solutions that improve the health of horses. Cargill's rich history of creating innovative equine nutrition solutions includes our Nutrena®, Progressive Nutrition®, Legends® and ProElite® brands of feeds and supplements.

Cargill®

TOPLINE BALANCE®

Nutrena's unique approach to topline health.
Learn more at www.toplinebalance.com

We believe a horse's topline plays an important role in how it performs, looks and feels. Our industry-leading topline assessment tool and a wealth of resources about topline health can be found at toplinebalance.com.

When it comes to nutrition that supports the health of your clients' horses, Cargill's team of equine nutrition experts is here to help you. Please visit our exclusive equine veterinarian website vetnutritioninfo.com where you will find resources to help your staff and your clients. If you have questions or a need for training and assistance, please contact us at (800) 367-4894 or visit our website.

INDUSTRY

Delegate Corner: AVMA adopts AAEP-backed resolution on use of hog rings

By Stuart Brown II, DVM and Margo Macpherson, DVM, MS, DACT

Dr. Stuart Brown

Dr. Margo Macpherson

The AVMA House of Delegates (HoD) winter session, held Jan. 10 in Chicago, Ill., in conjunction with the Veterinary Leadership Conference, featured voting on four resolutions and extensive discussion of potential practice liability involving student externs and practice volunteers.

Of particular interest to equine practitioners was a proposed resolution concerning the management of cribbing in horses and condemnation of the use of hog rings or other devices placed around the incisor teeth that cause persistent discomfort while leading to periodontal disease. The resolution also encouraged further research into the underlying causes of cribbing. Previously, the AAEP had adopted a position containing similar language on the use of hog rings to prevent cribbing at the recommendation of its Welfare and Public Policy Advisory Council. This resolution was supported by the AAEP and ultimately passed by the HoD without amendments. The other resolutions—on development of technology use in veterinary medicine, endorsement of the use of microchips for electronic identification in veterinary practice and a policy revision related to the declawing of domestic cats—all passed, the latter after much debate on the floor.

The session also included open discussion of several Veterinary Information Forum (VIF) topics, including student externs/practice volunteer potential liability, which is especially important to those of us in large animal private practice. Recent issues have arisen in claims around risks in large animal practice when those volunteering or learning about the profession accompany us on farm calls and in practice settings where accidents may occur and may not be covered under existing practice policies for employees and associates. To understand these concerns, the HoD voted for the AVMA board to work with PLIT on an awareness campaign and toolkit to assist the membership in protecting students, volunteers and practitioners. Other VIF discussion topics were telehealth regulations in the profession, cannabis use in veterinary medicine, an update on sexual harassment in the workplace and utilization of veterinary technicians in continuance of our discussions in 2019.

This marked the first HoD meeting for our newly installed Alternate Delegate, Dr. Margo Macpherson. We were joined by AAEP's President Dr. David Frisbie, "Emerging Leader" Dr. Zach Loppnow and Executive Director David Foley in what is a unique opportunity to network with our colleagues across veterinary medicine and the leadership of the broader AVMA. These relationships are invaluable in serving the interests of the AAEP membership when matters affecting equine practice are addressed through resolutions and bylaws amendments presented on the floor of the HoD. Our guidance on such issues is especially sought by our constituents who comprise the Allied Caucus in the HoD in species-specific discussions of equine veterinary medicine.

As always, we appreciate the opportunity to represent the AAEP membership at the AVMA House of Delegates, and we welcome your feedback and input on issues you face in the care of your equine patients.

Dr. Brown, a partner in Hagyard Equine Medical Institute in Lexington, Ky., serves as AAEP's delegate to the AVMA House of Delegates. Dr. Macpherson, AAEP's alternate delegate, is a professor at the University of Florida College of Veterinary Medicine.

WELLNESS

AAEP establishes Wellness Committee

The AAEP has elevated its Wellness Task Force into a standalone committee charged with developing and providing resources to the membership on wellness and wellbeing issues, including educational programming, in an effort to improve quality of practice and life.

The Wellness Committee is chaired by Dr. Rob Franklin, owner of or partner in multiple equine and small animal practices in Texas. Other committee members are Drs. Aimee Ahearn, Keith Chaffin, Amy Grice, Margo Macpherson, Jamie Pribyl and Cara Rosenbaum. Several additional members will be added this year.

For more information, including how to get involved with future volunteer service on a council or committee, visit aaep.org/about-aaep/committees-and-councils.

Dr. Rob Franklin

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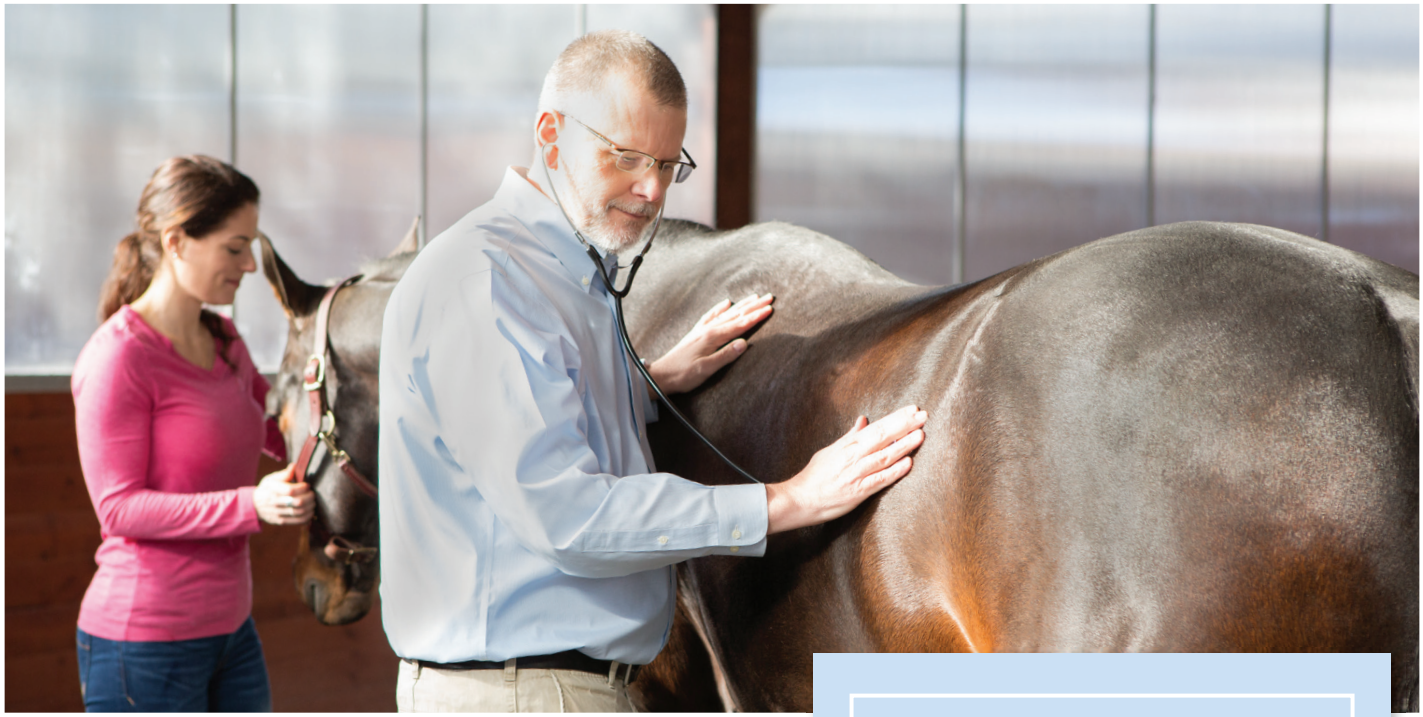

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EQUINE VETERINARY EDUCATION
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Highlights of recent clinically relevant papers

L-lactate and glucose concentrations

In recent studies on horses and ponies with gastrointestinal disease blood L-lactate and glucose concentrations were higher in ponies than in horses, possibly because of differences in body condition (BC). In this study, Bettina Dunkel and colleagues in the UK investigated the correlation between L-lactate and glucose concentrations and BC score in healthy horses and ponies.

Breed, weight, height, and subjective and objective measures of BC were recorded for systemically healthy client-owned ponies (n = 101) and horses (n = 51) and L-lactate and glucose concentrations were measured. The association between L-lactate concentrations, equid type (pony or horse), BC, age, and glucose concentrations was investigated using a multivariable model.

Weak but significant negative correlations were detected between L-lactate concentration and average BC score, heart girth:height ratio, and age. Glucose concentrations were significantly positively correlated with neck length:heart girth ratio and heart girth:height ratio. L-lactate and glucose concentrations were weakly correlated. In the final multivariable model, age and heart girth:height ratio were significantly associated with the natural logarithm of L-lactate concentration, representing a 2% decrease in L-lactate concentration per year increase in age and 10% decrease in L-lactate concentration per 0.06 unit increase in heart girth:height ratio.

These results indicate that age and BC significantly influence L-lactate concentrations in healthy horses and ponies.

Equine influenza annual booster vaccinations

This observational study by Sarah Gildea and colleagues in Ireland investigated equine influenza (EI) outbreaks at four Thoroughbred racing yards in Ireland over a 4-week period between December 2014 and January 2015.

Repeat sampling (nasopharyngeal swabs and clotted blood samples) of all horses on affected premises was performed on a weekly basis until all horses tested negative for EI by RT-PCR. Antibodies were measured against the Irish Florida sublineage clade 2 which demonstrates 100% HA nucleotide identity to the Florida clade 2 OIE recommended vaccine strain A/eq/Richmond/1/07.

Samples were collected from 118 horses over four affected premises. Forty-five horses (38.1%) developed clinical signs, 28 of which (62.2%) tested positive by RT-PCR. Eighty horses (67.8%) were up to date with their vaccinations, of which 27 (33.8%) developed clinical signs. Eighteen of the 27 horses (66.7%) that developed clinical signs had not received a booster vaccination within the previous 6 months, and 10 (37%) were due their annual booster vaccination at the time of developing clinical signs. The first documented cases on all premises (i.e. the index cases) were vaccinated in accordance with Turf Club rules. Vaccine breakdown (morbidity when vaccinated in accordance with the Turf Club rules) was observed in 27/80 horses (33.8%) with an up to date vaccination record.

Failure to implement appropriate biosecurity measures following the introduction of new horses and the return of horses from events contributed to disease spread, as did the movement of horses within premises. Mixing of racing and non- racing populations with inadequate vaccination histories also facilitated disease spread. Annual booster vaccination should not be relied on as the sole preventative measure against EI.

Ultrasonographic findings post-laryngoplasty

In this study, Sean Miller and Ann Carstens from the University of Pretoria, South Africa, reported ultrasonographic findings post-laryngoplasty in the horse.

Laryngoplasty is commonly used to treat laryngeal hemiplegia in Thoroughbred racehorses. Success of the laryngoplasty is usually determined using endoscopy. There is limited literature coverage of post-laryngoplasty and ventriculectomy ultrasonographic evaluation. In this prospective case series 10 Thoroughbred racehorses with left laryngeal hemiplegia were examined ultrasonographically and endoscopically 24–48 h presurgery, and 3–10 days, 30–50 days and 6–12 months after laryngoplasty and ventriculectomy. Anatomical structures and *plica vocalis* movements were described and measurements and gradings analysed.

Post-surgical ultrasonographic visualisation of *ventriculus laryngis* entrances was possible. The distance between *plica vocalis* in exhalation was significantly larger than that during inhalation. Pre- and post-surgical caudal *basihyoideum* and rostral *cartilago thyroidea* depth was significantly different in some instances. No significant differences in the *muscularis cricoarytenoideus lateralis* measurements were found. Complications in the extra-luminal structures were found in seven horses including soft tissue swelling, seroma, and haematoma. A luminal *plica vocalis* abscess and *plica vocalis* granuloma were also detected ultrasonographically.

These findings indicate that ultrasonography can be used to evaluate the post-laryngoplasty horse for assessing the success of the procedure, monitoring healing, and detecting complications.

Factors associated with euthanasia

In this study Danica Pollard and colleagues in the UK and Australia described factors associated with euthanasia in horses and ponies enrolled in a laminitis cohort study in Great Britain (GB).

Euthanasia is a complex topic, with animal owners using multiple factors to shape their decision-making process. This observational study used a prospective cohort design and aimed to describe owner-reported reasons for euthanasia, estimate the rate of euthanasia and identify associated factors in horses/ponies enrolled in a web-based epidemiological study of laminitis in GB. Self-selected horse/pony owners submitted regular management and health data over 29 months and reported dates and reasons for euthanasia during this period. The overall incidence of euthanasia was estimated and associated factors were identified.

Data were available for 1070 horses/ponies contributing 1093 horse-years at risk (HYAR), with 80 owner-reported

euthanasias. The incidence of euthanasia was 7.3 euthanasias per 100 HYAR. The most frequently reported health reasons contributing to euthanasia were laminitis-related consequences (25%), colic (21.3%), non-laminitic lameness (20%) and age-related deterioration, including owner-perceived compromised quality of life (20%). Health-related factors associated with significantly higher rates of euthanasia were colic (hazard ratio [HR] 26.4), pituitary pars intermedia dysfunction (HR 3.0) and lameness due to navicular syndrome (HR 5.9), soft tissue injury (HR 6.5) or laminitis (HR 2.7). Further factors included being pure bred (HR 1.7), female (HR 1.7), having poor owner-perceived hoof quality (HR 2.4), being entirely stabled (HR 5.0), being on loan or under temporary care of the study participant (HR 2.3) and participating in affiliated or professional competitions (HR 5.9). Euthanasia rates were significantly higher in the first two study years compared to the third. Animals whose owners used the study's custom-designed weight tracker tool had significantly lower rates of euthanasia (HR 0.6).

This study has identified a number of, arguably preventable, health-related factors associated with higher rates of euthanasia. Data on owners' decision-making process regarding euthanasia, including emotive and financial impacts, were not recorded but are important contributors to euthanasia that require better understanding.

Recurrent laryngeal neuropathy

This study by Masato Satoh and colleagues in Japan aimed to evaluate the use of transcutaneous ultrasound of the left cricoarytenoideus dorsalis muscle (LCAD) and right cricoarytenoideus dorsalis muscle (RCAD) to diagnose recurrent laryngeal neuropathy (RLN).

Resting endoscopy without sedation was performed on 164 Thoroughbreds and the horses were graded using the 4-grade Havemeyer system. Horses with resting grades 1 and 2 with no history of abnormal respiratory noise acted as controls, whereas horses with resting grades 3 and 4 with a history of abnormal respiratory noise at exercise were deemed to be clinically 'affected' by RLN.

Following endoscopy, the horses were sedated and transcutaneous ultrasonography of the larynx performed. The axial plane thickness, cross-sectional area, and echogenicity of the LCAD and RCAD were measured, and the LCAD: RCAD ratios in thickness and area compared between controls and affected horses.

Thickness and area of the LCAD showed a negative correlation with resting laryngeal grade. In contrast, the thickness of the RCAD showed a positive correlation with resting laryngeal grade. Increasing RCAD thickness was found in horses with resting grades 3.II and 4, while increasing RCAD cross-sectional area was found in horses with grade 3.II. LCAD was more hyperechogenic than RCAD in resting grades 3 and 4.

These results indicate that assessment of the CAD using transcutaneous ultrasonography may be a useful technique in determining whether to perform a nerve graft or laryngoplasty.

The horse–human relationship

In this scoping review of the current literature, John Burford and colleagues in the UK explored the nature of the horse–human relationship.

A literature search was performed using search terms relating to the nature of the horse–human relationship in horses used for pleasure riding. Original qualitative or observational research studies relating to the relationship between a horse and owner were analysed. Data were extracted on study method and population characteristics.

A total of 4481 studies were identified; 27 of these studies were included in the final data extraction. The studies covered 11 different areas, the most frequent were effect of humans on equine behaviour (5/27), equine training methods and behaviour (4/27) and horses within sport and leisure (4/27). A range of methodologies were used, with the most frequent being thematic analysis (6/27 studies), use of an instrument, tool or scale (3/27) and behavioural scoring (4/27). The majority of studies considered the human's perspective (20/27), six considered the horse perspective and one considered both the horse and human perspective. No studies investigated the same or similar aims or objectives.

The current evidence on the horse–human relationship is diverse and heterogenous, which limits the strength of evidence for any particular area. Future research should focus on developing reliable and repeatable tools to assess owner motivations and horse–human relationship, to develop a body of evidence.

S. WRIGHT
EVE Editorial Office

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Editorial

Improving the quality of care in equine veterinary practice

We all make mistakes, at home and at work. Human errors are inevitable. But how often in veterinary practice do errors, particularly those that lead to drastic consequences for the animal or a client complaint, lead to recriminations and feelings of guilt all round? In these enlightened times when we should be considering the health and wellbeing of our practice team, having an open just culture where mistakes can be discussed is vitally important. Looking at mistakes in veterinary practice can be a good way to get practice teams engaged with clinical governance and clinical audit.

Clinical audit at its simplest is the collecting and recording of clinical information with the aim of monitoring the quality of care. It can also be defined as a quality improvement process with the goal of continuously improving the quality of patient care. When veterinary surgeons talk about clinical audit they are usually thinking of outcome audits; these look at the results of a procedure or treatment, for example anaesthetic deaths or complications, or the results of particular surgical procedures. This is undoubtedly very useful but there are other equally useful forms of clinical audit. Process audits, which look at whether procedures are being followed, are also useful. For example, a practice might audit compliance with a treatment guideline for laminitis in ponies, or a protocol for post-operative antimicrobial and analgesic medication following castration.

The third form of audit is significant event audit (SEA), which is a qualitative rather than quantitative process. This is used widely in human healthcare practice and is an opportunity to learn from a single event. When a significant event has been identified – and this can be anything that affects care of patients or running of the practice, not just clinical events – first, all of the information about the event has to be gathered together; this could consist of clinical records, consent forms, anaesthetic records and letters of complaint from clients. Once this information has been collected, the next step is to get an account of what happened from everyone involved while it is still fresh in their minds. Then a meeting of the whole team needs to be organised. It is vitally important that this meeting is open, fair and honest. The purpose of this meeting is to encourage reflection and improvement, and to improve systems, not to apportion blame. The team should then try to analyse the incident as follows:

What happened?
Why did it happen? Both the main reason and any underlying reasons
What has been learned?
What needs to change?

When looking at why something happened, it is useful to break the reasons down into human factors, system factors and patient or client factors.

Equine practice example

It was a busy Monday morning at the equine hospital. A client had brought three 2-year-old Warmblood colts (Tom, Dick and Harry) to the hospital. Tom and Dick were due to have their hocks and stifles radiographed, while Harry was due to undergo castration using a closed technique under general anaesthesia. The client was in a hurry because she was late for work and asked that she simply 'dump the horses and go'; her usual veterinarian (part the ambulatory team of the practice) knew all the relevant histories of the horses. One of the hospital nurses admitted the horses and sorted out all of the relevant paperwork. As she left, the client jokingly told the nurse not to get the horses confused with each other because they looked very similar. However, Harry was noted to have some white hairs on his forehead which the other two horses did not have; this fact was noted down on the admission form. The morning schedule was disrupted because of two emergency case admissions. By lunchtime, things had settled down, and the surgeon got ready to perform Harry's castration. The horse was brought into the anaesthesia box by another nurse (the original nurse was on lunch break). The horse was prepared for surgery and intravenous anaesthesia was induced. At this point the original nurse came back from lunch and noticed that the horse about to undergo castration did not have any white hairs on his forehead – it was the wrong horse! Fortunately, the surgery itself had not been started, so the horse was allowed to recover from the anaesthesia and was unharmed by the experience. The surgeon immediately phoned the owner to explain the error, who thankfully was very understanding and did not wish to pursue the matter any further.

However, after discussing this 'near miss' in a significant event meeting the team suggested introducing name tags for all admitted horses as well as a pre-anaesthesia checklist to prevent similar occurrences happening in the future. These changes were implemented, and it was decided to audit use of the checklist and to review the changes after 6 months.

Practices need to have an open, 'no blame' culture in order to adopt SEA successfully; the process should involve the whole team and be open and transparent. All significant events or near-misses should be reported and discussed. When clinical protocols need to be drawn up or changed as a result of a SEA, the clinical team should be involved in looking at the evidence base and drawing up practice protocols, guidelines and checklists. There should be good communication and training to implement these protocols and guidelines, and they should be used by everyone. It may be that as a result of the SEA the team decides to follow up with outcome audits or process audits to monitor use of the new protocols.

Practices with an open supportive culture that have started to reflect on mistakes and complaints and learn from them have found that this can turn a negative event into a positive learning experience and increase team morale. Frank discussions analysing incidents, looking at all the factors involved, including human factors, system factors and patient (and owner) factors, can contribute to a bigger-picture approach. Acknowledging that non-medical factors can

Continued on page 131

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*Manfredi JM, Stapley ED, Nash D. Effects of a dietary supplement on insulin and adipokine concentrations in equine metabolic syndrome/ insulin dysregulation. In *Proceedings* Am Assoc Equine Pract 2018; 64:473.

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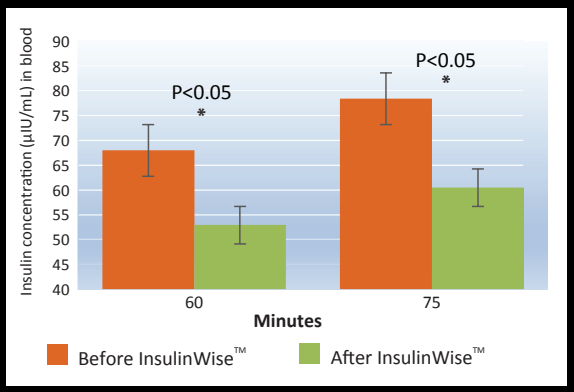
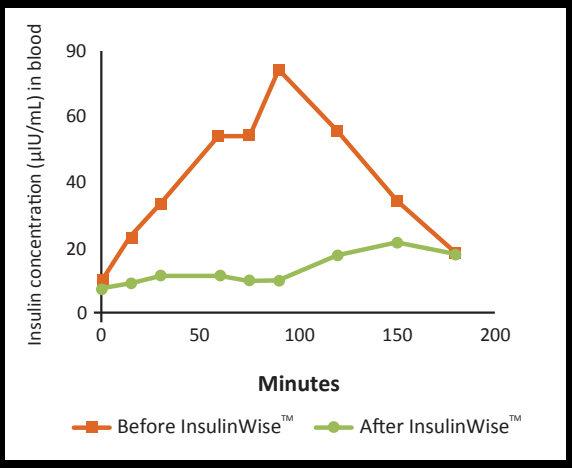


InsulinWise Supported a Decrease in Insulin Resistance

In four of the horses previously identified as insulin resistant, insulin regulation reverted to levels classified as normal after supplementation with InsulinWise.



Insulin Levels at 60 Minutes During Oral Sugar Tests from 2013 to 2017

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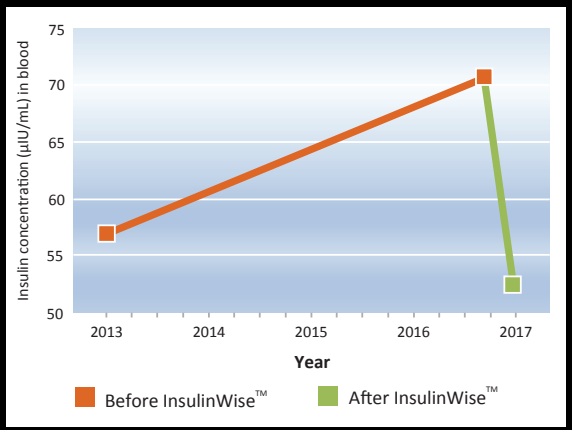

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Case Report

Haemangiosarcoma in two full sibling American Quarter Horse geldings

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Keywords: horse; haemangiosarcoma; neoplasia; haemoabdomen; heritable

Summary

This case report describes two full sibling gelding American Quarter Horses that presented separately for evaluation of an external mass (Case 1) and signs of colic and epistaxis (Case 2). The horses had the same owner and resided on the same property for the majority of their lives. Both horses were definitively or presumptively diagnosed antemortem with haemangiosarcoma, and on necropsy, multicentric (Case 1) and primary renal (Case 2) haemangiosarcoma were confirmed. A unique finding on necropsy was extensive bilateral renal involvement. Due to the low incidence of haemangiosarcoma in horses, the unique organ involvement and common ancestry of these two horses, a genetic cause is suspected.

Introduction

Haemangiosarcoma is an aggressive neoplasm of endothelial cell origin. Although it is a readily recognised disease in dogs, haemangiosarcoma is rare in horses and difficult to diagnose antemortem (Southwood *et al.* 2000; Mahne *et al.* 2014). There is no established classification system for haemangiosarcoma in horses, but juvenile, ocular, cutaneous, spinal, respiratory, musculoskeletal, intra-articular and disseminated forms have been described (Freestone *et al.* 1990; Southwood *et al.* 2000; Johns *et al.* 2005; Sansom *et al.* 2006; Pinn *et al.* 2011; Schaffer *et al.* 2013; Mahne *et al.* 2014; Raes *et al.* 2014). Because any organ or tissue can be affected, the disease is characterised by a wide variety of presenting complaints. Haemangiosarcoma has been reported in horses of all ages, and the prognosis for survival is poor (Southwood *et al.* 2000).

Genetic risk factors for canine haemangiosarcoma have long been suspected due to an increased prevalence in certain breeds (Hargis *et al.* 1992). Specific genetic mutations that increase the risk of developing haemangiosarcoma have been identified in dogs (Tamburini *et al.* 2009; Rowell *et al.* 2011; Thomas *et al.* 2014). A genetic predisposition for haemangiosarcoma has not been investigated in horses; however, Thoroughbreds are overrepresented in some studies (Southwood *et al.* 2000; Johns *et al.* 2005). This report describes the clinical, diagnostic and post-mortem findings of two full sibling American Quarter Horse geldings that developed disseminated haemangiosarcoma characterised by bilateral renal involvement. To the authors' knowledge, this is the first report describing a familial link in two cases of equine haemangiosarcoma.

Case details

Case 1

Case 1 was a 21-year-old American Quarter Horse gelding referred to Mississippi State University Animal Health Center for evaluation of a progressively enlarging mass on the right thoracic body wall of approximately 3 months' duration accompanied by weight loss.

On presentation, all vital parameters were within normal limits. A large, firm, haired, solitary external mass on the right thorax was noted (**Fig 1**). The mass measured 36 × 25 cm, extending horizontally from the level of the 9th to the 12th rib at the level of the point of the elbow and projected approximately 10 cm from the body wall. Initial bloodwork (CBC and serum chemistry) revealed a moderate hyperglobulinaemia (59 g/L; reference range [rr] 25–40 g/L) and mild hypoalbuminaemia (26 g/L; rr 28–39 g/L).

Thoracic radiographs and thoracic and abdominal ultrasonography were performed to further evaluate the mass and look for evidence of metastasis. On ultrasonographic examination, the right thoracic mass appeared heterogenous with a superficial capsule. The deeper portion of the mass had a whirled heterogenous pattern suggestive of an organised haematoma. Colour flow Doppler revealed that the mass was highly vascular. An irregular hyperechoic structure with an acoustic shadow was present in the centre

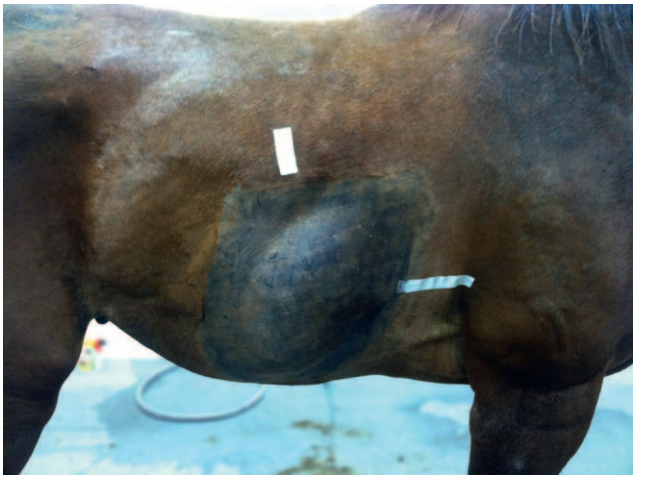

Fig 1: Large mass located over the lateral thoracic wall of Case 1. Tape markers were used to denote the area for biopsy following ultrasound examination.

of the mass, presumed to be an abnormal 11th rib (**Fig 2**). The mass extended from the subcuticular layer deep to the parietal surface of the thoracic and peritoneal cavities. An ultrasound of the thorax and abdomen revealed two small (1.5–2 cm) hypoechoic nodules at the periphery of the right lung and adjacent to the cranial pole of the left kidney. Thoracic radiographs revealed an approximately 1.5 cm, round, sharply marginated, soft tissue opacity in the right caudal lung lobe.

An ultrasound-guided aspiration of the mass was performed using an 18 gauge 1.5 in needle, and 30 mL of blood was obtained with ease. A biopsy instrument (Bard® Monopty®)[1] was used to obtain several samples from the centre and periphery of the mass. There was marked haemorrhage from the biopsy sites that required a pressure bandage.

Histopathology of the biopsy samples (**Fig 3**) revealed an expansive, compressive, infiltrative neoplasm composed of elongate spindle cells arranged predominantly in broad sheets with a lesser component lining irregular, blood-filled spaces and channels resembling vascular structures. Occasional fibrin thrombi were present within these spaces. The neoplastic cells had strong intracytoplasmic antifactor VIII immunohistochemical staining (**Fig 3**). These histopathological findings are consistent with haemangiosarcoma.

Due to the extent of the lesion, suspicion of metastasis and the grave prognosis associated with haemangiosarcoma in horses, the owners elected to pursue palliative treatment as long as the horse remained comfortable. The owners were advised of the risk and educated about the clinical signs of a fatal haemorrhage event should the mass rupture externally or into the thoracic cavity.

Eight weeks after his initial presentation, the horse was subjected to euthanasia by the primary veterinarian after displaying signs of colic and cardiovascular shock. The body was presented within 6 h of death for necropsy examination. Necropsy revealed a large volume of blood in the abdominal cavity. Expanding the retroperitoneum bilaterally were large, multilobulated, red to black, friable to firm masses that surrounded and invaded both kidneys. On cross section, the kidneys were visible within the centre of the masses, and contained multiple spherical, black, 1–2 cm diameter friable nodules in the renal cortices and medullas (**Fig 4**). Numerous similar 1–3 cm diameter nodules were found within multiple lung lobes and within the myocardium of the left ventricular free wall. Gross examination of the thoracic wall mass revealed a similar, well-encapsulated mass that involved the 9th to 12th rib with a focal pathologic fracture of the 11th rib. The lung adjacent to the mass was firmly adhered to the thoracic wall by fibrous tissue. Histopathology of the masses was identical to the ante-mortem biopsy, and confirmed multicentric haemangiosarcoma involving kidney (**Fig 5**), liver, lung, heart, adrenal gland, intercostal muscles and ribs. The neoplastic cells had strong intracytoplasmic antifactor VIII immunostaining.

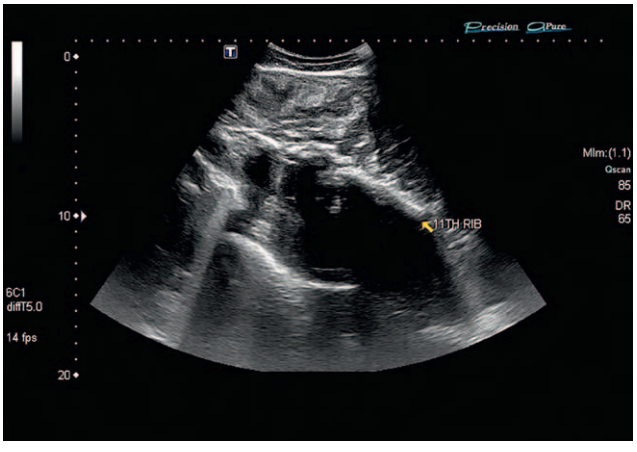

Fig 2: Longitudinal ultrasonographic image of the lateral thoracic wall mass from Case 1. Note the hyperechoic shadowing structure in the centre of the image (arrow) presumed to be an abnormal 11th rib and the whirled heterogenous pattern of the mass. Image obtained with a 4-MHz curvilinear probe.

Case 2

Case 2 was a 21-year-old American Quarter Horse gelding that presented 26 months after Case 1 for emergency evaluation of mild bilateral epistaxis and moderate colic signs

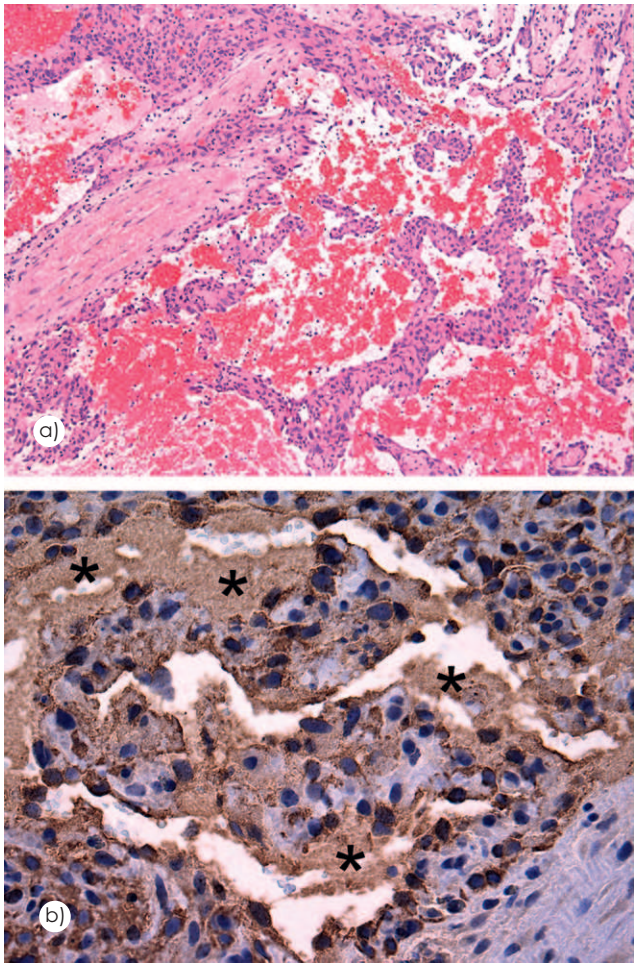

Fig 3: Biopsy of thoracic wall mass from Case 1 a) Neoplastic elongate spindle cells lining irregular, blood-filled spaces and channels resembling vascular structures. H&E stained section; 100×. b) Positive (brown) antifactor VIII immunostaining of thoracic wall haemangiosarcoma. The brown-stained material marked by * is blood within trabecular spaces formed by the neoplasm. 400×

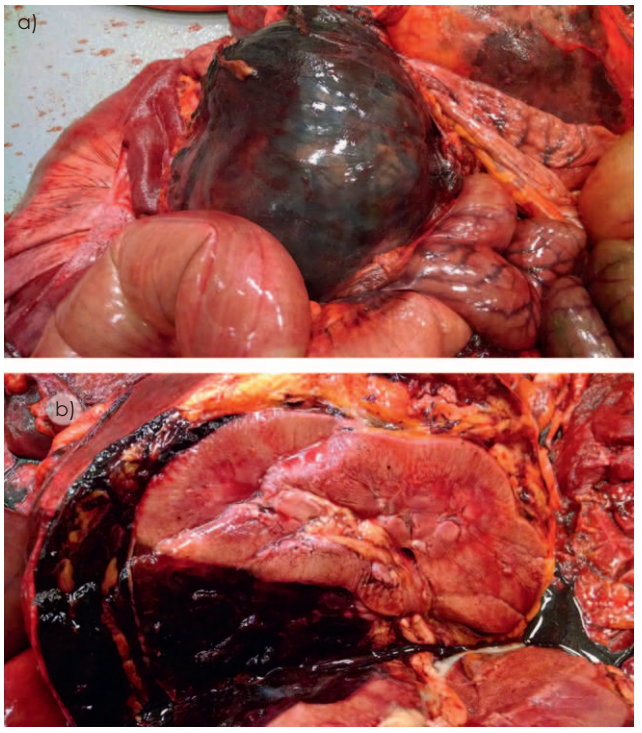

Fig 4: Post-mortem Case 1 a) large, red to black, retroperitoneal masses surrounded both kidneys (left kidney shown here). b) On cross section, the kidneys were visible within the centre of the masses.

of 12 h duration. Case 2 was the full brother of Case 1 and resided his entire lifetime with the same owners.

On presentation, the horse was depressed, moderately tachycardic (60 beats/min) with pale, tacky mucous membranes and a prolonged capillary refill time of 3 s. Gastrointestinal sounds were decreased to absent. Blood was present in both nostrils, but there was no active bleeding. An upper airway endoscopy was performed to investigate the cause of the epistaxis, but no abnormalities were noted.

A nasogastric tube was passed, and no reflux was obtained. On rectal examination, a large firm mass was palpable in the region of the left kidney. On abdominal ultrasound, a moderate amount of swirling, echogenic free fluid was visible along the ventral abdomen. A large irregular mass with a thick capsule was visible surrounding both kidneys. Colour flow Doppler demonstrated that the mass was highly vascular. The renal parenchyma of both kidneys contained multiple, heterogenous, hyper- and hypoechoic nodules (**Fig 6**). Abdominocentesis yielded a large volume of blood indicative of a haemoabdomen.

Haematological findings (CBC and serum chemistry) included a mild anaemia with a PCV of 25% (rr 26–42%) and red blood cell count of 4.77×10^{12}/L (rr 6–12.0). Cytological analysis of the abdominal fluid revealed a PCV of 12%, total protein of 52 g/L, red blood cell count of 2.34×10^{12}/L and nucleated cell count of 7.62×10^{9}/L with 50% nondegenerate neutrophils and 50% macrophages with frequent erythrophagocytes noted.

Based on the diagnostic findings, abdominal neoplasia with a secondary haemoabdomen was suspected. The owners elected to pursue supportive therapy. Intravenous

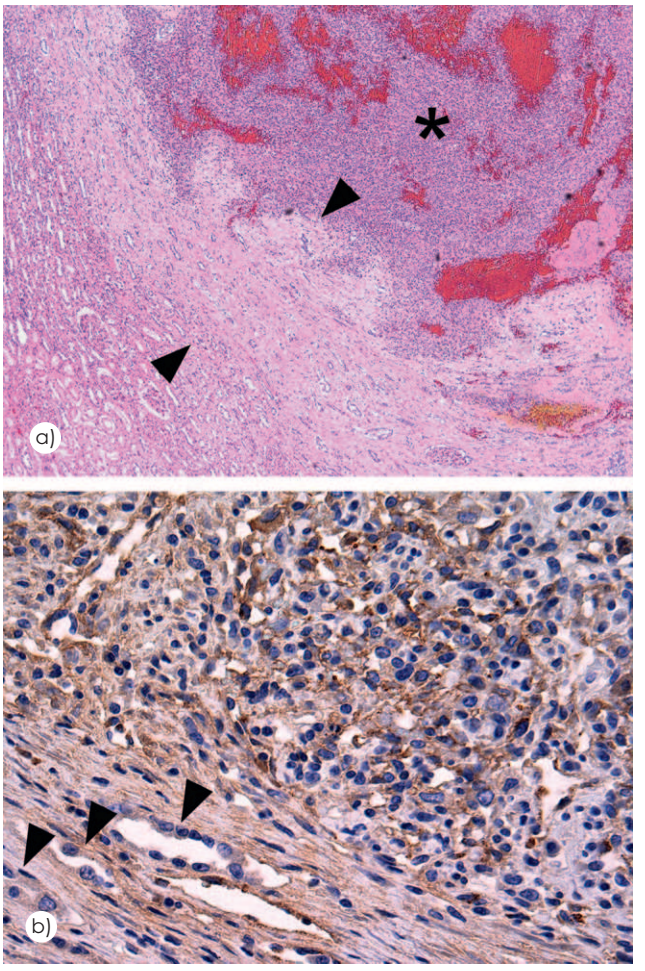

Fig 5: Renal mass from Case 1 a) highly cellular haemangiosarcoma (*) bordered by a broad zone of fibrovascular connective tissue (arrowheads) containing entrapped renal tubules. Compressed renal tissue is seen at the lower left of the image. H&E stained section; 40×. b) positive (brown) antifactor VIII immunostaining of renal haemangiosarcoma with three compressed atrophic renal tubules (arrowheads) seen at the lower left of the image. 400×

fluid therapy (lactated Ringer's solution CRI at 1 L/h) was initiated, and aminocaproic acid[2] (20 g/horse) diluted in 1 L of lactated Ringer's solution was administered. The following morning the horse remained depressed and tachycardic (56 beats/min) with pale mucous membranes and a prolonged capillary refill time. The PCV had decreased to 19%. Based on the horse's declining status and grave prognosis, the owners elected euthanasia.

Necropsy revealed lesions remarkably similar to Case 1. There were approximately 25 L of blood within the abdominal cavity. Expanding the retroperitoneum and replacing normal renal structures bilaterally were two large, multilobulated, red to black, friable to firm masses that surrounded and invaded both kidneys (**Fig 7**). The left retroperitoneal mass measured 43 × 18 × 12 cm, and the caudal portion of the mass contained a large blood clot that encompassed the left kidney. The right retroperitoneal mass measured 20 × 12 × 11 cm and was firmly adhered to the caudal margin of multiple liver lobes on the cranial border. On cut surface both kidneys contained

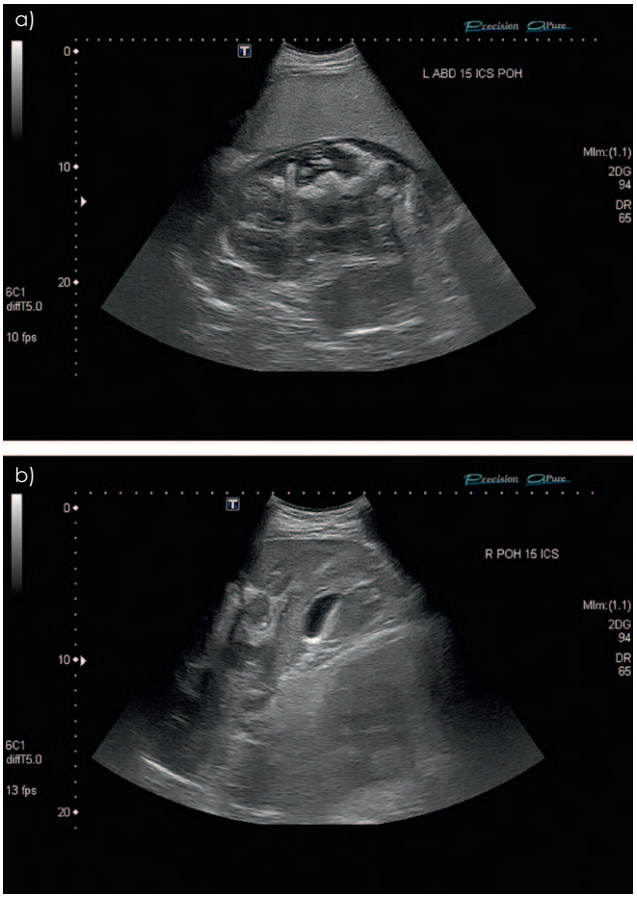

Fig 6: Ultrasonographic images of left (a) and right (b) kidneys of Case 2. Note the loss of normal renal architecture with the presence of hyper- and hypoechoic structures within the renal parenchyma. Images obtained with a 4-MHz curvilinear probe.

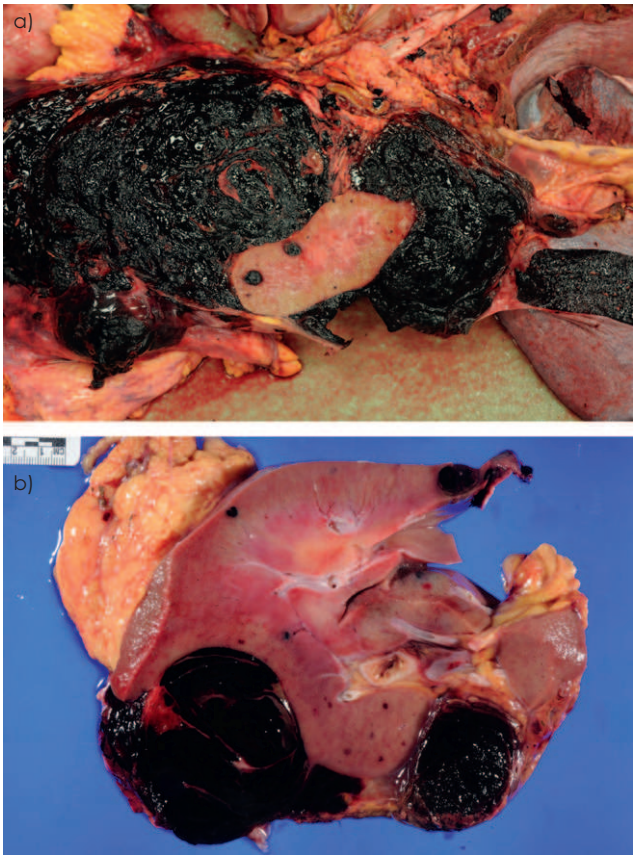

Fig 7: Post-mortem Case 2 a) large, multilobulated, red to black, friable to firm, retroperitoneal mass encompassing and invading the left kidney. b) Cut surface of right kidney demonstrating multifocal round, red to black soft nodules.

multifocal round, red to black, often cystic, soft nodules that ranged 5–20 cm in diameter (**Fig 7**).

Histopathology of the renal masses (**Fig 8**) showed multifocal, variably sized, cystic, blood-filled cavities lined by a neoplastic population of well-differentiated endothelial cells, with subjacent fibrosis that effaced renal architecture. The neoplastic cells were elongate plump spindle cells and formed both flat simple layers, cribiform patterns and poorly organised vascular channels. The neoplastic cells had strong intracytoplasmic antifactor VIII immunostaining (**Fig 8**). These findings are also consistent with haemangiosarcoma.

Discussion

Similar to man and in contrast to dogs, haemangiosarcoma is a rare neoplasm in horses, diagnosed in only 0.02–0.7% of equine biopsy specimens (Hargis and McElwain 1984; Valentine 2006). This case report details two similar cases of haemangiosarcoma occurring in full sibling American Quarter Horses with the same owner. The probability of this occurring due to chance alone would be extremely low, pointing to environmental or genetic factors as a likely cause. The development of angiosarcoma in human patients has been associated with exposure to vinyl chloride (Hollstein *et al.* 1994). Haemangiosarcoma has been documented following exposure to ionising radiation in dogs (Benjamin *et al.* 1975) and exposure to a variety of drugs and chemicals in mice and rats (Cohen *et al.* 2009). In this case, a thorough questioning of the owner regarding the horses' environment did not indicate exposure to a known carcinogen. A breed predilection for the development of haemangiosarcoma in dogs has long been recognised, strongly implicating heritable risk factors in this species. Factors associated with an increased incidence or heritability of haemangiosarcoma in certain dog breeds include: reduced expression of tumour suppressor genes (Yonemaru *et al.* 2007), oncogene copy number aberrations (Thomas *et al.* 2014) and breed-associated tumour gene expression profiles (Tamburini *et al.* 2009). Familial conditions have been recognised in man and rats that predispose to vascular tumours, including haemangiosarcoma (Everitt *et al.* 1992; Cohen *et al.* 2009). The genetic factors associated with haemangiosarcoma in dogs vary by breed and involve pro-oncogene or pro-inflammatory genes (Tamburini *et al.* 2009; Kim *et al.* 2015). No specific mutation has been reported. The utility of performing testing for similar genes in horses is low due to the multifactorial nature of oncogenesis, the unreported distribution of pro-inflammatory and pro-oncogene genes across the normal horse population, and the rare nature of the disease. A pedigree analysis of the sire and dam of these cases revealed that

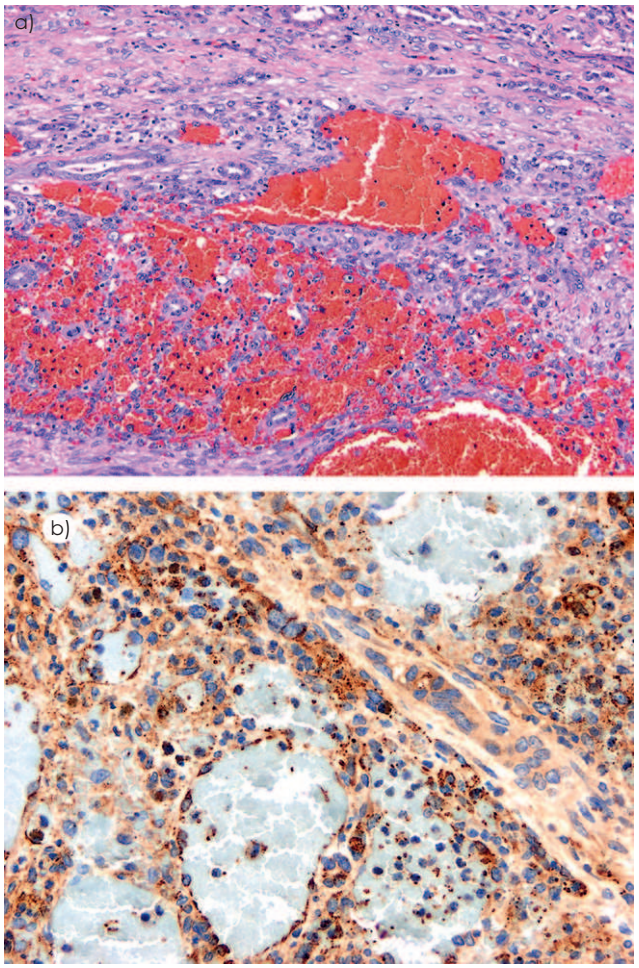

Fig 8: Renal mass from Case 2 (a) Multifocal, variably sized, cystic, blood-filled cavities lined by a neoplastic population of well-differentiated endothelial cells, with subjacent fibrosis that effaced renal architecture. (b) Positive (brown) antifactor VIII immunostaining showing marked expression in neoplastic endothelial cells lining blood-filled spaces.

they were three-fourth siblings. The horses in this report not only shared the same sire and dam but also had a single grandsire, and their paternal granddam was also their maternal great-granddam. In the equine industry, the practice of line breeding has increased the prevalence of disease conditions that would otherwise occur rarely, such as hyperkalemic periodic paralysis, heritable equine regional dermal asthenia and overo lethal white syndrome among others. Although the shared dam of these two horses was deceased, the owners were counselled that this genetic line may have a heritable predisposition for haemangiosarcoma and continued breeding of their full siblings or sire is not recommended.

The two horses in this case report had dramatically different presenting complaints. Case 1 presented for routine evaluation of a mass and was in relatively good overall health at the time of presentation. Case 2 presented on emergency with signs of colic and epistaxis. Because any organ or tissue can be affected, haemangiosarcoma may present with a wide variety of clinical signs including lameness, limb swelling, neurological signs, epistaxis, dyspnoea, colic, weight loss, depression, cardiovascular shock and poor performance among others (Southwood *et al.* 2000; Johns *et al.* 2005; Hirsch *et al.* 2009; Mahne *et al.* 2014). Signs related to respiratory dysfunction are most commonly reported in cases of disseminated haemangiosarcoma (Collins *et al.* 1994; Southwood *et al.* 2000; Teschner *et al.* 2014). Epistaxis, as seen in Case 2, is a common presenting complaint in cases where the neoplastic process affects the lungs, sinus or upper airway (Waugh *et al.* 1977; Stencel and Groteluesch en 1989; Sweeney and Gilletee 1989; Southwood *et al.* 2000; Burks *et al.* 2009); however, antemortem upper airway endoscopy and post-mortem examination could not determine a neoplastic source of the historical epistaxis in Case 2. Despite the differences in presentation and case progression, the terminal clinical manifestations (signs of colic and hypovolaemia) and necropsy findings of haemoabdomen with extensive bilateral renal involvement were remarkably similar.

Obtaining an antemortem diagnosis in cases of disseminated haemangiosarcoma can be challenging due to the difficulty and risk associated with obtaining samples from tumours affecting internal organs. In addition, horses often present with signs of haemorrhage (e.g. epistaxis, haemoabdomen, wound haemorrhage), hence trauma may be higher on a clinician's differential diagnosis list than a neoplastic process (Stencel and Groteluesch en 1989; Mahne *et al.* 2014). Ultrasonography is a noninvasive tool that can be used to evaluate the thorax and abdomen for evidence of a neoplastic process and provide information about the extent of primary and metastatic lesions. Haemangiosarcoma lesions are frequently described as poorly defined cavitary masses with a complex sonographic appearance. A complex appearance is a mixture of anechoic, hypoechoic and hyperechoic components with or without distal acoustic enhancement (Mattoon and Nyland 2015). In a large case series of equine disseminated haemangiosarcoma, a definitive antemortem diagnosis was reached in only 4 of 35 (11%) cases (Southwood *et al.* 2000). A histopathological diagnosis is more easily reached in cases where the index of suspicion for neoplasia is high and when masses are located in external areas that are amenable to biopsy sampling, such as with Case 1. Neoplastic cells are rarely found on cytological examination of haemorrhagic abdominal or pleural fluid (Southwood *et al.* 2000), as with Case 2. Common features of the disease that may lead the clinician to suspect haemangiosarcoma are the retrieval of peripheral blood upon aspiration of a mass and excessive bleeding at sites of aspiration (Stencel and Groteluesch en 1989), biopsy (Waugh *et al.* 1977; Cottle *et al.* 2008), surgery (Kiupel *et al.* 2000), or trauma to the mass (Hargis and McElwain 1984; Jean *et al.* 1994). Both of these occurred during sampling of the thoracic mass in Case 1. Excessive or prolonged haemorrhage is a common clinical finding in cases of haemangiosarcoma, and should prompt further diagnostics such as imaging or biopsy.

It is unlikely that early surgical resection of the thoracic wall mass in Case 1 would have been curative because involvement of the muscles of the chest wall would have made complete resection challenging even early in the disease process. Local recurrence or disease progression due to undetected metastases is common even with aggressive surgical resection (Moore *et al.* 1986; Johns *et al.* 2005; Burks *et al.* 2009; Hirsch *et al.* 2009). Interstitial brachytherapy in

combination with surgical resection resulted in local resolution of haemangiosarcoma involving the rostrum of an American Saddlebred gelding, but the animal was subjected to euthanasia 6 weeks later due to widespread metastatic disease (Burks *et al.* 2009). In dogs with subcutaneous or intramuscular haemangiosarcoma, only 25% of patients survive to 1 year with aggressive surgical resection with or without adjunctive treatment such as radiotherapy or chemotherapy (Shiu *et al.* 2011). Successful surgical resection of haemangiosarcoma lesions in horses with medium to long-term survival has been reported in a small number of cases involving the penis (Byrne *et al.* 2014), tarsal synovial sheath (Van Pelt *et al.* 1972), mandible (Johns *et al.* 2005), third eyelid (Sansom *et al.* 2006), conjunctiva (Pinn *et al.* 2011), vulva (Gumber *et al.* 2011) and skin (Hargis and McElwain 1984). Eight cases of haemangiosarcoma involving the thoracic wall in horses have been described in the literature (Waugh *et al.* 1977; Rossier *et al.* 1990; Collins *et al.* 1994; Johns *et al.* 2005; Tan *et al.* 2014; Teschner *et al.* 2014), and haemangiosarcoma should be considered a differential diagnosis for enlarging masses in this location. However, there are no reports of successful surgical resection of a haemangiosarcoma lesion in this location that achieved long-term survival.

In cases of disseminated haemangiosarcoma, the most commonly affected sites are the lungs and pleura, followed by the skeletal muscle, spleen and heart (Southwood *et al.* 2000), but any tissue or organ can be affected. Both horses in this case report had bilateral renal involvement with extensive disruption of the renal architecture and vasculature that led to perirenal haemorrhage that eventually ruptured the retroperitoneal space and led to haemoabdomen. Interestingly, neither horse had changes in serum blood urea nitrogen or creatinine on admission or clinical or historical evidence of renal dysfunction. In Case 1, the large thoracic mass and widespread organ involvement suggested that the renal involvement was likely due to widespread metastasis. Case 2 was classified as a primary renal haemangiosarcoma, as no additional masses were found. Three cases of unilateral primary renal haemangiosarcoma have been reported in the literature (Southwood *et al.* 2000; Hughes *et al.* 2017), but to our knowledge, this is the first report describing bilateral primary renal haemangiosarcoma in a horse.

These cases demonstrate the importance of diagnostic imaging and histopathology in obtaining an antemortem diagnosis of haemangiosarcoma in the horse. Haemangiosarcoma should be on the clinician's differential diagnosis list in cases with large vascular visceral or external masses or in the case of unexplained haemorrhagic effusions such as haemoabdomen. To the authors' knowledge, this is the first report of a familial link in two cases of haemangiosarcoma.

Authors' declaration of interests

No conflicts of interest have been declared.

Ethical animal research

Not applicable to this case report.

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Authorship

All authors participated in the care and/or diagnosis and management of the cases described in this report. All authors have provided significant contributions to the preparation of this manuscript and all have confirmed in writing their approval of the final version of this manuscript.

Manufacturers' addresses

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[2]Hospira, Inc., Lake Forest, Illinois, USA.

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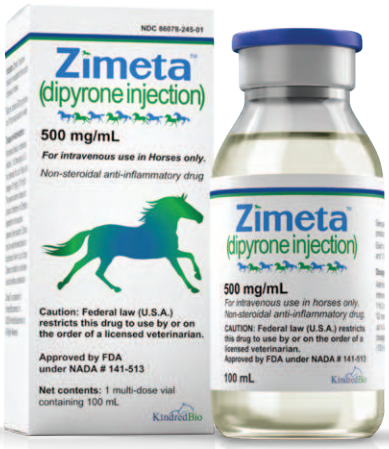

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Case Report

Ossifying fibroma as a cause of blindness in a 5-year-old Quarter Horse gelding

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Summary

A 5-year-old Quarter Horse gelding presented to Texas A&M University Veterinary Medical Teaching Hospital with a several week history of bilateral blindness. Neurological deficits included an absent menace response and severe atrophy of the optic nerve head in the left eye (OS) as well as decreased vision in the right eye (OD). Advanced imaging consisting of computed tomography (CT) and magnetic resonance imaging (MRI) confirmed a large mass in the base of the skull invading the sinuses and asymmetrically compressing the optic nerves rostral to the optic chiasm. Due to the size and location of the mass as well as severity of associated neurological signs, humane euthanasia was elected. Necropsy examination identified a large mass effacing the sphenopalatine sinuses and compressing the optic nerves. Histologically, the mass was identified as an ossifying fibroma (OF) and degeneration of the optic nerves was confirmed. As an OF in this location has never been described in a horse, this case demonstrates a new differential for blindness in horses.

Introduction

Ossifying fibromas (OF) are uncommon, benign, fibro-osseous lesions that have been described in several species, including human patients, dogs, horses, rabbits, sheep, mice and llamas (Morse *et al.* 1988; Rogers and Gould 1998; Whitten *et al.* 2006; Han *et al.* 2016). Histologically, the tumour comprises a proliferating fibrous stroma containing irregular spicules of osteoid or bone tissue (Morse *et al.* 1988; Kodaira *et al.* 2010). In domestic animals, the most commonly affected site is the head, especially the mandible and nasal sinuses, and it typically affects younger animals (Morse *et al.* 1988; Soltero-Rivera *et al.* 2015).

Ossifying fibromas have been previously reported in horses, most frequently affecting the mandible (Morse *et al.* 1988). In human subjects, OFs have been described in the cranium (Chang *et al.* 2009; Nakajima *et al.* 2013; Barrena Lopez *et al.* 2016); however, this localisation has not been described in the horse. This case report describes an unusual presentation of an OF at the base of the skull resulting in neuro-ophthalmic deficits.

Case history

A 5-year-old Quarter Horse gelding used for barrel racing was presented to Texas A&M University Veterinary Medical Teaching Hospital with an approximate 3-week history of acute onset blindness. At the onset of signs, the horse was found in the pasture reluctant to ambulate, with bilaterally dilated pupils, approximately 12 h after successfully barrel racing. There was no evidence of a traumatic event. Historically, the horse was reported to have poor performance several weeks prior to presentation. At the onset of blindness, systemic therapy with dexamethasone and flunixin meglumine was initiated with suspected mild improvement in vision; all treatments were discontinued prior to referral. Serology testing for Eastern equine encephalitis (EEE) virus, Western equine encephalitis (WEE) virus, West Nile Virus (WNV), equine herpesvirus-1 and equine protozoal myeloencephalitis (EPM) were negative.

Clinical findings

Upon presentation, the horse was bright and alert and in good body condition (450 kg, BCS 5/9). Vital parameters were all within normal limits with a heart rate of 48 beats/min, a respiratory rate of 16 breaths/min and a rectal temperature of 37.7°C. Full neurological evaluation revealed no change in mentation, proprioceptive deficits, muscle atrophy or evidence of ataxia; however, neuro-ophthalmic deficits were observed. The left eye (OS) lacked a menace response, direct pupillary light reflex (PLR) and dazzle reflex. It displayed resting mydriasis, though it received a weak consensual PLR from the right eye (OD). An inconsistent menace response, a sluggish direct PLR and a positive dazzle reflex were present in OD but the consensual PLR from OS to OD was absent. Fundoscopic evaluation of both eyes (OU) was performed. The left fundus displayed a markedly pale and slightly depressed optic nerve head and was otherwise normal in appearance. The right fundus displayed a pale, mottled pink optic nerve head with normal contour. Intraocular pressure, assessed via applanation tonometry (Tono-Pen VET™[1]), was within normal limits OU. Historical poor performance was attributed to neuro-ophthalmic deficits. No further abnormalities were noted on physical examination. Based on the neurological abnormalities, advanced imaging including sonographic evaluation of the optic nerves, and magnetic resonance imaging (MRI) and computed tomography (CT) of the head were elected.

Diagnostic imaging

Ultrasonography of both eyes was performed under sedation (detomidine hydrochloride 0.6 mcg/kg bwt i.v. [Dormosedan®][2]). The right and left eyes were within normal limits. Increased heterogeneity of the extraocular muscles and optic nerves were detected in the most caudal aspect of the left orbit, rostral to the optic foramen as compared with their appearance in the right orbit.

MRI of the head was performed under general anaesthesia in right lateral recumbency using spine and body coils in a 3-T MRI (Siemens Magnetom Verio[3]). A 14 gauge Mila catheter was placed in the left jugular vein and the patient was sedated with xylazine (Rompun[4]) (0.6 mg/kg bwt i.v.) prior to anaesthetic induction with a combination of diazepam[5] (0.03 mg/kg bwt i.v.) and ketamine (Ketaset®[2]) (2.2 mg/kg bwt i.v.). The gelding was maintained under anaesthesia using sevoflurane[6] inhalant anaesthetic with supportive care provided as needed during the procedure. T2-weighted sagittal (**Fig 1**), dorsal (**Figs 2** and **3**) and transverse plane (**Figs 4** and **5**), transverse plane T2* (**Fig 5**), transverse plane T2 FLAIR, and T1-weighted transverse, sagittal (**Fig 6**) and dorsal plane images of the brain were obtained. Additional T1-weighted transverse, sagittal (**Fig 6**) and dorsal plane images of the brain were acquired following i.v. administration of 0.058 mmol/kg bwt gadopentate dimeglumin (Magnevist® [0.05 mmol/mL][4]). A large, well-circumscribed, multilobulated mass was detected to be filling the right and left sphenopalatine sinuses with destruction of the associated septum between them. The mass extended into the caudoventral aspect of the left caudal maxillary sinus; where it contacted, the caudoventral aspect of the ethmoid turbinates. The caudodorsal border of the mass severely compressed both of the optic nerves just rostral to the optic chiasm. The left optic nerve could not be traced all the way to the globe and appeared thinner as compared with the right optic nerve (**Fig 3**). The right optic nerve was more clearly delineated along its tract from the optic chiasm to the caudal globe. The mass had mixed signal intensity and was T1 (**Fig 6**) and T2 (**Figs 1**–**5**) isointense to the grey matter parenchyma and hypointense to white matter parenchyma. There was a signal void throughout the majority of the mass on T2* images (**Fig 5**). Heterogeneous contrast enhancement was noted within the mass (**Fig 6**). A small amount of fluid was detected within the rostral aspect of the right sphenopalatine sinus.

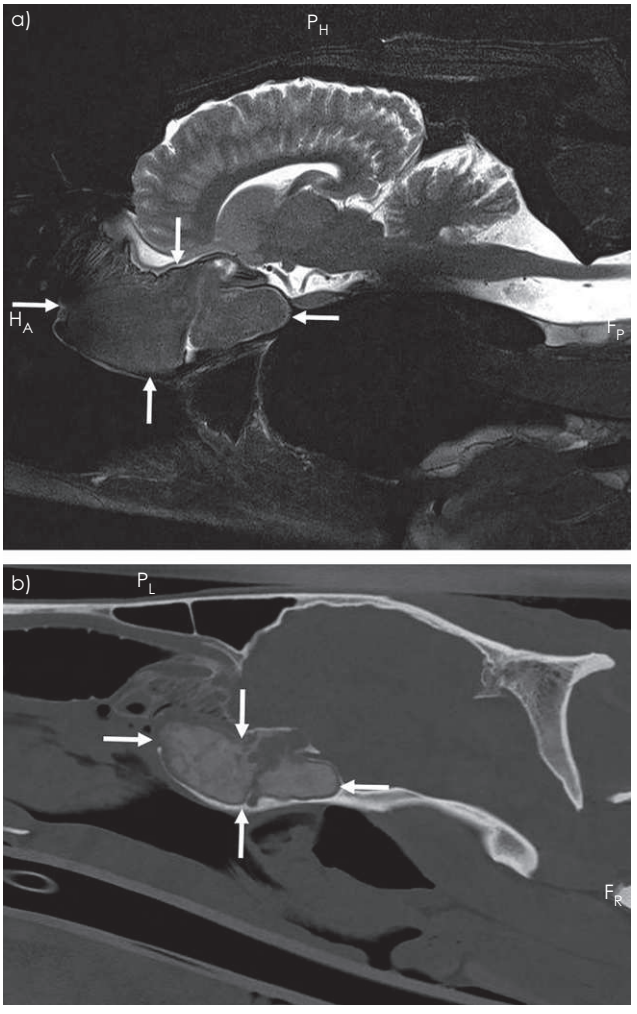

Fig 1: Sagittal plane T2-weighted MRI a) and sagittal plane reformatted CT b) images of the mass within the left sphenopalatine sinus (arrows). The mass had mixed signal intensity on T2-weighted MRI and was soft tissue and mineral attenuating on CT. Rostral is to the left of the images.

Multidetector CT examination with a 40-slice scanner (Siemens Somatom[3]) was performed under general anaesthesia immediately after the MRI. The horse was placed in dorsal recumbency. Sagittal (**Fig 1**), dorsal (**Fig 2**) and transverse (**Fig 4**) plane images were reconstructed in bone and soft tissue windows with slice thickness of 3 mm. The mass was soft tissue and mineral attenuating. There was thinning and osteolysis of the lateral margins of the left and right sphenopalatine sinuses and dorsal margin of the left sphenopalatine sinus. A focal region of smooth periosteal proliferation was present on the lateral aspect of the left sphenopalatine sinus.

Based on the imaging results, a presumptive diagnosis of neoplasia of the skull base was made. Due to the clinical presence of neurological signs in combination with a poor prognosis for future athletic performance, humane euthanasia was elected. Post-mortem examination with histopathology of selected tissues was performed.

Post-mortem examination

A large, tan, hard mass that effaced endoturbinate III, the middle conchae (endoturbinate II) and the sphenopalatine sinuses bilaterally was noted to be arising from the sphenoid bone (**Fig 7**). The mass invaded the cranioventral cranium elevating the ventromedial aspect of the left orbit. The sphenopalatine sinuses were markedly reduced and filled with a moderate amount of purulent exudate. The most caudal aspect of the dorsal conchae were bilaterally, markedly firm and thick with prominent vasculature.

Histopathology of the mass revealed a locally invasive and extensive proliferation of many irregular woven bone trabeculae lined with osteoblasts within a fibrous stroma, consistent with an ossifying fibroma. Axonal degeneration with digestion chambers and infiltration of gitter cells were noted within the optic nerves, optic chiasm and optic tracts, compatible with the neurological deficits noted clinically.

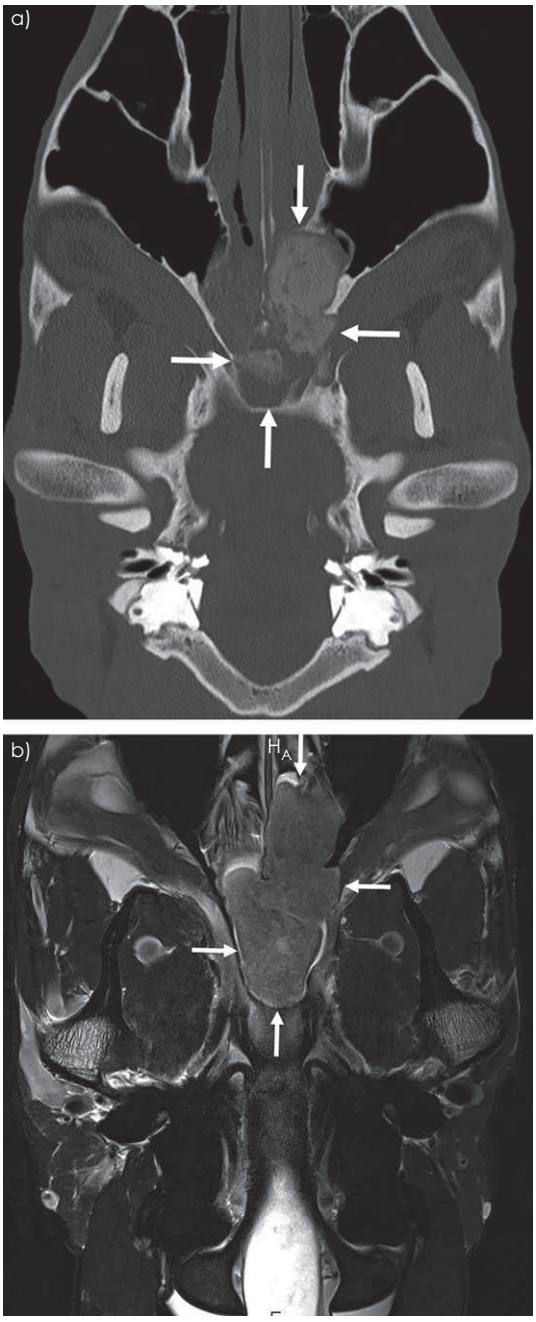

Fig 2: Dorsal plane reformatted CT a) and dorsal plane T2-weighted MRI b) images of the mass within the right and left sphenopalatine sinuses (arrows) with destruction of the ethmoid turbinates on the left side. Left is to the right of the images.

Histopathology of the remainder of the visual pathway was not performed. A secondary sinusitis of the sphenopalatine sinuses was confirmed.

Discussion

Ossifying fibroma (OF) is an uncommon tumour that most commonly presents in the rostral mandible of young horses. This presentation is typically classified as equine juvenile ossifying fibroma (EJOF) (Morse *et al.* 1988). A similar syndrome, seen in human subjects, is juvenile ossifying

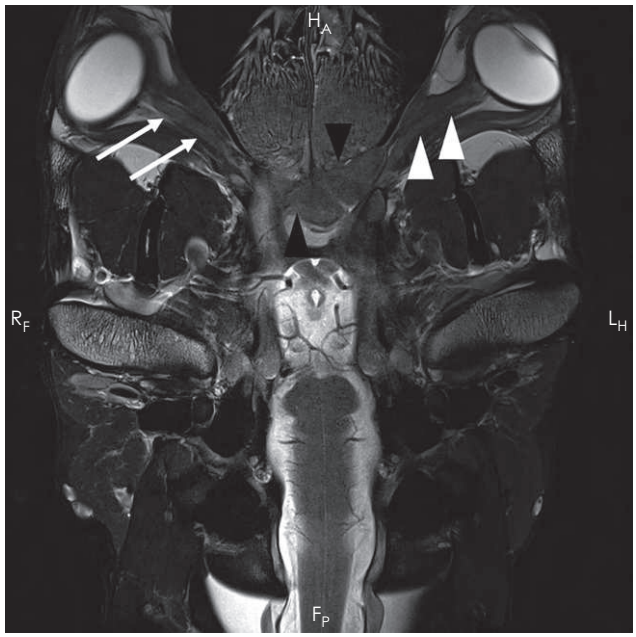

Fig 3: A dorsal plane T2-weighted MRI image demonstrating the difference between the left and right optic nerves. The right optic nerve (white arrows) is normal in size and shape. The left optic nerve (white arrowheads) is small and poorly defined due to degeneration secondary to compression caused by the mass (black arrowheads). Left is to the right of the image.

fibroma (JOF), with a heterogeneous, benign fibro-osseous tumour of the craniofacial skeleton being the most common presentation (Han *et al.* 2016). As in horses, the most common presentation of JOF is in the maxilla and mandible, with other areas including the orbital bones and paranasal sinuses, and less commonly the skull (Han *et al.* 2016). In human medicine, there are several reports of ossifying fibromas in the skull with reports of proptosis and hypertelorism in one patient and a complaint of central blindness in another (Bohn *et al.* 2011; Nakajima *et al.* 2013).

Ossifying fibroma must also be differentiated from other morphologically similar lesions that can occur in horses, including osteoma, fibrous dysplasia and osteosarcoma. Osteomas tend to arise as solitary outgrowths from the surface of a bone, and like OFs, are composed primarily of trabeculae of woven bone that are rimmed by osteoblasts (Thompson and Dittmer 2016). Fibrous dysplasia is a tumour-like lesion that arises within the bone and is characterised by an ample fibrous stroma that is devoid of osteoblasts, which both distinguishes it from OF and osteoma, and markedly reduces affected bone strength (Thompson and Dittmer 2016). In terms of prognosis, differentiating OF and osteosarcoma is perhaps the most important, and can be done based on the more developed bony trabeculae lined by a single layer of non-neoplastic osteoblasts, the overall lower cellularity, low mitotic index and lack of malignant features in OF (Thompson and Dittmer 2016).

Both EJOF and JOF have similar histopathological characteristics. These are described as dense fibroblastic stromas with isomorphic fibroblasts transforming into osteoblasts, proliferating fibroblast-like spindle cells with oval middle-sized nuclei and fusiform slightly basophilic cytoplasm with irregularly shaped osteoid spicules and woven bone

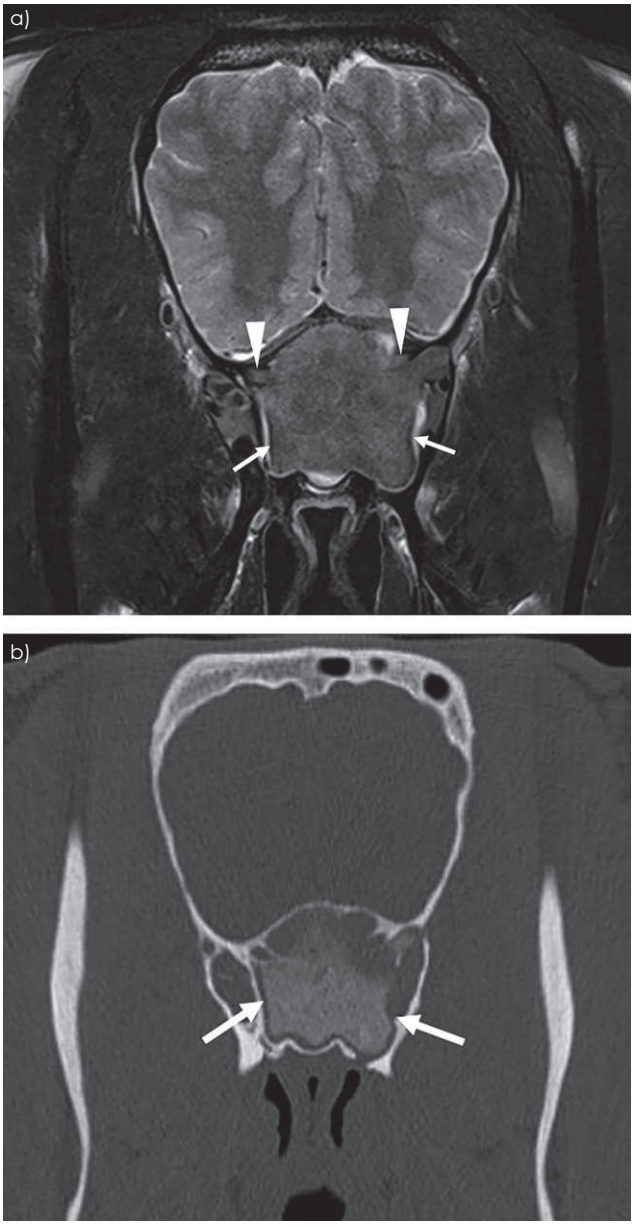

Fig 4: Transverse plane T2-weighted MRI a) and CT b) images of the mass within the right and left sphenopalatine sinuses (arrows). The mass was causing compression of the right and left optic nerves (arrowheads), which was more severe on the left. Left is to the right of the images.

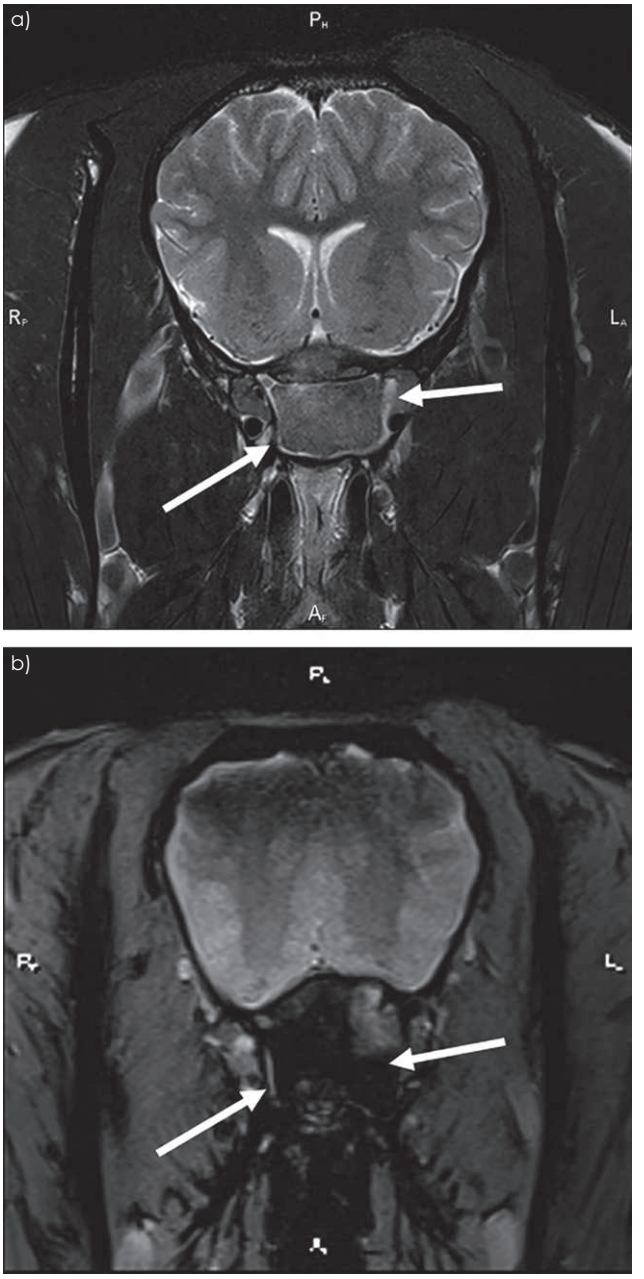

Fig 5: Transverse plane T2-weighted a) and T2 star-weighted b) MRI images. The mixed signal intensity mass is filling the right and left sphenopalatine sinuses (white arrows) and creating a large T2 star signal void due to the mineral component of the mass. Left is to the right of the images.

rimmed with osteoblasts (Morse *et al.* 1988; Kodaira *et al.* 2010). Histological differences in human subjects divide JOF into trabecular and psammomatoid OFs, with one having a higher predilection for jaw involvement and the other more commonly seen in the paranasal sinuses respectively (El-Mofty 2002). These lesions are histologically benign and locally aggressive with metastasis not reported.

In human subjects with OF, CT is the preferred imaging modality and typically reveals heterogeneous proliferation of dense calcified septa and flecks of bone (Mohsenifar *et al.* 2011; Cissell *et al.* 2012). MRI images of OFs have also been described in both human subjects and horses (Hoppe *et al.* 2003; Van Thielen *et al.* 2013; Ciniglio Appiani *et al.* 2015; Owosho *et al.* 2015; Salina *et al.* 2017). Lesions associated with OF are most commonly hypointense on T2-weighted images. Similar T2-hypointense lesions can be seen with lymphoma, melanoma and other sinonasal neoplasms, and is not distinctive to OF lesions. Causes of T2-hypointense signal features can be explained due to the low cellularity and high nucleocytoplasmic features of these neoplasms (Salina *et al.* 2017). Previously reported CT and MRI of an ex vivo mandibular EJOF in a 5-month-old Draught horse showed similar findings to those described in human subjects with a

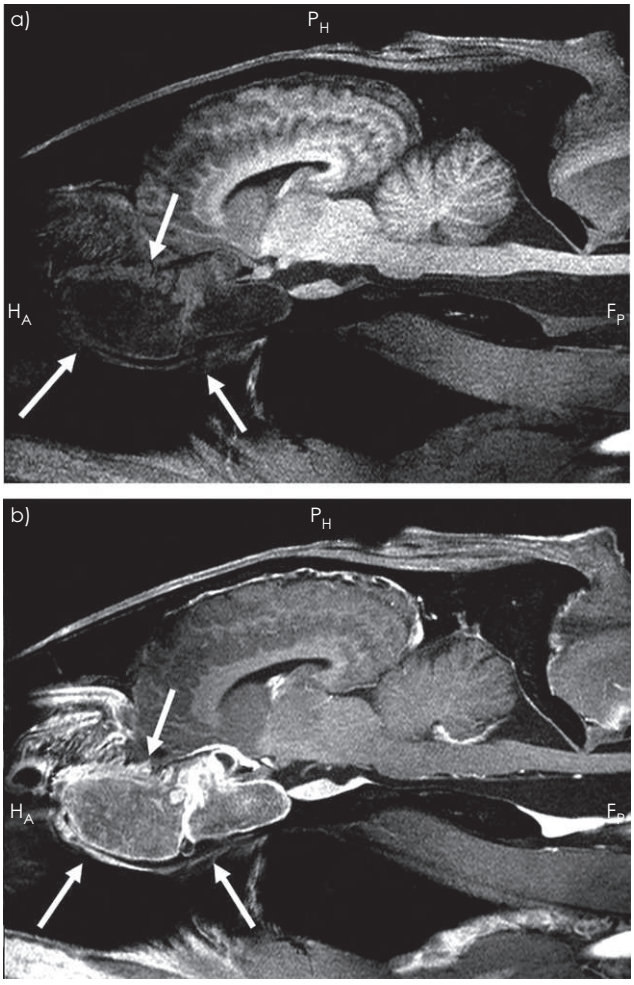

Fig 6: Sagittal plane T1-weighted MRI images both pre- a) and post-contrast b). The mixed signal intensity mass within the left sphenopalatine sinus (arrows) demonstrates heterogeneous contrast enhancement. Cranial is to the left.

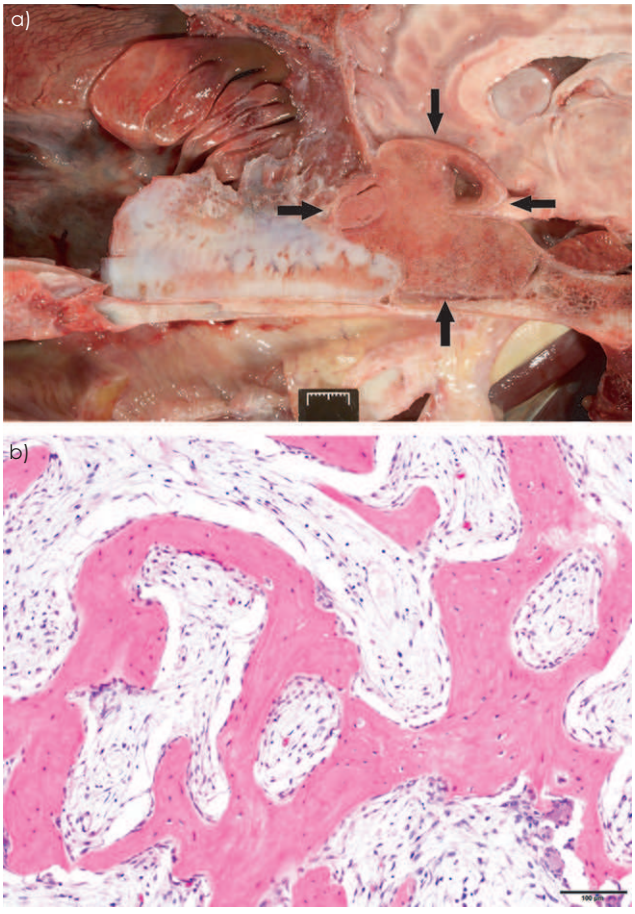

Fig 7: Gross a) sagittal image of the mass within the left sphenopalatine sinus (arrows). Histology b) of the mass showed many well-developed trabeculae of woven bone on a fibrous stroma, 10 ×, H&E.

medium intensity in all sequences and planes of MRI (Van Thielen *et al.* 2013). CT used in conjunction with MRI improves surgical planning due to its superiority in spatial relations of the mass as compared with the surrounding bone (Owosho *et al.* 2015). This is similar to the images noted in this case with both CT and MRI performed to better define the mass.

In this case, MRI was elected to further evaluate the visual pathway due to the localisation of clinical signs to the optic nerves. MRI has superior positional relationship in evaluating the optic pathway and would help evaluate any further cortical lesions that may present with similar clinical signs. Due to the detection and appearance of the mass on MRI and to explore the possibility of surgical excision, multidetector CT (MDCT) was subsequently performed for surgical planning given its superior spatial resolution and ability to evaluate bony structures as compared with MRI (Scrivani 2011). CT has previously been used to evaluate size of pituitary adenomas associated with pituitary pars intermedia dysfunction (PPID) in the horse (Pease *et al.* 2011; Madrigal *et al.* 2018). The combination of both imaging modalities was elected to give a better clinical picture prior to treatment decisions.

In human medicine, the most common treatment for OF is surgical excision, using CT and MRI for surgical planning, and is considered curative (Triantafillidou *et al.* 2012; Titinchi and Morkel 2016). Endoscopic resection of paranasal and skull base OF in human subjects has been performed with successful outcome and decreased recurrence (Zawadzka-Glos *et al.* 2011; Collin *et al.* 2014; Ye *et al.* 2017). Treatment options in horses have most commonly included surgical excision with mandibulectomy (Morse *et al.* 1988; Richardson *et al.* 1991; Kawcak *et al.* 1996; Lechartier *et al.* 2015). Newer therapy including radiotherapy and local chemotherapy is largely dependent upon the location of the mass (Robbins *et al.* 1996; Pellmann *et al.* 2002; Orsini *et al.* 2004; Strickler *et al.* 2017). Radiotherapy as an adjunctive therapy has been used successfully in two horses (Robbins *et al.* 1996; Orsini *et al.* 2004). One horse had previously undergone radiotherapy after surgical debulking of a paranasal OF with recurrence several years later (Orsini *et al.* 2004). For the horse in this report, due to the location of the mass, surgical debulking was not possible without great risk of complications. In addition, the large size of the mass and the presence of neurological deficits made radiotherapy unlikely to result in successful outcome with return to performance.

The presenting complaint of blindness in this case, makes this an unusual presentation of an ossifying fibroma. Other differentials for blindness may include infectious (Steckel *et al.* 1982; Barnett *et al.* 2008; Hart *et al.* 2008; MacKay 2014, 2015;

Furr 2015), parasitic migration (Bryant *et al.* 2006), brain abscess (Spoormakers *et al.* 2003), enlarged pituitary gland (Wallace *et al.* 1996), cholesterol granulomas (Tofflemire *et al.* 2013), neoplasia such as lymphoma (Roth and Siatkowski 2000; Sano *et al.* 2017), toxin or drug ingestion (Cymbaluk *et al.* 1978; Uhlinger 1991; Ross *et al.* 1993; Wilkins *et al.* 1994; Swor *et al.* 2009) and traumatic (Martin *et al.* 1986; Millichamp 1992; Matz *et al.* 1993; Reppas *et al.* 1995). Advanced imaging of the head would help further differentiate between these causes. Horses with neurological signs localised to the central nervous system should undergo advanced imaging to help further characterise the lesion.

In conclusion, this was an unusual case, given the presentation of acute blindness and the diagnosis of an OF in an atypical location.

Authors' declaration of interests

No conflicts of interest have been declared.

Ethical animal research

Client consent was obtained prior to treatment. No additional ethical review was required.

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None.

Authorship

All authors contributed to the case treatment, management, and/or preparation of the manuscript.

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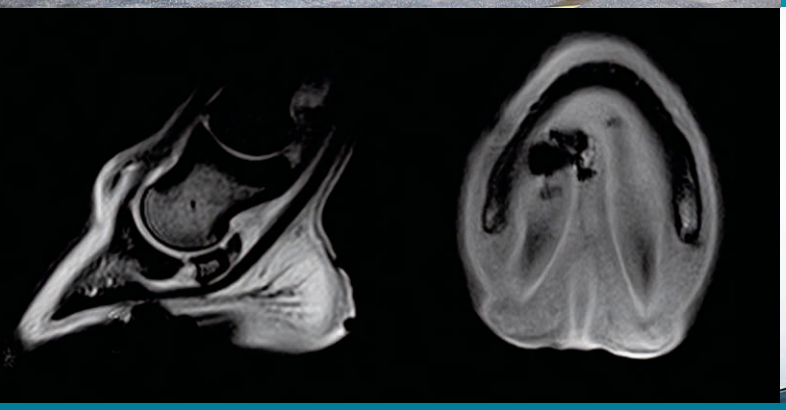

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Continued from page 116

contribute to undesirable outcomes can shift the emphasis away from blame to what can be improved. Advice about how to undertake clinical audits, including SEAs, can be found at https://knowledge.rcvs.org.uk/quality-improvement/. It is important for the mental health of the profession that we support colleagues and work in an open culture where mistakes can be acknowledged and discussed. The interesting article from Professor Albert Wu — Medical error: the second victim – (Wu 2000) discusses this in the human healthcare context. As Liam Donaldson, Chief Medical Officer for England at the time, said in 2004 'To err is human, to cover up is unforgiveable and to fail to learn is inexcusable'.

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Case Report

Abscessation following intralesional formalin treatment of congenital parotid salivary duct atresia

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Keywords: horse; 10% neutral-buffered formalin; parotid salivary gland; abscessation; congenital atresia

Summary

A 5-month-old colt with a history of nonpainful left-sided facial swelling present since birth was presented for evaluation and treatment. A diagnosis of congenital parotid salivary duct atresia was made, and surgical correction was attempted but was unsuccessful. Follow-up treatments consisted of repeat intralesional injection of 10% neutral-buffered formalin. The horse developed ventral mandibular abscessation with multiple draining tracts secondary to this treatment; however, no other significant complications occurred and a cosmetic outcome was achieved.

Introduction

Congenital atresia of the parotid salivary duct (termed Stensen's duct in the human literature) is a rare condition in the horse, with few reported cases (Fowler 1965; Talley *et al.* 1990; Sadler *et al.* 1999). The condition is also rarely reported in man, with suggestion of a heritable component (Lee *et al.* 2015; Wang *et al.* 2011; Yoruk *et al.* 2013). In some human cases, the condition occurs concurrently with other abnormalities of the first branchial arch (Almadori *et al.* 1997; Wiedemann 1997). Diagnosis of the condition is typically made by visual examination of a nonpainful tube-shaped swelling coursing along the ventral aspect of the mandible towards the base of the ear. Confirmation of parotid duct atresia may be made via fluid aspiration and analysis and contrast sialography (Sadler *et al.* 1999; Dixon and Gerard 2012). Fluid analysis typically reveals an alkaline substance (approximate pH 8) with low cellularity and a mucus-rich background (Fowler 1965; Talley *et al.* 1990; Sadler *et al.* 1999).

Previously reported treatment options for dilations of or injuries to the parotid salivary duct include surgical removal of the gland (Bracegirdle 1976; Peddie *et al.* 1971), surgical removal and proximal ligation of the duct (Sadler *et al.* 1999), ligation of the proximal duct without duct removal (Harvey 1977), surgical creation of a new opening for the duct into the mouth (Hurov 1961; Talley *et al.* 1990), and chemical ablation of the gland with 10% formalin, 2% chlorhexidine, 2–3% silver nitrate, or iodinated contrast (Watters and McGovern 1979; Schmotzer *et al.* 1991; Schumacher and Schumacher 1995). Intralesional formalin has also been used successfully for treatment of progressive ethmoid haematomas (Schumacher *et al.* 1998; Marriott *et al.* 1999), epidermal inclusion cysts (Frankeny 2003), and a subepiglottic cyst (Dougherty and Palmer 2008). Complications reported with use of intralesional formalin are uncommon but include the development of acute neurological symptoms necessitating euthanasia in two horses, both of which occurred after passage of formalin through the cribriform plate (Frees *et al.* 2001; Maischberger *et al.* 2014), and the development of transient laminitis symptoms in another (Schumacher *et al.* 1998). This report describes treatment of unilateral congenital parotid salivary duct atresia in a 5-month-old colt using 10% neutral-buffered formalin with the development of abscessation as a secondary complication.

Case history

A 5-month-old paint colt was presented to the Michigan State University Veterinary Teaching Hospital for evaluation and treatment of a large swelling on the ventral and lateral portions of the left mandible, present since birth. The horse had shown no signs of pain or discomfort on palpation of the mass at any time. The owner had reportedly aspirated clear fluid from the mass several times, draining the mass of almost all of the swelling; however, each time the swelling quickly returned. After multiple different attempts at draining the fluid, the owner aspirated purulent debris from the mass. The client's primary care veterinarian then examined the colt and recommended broad-spectrum antimicrobials and referral for additional diagnostics and treatment.

Clinical findings

On presentation, a large, fluid-filled tubular swelling was present on the left lateral and ventral mandible, beginning at the base of the ear and extending rostrally to the level of the second mandibular premolar (706) and ventrally beneath the body of the mandible. The location and shape of the swelling corresponded to the location and course of the parotid salivary gland and duct (**Fig 1**). Fluid was aspirated from the mass and submitted for cytology, which revealed a pale basophilic fluid of low-to-moderate cellularity and a mild macrophagic inflammation with evidence of pathologic haemorrhage; low numbers of mixed bacteria were present, consistent with the history of repeated attempts at drainage of the swelling by the owner. Radiographs of the region revealed multiple soft tissue opacities ventral to the mandible. Contrast sialography was not performed due to financial constraints. Based on history, location and character of the swelling, and fluid cytology, a tentative diagnosis of congenital left parotid salivary duct atresia was made. Potential treatment options discussed included surgical creation of a new duct opening into the mouth, removal and proximal ligation of the duct +/- parotid salivary gland removal, and chemical ablation. Surgical creation of a new gland opening was elected.

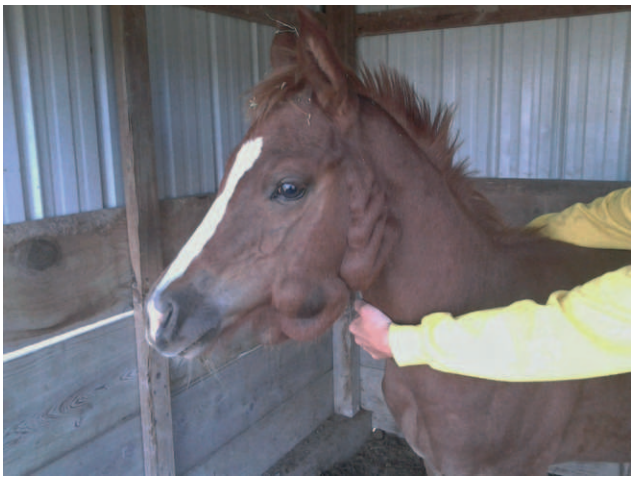

Fig 1: Image of the colt 1 week prior to presentation. A tortuous, tubular swelling is visible that corresponds to the approximate location of the parotid salivary gland and duct.

Treatment and follow-up care

Surgical creation of a buccal ostium for the duct was performed under general anaesthesia using a technique modelled after one previously used in a canine case (Hurov 1961). However, the opening quickly developed a stricture and became obstructed with scar tissue 1 week post surgery. A second surgery was not pursued due to financial limitations and low likelihood of success. The horse represented 10 days post surgery, and chemical ablation of the parotid gland and duct was elected as an alternative. The horse was sedated with 0.8 mg/kg bwt xylazine (Xylamax)[1] given i.v. once. Using 18 gauge needles placed at four separate locations, the majority of the fluid was drained from the swelling and 30 mL of 10% neutral-buffered formalin[2] was injected into the cavity representing the parotid duct and into the ventral parotid salivary gland. The horse was discharged with instructions to administer 2.2 mg/kg bwt phenylbutazone orally twice daily for 2 days and to monitor the injection sites for increased swelling and/or discharge. No increase in swelling or discharge was noted by the owner following the first injection. The horse's attitude and appetite remained normal.

The horse was presented for recheck 2 weeks post formalin injection. At this time, the tubular swelling had decreased slightly in size since the last visit. The horse was again sedated with 0.8 mg/kg bwt xylazine (Xylamax)[1] given i.v. once. Using two 18 gauge needles placed in the ventral parotid gland and one placed in the proximal duct, the majority of fluid was removed from the tubular swelling and 40 mL total of 10% neutral-buffered formalin[2] was injected. Fifteen mL was placed in each location in the ventral parotid gland and an additional 10 mL in the proximal duct. The colt was discharged with instructions to monitor the injection sites for increased swelling, discharge, and pain; no medications were prescribed. No complications were reported initially post injection; no change was noted in the size or shape of the tubular swelling for several weeks.

The colt was represented 6 weeks following his second injection for evaluation of two areas of drainage ventral to the mandible. On presentation, there were two small draining tracts on the ventral aspect of the mandible; the tissues surrounding these tracts were soft and sensitive to palpation. The locations of the draining tracts did not appear to be associated with previous injection sites. The tubular swellings in the locations of the parotid duct and gland had decreased in size by about 50% and were more firm on palpation than previously noted (**Fig 2a**,**b**). The horse was sedated with 0.8 mg/kg bwt xylazine (Xylamax)[1] given i.v. once and the ventral mandible was clipped and aseptically prepared. Haemostatic forceps were used to dilate the openings of the draining tracts to facilitate drainage of copious amounts of serosanguinous discharge and purulent debris. Carmalt forceps were inserted into the two openings and used to retrieve concretions of inspissated purulent material. Yellow–grey necrotic remnant tissue of what was presumed to be the parotid duct lining protruded from the openings in the draining tracts. Dilute povidone–iodine solution (final concentration approximately 0.25%) was then used to lavage both tracts. The patient was discharged with instructions for daily lavage of the draining tracts and trimethoprim and sulfadiazine powder (Uniprim[3]) prescribed empirically at a dose of 30 mg/kg bwt orally once daily for 10 days.

The patient was presented for re-evaluation 4 weeks later. The tubular swelling had improved dramatically, with only a small amount of firm swelling remaining ventrally. One small draining tract was still present; however, discharge from the tract was minimal. The colt was sedated with 0.8 mg/kg bwt xylazine (Xylamax)[1] i.v. once and Carmalt forceps were used to enlarge the remaining opening; a small volume of purulent discharge was expressed from the opening. The tract was lavaged with dilute povidone–iodine solution. The patient was discharged with instructions for continued monitoring of the site. Follow-up communication with the owner indicated that the minimal remaining drainage ceased and the tract healed completely over the next 2–3 weeks. The remaining firm swelling/thickening of the ventral mandible continued to remodel and decrease in size over the next 2 months. The colt was presented for recheck evaluation 3 months after his last visit (approximately 6 months following first formalin injection). At that time, all wounds were completely healed and the contour of the horse's mandible was normal (**Fig 3**). Follow-up communication with the owner for the next 3 years indicated that the horse has performed very well with an excellent cosmetic outcome and no further complications.

Discussion

The parotid salivary gland is the largest salivary gland in the horse; its location is bordered by the caudal border of the mandible, the base of the ear, the wing of the atlas and the linguofacial vein. The medial gland is adjacent to the maxillary vein, internal and external carotid arteries, and facial, glossopharyngeal, and hypoglossal nerves. Multiple radicles collect the secretions of this gland at its ventral aspect, and these unite to form the parotid duct. The normal course of the duct is alongside the facial artery and vein, coursing around the ventral curvature of the mandible and then extending laterally and dorsally to exit at its buccal ostium, located adjacent to the maxillary second or third (107, 108, 207, or 208) cheek tooth (Budras *et al.* 2009). Congenital atresia of the parotid duct rarely occurs in the horse, with three reported cases in the literature (Fowler 1965; Talley *et al.* 1990; Sadler *et al.* 1999).

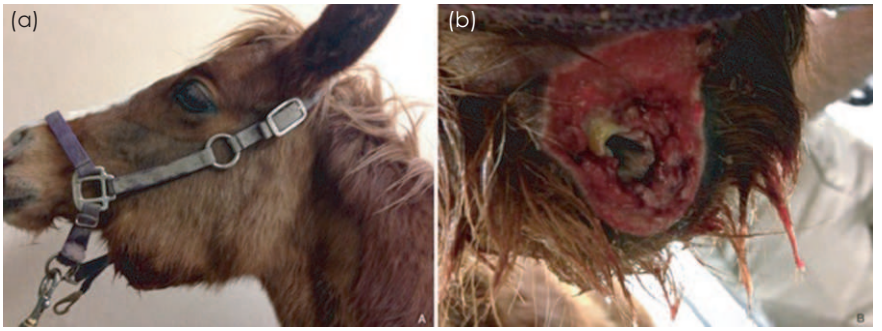

Fig 2: Visual appearance of the colt 6 weeks after the second formalin injection. Note (a) the ventrolateral swelling is still present but is much less defined and has decreased in size significantly. Granulation tissue is present on the ventral mandible associated with abscess drainage; necrotic remnant tissue from the parotid duct is visible in the centre of the granulation tissue (b).

Fig 3: Appearance of the colt 3 months after resolution of drainage from the ventral mandible. Cosmetic outcome was excellent.

Attempted treatments employed for previously reported cases of duct atresia included surgical resection of the duct with concurrent ligation of the radicles as they entered the gland (Sadler *et al.* 1999), surgical creation of a buccal stoma for the duct (Talley *et al.* 1990; unsuccessful in this case) and chemical destruction of the gland (Talley *et al.* 1990). Due to close proximity of neurovascular structures to the gland and difficulty of the procedure, surgical removal of the gland is typically not recommended (Schumacher and Schumacher 1995). Ligation of the duct may not reliably result in atrophy of the gland, particularly with long-standing distension (Talley *et al.* 1990). Creation of a new buccal ostium, whether for treatment of this condition or other obstructive conditions or fistulas of the parotid duct, is frequently unsuccessful due to stricture of the opening (Talley *et al.* 1990; Schumacher and Schumacher 1995). While preoperative radiographs and contrast sialography may aid in presurgical planning for some obstructive conditions or fistulas of the duct, it is unlikely to have changed the surgical approach and subsequent outcome for this case. Chemical ablation of the gland has been explored as a treatment option for multiple abnormalities affecting the parotid gland and duct and has been met with the fewest complications; it also represents a more economical and less invasive approach to treatment (Schmotzer *et al.* 1991; Schumacher and Schumacher 1995). Clinically, no long-term complications have been noted secondary to destruction of the parotid gland in the horse, likely because secretions from the remaining salivary glands are adequate to maintain normal function. While use of 2% to 3% silver nitrate, 2% chlorhexidine and 10% formalin have all been used successfully for chemical ablation of the parotid gland, formalin resulted in the fewest complications during and in the first 30 days post-treatment (Schmotzer *et al.* 1991). Lugol's iodine solution has been reported to successfully destroy the parotid gland as well, but caused severe swelling of the gland and secondary pharyngeal collapse (Frank 1964). Use of iodinated contrast sialography has also reportedly been followed by atrophy of the gland, with histological changes identical to those seen in formalin-treated glands (Schmotzer *et al.* 1991).

Intralesional formalin has also been employed with success for treatment of several other conditions in the horse, including progressive ethmoid haematomas (Schumacher *et al.* 1998; Marriott *et al.* 1999), epidermal inclusion cysts (Frankeny 2003), and one subepiglottic cyst (Dougherty and Palmer 2008). Rare complications reported with the use of formalin for treatment of progressive ethmoid haematoma included transient laminitis symptoms in one horse (Schumacher *et al.* 1998) and severe neurological symptoms secondary to a communication between the nasal cavity/ethmoid turbinates and cranial vault in another (Frees *et al.* 2001). Severe neurological symptoms have also been reported as a complication after intralesional formalin for treatment of an ethmoid adenocarcinoma in one horse, thought to be secondary to migration of formalin through an intact cribriform plate (Maischberger *et al.* 2014). The proposed mechanism of action of formalin is hydrolysis of protein resulting in tissue coagulation (Schumacher *et al.* 1998). Based on the above previous complications reported with use of intralesional formalin for other conditions, damage to adjacent neurovascular structures may be a potential risk associated with intralesional formalin injection for congenital parotid salivary duct atresia. However, no such complications were noted in this case.

While repeat injections of formalin have not been discussed previously for chemical ablation of the parotid salivary gland (reported cases have used only a single injection), repeat injections are frequently employed for the treatment of progressive ethmoid haematomas. A reliable expectation for the duration of time expected to result in chemical ablation of the parotid gland has not been

established. Schumacher *et al.* (1998) reported discontinuation of secretory activity of the gland in <21 days for all cases receiving an adequate injection volume; however, all horses treated with what the authors defined as an adequate volume of 10% neutral-buffered formalin in this study were clinically normal. Talley *et al.* (1990) reported that the horse was clinically normal 8 months post-injection; however, follow-up between 2 weeks post-injection and follow-up at 8 months was not discussed. In this case, we opted to repeat injection after 2 weeks. This decision was made based on chronicity and severity of swelling, as well as on the need for repeat injections when treating progressive ethmoid haematomas in the authors' experience. In addition, there was no change in the degree of tubular swelling in the 2-week period after the first injection.

Prior reports of formalin use for treatment of progressive ethmoid haematomas, epidermal inclusion cysts, subepiglottic cyst, and parotid gland chemical ablation have not reported abscessation as a complication. Development of abscessation in this case is presumed to be secondary to necrosis of the lining of the parotid duct. Repeated treatment, as well as the pre-existing bacterial infection noted before the horse initially presented, may have also predisposed this horse to abscessation. While this complication prolonged healing time, the patient did not exhibit fever, excessive pain, pharyngeal swelling, or a decrease in appetite throughout the treatment period. The cosmetic outcome of this case was excellent. Secondary abscessation should be considered a potential sequela to intralesional formalin for treatment of parotid salivary duct atresia and should be discussed with the client prior to treatment; however, this method should be regarded as a safe and effective treatment option.

Authors' declaration of interests

No conflict of interest have been declared.

Ethical animal research

The horse discussed in this case report was a client-owned animal. The owner gave consent for all treatments performed and for publication.

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None.

Authorship

Both authors provided substantial contribution to study design and execution via diagnostics, treatment planning, and treatment execution of this clinical case. Both authors also contributed to analysis and interpretation via evaluation of case progression and outcome. Both authors prepared and approved the final manuscript.

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Case Report

Treatment of a poorly differentiated sarcoma in the oropharynx of a horse

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Keywords: horse; sarcoma; leiomyosarcoma

Summary

A 10-year-old Thoroughbred mare presented for evaluation and treatment of a subepiglottic mass. Prior to admission the mare had been seen at another referral hospital where a laryngotomy was performed in an attempt to remove the mass but was unsuccessful. The mare had a history of making an abnormal respiratory noise, most noticeable when exercised with the head and neck in a flexed position. Resting endoscopic examination revealed a right-sided deviation of the epiglottis and elevation of the soft palate causing narrowing of the airway. A lateral radiographic projection of the head revealed a mass at the base of the epiglottis extending into the oropharynx. A full mouth speculum was applied and the scope was passed orally revealing the cranial pole of the mass (**Fig 1**). An endoscope was inserted through a previous laryngotomy site and the mass could be visualised ~15 cm oral to the site. A smooth, round, pale tan to flesh coloured, roughly 9 cm^3 soft tissue mass was identified in the oropharyngeal cavity with attachments to the soft palate, epiglottis, oral mucosa and tongue. The tumour was excised through the laryngotomy site using standing transendoscopic laser and sharp excision. Moderate haemorrhage impaired visualisation and two additional procedures were performed the following 2 days to achieve complete removal of the mass. Histopathological examination of the excised tissue revealed a poorly differentiated sarcoma with features of a leiomyosarcoma (**Fig 2**), a rarely identified neoplasm in the oropharynx of the horse. Follow-up endoscopic examination revealed a small defect on the right caudal free margin of the soft palate. The mare developed mild coughing, dysphagia and intermittent dorsal displacement of the soft palate (iDDSP) after surgery. There was no evidence of regrowth 8 months post operatively and the mare was able to resume full training. This case demonstrates some of the difficulties associated with the diagnosis and excision of locally invasive masses within the oropharynx.

Key points

- Leiomyosarcoma is a rare neoplasm of the oropharynx of the horse.
- Histological and immunohistochemical analysis can be used to guide treatment and prognosis of oropharyngeal masses.
- Treatment of oral and pharyngeal masses should be carefully selected based on histological analysis with special consideration for risk to upper airway function.

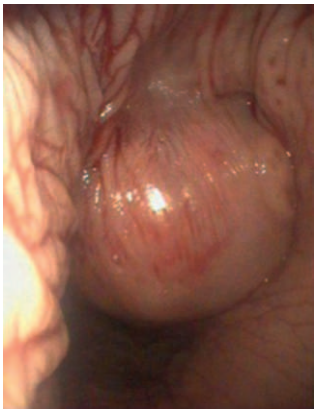

Fig 1: Preoperative endoscopic view of the oropharynx. The cranial pole of the subepiglottic mass can be easily identified.

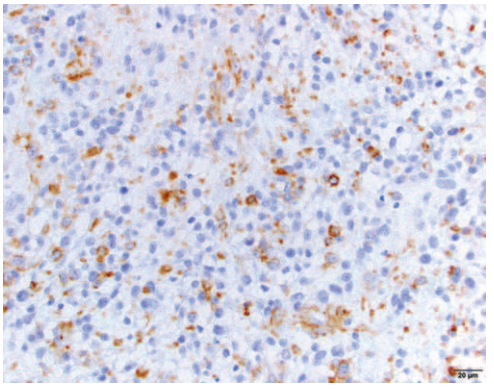

Fig 2: Immunohistochemistry for smooth muscle actin. Approximately 30–40% of the neoplastic cells have strong cytoplasmic immunoreactivity. DAB, 400 ×.

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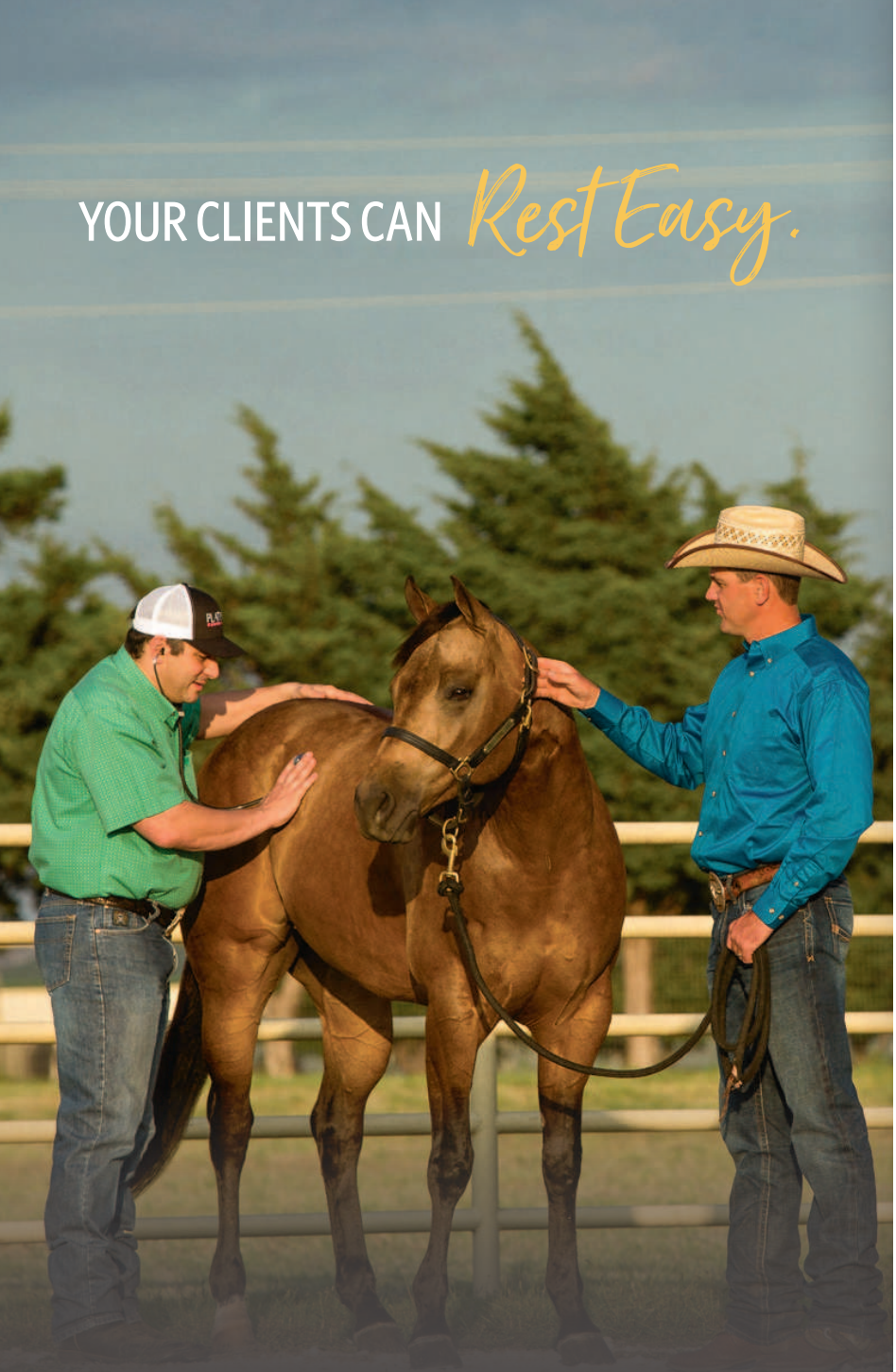

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Case Report

Long-term outcome of treatment of a squamous cell carcinoma of the foot by amputation of the distal limb in a pony

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Keywords: horse; foot; squamous cell carcinoma; neoplasia; amputation

Summary

This report describes a rare case of squamous cell carcinoma (SCC) in a 10-year-old Shetland pony. The pony was presented for evaluation of a chronic, ulcerating mass of the foot associated with a nonweightbearing lameness of the right forelimb. Foot radiographs revealed an aggressive bone lesion with severe osteolysis of the distal phalanx. Amputation of the digit was performed under general anaesthesia at the level of the metacarpophalangeal joint using a palmar flap technique and a transfixation cast for protection of the stump. Avascular necrosis, infection and dehiscence of the stump occurred 3 weeks later and a second amputation was performed at the level of the proximal third of the third metacarpal bone. Histopathology revealed a squamous cell carcinoma. After healing of the stump, a prosthesis was fitted to the limb for improved ambulation of the pony. Two years after the amputation, telephone follow-up with the referring veterinarian and the owner, revealed that the pony was healthy and able to go out daily in a paddock with its prosthesis. SCC represents an unusual indication for limb amputation. Successful outcome is rarely reported in horses.

Introduction

Squamous cell carcinoma (SCC) is one of the most common neoplasms in horses, that mostly affects ocular structures, the external genitalia and the gastric mucosa (Thomas *et al.* 2008; Taylor and Haldorson 2013). Neoplasia and tumour-like lesions involving the equine foot are rare, with the exception of keratomas (Honnas 1997; O'Grady and Horne 2001; Butler *et al.* 2008; Redding and O'Grady 2012). Of the few cases of digital neoplasia reported in the literature, melanoma was the most common (Honnas *et al.* 1990; Floyd 2003). Malignant glomus tumours, intraosseous epidermoid cysts and haemangiomas have also been reported to involve the foot (Gelatt *et al.* 1996; Fraser *et al.* 2006; Sanz *et al.* 2006; Brounts *et al.* 2008; Headley *et al.* 2009). SCC of the epidermal laminae has been reported in four horses (Henkels 1922; Barrett *et al.* 1964; Berry *et al.* 1991; Durham and Walmsley 1997). Three of them were subjected to euthanasia shortly after diagnosis. Amputation was performed in only one horse but the tumour recurred 3 months after surgery and the horse was also subjected to euthanasia eventually (Henkels 1922). Amputation has also been reported in a second case with melanoma but metastasis had already occurred proximally and the horse was euthanised shortly after surgery (Floyd 2003). This case report details the clinical, imaging, histopathological features, as well as the treatment and long-term outcome of a SCC of the epidermal laminae successfully treated by amputation.

Case history

A 10-year-old, grey, Shetland pony mare, weighing 136 kg, was presented at the Equine Referral Hospital with a chronic, nonweightbearing lameness of the right forelimb and a suspicion of digital neoplasia. The pony had a 3-year history of recurrent foot abscesses and had been treated for the first time by the referring veterinarian 1 year prior to presentation at the hospital. He had graded her right fore lameness as 4/5 on the AAEP lameness scale. A deep crack of the dorsal hoof wall, running from the solar margin up to the coronary band, had been noticed at the time. Radiographs had revealed moderate osteolysis of the distal aspect of distal phalanx. Exploration of the foot had revealed a hoof abscess that had been opened, curetted and drained. Although the pony had initially become sound after this treatment, several more episodes of solar abscessation had occurred and been treated each time with phenylbutazone, antibiotics and curettage over a period of 11 months. One month prior to presentation, the pony had become nonweightbearing lame and a discharging tract had appeared at the level of the coronary band. Further radiographs had revealed more severe osteolysis of the distal phalanx, leading to a suspicion of neoplasia. A dorsal hoof wall resection had been performed and the affected area of the distal phalanx had been debrided by the referring veterinarian, leaving a large, dorsal defect in the hoof capsule.

Clinical findings

On admission, the pony was nonweightbearing lame in the right forelimb. At rest, the pony held the limb slightly flexed with minimal weightbearing. An extensive defect in the dorsal hoof wall remained with a granulating, bleeding, ulcerated mass protruding from the exposed soft tissues of the hoof wall and the coronary band (**Fig 1**). The tissue was malodorous, and both painful and friable on palpation. There was marked swelling of the soft tissues in the pastern region. Radiographs revealed severe distortion of the hoof capsule, subluxation of the distal interphalangeal joint and absence of the dorsal two-thirds of the distal phalanx. Only the subchondral bone plate, the lateral palmar process and the extremity of the medial palmar process remained visible (**Fig 2**). In view of the destructive and invasive nature of the bone lesion and the external appearance of the soft tissue mass, a tentative

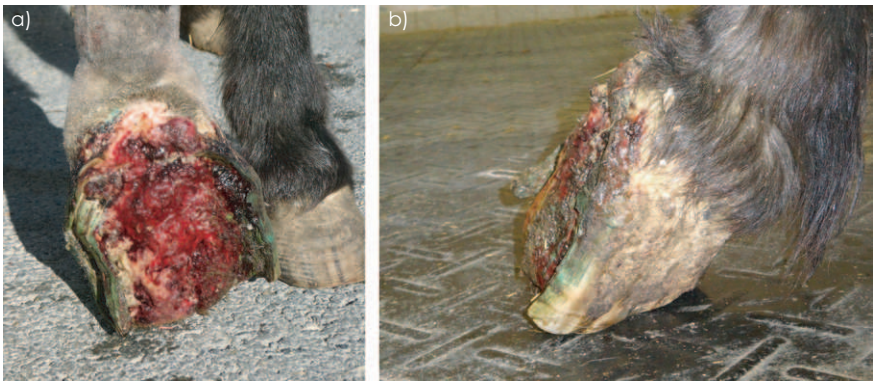

Fig 1: Dorsal (a) and medial (b) views of the right front foot showing a large granulating mass occupying a large dorsal hoof wall defect and extending proximally across the coronary band.

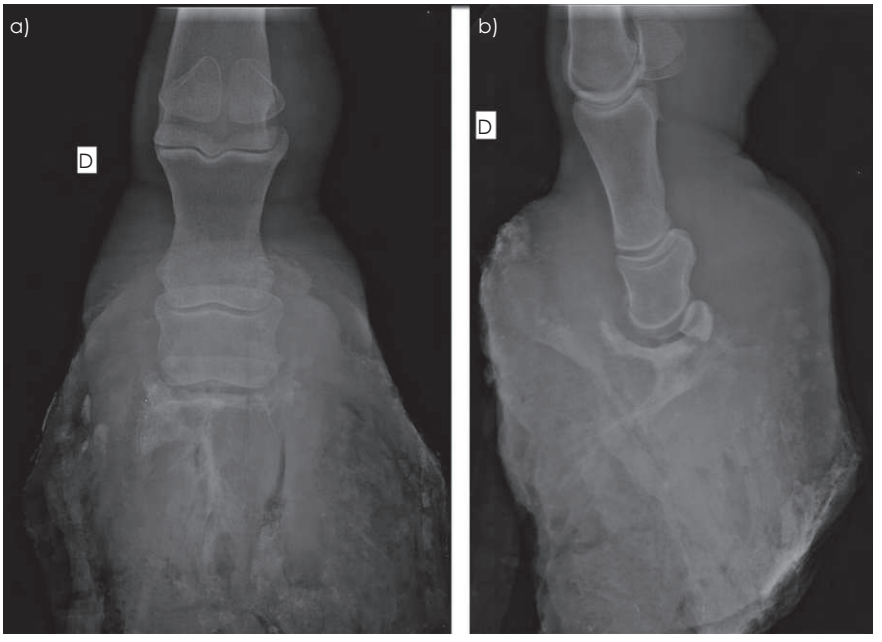

Fig 2: Dorsopalmar (a) and lateromedial (b) radiographic views of the right front foot showing severe osseous resorption of the distal phalanx along with marked distortion of the normal anatomy of the foot and pastern.

clinical diagnosis of neoplasia was made. The owner was informed that the only possible treatment would consist of amputation at the level of the metacarpophalangeal joint. However, the owner was also alerted to the need for lifelong, intensive and close supervision of the pony, including daily application and removal of a prosthesis and care of the amputation stump.

Surgery

Preoperative broad spectrum antibiotics (procaine benzylpenicillin [Depocilline] 22,000 UI/kg bwt i.m.[1] and gentamicin [G4] 6.6 mg/kg bwt i.v.[2]), NSAIDs (phenylbutazone [phenylarthrite] 4.4 mg/kg bwt i.v.[3]) and tetanus prophylaxis (serum antitétanique 300)[4] were administered. The pony was anaesthetised and positioned in dorsal recumbency with the right forelimb in extension, attached to a horizontal bar. A tourniquet was applied proximal to the carpus to minimise intraoperative haemorrhage. Neurectomy of the palmar nerves was performed at the level of transition between the middle and distal thirds of the third metacarpal bone, proximal to the fetlock joint, using the guillotine technique (Fürst and Lischer 2012). Two threaded 4.8 mm transfixation pins[5] were placed at 30° diverging angles in the distal third of the third metacarpal bone. Amputation was then performed at the level of the metacarpophalangeal joint (**Fig 3**). The joint was disarticulated and a palmar flap technique used to suture the tendons over the condyle to protect the stump, as previously described (Vlahos *et al.* 2010). A transfixation cast with an aluminium U-bar (**Fig 4**) was placed over the stump up to the distal carpus (Koger *et al.* 1970). Recovery from anaesthesia was assisted and uneventful and the pony started bearing some weight on the transfixation cast soon after surgery. However, she remained very lame, in spite of the

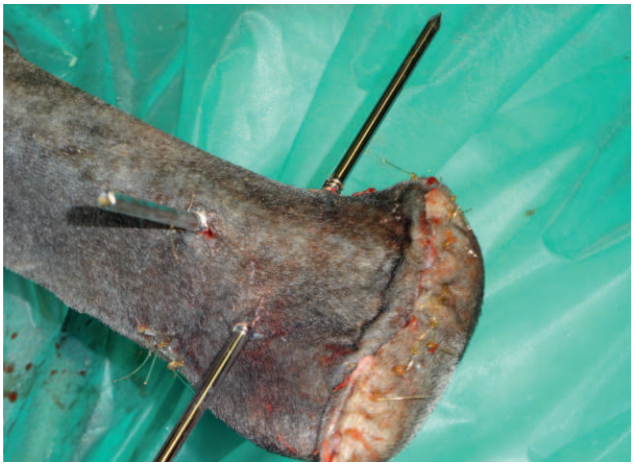

Fig 3: Amputation stump closed with a palmar flap technique over the distal end of the third metacarpal bone during the first amputation.

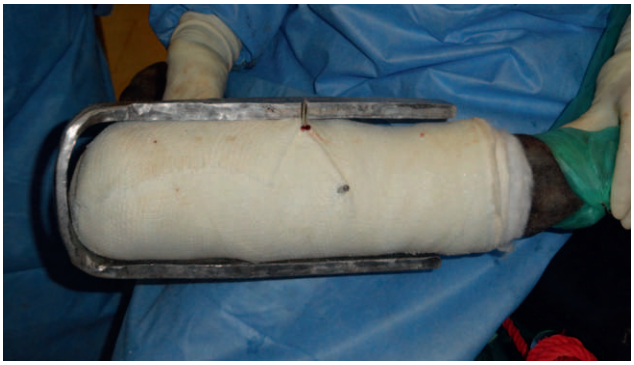

Fig 4: Aluminium U-bar incorporated in a transfixation fibreglass cast

administration of analgesic medication with NSAIDs (phenylbutazone 4.4 mg/kg bwt i.v. b.i.d. [phenylarthrite][3] for 12 days and then 2.2 mg/kg bwt per os b.i.d. [Equipalazone][6] , for 16 days) and morphine[7] (0.1 mg/kg bwt i.v. q. 4 h) for 4 days and then as necessary for the next 6 days. A 100 µg fentanyl patch (Durogesic patch)[8] was also applied for 3 days, starting 4 days after surgery and then discontinued. Antibiotics (procaine penicillin 22,000 UI/kg bwt i.m. b.i.d.[1] and gentamicin 6.6 mg/kg bwt i.v. s.i.d.[2]) were administered for 7 days and then replaced by oral trimethoprim-sulphamide administration (25 mg/kg bwt per os b.i.d. [Avenix][3]) for 2 weeks.

Radiographs of the stump in the cast were taken 3 days after surgery and did not reveal any abnormalities (**Fig 5a**). The pony became progressively more comfortable over the next 3 weeks. However, after 3 weeks she became suddenly nonweightbearing lame again in spite of continued stall confinement. Radiographs taken at this time revealed a small area of osteolysis in the subchondral bone of the medial condyle of the third metacarpal bone. There was severe swelling with areas of suspected gas opacity in the soft tissue covering the condyle, leading to the suspicion of wound dehiscence and infection (**Fig 5b**). No sign of fracture or pin breakage was identified.

It was decided to remove the cast because of the persistent discomfort and the suspicion of infection from the radiographs. The pony was again positioned in dorsal recumbency and the transfixation cast removed. Complete dehiscence of the suture line, extensive skin necrosis and profuse purulent discharge were observed. Osteomyelitis of the third metacarpal condyle was identified. It was decided to perform a second amputation 5 cm distal to the level of the carpo-metacarpal joint using the same 'palmar flap technique' as previously. Antibiotic administration consisted of trimethoprime-sulphamide (15 mg/kg bwt i.v. b.i.d. [Borgal][2] for 5 days followed by 25 mg/kg bwt per os b.i.d. [Duragesic patch][8] for 14 days). A heavy bandage with two long PVC gutter splints that extended from the level of the elbow to 30 cm distal to the level of the amputation, one dorsal and one caudal, was placed. The space between the stump and the distal end of the splints was filled with loosely packed cotton wool, thereby avoiding any pressure on the stump. Assisted recovery from general anaesthesia was again uneventful.

Histology

The neoplastic mass that had been removed during the first amputation was submitted for histology. Histological examination revealed the presence of a not capsulated, not demarcated moderately cellular tumour, highly infiltrating the connective tissue. The neoplasia was composed of islets of polygonal cells, with a squamous differentiation. At the periphery cells were moderate in size, with a moderate nucleo-cytoplasmic ratio. Cytoplasm was lightly eosinophilic and nucleus was round, centrally located, with dispersed chromatin. Toward the centre of the islets, cells increased in size, presented visible desmosomes, a more eosinophilic cytoplasm and a persistent, nucleus (dyskeratosis). Keratin lamellae were present in the centre. Anisocytosis and anisokaryosis were moderate, and a mitotic index of 2 in 2.37 mm^2 area was obtained. The connective tissue was moderately infiltrated by neutrophils, lymphocytes and plasma cells. The histological diagnosis was well differentiated and infiltrative SCC at the level of the germinal layer of the epidermal laminae of the hoof wall. The surgical margins were not infiltrated by tumoural cells and vascular emboli were not observed (**Fig 6**).

Post-operative management

After the second amputation, the pony remained very painful, lying down more than usual, with an elevated heart rate and only weightbearing sporadically on the splint, despite the use of 100-µg fentanyl patches[7] for 3 days followed by morphine[6] at 0.1 mg/kg bwt i.v. q.i.d. for 6 days and then i.m. q.i.d. for 3 days. After 12 days, she became gradually more comfortable again and started bearing more weight on the splinted limb. The bandage was changed and healing of the stump was evaluated daily. Two weeks after surgery, skin sutures were removed in spite of the presence of a small discharging sinus at the lateral margin of the suture line. A bacteriological sample was obtained for culture and sensitivity. *Proteus mirabilis* spp. was isolated from the sample and found to be resistant to trimethoprime-sulphonamide and therefore antibiotic treatment was discontinued. Radiographs revealed no further abnormalities at the cut

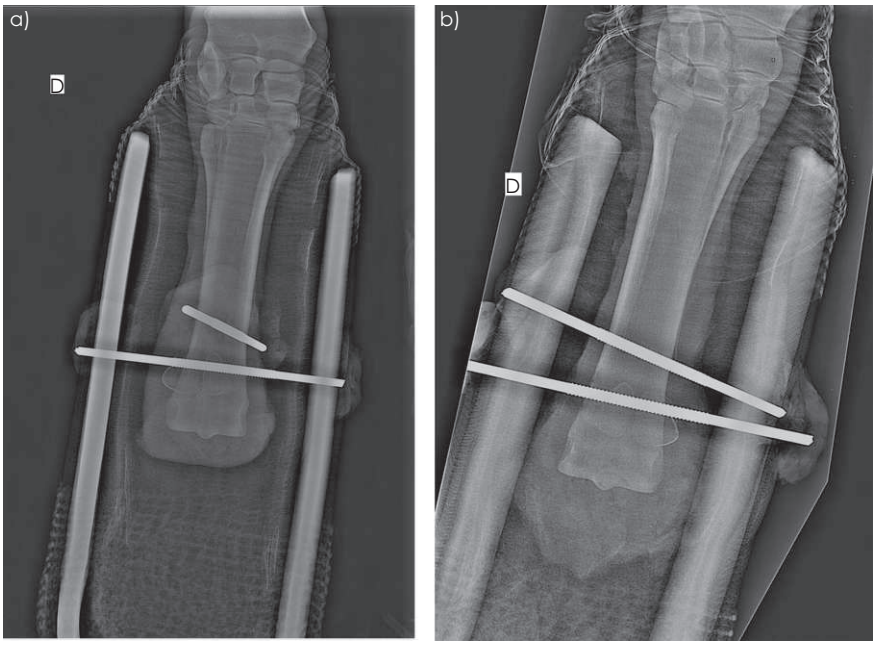

Fig 5: Dorsopalmar radiographic views of the stump through the fibreglass transfixation cast at 1 week (a) and 3 weeks (b) after amputation surgery. There is severe soft tissue swelling with irregular soft tissue opacity at the distal end of the stump.

bone surface. With daily bandage changes and cleaning of the skin with swabs and sterile saline, wound healing progressed uneventfully.

Prosthesis fitting and long-term follow-up

Eight weeks after the second surgery, a permanent prosthesis was fitted to the healed amputation stump. The stump was dressed with a custom-made neoprene sleeve (**Fig 7a**). The socket-type prosthesis used in this case consisted of a prosthetic cup made of hard, thermoplastic synthetic polymer with a stainless steel foot and a round rubber cover protecting the distal end of the stainless steel (**Fig 7b**). A padded, gel-based stump cover was placed into the prosthetic cup to provide a soft, nonabrasive contact surface for the skin at the distal end of the stump. Finding the correct size of prosthesis to fit the stump took several attempts. The first prosthesis created a small ulcer on the stump that was allowed to heal by reverting back to a splinted bandage to avoid any weightbearing on the stump. Once the skin ulcer had healed, a smaller prosthetic cup was chosen and this time the pony was comfortable and the skin on the distal end of the stump remained healthy for the remainder of the hospitalisation period. She was discharged from the hospital 1 month after the second surgery (8 weeks after first presentation), with instructions to remove the prosthesis and the sleeve every night when she came in to her stall and to evaluate the stump for any abnormalities.

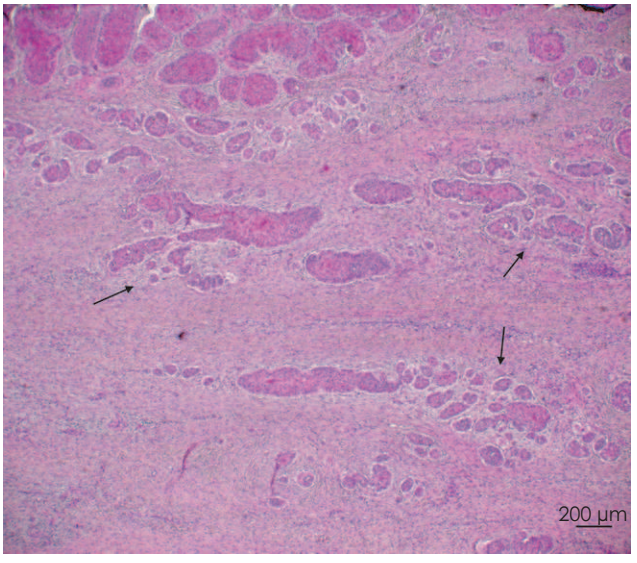

Fig 6: Histology feature showing a well differentiated and infiltrative SCC (Haematoxylin-eosin staining, ×5). Islets of polygonal epithelial cells infiltrating the connective tissue are visible (black arrows).

Nineteen months after surgery, a telephone interview with the referring veterinarian and the owner, as well as video recordings sent by the owner, revealed that the pony was able to go out into a paddock daily and remained comfortable even though small pressure sores continued to appear intermittently on the stump. The pony was putting full weight on the prosthesis when walking around her paddock and was even able to trot intermittently. Follow-up radiographs did not show any new bony abnormalities.

Discussion

Tumours of the foot have been reported infrequently in the horse. Clinical signs are very similar between different tumours. Typically, there is a history of recurrent abscess formation and intermittent mild to severe lameness despite treatment. Distortion of the hoof capsule is sometimes observed (Dyson 2011). Radiographic examination provides

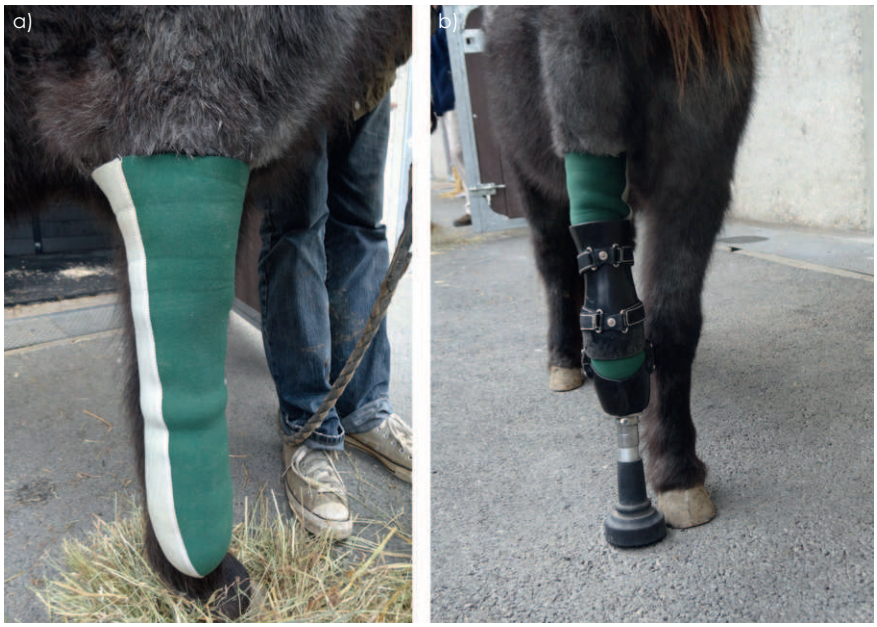

Fig 7: Placement of the permanent prosthesis: a neoprene sleeve is placed to protect the skin at the stump (a) and the prosthetic cup (b).

the basis for a diagnosis, even though the earliest changes associated with neoplasia of the foot can be easily missed. Typical signs are a smoothly demarcated radiolucent defect in the solar margin of the distal phalanx due to external pressure from the tumour on the dorsal aspect of the distal phalanx causing bone resorption (Gibbs 1994; Butler *et al.* 2008; Dyson 2011). Keratomas and other space-occupying non-neoplastic lesions usually result in a smooth and sharply delineated, radiolucent, semi-circular notch in the solar margin surrounded by a margin of sclerotic bone (Honnas 1997; Butler *et al.* 2008). Unlike the area of bone loss caused by neoplastic lesions, bone resorption caused by infection may present with more irregular margins and new bone formation (Dyson 2011). The difference between a space-occupying neoplastic mass of the hoof wall and septic osteitis may be less clear in the early stages of the disease, when the radiographic appearance may be similar for both (Dyson 2011). In our case, radiographs were performed only late during growth and expansion of the tumour, and showed severe osteolysis of the distal phalanx, which had largely disappeared due to the invasive character of the tumour. Therefore, radiographs suggested an aggressive soft tissue tumour of the foot.

Owing to the degree of tissue destruction in the foot, the size of the lesion, and the owner's unwillingness to consider euthanasia, amputation was elected as the primary treatment choice. The decision to amputate a horse's limb is a difficult one as it raises pertinent questions about the quality of life of the patient, and the need for round-the-clock care and dedication from the owner. Other factors to consider are the temperament of the horse, and the cost of the post-operative care and the prosthesis (Crawley *et al.* 1989; Kelmer *et al.* 2004).

Several injuries have been suggested in the literature as suitable candidates for distal limb amputations such as chronically painful septic joints, intractable osteomyelitis, open comminuted fractures and laminitis (Crawley *et al.* 1989; Vlahos *et al.* 2010). Neoplasia is an uncommon indication but has been reported at least twice (Henkels 1922; Floyd 2003) and should be considered before metastasis occurs. In previous reports, the most common reasons for failure were chronic complications such as osteomyelitis of the stump, cutaneous pressure sores from the prosthesis, catastrophic fracture of the third metacarpal or metatarsal bone during anaesthetic recovery, and contralateral limb failure (Koger *et al.* 1970; Nayak and Mohanty 1994; Floyd 2003; Kelmer *et al.* 2004; Vlahos and Redden 2005). Therefore, surgery must be performed before overload injury occurs in the contralateral limb (Crawley *et al.* 1989).

The determining factor for successful outcome of an amputation is the development of a healthy stump (Vlahos and Redden 2005). Direct weightbearing on the stump in the immediate post-operative period makes the management of the stump difficult and is associated with its failure (Kelmer *et al.* 2004; Vlahos and Redden 2005). Stump failure was the reason for a second amputation at a more proximal level in this report, as has been reported previously (Floyd 2003; Vlahos and Redden 2005). The level at which a limb should be amputated is controversial. Prostheses are usually easier to apply and maintain on the distal limb than on the carpus or the hock because of their mobility. More distal amputations are also less likely to result in severe pressure sores (Nayak and Mohanty 1994; Vlahos and Redden 2005; Desrochers *et al.* 2014). Therefore, it has been recommended to perform the amputation as distal as possible for improved post-operative stump management (Vlahos and Redden 2005).

In our case, a distal amputation site through the distal or proximal interphalangeal joint with transposition of tissue from the frog to provide a stronger bearing surface under the stump (Vlahos and Redden 2005), was not considered possible because of the severe soft tissue destruction, the size of mass and the need for clean excision margins. Therefore, amputation was performed by disarticulating the metacarpophalangeal joint. Disarticulation is preferred over amputation through a diaphysis to provide a wider surface

for weightbearing on the prosthesis (Nayak and Mohanty 1995; Vlahos and Redden 2005; Desrochers *et al.* 2014). Other proffered advantages of disarticulation have been reduced haemorrhage, and faster soft tissue healing with less risk of dehiscence because of the absence of sharp bone margins (Desrochers *et al.* 2014). A diaphyseal amputation site has been proposed by others, however, who appear to prefer amputation at the level of the proximal third of the third metacarpal or metatarsal bone (Crawley *et al.* 1989; Kelmer *et al.* 2004). We wonder if amputation by disarticulation, despite proper cartilage curettage and synovial membrane removal, may not be more prone to wound dehiscence and infection. The dense subchondral bone does not provide access to vascular ingrowth from deeper cancellous bone and this may contribute to poor vascularity of the tendons and skin of the palmar tissue flap that is sutured over the osseous stump. The potential persistence of synovial tissue at the disarticulation site can lead to fistula formation. Dehiscence and stump infection may follow (Vlahos and Redden 2005). No matter where the leg is amputated, however, the nutrient artery should be preserved (Vlahos *et al.* 2010) and the healing process may be protracted.

The use of a transfixation pin cast is also somewhat controversial (Vlahos *et al.* 2010). The presence of transfixation pins at the amputation stump may increase the risk of contamination, wound infection and dehiscence, osteomyelitis, bone fracture and pin breakage. We managed the second stump without transfixation pins and cast, but with a heavy bandage with two long, rigid PVC splints up to the axillary region, thereby mimicking somewhat the effect of a Thomas Splint. It allowed us to change the bandage and clean and dress the stump more regularly than with a cast. It also prevented any direct pressure of weightbearing on the stump. These factors may have allowed better stump healing. A real Thomas splint might have been preferable to a transfixation cast with a U-bar to reduce the risk of stump healing complications before placement of a permanent prosthesis, unfortunately none was available at the time of hospitalisation (Ladefoged *et al.* 2017).

Previous reports on fitting prosthetics to horses have mentioned the complications of pressure sores as a potential long-term problem (Vlahos and Redden 2005). The small weight of the pony in this report was probably a positive factor in the avoidance of this complication and in the positive outcome.

In previous reports, 9/18 horses survived at least 18 months after amputation (Crawley *et al.* 1989) and 8/26 survived more than 24 months (Vlahos and Redden 2005), but none underwent amputation for the treatment of neoplasia. In this report, the pony is still alive at the time of follow-up 26 months after surgery with no signs of recurrence or complication due to the amputation.

Authors' declaration of interests

No conflicts of interest have been declared.

Ethical animal research

The client-owned animal was treated by amputation after informing the client of inherent risks. The client consented to surgery and histopathological diagnosis of tissue recovered from the animal. This case study was retrospective in nature.

Source of funding

None.

Antimicrobial stewardship policy

The horse described in the manuscript was not given any quinolones, extended spectrum beta-lactam antimicrobials or macrolides, nor does this study aim to investigate any aspect of these drugs.

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Authorship

M. Schramme was the primary clinician on the case and the faculty surgeon overseeing the case. I. François and N. Moulin were the surgical residents involved in the case evaluation and the surgical and post-operative care of the patient. S. Belluco was in charge of the histology analysis. N. Moulin and M. Schramme were responsible for the preparation of the manuscript. All authors approved the final version of the manuscript.

Manufacturers' addresses

[1]Intervet MSD santé animal, 49071 Beaucouze, France.
[2]Virbac, 06510 Carros, France.
[3]Vetoquinol, 70200 Lure, France.
[4]Merial, 69007 Lyon, France.
[5]Imex Veterinary Inc., Longview, Texas, 75604 USA.
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Clinical Commentary

Amputation of a limb and use of a prosthesis in horses

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In this issue, Moulin *et al.* (2020) report on the amputation of a distal forelimb and fitting of a prosthesis to a Shetland pony, as treatment for a squamous cell carcinoma.

Limb amputation in equines is still comparatively unusual, although the first reported was carried out over four decades ago by Barrie Grant in the USA, and many more have been carried out by several veterinary surgeons since. A quick search of the internet will reveal many members of the public and the veterinary profession expressing outrage at reports of prosthetic limbs being fitted to horses, but are they perhaps reacting to a perceived idea, and not expressing a fully informed and fully thought out opinion? Are they seeing the horse purely as a 'working' animal, valued as such, and not considering it as a sentient being or someone's pet?

Amputation and fitting of prosthetics is of course well established as a procedure in many species. The first such case in man must be lost in the mists of time but what self-respecting pirate would say no a wooden leg? More recently at the end of the 18th century, there was a report in The Veterinarian (the old UK veterinary journal, not the current Australian version) which reported on the fitting of a prosthetic limb to a cow – unfortunately the senior author of this commentary (C.M.C.) has mislaid the reference and searching for an article of this date means sitting in a library, and reading through each and every copy of the journal, the idea of indexes, let alone references was still some way away. The report was quite sketchy on detail and gave no information on 'long-term' follow-up, but the attempt to save a three-legged cow was made at least 150 years ago.

Of course no one today thinks twice about whether or not humans should have prosthetic limbs – the surgery and science have progressed to the point where athletes with prosthetic limbs can literally leave the rest of us standing, as they vie to compete with whole-bodied Olympians. Amputation of limbs in dogs and cats has been carried out for a number of conditions ranging from osteosarcoma, to road accidents, for many years. I think few vets would query this as a valid and justifiable treatment for life-threatening conditions in these species. Their size of course is an advantage, as they manage well on three legs, to the extent that many sheepdogs have continued to work after such surgery.

So if this treatment has become accepted if not totally routine in dogs, why not the horse? Size of course is a complicating problem and the fact that horses do require support at each corner, whereas many dogs can manage well on three legs. The patient described, however, was little bigger than a dog, in fact probably smaller than some! The tumour involved had already resulted in severe remodelling and loss of the pedal bone, to the extent that other treatments were not practical. With respect to Shetland ponies, many are pets rather than working horses, so why not apply a treatment that would be standard in other pet species? From the report, both patient and owner seem happy with the outcome 2 years after surgery.

So if we look at the subject of prosthetics in horses logically, if we can give the patient quality of life, and the owner is prepared to pay the bill and provide the aftercare, why should we not feel this to be a valued treatment? Vlahos *et al.* (2010) reported on the results of amputation in 34 cases. Twenty-two of these were successful and were followed up at 6 months post surgery. Of these, 15 were potentially valuable from a breeding perspective, but seven were of 'sentimental' value only. Perhaps the figures look a little gloomy? The mean survival time was 31 months post surgery, which may seem short. However, the first author when following up on several series of cases of competitive horses he has treated for different problems has found the average time for continuing to compete post treatment for most conditions averaged about 18 months, before some other problem arose. When first started, many treatments have relatively poor outcomes, but improve with experience. The first transplants in humans were comparatively short-lived, but now they are regarded almost as routine, and few question their value.

One of the writers (C.M.C. – assisted by K.C.) carried out what was probably the first successful equine limb amputation in Europe at the turn of this century, but only after considerable sole searching and long discussion with Barrie Grant and the owner. There are many factors that must be considered before embarking on this line of treatment. Firstly, has the horse the potential to live a pain-free 'happy' existence if treatment is successful? If it is already arthritic or has other chronic problems, then amputation and fitting of a prosthetic limb should not even be considered. If required as a working animal, this is not a suitable treatment option; but if a 'pet' horse, or if there is breeding potential, then further considerations need to be made before a decision is taken.

Long-term, prosthetic limbs require a lot of care and attention on at least a daily basis and the horse would need to be of a suitable temperament to accept this. The limb stump requires daily cleaning, drying and repositioning of the prosthesis. The horse will need to be stabilised during this process, in our case a padded rest was made for the horse to use to balance on whilst the prosthesis was cleaned. It is essential that the horse has the correct temperament, and the owner is willing and able to take on such a commitment, 365 days a year. There is also the matter of expenses in both veterinary fees and maintenance/replacement of prosthetics and bandages. With time not only do the prosthetics wear, but the limb stumps also change shape, so it is not a case of one prosthetic lasting for life, and they do not come cheap! The stump will be at risk of developing pressure sores, even when correct care of the stump is provided; dependent on size of patient. The weight borne by tissues not developed for this purpose will almost inevitably lead to areas of pressure

necrosis of underlying tissues, both in the initial healing period and on an ongoing basis. This can lead to necrotic tissue on the stump and subsequent systemic infection. In our experience, these were controllable but led to periods of pain and discomfort and required management; ranging from simple lavage to vacuum dressings and systemic antimicrobials combined with pain relief as required.

In cases with chronic lameness developing prior to surgery, the horse gradually becomes familiar with one limb being 'sub-standard' and adjusts to favouring this limb. This is a help once the limb has been amputated, as the horse is already used to adapting its gait. The cause of lameness however is also relevant. In the case of Moulin *et al.* (2020), there was a local source of bone degeneration. Any infection was presumably secondary. The case the authors of this commentary dealt with had progressing ischaemic necrosis due to thrombosis of the digital arteries, leading to a slowly progressive lameness. The authors are aware of two cases with chronic infectious osteomyelitis, which could not be controlled prior to, or post surgery, with resultant bone necrosis. This may be a contraindication for this treatment.

If the owner, horse, and finances are conducive to this treatment; a committed team is needed, not so much for surgery which is relatively straightforward, but for aftercare, especially in the initial phase. The size of the patient is crucial, smaller and lighter patients have a better chance of success and minimising stump complications. If the patient exceeds 500 kg, problems become far more serious. Problems arise as soon as surgery is complete. The surgical stump cannot take weight successfully until it is healed, requiring support before a prosthesis can be fitted. Recovery involves standing without any pressure on the surgical site. Some surgeons have used pins through the bone immediately proximal to the surgical site to transfer weight to a temporary prostheses. The writer used a steel cage splint, well-padded to transfer the load from the carpus and upper metacarpus. Some surgeons have recommended the use of slings for recovery. However it is achieved, recovery is a difficult time, and the horse's temperament plays a vital part in the outcome. Then, the horse must still be supported for several weeks whilst the surgical site heals, a prosthesis may then be fitted, but the stump will shrink, and change shape over the ensuing weeks. It is essential that the socket on the prosthesis should fit well, or sores from rubbing will occur. The socket also needs remarkable properties of give and resilience if it is to carry the loads without causing pressure sores. The project will suffer unless you have someone who is dedicated to make the prosthesis.

Whilst the immediate reaction to the thought of limb amputation and prosthesis in a horse may be negative, it is worth thinking the case through. In our single case, the last but one visit to our patient was in summer, when owner and horse were happily picking blackberries from the hedge rows. Our final visit some 5 years after surgery was to diagnose a fractured pelvis after he had fallen on a concrete ramp. Even the most optimistic of owners realised he needed more than one good leg to stand on!

In summary, if amputation is to be considered a dedicated owner and team of professionals is required and a very amenably tempered patient is essential. The owner must realise the best outcome is for a comfortable pet or breeding animal, and that constant 24 h care will be needed throughout its remaining life.

Authors' declaration of interests

No conflicts of interest have been declared.

Ethical animal research

Not applicable.

Authorship

Both authors contributed to this manuscript.

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Original Article

Correlation of epiploic foramen length to height, weight, breed, gender and age in horses

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Summary

Epiploic foramen entrapment (EFE) is one of the most common causes of small intestinal strangulation in horses. Cribbing and previous episodes of colic are suggested as risk factors for its occurrence. The aim of this study was to correlate the height, weight, breed, gender and age to the epiploic foramen (EF) length. Forty-three horses were submitted to post-mortem measurement of epiploic foramen with abdominal and thoracic organs positioned in situ. After data collection, linear regression between EF length and the explanatory variables was performed. None of the post-mortem physical variables was associated with EF length, supporting the hypothesis that there is no association between EF length and age, and that increased intra-abdominal pressure is the most important factor predisposing to EFE recurrence.

Introduction

Epiploic foramen entrapment (EFE) is the second most common strangulating intestinal injury in horses undergoing laparotomy and has been reported in 5–7.7% of all surgical cases, 14–19% of all small intestinal injuries and 2.1–8.4% of all colics (Archer *et al.* 2004a,b; Freeman 2012).

The epiploic foramen (EF) is a 4–6 cm length space situated in the right craniodorsal abdominal region, limited by important anatomic structures, such as the pancreas, liver, portal and caudal cava veins, stomach and duodenum (Freeman and Pearn 2015; van Bergen *et al.* 2015). The foramen connects the omental bursa to the peritoneal cavity (Vachon and Fischer 1995; Schmid 1997; Mueller *et al.* 2008; Freeman 2012; Freeman and Pearn 2015).

The occurrence of EFE has previously been related to increasing age, based on the association between advanced age and right hepatic lobe atrophy, which could lead to a greater length of the EF, increasing the probability of EFE (Wheat 1972; Livesey *et al.* 1991; Engelbert *et al.* 1993). However, this theory was not corroborated by subsequent studies (Schmid 1997; Freeman and Schaeffer 2001; Archer *et al.* 2004b; Kilcoyne *et al.* 2016).

The aim of this study was to correlate the post-mortem EF length to age, breed, gender, weight and height. The identification and correlation of these individual features to this condition could provide evidence to its probable causes, severity of strangulation, and also substantiate preventive strategies.

Materials and methods

Specific owner ethical consent for the cadaver component was not obtained, although all owners were informed about this research project and given the option to exclude the patients from post-mortem studies.

Post-mortem evaluation was performed in 43 horses forwarded to the pathology department between 2014 and 2016 at the Veterinary Hospital. The cause of the death was not colic caused by EFE. Horses under 2 years of age were excluded from the study to reduce the effect of growth on their height, which could confound the association between height and foramen length.

Data collection including age, breed, gender, weight, height, EF length and cause of death was performed. Forty-three horses were included in this study, including 20 Quarter Horses, 18 of mixed breed and five of other breeds (two Mangalarga Paulista, one American Trotter, one Criollo and one Lusitano). There were 19 geldings and 24 mares, presenting mean age of 11.3 ± 7.02 years, mean body weight of 378 ± 76.9 kg and mean height of 159.2 ± 8.7 cm.

The height was measured with a measuring tape, taking the distance between the distal hoof wall and the wither. The age indicated in the patient record was confirmed by teeth-based age estimation.

Post-mortem evaluation was performed with all organs in situ, after removal of the costal arch and abdominal wall, with the horse placed in left lateral recumbency. The right dorsolateral abdominal quadrant was accessed and, after identifying the duodenum and the caudate lobe of the liver, the measurements were performed using a stiff ruler marked in centimetres (**Fig 1**), positioned over the hepatic caudate lobe, so that the scale was kept in direct contact with the foramen borders. All measurements were made by two authors, taking the average as the final length. The limits of the measurements were considered at the points where the gastropancreatic fold attaches, cranially and caudally, to the caudate hepatic lobe.

Initially, the distribution of the epiploic foramen length was analysed and descriptive statistics were produced accordingly. Linear regression models (PROC GLM[1]) were constructed to assess the association between the length of the epiploic foramen (cm) (outcome variable) and weight (kg), height (cm) (continuous variables), gender, different categories of age (2–8, 8–14 and ≥14-years) and breed (categorical variables). Quadratic terms were also included in the models but none remained as significant. The Tukey's test was used to adjust the P-value when multiple

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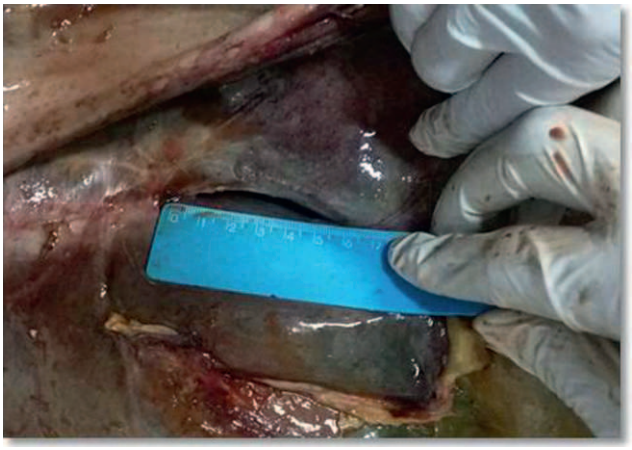

Fig 1: Post-mortem EF measurement using a stiff ruler graded in centimetres.

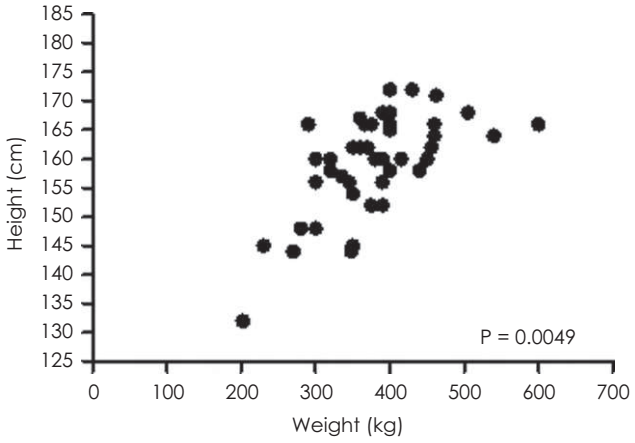

Fig 2: Correlation between horse height and body weight.

comparisons were made. All analyses were performed at a significance level of 0.05.

Results and discussion

There was no correlation between EF length and the categorical variables gender, breed or age (**Table 1**).

A positive correlation was found between height and weight (**Fig 2**). Thus, the taller horses were also the heavier ones, minimising the probability of misinterpretation of the results due to abnormal physical features. Individually, every continuous variable was associated with EF length (**Fig 3**).

The absence of correlation between height and EF length does not agree with the results reported by Archer *et al.* (2008), which demonstrated a greater risk of EFE in taller horses, describing an increase on the EFE risk of 1.05 time for each additional centimetre of height.

In the present study, we used a sample mostly comprised of Quarter Horses and there was no correlation between height and EF length. Although previous studies did not investigate this association, a positive correlation between height and EFE was reported in samples mostly comprised of Thoroughbreds. Although it is well described that Thoroughbreds are more susceptible to EFE (Vasey 1988; Vachon and Fischer 1995; Archer *et al.* 2004a), EFE occurrence could be more related to other causes, such as changes in intra-abdominal pressure, than the EF length. We suggest that the positive correlation between Thoroughbreds and EFE reported in previous studies might be due to the high prevalence of cribbing in this breed, since cribbing increases intra-abdominal pressure in horses (Wickens and Heleski 2010; Albanese *et al.* 2013).

In a similar post-mortem evaluation, van Bergen *et al.* (2015) found a significant positive correlation between weight and EF circumference by filling and distending this and adjacent cavities with a material that expanded and provided an anatomical cast of the relevant structures. Even though the weight ranges included in the study of van Bergen *et al.* (2015) (140–700 kg) and in the present study (202–600 kg) were similar, the methodological differences could explain the difference in the association between weight and the foramen size. In the present study, the length of the epiploic foramen was measured with a ruler, which could be imprecise, especially because the edges of the foramen were measured in a totally collapsed position. Additionally, in this relaxed state the foramen could assume

TABLE 1: Mean, standard deviation, standard error, minimum and maximum values of EF length (n = 43), by gender, breed and age distribution

Individual features	Mean*	Standard deviation	Standard error	Minimum	Maximum
Gender					
Mare (n = 24)	4.59	1.09	0.22	2.60	7.5
Gelding (n = 19)	3.92	0.97	0.22	2.1	6.3
Breed					
Quarter Horse (n = 20)	4.61	1.08	0.24	2.6	7.5
Mixed breed (n = 18)	4.12	1.05	0.25	2.8	6.3
Others† (n = 5)	3.66	0.93	0.42	2.10	4.4
Age					
2–8 years (n = 18)	4.48	1.24	0.29	2.6	7.5
8–14 years (n = 10)	4.35	0.84	0.27	3.4	5.8
≥14-year-old (n = 15)	4.03	1.03	0.27	2.10	6.3

*No statistical difference (P<0.05) was found between any pairwise comparisons between means.
†Mangalarga Paulista, Lusitano, American Trotter, and Criollo.

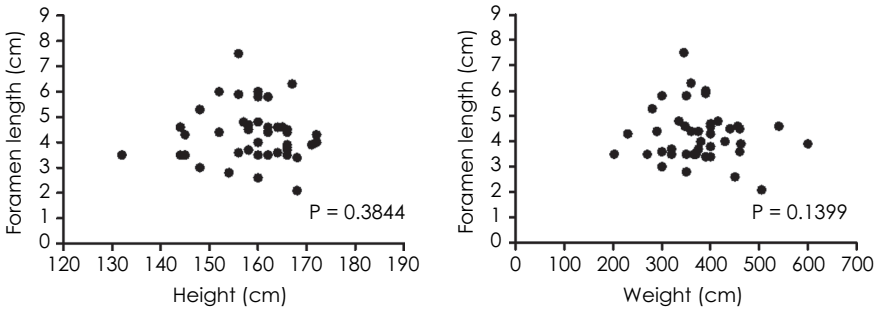

Fig 3: Correlation between EF length and horse height (left) or body weight (right).

different lengths under different conditions. Therefore, this could have been an imprecise method of measurement, allowing measurement flaws and becoming a limiting factor of the study, despite the larger sample.

According to previous reports, there is no correlation between EFE and gender (Vasey 1988; Archer *et al.* 2004b, 2008), which agree with our findings. In a case–control study, Kilcoyne *et al.* (2016) evaluated 73 horses with EFE, observing a higher occurrence in geldings. In contrast, Archer *et al.* (2004b) did not describe this correlation in their study with 71 horses. Due to the higher proportion of geldings and mares in the general population of the hospital's routine, this study did not include stallions.

The EFE occurrence used to be associated with age, as older horses present right hepatic lobe atrophy. Since this lobe is close to the delimiting structures of the EF, its atrophy could increase the length of the foramen (Wheat 1972; Livesey *et al.* 1991; Engelbert *et al.* 1993). However, this hypothesis has not been validated in subsequent studies (Schmid 1997; Freeman and Schaeffer 2001; Archer *et al.* 2004a; van Bergen *et al.* 2015).

Schmid (1997) performed a post-mortem measurement of the EF in 15 horses of different ages, determining that there is no difference on EF length throughout the ageing process. Similar results were demonstrated by van Bergen *et al.* (2015), who did not find any correlation between age and EF length in 30 horses. In addition, Freeman and Schaeffer (2001) compared the mean age of the animals affected by small intestine strangulation and those who presented specific strangulation due to EFE, demonstrating no age difference between groups. Other studies reiterated this affirmation, as shown by Kilcoyne *et al.* (2016) in a study that demonstrated a higher incidence of EFE in mid-age horses, and Archer *et al.* (2004b), who found a higher occurrence in horses ranging from 4 to 15 years of age. Even though this study did not directly assess right hepatic lobe atrophy, our findings agree with the absence of correlation between age and EF length, showing a lower mean EF length in horses older than 14 years, as compared to the other groups (**Table 1**).

Conclusion

Results of this study suggest an absence of positive correlation between EF length and ageing. Although height and EF length were not correlated in this study, more studies are needed to investigate the association between height and the occurrence of EFE. None of the physical variables were associated with post mortem EF length, supporting the theory that increased intra-abdominal pressure is the main determinant for EFE occurrence.

Authors' declaration of interests

No conflicts of interest have been declared.

Ethical animal research

The hospital from which materials were derived for this study consistently uses an admission/consent form that includes an option for owners to opt out of research studies.

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Authorship

J.M. Alonso contributed to study design, study execution, data analysis and interpretation, and preparation of the manuscript. C.A. Hussni contributed to study design. G.S. Rosa and M.F. Marsiglia contributed to study execution, data analysis and interpretation, and preparation of the manuscript. J.C.F. Pantoja contributed to data analysis and interpretation. All authors gave their final approval of the manuscript.

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Original Article

Novel findings from a beta coronavirus outbreak on an American Miniature Horse breeding farm in upstate New York

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Summary

This case report describes an outbreak and novel findings associated with a beta coronavirus (BCoV) infection that occurred on an American Miniature Horse (AMH) breeding farm in upstate New York, in January and February of 2013. Twenty-nine AMH and one donkey were present on the farm when the outbreak occurred. One 10-year-old Quarter Horse mare, stabled at a separate location and owned by an employee of the farm, also tested positive. A polymerase chain reaction (PCR) assay for the detection of BCoV was performed at the Animal Health Diagnostic Center (AHDC) at Cornell on all faecal samples. The PCR assay used detects multiple beta coronaviruses, including, but not limited to, equine enteric coronavirus (ECoV). Novel findings regarding this BCoV infection in horses were recognised in this outbreak study. To the authors' knowledge, this is the largest outbreak of BCoV described thus far in a closed herd on a single premise. The case fatality rate was 0% unlike that described in a previous outbreak of ECoV involving miniature horses and a miniature donkey (Fielding *et al.* 2015). The morbidity rate was lower in this outbreak than in previously described studies (Oue *et al.* 2013; Pusterla *et al.* 2013). This outbreak also demonstrated the potential for BCoV transmission via farm personnel. The duration of shedding of virus in the faeces among some asymptomatic horses in this outbreak was longer than previously described clinical cases of ECoV (Pusterla *et al.* 2013; Nemoto *et al.* 2014). This study suggests that asymptomatic animals may play a role in the maintenance of BCoV during an outbreak; therefore, the need for diagnostic testing of both clinically affected and apparently clinically normal horses on a premises followed by appropriate biosecurity and control measures.

Introduction

Beta coronavirus (BCoV) was first detected and characterised from a foal with enterocolitis in 1999 (Davis *et al.* 2000). A more recent prevalence study demonstrated the equal likelihood of isolating ECoV from both gastrointestinal-diseased and healthy foals (Slovis *et al.* 2014). As a co-infecting agent, however, this same study showed a significant association between ECoV and gastrointestinal disease in foals (Slovis *et al.* 2014). Aside from gastrointestinal disease in foals, ECoV has also been associated with outbreaks in adult horses in racing facilities in Japan and in boarding facilities in the US (Oue *et al.* 2011, 2013; Pusterla *et al.* 2013). In these outbreaks of adult horses, the most common clinical signs associated with ECoV infection were anorexia, lethargy, fever and less commonly specific signs of gastrointestinal disease (Oue *et al.* 2011, 2013; Pusterla *et al.* 2013; Nemoto *et al.* 2014). ECoV has also rarely been associated with necrotising enteritis and hyperammonaemic encephalopathy in horses (Fielding *et al.* 2015; Giannitti *et al.* 2015). The purpose of this study is to describe an outbreak of BCoV that occurred on an American Miniature Horse (AMH) breeding farm in upstate New York. To the authors' knowledge, this outbreak of BCoV constitutes the largest one described in a single, closed herd situation. The clinical presentation, faecal PCR results and faecal shedding of the virus for the animals involved in this outbreak are described. Possible transmission of BCoV via human movement from the outbreak site to one horse at a barn off the premises is also described. Aside from the size of this outbreak, several other factors also set it apart from other BCoV outbreaks previously described in the literature including the mortality rate, morbidity rate and duration of faecal shedding (Pusterla *et al.* 2013; Nemoto *et al.* 2014; Fielding *et al.* 2015).

Herd history

The BCoV outbreak reported here occurred at an American Miniature Horse farm in upstate New York from late January to early February of 2013. The outbreak of BCoV on this farm included 29 miniature horses and one donkey ranging in age from 6 months to 15 years (median 5.5 years). The horses were housed in individual pens within a single open barn, and the adult jennet was housed in a separate shed outside, disconnected from the main barn (**Fig 1**). The pens within the main barn allowed for physical contact between individuals in adjacent pens. The most recent addition to the farm arrived approximately 3 months prior to the onset of this outbreak. There was no recent travel history for any of the animals on the farm.

Clinical findings

The outbreak began with the onset of fever, lethargy and mild colic signs (flank watching, laying down frequently, and anorexia) in two 3-year-old mares in adjacent pens (**Fig 1**, Index Cases 1 and 2). These two cases, beginning simultaneously, were considered the index cases of this outbreak. In total, five horses (all positive for BCoV on faecal PCR and ages ranging from 6 months to 12 years; median 5 years) developed clinical signs. The clinical signs of anorexia, lethargy and fever (ranging

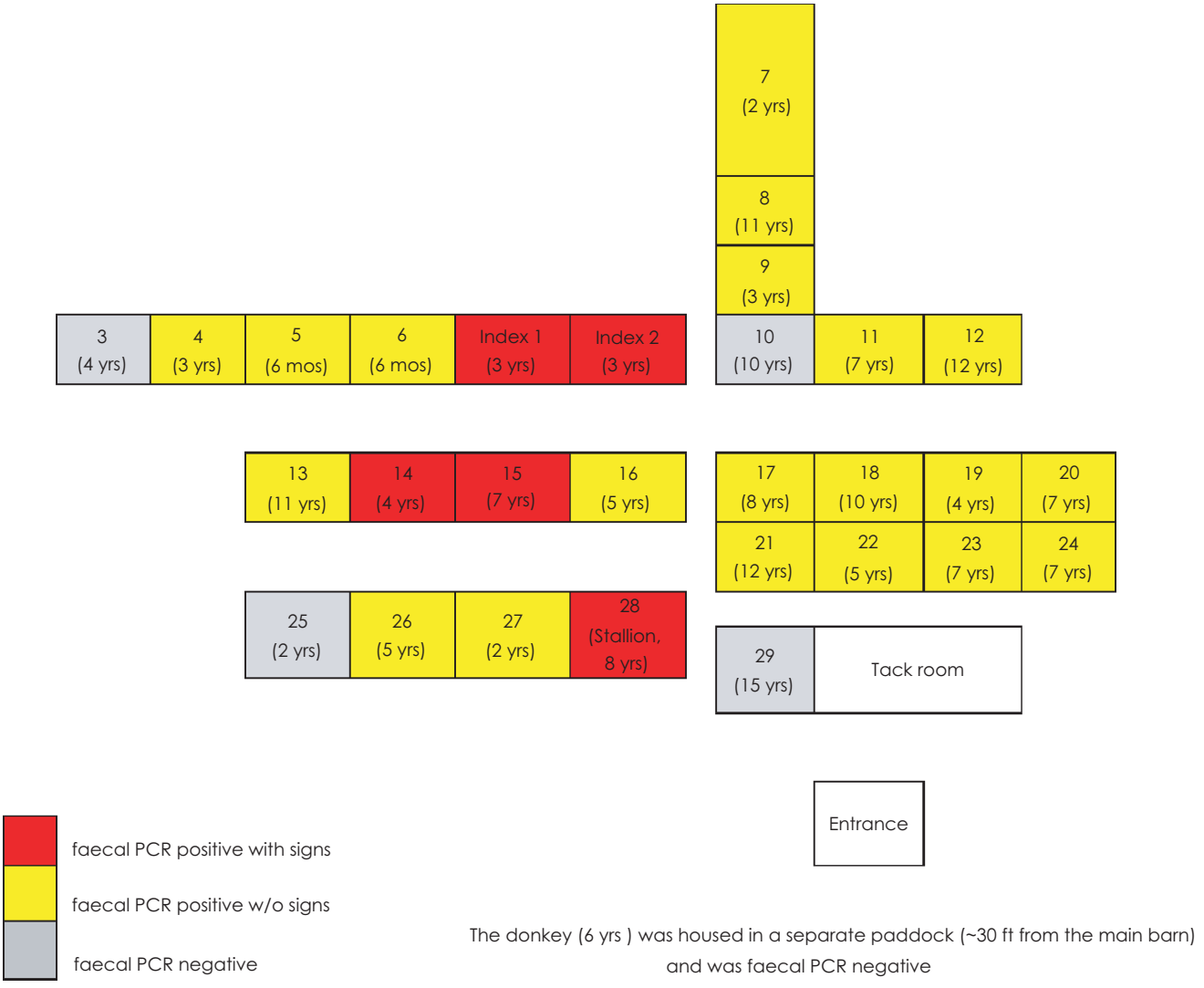

Fig 1: Barn layout demonstrating the location and age of all BCoV faecal PCR-positive animals (with and without clinical signs) and BCoV faecal PCR-negative animals.

from 102.5 to 104.4°F; 39.2 to 40.2°C) were consistent among the five miniature horses who developed clinical illness over the course of the outbreak (**Table 1**). One infected horse also developed diarrhoea while two other infected horses developed mild colic signs and had decreased faecal production. Clinical signs in four of the five horses were self-limiting and resolved in 2–5 days with nonsteroidal anti-inflammatory drug (NSAID), flunixin meglumine, administration by the owner for febrile episodes. Two mares (the index cases) were given antibiotics at the onset of clinical signs, including trimethoprim sulphamethoxazole tablets orally and oxytetracycline intravenously. These treatments were administered prior to the diagnosis of BCoV. An 8-year-old stallion also required supportive care on the farm with intravenous fluids due to dehydration associated with diarrhoea. One of the index cases (Index Case 2) continued to be febrile, inappetent, had no manure production, and mild colic signs after 5 days of treatment on the farm and was referred for more intensive care to the Cornell University Equine Hospital (see hospitalised mare section). Once the diagnosis of BCoV infection was made via molecular detection of the virus in the faeces (PCR testing) from the hospitalised horse, faecal samples were collected from both clinically ill and healthy horses and the donkey on the premise for PCR detection of BCoV at various times over a 26-day period beginning 9 days after the onset of clinical signs. All individuals on the farm had a minimum of one faecal PCR performed and a maximum of six faecal PCR tests for BCoV over that period. EDTA whole blood was also collected from six faecal BCoV PCR positive horses (three affected and three unaffected) and tested for BCoV by PCR. These blood samples were collected on Day 9 after clinical signs began in the index cases; Days 2, 4 and 9 after clinical signs developed in the three affected horses. Complete blood count (CBC) and serum chemistries were also performed on the index case who required hospitalisation.

One faecal sample was also collected for molecular detection of BCoV from a 10-year-old Quarter Horse mare who was owned by an employee of this farm, but housed at

TABLE 1: Clinical and diagnostic (molecular) results from the 30 animals (29 horses and 1 donkey) involved in the BCoV outbreak in Upstate New York.

	Number of animals (n = 30)	Percentage of total
With any clinical signs	5	17
Anorexia	5	17
Fever	5	17
Colic	2	7
Soft formed faeces/diarrhoea	1	3
No clinical signs detected	25	83
Fatality	0	0
Faecal PCR-positive sick	5	17
Faecal PCR-negative sick	0	0
Faecal PCR-positive normal	20	67
Faecal PCR-negative normal	5	17

	Number of animals (n = 6)	Percentage of total
Blood PCR-positive sick	3	50
Blood PCR-negative sick	0	0
Blood PCR-positive normal	1	17
Blood PCR-negative normal	2	33

a separate location with additional horses. This horse developed a fever of unknown origin approximately 1 week after clinical signs were first detected in the two index cases at the primary farm.

Hospitalised mare

On arrival to the Cornell University Equine Hospital, Index Case 2 was lethargic and slightly underconditioned with a body condition score of 4/9. Her mucous membranes were dark red with a toxic line and her capillary refill time was about 3 s. Her sclera appeared mildly icteric and she was tachycardic (60 beats/min). Digital pulses were palpable in both front limbs and all four hooves were warm, but lameness was not noted. Her rectal temperature was 38.1°C (100.6°F). Significant CBC findings included an elevated HCT (47%, normal 34–46%) and low total solids (TS 49 g/L; normal 52–78 g/L) suggestive of both dehydration and protein loss. A leucopenia (4.7×10^9/L; normal 5.5–12.5 $\times 10^9$/L) characterised by lymphopenia (1.5×10^9/L; normal 1.8–5.0 $\times 10^9$/L) and neutropenia (2.8×10^9/L; normal 3.0–7.0 $\times 10^9$/L) was present. Serum chemistry abnormalities included hyperlactataemia (3.56 mmol/L; normal 0.3–1.5 mmol/L), hyponatraemia (126 mmol/L; normal 128–142 mmol/L), hypochloraemia (93 mmol/L; normal 100–111 mmol/L) and elevated aspartate aminotransferase (AST) (834 U/L; normal 100–600 U/L). The mare was treated with supportive care including intravenous fluids (crystalloids and colloids), omeprazole, pentoxifylline and ice boots.

The mare continued to improve over the next few days: her temperature remained normal, clinical pathologic parameters normalised, appetite gradually increased and she finally passed faeces on Day 3 of hospitalisation (8 days after onset of clinical signs). A sample of that faeces was collected and tested positive for beta coronavirus by PCR. For infection control purposes, all animals admitted to Cornell University Equine Hospital are required to have a faecal Salmonella culture performed. This faecal sample was negative for Salmonella by culture. A faecal quantitative floatation was performed, and two strongyle eggs/gram were detected. Targeted diagnostic testing was performed on this case due to economic concerns. For this reason, along with season of the year (January in upstate New York), and the clinical signs present, other enteric pathogen testing was not performed.

Diagnostic test results

The aetiologic agent of the outbreak was determined to be a beta coronavirus based on molecular detection of virus in the faecal sample from the hospitalised mare initially, followed by molecular detection in additional faecal and whole blood samples from other miniature horses on the farm. The PCR assay used will also detect other members of the betacoronavirus family, including bovine enteric coronavirus, canine respiratory coronavirus, human coronavirus OC43 and equine enteric coronavirus. The primers and probe sequences target a conserved region within the nucleocapsid gene and were provided by a third party under a confidentiality agreement. The assay was originally validated using in vitro RNA transcripts containing the target region derived from bovine enteric coronavirus. Analytical sensitivity was determined to be 100 copies with a slope of 3.327 and an efficiency of 99.79%. All samples are run with an exogenous RNA control (encapsulated RNA phage) added at the samples lysis step to monitor for RT-PCR inhibition.

Once the diagnosis of beta coronavirus was made on the hospitalised index case, faecal samples were collected from the remaining 29 animals at the farm (four of which also had current or previous clinical signs). Molecular diagnostic test results and clinical signs are summarised in **Table 1**. Fifteen of those animals sampled initially were positive via faecal PCR for BCoV. In total, 25 animals (83%) on the primary premise tested positive over the course of the 4-week period during which faecal samples were collected. Five (20%) of the 25 animals who tested positive demonstrated clinical signs associated with BCoV, while 20 (80%) of the positive animals remained asymptomatic. No animals displaying clinical signs tested negative for BCoV. EDTA whole blood was also collected from six of the miniature horses that were PCR positive on faeces. These blood samples were collected one time, 9 days after the outbreak began on the farm. Four of these animals were PCR positive for BCoV on whole blood, three of which had previously (n = 1) or currently (n = 2) demonstrated clinical signs. Furthermore, virus isolation (VI) was performed on the EDTA whole blood samples and equine herpesvirus-2 (EHV-2) was isolated from two of the horses, one yearling without any clinical signs and one adult stallion with clinical signs. Isolation of this (EHV-2) virus from EDTA whole blood in conjunction with molecular detection of BCoV in whole blood has not been reported previously and the role that EHV-2 played in this outbreak, if any, is unclear. BCoV (including ECoV) is not routinely recovered by VI and most studies on ECoV prevalence rely on PCR assays (Pusterla *et al.* 2013, 2015; Miszczak *et al.* 2014; Hemida *et al.* 2017). To the authors' knowledge, this was the first time that BCoV had been diagnosed in an adult horse in New York State and little was known about its role in disease in adult horses at the

time. VI is not a pathogen-specific testing modality, so it is often performed on whole blood samples from horses with fevers of unknown origin as a means of detecting viraemia due to unknown viral pathogens. VI was performed on the whole blood samples in this outbreak as part of an investigative workup for a fever of unknown origin and also because of the possibility, although unlikely, of isolating BCoV for further characterisation. The faecal sample collected from the farm employee's horse (housed in a separate location, approximately 6 miles from the primary premises) tested positive for BCoV by PCR. No additional samples were collected from this horse, so follow-up testing was not performed. To the authors' knowledge, no other horses present at this separate facility (6–8 total horses in the barn) became ill or were tested for BCoV.

Faecal samples were collected intermittently over the next several weeks from all AMH and the donkey on the primary premises. One horse tested positive initially and was still positive 25 days later on faecal PCR. Two other horses demonstrated BCoV shedding in faeces on two samples collected 22 and 18 days apart. There was no correlation seen between beta coronavirus cycle threshold (Ct) values in faecal samples and expression of clinical signs. Follow-up samples beyond that time period were not collected and all three of these horses remained asymptomatic throughout the entire duration of the outbreak.

Discussion

The lack of mortality in this BCoV outbreak is in contrast to the case fatality rates reported in some previous outbreaks involving adult horses (Oue *et al.* 2011, 2013; Pusterla *et al.* 2013; Fielding *et al.* 2015). Previous studies have demonstrated that ECoV is a very common agent present in healthy foals <20 weeks of age (Slovis *et al.* 2014). For this reason, it has been hypothesised that there may be a protective effect of breeding farms against ECoV due to constant exposure of the mares to ECoV shed by the foals. This farm was not bringing in outside mares to be bred to their stallion. The stallion was only used for breeding the mares on this farm and the farm generally produced up to 6 foals per year. All mares and geldings were turned out together for exercise, so all had contact with each other daily and the stallion was turned out separately. Perhaps, the presence of foals on this farm helps explain the lack of mortality and the low morbidity seen in this outbreak compared with that described elsewhere. The exposure of adult horses to foals, could however, also explain the source of this outbreak as the two index cases were on one side of the barn, adjacent to the only two weanlings (6 months old) in the barn, who also tested positive for BCoV but never developed clinical illness. Ventilation of the barn, alone, does not offer much insight to disease spread of aerosolised viral particles as the barn had upward ventilation throughout. ECoV has been described in one outbreak among adult miniature horses and a miniature donkey originating from a single competition (Fielding *et al.* 2015). The case fatality rate of this outbreak was 27% among those animals who tested positive for ECoV in their faeces (Fielding *et al.* 2015). Other prior outbreaks have published case fatality rates ranging from 0 to 7% (Oue *et al.* 2011, 2013; Pusterla *et al.* 2013).

The published durations of faecal shedding of ECoV has ranged from 3 to 14 days among outbreaks and experimental infections in adult horses (Nemoto *et al.* 2014; Fielding *et al.* 2015). Over the course of this outbreak, BCoV PCR was performed on faecal samples from each animal as few as one time and as many as six times. The prolonged shedding periods of at least 25, 22 and 18 days duration occurred in three horses who failed to demonstrate any associated clinical signs throughout the outbreak period. To the authors' knowledge, these durations of faecal detection are longer than previously described in animals lacking clinical signs of illness. In contrast, a European paper described one horse who shed ECoV in faeces for 35 days but subsequently died with severe diarrhoea (Miszczak *et al.* 2014). Similarly, faecal samples from a 28-year-old horse, submitted to the Animal Health Diagnostic Center (AHDC) at Cornell for BCoV faecal PCR testing, were positive at Days 1, 28, 63 and 99 after onset of disease. This horse originally demonstrated clinical signs of a fever 40°C (104°F), mild colic signs, lethargy, anorexia and developed soft-formed faeces. Clinical illness lasted for a total of 7–10 days (A. Glaser, personal communication 2014). This information suggests that a potential for prolonged shedding, longer than the previously published 14 days, should be considered in any biosecurity plan following BCoV infection at a facility.

Horse 13 (**Fig 1**) was the most recent addition to this farm. This gelding was brought to the farm approximately 3 months prior to the onset of the outbreak. In this outbreak, Horse 13 tested positive for BCoV on faecal PCR during the outbreak but remained asymptomatic. While this may represent another possible source of this outbreak, it is difficult to explain why clinical disease would not have been seen sooner in the index cases if the new horse was shedding beta coronavirus upon arrival, as the incubation period for ECoV has been demonstrated to be 2–4 days post inoculation (Nemoto *et al.* 2014). If this horse was the source of the outbreak, it would represent a very prolonged shedding period (which is possible, as mentioned above) or else intermittent shedding of BCoV, which, to the authors' knowledge, has not yet been documented.

An association has been demonstrated between viral load and mortality in ECoV outbreaks (Fielding *et al.* 2015). Although viral load was not measured in this outbreak, there was no correlation detected between beta coronavirus Ct values in faecal samples and expression of clinical signs, so it is unlikely that differences in viral load were solely responsible for the differences seen in disease expression in this outbreak. Other factors affecting mortality may include strain differences as well as environmental and host characteristics. The miniature horses of this report were all in excellent lean body condition. Such ideal condition may have offered protection from the common secondary complication, hepatic lipidosis, that may plague sick, inappetent miniature horses. The one animal which required care at a referral veterinary hospital had been treated for 5 days on the farm with nonsteroidal anti-inflammatory medications, perhaps contributing significantly to the prolongation of clinical signs. Previously described outbreaks of ECoV demonstrated morbidity rates ranging from 20 to 67% (Pusterla *et al.* 2013; Fielding *et al.* 2015). The morbidity rate in this BCoV outbreak was only 17% (5 of 30 horses showing clinical signs), with 80% of the positive animals in this outbreak remaining asymptomatic. This is in contrast to only 33% asymptomatic, positive animals in a previously described ECoV outbreak

among a similar population (Fielding *et al.* 2015). As mentioned previously, this discrepancy could also be explained by the hypothesis that exposure of adult horses to BCoV from foals may offer some protection against morbidity and mortality associated with this virus. This also suggests that there may be a greater likelihood than previously suspected of asymptomatic animals perpetuating an outbreak of BCoV. At the time of this outbreak, there was no equine-specific antibody test available to detect horses with subclinical or previous ECoV infections. Currently, there is an ECoV S protein-based ELISA that would have been useful to further characterise the role of asymptomatic shedders in this BCoV outbreak (Kooijman *et al.* 2016).

This outbreak also suggests that people can play a role in transmission of BCoV among horses. The horse who was housed at a separate facility, but owned by an employee of the primary premises, developed clinical signs compatible with BCoV and tested positive for BCoV on faecal PCR. Although an unrelated BCoV transmission and infection could have occurred on the second farm, a more likely explanation for the source of transmission was the farm employee as there were no other common contacts shared between the two farms. This highlights the need for stringent biosecurity efforts, including the limit of human movement to other farms during a BCoV outbreak.

Our findings suggest all individuals at risk for disease should be tested, not just those demonstrating clinical signs, prior to lifting quarantine measures. Further work is necessary to establish guidelines for BCoV quarantine timeframes as animals both with and without obvious clinical signs may shed virus for prolonged periods of time.

Authors' declaration of interests

No conflicts of interest have been declared.

Ethical animal research

This investigation was focused on studying the animals affected by an outbreak of equine coronavirus. It involved only client-owned animals. Client confidentiality was maintained and consent from the owner for all diagnostic testing was provided at the time of the investigation.

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Authorship

E. Goodrich contributed to the study design, study execution, data analysis and interpretation and preparation of the manuscript. L. Mittel and S. Ness contributed to the study design and study execution. A. Glaser provided expertise regarding the molecular assay used in this study. R. Radcliffe contributed to the preparation of the manuscript. T. Divers contributed to the study design, study execution and preparation of the manuscript. All authors gave their final approval of the manuscript.

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Perspectives from an Equine Expert Panel on

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Review Article

Intestinal neoplasia: A review of 34 cases

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Keywords: horse; neoplasia; intestinal; colic; abdominal; lymphoma

Summary

The clinicopathological features of 34 horses with a histological diagnosis of intestinal neoplasia were reviewed; these included 17 horses with lymphoma, five with gastrointestinal stromal tumours (GISTs), four with adenocarcinomas, three with leiomyosarcomas, two with leiomyomas, two with squamous cell carcinomas (SCC) and one with adenocarcinoma/mesothelioma. The mean age at presentation was 19 years (range 3–36 years), and 81% of cases occurred in horses aged 15 years or older. Weight loss, acute or recurrent colic, inappetence, diarrhoea, depression and pyrexia were the most common presenting clinical signs. Hyperfibrinogenaemia, hypoalbuminaemia and leukocytosis were the most common clinical pathological findings. Transabdominal ultrasonography and exploratory laparotomy were the most useful diagnostic tests. Neoplasia was identified in all regions of the intestinal tract, with the jejunum being most frequently affected. The presence of mass lesions or thickened intestinal walls on transabdominal ultrasound, coupled with other clinical findings, were suggestive of intestinal neoplasia. Where possible, complete surgical resection offered the best prognosis, but generally the prognosis was poor to hopeless.

Introduction

Intestinal neoplasia is rare in horses (Baker and Leyland 1975; Sundberg *et al.* 1977; Pascoe and Summers 1981; Bastianello 1983). One review of intestinal tumours from the USA reported alimentary lymphoma to be the most common intestinal neoplasm followed by adenocarcinoma, with a possible predisposition to adenocarcinoma in the Arabian breed (Taylor *et al.* 2006). In many countries, including the UK, there is an increasing number of geriatric horses, over 15 years old (Ireland *et al.* 2011). Since the risk of malignant tumours in the horse is age-dependent (Priester and Mantel 1971), changes to the mean age of horses in the population might be associated with changes in the incidence of different tumour types. In addition, the increasing use of immunohistochemistry and the development of new markers allows for the more accurate determination of specific tumour types/origins that was not previously possible. Thus, more current data on the most frequently diagnosed equine tumour types should be of value to inform veterinary surgeons treating clinical cases and to provide data for comparative research (Knowles *et al.* 2015). The aims of this study were to describe the tumour types and clinicopathological features of a sample of horses diagnosed with intestinal neoplasia in the United Kingdom in the last 15 years.

Materials and methods

Computerised medical records at a referral equine hospital and a first opinion equine clinic in the southeast/east of England were searched for cases of intestinal neoplasia that presented between 2001 and 2016. Cases were only included if a histopathological diagnosis of intestinal neoplasia was confirmed from either surgical biopsies or tissue samples collected post-mortem. Biopsies were placed immediately into 10% neutral buffered formalin (NBF), and post-mortem samples were collected within 30 min of death and fixed immediately in NBF. The site of sampling was selected by the clinician, based on the gross surgical or post-mortem findings. Fixed tissues were processed routinely to paraffin wax, sectioned at 4 μm, and stained with haematoxylin and eosin (HE). Selected tissues were additionally stained immunohistochemically using antibodies to the following antigens: CD3, CD79a, PAX5, CD117, vimentin, desmin, SMA, S100 and cytokeratin (CK). Information retrieved from the clinical records included signalment, history, presenting clinical signs and results of diagnostic tests, including routine haematology, serum biochemistry, rectal examination, transabdominal ultrasonography, abdominocentesis, gastroscopy, oral glucose absorption test and rectal biopsy. Treatments, outcomes and, where appropriate, surgical findings and results of post-mortem examination were also recorded.

Results

Thirty-four cases of intestinal neoplasia were identified during the study period. Four horses presented to the first opinion practice and 30 to the referral hospital. The final diagnoses included alimentary lymphoma (17 horses) (**Figs 1–4**), gastrointestinal stromal tumour (GIST) (five horses), adenocarcinoma (four horses) (**Figs 5** and **6**), leiomyosarcoma (three horses) (**Fig 7**), leiomyoma (two horses), squamous cell carcinoma (two horses) and one adenocarcinoma/mesothelioma (**Table 1**). There were 15 geldings and 19 mares. Age was recorded in 33 horses, and ranged from 3 years to 36 years, with a mean age of 19 years and a median age of 18.5 years; 81% of cases were in horses aged 15 years or older. Breed was recorded in 33 horses: 16 (48%) were ponies (three cross-bred ponies, six Welsh Mountain ponies, two New Forest

ponies, three Shetland ponies, one Connemara and one Connemara-cross pony) and there were four Cobs, three Arabians or Arabian-crosses, five Thoroughbreds or Thoroughbred-crosses, one Warmblood, one Shire-cross, two Irish Draught-crosses and one crossbred "hunter".

Ten horses had an acute presentation with no significant previous history of clinical signs prior to examination; nine of these presented with acute onset colic and one with respiratory distress. The remaining 24 horses had a range of duration of clinical signs prior to presentation from 2 days to 18 months. The most common clinical sign was weight loss (14/34 cases, 41%). Other clinical signs recorded were recurrent colic (10/34; 29%), reduced appetite (8/34; 24%), diarrhoea (7/34; 21%), depression/lethargy (6/34; 18%), pyrexia (5/34; 15%), patchy sweating (1/34) and peripheral lymphadenopathy (1/34). A table summarising the presenting clinical signs of the 34 horses is available online (**Supplementary Item 1**).

On presentation, 11/34 horses (32%) had tachycardia (heart rate >48 beats/min), 7/34 (21%) had tachypnoea (respiratory rate >20 breaths/min), 9/34 (26%) had colic unresponsive to analgesia, and 6/34 (18%) had ventral oedema. Results of rectal examination were recorded in 21/34 (62%) cases, and a palpable mass was detected in 6/21 (29%) horses, intestinal thickening in one, and an intestinal abnormality (impaction, distended small intestine, possible intestinal entrapment) in 7/21 (33%) horses. Abdominocentesis was performed in 20 cases; seven of these (30%) had elevated peritoneal total nucleated cell counts (range 8.4–285 $\times 10^9$/L; normal reference range <5 $\times 10^9$/L), 3/20 (15%) were sero-sanguinous, 2/20 (6%) had elevated total protein concentration (>20 g/L) and 1/20 (6%) had abnormal lymphoid cells on cytological examination.

Results of routine haematological and serum biochemical profiles were recorded in 30 cases. Sixteen horses (53%) had hyperfibrinogenaemia (plasma fibrinogen concentration 4.9–10 g/L; normal reference range [nrr] <4.0 g/L); 12 horses (40%) had hypoalbuminaemia (serum albumin concentration 14–29 g/L; nrr 31–40 g/L); eight horses (24%) had leukocytosis (total WBC count >9.5 $\times 10^9$/L) with neutrophilia, and two horses (5%) had leukopenia (total WBC count <5.5 $\times 10^9$/L). Four horses (13%) were anaemic, (RBC <5.5 $\times 10^{12}$/L, Hb <11/dL). Four horses (12%) had an elevated alkaline phosphatase concentration (>360 iu/L), 2 (5%) had elevated glutamate dehydrogenase (>11 U/L), 3 (8%) had elevated gamma-glutamyl transferase (>50 iu/L), 2 (5%) had elevated blood urea (>3 mmol/L) and 2 (5%) had elevated serum triglyceride concentrations (>0.8 mmol/L). Three horses (8%) were hyperglobulinaemic (serum globulin concentration >40 g/L). One horse had an elevated blood lactate concentration, although this was only assayed in one case. Serum amyloid A concentration was elevated (>3 mg/L) in the four horses in which it was measured.

Transabdominal ultrasonography was performed in 23 horses using either a GE Vingmed Vivid three, GE Logiq E9 or GE Logiq P5 ultrasound scanner. No abnormalities were recorded in two cases (9%), but clinically significant findings were noted in the other 21 horses; four horses (17%) had increased small intestinal mural thickness (>4 mm), (**Fig 8**), one had a displaced spleen and inability to visualise the left kidney, 10 (43%) had one or more soft tissue masses (**Figs 4** and **9**), 7 (30%) had distended small intestine, and one had possible

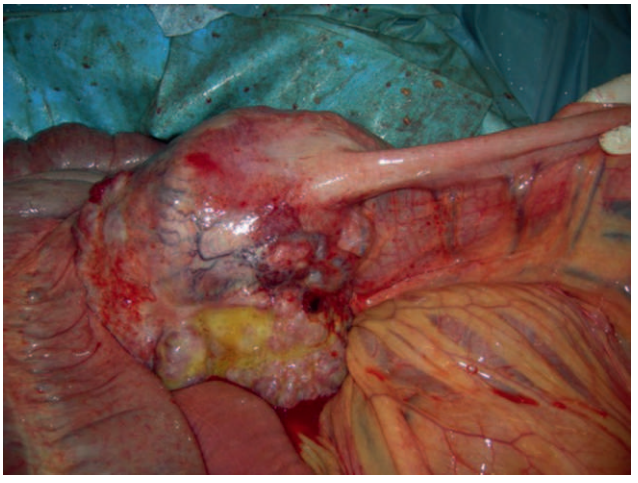

Fig 1: Case 11 (B cell lymphoma). Intestinal lymphoma mass affecting the jejunum and its mesentery identified at exploratory laparotomy.

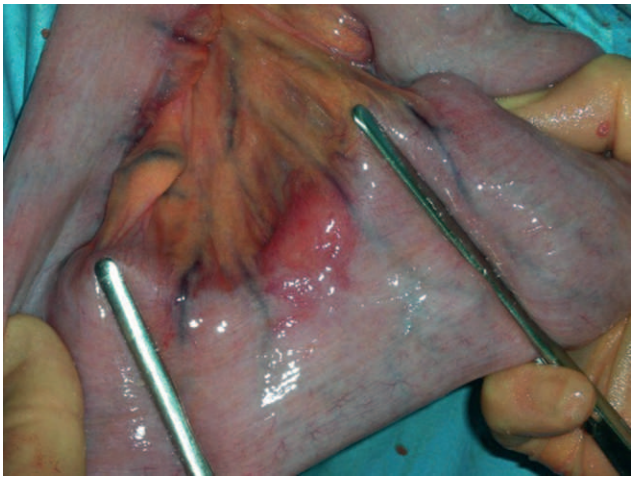

Fig 2: Case 7 (T cell lymphoma). Serosal nodule at the mesenteric border of the jejunum identified at exploratory laparotomy.

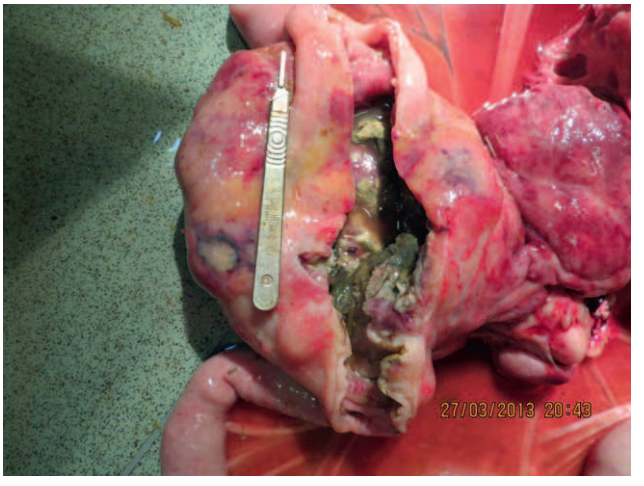

Fig 3: Case 19 (B cell lymphoma). Post-mortem appearance of intestinal lymphoma resulting in pseudodiverticulum formation.

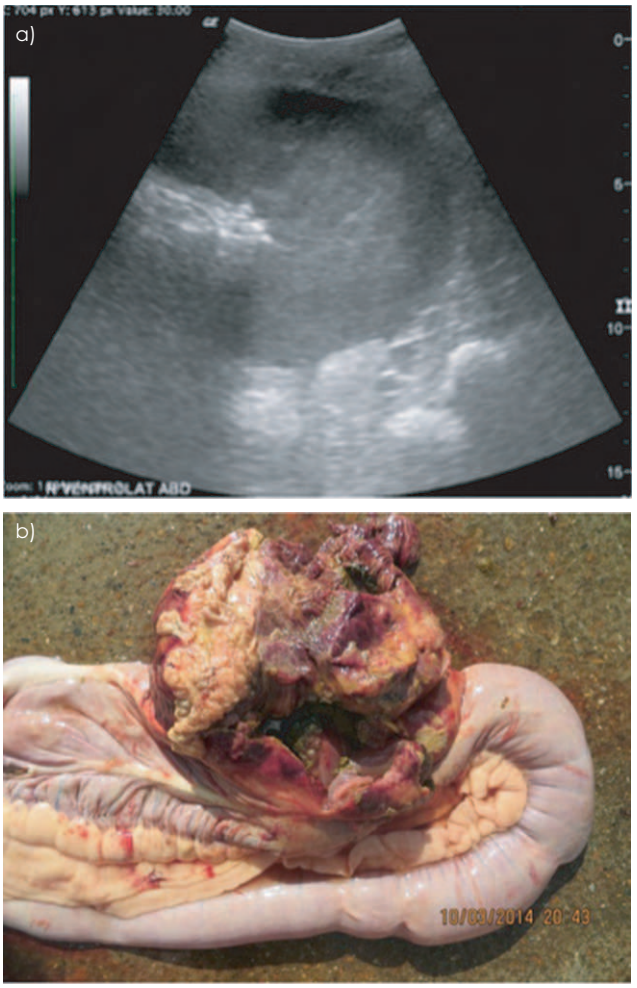

Fig 4: Case 24 (T cell lymphoma). a) Transabdominal ultrasound image from the right ventrolateral abdomen showing a mass of broadly homogeneous echogenicity, and b) corresponding post-mortem appearance of intestinal lymphoma mass affecting the left ventral colon.

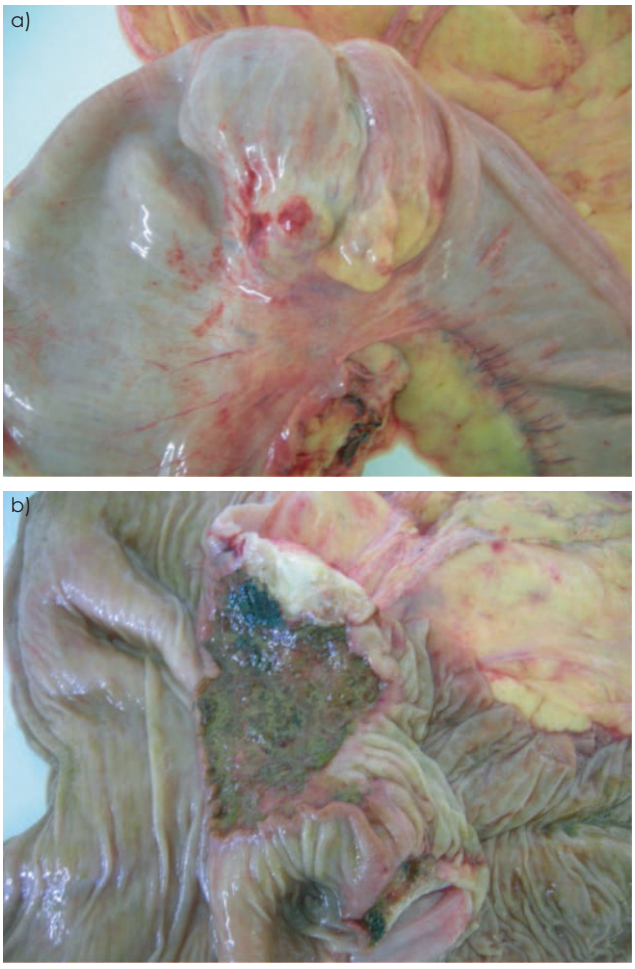

Fig 5: Case 15 (adenocarcinoma). a) Post-mortem appearance of the serosal surface of the large colon showing the presence of neoplastic masses. b) Mucosal surface showing adenocarcinoma and associated mucosal ulceration.

intraperitoneal adhesions restricting small intestinal motility. Oral glucose absorption tests (Roberts and Hill 1973) were performed in 4/34 horses; three horses with lymphoma had results indicative of "partial malabsorption" (Mair *et al.* 1991) and one horse with adenocarcinoma had a normal result.

Histopathological examination of rectal biopsies was performed in 3/34 (9%) horses; one showed no significant abnormality, one confirmed lymphoma (Case 6), and one, subsequently diagnosed with lymphoma (Case 12), showed a mild chronic proctitis with intraepithelial eosinophils. Gastroscopy was performed in 6/34 horses (18%), and abnormalities were noted in four cases (hyperkeratosis and/or squamous mucosal ulceration [Sykes *et al.* 2015]). In one horse, white nodular lesions of the duodenal mucosa were identified; grab biopsies of the duodenal mucosa revealed a lymphocytic plasmacytic infiltrate, and this horse was subsequently diagnosed with duodenal lymphoma at post-mortem examination.

An ante-mortem diagnosis of neoplasia was made in 23/34 horses (68%), 18 at exploratory laparotomy, three by laparoscopy, one by lymph node biopsy and one by rectal

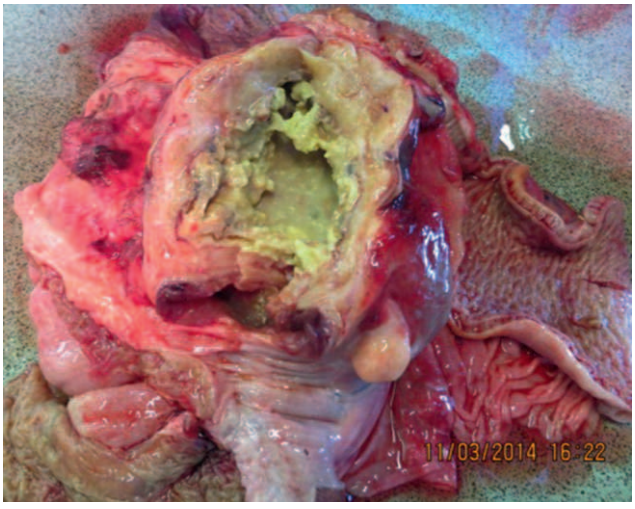

Fig 6: Case 21 (adenocarcinoma). Post-mortem appearance of the mucosal surface of a large adenocarcinoma at the ileo-caecal junction.

biopsy. Diagnosis was made at post-mortem examination in 11/34 horses (32%). Eleven of 18 horses (61%) undergoing exploratory laparotomy were euthanized at surgery and one of three was euthanized following exploratory laparoscopy. Neoplasia was considered an incidental finding in 5/18 horses undergoing exploratory laparotomy, all of which had acute colic for another reason (one small intestinal volvulus, Case 29), strangulating lipoma (3, Cases 18, 30 and 34), and mesenteric rent causing intestinal entrapment (1, Case 20). Three of these horses were euthanized at surgery due to significant gastrointestinal compromise, and the other two were alive at the time of writing, following correction of the intestinal abnormality and resection of the neoplasm.

The sites of the intestinal tract where the neoplasms were located are shown in **Table 1**. Immunohistochemistry was performed in 23 cases; specific staining patterns were recorded in 21/23 cases (91%) and are documented in **Table 2**, **Figures 10–13**.

Survival time from the onset of clinical signs ranged from 1 day to 6 years. Ten horses (29%) survived to discharge from the clinic, and were managed on oral prednisolone (prednicare)[1] (1), oral codeine phosphate (codeine)[2] (2), or both (1), or no further treatment (6) (**Table 3**). At the time of writing, 3/34 cases (9%) were alive and reported to be well; all had surgical resection of masses (two leiomyomas, Cases 25 and 30, discharged 10 months and 17 months prior to writing, and one GIST, Case 32, discharged 2 months prior to writing). Case 25 was seen 5 months' post discharge for colic which responded to analgesia, however, rectal examination revealed nodules at the base of the mesentery. None of the

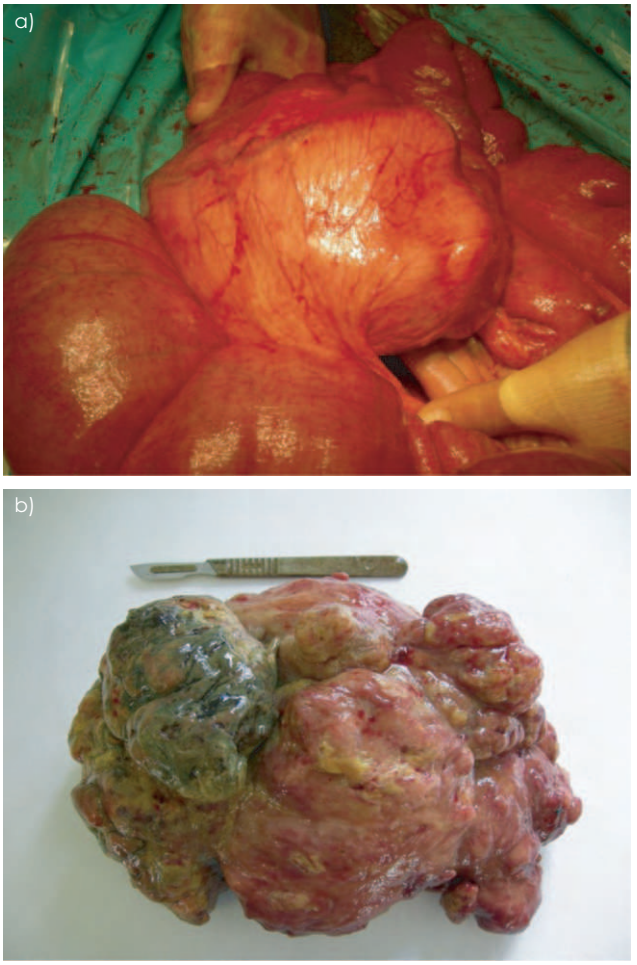

Fig 7: Case 8 (leiomyosarcoma). a) Surgical appearance of colonic mass. b) Gross appearance of the leiomyosarcoma.

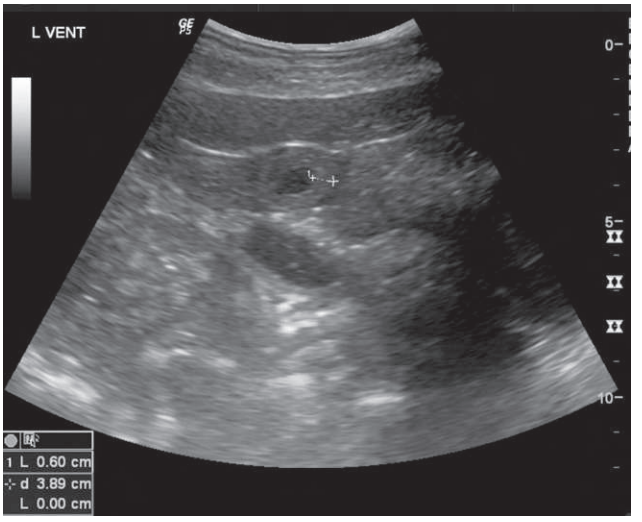

Fig 8: Case 23 (lymphoma). Transabdominal ultrasound image showing thickened small intestinal wall due to neoplastic infiltration.

TABLE 1: Site of origin and type of intestinal neoplasms in 34 horses

		Tumour						
Site of tumour		Lymphoma	GIST	Adenocarcinoma	Adenocarcinoma/ Mesothelioma	Leiomyoma	SCC	Leiomyosarcoma
SI	Duodenum	1		1				
	Jejunum	8	2			1		2
	Ileum	1						
LI	Caecum		2					1
	Caeco-colic junction			2				
	Large Colon	3	1					
	Small Colon	1		1		1		
	Widespread	2			1		2	
	Unknown	1						

SI, small intestine; LI, large intestine.

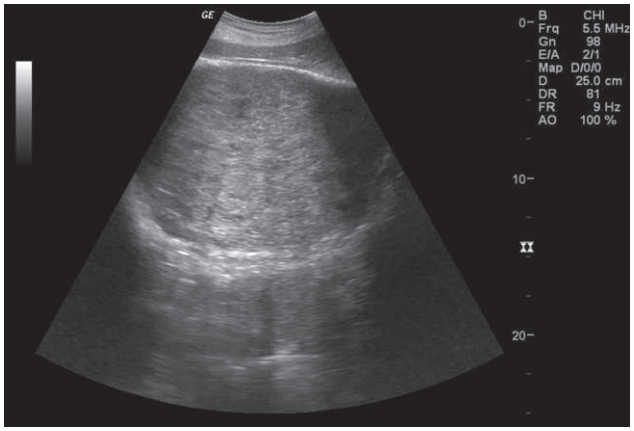

Fig 9: Case 25 (leiomyoma). Transabdominal ultrasound image from the right lateral abdomen showing a large mass of homogeneous echogenicity, confirmed as leiomyoma at exploratory laparotomy.

surviving horses were discharged from the hospital on any further treatment. Of the remaining 31 horses, three were lost to follow-up, 27 horses were euthanised and one died. One horse (Case 14) that had surgical resection of a focal jejunal B cell lymphoma mass survived 6 years following surgery prior to presenting with recurrent colic and weight loss associated with recurrence of intestinal lymphoma.

Discussion

The commonest intestinal neoplasm diagnosed in this series of horses was lymphoma, which was identified in 17 of 34 horses (50%); this prevalence is similar to the results of a previous review of intestinal neoplasia in which lymphoma was found in 19 of 34 cases (56%) (Taylor *et al.* 2006). Lymphoma is considered to be the commonest malignant neoplasm of the horse, and occurs in various forms, including multicentric, alimentary, mediastinal and cutaneous (Rebhun and Bertone 1984; Mair and Hillyer 1997; Knowles *et al.* 2015). As was documented in this series, horses affected with alimentary lymphoma most commonly present with either recurrent colic and/or weight loss. The average age of the 17 horses with lymphoma was 18.6 years, which is similar to the mean age of 16 years recorded by Taylor *et al.* (2006). The overall percentage of lymphoma cases among all intestinal neoplasms in the current study (2001 to 2016) was also very similar to the results of Taylor *et al.* (2006) (data from 1990 to 2005) (50 and 56% respectively). Thirteen lymphoma cases in the present study had a chronic presentation (recurrent colic with or without weight loss) whereas four had an acute presentation (acute colic). Lesions identified at surgery or post-mortem examination varied from intestinal mural thickening to discrete masses, and metastases/multicentric tumours were common; this was similar to the findings of Taylor *et al.* (2006). Of 16 cases where the distribution of lymphoma was recorded, 10 (63%) involved the small intestine, 4 (25%) involved the large intestine and 2 (13%) involved multiple areas of the intestinal tract. This concurs with previous reports, where the small intestine was identified as the commonest site of alimentary lymphoma formation (Platt 1987; Taylor *et al.* 2006). Immunohistochemistry (the utilisation of antibodies for the detection of specific antigens in tissue sections) was used primarily as a supplement to the classical morphological approach in the diagnosis of specific neoplasms (Ramos-Vara 2005). It revealed that nine of 13 cases (69%) of lymphoma were T cell lymphomas, three (23%) were B cell lymphomas and one was unclassified; this agrees with previous reports (Pinkerton *et al.* 2002; Meyer *et al.* 2006; Sanz *et al.* 2010). Immunophenotyping of neoplastic lymphocytes as being of B cell, T cell or NK-cell origins is commonly used in human and small animal patients, where this information can aid in disease classification and monitoring, prognosis prediction and therapeutic selection (Gudgin and Erber 2005). The use of immunohistochemistry in aiding treatment decisions and identifying prognostic markers has not yet been developed in equine oncology, and were not applicable in this study. Reports of immunophenotyping of equine lymphomas to date suggest that multicentric, alimentary and mediastinal lymphomas are frequently of T cell origin, and cutaneous lymphomas are either T cell or T cell-rich B cell types (Asahina *et al.* 1994; Pinkerton *et al.* 2002; Gavazza *et al.* 2003; Meyer *et al.* 2006; Taylor *et al.* 2006; de Bruijn *et al.* 2007; Mitsui *et al.* 2007; Munoz *et al.* 2009; Sanz *et al.* 2010; Mair *et al.* 2011). An epitheliotropic form of T cell lymphoma was commonly seen in the present study.

The other neoplasms identified in this study included smooth muscle tumours (leiomyoma or leiomyosarcoma) (15%), GISTs (15%), adenocarcinoma (12%) and squamous cell carcinoma (6%). The increased sensitivity afforded by immunohistochemistry was of particular value in distinguishing between different mesenchymal tumours (leiomyoma/leiomyosarcoma and GIST). However, in one horse, it was not possible to differentiate between adenocarcinoma and mesothelioma, even after immunohistochemical evaluation. Immunohistochemistry is now widely available, but despite the use of a number of antibodies for distinguishing mesothelioma from other malignancies, precise differentiation is not always possible (Cury *et al.* 1999). The distribution of tumour types other than lymphoma in the present study is different to that reported by Taylor *et al.* (2006), who reported 11/34 (32%) adenocarcinoma and 4/34 (12%) smooth muscle tumours. Nonlymphoid mesenchymal tumours of the gastrointestinal tract were traditionally classed as leiomyoma or leimoyosarcomas, however, immunohistochemical analyses of such tumours has identified some neoplasms consisting of undifferentiated mesenchymal cells, at times mixed with mature myogenic, myofibroblastic or neural components. These tumours are now classified as GISTs; GISTs were not reported in the study of Taylor *et al.* (2006), but it is possible that some GISTs were erroneously diagnosed as smooth muscle tumours in that study. However, this does not account for the large difference between the studies in the relative prevalence of adenocarcinomas (32% in the study of Taylor *et al.* 2006 vs. 12% in the current study) compared with the prevalence of GISTs/smooth muscle tumours (12% in the study of Taylor *et al.* 2006 vs. 30% in the current study). This difference may relate to the higher numbers of Arabian horses in the study by Taylor *et al.* (2006) (16/34 horses, 37%) compared with the present study (3/34 horses, 9%), and the apparent predisposition of Arabians to adenocarcinomas (Taylor *et al.* 2006).

Gastrointestinal stromal tumours were identified in five of 34 horses (15%). The use of immunohistochemistry aided identification of these tumours, suggesting that these tumours

TABLE 2: Results of immunohistochemistry in 21 intestinal tumours

		Immunohistochemistry								
Case no.	Neoplasm	CD3	CD79a	PAX5	CD117	Vimentin	Desmin	SMA	S100	CK
1	Lymphoma T cell	+++	-ive	-ive	NT	NT	NT	NT	NT	NT
4	Lymphoma T cell epitheliotrophic	+++	-ive	Scattered +	NT	NT	NT	NT	NT	NT
6	Lymphoma T cell epitheliotrophic	+++	-ive	-ive	NT	NT	NT	NT	NT	NT
7	Lymphoma T cell epitheliotrophic	+++	-ive	-ive	NT	NT	NT	NT	NT	NT
8	Leiomyosarcoma	NT	NT	NT	-ive	++	Patchy +	+++	Patchy +	NT
11	Lymphoma B cell	+ive Infiltrating T cells	++	Diffuse +	NT	NT	NT	NT	NT	NT
13	Lymphoma T cell	+++	Scattered +	-ive	NT	NT	NT	NT	NT	NT
14	Lymhoma B cell	-+ Infiltrating T cells	+++	Patchy ++	NT	NT	NT	NT	NT	NT
17	Lymphoma	Scattered +	Patchy +	-ive	NT	NT	NT	NT	NT	NT
18	GIST	NT	NT	NT	+++	+++	-ive	++	Patchy +	NT
19	Lymphoma B cell	+++ in remainder of cells	+++ in some viable cells	-ive	NT	NT	NT	NT	NT	NT
20	Leiomyosarcoma	NT	NT	NT	-ive	Patchy	+++	++	-ive	NT
22	Lymphoma T cell	+++	10%+++	-ive	NT	NT	NT	NT	NT	NT
23	Lymphoma T cell	+++	Scattered +	-ive	NT	NT	NT	NT	NT	NT
24	Lymphoma T cell	+++	-ive	-ive	NT	NT	NT	NT	NT	NT
29	GIST	NT	NT	NT	+++	+++	-ive	Patchy ++	++	NT
30	Leiomyoma	NT	NT	NT	Scattered +	Patchy +	+++	+++	Patchy +	NT
31	Adenocarcinoma or mesothelioma	NT	NT	NT	NT	Multifocal + to +++	NT	NT	NT	+++
32	GIST	NT	NT	NT	++	+++	-ive	++	-ive	NT
33	Lymphoma T cell	Diffusely +	-ive	Very occasional	NT	NT	NT	NT	NT	NT
34	GIST	NT	NT	NT	+++	+++	Smooth Muscle cells + Neoplastic cells -ive	Smooth Muscle cells + Neoplastic cells -ive	NT	NT

CD3, cluster of differentiation 3; CD79a, cluster of differentiation 79a; PAX5, paired box 5; CD117, C-kit/proto-oncogene receptor tyrosine kinase; SMA, smooth muscle actin; S-100, S-100 protein; CK, cytokeratin; NT, nontested.
Staining intensity: -ive, negative; +, mild; ++, moderate; +++, marked.

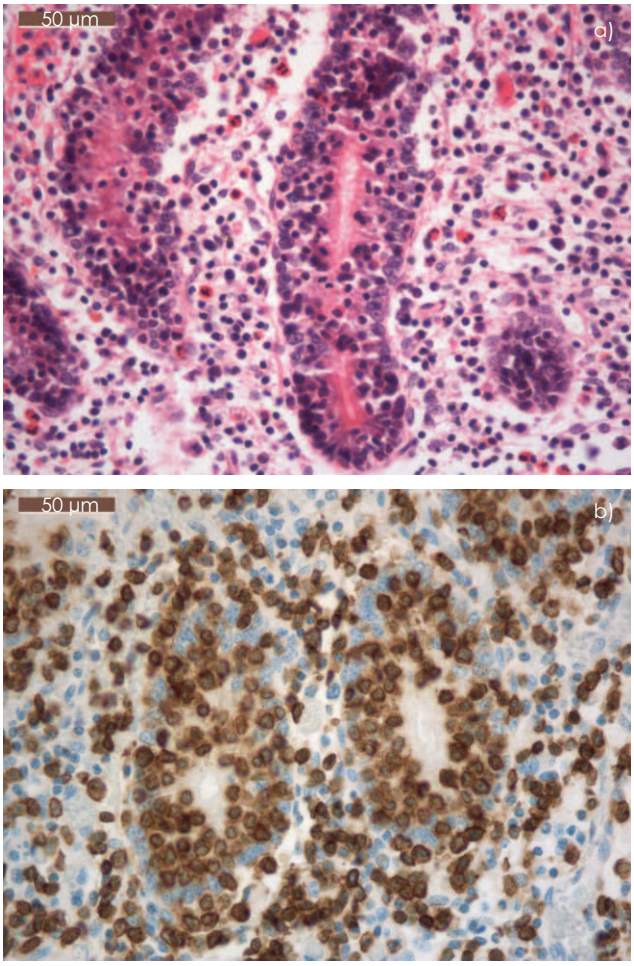

Fig 10: Case 6 (T cell epitheliotrophic lymphoma). a) Photomicrograph showing crypt epithelium infiltrated by neoplastic lymphocytes with scattered lymphocytes and eosinophils in lamina propria. HE × 40. b) Immunohistochemistry (CD3) showing positively staining (brown) neoplastic intraepithelial lymphocytes.

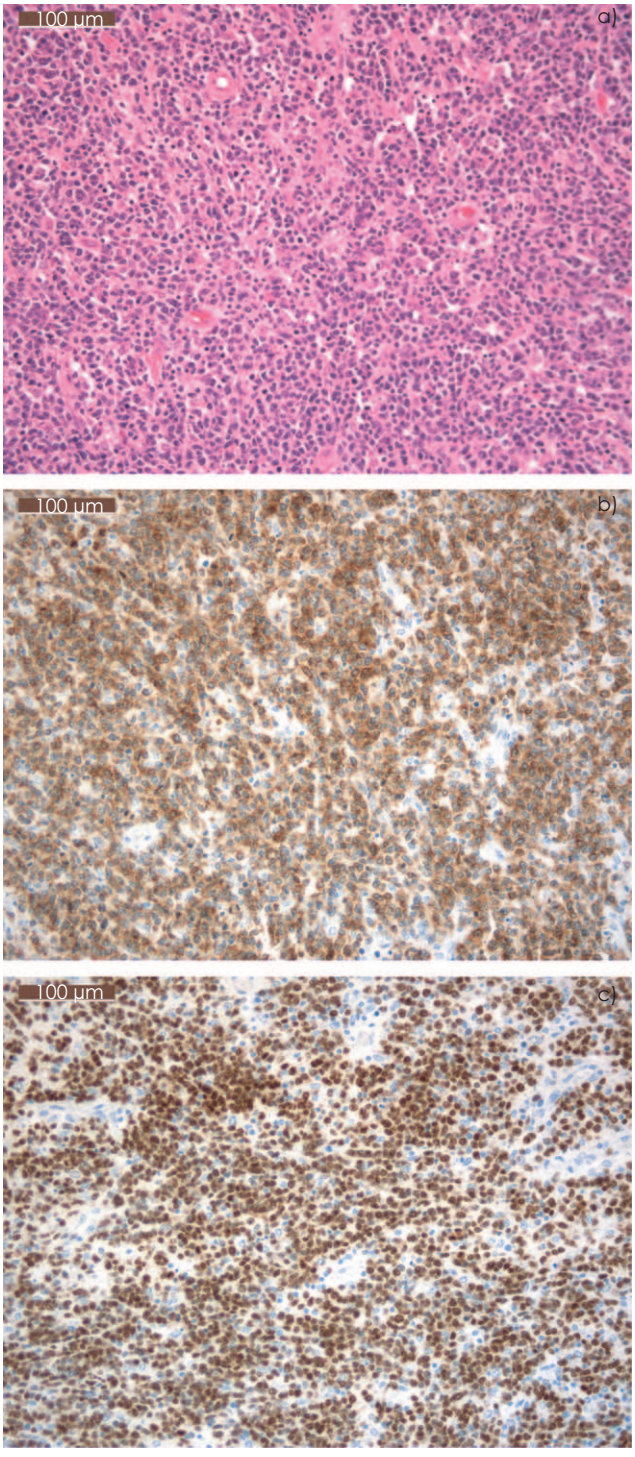

Fig 11: Case 14 (B cell lymphoma). a) Sheet of round neoplastic cells. HE × 20. b) Immunohistochemistry (CD79a). Positive cytoplasmia staining of the majority of neoplastic cells with fewer nonstaining T cells. Mitotic figures are visible. c) Immunohistochemistry (Pax5) positive nuclear staining of B cells (and nonstaining T cells).

are not as rare as once thought (Del Pietro *et al.* 2001; Hafner *et al.* 2001; Muravnick *et al.* 2009; Rapp *et al.* 2014). The average age of horses with GISTs (23.6 years) was older than that of lymphoma (18.6 years), consistent with other reports of GISTs in horses (Del Pietro *et al.* 2001). Four cases had an acute presentation and one chronic. In two acute colic cases, the tumour was an incidental finding at exploratory laparotomy. This is consistent with previous reports of GISTs where the tumours were also commonly found as incidental findings during laparotomy or necropsy (Del Pietro *et al.* 2001; Hafner *et al.* 2001). The cases involved solitary or multinodular masses, varying in size from a few cm to 50 cm in diameter. GISTs were more commonly located in the large intestines.

Tumours believed to be of smooth muscle origin were diagnosed in five horses (three leiomyosarcomas and two leiomyomas), confirming the proposition that these are uncommon tumours of the intestines (Hulland 1978). Although there are a number of older reports of intestinal smooth muscle tumours in horses (Collier and Trent 1983; Mair *et al.* 1990, 1992; Haven *et al.* 1991; Casper and Doran 1993), at least some of these are likely to have been misclassified and were in fact GISTs.

All four cases of adenocarcinoma identified in this series had chronic presentations with recurrent colic, which is similar to previous reports of this tumour (Wright and Edwards 1984;

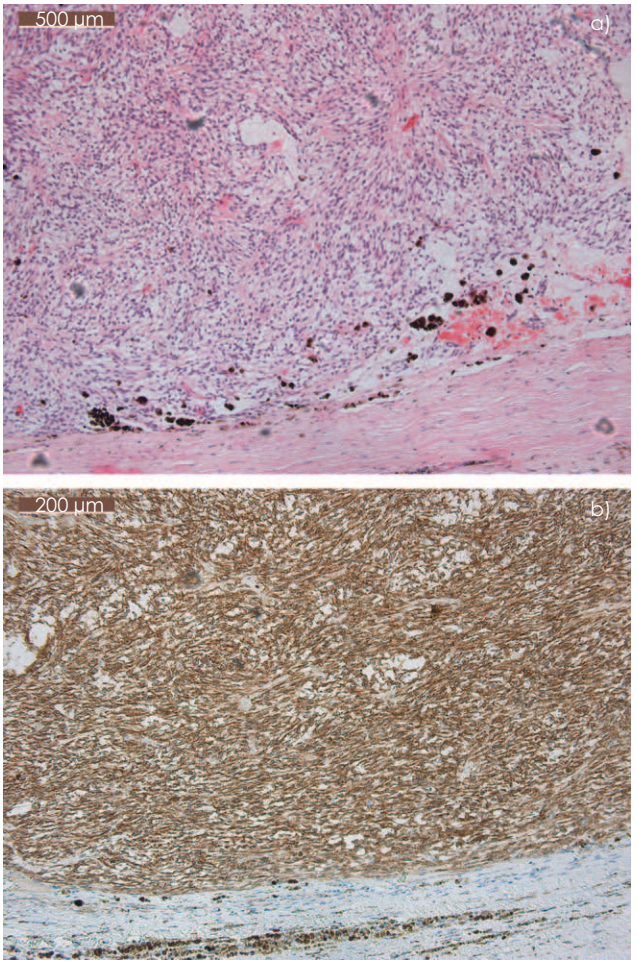

Fig 12: Case 18 (GIST). a) Photomicrograph showing spindle cell tumour adjacent to the external smooth muscle layer at the bottom of the figure. The dark cells in the smooth muscle are haemosiderophages indicating previous haemorrhage. HE × 10. b) Immunohistochemistry (CD117; c-Kit). Positive (brown) cytoplasmic staining of spindle cells of the GIST.

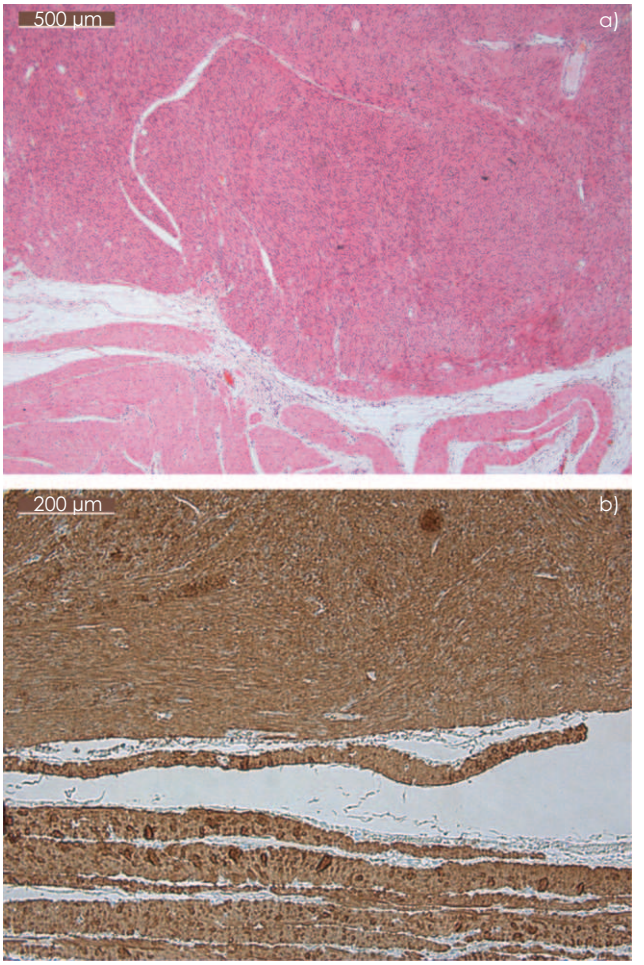

Fig 13: Case 20 (leiomyosarcoma). a) Photomicrograph of intestinal leiomyosarcoma with normal external muscle layers at bottom of the figure (artefactual processing splits are present deep to the tumour and in the external muscle layers). HE × 4. b) Immunochemistry (desmin). Positive staining (brown) of tumour cells and the external muscle layers (artefactual processing splits are present deep to the tumour and in the external muscle layers).

Honnas *et al.* 1987; Harvey-Micay 1999; Taylor *et al.* 2006). The case of undifferentiated adenocarcinoma/mesothelioma also had a chronic presentation with pyrexia of unknown origin; undulating fever has been reported previously in horses with intestinal adenocarcinoma (Fulton *et al.* 1990). The average age of cases with adenocarcinoma and adenocarcinoma/mesothelioma was 16.8 years, compared with 20 years in 11 cases reported by Taylor *et al.* (2006). Adenocarcinoma was found most commonly in the large intestine (three of four cases), in agreement with most other reports of intestinal adenocarcinoma (Rottman *et al.* 1991; Kirchhof *et al.* 1996; Harvey-Micay 1999), but different to the cases reported by Taylor *et al.* (2006), who reported 82% of cases in the small intestine.

There was no sex or breed predispositions found in the current study. This is in contrast with an apparent predisposition to adenocarcinoma in Arabians identified by Taylor *et al.* (2006). The Arab/Arab-crosses in the current study had lymphoma (one case) and GIST (two cases). These differences in breed prevalence are likely to be a reflection of differences in breed compositions of the caseloads in the two different geographical areas. Forty-eight percent of cases in the current study were in pony breeds; although this might suggest a breed susceptibility, it is more likely to be a reflection of clinic caseloads or may be due to the longer lifespan of ponies, given that the average age of presentation was 19 years. Other studies have reported a trend to keep horses and ponies into older age and to provide higher levels of veterinary care to older horses (Brosnahan and Paradis 2003; Ireland *et al.* 2011). The results of the present study likely reflect these observations.

Ten cases had an acute presentation, nine with colic and one with respiratory distress. The remaining 24 horses had a clinical course prior to presentation of weeks to months, indicating that the diseases had a progressive nature. Despite this, there are previous reports of acute presentation of intestinal neoplasia (Spoormakers *et al.* 2001; Moran *et al.* 2008; Sanz *et al.* 2010; Matsuda *et al.* 2013), likely due to the local inflammation caused by the tumour and mass lesions affecting gastrointestinal motility, predisposing to entrapment, intussusception and volvulus. In five cases the tumour was

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TABLE 3: Diagnoses and survival times in horses discharged from hospital/clinic

Case number	Diagnosis	Surgical resection performed	Survival time from discharge	Alive at time of writing	Treatment post discharge
1	Lymphoma	No	12 days	No	Prednisolone
2	Leiomyosarcoma	Yes	Discharged	Lost to follow-up	None
4	Lymphoma	No	2 months	No	Codeine
6	Lymphoma	No	Discharged	Lost to follow-up	Codeine and Prednisolone
10	Lymphoma	No	Discharged	Lost to follow-up	None
12	Lymphoma	No	4 months	No	Codeine
14	Lymphoma	Yes	6 years	No	None
25	Leiomyoma	Yes	10 months	Yes	None
30	Leiomyoma	Yes	17 months	Yes	None
32	GIST	Yes	2 months	Yes	None

found at surgery as an incidental finding and removed. Three cases were euthanized due to significant intestinal compromise, but the remaining two cases continue to do well post-operatively (discharged 2 and 17 months prior to writing, respectively), after complete resection of the mass/nodule (GIST in one and a serosal leiomyoma in one). These cases would likely have presented with a more chronic nature at a later date as the tumours progressed, but are an indication that if early detection and surgical resection is possible, the prognosis may be good.

Weight loss, likely secondary to protein losing enteropathy, malabsorption and/or cancer cachexia, was the most common historic clinical sign. Hypoalbuminaemia was identified in 12 of the horses, and an oral glucose absorption test revealed abnormal results in 3/4 cases in which it was performed. Reduced appetite was also reported in 8/34 horses. Hyperfibrinogenaemia was recorded in 16 of the 30 horses, and elevated serum amyloid A concentration in four horses (serum amyloid A was not assayed in the majority of cases); these acute phase responses were likely due to the release of inflammatory cytokines by the neoplasm and surrounding tissues. Anaemia was present in only four cases (12%), which was fewer than expected as it is generally considered to be a hallmark of chronic disease and has been previously described in association with one-third of cases of lymphoma (Schalm 1981).

Rectal examination identified an abnormality in 14/21 horses (67%); of these there was a palpable mass in six cases, a finding highly suggestive, but not conclusive, of neoplasia. Rectal biopsy was abnormal in 2/3 cases (67%) (lymphoma in one horse and proctitis in another). Taylor *et al.* (2006) reported abnormal rectal biopsy histopathological findings in 6/6 horses (proctitis in three and lymphoma in three). Although inflammatory changes are commonly seen in rectal biopsies of clinically normal horses, these results suggest that rectal biopsy may be helpful in some cases of intestinal neoplasia such as diffuse lymphoma.

Transabdominal ultrasonography revealed clinically significant abnormalities in 91% of cases (21/23 horses), and the findings were comparable with surgical and post-mortem findings. The commonest ultrasonographic abnormality was a soft tissue mass (10/23 cases, 43%), (**Figs 4** and **9**), and in all of these cases a mass was subsequently found at surgery or post-mortem examination. Previous reports of intestinal neoplasia describe increased intestinal mural thickness to be the most common finding (Taylor *et al.* 2006), with other reported abnormalities including lymphadenopathy, peritoneal effusion, and splenic or hepatic lesions (Janvier *et al.* 2016). The latter findings are nonspecific and may be seen in cases of inflammatory bowel disease, peritonitis, splenic or hepatic disease. The good correlation between the presence of a mass on transabdominal ultrasonography and the post-mortem and surgical findings, and the finding of a mass lesion in nearly 50% of cases in which ultrasound was performed, underline the importance of this diagnostic modality in reaching a tentative diagnosis of intestinal neoplasia. However, more invasive diagnostic procedures (e.g. biopsy or aspirates) are required for a definitive diagnosis.

Exploratory laparotomy was performed in 18 horses, and provided a definitive diagnosis of neoplasia in all cases; furthermore it allowed surgical resection in seven cases. All surviving cases at the time of writing had resection of the neoplasm at exploratory laparotomy.

The most common site of tumour origin was the jejunum (13 cases). Sixteen cases had neoplasia of the small intestine, 12 of the large intestine, five had generalised disease and the lesion location was not recorded in one case. These findings are broadly similar to those of Taylor *et al.* (2006), who recorded the location of neoplasia in the small intestine in 76% of cases, the large colon in 38%, caecum in 24% and small colon in 21% (with 26% having multiple sites).

This report confirms that intestinal neoplasia usually presents as a chronic debilitating disease, but can also be identified as an incidental finding in horses undergoing exploratory laparotomy for acute colic. In agreement with previous reports (East and Savage 1998; Taylor *et al.* 2006), our findings confirm that intestinal neoplasia is most commonly seen in older horses, and most commonly affects the small intestine; our series had no breed predispositions. Alimentary lymphoma was the commonest intestinal neoplasm in our population of horses, followed by GISTs, smooth muscle tumours (leiomyoma and leiomyosarcoma), and adenocarcinoma. Transabdominal ultrasound was a valuable diagnostic tool in the investigation of these cases. Complete surgical resection, if possible, offers the best prognosis, but prognosis in most cases remains grave.

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No conflicts of interest have been declared.

Ethical animal research

No declaration required for this clinical review. Owners gave consent for publication of images.

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Authorship

J. Spanton and T. Mair worked equally on the review design, data analysis and interpretation, preparation and final approval of the manuscript. J. Spanton executed the review of information for each case. D. Fews performed the majority of histopathology and immunohistochemistry on the cases within the review. All authors gave their final approval of the manuscript.

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Supporting information

Additional Supporting Information may be found in the online version of this article at the publisher's website:

Supplementary Item 1: Summary of the presenting clinical signs in 34 horses with intestinal neoplasia.

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Critically Appraised Topic

Wobbler surgery: What is the evidence?

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Summary

In a recent multicentre study, 66% (173/266) horses diagnosed with cervical vertebral malformation (CVM) were subjected to euthanasia – 96% of those due to perceived poor prognosis (Levine *et al.* 2010). Reported prevalance of CVM in Thoroughbred horses is 1.3–2% (Wagner *et al.* 1986; Oswald *et al.* 2010). Conservative and surgical treatment strategies are still mired in controversy as to their ability to successfully alleviate clinical signs of ataxia and return horses to an intended use of any sort.

Question

In horses with cervical vertebral stenotic myelopathy (CVSM) (Wobbler syndrome, cervical vertebral malformation [CVM]), is surgical treatment more effective than medical treatment in alleviating clinical signs of ataxia?

Search strategy

Literature searches were conducted for articles published in English on the Pubmed database (inception to May 2017), the CAB Abstracts database (1973 to January 2017) and using Google Scholar. Search terms included 'equine', 'cervical', 'myelopathy', 'interbody', 'fusion', 'wobbler' and 'ataxia'. Conference proceedings were also checked. Articles were included if they reported outcome following treatment of cervical vertebral stenosis or myelopathy. Given the paucity of recent literature, all literature was reviewed and most of those relevant to parameters above were included in the review. The most relevant surgical papers are tabulated to provide a comparison of evidence for surgical intervention of CVSM (**Table 1**).

Discussion

Conservative treatment consists of combinations of strict stall confinement, anti-inflammatories and dietary modifications designed to reduce growth spurts in younger horses. Resolution of neurological signs was observed in 75% of mildly affected (neurological) foals or yearlings with equivocal radiographic changes who were fed decreased protein and low nonstructural carbohydrates (total 1.5% bodyweight, which is 75% of the 2% bodyweight recommended feed for normal horses) with soaked hay, vitamin E and selenium and had prolonged total confinement (Donawick *et al.* 1993; Kronfeld 1993). Alternate flunixin meglumine (1.1 mg/kg per os) and dexamathasone (0.02 mg/kg per os) administration for 30 days in conjunction with vitamin E supplementation (5000 IU daily) aids in reduction in physitis and the cord damage associated with degenerative myelopathy (Nout and Reed 2003). Thoroughbreds with radiographically evident CVM who go on to race following conservative treatment have significantly less neurological grades in the thoracic and pelvic limbs, are less than 1 year of age and have dynamic radiographic changes – epiphyseal flaring and caudal extension of the dorsal laminae – both of which can remodel when the growth rate of the horse is managed (Hoffman and Clark 2013). Permanent changes of the cervical spine (kyphosis or cranial stenosis on standing lateral cervical radiographs) cause repeated compression of the spinal cord. Affected young Thoroughbreds were significantly less likely to race and are more likely to be subjected to euthanasia when treated conservatively (Hoffman and Clark 2013). Only 30% had at least one racing start (Hoffman and Clark 2013). However, CVM was a presumptive diagnosis with myelographic confirmation in only 5/103 cases calling into question the real incidence of those individuals truly affected with cervical stenosis resulting in cord compression. Therefore, it is logical to conclude that the horses <1 year of age with evidence of kyphosis and/or stenosis of the cervical foramen require surgical fusion for a successful outcome.

In the skeletally mature horse, clinical signs of CVSM are due to degenerative pathology of the articular process joints and the surrounding soft tissues that result in static (most commonly) or dynamic cord compression most commonly in the caudal cervical articular process joints (C5 to T1). Resolution of ataxia in such horses depends on response to systemic and increasingly intra-articular medication. Successful treatment is therefore dependent upon accurate site specific identification of bone and soft tissue proliferation of the articular process joint. Radiographic and ultrasonographic lesion identification (Birmingham *et al.* 2010) has been superceded with the advent of computed tomographic myelography in which bone detail is greatly enhanced (Kristoffersen *et al.* 2014). Specific site, laterality and location of bone related lesions, as well as presence of lateralised or ventral to dorsal compression can be realised (Kristoffersen *et al.* 2014). In conjunction with flexed radiographic myelographic views, this procedure is now transforming our understanding of cervical pathology and the consequences on the spinal cord. It enables more accurate identification of pathology, the presence of axial versus abaxially located bony pathology which in turn has a bearing of how that horse will respond to intra-articular medication. Evidence for conservative therapy of CVSM in the skeletally mature horse largely involves the use of intra-articular medication based on radiographic evidence of typical degenerative changes in conjunction with clinical signs. Following intra-articular corticosteroid medication, 32% of horses have improved performance although in 50% of the improved cases the effect lasted only 1–6 months (Birmingham

TABLE 1: Clinically relevant reports illustrating clinical features and outcomes in horses that have undergone cervical interbody fusion

Author	No. of horses	Neurological grade	Discipline	Diagnostic criteria	CVSM type	Arthrodesis technique	Criteria for success	Outcome
Nixon and Stashak (1983)	17	Mixed	Sport horse/ pleasure	Myelogram	Static	Basket	Resolution	100%
Walmsley (2005)	28	Grade 1–3	WBs/PH	Myelogram	Static and Dynamic	Basket	Return to intended use and normalised gait	61% overall C3/4: 71% C6/7: 56%
Grant *et al.* (1985)	72	Grades 1–4	Racing/ Sports/ Mixed	Myelogram	Static and Dynamic	Basket	Return to intended use Competitive use	79% 65%
Nixon (2002)	27	Unknown	Mixed	Myelogram	Dynamic and Static	Basket	Resolution of ataxia	56%
Moore *et al.* (1993)	73	Grades 1-4	Mixed	Myelogram	Dynamic and Static	Basket	Improved neurological function Return to racing	77% 23%
Grant *et al.* (2007)	12	Triple level median grade 3	Mixed	Myelogram		Basket	Improved neurological function Return to ridden work	92% 1 grade 75% 2 grades 83%
Reardon *et al.* (2009)	1	Grade 3	3-month-old foal	Myelogram	Dynamic	Locking compression plate	Resolution of ataxia	100%
Total	230		Foal to mature	Myelogram	Dynamic and Static		Return to ridden exercise or improved neurological function	74.7%

et al. 2010). Older ataxic horses had a 60% improvement with an average 2 grades improvement of ataxia that was effective for 1–8 years (average 2 years) (Kristoffersen *et al.* 2014). Horses with milder grades of ataxia (less than grade 3), normal MSD ratios and moderate APJ changes (grade 3a–4b) are good candidates for medication (Hepburn 2012).

Surgical intervention for CVSM in the form of cervical intervertebral body fusion has been performed in horses for nearly 40 years on an estimated 2500 horses (Moore *et al.* 1993). Dynamic instability of the cervical spine resulting from malarticulation of adjacent vertebrae requires cervical arthrodesis to stabilise the malarticulated vertebrae and prevent further compression of the spinal cord irrespective of the age of horse. Similarly degenerative changes affecting the axial surfaces of the APJs that result in impingement of the spinal cord when the neck is in flexion or extension will be unlikely to respond to conservative treatments and require stabilisation for maximising prevention of further spinal cord trauma. With strict selection criteria including >/=50% narrowing of the dorsal myelo- graphic contrast column, grades 1–4 neurological horses of ages from 6 months to 24 years of age and of disciplines including showing, pleasure, racing, dressage, showjumping and eventing have had surgery successfully performed (Nixon and Stashak 1983; Grant *et al.* 1985, 2007; Nixon 2002; Walmsley 2005; Reardon *et al.* 2009; Araujo *et al.* 2015). Definition of success includes return to riding, racing, showing, training, ability to be used for breeding purposes or resolution/improvement in neurological symptoms (Nixon and Stashak 1983; Grant *et al.* 1985, 2007; Moore *et al.* 1993; Nixon 2002; Walmsley 2005; Reardon *et al.* 2009; Araujo *et al.* 2015). Resolution of neurological signs was reported following C5/6 or C7/T1 fusion in 17 cases with static compression due to degenerative changes of the articular process joints. Indeed, regression of bony arthritic changes was seen 12 months post-operatively with all horses showing resolution of neurological signs (Nixon 2002). Walmsley (2005) reported a 61% return to a satisfactory gait after 12 months follow-up of 28 cases. 56% of skeletally mature horses with C6/7 compressive lesions returned to ridden exercise or intended use and had a normalised gait (Walmsley 2005). 71% (5/7) horses with C3/4 compression returned to full work with a normalised gait (Walmsley 2005). Grant *et al.* (1985) reported 57/72 (79%) horses returning to intended use and 65% of these returning to competitive functions as either racing or showing disciplines (Grant *et al.* 1985). 56% of 27 surgically arthrodesed mixed age and discipline horses had resolution of ataxia although the neurological grade and site of the lesion was not reported (Nixon and Stashak 1983). Neurological function was improved in 56/73 (77%) of horses undergoing cervical interbody fusion with 23% returning to race training (Moore *et al.* 1993). Most impressively in a report of 12 surgically managed, myelographically confirmed triple level cervical cord compression cases with a median presurgical ataxia score of 3/5 and a median age of 1 year, 92% improved 1 and 75% 2 neurological grades after 1 year. 10/12 horses returned to ridden exercise, two of which raced and won. Horses can live productive/competitive lives without the need for daily medication therefore demonstrating the clear benefit of surgical management in cases in which conservative treatment would have been unlikely successful. It should be noted that in three horses >/= to 4 years all cases improved from 3/5 to 1/5 and returned to being ridden pleasure horses in this report (Grant *et al.* 2007).

Clinical conclusions

In summary, surgical correction of CVSM carries a favourable long-term outcome in yearlings and skeletally mature horses for resolution of ataxia. Although success rates of surgical correction in horses </= to 18 months of age in which the dynamic form of CVSM are more commonly seen are greater, good outcome for mature horses with static

degenerative myelopathy are also reported. With both groups of horses, surgical cervical inter body fusion has a higher published success rate than conservative treatment in all but the lowest grades of ataxia caused by confirmed degenerative soft tissue lesions of the older horses APJs.

Author's declaration of interests

No conflicts of interest have been declared.

Ethical animal research

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