EQUINE VETERINARY EDUCATION/AMERICAN EDITION

VOLUME 32 NUMBER 6

JUNE 2020

EQUINE VETERINARY EDUCATION

American Edition | June 2020

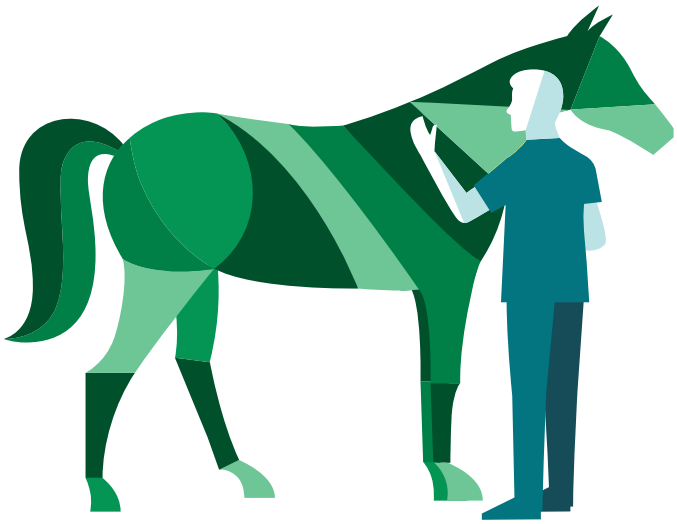
BEVA

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

IN THIS ISSUE:

stablelab

Stablelab detects infections with 30 times greater sensitivity than a thermometer.[1]



Stablelab is a hand held device that measures Serum Amyloid A, a biomarker of infection, and provides results in 10 minutes stall side.

Detect
Detect and measure infection

Monitor
Monitor response to treatment

Screen
Implement protocols to catch problems early

Incorporate Stablelab into your routine clinical exams in cases such as:

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- ADR
- Cellulitis
- Colic
- Critical care
- Diarrhea
- EIPH
- General infections
- Infectious disease
- Joint sepsis/flare
- New foal exam
- Fever of unknown region
- Maladjusted foal
- Metritis
- NICU
- Peritonitis
- Pneumonia
- Poor performance
- Postoperative follow up
- Postpartum
- Premature foal
- Preoperative screening
- Respiratory disease
- Rhodococcus equi
- Rotavirus
- Shipping fever
- Strangles
- Viral infections
- Umbilical infection

hello@stablelab.com | **www.stablelab.com**

[1] Oertly. et al. The accuracy of Serum Amyloid A in determining early inflammation in horses following long-distance transportation by air. AAEP Proceedings, 2017 460-461.

zoetis

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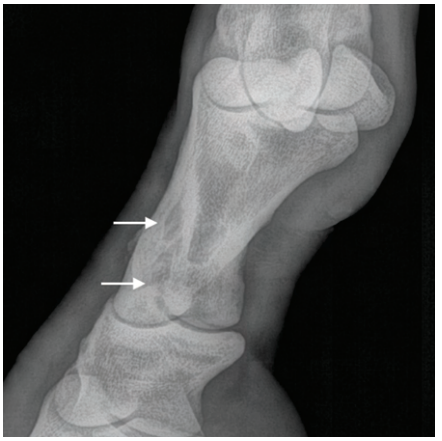

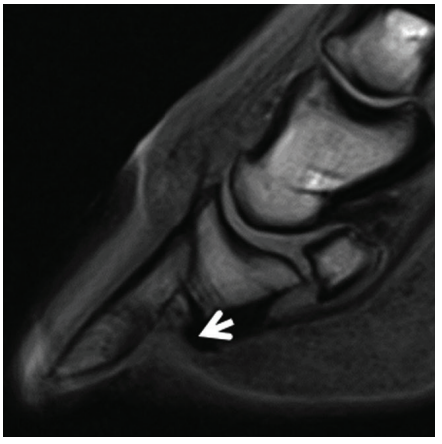

Cover photo by Dr. Ruth Sobeck.

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EQUINE VETERINARY EDUCATION
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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: Progressing through challenges

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

Dr. David Frisbie

I hope this finds you safe and well. I am writing this letter between figuring out what a straight angle is for my daughter's homeschool math class and what seems to be a traffic jam of Zoom meetings, hoping that more elective orthopaedic cases materialize soon.

We have always known trying to define a routine day in equine practice is difficult, but the last few months have raised so many uncertainties and questions that have unknown or ill-defined answers that it is staggering to me. As we cope and continue on in our own ways, the AAEP community and staff continue to impress me and make me proud to be an AAEP member. Donations of time, PPE and ventilators are just a few of the examples we have seen from our community as well as the daily resiliency of managing constantly in-flux clinical practice, anxious staff and clients, and a new type of home life.

The AAEP continues to assess and adapt to membership input, trying to best serve our members. Hopefully, you have had an opportunity to visit AAEP Anywhere, which launched in April. AAEP Anywhere is our online learning platform where members can obtain free CE credits for license renewal as part of their member benefits. New content is routinely added to the service, which you'll find at aaepanywhere.org; simply log in using the same credentials you use to access the main AAEP website. Another great example of the AAEP responding to members' needs is the recent return of a document retrieval service to help members obtain the latest scientific publications.

Our strategic work continues to move forward as well. As you may remember, our strategic planning of 2019 led to three main areas of focus: the profession, continuing education and the horse. Specifically, with regards to the profession, our goal is to improve the retention of veterinarians in equine practice. To help achieve this goal, we are ramping up AAEP's Outrider mentorship program and planning for a leadership workshop this fall in Lexington for some of our newer members. In the long run, we will be gathering pertinent feedback utilizing a mission model canvas (a tool validated by Stanford Business School) to develop programming and other resources to address retention and recruitment.

Many of our CE goals are coming to fruition with the launch of the online CE portal mentioned earlier and the analysis of the recently conducted CE Needs Assessment, which provided great feedback for future programming and strategy from over 1,600 member respondents. Meanwhile, recently developed and released medication guidelines for horses in competition and how they relate to health and welfare issues are early successes of the goal centered around the horse. All of these accomplishments are occurring in the first year of a three-year plan.

How to proceed with scheduled meetings for 2020 is also an area in which we find ourselves in need of flexibility and creativity. Due to current travel restrictions and safety concerns, we have rescheduled the summer Focus and 360° meetings for 2021, with all registrants receiving a full refund. In place of these offerings, we are working to create a virtual meeting for August. At this point, the Annual Convention in Las Vegas is still a go but we will continue to monitor events for the fall with member and staff safety in the forefront of our minds.

...we don't know what each day will bring, but being resilient, having a sense of humor and doing our best will yield a sense of accomplishment as we forge ahead.

For those of you who held on to the end, a straight angle is one defined by 0 degrees or yes, you guessed it, a straight line—OMG how embarrassing to have to need to look this up! I think the moral here is we don't know what each day will bring, but being resilient, having a sense of humor and doing our best will yield a sense of accomplishment as we forge ahead.

Be safe, be well.

5 things to know about AAEP this month

1. Save considerably on your annual convention registration and hotel room by taking advantage of early-bird rates at convention.aaep.org.
2. Learn more about the AAEP's new Virtual CE Summer Series on the topics of lameness and imaging at aaep.org/meetings.
3. Access revised guidelines for selected core and risk-based vaccines on the Publications App or at aaep.org/guidelines/vaccination-guidelines.
4. Review the AAEP Healthy Horse Protocol: Biosecurity Guidelines for Racetrack Entry and Stabling on the Publications App or at aaep.org/guidelines/infectious-disease-control.
5. Discover The Foundation for the Horse's growing impact in its 2019 annual report, accessible on the Publications App or at foundationforthehorse.org/about/financial-reports.

Updated Vaccination Guidelines available

Routine vaccinations considered essential during COVID-19 pandemic

The Infectious Disease Committee has issued revised guidelines for the administration of selected core and risk-based vaccines to horses. The recommendations are based on the age of the horse and its previous vaccination history and are meant to serve as a reference for veterinarians.

Among important modifications to the Vaccination Guidelines for Horses:

- The **Adult Horse Vaccination** and **Foal Vaccination charts** have been updated to match changes made in various vaccination guidelines and vaccine manufacturer label recommendations. Changes to the foal chart also include updates to the Rabies vaccination recommendations for vaccinated vs. unvaccinated mares. Changes to the adult horse chart include updates to the broodmare section to recommend vaccinating those mares pre-partum with a "respiratory EHV" product in addition to the abortion product.
- The **Anthrax** guidelines indicate that the disease can be contracted in an endemic area via vector-borne transmission. Further recommendations have been added for horses during an outbreak (e.g., vaccinate afebrile horses not showing clinical signs).
- The **Eastern Equine Encephalomyelitis** and **Western Equine Encephalomyelitis** guidelines encourage veterinarians to consult with vaccine manufacturers for their geographic region and to consider the region's case frequency for the current year and in recent years.
- The **Equine Influenza** guidelines include recommendations for horses that have recovered from natural infection. It also notes that some facilities and competitions may require vaccination within the previous 6 months to enter.
- The **Equine Viral Arteritis** guidelines indicate that the occasional stallion may shed very low concentrations of vaccine virus in its semen for several days following first-time EVA vaccination and the recommendation to confirm negative status prior to vaccination.
- The **Leptospirosis** guidelines incorporate recommendations for foals as young as 3 months of age and emphasize that the licensed vaccine is safe for pregnant mares at all stages of parturition.
- The **Rabies** guidelines provide guidance for how to approach a horse that has been exposed to a confirmed rabid animal.

The Infectious Disease Committee emphasizes that routine vaccinations are considered essential during this COVID-19 pandemic, and overdue vaccinations should be completed to help prevent disease in horses. Duration of immunity for some vaccines might be limited to 6 months; therefore, maintaining a routine vaccination schedule is critical for horses at high risk of developing these diseases, and vaccinations should be scheduled as soon as reasonably possible to ensure the health and welfare of the horse. In all cases, veterinarians should consider local conditions and current state-imposed regulations to determine when vaccinations can be completed safely during this unprecedented time.

The complete guidelines, along with easy reference charts, are available at aaep.org/guidelines/vaccination-guidelines and on the Publications App. Search "AAEP Publications" at the App Store or Google Play to download.

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

By William Moyer, DVM, DACVSMR

My initiation into disaster response involved a two-barn fire at a racetrack just four years into my career in 1974. When I arrived on scene as the only veterinarian, fire trucks with sirens blaring were headed in as horsemen attempted to manage approximately 900 horses. Few horses were injured from the fire, but the onrush of well-meaning fire personnel led to serious injury of three frightened horses.

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

Following that successful effort, our Large Animal Clinical Sciences Department began setting up and managing horse evacuations in subsequent disasters. This eventually led to creation of the Texas A&M University Veterinary Emergency Team, which has responded to scores of disasters, often with Texas Task Force I (search and rescue). Ultimately, TAMU VET convinced the College of Veterinary Medicine to create a required two-week rotation in emergency medicine and management.

My appreciation for the complexity and difficulty of providing veterinary care during disasters is renewed and reinforced with each experience, yet provision of rapid and adequate care to those affected remains challenging. Clearly, human concerns such as ensuring power, water, food, shelter, medical care, etc. is the priority; animal welfare is secondary, although both human and animal health mutually benefit from efficient resolution of crises.

The AAEP and its charitable arm—The Foundation for the Horse—have supported disaster relief efforts since 2005 through funding of equipment such as portable care units; providing supplies, feed and expertise; and coordinating with on-site practitioners to address greatest areas of need. AAEP members should be proud of The Foundation's past, present and future efforts to help horses and devastated owners during disasters.

Want to get involved? Here's how you can help animals in future disasters:

- Acquire training and learn how to participate with local, regional, state and national disaster management efforts. A disaster logistics dry lab will be offered at the 2020 AAEP Annual Convention. Sign up!
- Contact local emergency services regarding your interest in learning about and aiding in their plans to protect, save and return horses/animals to owners. Such engagement is overwhelmingly welcomed.
- Understand that emergency medicine is one animal at a time whereas disaster medicine/management often involves multiple animals. Therefore, it is important to know how to triage based on multiple factors such as safe access to those injured; availability of useful resources (medical supplies, shelters, transport, etc.); personnel security; and access to supporting veterinarians and technicians.
- Become a state or provincial equine emergency and disaster liaison with The Foundation for the Horse/AAEP to facilitate communication, needs and resources during disasters in your area. To help, contact Keith Kleine at kkleine@aaep.org.
- Encourage your CVM to include disaster medicine/management in its curriculum.
- Recognize your potential community impact—you may be the best or only expert for managing animal injury. You know what resources exist and you can make a difference; thus, you are awesome!

Dr. Moyer during his 2008 deployment to Iraq with a small team from Texas A&M to rebuild an active agricultural entity.

Being a first responder is not possible for everyone; however, knowing what is needed to respond means that all of us can be involved. This might be as a responder, resource provider, housing or shelter coordinator, medical expert via cellphone, expert on horse handling and transport, or financial contributor. The list of needs is endless.

With training and understanding, we—the AAEP and the veterinary medical profession—can upscale our collective ability to help both humans and animals when disaster strikes. Today is the day to plan how you can help others during the next disaster.

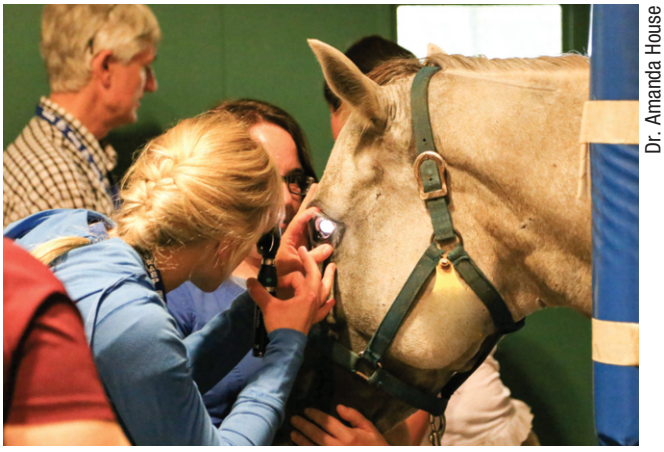
Dr. Moyer, 2011 AAEP president, lives in Billings, Mont. He retired from Texas A&M University College of Veterinary Medicine in 2015 after 22 years with the university.

360°, Focus postponed to 2021; new online CE series in works for August

Due to ongoing uncertainties surrounding coronavirus and its impact on travel and member safety, the AAEP has postponed both of its in-person summer continuing education events until 2021.

To fill the summer void and provide members with a meaningful learning experience, the AAEP is creating a Virtual CE Summer Series that will offer up to 16 hours of online, RACE-approved CE on the topics of lameness and imaging. Although the details were being formulated at press time for this issue, the series is expected to comprise a pair of two-hour courses each week during August. Members interested in this online learning opportunity are encouraged to check aaep.org/meetings for the most current information.

Those who were registered for or interested in the 360° Ophthalmology meeting should mark their calendar for June 23–26, 2021, when the immersive, small-group learning event is brought back at the University of Florida. Meanwhile, the 2021 date for the Summer Focus Conference & Labs, with tracks devoted to Podiatry and Sport Horse Medicine, has not been finalized. The meeting will remain in Lexington, Ky.



Dr. Amanda House

360° Ophthalmology will be held June 23–26, 2021, at the University of Florida.

Help your practice shine at the AAEP's 66th Annual Convention

Save $200 when registering online by Sept. 15

Acquire winning ideas that will help you and your practice shine through economic crisis and recovery at the AAEP's 66th Annual Convention, Dec. 5–9 in Las Vegas, Nev.

In a sign of the times, this year's convention may look a little different as health and safety protocols will be implemented by convention vendors Mandalay Bay, Freeman and Experient to ensure the wellbeing of attendees. However, the core of the convention will remain untouched with attendees taking home sound medicine ideas, disciplined management principles, wellness strategies and important relationships with colleagues and industry suppliers.

A slate of wet and dry labs will offer hands-on learning and skills development.

Attendees will once again have ample opportunities to go hands-on by participating in one or more wet and dry labs. Wet lab offerings under development for Saturday, Dec. 5 include dentistry and ultrasound, the latter held in conjunction with ISELP. A disaster logistics dry lab on the same day will equip participants to engage with local, regional, state and national disaster management efforts. Additional small-group dry labs will be presented on Sunday, Dec. 6 on the topics of podiatry, navicular bursa injection, uterine culture and cytology interpretation, and ultrasound-guided spinal joint injection.

Registration for all labs is on a first-come basis and should be completed when registering for the convention. Save $200 off the standard convention registration rate when registering by Sept. 15 at convention.aaep.org. You may also book your hotel room and browse the educational program on the site. Save $50 per night on your hotel room when booking by Sept. 15.

The educational program will encompass more than 100 hours of CE among evidence-based sessions that include imaging, infectious and non-infectious diseases, lameness, racehorse medication, rehabilitation, reproduction, sports medicine and more. Additional sessions will cover business topics, ethics and wellness; and the Kester News Hour will return in the popular format unveiled last year.

Supplement your learning by connecting with old classmates and colleagues and forming new relationships at daily social events; engaging with more than 300 solutions providers inside the trade show; and, if you're between jobs or looking for a new opportunity, meeting with dozens of practices that will be on-site looking to fill open positions through the convention career fair.

In what has been a year like no other, wrap up 2020 by joining with your AAEP family for a meeting like no other in a destination like no other.

Sport horse, field procedures courses added to AAEP Anywhere

In the first few weeks since the launch of the members-only online learning platform AAEP Anywhere, more than 325 CE certificates have been awarded for completion of interactive courses and timely podcasts covering a variety of clinical and practice management topics.

Most courses are RACE accredited, and additional courses are regularly added to the service. Recently added courses include:

- Lower Back and Pelvis Related Discomfort and Counter-Performance Issues in the Sport Horse by Dr. Philippe H. Benoit
- Essential Components of the Pre-Purchase Exam by Dr. D. Reese Hand
- How to Treat Complications of Castration in the Field by Dr. Tim G. Eastman

- How to Calculate the Dollars and Sense of Adding Oocyte Aspiration to Your Practice by Dr. Ryan A. Ferris

If you're looking to pick up an hour or two of CE toward license renewal, log in at aaepanywhere.org using the same credentials you use to access the AAEP's website. If you have questions about AAEP Anywhere, contact Karen Pautz, director of education, at ce@aaep.org or (859) 233-0147.

Ethics in the time of COVID-19

By Jackie Christakos, DVM

Dr. Jackie Christakos

We are living in an unprecedented time, full of uncertainty and anxiety. As veterinarians, we hold more knowledge than the average human in understanding infectious disease, herd health, and the variability of disease processes in individuals, which likely gives us some peace of mind amid the COVID-19 pandemic. Since our profession is considered essential in most states, many of us have been fortunate to retain our jobs; however, our daily operations have been anything but business as usual.

Many have been or are currently subject to executive orders from state leadership, requesting veterinary practices limit elective surgeries and procedures to preserve personal protective equipment (PPE) needed by human health care workers on the front lines. Additionally, practitioners have been asked to alter day-to-day interactions dramatically to conform with social distancing guidelines and do our part to limit the spread of the coronavirus. The caveat: veterinarians are required to use their own professional judgment in interpretation of these guidelines in the way they see fit. Herein lies the difficult, ethical decisions that keep many of us up at night.

How can I follow these guidelines and keep my staff employed? How will limiting these key procedures effect my ability to provide for myself and my family? What truly constitutes an urgent procedure? Why do I have to follow the guidelines if my neighbor practice chooses not to?

The answer is likely that there is no one answer—no one size fits all for every practice. Decisions must be made on a day-to-day, case-by-case, community-by-community basis. Government mandates and overall risk may be variable, even between neighboring counties. However, this strange time in history has forced us to ask ourselves if we are choosing from a position of self-interest or for the greater good of our fellow humans. How we perform our daily work may literally be the difference between life and death—for our equine patients as always but now also for the humans who care for them. The gravity of our decisions is greater than ever.

I have grappled with these ethical dilemmas in my own practice. Should I continue to perform lameness exams that are technically non-urgent but utilize no needed supplies for the human health crisis? Am I doing all I can to "flatten the curve" if I am interacting with multiple clients who are outside my social circle on a daily basis? If I stop seeing these cases, do my patients suffer the consequences?

As an associate of a large referral and primary care practice, I can tell you the discussions amongst veterinarians, staff, and practice owners have been frequent and heartfelt. All want to do the right thing: protect our families, staff, and clients; provide excellent care for our equine patients; and continue to make a living doing so. At times, though, these values have seemed mutually exclusive.

As a practice, we elected to suspend all non-critical joint injections, lameness procedures requiring PPE, and non-emergent surgical procedures during the time of our state's executive order, a difficult decision with significant financial consequences. We continue to care for our patients via emergency and wellness/maintenance care, but entered the strange new world of wearing masks, providing them to clients with whom we interact, and maintaining social distancing to name just a few of the enhanced biosecurity measures adopted by our clinic. Our waiting room, office, and barns are closed to visitors; and clients are required to wait outside during clinic appointments. Our weekly meetings have become virtual—we are proud that even the "technosaurs" among us have adapted and joined online. We miss the daily interactions with our colleagues that used to be commonplace, but in a way have bonded over a shared goal: safe and ethical practice.

I have no doubt some in our area feel we are continuing to do too much, while others may say we have gone overboard in the opposite direction by suspending the procedures we have. At the end of the day, our clinic had to come to its own decision and ethical boundaries, guided by our state's executive order as a framework. Knowing I am not compromising my own ethics, the social guidelines in my area, or the potential care of humans impacted by this terrible virus means the thing that keeps me up most at night is the emergency pager.

The late Supreme Court Justice Potter Stewart said, "Ethics is knowing the difference between what you have a right to do and what is right to do." Equine veterinarians are resilient, inventive folks. We will get through this difficult time with our strength, resolve, and adherence to that inner moral compass that leads us to what is right for our practices, our communities, and our patients. Stay safe out there.

AAEP ETHICAL PRACTICE Every Day-Every Time

Dr. Christakos is an associate with Littleton Equine Medical Center in Littleton, Colo., and a member of the AAEP's Member Engagement and Professional Conduct & Ethics committees.

Renew to maintain the benefits of professional family, resources

Flexible payment options available for members with financial constraints

Despite the challenges of COVID-19, the pandemic has reinforced the importance of community and togetherness in everyday life—both personal and professional. As a community of horse doctors, the AAEP strives to help members deliver excellent care, grow their practice and find satisfaction, even in the most trying of circumstances. As we approach the end of the membership year, we sincerely thank you for your perseverance through the difficulties and uncertainties of recent months and ask that we continue moving forward together.

The new membership year begins July 1, and the AAEP understands the sudden financial constraints for many practitioners. If you are unable to renew in full, the AAEP now offers both quarterly and monthly installment options to provide you with as much flexibility as possible. Renewing your membership maintains valuable benefits regardless of your career stage:

New practitioners: acquire timely case assistance in the AAEP Member Vet Talk group on Facebook and the online Rounds discussions; and obtain valuable support and advice in the non-clinical aspects of practice that are essential to career fulfillment through the new Outrider mentorship program.

Veteran practitioners: boost inventory efficiency and save money on many of the products and services used in everyday practice through complimentary membership in the AAEP Inner Circle on Vetcove and The Veterinary Club group purchasing program.

All practitioners: take advantage of no-cost online CE through the new AAEP Anywhere learning platform; save

Take advantage of discounted rates for AAEP CE events to bring home new knowledge and great memories of friends and colleagues.

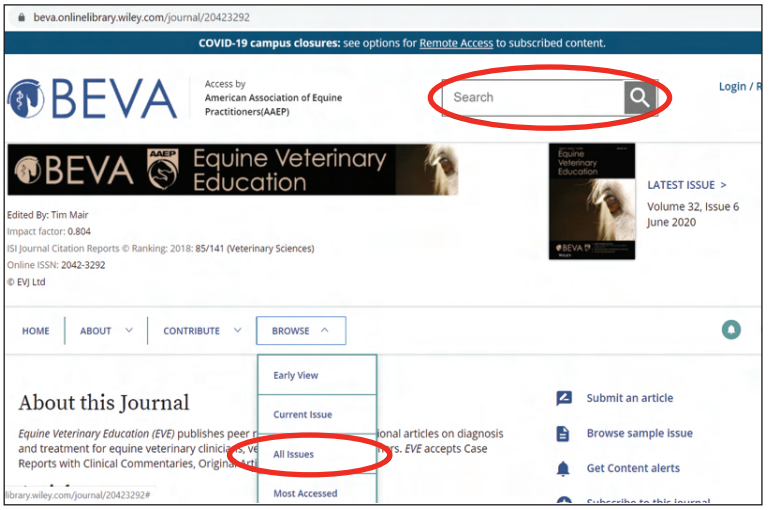
with preferential rates at AAEP's in-person CE events; satisfy your medical curiosity using the recently reinstated document retrieval service; acquire the latest diagnostics and treatments in the convention *Proceedings* and *EVE*; monetize your used practice equipment or save on the cost of purchasing through the Equipment Marketplace; and manage your business through the current pandemic using the regularly updated resources published in the COVID-19 area of aaep.org.

Membership renewal can be completed at aaep.org/membership-dues-renewal. If you need assistance, contact Megan Gray, member concierge, at mgray@aaep.org or (859) 233-0147.

Access full Case Reports in the Wiley Online Library

The introduction of one-page Case Report summaries within *EVE* each month has helped fast track dissemination of clinically relevant information to readers but also has prompted the occasional question of how to access the full version of Case Reports.

Full Case Reports are available free to AAEP members through the Wiley Online Library. To get there, point your browser to aaep.org/equine-veterinary-education and click the Wiley Online Library link in the introductory copy on the page. On the Wiley site, use the search function to find the article; or select "All Issues" from the "Browse" drop-down menu to locate the pertinent issue and then click the appropriate headline within the Table of Contents.



If you encounter difficulties or have questions about this service, please contact John Cooney, publications coordinator, at jcooney@aaep.org or (859) 233-0147.

Members in the News

Dr. Katie Flynn appointed to Kentucky post

Dr. Katie Flynn, chair of the AAEP's Infectious Disease Committee and recipient of the 2019 President's Award, is the new deputy state veterinarian at the Kentucky Department of Agriculture.

Dr. Flynn received her veterinary degree from the University of Glasgow, Scotland, and previously served as the veterinary specialist for the California Department of Food and Agriculture's Animal Health Branch.


Dr. Katie Flynn


Dr. Glenn Blodgett


Dr. Harry Werner

Dr. Glenn Blodgett receives hall of fame nod

AQHA Past President Dr. Glenn Blodgett, longtime resident veterinarian and manager of the horse division at the Four Sixes Ranch in Guthrie, Texas, has been selected for induction into the American Quarter Horse Hall of Fame in 2021. The induction ceremony will occur during the 2021 AQHA Convention in San Antonio, Texas.

In Dr. Blodgett's tenure at the Four Sixes, the ranch has become an all-time leading breeder of racing and performance American Quarter Horses. Dr. Blodgett earned his veterinary degree from Texas A&M University.

Dr. Harry Werner receives AVMA Animal Welfare Award

The American Veterinary Medical Association has honored AAEP Past President and animal welfare authority Dr. Harry Werner as winner of the 2020 AVMA Animal Welfare Award.

The award recognizes an AVMA-member veterinarian for their achievement in advancing the welfare of animals via leadership, public service, education, research/product development, and/or advocacy.

Dr. Werner, who received his veterinary degree from the University of Pennsylvania, was founding owner of Werner Equine in North Granby, Conn., which merged with Grand Prix Equine earlier this year.

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convention.aaep.org

Keeneland, Fasig-Tipton enact medication policy changes for auctions

Keeneland and Fasig-Tipton have implemented restrictions on the use of non-steroidal anti-inflammatory drugs (NSAIDs), corticosteroids and bronchodilators, including Clenbuterol, for all horses sold at sales conducted by the two Thoroughbred auction houses.

The following medication rules changes are effective immediately:

NSAIDs

- No more than one NSAID administered within 24 hours prior to sale for all horses except 2-year-olds and horses in training.
- No NSAIDs administered within 24 hours prior to sale for 2-year-olds and horses in training.

Corticosteroids

- No more than one corticosteroid administered within 14 days prior to sale for all horses except 2-year-olds and horses in training.
- No corticosteroid administered within 14 days prior to sale for 2-year-olds and horses in training.

Bronchodilators (including Clenbuterol)

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Dr. Joe Lyman

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Highlights of recent clinically relevant papers

Perioperative antimicrobials for arthroscopy

This retrospective study by Noah Muntwyler and colleagues in Canada aimed to describe perioperative antimicrobial use in horses undergoing elective arthroscopy.

This study included 150 horses that had undergone elective arthroscopy at one institution over a 23-month period. Horses with a suspected infectious orthopaedic disease or with a comorbidity that may have impacted prophylactic antimicrobial use decisions were excluded. Medical records were reviewed to evaluate preoperative, intraoperative, and post-operative antimicrobial drug selection, dose, and timing. Associations between body weight and underdosing were evaluated.

Systemic preoperative antimicrobials were administered to 149/150 (99.3%) horses. Only 53 (40.2%) horses were administered doses within 60 min of surgical incision. First incision was performed more than two half-lives after administration of sodium penicillin in 46/131 (35.1%) horses but in only 1/106 (0.8%) horses that received trimethoprim-sulfadoxine. Body weight was associated with underdosing for penicillin and trimethoprim-sulfadoxine but not gentamicin. Twenty-six (17%) horses received one post-operative antimicrobial dose, while antimicrobials were continued in hospital for a mean of 22.3 h after surgery in the other 123 horses. Of the 149 discharged horses, 115 (77.2%) were prescribed antimicrobials after discharge for 3–10 days.

Deviations from common recommendations were apparent. The authors recommended that perioperative antimicrobial use practices should be regularly assessed to provide a benchmark and identify areas for intervention.

Fatal intestinal inflammatory lesions

In this study Melissa Macías-Rioseco and colleagues in the USA aimed to determine incidences and underlying causes of fatal intestinal inflammatory lesions (FIILs) and demographic characteristics of affected equids necropsied at any of the California Animal Health and Food Safety Laboratory facilities between January 1990 and April 2013.

This study included 710 equids with FIILs, including colitis, duodenitis, enteritis, enterocolitis, enteropathy, enterotyphlitis, gastritis, gastroenteritis, ileitis, jejunitis, typhlitis, or typhlocolitis, alone or in combination. Following a review of medical records, data was collected including animal age, sex, geographic origin, necropsy submission date, and breed, purpose, or characteristic of use. Descriptive statistics were compiled and reported as numbers and percentages.

The most common FIILs were colitis (323/710; 45.5%), enteritis (146/710; 20.6%) and typhlocolitis (138/710; 19.4%). The underlying cause of most FIILs was categorised as either undetermined (465/710; 65.5%) or bacterial (167/710; 23.5%). *Clostridium* spp. and *Salmonella* spp. were the most common bacteria responsible for FIILs.

These results indicated that the underlying cause for most FIILs could not be identified; however, when it was identified, it was most commonly bacterial and typically *Clostridium* spp. or *Salmonella* spp., which could be useful information for practitioners when evaluating and managing horses and other equids with intestinal distress. Knowledge of the most common FIILs and their underlying causes may help in diagnosing and mitigating intestinal disease in equids.

Tonometry

This study by Andrew Lewin and colleagues in the USA aimed to determine whether applanation or rebound tonometry has the lowest inter- and intra-user variation when measuring intraocular pressure (IOP) in horses.

Four examiners used rebound (ICare® TonoVet) and applanation (TonoPen®) tonometers to measure the IOP in triplicate in 10 normal horses before and after sedation with xylazine. The order of examiners, eye examined first and instrument used first were determined randomly and varied between horses. Coefficient of variation (CV) values were calculated from the mean of each examiner for each condition combination to determine inter-user variation. For intra-user variation, CV values were calculated from the individual measurements of each examiner for each condition combination. CV values were also assessed in relation to other variables using ANOVA.

The rebound tonometer was found to have significantly lower inter-user (15.4% vs. 21.7%) and intra-user (9.1% vs. 16.1%) variation in unsedated horses and lower intra-user (8.4% vs. 14.7%) variation in sedated horses than the applanation tonometer. Both instruments had similar inter-user variation in sedated horses. For the rebound tonometer, sedation did not affect inter-user or intra-user variation, but for the applanation tonometer inter-user variation was lowest while horses were sedated (16.0% vs. 21.7%). No other variable assessed was found to have an effect on IOP.

Rebound tonometry may be the preferred instrument to minimise intra-user and inter-user variation for IOP measurement in unsedated horses.

Failure of passive transfer

This study by Eduardo Mortola and colleagues in Argentina assessed the validity of the immunocrit method to detect failure of passive transfer (FPT) in foals. The technique is based on the ability of ammonium sulphate to precipitate the immunoglobulin fraction of serum.

This study included 211 newborn Thoroughbred foals over a 2-year period. Blood samples were obtained after foals had suckled from their dam at 10–14 h old. A 40% ammonium sulphate solution was used to precipitate the immunoglobulins in the serum. The separation between the precipitate and the liquid supernatant was measured using a haematocrit reader. The assay was performed in triplicate and included a negative control with a serum sample taken before the foal suckled colostrum. Results were compared with those of agarose gel electrophoresis which also measures total immunoglobulins.

The values obtained by the immunocrit method were significantly correlated ($R = 0.871$) with those measured by agarose gel electrophoresis. A cut-off value of 8 g/L of serum immunoglobulins by agarose gel electrophoresis and its equivalent of 9.5% for the immunocrit test was indicative of

FPT. The sensitivity and specificity of the immunocrit method at this cut-off point were 94% and 82% respectively.

The immunocrit test is a quantitative, quick, inexpensive, reliable and objective method to detect FPT in foals.

Distribution of pelvic fractures

The aim of this study by Claire Moiroud and colleagues in France was to analyse the pelvic fracture distribution and location in a referral centre caseload.

Medical records of 6717 horses examined over a 7-year period were reviewed to identify all horses diagnosed with a pelvic fracture. The 86 horses identified were divided into three disciplines: Thoroughbred racehorses (TBR), Standardbred trotter racehorses (STR) and non-racing sport horses (NRSH).

A pelvic fracture was diagnosed in 1.3% of the cases. Prevalence was significantly higher in TBR (4.2%) and, regardless of the discipline, in horses under the age of 6 years (2.2%). STR were significantly younger than TBR and NRSH at the time of fracture (median ages 1, 3 and 4 years old, respectively). Fractures of the ilium were the most common (44/86). No ilial wing fractures were diagnosed in STR and isolated acetabular fractures were only diagnosed in foals and yearlings. Fatigue fractures were only diagnosed in TBR, affecting 9/22 TBR (foals and yearlings excluded) and were most often located in the ilial wing (7 fatigue fractures out of the 12 ilial wing fractures). The median age of horses suffering from a pelvic fatigue fracture was 4 years.

This study confirms that young horses (under the age of 6 years) as well as TBR are likely to be at higher risk of a pelvic fracture. Fatigue fractures of the ilial wing rarely occur in STR while they are more frequent in young TBR in training.

Outcome of pelvic fractures

This study by Claire Moiroud and colleagues in France evaluated the reliability of fracture location and horse sporting discipline as prognostic indicators after a pelvic fracture.

Data were collected for the short- and long-term follow-up of all cases with a diagnosis of pelvic fracture from a referral centre over a 7-year period. Information was obtained for 75 horses through a postal and internet survey. The proportion of horses returning to competition following fractures was compared between groups according to the competition discipline and the characteristics of the fracture.

Forty-six of 75 horses returned to or began their intended activity. This proportion was significantly lower in the group of horses that sustained a comminuted fracture irrespective of the fracture location (11/25). The proportion of Standardbred trotter racehorses returning to a sporting career after pelvic fracture (9/20) was not significantly different from horses competing in other disciplines (37/55). Cases of multiple pelvic fractures in the study population, and particularly those involving the acetabulum, had the worst sports prognosis (2/8 and 0/4). Nevertheless, two foals and one yearling (3/5) with isolated fracture of the acetabulum went on to race.

A clear characterisation of the fracture is essential for prognosis, as comminuted fractures appear to have a poorer athletic prognosis. Despite a lack of significance, prognosis seems poorer for Standardbred trotter racehorses and for cases with acetabulum involvement in multiple fractures. Further studies with larger sample sizes are needed to confirm these results.

Head-tail rope assisted recoveries

This clinical trial by Stefanie Arndt and colleagues in Germany compared head-tail rope assisted and unassisted recoveries in horses undergoing general anaesthesia for elective surgeries.

A total of 301 healthy horses undergoing elective surgeries were randomly assigned to recover with head-tail rope assistance (group A) or unassisted (group U); 305 recoveries (154 group A; 151 group U) were analysed. Anaesthesia was maintained with isoflurane and triple drip. For each recovery, attempts to stand, duration, quality, and recovery-associated injuries were recorded. Data were analysed by linear regression and analysis of covariance.

Anaesthesia duration was similar between groups (mean 70 min). Group A had fewer attempts to stand than Group U (Group A median = 1 vs. Group U median = 3) and shorter duration of recovery (Group A mean 36 min vs. Group U mean 41 min). Recovery quality in Group A (28 points) was better than Group U (38 points). More horses had recovery-associated injuries in Group U (n = 9) compared with Group A (n = 2). One horse per group was euthanised.

Head-tail rope assistance reduced standing attempts, shortened recovery duration, improved recovery quality, and reduced recovery-associated minor injuries after general anaesthesia for elective surgery in healthy horses. Fatalities could not be prevented.

S. WRIGHT
EVE Editorial Office

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Editorial

Dosing equine antimicrobials: Ensuring clinical success and avoiding antimicrobial resistance

Summary

Underdosing of equine antimicrobials is a global issue and may be contributing to antimicrobial resistance in horses. Recent research in Australia has identified that most antimicrobial use in peer-reviewed literature is at a higher dose than that currently on the label for many common equine antimicrobials in the United States, the UK and Australia. These dosing regimens used are now considered the most appropriate doses to be using in horses and veterinarians treating equine patients should be aware of the contemporary dosing regimens.

Antimicrobial resistance is a global health emergency in people which is bringing antimicrobial use in animals under scrutiny, particularly in food animals. However, of all sectors of the veterinary profession, antimicrobial resistance in equine and companion animal patients appears to be a much bigger problem than in food animal species (Gibson *et al*. 2008; Platell *et al*. 2011; Abraham *et al*. 2016; Saputra *et al*. 2017). There are likely several contributing factors for this problem. Firstly, a wider range of antimicrobials are used in animals not destined for food (Hardefeldt *et al*. 2017b). Regulation is more restrictive for drug administration to food animals, mostly by the way of residue detection and setting of with-holding periods. In addition, antimicrobials are more readily available for use off-label in companion animals and horses and, at least in the European Union, off-label antimicrobials were most frequently reported by equine veterinarians (Committee for Medicinal Products for Veterinary Use 2017). Also, the economic factors that affect antimicrobial use in food animals are often less important in companion animals and horses, due to their high value or importance to animal owners, so newer, more important antimicrobials to human medicine, can be used despite their higher cost.

Secondly, antimicrobials are often prescribed 'just in case' in equines such as those used prophylactically for clean surgical procedures (Hardefeldt *et al*. 2017a) or for horses with respiratory signs consistent with inflammatory airway disease (Weese and Sabino 2005) and in other conditions. A combination of factors may be driving veterinarians to prescribe to these horses including pressure, or perceived pressure, from clients and a fear of deterioration in a patient leading to litigation (Hardefeldt *et al*. 2018a). This overuse of antimicrobials is often seen as unlikely to cause harm; however, a change in mindset is required in the equine sector to recognise the role prescribing plays in the emergence of antimicrobial resistance that is affecting our patients and contributing to our loss of social licence as a profession.

Thirdly, underdosing of antimicrobial agents has been well documented in prescribing to equine patients (Hardefeldt *et al*. 2017a). Appropriate dosing with antimicrobial agents is critical for effective treatment and also in the fight against AMR. All antimicrobial use can select for AMR, but exposure to subtherapeutic levels of antimicrobial agents may increase the rate of development of AMR, particularly when exposure is prolonged or recurrent (Guillemot *et al*. 1998; Gullberg *et al*. 2011; Liu *et al*. 2011). A predominant use of dose rates lower than those that result in plasma concentrations above the minimum inhibitory concentrations, required for efficacy against common equine pathogens, is of particular concern to the equine industry and may be leading to the emergence of AMR affecting horses. Poor teaching of veterinary undergraduates is one potential reason for failure of veterinarians to administer appropriate doses of antimicrobial agents. Australian university equine veterinarians had 3.2 times higher odds of compliance with guidelines than general practitioners in the 2016 survey (Hardefeldt *et al*. 2017a). In addition, students in the final 2 years of study in Australia self-identified good knowledge of antimicrobial pharmacology (Hardefeldt *et al*. 2018c), although similar data are not available for other jurisdictions. Thus, it seems unlikely that inappropriate university teaching is the primary reason for underdosing of antimicrobial agents in equine and bovine practice. A second potential contributor to inappropriate dosing is the labelling of antimicrobials. Some of the doses recommended on the labels for antimicrobials fall below those now recognised as appropriate. Recommended doses on the labels for procaine penicillin are lower than those currently recommended in the literature in Australia, the United States and the UK, and the label for gentamicin recommends doses that are lower than those currently recommended in the literature and dosing frequency higher than currently recommended in Australia. Gentamicin is only labelled for intrauterine use in the USA (Love *et al*. 1983; Bywater *et al*. 1985; Firth *et al*. 1986; ten Voorde *et al*. 1990; Uboh *et al*. 2000; Bauquier *et al*. 2015). While the dose recommended by the label is likely to be a factor influencing some veterinarians, the label is clearly not the only factor leading to inappropriate antimicrobial dosing. Respondents to an equine survey frequently used off-label (appropriate) doses of gentamicin in horses (89% of dose rates appropriate), but often used labelled (inappropriate) doses of procaine penicillin (32% of dose rates appropriate) (Hardefeldt *et al*. 2018b). Historical prescribing, and the culture of equine practice, is likely also playing a role with frequent anecdotal reports that the volume of intramuscular penicillin required for appropriate dosing was inhibiting the use of this drug at the recommended dose.

It is on this final point that our group has been particularly interested in. Our interest was primarily due to the out-dated dose recommendations on labels that accompany many antimicrobials in Australia. A problem that is also present in the UK and in the United States. We undertook a content review of articles appearing in the major equine journals around the world (Equine Veterinary Journal, Equine Veterinary Education, Australian Veterinary Journal, Australian Equine Veterinarian, the Journal of Veterinary Internal Medicine and the Journal of Equine Veterinary Science) between January 2015 and August

2018 and searched for antimicrobial dosing regimens for the common equine antimicrobials (procaine penicillin G, gentamicin and trimethoprim sulphonamide) to assess the doses being used globally (Hardefeldt *et al*. 2019). In 83% of papers describing the use of penicillin, a dose of 20–25,000 IU/kg administered every 12 h was used (Hardefeldt *et al*. 2019), a dose used by only 29% of respondents to an Australian survey (Hardefeldt *et al*. 2017a). In 93% of papers describing the use of gentamicin, a dose of 6.6 mg/kg administered every 24 hours was used (Hardefeldt *et al*. 2019), a dose used by 80% of respondents to an Australian survey (Hardefeldt *et al*. 2017a) but much higher than the labelled dose of 1.5–2 mg/kg (Australian Pesticides and Veterinary Medicines Authority 2017). In all papers describing the use of trimethoprim sulphonamides a dose of 20–30 mg/kg administered every 12 h was used (Hardefeldt *et al*. 2019), a dose used by only 30% of respondents to an Australian survey (Hardefeldt *et al*. 2017a).

Many antimicrobials used commonly in equine practice have current dosing recommendations higher than in the past, based on advances in knowledge of drug pharmacokinetics, pharmacodynamics and target plasma antimicrobial concentrations. Procaine penicillin G should be administered at 22,000 IU/kg every 12 h. Gentamicin should be administered at 6.6 mg/kg every 24 h in adults and 8.8 mg/kg every 24 h in neonates. Therapeutic drug monitoring for gentamicin should be considered, where possible, to aid in decisions on both dose and inter-dosing interval. Trimethoprim sulphonamide should be administered at 30 mg/kg every 12 h. Veterinarians treating equine patients should be aware of the current recommended dose rates and inter-dosing intervals to ensure efficacy in therapy and to preserve the usefulness of these antimicrobials for the future.

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Case Report

Pituitary gland abscess in a horse subsequent to head trauma

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Keywords: horse; pituitary; abscess; trauma; head

Summary

A 5-year-old Thoroughbred gelding with recent history of head trauma presented with multiple facial swellings, bilateral mucopurulent nasal discharge, neck pain, inappetence and depression. One month prior to presentation, the horse had run into a fence causing a wound below the left eye which healed well. Three weeks later, a left sided nasal discharge became evident; the horse was dull, ataxic on all four limbs, had multiple swellings over the head and was severely painful on neck flexion. The horse was medically treated with supportive therapy but his condition deteriorated. Immediately prior to referral, swelling over the right guttural pouch had become more pronounced and extended to the area adjacent to the right temporomandibular joint (TMJ) and blood was obtained on aspiration. On admission to the hospital, the horse was quiet but responsive, in thin body condition (BCS 4/9) and had a bilateral serosanguinous nasal discharge. Four palpable swellings of the head were present; one was found in the right supraorbital fossa, a second was approximately 4 cm in diameter, located ventral to the right TMJ and was firm and painful on palpation. A third, more diffuse swelling was positioned immediately caudal to the vertical ramus of the right mandible and was also painful on palpation. The fourth nonpainful swelling was over the right nasoincisive notch. On physical examination, the horse had a stilted gait when circled to the left and when walked backwards, and the range of neck flexion was reduced bilaterally. The horse walked with the head and neck extended; however, there were no signs of ataxia or paresis in any limb. On computed tomographic examination, the pituitary gland measured 1.9 × 2.4 × 3.7 cm (dorsoventral height, laterolateral width and rostrocaudal length respectively), which is slightly larger than the sizes published for clinically normal horses. A focal area of hyperattenuation, likely consistent with mineralisation, was present in the caudal aspect of the gland, immediately left of midline (**Fig 1**). Differential diagnoses for the pituitary lesion included normal age-related changes in size, melanotrope hyperplasia and macroadenoma formation in the pituitary pars intermedia as most likely differentials; other differential diagnoses such as an infectious or inflammatory process of the pituitary gland (abscessation, pituitary hypophysitis), or cystic echinococcus (*Echinococcus equinus*) were considered less likely. Soft tissue swelling was seen in the dorsal aspect of the right guttural pouch surrounding several cranial nerves, with fluid-like material in the dependent portions of the right guttural pouch. Imaging findings consistent with periapical infection of tooth 209 and secondary sinusitis were also present. These were likely chronic and unrelated to the recent clinical history. The CSF sample contained mild mixed pleocytosis and increased protein concentration. The horse's demeanour deteriorated requiring euthanasia. Post-mortem examination revealed a pituitary gland abscess. In conclusion, this horse likely suffered abscessation of the pituitary gland as a result of extension of a guttural pouch infection or haematogenous spread. Although this is an unusual condition, it should be considered in horses that remain dull after head trauma, and if focal mineralisation is found in a mass on CT. The recent history of head trauma makes it likely that this was the result of trauma.

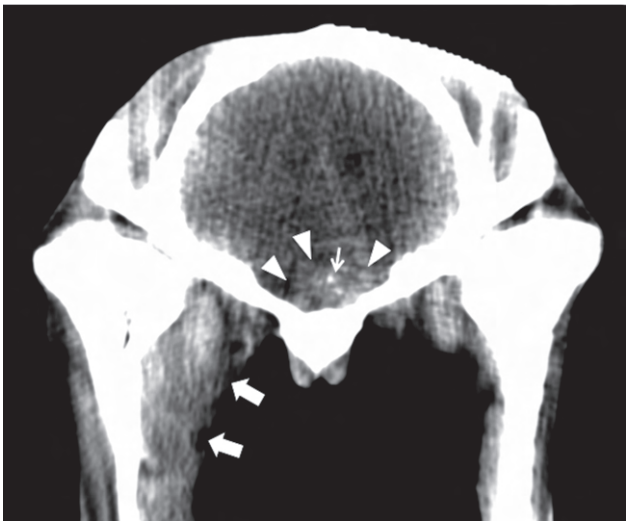

Fig 1: Transverse brain algorithm (window length 50, window width 100) computed tomography image at the level of the pituitary fossa. The right side of the horse's head is on the left side of the image. The pituitary lesion is highlighted by the arrowheads. An area of hyperattenuation, consistent with mineral attenuation, is present within the left side of the pituitary fossa (arrows). The soft tissues of the dorsal and lateral aspects of the right guttural pouch are also thickened (block arrows).

Key points

- Pituitary abscessation can occur in horses, albeit rarely, and can result from local infection or haematogenous spread.
- Pituitary abscessation should be a differential diagnosis in horses that remain dull after head trauma.
- If focal mineralisation is found within a pituitary mass on computed tomographic examination, abscessation of haematogenous origin should remain a differential diagnosis.

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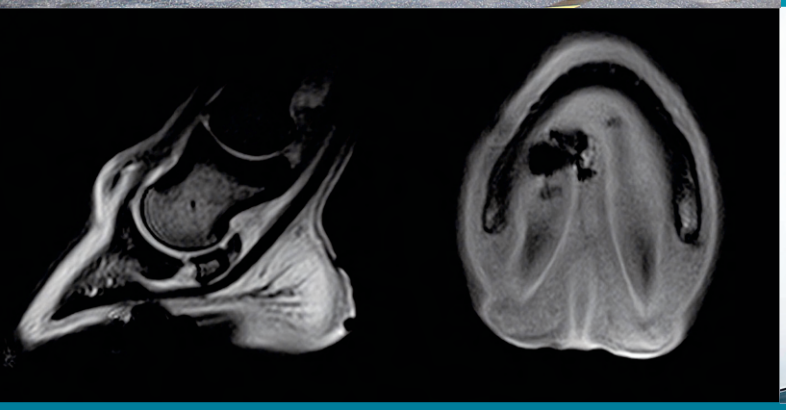

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Equine vet. Educ. (2020) **32** (6) 287
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Case Report

Primary ossifying fibroma of the proximal phalanx in a horse

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Keywords: horse; ossifying fibroma; bone neoplasia; pastern; proximal interphalangeal joint

Summary

A 5-year-old Welsh pony cross mare presented with a 3-month history of mild lameness and firm swelling around the left hindlimb pastern region. Lameness examination revealed a grade 2/5 left hindlimb lameness, which significantly worsened with distal limb flexion (AAEP 5-point grading lameness scale). Radiographs of the left hind pastern were obtained and showed well-circumscribed lucent articular and subchondral areas of lysis (**Fig 1**). An ill-defined lucent zone extended into the mid-proximomedial aspect of the proximal phalanx with areas of cortical lysis. The areas of lysis were bordered by moderate sclerosis and a focal area of undulant periosteal bone production was present at the distodorsomedial aspect of the proximal phalanx. Given the radiographic findings, a traumatic osseous cyst-like lesion was the top differential diagnosis. The proximal areas of osteolysis were considered potential areas of osteonecrosis. Though less likely, other differential diagnoses considered included neoplasia such as osteosarcoma or haemangiosarcoma and osteomyelitis. The horse was pasture rested for 5.5 months and then re-evaluated, but the lameness and swelling had progressed. Due to progressive worsening in clinical signs as well as financial limitations, euthanasia was elected. On post-mortem examination, a lesion was grossly identified on the distomedial aspect of the proximal phalanx. Histological features of the tumour tissue in the distal aspect of the proximal phalanx showed low mitotic index and a storiform pattern of moderately hyperchromatic fibroblast-like spindle cells. Furthermore, spicules of woven bone bordered by osteoblasts were distributed throughout the tissue. The mass was histologically diagnosed as an ossifying fibroma. This case report describes the first report of an ossifying fibroma affecting the pastern region in a horse. An ossifying fibroma should be considered when there is radiographic evidence of extensive lysis extending into the medulla and proximal cortical bone.

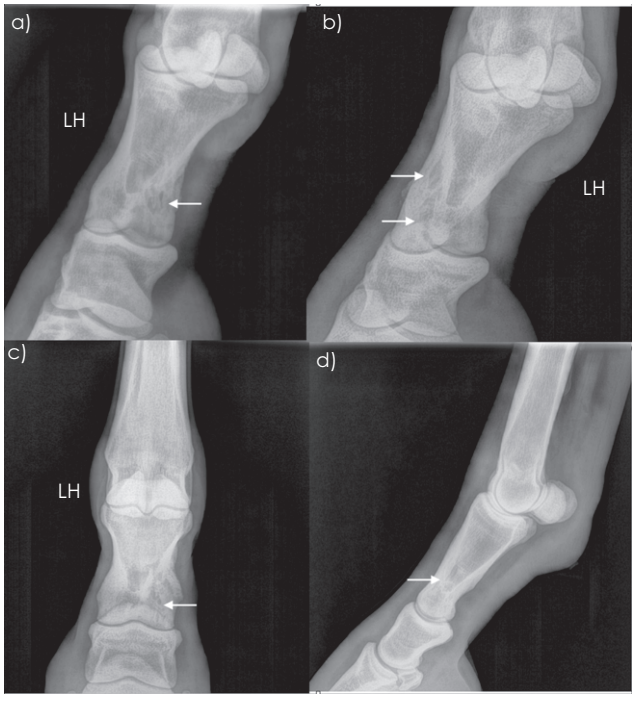

Fig 1: Radiographs of the left hind distal limb, centred on the proximal phalanx. a) Dorsomedial-plantarolateral oblique. b) Dorsolateral-plantaromedial oblique. c) Dorsal-plantar. d) Lateromedial. Multifocal areas of well-defined ovoid osteolysis are present in the distomedial aspect of the proximal phalanx (white arrows). The areas of lysis are bordered by moderate sclerosis. Ill-defined areas of lysis extend to the distomedial subchondral bone and articular surface, best seen in image a) and c). A focal area of undulant periosteal bone production is present at the distodorsomedial aspect of the proximal phalanx, best seen on image b).

Key points

- Primary bone neoplasia and specifically fibro-osseous tumours involving the distal limb are rare in horses.
- An ossifying fibroma should be considered when there is radiographic evidence of extensive lysis extending into the medulla and proximal cortical bone.
- Histopathology is needed to definitively diagnose an ossifying fibroma and distinguish it from other similar osseous lesions.

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Case Report

Oesophageal ectasia as a cause of dysphagia and milk regurgitation in a neonatal foal

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Keywords: horse; congenital; dysfunction; oesophagus; pharynx

Summary

Dysphagia and milk regurgitation are infrequently observed in neonatal foals but can arise from anatomic or functional disorders of the pharynx and upper airway or from anatomic or neuromuscular disorders of the oesophagus. In the report presented here, a 4-day-old Quarter Horse filly was examined for milk regurgitation at 4 days of age, which was more pronounced when the head was lowered. Oesophageal peristalsis was observed on oesophagoscopy but a large amount of milk pooled throughout the thoracic oesophagus, extending for approximately 20 cm. Contrast radiography revealed similar findings of pooling of contrast in the thoracic oesophagus (**Fig 1**). The foal was subsequently diagnosed with aspiration pneumonia and transient oesophageal ectasia. Ectasia has rarely been documented in horses and is a nonspecific term defined as the dilation or expansion of a hollow or tubular structure and can be a normal or pathophysiological process. Conservative management was elected including oral antimicrobials and instructions for the owner to intermittently elevate the forelimbs to facilitate passage of milk out of the dilated oesophagus. The milk regurgitation resolved and reassessment of the foal at 6 weeks of age documented the absence of oesophageal ectasia and resolution of aspiration pneumonia. The foal was healthy and consuming food normally 8 months after initial examination and was in good body condition. This case is unique in that the oesophageal ectasia improved with time; furthermore, other potential causes of dysphagia and milk regurgitation of oesophageal origin in neonatal foals are discussed.

Key points

- Milk regurgitation in neonatal foals may occur from transient oesophageal ectasia, a condition that might resolve over time.
- Diagnostics such as upper airway and oesophageal endoscopy, plain and contrast radiography, fluoroscopy and computed tomography may assist in defining the aetiology of milk regurgitation.
- Other causes of milk regurgitation in neonatal foals resulting from an oesophageal disorder include megaesophagus, oesophageal stricture, duplication, diverticulum, fistula and vascular ring anomalies.

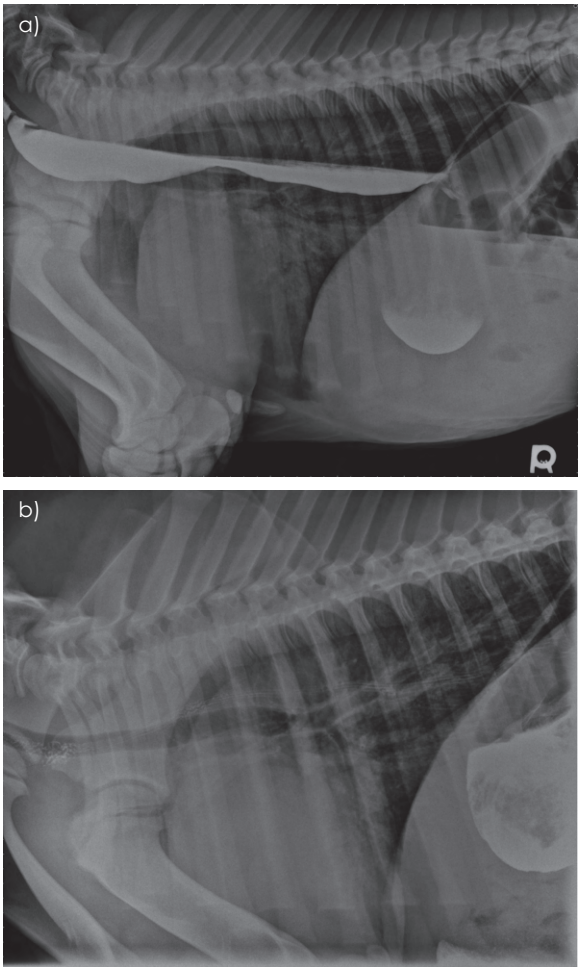

***Fig 1:** Standing right lateral radiograph of the thorax 30 s following barium administration. a) Admission radiograph demonstrating the oesophagus which is well delineated by positive contrast medium ventrally and the dorsal border outlined by gas. The barium pools throughout the ventral oesophagus with minimal progression into the gastric lumen. b) Six weeks after initial presentation where the barium is coating the oesophageal wall, with a small amount of residual barium at the level of the thoracic inlet. There is no retention of barium within the oesophagus nor oesophageal dilation and the normal mucosal folds of the oesophagus are delineated by barium. There is normal progression of barium into the gastric lumen without evidence of oesophageal pooling and no regions of dilation are identified.*

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Case Report

Extensive and invasive guttural pouch granuloma in a 2-year-old gelding

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Keywords: horse; *Aspergillus fumigatus*; empyema; guttural pouch; infection; mycotic granuloma

Summary

This report describes a case of an unusually extensive and invasive fungal granuloma within the right guttural pouch and its surrounding area of a 2-year-old Noriker gelding, causing diverse neurogenic deficits and tissue destruction. The gelding was initially presented with cachexia, unilateral nasal discharge, intermittent fever, swelling of the right side of the head, facial nerve paralysis and dysphagia. The right guttural pouch was not accessible to endoscopic examination initially, but after anti-inflammatory medical management, empyema and an extensive, solid mass appeared within the guttural pouch. Surgical exploration and excision were attempted but were unsuccessful. Histopathological examination identified *Aspergillus fumigatus* as the causative infective agent of the extensive fungal granuloma, and the consequent invasion and destruction of surrounding bone and soft tissue structures.

Introduction

Guttural pouch disease in the horse is fairly common. Bacterial and fungal infections, as well as neoplasia, occur in the guttural pouch. *Aspergillus fumigatus* is the most common fungal infective agent of the guttural pouch. *Aspergillus species* are found worldwide in human subjects and in almost all domestic animals. They are commonly found in soil with an occasional potential to infect living hosts (Seyedmousavi *et al.* 2015). Healthy animals are generally able to ward off infections, but massive or long-term exposure can lead to severe illness (Pitt 1994; Arne *et al.* 2011). In horses, *Aspergillus* species primarily cause guttural pouch infections and pneumonia through inhalation of airborne conidia. It is a rare, but life-threatening infection, with a prevalence ranging from 0.5 to 17% in some European studies (Guillot *et al.* 1997). Predisposing factors include intestinal inflammation, prolonged administration of antibiotics, immunosuppression, or the presence of endocrinopathies or neoplasia (Carrasco *et al.* 1996). Mostly adult horses are infected, but foals can be affected as well (Chidlow and Slovis 2017). Typical lesions of guttural pouch mycosis are characterised as clearly demarcated, yellow-brown, necrotic tissue, which is firmly adhered to the surface of the medial compartment of one of the guttural pouches (Cook 1966; Markus *et al.* 2005). The most common clinical sign is unilateral epistaxis caused by invasion of the internal carotid artery (ICA) while the second common clinical sign is dysphagia due to pharyngeal paralysis caused by cranial nerve affection. The epistaxis is not associated with exercise. Fatal haemorrhage can occur with ulceration of the ICA and less commonly of the external carotid artery or maxillary artery. Inflammation of the cranial nerves can lead to dysphagia, laryngeal hemiplegia, facial paresis or Horner`s syndrome (Freeman 2015). Mycotic invasion of the stylohyoid bone can also occur. Extension of the infection to the surrounding structures is rare but has been described in the atlanto-occipital joint and even to the brain (Dixon and Rowlands 1981; Walmsley 1988). The diagnosis of aspergillosis in animals is not straightforward. Endoscopy, combined with history and clinical signs, may be suggestive of the diagnosis (Freeman 2015). Microscopic demonstration of hyphae, cultural isolation and polymerase chain reaction (PCR) are important diagnostic tools (Ludwig *et al.* 2005; Gomez 2014).

Medical management is difficult and antimicrobial resistance occurs; surgical treatment is often inevitable (Seyedmousavi *et al.* 2015).

This report describes a granuloma involving the guttural pouch caused by *Aspergillus fumigatus*, causing cachexia, facial nerve paralysis and empyema in a 2-year-old gelding.

History

A 2-year-old Noriker gelding presented with a 2-week history of weight loss, unilateral nasal discharge, intermittent fever and swelling of the right site of the face. The referring veterinarian (rDVM) had taken a nasal swab of the discharge and submitted the sample for aerobic bacterial culture and sensitivity testing. Culture results showed *Staphylococcus intermedius* infection. Based on sensitivity results, the rDVM initiated antimicrobial treatment with trimethoprim sulfamethoxazole (Sulfatrim Pulvis)[1] at doses of 20 mg/kg bwt orally twice daily for 14 days, but clinical symptoms remained and he then referred the case.

Clinical examination

On presentation, the gelding was cachectic and had a rectal temperature of 39°C. A hard, painful swelling was present on the right side of the head, extending from the base of the right ear to the right jaw with intact skin. Right-sided facial nerve paralysis characterised by a hanging ear and drooped lip was apparent. The right submandibular lymph node was mildly enlarged, but not painful. The remainder of the physical examination was within normal limits.

A complete blood count (CBC) was performed and revealed hypochromic, microcytic anaemia (HGB 8.8 g/L,

MCV 37.4 fl, RBC 6.29 × 10^{12}/L, HCT 23.5 L/L) and neutrophilic leucocytosis (PMN 10.38 × 10^{9}/L, WBC 13.86 × 10^{9}/L). Anaemia was thought to be due to chronic disease; neutrophilia was likely due to stress or inflammation. Based on serum biochemistry (SBC), hyperproteinaemia (97 g/L) characterised by hyperglobulinaemia (69 g/L) was apparent, indicating severe inflammation.

The horse was sedated with detomidine (Detogesic)[2] 3 mg i.v., and an upper airway endoscopy was performed which revealed severe swelling of the right dorsal pharyngeal area and mucopurulent discharge at the right guttural pouch opening. The pouch itself was not accessible. Samples from the discharge at the right pouch opening were taken and submitted for *Streptococcus equi equi* (S. equi) (strangles) PCR, since strangles is one of the most common reasons for guttural pouch infection and facial nerve dysfunction (Judy *et al.* 1999). Strangles is also known to be endemic in the respective area. The left guttural pouch was accessible to endoscopy and deemed unremarkable.

Radiographs of the head were taken and revealed osteolysis of the caudal curvature of the mandible, osteolysis of the right stylohyoid bone combined with active periostal reaction and a radiopaque area of the right guttural pouch (**Fig 1**). Bilateral thoracic radiographs were taken in order to investigate potential abscesses from assumed *S. equi* infection, but were unremarkable.

A transcutaneous fine needle aspiration (FNA) of the mass was performed approximately 10 cm beneath the right ear and the sample was submitted for cytological evaluation.

Treatment

The gelding was hospitalised within the isolation unit and treatment was initiated with procaine benzylpenicillin (Procain-Penicillin-G)[1] 20,000 IR/kg i.m. twice daily and flunixin meglumine (Flunidol)[3] 1.1 mg/kg i.v. once daily for assumed *S. equi* infection and to decrease inflammation. The medication regime was maintained throughout hospitalisation. On Day 2 of hospitalisation, endoscopy was repeated following sedation at the same dosage and the right guttural pouch was now accessible. Yellow, thick, purulent discharge was visible and the empyema was irrigated with 0.9% sterile saline (NaCl 0.9%).[4] Afterwards, 10 mL of procaine benzylpenicillin (Procaine-Penicillin-G)[1] were instilled into the pouch. On Day 5 of hospitalisation, the right guttural pouch was irrigated again. This time a mass involving the stylohyoid was visible. Only the medial compartment of the right pouch could be visualised as the lateral compartment was completely obscured by the mass. A mucous membrane and small abscesses locally covered the mass.

Cytology results of the FNA of the mass became available and showed neutrophilic inflammation. CBC and SBC were repeated, and anaemia, neutrophilic leucocytosis and hyperproteinemia still remained. Monocytosis (0.69 × 10^{9}/L) was now apparent, reflecting the chronicity of the process.

Because no clinical improvement was appreciated and the neurological signs did not subside, surgical removal of the mass was advised to reduce the pressure on the nerves. Medical treatment was not considered adequate for reducing the size of the mass. Although computed tomography (CT) was recommended prior to surgery, the owners declined due to financial restrains. On day 7 of hospitalisation, removal of the mass was attempted under general anaesthesia. The horse was positioned in left lateral recumbency, and the right side of the head was aseptically prepared for surgery. The mass was firm and immobile. It could be palpated from underneath the cartilage of the ear, ventrally along the caudal border of the mandible, ending just proximal to the lingual facial vein. The caudal-most border of the mass was palpated about 20 cm caudal to the mandible. A skin incision was made from the base of the ear ventrally, just above the lingual facial vein. The parotidoauricular muscle (o. auricularis ventralis) was dissected parallel to its fibre course and the superficial cervical fascia was incised. The parotid gland was visualised and it became apparent that the parotid gland was incorporated into the mass. It was decided to proceed with the attempt to remove the mass. The maxillary vein was double ligated with polyglycolic acid (Polysorb 0 USP). The dorsocaudal part of the mass could be loosened from the wing of the atlas, while the caudal part could be released from its surrounding tissue. Due to the size of the swelling, it was decided to debulk a portion of the mass in order to visualise the cranial extent of the swelling. The cut surface revealed a spongy mass with a homogenous yellow-white fibrous structure intermingled between glandular tissues. A tissue sample of the mass was taken (**Fig 2**). It became

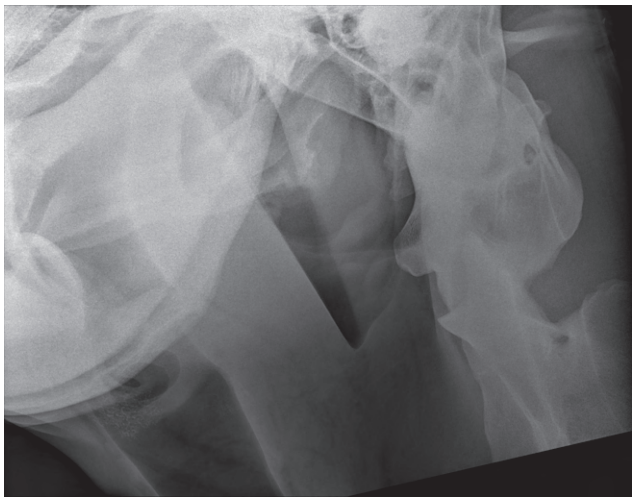

Fig 1: Lateral radiograph of the guttural pouch area showing osteolysis of the mandible and right stylohyoid bone, and a radiopaque area in the region of the right guttural pouch.

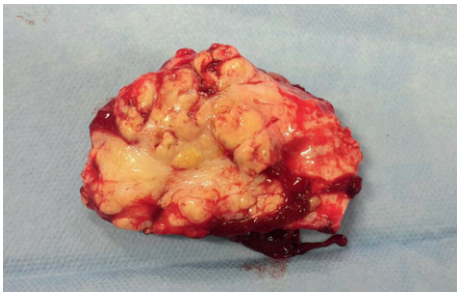

Fig 2: Biopsy from the mass obtained during surgery.

obvious that the mass infiltrated tissues located both axially and cranially. Due to the firm attachments to the surrounding tissues, the mass could not be fully removed surgically. The horse was subsequently subjected to euthanasia.

Based on the interest of the clinicians, consent was obtained from the owner to further investigate the full extent of the lesion and the cause of the mass. Therefore, a post-mortem CT scan and histopathological examination of the head were performed. Unfortunately, a necropsy of the whole body could not be performed at that time.

Computed tomography scan revealed hypertrophy and osteolysis of the right stylohyoid bone with malformation of the caudal part of the bone. The guttural pouch was occluded by soft tissue with the exception of the medial compartment (**Fig 3–5**). The left guttural pouch and stylohyoid bone showed no visible changes.

Histopathological findings

Anatomic-pathological examination of the head and histopathological examination of the mass were performed. *Aspergillus fumigatus* was identified by PCR as an inciting infectious agent. The mass was firm with connective tissue induration measuring 17 × 10 × 14 cm. It involved the entire lateral compartment of the right guttural pouch, replacing part of the medial pterygoid muscle, and extending to the stylohyoid bone and the right trigeminal nerve. The tissue of the mass was characterised as pyogranulomatous, necrotising inflammation with granulation tissue with calcification and metaplastic ossification. The stylohyoid bone showed severe chronic pyogranulomatous osteomyelitis, destroying and replacing normal bone tissue, with intralesional fungal hyphae. The severity of the osteolysis and bone remodelling represented the chronicity of the process. Intralesional samples stained with Grocott and PAS showed hyphae. There was perineuritis and fibrosis visible affecting the trigeminal nerve. Periosteal reaction and osteolysis of the mandible were also present, minimally on the medial aspect and more extensive laterally. Culture revealed growth of diverse bacteria, such as *Citrobacter* spp., *Escherichia coli,*

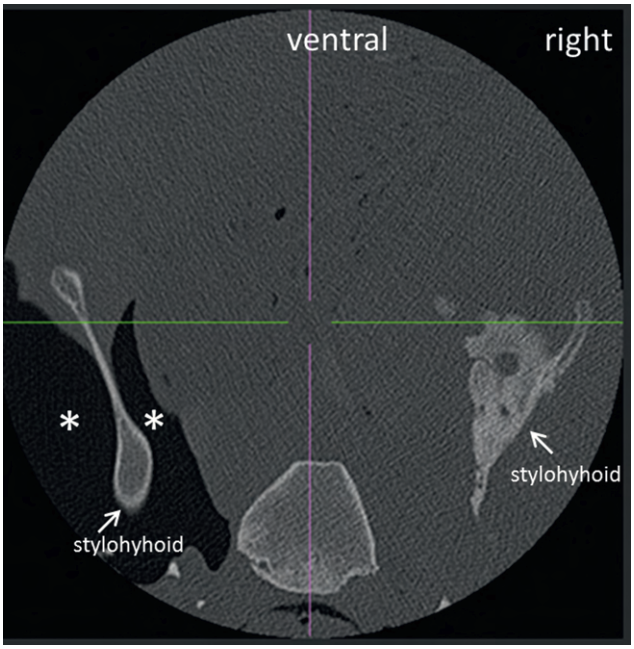

Fig 3: A transverse computed tomography image (bone window) at the level of the basilar skull demonstrating hypertrophy and osteolysis of the right stylohoid bone. The right guttural pouch is filled with soft tissue. * = left guttural pouch medial and lateral.

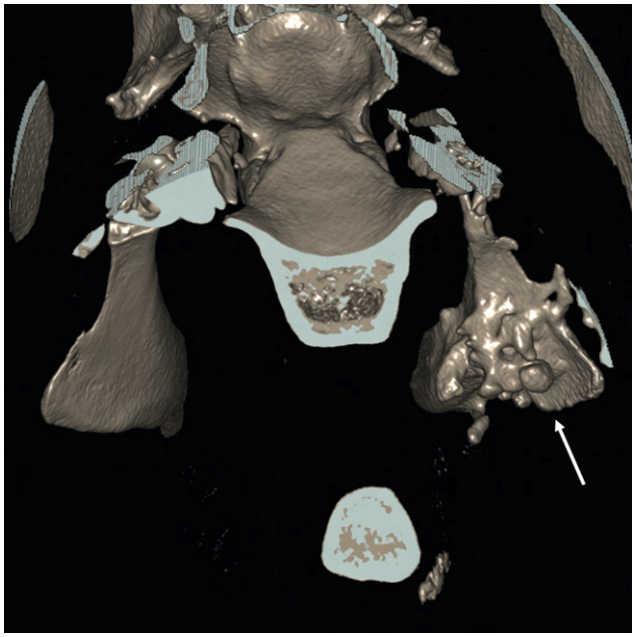

Fig 4: A 3D transverse computed tomography reconstruction image demonstrating hypertrophy and osteolysis of the right stylohyoid bone (arrow). View from caudal.

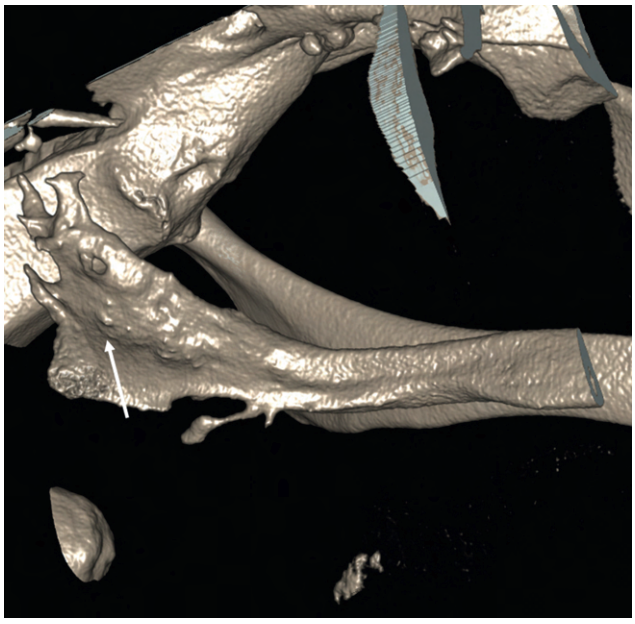

Fig 5: A 3D longitudinal computed tomography reconstruction image demonstrating hypertrophy and osteolysis of the right stylohyoid bone (arrow). View from the right side.

Staphylococcus spp., *Streptococcus* spp., which is suggestive of secondary bacterial infections responsible for the empyema.

Discussion

The diagnosis of guttural pouch mycosis in the horse is usually obtained via endoscopy and supported by culture and/or microscopic observation of hyphae. In this case, endoscopy of the guttural pouch was difficult due to the mass effect of the fungal granuloma and empyema present from secondary bacterial infection. Therefore, guttural pouch irrigation, anti-inflammatory, and antimicrobial treatment were instituted to decrease the interference of these processes during endoscopy. Because *S. equi* infection is one of the most common causes of guttural pouch empyema (Judy *et al.* 1999), and known to be endemic in the respective area, its presence as the inciting infective agent was a reasonable assumption. Guttural pouch mycosis usually involves the medial compartment (Edwards and Greet 2007); however, primary lesions of the lateral wall of the lateral compartment have been described (Freeman 2015). The occurrence of the fungal granuloma localised to the lateral compartment entirely is uncommon. In the described case, neither typical fungal plaques nor discoloration of the guttural pouch endothelium were seen; only an invasive mass occupying the lateral compartment with an intact mucosal lining and, locally, some small abscesses were seen. Cytology of the fine needle aspiration was nonspecific and was not indicative of fungal disease. Only once histopathologic examination of the mass was performed, did the microscopic presence of hyphae indicate fungal disease. PCR identified *Aspergillus fumigatus* as an infective agent. In most previously described cases, the mycosis remained localised; however, in some cases, the extension was so expansive that cranial nerves IX, X, XI and XII coursing within the guttural pouch, or cranial nerves V, VII, and VIII located in close proximity to the pouches are involved, causing additional clinical signs. In this case, the facial and trigeminal nerves were both affected, causing a hanging ear and drooped lip. The facial nerve and its branches, including the mandibular nerve, pass adjacent to the caudal dorsal roof of the lateral compartment of the guttural pouch and were incorporated into the fungal granuloma. Another structure involved was the stylohyoid bone, which was malformed by osteitis, caused by the infiltrative expansion of the lesion. Dysphagia is often caused by lesions within the guttural pouch affecting the pharyngeal branches of the vagal (X) and glossopharyngeal (IX) nerves, which was assumed to be causative in the respective case, but unfortunately, the pathologist did not report on the involvement of these structures. Massive swelling of the dorsal pharyngeal area could have contributed to dysphagia as well.

Fungal disease of the airway in the horse most commonly occurs through airborne inhalation with conidia of *Aspergillus fumigatus* and, consequently, the medial compartment of the guttural pouch. In this case, the medial compartment was unaffected and thoracic radiographs did not indicate fungal pneumonia. It can be speculated if the aspergillosis could have originated in the intestine and become systemic via haematogenous spread. Because intestinal inflammation and immunosuppression are known to predispose animals to aspergillosis, the intestine as an origin of infection could be an alternative explanation to primary airway contamination (Sweeney and Hebecker 1999; Tunev *et al.* 1999; Marti Aguado *et al.* 2017). A whole-body necropsy could have been helpful to understand the aetiology of the infection, and possible affection of other organs, but was not available at that time.

The magnitude of the described fungal granuloma in the guttural pouch and surrounding area was unexpected. The size of the mass was suggestive of another aetiology, such as fibroma, melanoma or haemangiosarcoma, as they can occur in the guttural pouch (Merriam 1972; Baptiste *et al.* 1996). However, there is one report of an extensive fungal granuloma originating in the anterior dorsal aspect of the right guttural pouch, measuring $5 \times 2 \times 2$ cm, that was presumed to have spread to the cranium causing blindness. The route of infection to the guttural pouch in that case was speculated to be haematogenous (Hatziolos *et al.* 1975).

An extensive granuloma or tumour involving the lateral compartment of the guttural pouch was considered to be the cause of the clinical signs in this case. Whether the involvement of the guttural pouch was primary or secondary could only be speculated. Generally, mycoses originating in the guttural pouch do not extend into the adjacent structures, such as the musculature of the mandible, the bone of mandible, the parotid gland and surrounding areas. The distribution of lesions in this horse was unusual. The most advanced lesions were lateral to the guttural pouch, suggesting this as the site of initial infection, with secondary dissemination to the guttural pouches. As differential diagnoses, a mycetoma-like granuloma should be considered. Mycetomas are chronic, pyogranulomatous infections of subcutaneous tissue and contiguous bone caused by actinomycetes (actinomycetoma) or fungi (eumycotic mycetoma). The initial lesion can be a small subcutaneous swelling following minor trauma (for instance a penetrating thorn). Destruction of deeper tissues and deformity of the underlying fasciae and bone may occur in late stages. Pythiosis caused by *Pythium insidiosum*, which is seldom diagnosed in Europe, could also be a potential cause of granuloma formation (Gaastra *et al.* 2010). The most successful approach for resolution of mycetomas is reported to be surgical excision followed by prolonged systemic antifungal administration; however, complete removal of infected tissue is complicated by the locally invasive nature of the lesion, as was observed in this specific case (Lopez *et al.* 2007; Cafarchia *et al.* 2013).

Considering the mycosis of the guttural pouch as a primary cause, medical management early in the disease process can be rewarding, but surgical intervention to reduce the blood supply is often inevitable (Caron *et al.* 1987). In this case, medical management was not an option due to the extent of the mass, and surgical exploration was indicated to explore whether removal would be a viable treatment option. Surgery revealed the entire extent of the mass and the involvement of several structures, including the stylohyoid bone, trigeminal nerve and vasculature, which made extraction of the mass impossible.

Authors' declaration of interests

No conflicts of interest have been declared.

Ethical animal research

This paper is concerned with a case report, handled in private practice. It was not a research study.

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Authorship

A. Rijkenhuizen was the surgeon on the case and K. Shell was the internist on the case. Both authors handled the case and prepared the manuscript equally.

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Clinical Commentary

Guttural pouch diseases in horses: A challenging differential diagnosis

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Keywords: horse; guttural pouch; granuloma; mycosis; pathogenesis

Guttural pouch mycosis is a rare and intriguing condition in horses (Lepage *et al.* 2004; Freeman 2015; Cadoré *et al.* 2019), characterised by the development of fungal plaques in the mucosal lining of the guttural pouches, mainly in the median compartment (Cook 1968; Cook *et al.* 1968; Cafarchia *et al.* 2013; Seyedmousavi *et al.* 2015), as well as in some associated neurovascular or osseous structures. Despite its clinical importance, the pathogenesis remains poorly understood (Lepage *et al.* 2004; Greppi *et al.* 2017). The filamentous fungi *Aspergillus nidulans* and *A. fumigatus* appear to be the most commonly responsible agents for this peculiar disease (Cook *et al.* 1968; Ludwig *et al.* 2005).

In their clinical publication, Shell and Rijkenhuizen (2020) report on an unusual presentation of guttural pouch mycosis, with extensive granuloma formation within the guttural area in a 2-year-old gelding, associated with neurological signs and destruction of the surrounding tissues. This case allows us to question the key steps to be considered to improve diagnosis and care when facing an atypical presentation of guttural pouch disease.

Clinical examination was performed according to usual procedures, and radiography revealed signs of hyoid and mandible osteolysis. Cytological examination of fine needle aspiration was not conclusive as it only displayed neutrophilic inflammation. At this stage, tomodensitometry (TDM) may have helped to confirm the diagnosis and rapidly implement treatment.

Due to the swelling and the extension of the mass, its exact localisation was difficult to address. After treatment with antibiotic and anti-inflammatory drugs that failed to induce significant mass reduction, the surgery unfortunately failed to completely remove the mass or to establish the relation between the granuloma and other structures such salivary gland and mandible. Surprisingly, osteolysis was mainly observed in the mandible, and in the right hyoid bone. While hyoid lesions were similar to that has been already reported (in Cadoré *et al.* 2019) but without observation of fungal filaments, the description of the mandibular lesions might have helped to fully document this unusual presentation and to associate the observed lesions to the granuloma. Ultrasound exploration might have been helpful to assess the anatomical presentation, especially the involvement of vessels and salivary glands as reported by the authors.

Surprisingly, no fungal plaque nor discoloration of the guttural pouch wall, two common manifestations of the disease, were observed. Cytological examination failed to point out fungus-associated disease. Nevertheless, *Aspergillus fumigatus* was amplified by PCR but without any information about the carried-out technique on post-mortem samples of the mass. Airborne inhalation is the main route of *A. fumigatus* entry. In this peculiar case, the authors excluded this route of contamination, in the absence of lesions in the medial compartment of the guttural pouch as well as the absence of fungal pneumonia based on thoracic radiographs; but there is no definitive proof supporting the link between airborne inhalation and mycosis localisation in the medial compartment (Lepage *et al.* 2004). Therefore, the authors hypothesised blood contamination from *Aspergillus* originating from the intestine and its haematogenous spread. While this hypothesis cannot be completely excluded, there is no factual evidence to support it in the reported case.

The horse experienced nervous signs especially associated with the trigeminal nerve, and to a lesser extent to vagal and glossopharyngeal nerves. At this point, the localisation of the granuloma cannot completely support a direct interaction between the mass and the neurological manifestations. Indeed, unrelated events may have contributed to the disease observed in this 2-year-old horse and an independent origin cannot be completely excluded.

To summarise, the histopathological description, without granular lesions nor fungal invasion, is quite atypical for a fungus-induced mycetoma, otherwise very rare in horses and frequently observed in cutaneous or subcutaneous tissues (Randleff-Rasmussen *et al.* 2017). Histological examination might have been compared to aspergillosis granuloma in the mediastinum presenting with septated hyphae and *Aspergillus*-positive cultures that have been reported (Moore *et al.* 1993). The origin of the granuloma remains uncertain and could have been questioned as well as the origin and mechanisms leading to mandibular osteolysis in the absence of guttural pouch wall breaking. Based on the absence of fungal plaques in the guttural pouch, fungal cultures or cytological evidence, the role of *Aspergillus* cannot be completely established for this atypical and severe presentation related to guttural pouch disease; finally the horse had to be subjected to euthanasia in the absence of mass regression upon antimicrobial treatment or improvement following attempted surgical mass removal. At this stage there is only molecular evidence to support a fungal aetiology, and secondary infections may have played a role in the disease progression.

This case illustrates the difficulty to properly perform diagnosis in the face of an atypical presentation of guttural pouch disease. Clinicians must keep in mind some rare guttural pouch diseases such as tumours or granulomas (Kent Scarrat and Crisman 1998; Drew *et al.* 2018) for differential diagnosis, but also the various clinical features of this fungus-induced disease. TDM in the early stage may help to ascertain diagnosis. Fungal aetiology should be clearly established by observation of fungal plaques in the guttural pouches (even so this may be unreliable due to the presentation of the lesions), isolation and fungal identification by culture or by a standardised PCR. In this case report, while neurological symptoms were observed, the direct link with lesions of the guttural pouch was not completely established, and independent events cannot not be excluded.

In conclusion, this interesting report illustrates the challenge of differential diagnosis in the face of atypical forms of guttural pouch disease in horse. It demonstrates that much needs to be done to fully elucidate the pathogenesis of guttural pouch disease; models of experimentally-induced disease may help to understand the pathogenesis as well as to describe the various presentations of the disease (Greppi *et al.* 2017).

Authors' declaration of interests

No conflicts of interest have been declared

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

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Case Report

Partial gastrectomy and total splenectomy for the treatment of a gastric mass in a horse

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Keywords: horse; gastrectomy; gastric mass; splenectomy; recurrent colic

Summary

A 9-year-old cob mare with a history of recurrent colic presented during an acute colic episode. Ultrasonography revealed a mass emanating from the greater curvature of the stomach and was tightly adhered to the cranial edge of the spleen. Partial gastrectomy and total splenectomy were performed via a midline celiotomy incision. The mass was subsequently confirmed to be granulomatous inflammation, postulated to be secondary to a penetrating injury to the stomach. Post-operatively, the mare had episodes of recurrent colic that were successfully managed with optimisation of the horse's diet and feeding regime. At 10 months' post-operatively the mare was managed on full turn out, with no evidence of colic and had returned to the previous level of ridden work. The horse then presented 14 months post-operatively with severe colic due to a large colon impaction and displacement and was euthanased. This is the first report to describe successful partial gastrectomy as a treatment option for a gastric mass in the horse.

Introduction

Gastric masses are infrequently reported in the horse, with neoplastic disease described most commonly. Neoplastic masses affecting the equine stomach include squamous cell carcinoma (Meagher *et al.* 1974; Tennant *et al.* 1982; Olsen 1992; McKenzie *et al.* 1997; Taylor *et al.* 2009; Mair *et al.* 2010), adenocarcinoma (Patton *et al.* 2006; Taylor *et al.* 2009), mesothelioma (Taylor *et al.* 2009), leiomyoma (Taylor *et al.* 2009), leiomyosarcoma (Boy *et al.* 1992), gastrointestinal stromal cell tumours (GIST) (Del Piero *et al.* 2001; Haga *et al.* 2008), and lymphoma (Taylor *et al.* 2009). Benign adenomatous polyps are also described (Morse and Richardson 1988; Furness *et al.* 2013; Marley *et al.* 2016), and rarely, gastric abscesses are also reported (Arnold and Chaffin 2012).

Horses diagnosed with gastric masses often have non-specific clinical signs, including colic, weight loss, inappetence, lethargy (McKenzie *et al.* 1997), and hypersalivation (Taylor *et al.* 2009). Clinical signs are often not evident until late in the course of disease, and survival time is often short after identification of gastric masses (Tennant *et al.* 1982; McKenzie *et al.* 1997; Taylor *et al.* 2009). Most reports have focused on neoplastic disease, which has a high incidence of metastasis (up to 78% in one study [Taylor *et al.* 2009]), or benign polyps that have resulted in fatal gastric outflow tract obstruction (Morse and Richardson 1988; Furness *et al.* 2013). For this reason, gastric masses are of significant concern when identified in equine patients.

Treatment options are often limited, and inaccessibility via a midline celiotomy incision has hampered gastric surgery in the horse. Transendoscopic surgical removal of a small gastric adenomatous polyp has been reported (Marley *et al.* 2016), and gastrectomy has been used to successfully treat gastric masses in other veterinary species (Walter *et al.* 1985; Lee *et al.* 2014; Gardhouse *et al.* 2016). To date, there are no reports of surgical removal of large or infiltrative gastric masses in the adult horse. This report describes a horse presented with recurrent colic, in which a mass was identified emanating from the stomach and was tightly adhered to the spleen. The mass was subsequently confirmed to be granulomatous inflammation, which was considered likely to be secondary to a penetrating gastric injury. This was treated surgically, necessitating splenectomy and partial gastrectomy. Short and long-term complications (mild colic) were responsive to management changes and oral phenylbutazone and hyoscine butylbromide. The mare had four colic free months and returned to ridden exercise but was euthanased 14 months later following development of colic (due to a right dorsal displacement) refractory to analgesia.

Case history

A 9-year-old Cob mare was referred to the Weipers Centre Equine Hospital for evaluation of acute colic that was unresponsive to treatment. The horse had a history of recurrent colic of two and a half years' duration, which had been successfully treated medically on multiple occasions. The colic episodes had occurred with varying frequency, and at their most frequent occurred weekly. Investigation prior to referral led to an initial diagnosis of inflammatory bowel disease (based on a clinical improvement following treatment with corticosteroids) and hepatitis (due to increased serum bile acids) that was treated with trimethoprim sulfadiazine. One week prior to referral the horse was noted to have increased acute phase protein concentrations (fibrinogen 7.8 g/L, reference <4; serum amyloid A 578 mg/L, reference <5.4).

Clinical findings at presentation

The horse was in good general body condition (BCS 3/5, 517 kg), and was quiet, alert, and responsive. Heart rate was 48 beats/min, respiratory rate was 8 breaths/min, and rectal temperature was 37.8°C. Mucous membranes were pale

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pink, with a capillary refill time of 2 s. Borborygmi were reduced in the right dorsal quadrant. General clinical examination was otherwise unremarkable.

Transabdominal ultrasound was performed, revealing the stomach to be distended with fluid content. There was an increased volume of anechoic peritoneal fluid. A nasogastric tube was passed, and 13 L net reflux was obtained. Rectal palpation revealed a large gas distended viscus in the right dorsal abdomen. Abdominocentesis was performed, and fluid analysis was within normal limits.

A tentative diagnosis of right dorsal colon displacement was made, and the horse was treated conservatively. A jugular catheter was placed, and a bolus of Hartmann's solution (Vetivex 11[1] 10 mL/kg) was administered. No further nasogastric reflux was obtained. Food was withheld overnight, and no colic signs were observed. Reassessment the following day confirmed resolution of the abnormalities on rectal palpation.

Transabdominal ultrasonography

Repeat abdominal ultrasonography was performed; the gastric contour was small, with no fluid distension. An elliptical structure was visible extending from the left intercostal space 8–14 (**Fig 1**). The structure was tubular, following the contour of the greater curvature of the stomach and cranial edge of the spleen, and heterogeneous with a multiloculated appearance. Hypoechoic regions were interspersed with multiple hyperechoic areas, consistent with gas or mineralised material. It was not clear whether the mass arose from the stomach or the spleen.

Gastroscopy

Gastroscopy revealed a convex appearance to the squamous mucosa (**Fig 2**), consistent with external compression. The proximal duodenum was visualised endoscopically, and was flattened, consistent with extraluminal compression. The visible gastric mucosa was otherwise normal.

Percutaneous fine needle aspirate

An ultrasound guided aspirate of the fluid within the mass was obtained under sedation (detomidine [Domidine[1] 0.01 mg/kg bwt i.v.]; butorphanol [Dolorex[1] 0.02 mg/kg bwt i.v.])

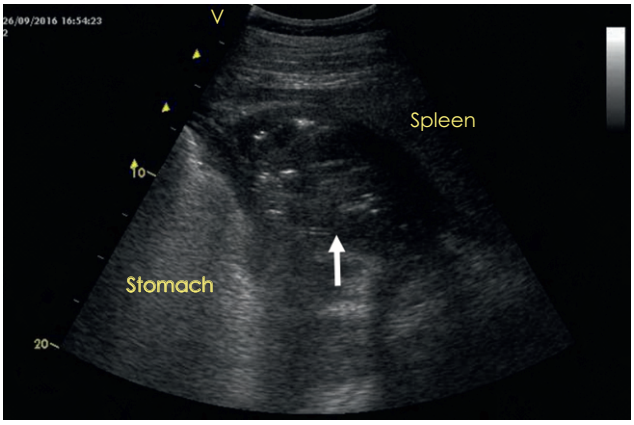

Fig 1: Transabdominal ultrasound image showing an elliptical structure (white arrow) located between the spleen and stomach. Multiple hypoechoic areas are visible, interspersed with focal echodense regions, denoting either gas or mineralised material.

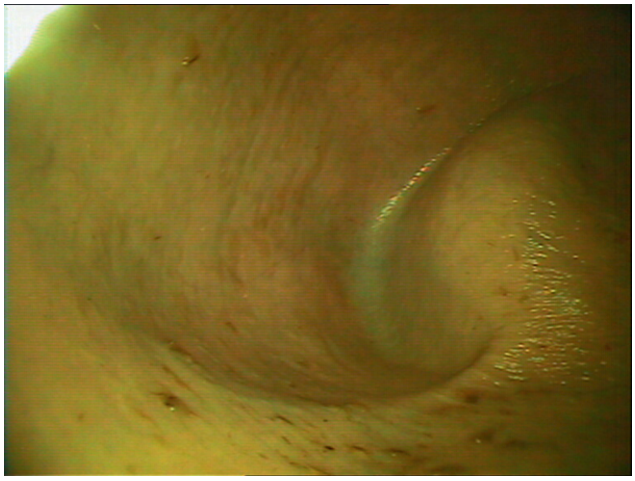

Fig 2: Gastroscopic image showing the squamous mucosa of the greater curvature of the stomach. This shows a large indentation in the stomach wall, but the mucosa was unaffected.

and local anaesthesia. A total of 150 mL of serosanguinous fluid was aspirated. Cytological analysis revealed a high proportion of neutrophils (77%) and macrophages (22%). Sparse cultures of *Fusobacterium* and *Prevotella* spp. were identified.

Surgery

Due to the history of chronic colic and risk of gastric rupture secondary to pyloric outflow obstruction an exploratory abdominal celiotomy was performed to further investigate the mass.

Procaine benzylpenicillin (Depocillin[2] 20 mg/kg bwt i.m.), gentamicin sulphate (Genta-equine[1] 6.6 mg/kg bwt i.v.), and flunixin meglumine (Meflosyl,[3] 1.1 mg/kg bwt i.v.) were administered prior to induction of anaesthesia.

The horse was positioned in dorsal recumbency and prepared for aseptic surgery in routine fashion. A 47 cm ventral midline abdominal celiotomy incision, extending from the umbilicus cranially, was performed which allowed visualisation of the mass. The mass was 20 × 10 × 7 cm and was tightly adhered to the cranial edge of the spleen and the caudoventral portion of the stomach. The decision to perform a total splenectomy was made due to the inability to ascertain the degree of splenic invasion, and the concern that the mass may have been neoplastic. The dorsal portion, and apex of the spleen was grasped and the spleen was elevated towards the incision allowing the nephrosplenic ligament to be visualised and transected, exposing the splenic artery and vein which were triple ligated with encircling ligatures of 3.5 metric polydiaxanone (PDS 11[4]) and with the use of electrosurgery (Ligasure-US surgical[5]). The artery was ligated prior to the vein in an attempt to reduce the blood volume of the spleen. Following ligation of the vascular supply a posterior resection of the remaining portion of the nephrosplenic ligament and phrenicosplenic ligament were performed at depth, under visualisation with careful retraction near the hilus. This allowed complete exteriorisation of the spleen, and the partial exteriorisation of the mass where it was attached to the gastric wall. Further exploration confirmed that the mass was intimately associated with the stomach and a decision was made to perform a partial

gastrectomy. The surgical site was isolated using moistened laparotomy sponges and impervious drapes. Four large Doyen bowel clamps were placed across the stomach isolating the mass and sharp dissection was used to incise the gastric wall, removing the affected portion of the stomach, associated mass and the spleen. The stomach was closed with a combination of inverting suture patterns (Parker-Kerr, Cushing and Lembert). Thorough abdominal lavage with 25 L of Hartmann's solution was performed and the laparotomy incision was closed in a routine manner. A stent was placed and removed 48 h post-surgery.

Post-operative progression

Post-operatively the horse received intravenous Hartmann's solution for 48 h (50 mL/kg/day). Due to the potential contamination of the abdominal cavity with gastric contents during surgery and risk of septic peritonitis, antimicrobial therapy was continued for 7 days with penicillin, gentamicin, and metronidazole (Metronidazole[6] 15 mg/kg bwt per os q. 8 h). Clinical signs of endotoxaemia developed within 5 h of surgery. The horse was pyrexic, tachycardic, and had congested mucous membranes. Flunixin was administered (1.1 mg/kg bwt i.v.) but the horse progressed to develop colic signs (bruxism and pawing) 8 h post-operatively. A nasogastric tube was passed yielding 2 L of haemorrhagic reflux. Morphine (Morphine Sulfate Injection[7] 0.1 mg/kg bwt i.m. q. 6 h) was administered on three occasions as pain was refractory to analgesia with flunixin and sedation with detomidine, and the signs of colic resolved. Twelve hours after surgery the horse was bright, alert, and showed no signs of abdominal pain.

Prophylactic cryotherapy was applied to all four feet for 48 h to minimise the risk of laminitis, and a hernia belt[8] was applied for the duration of hospitalisation. A moderate amount of serosanguinous fluid drained from the incision for the first 12 h post-operatively, after which no further incisional complications were noted.

Treatment with omeprazole (Gastrogard[9] 4 mg/kg bwt per os q. 12 h for two doses, decreasing to q. 24 h thereafter) and sucralfate (Sucrabest[10] 20 mg/kg bwt per os q. 6 h) was started after surgery. Gradual oral water reintroduction began 16 h post-operatively. Food was reintroduced 24 h after surgery, with small volume wet fibre mashes (250 g fibre nuts with 1 L warm water) offered initially. This was incrementally increased until ad libitum water was offered and short walks to grass were introduced 48 h after surgery. As feed volume was increased, the horse became dull and tachycardic, consequently feed was maintained at 50% of required daily ration for 5 days. On two occasions the horse showed signs of mild discomfort, and food material was lavaged from the stomach via nasogastric tube. Small haynets were added to the ration 1 week post-operatively, and the horse showed no signs of colic when trickle fed small volumes. The ration was increased incrementally over an 8-day period until the mare was receiving a diet of 2% bwt soaked hay.

Gross evaluation of the mass

After excision, two discharging tracts were noted; one leading to the resected portion of margo plicatus, and one at the glandular mucosa. Grossly the mass was tightly adhered to the cranial edge of the spleen (**Fig 3**), was well encapsulated, contained sheets of tissue, and a large amount of foul smelling, tan coloured necrotic material. The contents of the mass were explored for evidence of a foreign body, but nothing was identified. The mass and spleen were radiographed, but no evidence of a metallic foreign body was found.

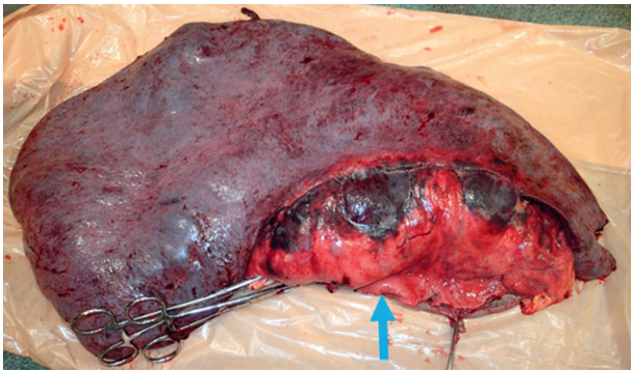

Fig 3: Photograph post-excision showing the mass (blue arrow) intimately associated with the spleen after excision.

Histopathology

Histopathological evaluation of the mass (contents, capsule, and connection to stomach/spleen) revealed the contents of this structure to consists of sheets of necrotic round cells, however, due to the extensive necrosis the cell type could not be ascertained. The wall of the mass contained a layer of granulation tissue, amongst which moderate to large numbers of inflammatory cells were seen. The cell population was mostly heterogenous. Focally a more monomorphic lymphocyte population was present. Immunohistochemistry (using antibodies for CD3, CD79a, Pax5, MUM1, MAC387, MHCII and CD20) was performed to further explore this lymphocytic population. Results were inconclusive due to inconsistent staining of the suspicious population with the markers applied. Further examination of the sections by two boarded pathologists favoured the presence of a chronic inflammatory process over a neoplastic process (lymphoma).

Diagnosis

A large, well encapsulated, chronic inflammatory gastric mass causing extra-luminal gastric outflow obstruction. Given the location the most probable aetiology was considered to be a chronic inflammatory response to a previous penetrating gastric injury.

Discharge

The horse was discharged from the clinic 17 days after surgery. Prophylactic treatment with omeprazole was continued for 11 days after discharge (1 mg/kg bwt per os q. 24 h). The owner was advised to feed a daily ration of 2% bwt dry weight hay soaked for 30 min, divided into several nets throughout the day. The horse received three feeds a day consisting of 500 g soaked fibre nuts with a feed balancer and was grazed in hand for 10 min three times daily.

The horse completed a further 4 weeks of box rest and was initially walked twice daily in hand for 5 min, increasing

to 20 min twice daily by week four. Turnout was then reintroduced, at first in a 10 m^2 paddock for 6 weeks, followed by normal turn out to pasture.

Case progression

Five weeks post-discharge the mare had gained 23 kg bodyweight. Mild self-limiting colic episodes, associated with small alterations in diet and often preceded by mild diarrhoea were reported, occurring up to once a week.

Clinical examination and repeat blood biochemistry were unremarkable. On gastroscopic evaluation after 16-h feed withdrawal there was still a small, soft mass of feed within the stomach. Repeat gastroscopy the following day revealed that the glandular mucosa was 'puckered' in appearance and had not significantly remodelled. There was no visible structural obstruction to the gastric outflow tract. There was no gastric impaction present on repeat gastroscopy 4 months later.

The period of time spent at grass was increased gradually; and at 10 months post-operatively the horse was managed at pasture and had returned to the previous level of ridden work successfully.

Fourteen months post-operatively the horse re-presented to the Weipers Centre Equine Hospital for colic signs of 6 days duration following a change from pasture to 24-h stabling. On arrival the mare was refractory to analgesia (flunixin 1.1 mg/kg bwt i.v.; morphine 0.1 mg/kg bwt i.v.; detomidine 0.02 mg/kg bwt). The examination was consistent with a large colon impaction and displacement. The owner declined surgical intervention and the horse was euthanased.

Post mortem examination

Post mortem examination revealed a right dorsal displacement of the large colon, and a substantial large colon impaction, with approximately 75% of the large colon lumen full of impacted ingesta. The gastrectomy site was examined, and fibrinous tags were noted on the serosal surface of the stomach, in addition to a focal fibrinous adhesion between the stomach and the diaphragm.

Discussion

Partial gastrectomy has not been reported in the equine literature. Partial gastrectomy may offer treatment for horses diagnosed with well demarcated gastric masses in a surgically accessible position with no evidence of metastasis.

In the case described here, the horse's initial recurrent colic episodes were likely due to compression of the gastric outflow tract which resulted in accumulation of gastric contents and increased intraluminal pressure. The horse was considered to be a good candidate for surgery due to the risk of fatal gastric rupture, the accessibility of the mass via a midline abdominal celiotomy incision, the well circumscribed nature of the mass, and the lack of any identifiable metastases.

There is a paucity of information regarding surgical access to the stomach in horses; with access to the equine cranial abdomen proving challenging due to the size and depth of the abdomen, and the position of the abdominal viscera. Gastric surgery via a laparoscopic approach has not been described but offers a potential approach for the future. Gastrotomy has been used to successfully treat gastric impactions (Parker *et al.* 2011), and a single case report describes transendoscopic removal of a gastric polyp from the lumen of the stomach (Marley *et al.* 2016). In foals, gastrojejunostomy, or gastroduodenostomy have been described for the treatment of gastric outflow obstruction (Zedler *et al.* 2009), however, to the authors' knowledge there are no reports of surgical treatment of gastric masses or partial gastrectomy in the adult horse. The use of surgical stapling devices was considered during the treatment of the case described here, however, the thickness of the gastric wall, and limited space available for manoeuvring the stapler precluded this approach.

The extent to which the equine stomach can remodel is unknown. It is intuitive that resecting glandular mucosa may predispose affected horses to severe squamous ulceration, which may have lifelong consequences if the glandular portion is unable to remodel to accommodate a larger volume of gastric content. However, on repeated gastroscopic evaluations of this horse no gastric ulceration was present. There was evidence that gastric emptying was delayed initially, which is likely to have been a contributing factor to the episodes of post-operative colic. Meal size and composition are known to affect gastric emptying in healthy horses, and smaller, low starch feeds with a higher fibre content empty faster than high starch feeds (Métayer *et al.* 2004). In this case reducing meal size of a high fibre, low starch meal was associated with reduced frequency of colic episodes. In dogs and humans, gastric emptying following distal gastrectomy is dependent on the viscosity of food material ingested and on small intestinal contractility, which is influenced by the gastroenterotomy technique used (Ehrlein *et al.* 1987). There are no studies in the horse describing motor function of any section of the alimentary tract following resection, but disruption to intestinal motor activity has been reported in dogs following distal intestinal resection (Quigley and Thompson 1993). Conversely, humans undergoing sleeve gastrectomy have been shown to have accelerated gastric motility when assessed scintigraphically (Melissas *et al.* 2013). In this case, it is possible that adhesion formation between the stomach and diaphragm contributed to the post-operative episodes of recurrent colic but altered motility cannot be ruled out as a contributing factor. It is most likely that the final episode of colic was precipitated by management change rather than being directly related to the previous surgery.

A number of approaches have been described for splenectomy in the horse (Witzel and Mullenax 1964; Dennig and Brocklesby 1965). These include splenectomy approached from the left side of the horse, with the horse standing and sedated or in right lateral recumbency, with or without resection of the 16th, 17th and/or 18th rib (Roberts and Groenendyk 1978), laparoscopic assisted splenectomy (Ortved *et al.* 2008; Gracia-Calvo *et al.* 2015), and transthoracic splenectomy (Rigg *et al.* 1987).

In this case, splenic involvement had not been anticipated prior to surgery, and it was only after exploration of the abdomen that the extent of the mass and involvement of the splenic capsule and body were identified. The intimate relationship between the mass, spleen and gastric wall greatly restricted the options for splenectomy using the previously described techniques and consequently the decision was made to remove the spleen, mass, and affected portion of the

stomach as described through a ventral midline celiotomy incision. Involvement of the spleen in abdominal masses has previously been described (Nyack *et al.* 1984), and with retraction from an assistant, illumination, and the use of long handled instruments and electro-surgery, it is possible to remove all, or a portion, of the spleen via a ventral midline approach (P. Pollock, personal communication). Exteriorisation of the spleen can be facilitated and improved, by grasping the apex of the spleen and systematically sectioning the nephrosplenic, phrenicosplenic and gastrosplenic ligaments as the spleen is pulled towards the incision. In this case the decision to remove the spleen in its entirety was made due to the involvement of the gastric wall, making dissection and manipulation difficult, and concern that the mass may have been neoplastic.

In conclusion, this report describes a case with an unusual reason for recurrent colic and suggests that partial gastrectomy may be considered as a treatment for some gastric masses in the horse depending on their configuration and position. Post-operative complications are likely to include colic, which may be successfully managed by dietary adjustment. The likelihood of a successful outcome following gastric resection needs to be assessed on a case by case basis, with thorough discussion of the risks and potential aftercare requirements with the client beforehand.

Author's declaration of interests

None declared.

Ethical animal research

This report describes a case that was admitted to the Weipers Centre Equine Hospital for investigation and treatment. The decision to publish the case was made retrospectively, and clinical decision making was not affected by the publication of this report.

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Authorship

The case was diagnosed and treated pre- and post-operatively by A.G. Raftery and S.J. Voss. Surgery was performed by P.J. Pollock and F. Barceló Oliver. A. Rupp was responsible for histopathological diagnosis. S.J. Voss primarily prepared the manuscript; all authors contributed to and approved the manuscript.

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Clinical Commentary

Recurrent colic and abdominal masses in horses – diagnostic and therapeutic challenges

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The case report by Voss *et al.* (2020) in this issue describes the diagnostic approach, surgical treatment and outcome of a horse with a granulomatous gastric mass of suspected traumatic origin causing recurrent colic. The case report is interesting from a number of perspectives. It highlights the importance of a complete, multifaceted approach to the investigation of horses with abdominal pain that defy rapid diagnosis, such as those with recurrent colic. It also shows that even in a referral centre, tentative diagnoses are rendered, which are then re-examined and re-categorised. In the internet-age, and with omnipresent social media, this careful, systematic approach to complicated cases can be misinterpreted by clients as "the vet doesn't know"!! The art of veterinary medicine is in the communication of the fact that indeed, the vet does not know, but they are following a logical path to determine the cause of the current condition. Only after this has been addressed can a treatment modality, or process, begin.

Recurrent colic is often defined as repeated episodes of colic over a period of time, such as a month or a year (Hillyer and Mair 1997). The term certainly seems appropriate for the horse in this report, which had shown frequent colic episodes (at times weekly) over an extended time period of 2.5 years. Recurrent colic can be differentiated from chronic colic, and this term may be most appropriate for cases of colic lasting for several days (Mair and Hillyer 1997; Mair and Edwards 2007). Causes of both chronic (Mair and Hillyer 1997) and recurrent colic (Hillyer and Mair 1997; House and Warren 2016; Stewart *et al.* 2018) have been reviewed, and many individual reports outline the broad range of intestinal and extra-intestinal disorders that should be considered. In a subset of horses with chronic or recurrent cases of colic, an aetiology cannot be identified.

The diagnostic approach to cases of recurrent or chronic colic has to be comprehensive, and common as well as uncommon causes of colic must be considered. Where abdominal masses can be identified, as in the horse of this report, the challenging question of differentiating between neoplastic and non-neoplastic aetiologies arises. Here, a mass between the stomach and spleen was identified based on ultrasonography but could not be confidently attributed to either organ. Gastroscopy showed that the mass was extra luminal to the stomach, thereby precluding direct visualisation and the collection of biopsies. Gastroscopy should be pursued in any mass that possibly involves the stomach (**Figs 1–3**); however, if this modality is unavailable, contrast radiography has been suggested as a possible alternative that can demonstrate mass lesions in the distal oesophagus and proximal stomach (East and Savage 1998).

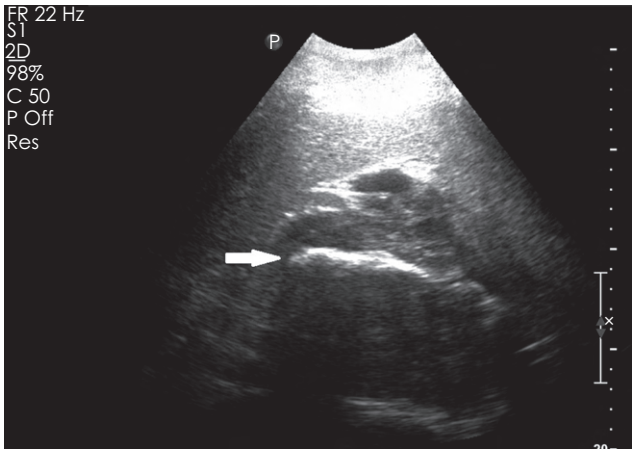

Fig 1: Ultrasonographic image of an abdominal mass located between the stomach and spleen in an 11-year-old gelding. Similar to the case described by Voss et al. (2020) in this issue, the mass could not be definitively attributed to the stomach or spleen. A gastrointestinal origin was suspected as the central hyperechoic line (arrow) within the predominantly hypoechoic mass was thought to represent a gas-filled lumen.

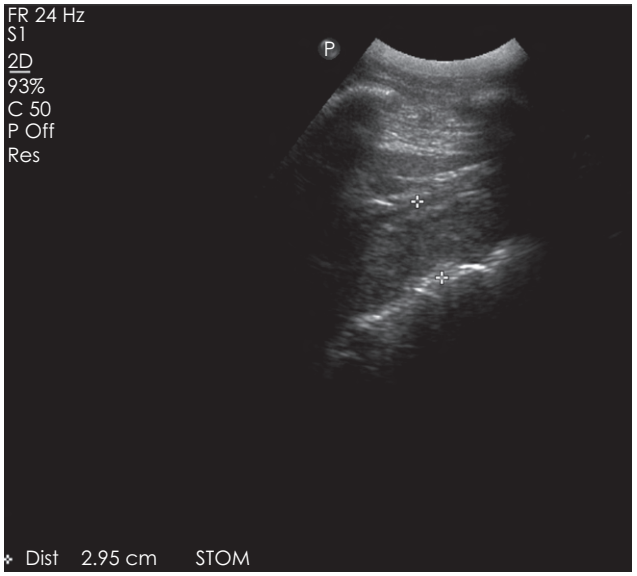

Fig 2: The thickened and hypoechoic visible portion of the gastric wall (between calipers) in the same horse.

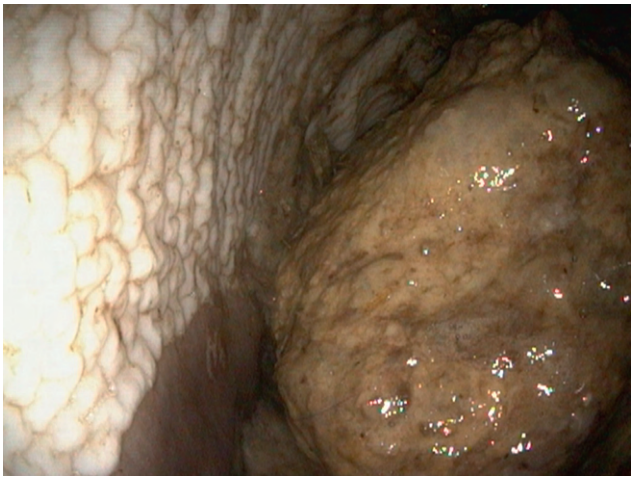

Fig 3: Endoscopic image of an intragastric mass in the same horse. The mass was confirmed as a squamous cell carcinoma that extended out from the nonglandular gastric mucosa through the stomach wall and into the adjacent liver and spleen.

Increased concentrations of acute phase proteins prior to referral of the horse of this report may be interpreted as nonspecific indicators of inflammation, and do not reliably differentiate between neoplastic and non-neoplastic masses such as abscesses or granulomas. Peritoneal fluid analysis was normal, which supports the clinical experience that this test is only moderately useful to differentiate neoplasia from abscesses or other masses. Peritoneal fluid revealed neoplastic cells in one of six horses with gastric squamous cell carcinoma and liver metastases in one study (Tennant *et al.* 1982), and in 3 of 5 cases of gastric squamous cell carcinoma in another study (Olsen 1992). Similarly, peritoneal fluid analysis confirmed the presence of neoplasia in as few as 44–50% of cases of abdominal neoplasia overall (Zicker *et al.* 1990; Recknagel *et al.* 2012). With regard to the diagnosis of abdominal abscesses, peritoneal fluid analysis provided a definitive diagnosis in 20% of cases in one study (Zicker *et al.* 1990) and was reported to have a diagnostic sensitivity of 40% for predicting abdominal abscesses in another study (Arnold and Chaffin 2012). Clinicians should be aware of these limitations to avoid ruling out neoplasia or abdominal abscesses prematurely in horses with abdominal masses (Tennant *et al.* 1982; Ford *et al.* 1987; Zicker *et al.* 1990). In the case reported here, a fine needle aspirate was obtained to characterise the mass further; however, the cytological description does not clearly identify inflammation as septic or nonseptic, and the authors do not comment on the presumed relevance of positive culture results, or on their 'working diagnosis' prior to exploratory laparotomy. It may be interesting to note that the horse had managed to maintain a good body condition despite its prolonged history of recurrent colic, possibly indicating that neoplasia was less likely.

Exploratory laparotomy was pursued in this report based on the history of chronic colic, the perceived risk of gastric rupture secondary to pyloric outflow obstruction, the inability to ascertain the nature of the abdominal mass through other means, the accessibility of the mass through a midline incision, and the assessment that no metastases were present. Evaluation for metastases is an important consideration where neoplasia is considered or suspected, especially if additional clinical signs are present and before invasive and costly procedures such as an exploratory celiotomy are pursued. It should also be considered that an identified mass may represent a metastasis rather than the primary tumour. As the authors of this report state, metastasis is common in cases of gastric neoplasia, and was identified in 78% of cases in one study (Taylor *et al.* 2009). Gastric squamous cell carcinoma as the most common gastric neoplasia is usually locally invasive but can metastasise to the lymph nodes and lungs (East and Savage 1998) and the authors do not comment on consideration of thoracic radiography or thoracic ultrasound as part of their investigation. Adenocarcinoma, squamous cell carcinoma, malignant melanoma, fibrosarcoma, undifferentiated sarcoma and haemangiosarcoma have been reported as the most common tumours to metastasise to the chest (Mair *et al.* 2004). Involvement of the thoracic cavity may go along with significant pleural effusion and clinical signs of respiratory distress, reduced breath sounds, ventral oedema and jugular distension; however, increased respiratory rate was also seen as a nonspecific clinical sign in a number of cases of gastric neoplasia in one study (Taylor *et al.* 2009).

It is interesting that the authors did not elect to perform a standing exploration of the abdomen laparoscopically, to further delineate the extent of the mass, or to assess the abdomen for metastases prior to general anaesthesia; especially as the preoperative diagnostic tests had failed to determine whether the mass arose from the stomach or the spleen. Ultimately, as clearly demonstrated in the case report, it made no difference to the successful outcome, but it may have added further useful information before the definitive surgical approach. This point is further illustrated by a statement in the discussion that "…splenic involvement had not been anticipated prior to surgery". This was surprising given that the thorough preoperative investigation had shown a mass that was clearly adjacent to the spleen and so at least passing thought to splenic involvement must have been considered.

As stated, there have been limited reports of the surgical treatment of gastric masses, or of splenectomy, for either clinical or research purposes, in the horse. The authors' report of a partial gastrectomy is novel, as is the ventral midline celiotomy approach to splenectomy. Gastric surgery is fraught with complications, not least of which is abdominal contamination. The surgery site is protected using laparotomy sponges, or drapes, but intraoperative contamination is difficult to prevent (Parker *et al.* 2011). Further, one of the authors of this commentary has had the misfortune of having post-operative tearing of the gastric wall occurring at the site of gastrotomy closure, which resulted in fulminant septic peritonitis and euthanasia. Reports of laparoscopic splenectomy (Ortved *et al.* 2008; Sherlock and Peroni 2012) still describe resecting a rib to retrieve the spleen at the end of surgery. It is unclear why the organ is not placed in a laparoscopic retrieval bag, with or without morcellation, before removal from the abdomen. This is routinely performed in the laparoscopic removal of large ovaries (Wilderjans 2012). Additionally, as horses are already under anaesthesia, they could be rolled into dorsal recumbency to undergo a midline mini-laparotomy to retrieve the organ. This would result in less surgical trauma and reduce post-operative morbidity. The novel ventral midline celiotomy approach to splenectomy in the current report is of significant interest as it

allowed exploration of the abdomen, access to the stomach and subsequently negated the need for rib resection following splenectomy. We would encourage the authors to publish a more detailed description of their surgical approach.

Continued mild colic episodes after surgical mass removal in the horse of this report were attributed at least in part to altered, likely delayed, gastric emptying, and were primarily managed by adjusting feeding amounts and feeding frequency while maintaining a high fibre diet. There is a paucity of information regarding the influence of meal composition and meal size on gastric emptying in horses, but in general terms, gastric emptying rate is affected by food type, meal volume and composition, meal nutrient content, and subject gender (Bornhorst and Singh 2014). As the authors indicate, larger meal sizes and increased starch content (reduced fibre content) prolonged the time until feed was emptied from the stomach in healthy horses (Metayer *et al.* 2004). The type of fibre may also matter as insoluble fibre emptied more rapidly than soluble fibre in pigs (Guerin *et al.* 2001). In patients undergoing gastric surgery, the potential impact of surgical technique on gastric motility needs to be considered. Evaluation of gastric emptying in this horse would have certainly been interesting, but methodologies for measuring solid-phase gastric emptying in horses were likely not feasible in this patient.

Given the small size of the equine stomach to begin with, the approach of providing multiple small meals following partial gastrectomy seems intuitive, and it might be expected that the horse would have voluntarily restricted its feed intake similar to humans undergoing bariatric surgery (Gagner *et al.* 2009). As mentioned in the case report, human patients undergoing a type of bariatric surgery known as 'sleeve gastrectomy', which results in reduction of stomach volume to about 20% of its original size, generally experience accelerated gastric emptying that is attributed to removal of gastric pacemaker cells in the fundus (Sioka *et al.* 2018). Given the likely differences in surgical technique between sleeve gastrectomy and partial gastrectomy described here, it is uncertain whether these findings can be extrapolated to the case. While the fundus and gastric body serve as a food reservoir, antral motility in the distal stomach is primarily responsible for the mixing, crushing and physical breakdown of food into particles small enough to enter the small intestine (reviewed in Bornhorst and Singh 2014). Reduced antral motility is seen in human patients with gastroparesis (Bharadwaj *et al.* 2016), and these patients benefit from dietary management that reduces the reliance on antral contractility by reducing fat and emphasising soluble fibre. While it is unclear exactly how gastric motility was affected by partial gastrectomy in the horse of this report, it is interesting to note that the stomach was apparently slow to empty following surgery, which may indicate an effect of altered antral motility. While this horse appeared to adjust to a rather 'normal' diet of mostly hay and grass over time, the functions of the different regions of the stomach should be considered in horses undergoing gastric surgery, and at least temporary dietary modifications may need to be undertaken to minimise complications related to altered gastric emptying.

Authors' declaration of interests

No conflicts of interest have been declared.

Ethical animal research

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Authorship

Both authors prepared the manuscript and approved it in its final form.

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Case Report

Use of fibrin sealant in a horse with an intratracheal dorsal laceration

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Keywords: horse; trachea; laceration; perforation; emphysema; fibrin sealant; fibrin glue

Summary

Full-thickness tracheal perforations are rarely encountered in horses. In the absence of external wounds, the lesion often stays unrecognised until the efflux of air into the subcutaneous tissues induces emphysema. Different treatments have been described and the choice is based on the size of the lesion and the severity of the subcutaneous emphysema.

We describe the case of a 9-year-old Hanoverian gelding that was presented to our clinic with severe emphysema but no external wounds. Endoscopy of the upper airways revealed a full thickness defect on the dorsal aspect of the trachea (**Fig 1**). Several methods to reduce the increase of the emphysema were attempted, including packing of the area around the tracheal defect, diversion of the air flow through tracheotomy and covering the defect with collagen sponge. Finally, the use of fibrin glue, applied perpendicular to the defect using an i.v. catheter (**Fig 2**), seemed to improve the clinical signs of emphysema and to hasten the healing of the defect. The mechanism of action of fibrin glue is based on the interaction between the components thrombin and fibrinogen which, similar to the blood coagulation cascade, results in the formation of cross-linked fibrin. Emphysema was also managed with stab incisions on the skin of the ventral border of the mandible, shoulder and stifle. The incisions facilitated the escape of subcutaneous air when massaged towards them. Seven days after the application of the fibrin glue, a repeat endoscopy revealed a decreased size of the defect which was already covered by granulation tissue. Fibrin gel has proven a valuable scaffold for tissue engineering in people and its properties made the substance suitable for this case. To our knowledge, there has been no previous report of the use of a fibrin sealant for the treatment of tracheal lacerations. We believe that the application of the fibrin glue facilitated the closure of the defect in this case.

Key points

- Lacerations of the trachea can lead to severe emphysema, which should be treated promptly, as it can lead to complications such as life-threatening pneumothorax, pneumomediastinum and skin necrosis, as a sequela of the separation of the dermal layers.
- A multi-treatment design to remove the existing subcutaneous air and to cover the tracheal defect, proved to be the key for the successful, quick and uncomplicated recovery of this patient.
- The use of fibrin glue has a potential for healing of defects that are difficult or not suitable for surgical repair, including lacerations of the trachea in horses.

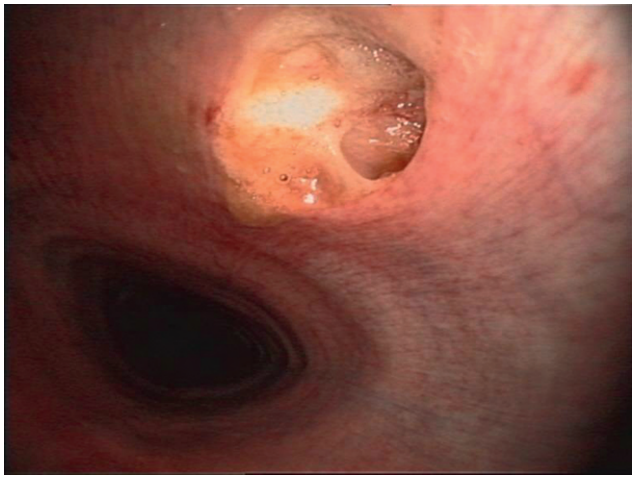

Fig 1: Endoscopic view showing the laceration of the dorsal tracheal membrane.

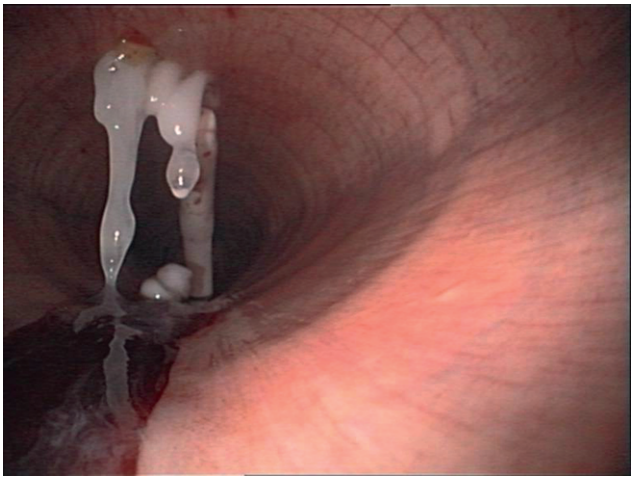

Fig 2: Endoscopic view showing the fibrin glue in the dorsal laceration as 'stalactites'.

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Clinical Commentary

Noninfectious causes of subcutaneous emphysema

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Keywords: horse; trauma; emphysema; airway

The case report by Coco *et al.* (2020) describes an innovative and very efficient way of treating a tracheal perforation that was not amenable to surgical repair. The fibrin glue created an immediate seal and stopped further progression of the severe subcutaneous emphysema. Subcutaneous emphysema (SE) is the pathological accumulation of air or gas in the subcutaneous tissues, creating a soft swelling that crepitates when palpated. In horses, SE can be infectious or noninfectious in origin. While malignancies have been reported to cause emphysema in people (Chu and Glare 2000), this has not been documented in horses. Therefore, traumatic and surgical wounds are the principal causes of noninfectious SE in the horse.

Axillary wounds

Axillary wounds are typically accompanied by some degree of SE that becomes apparent within 3 days of the injury. It is generally accepted that benign (noninfectious) post-traumatic emphysema is the result of a '*ball-valve effect*' at the level of the lacerated skin or deeper tissue layers (Chu and Glare 2000). Air is able to enter freely through the wound, but flow in the opposite direction is (partially) obstructed. This one-way movement of air across the defect is typically facilitated by increased movement of the horse. Once the air is trapped between tissue layers, simple removal of the ball-valve obstruction is not enough to allow the air to escape. Since complete primary closure of the wound is usually contraindicated, the continued influx of air needs to be minimised by sealing the wound with packing and restricting movement of the horse. It is important to remember that the entrapped air can travel along facial planes, resulting in a pneumomediastinum or even a potentially life-threatening pneumothorax (Fowler *et al.* 2013; Joswig and Hardy 2013).

Although axillary wounds are most notorious for being accompanied by SE, air accumulation in the tissues surrounding a laceration can also occur in other anatomical regions. For example, hindlimb movement can similarly drive air into the loose subcutaneous tissues surrounding an inguinal wound.

Trauma of the respiratory tract

Subcutaneous emphysema can occur following penetrating injury to any part of the airway. In cases where the overlying skin is damaged, the cause of emphysema is easily identifiable while blunt trauma can make it more difficult to find the source of the escaping air.

Fractures of the nasal passages or paranasal sinuses can allow air to escape into the overlying subcutaneous tissue (Dixon 2014). Cases where the skin is not disrupted may go unnoticed for a while, especially when the emphysema expands slowly. If the fracture is not repaired, a head bandage can help to limit expansion of the emphysema until a seal has formed at the fracture site.

Guttural pouch rupture is an uncommon cause for emphysema formation. Swelling is first recognised in the throatlatch region. Trauma to the wall of the guttural pouches can be the result of high-volume guttural pouch lavage, typically performed to conservatively manage guttural pouch empyema (Fogle *et al.* 2007). Perforation of the guttural pouch has also been described as a rare complication of nasogastric intubation (Gillen *et al.* 2015). With a diameter of 3–4 cm (Baptiste 1997), the pharyngeal ostium is large enough to allow a small nasogastric tube to enter the guttural pouch when the horse swallows and the ostium opens. While the perforation can be expected to heal by secondary intention, surgical intervention might be necessary to treat the initial disease (e.g. empyema) or to stop or slow down an expanding emphysema. If this cannot be accomplished by simply inserting a Foley catheter through the pharyngeal ostium, the guttural pouch might have to be surgically opened to reduce air pressure in the pouch or to pack the perforation site (Davis and Caniglia 2015).

Blunt trauma to the neck can result in tracheal perforation, which typically leads to various degrees of SE. As described in the case report by Coco *et al.* (2020), the emphysema can cover the entire body within a few days and might cause pneumomediastinum and -thorax (see 'Axillary Wounds'). The tracheal perforation and its exact location are best diagnosed endoscopically (Prange 2015; Coco *et al.* 2020). In order to stop or minimise the continued leaking of air into the surrounding tissues, the tracheal defect needs to be closed/sealed. If that is not possible, a tracheostomy tube is placed either through the primary defect or caudal to it, so that it bypasses the tracheal perforation.

Thoracic trauma is identified in up to 20% of newborn foals, with dystocia and foaling in primiparous mares being risk factors for these injuries (Jean *et al.* 1999). Although clinical signs are often absent and foals recover fully, fractured ribs can puncture the underlying lung and cause haemo- and/or pneumothorax. Air escaping from the lung may also dissect into the overlying tissues. SE over the thoracic wall in a newborn foal should therefore be considered an indicator of a potentially life-threatening lung puncture and result in immediate referral to a tertiary centre.

Trauma of the alimentary tract

Accidental or surgical trauma of the oral cavity and oropharynx is a known cause for emphysema formation in people and dogs (Lopez-Palaez *et al.* 2001; Doran *et al.* 2008). Although no studies have reviewed this particular problem in

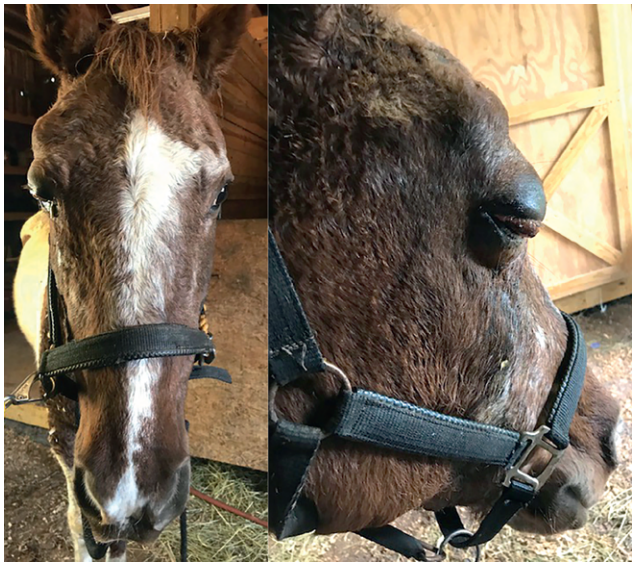

Fig 1: A 28-year-old horse with facial emphysema secondary to a perforating wound in the right pterygomandibular fold (Image courtesy of Dr. B. Scarlett, Asheboro, NC).

horses, wounds in the equine oral cavity can allow air to enter the surrounding tissues. **Figure 1** shows a 28-year-old American Paint Horse mare with an oral wound in the right pterygomandibular fold, the mucosal fold that stretches from the palate to the mandible, directly behind the last molars. The horse initially developed diffuse emphysema over the right side of its face, with the most pronounced swelling in the supraorbital fossa and upper eyelid. After most of the initial emphysema had receded, a cellulitis with subsequent abscess formation of the affected tissue planes developed.

Similarly, oesophageal perforations that initially present with SE quickly develop cellulitis due to the contamination with aerobic and anaerobic bacteria that enter the tissues surrounding the perforation (Kruger and Davis 2013).

An unusual cause of SE has been described in a horse with perforation of the caecal base. The retroperitoneal emphysema that developed secondary to the intestinal rupture had travelled through the inguinal canal and led to emphysema formation that could be palpated in the right inguinal region and over the right stifle. The horse was subjected to euthanasia intraoperatively (Gray *et al.* 2014).

Iatrogenic causes

Surgery of the respiratory tract can result in post-operative emphysema formation if air continues to escape from the airway but becomes entrapped under a closed skin incision. This has been described following primary closure of laryngotomy incisions (Lindegaard *et al.* 2016). The authors emphasise the importance of an air tight closure of the laryngeal mucosa and cricothyroid ligament with simple interrupted sutures to minimise the risk of this complication. Surgery of the paranasal sinuses may also leave a path for air to enter the subcutaneous tissues surrounding a sinus flap or trephination (Freeman 2003).

Subcutaneous emphysema of various degrees can also develop around the portal sites during and after laparoscopy and thoracoscopy. The risk of this typically benign complication can be reduced by incising only the superficial layers of the portal site with a blade and penetrating the deeper layers with the trocar. This creates a tight seal around the cannula and minimises the amount of CO_2 that can escape into the tissues (Klohnen and Peroni 2000; Hendrickson and Lee 2012). Known risk factors of gas extravasation and emphysema formation in human laparoscopy include several attempts of abdominal entry, incorrect cannula or Veress needle placement (failure to penetrate peritoneum), use of >5 cannulas, using cannulas as fulcrums and the endoscope as a lever, intra-abdominal pressure >15 mmHg and procedures that last >3.5 h (Ott 2014). Upon completion of the procedure, suction can be used to remove the gas from the peritoneal or pleural cavity to reduce the chance of post-operative emphysema formation.

Treatment

In many cases, preventing more air from entering the subcutis and deeper tissue layers is sufficient. As described above, this could entail strict stall rest for a patient with an axillary laceration or a temporary tracheostomy to bypass a tracheal perforation that cannot be repaired. The already formed emphysema will then be absorbed with time, although this can take up to several weeks. While it is unusual for the emphysematous tissues to become infected, close monitoring and, if indicated, administration of broad-spectrum antibiotics is recommended.

Reduction of the SE itself might become necessary if the entrapped air prevents access to important structures, for example, the jugular veins for catheter placement (Coco *et al.* 2020), or in cases where a widespread emphysema creates an insulating layer that prevents the horse from adjusting to hot weather (Adam and Southwood 2006). Occasionally, SE in the neck region results in laryngeal emphysema, requiring close monitoring of the horse for any signs of respiratory distress (Trostle *et al.* 1995). Removal of the air can be accomplished through multiple skin incisions (Coco *et al.* 2020) or with the help of a needle or drain that is placed into the subcutaneous tissue and attached to a suction device (O'Reilly *et al.* 2013).

Author's declaration of interests

No conflicts of interest have been declared.

Ethical animal research

Not applicable.

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Case Report

Standing low-field magnetic resonance imaging as a diagnostic modality for solar keratoma in a horse

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Keywords: horse; magnetic resonance imaging; solar keratoma; lameness; space-occupying mass

Summary

A 22-year-old Friesian gelding was presented with a history of chronic, nonresolving mild (1/5) lameness localised to the right front foot. The lameness was accentuated (2–3/5) when the horse trotted in soft surface. There was a cleft in sole adjacent to the apex of the frog. A palmar digital nerve block successfully eliminated the lameness. Radiographs revealed a smoothly marginated circular lucent area (5 × 5 mm) with a rim of increased opacity adjacent to the solar canal of the distal phalanx (**Fig 1**). These findings were consistent with osteolysis or bone resorption. The radiological differential diagnosis included a space-occupying mass adjacent to solar canal causing disturbance of the blood supply. Magnetic resonance imaging (MRI) was acquired with a 0.27T MRI scanner in a standing position and revealed a marked deformation and interruption of the solar cortex of distal phalanx caused by a reversed V-shaped smoothly demarcated focal lesion located dorsal to the solar canal (**Fig 1**), which caused an invagination of the intact solar corium into the distal phalanx and occupied the space between the solar foramina. The focal lesion had an intermediate signal intensity on T1 images and low signal on T2*, T2 FSE and STIR images. The T2*-weighted images showed a moderate fat-water cancellation artefact dorsal to the lesion. On STIR images, there was a focal area of intermediate high signal intensity peripheral to the lesion. The MRI diagnosis was a space-occupying mass causing a fluid-based osteopathy. The mass was removed surgically and submitted for histopathology, which revealed a keratoma and periosteal fibrosis. Six weeks' post-surgery the horse returned to the previous work level and at 8 months follow-up showed no recurrence of the keratoma. This case report illustrates the clinical presentation of solar keratoma, which should be considered when abscessation or chronic lameness attributed to the hoof are the presenting complaints. MRI enables identification of space occupying mass lesions and provided detailed information about the surrounding tissues. Identifying and evaluating pathology through this modality create a superior understanding of hoof abnormalities and planning of surgery.

Key points

- Keratoma can originate from unusual locations of hoof capsule such as the solar surface.
- Solar keratoma should be considered when there is a solar abnormality, such as a cleft, combined with a history of abscessation or chronic lameness.
- MRI is a helpful diagnostic tool for solar keratoma and enables precise anatomical localisation and surgical planning.

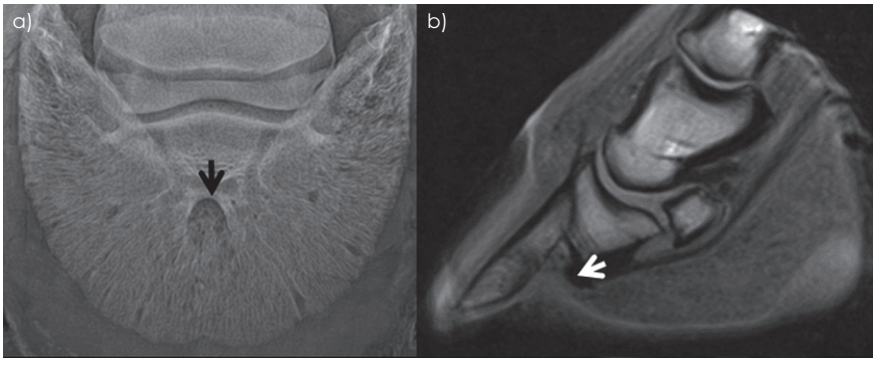

***Fig 1:** a) Dorsolateral-45°-palmaromedial oblique radiograph of right front foot. Medial is to left. There is a smoothly marginated circular lucent area with rim of increased opacity adjacent to the solar canal of the distal phalanx (arrow). b) T1-weighted 3D sagittal image, it shows a discontinuous of solar cortex of distal phalanx with smoothly demarcated focal area of intermediate signal intensity mass located dorsal to the semilunar canals and extends into the disrupted area.*

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Clinical Commentary

Decision making with keratomas: How advanced imaging can advance your cause

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Keratomas are an infrequent but recognised problem in the horse's foot which usually become clinically significant due to their effects on altering the otherwise highly organised and functional architecture of the hoof. Although keratomas may be noticed during trimming as an incidental finding, in the clinical setting their classic presentation would be as a cause of lameness. This is largely due to the loss of the normal efficient barrier provided by the external hoof to ascending infection and therefore cases often present with chronic, intermittent lameness associated with a discharging tract. Whether they are the cause or effect of infection is still subject to debate and not within the scope of this commentary to resolve.

In the paper this commentary accompanies, Mageed *et al.* (2020) diagnose a solar keratoma using standing low-field magnetic resonance imaging (MRI). The use of advanced imaging to augment the diagnosis of a foot-related condition such as a keratoma is well-documented but in previously published case series the keratomas described have been related to ones affecting the hoof wall as opposed to the sole (Getman *et al.* 2011; Mair and Linnenkohl 2012). Solar keratomas, albeit less common, are still recognised (Miller and Katzwinkel 2015) and therefore it is the use of advanced imaging to make the diagnosis in this location which forms the basis for the case report in this issue.

A diagnosis of a keratoma is usually based on clinical signs (e.g. abnormal horn appearance), history (e.g. recurrent abscessation) and imaging. Traditionally, radiography is used for the latter where the appearance of the distal phalanx may infer the presence of a keratoma. The classical appearance of a smooth semi-lunar defect in the margin of the distal phalanx is consistent with a space occupying lesion, although active bone lysis leading to irregularity of the margin may also be present, particularly in face of ongoing infection. Occasionally, an increase in soft tissue density may be seen associated with the bony changes. However, it should be recognised that the absence of bone loss radiographically does not necessarily rule out the presence of a keratoma.

The advent of advanced imaging techniques has improved the ability to demonstrate the presence of a keratoma. Both MRI and computed tomography (CT) have been described as an adjunct to surgical removal. In the work by Getman *et al.* (2011), advantages of these modalities allowed accurate identification of the location of the keratoma, thereby allowing for a smaller hoof wall resection to be made. This may lead to reduced post-operative morbidity since an earlier paper by Boys Smith *et al.* (2006) showed a significant difference in outcome based on surgical technique used (partial or complete hoof wall resection). On CT, keratomas appear as a mass protruding from the hoof wall into the distal phalanx. Although the mass may have a similar radiodensity to hoof wall, CT offers the advantage of being able to 3-D reconstruct the images to allow full appreciation of the extent of changes within the hoof/distal phalanx. MRI however, relies on the signal intensity from H^+ nuclei of the composite tissues. Since the water content of the hoof wall is bound within the keratin substructure, the hoof wall itself has a low-signal appearance (the margins of the external hoof, however, can be enhanced through the use of water-soaked swabs or bandages around the hoof during image acquisition). Therefore, it is the presence of the keratoma protruding into the underlying corium and bone which is often noted. The signal intensity of the keratoma, however, is not uniform in all cases and can appear as a hypointense or heterogenous low to medium signal intensity structure on T1- and T2*-sequences with the occasional one having a high-signal intensity (Mair and Linnenkohl 2012). Often the surrounding tissue/bone has an increased signal intensity to the keratoma proper suggesting active changes. One postulated reason for this difference in signal intensity of the keratoma may reflect the margination of the lesion; those with a heterogenous T1 and T2*-weighted signal were seen to be ill-defined at surgery (Mair and Linnenkohl 2012) whereas hypointense ones had a more classical conical appearance. It is also important to remember that MRI is not pathognomonic for a particular lesion but only shows relative changes in signal intensity based on H^+ ions. Hence for definitive diagnosis, histology should be performed as other space-occupying lesions could mimic the signal intensity changes.

The ability of MRI to identify the location of the keratoma may influence the incidence of post-operative morbidities and the outcome of the case. Although a number of factors are likely to contribute, the differences in stress experienced on hoof wall and sole in the post-operative period are expected to be of importance. It is likely that the hoof wall will receive higher stresses compared to the solar region during recovery and although the hoof wall can be supported (e.g. by undertaking a partial rather than complete resection as well as through the use of shoes), the stress concentration through the remaining hoof wall may still lead to cracks and failure of the tissue. Therefore since the solar region can be protected more adequately, one may predict there would be a reduction in post-operative morbidities in this location, although due to the lower frequency of solar vs. hoof wall keratomas this is only a supposition. Interestingly though in both case reports detailing solar keratomas, the horses returned to their previous level of work within 4–6 weeks after surgery (Miller and Katzwinkel 2015; Mageed *et al.* 2020).

Continued on page 334

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1 Data on file.

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

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

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Case Report

Tracheal rupture following general anaesthesia in a horse

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Keywords: horse; trachea; rupture; intubation; anaesthesia

A Dutch Warmblood, with no other underlying clinical disease, presented for surgical excision of a sarcoid tumour on the distal right pinna under general anaesthesia. The horse was premedicated with acepromazine, romifidine and butorphanol tartrate and anaesthesia was induced with guaiphenesin and ketamine. The trachea was intubated without issue on first attempt with a 30 mm internal diameter cuffed silicone endotracheal tube (ETT) and the cuff was inflated with approximately 30 mL of air but the intracuff pressure was not measured. Anaesthesia was maintained with isoflurane vaporised in 100% oxygen and a greater and inferior auricular nerve block with mepivacaine hydrochloride was performed to provide anaesthesia of the pinna. Total anaesthesia time was 95 min.

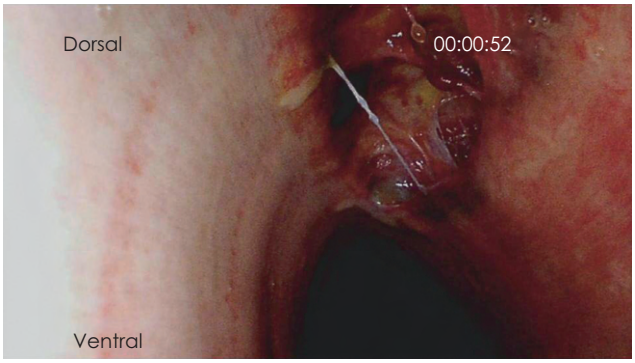

Fig 1: Endoscopic view of the trachea diagnosing the tracheal tear following anaesthesia. [Colour figure can be viewed at wile yonlinelibrary.com]

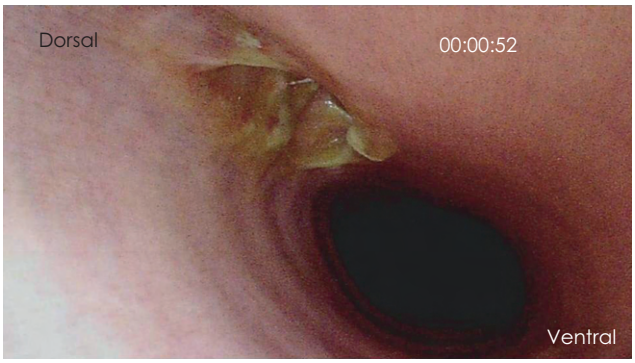

Fig 2: Endoscopic view of the trachea 10 days after anaesthesia showing progressive healing. [Colour figure can be viewed at wileyonlinelibrary.com]

At the end of the procedure, immediately before being moved to recovery, the horse became light and made repeated marked attempts to move whilst attached to the hoist. Anaesthesia was deepened with intravenous thiopental sodium and the horse was moved into the recovery room. The trachea was extubated with the cuff of the endotracheal tube inadvertently left partially inflated. Recovery was smooth and the horse stood uneventfully. The following day subcutaneous emphysema was noted around the neck extending ventro-caudally towards the thoracic inlet but no other clinical signs were apparent. Tracheoscopy revealed a 5 cm tear in the dorsal aspect of the trachea 70 cm caudal to the nares and an abnormal dorso-ventrally flattened trachea (**Fig 1**). A tracheostomy tube was placed to minimise the development of further emphysema and medical treatment consisting of procaine penicillin, gentamicin, flunixin meglumine and clenbuterol was initiated. Parenteral antibiotics were changed to oral trimethoprim sulphonamide after 5 days. The subcutaneous emphysema decreased over the following 10 days and the defect developed a layer of granulation tissue with visible progression on repeat tracheoscopy (**Fig 2**). The horse was discharged 16 days post-operatively with a further 7 days of trimethoprim sulphonamide. Repeat tracheoscopy one month after discharge revealed complete healing of the tear with no apparent stenosis of the tracheal lumen, however the dorso-ventral flattening was still apparent.

This case demonstrates the potential complications following intubation in the horse with a successful outcome following diagnosis of tracheal rupture.

Key points

- Intubation is not a benign process and tracheal rupture is a rare but potentially serious complication.
- Over-inflation of ETT cuffs, movement of the head and neck with an inflated cuff and tracheal abnormalities could contribute to tracheal rupture but further research is required to identify risk factors associated with tracheal injury in anaesthetised horses.
- Successful outcomes following tracheal rupture can be achieved with medical and nursing management.

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Clinical Commentary

Orotracheal intubation in the horse – Is bigger better?

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Keywords: horse; tracheal intubation; injuries

Summary

Access to the respiratory tract of an anaesthetised animal is a vital line of life. An endotracheal tube ensures a secure airway that will allow the delivery of anaesthesia and facilitates mechanical ventilation. The case report by Miller and Auckburally (2020) described in this issue highlights the potential complications associated with endotracheal intubation. Intubation using a 30 mm ID endotracheal tube in the average sized horse (500 kg) has been documented to have a high rate of tracheal injury. The manufacturing specifications of endotracheal tubes may contribute to the incidence of tracheal injury. Further research is needed to help minimise the morbidity and potential mortality associated with this anaesthetic procedure.

Introduction

Access to the respiratory tract is one of the lines of life, which allows the administration of oxygen and medications to anaesthetised animals. In order to achieve this goal, a secure seal must be obtained to facilitate mechanical ventilation, to prevent aspiration of foreign material and pollution of the work environment with inhalant anaesthetics (Trim 2015). In this issue, Miller and Auckburally (2020) describe the tracheal rupture of a 16-year-old, Dutch Warmblood (555 kg) following general anaesthesia for the removal of a sarcoid tumour on the distal right pinna. The horse was intubated with a 30 mm inner diameter cuffed silicone endotracheal tube (ETT) (Kruuse).[1] The authors of the report discuss several proposed factors, which may have contributed to the development of this injury including movement of the neck whilst intubated, extubation with the cuff inflated, overinflation of the cuff and dorsoventral flattening of the trachea. A temporary tracheostomy, nonsteroidal anti-inflammatories and antibiotics were given during the convalescence period. The ruptured trachea and tracheostomy scar had healed completely within 2 months of discharge.

Incidence of injury

There is a paucity of information in the research literature investigating the incidence of laryngotracheal injury following intubation in the horse. A study using 30 mm inner diameter ETT in horses weighing 453 $\pm$ 67 kg (n = 38) demonstrated that all the horses exhibited macroscopic lesions as detected by tracheoscopy 1 and 24 h post extubation (Heath *et al.* 1989). These results are similar to those found in another clinical series of 21 horses, which were examined endoscopically at the same time points as described by Heath *et al.* (1989) (Giguere and Blais 1996). In this second clinical series, there was only 1 out of 21 horses that was free of any lesions following orotracheal intubation. Tracheal injuries have been reported in the dog (Alderson *et al.* 2006) and the cat (Hardie *et al.* 1999; Mitchell *et al.* 2000). Tracheal injuries in cats are described as significant according to the AVMA Professional Liability Insurance Trust (Mitchell *et al.* 2000; Bednarski *et al.* 2011). It is likely that subclinical injuries occur more frequently than is clinically appreciated (Trim 2015).

Causes of tracheal injuries

Based upon the two survey studies of laryngotracheal injuries (Heath *et al.* 1989; Giguere and Blais 1996), there were significant injuries to the arytenoids and tracheal lesions caused by the apposition with the endotracheal tube cuff. Difficulty with the passage of the ETT is likely to have contributed to the lesions found on the arytenoids. With extension of the neck, the longitudinal axis will lengthen whilst the cross-sectional axis will shorten. This could contribute to an increase in appositional forces between the tracheal mucosa and cuff wall. The dimensions of the trachea change from laterolateral compression to dorsoventral flattening as you enter the thoracic inlet (de Freitas *et al.* 2001; Carstens *et al.* 2009). This anatomical variability makes it difficult to predict the effects of dorsi- and ventroflexion on the changes to cuff pressure with respect to neck position. Clinically this may be of importance during movement of the horse, myelographical examinations of the neck or cerebrospinal fluid taps. Changes in neck position can cause displacement of the endotracheal cuff up to 3.8 vertebral spaces in the dog (Quandt *et al.* 1993) thus causing shearing forces between the tracheal mucosa and cuff wall. Exposure to irritant substances, for example, the off-gassing of ethylene oxide can also lead to tracheal injuries (Schatzmann *et al.* 1981). See **Table 1** for a list of potential causes of laryngotracheal injuries in the horse.

Effect of inflation pressures

Using an experimental rabbit model, the tracheal perfusion pressure measured ranged from 14 to 28 mmHg (Nordin 1977). In part, this has formed the basis of the recommendations to avoid inflating the cuff pressure greater than 18 mmHg in animals (Castilho *et al.* 2003) and greater than 22 mmHg in humans (Briganti *et al.* 2012; Li Bassi *et al.* 2018). These inflation pressures would not be sufficient when using endotracheal tubes manufactured for horses. The most common type of ETT used for equine anaesthesia is made of silicone, which requires higher inflation pressures. In **Figure 1a** and **b** the relative elastance curves of silicone ETTs[1] ranging in size from 24 to 30 mm ID can be appreciated. The ETT cuff

TABLE 1: Potential causes of laryngotracheal injuries associated with orotracheal intubation

Excessive force used during intubation
Use of a relatively large tracheal tube
Over-inflation of the endotracheal cuff
Positioning of the endotracheal cuff near the thoracic inlet
Changes in position of the neck of the horse with the endotracheal cuff inflated
Chemical induced injuries (failure to rinse off disinfectants)

was inflated with air using a 60 mL syringe, which was connected to the pilot balloon via a three-way stopcock. A pressure transducer[2] was connected to this three-way stopcock via fluid-filled noncompliant tubing. Air was injected into the ETT cuffs in increments of 10 mL and the resultant cuff pressures and cuff diameters were measured in triplicate using electronic Vernier callipers.[3]

Due to the high elastic properties of silicone tubes, the pressure required to inflate these tubes to the average range of tracheal diameters as observed by Touzot-Jourde *et al.* (2005) are multiples of magnitude higher than the

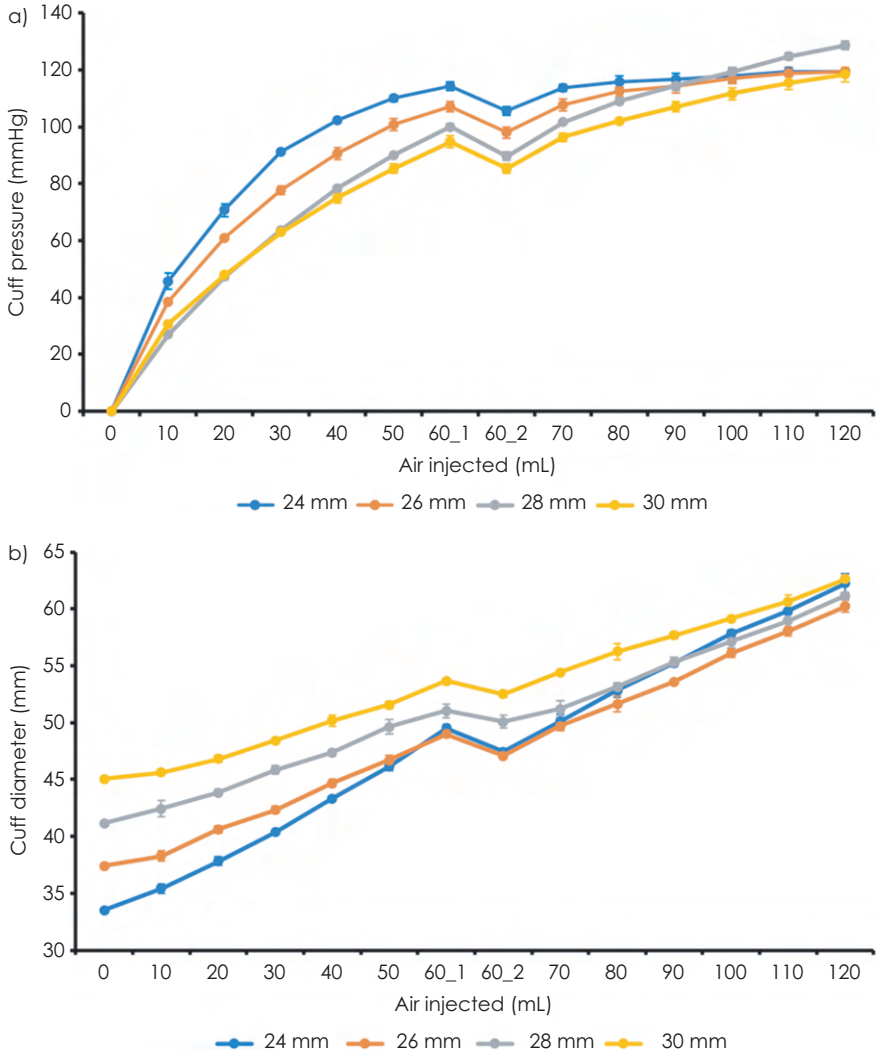

Fig 1: a) The elastance curve above was generated by the incremental injection of air using a 60 mL syringe. The pressure was measured (in triplicate) using a calibrated (to 0 and 100 mmHg) pressure transducer (LogiCal® Single pressure monitoring kit, MX9605[2]), which was connected directly to the pilot balloon of four different sized endotracheal tubes (24, 26, 28 and 30 mm ID) and the syringe via a three-way stopcock. The transducer was placed level with the horizontally suspended cuff. On the X-axis, the 60_1 and 60_2 represent the end of the first syringe full of air and the start of the second syringe of air. The three-way stopcock was closed to the atmosphere during the change over to the second syringe full of air. When the stopcock was opened, the pressure equilibrated between the syringe and the cuff, hence there was a reduction in cuff pressure. This methodology was used to replicate what has been performed in the clinical situation. All the tubes used in this series of experiments were either new or had been used for less than 2 months in clinical use. b) The above curve was generated by the incremental injection of air using a 60 bmL syringe. The radius of the cuff was measured (in triplicate) using a digital Vernier caliper (Absolute AOS Digimatic Model no. CD-6" ASX[3]) at its mid-point. On the X-axis, the 60_1 and 60_2 represent the end of the first syringe full of air and the start of the second syringe of air. The three-way stopcock was closed to the atmosphere during the change over to the second syringe full of air. When the stopcock was opened the pressure equilibrated between the syringe and the cuff, hence there was a reduction in cuff radius.

recommended inflation pressures when using Polychloride Vinyl ETTs (Castilho *et al.* 2003; Briganti *et al.* 2012) (**Fig 1a** and **b**). These higher cuff pressures are required to overcome the elasticity of the silicone cuffs (Dorsch and Dorsch 2008) and do not necessarily equate to the pressure exerted onto the tracheal mucosa (Briganti *et al.* 2012). The distensibility of the tracheal wall can accommodate the expanding cuff size to a limit, which point the pressure exerted by the cuff on the tracheal mucosa will increase in an exponential manner. Interestingly, when using similar cuff pressures observed by Touzot-Jourde *et al.* (2005) (**Fig 1a** and **b**) for a 30 mm ID ETT, the resulting cuff diameters are similar to the average tracheal diameter in horses weighing 500 to 600 kg (Touzot-Jourde *et al.* 2005; Carstens *et al.* 2009). There are currently no recommended inflation pressures for silicone tubes in the horse.

Different types of ET tube materials

The endotracheal tube itself is highly likely to be a contributing factor to tracheal injuries (Abud *et al.* 2005; Briganti *et al.* 2012). The dimensions of the cuff will influence the pressure exerted on the tracheal mucosa since pressure is a function of a force over a given area (Pressure = Force/Area). The larger the area of the ETT cuff for a given volume of air injected, the lower will be the pressure generated with the cuff. There are obvious differences in the length of the ETT cuff between the different manufacturers (**Table 2**) and also their shape.

The shape of the ETT cuff may also influence the amount of pressure being applied to the tracheal mucosa (Abud *et al.* 2005). An aneurysm of the cuff (**Fig 2**) can lead to herniation of the cuff and obstruction of the lumen of the ETT (Bergadano *et al.* 2004). These aneurysms of the cuff may also lead to small regional increases in pressure being preferentially applied to one aspect of the cuff-trachea surface interface. Age of the ETT may also influence the intracuff pressure (**Table 3**). Based upon a small survey of silicone ETTs and simply palpating these ETTs, there appears to be differences in the compressibility and stiffness of these tubes, however this needs further investigation to fully determine any potential differences. Briganti *et al.* (2012) found higher inflation pressures are necessary for silicone ETTs as compared to plastic ETTs. There appear to be differences in the elastance curves between the different manufacturers of silicone tubes[1,4] (**Table 3**).

TABLE 2: A comparison of the deflated cuff lengths (cm) of two different manufacturers of endotracheal tubes

Deflated cuff length (cm)	
Kruuse[1]	Surgivet[2]
5.7	7.5
5.2	7.5
6.6	9
7	9
8	9
9.5	10
9.8	10
9	12

Differences in the dimensions of the endotracheal cuff size can lead to differences in the resultant pressure (Pressure = Force/Area) being applied to the tracheal surface. [1]Kruuse UK Ltd. [2]Surgivet, Smiths Medical.

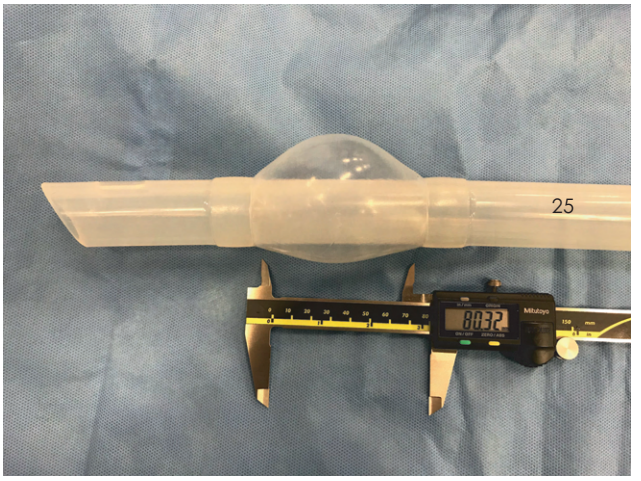

Fig 2: Weaknesses in the wall of the endotracheal tube cuff (26 mm ID[1]) can lead to nonuniform dilation of the cuff and the appearance of an aneurysm-like bulge in the cuff. Potentially this could lead to isolated areas of increased pressure exerted onto the tracheal mucosa. This is speculation and needs further research to elucidate this effect on the tracheal mucosa.

With respect to the dimensions of an ETT, the radius of the lumen is the major factor that will influence the flow of gas through it and the subsequent work of breathing. This is based upon the Hagen–Poiseuille equation ($Q = \Delta P \pi r^4 / 8 \eta L$) when there is laminar flow through the ETT. As the radius of the ETT increases, the resistance will decrease in an exponential manner. Assuming a constant dynamic air viscosity (18.6×10^5 Pa.s) (Bearden 1939; Montgomery 1947) with changes in air flow, the air resistance through ETTs can be calculated using the Hagen–Poiseuille equation (**Fig 3**). Comparing these calculations with the larger ETTs (>24 mm ID), the resistance curve is starting to flatten out so the rate of reduction in resistance is not as great as compared to the increase in the inner diameter (**Fig 3**). It should be noted that the length of the ETTs is gradually getting longer with respect to the inner diameter (see manufacturer specifications), which will counteract, in part, the benefits of increasing the radius. If the horse is mechanically ventilated throughout the anaesthetic period, the mild increase in resistance is compensated for by the mechanical activity of the ventilator, i.e. the work of breathing is performed by the ventilator thereby avoiding the negative impact of a slightly smaller tube. It is during the recovery phase that a slightly smaller ETT may negatively impact the work of breathing. This negative effect can be partially overcome by deflating the cuff so as to allow the horse to breathe around the tube but still secure the patency of the airflow. Intranasal phenylephrine can further assist airflow around the ETT by decreasing nasal oedema and improving the airflow through the nasal passages (Lukasik *et al.* 1997).

Other contributing factors

The effect of the position on the surgical table will influence the capillary pressure in the trachea. In dorsal recumbency, this will be slightly higher than compared to when a horse is in lateral recumbency due to the hydrostatic pressure differences in

TABLE 3: The cuff pressure and cuff diameter results [mean (s.d.)] listed above were derived using the same techniques described in the legend of Figure 1a and b

	Kruuse New[1]		Kruuse Old[1]		Surgivet Old[2]	
Volume of air injected	Pressure mmHg	Diameter mm	Pressure mmHg	Diameter mm	Pressure mmHg	Diameter mm
60 mL	94.67 (2.08)	53.65 (0.19)	107.67 (4.62)	53.10 (0.81)	51.33 (0.58)	49.93 (0.07)
90 mL	107.00 (1.73)	57.69 (0.26)	120.67 (3.79)	57.50 (0.42)	57.33 (0.58)	53.17 (0.44)

When considering the effect of ageing on the elastance (ΔPressure/ΔVolume) of these 30 mm ID tubes, there appears to be a difference between a new tube and an older tube (Kruuse UK Ltd.[1]) that have been used several times over. The resulting cuff diameters when injecting 60- or 90 mL are approximately equal to the average inner tracheal diameter of the distal cervical trachea as described by Touzot-Jourde *et al.* (2005) in horses weighing 535 ± 55 kg. On palpation of these tubes, there is an obvious increase in stiffness of the aged tube. Another comparison can be made between different manufacturers. This demonstrates the potential difference caused by the differences in manufacturing materials. Further studies are needed to be performed to investigate these effects. Results are displayed as the mean (standard deviation, s.d.). [2]Surgivet, Smiths Medical.

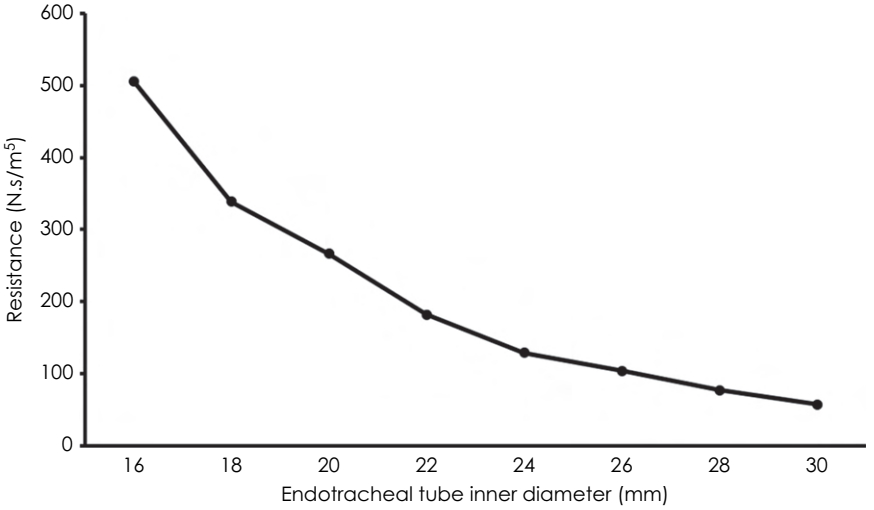

Fig 3: Based on the Hagen–Poiseuille equation ($Q = \Delta P\pi r^4/8\eta L$), resistance ($N.s/m^5$) to laminar air flow through this series of endotracheal tubes (16–30 mm inner diameter) can be calculated using the following equation $R = 8\eta L/\pi r^4$, assuming a constant dynamic air viscosity (η) (18.6×10^5 Pa.s). The dimensions, radius (r) and length (L) were based upon the specifications of the manufacturer, Kruuse UK Ltd., North Yorkshire, UK.

height. Positioning in dorsal recumbency may result in a mild protective effect against the pressures exerted by the cuff on the tracheal mucosal. Another unknown effect influencing tracheal blood flow is the cyclical changes in cuff pressure and deformation of the shape of the cuff on the trachea caused by mechanical ventilation (Kutter *et al.* 2013). The interaction between cuff shape and the efficiency of the resulting seal around the cuff requires further investigation.

So far, this discussion has focused mainly on the ETT itself; however, there are animal factors that may contribute to tracheal injury. The depth of anaesthesia and the persistence of laryngeal reflexes during intubation may contribute to the incidence of trauma to the larynx and trachea. During ketamine-based anaesthesia, laryngeal reflexes have been observed to be present in several species (Robinson and Johnston 1986; Young *et al.* 1993; Saxena *et al.* 2001). This may contribute to the difficulty with intubation, especially with larger tubes. In children, low doses of Propofol (0.8 mg/kg) have been found to help suppress laryngeal reflexes and to ease endotracheal intubation (Afshan *et al.* 2002). This is something the author does empirically in small ruminants to facilitate endotracheal intubation when using a diazepam-ketamine combination to induce general anaesthesia.

This case report by Miller and Auckburally (2020) highlights the inherent clinical complications that can occur with endotracheal intubation in the horse. This clinical discussion has highlighted some of the deficits in the clinical knowledge vis-a-viz endotracheal intubation in the horse. There are several areas of controversy that require further scientific investigation.

Suggestions on how to reduce the risks of tracheal injury caused by endotracheal intubation

- Ensure a sufficient depth of anaesthesia prior to attempting intubation
- Use minimal force when performing endotracheal intubation
- Consider using a smaller ETT than 30 mm ID in horses weighing less than 600 kg in order to minimise tracheal injury (Heath *et al.* 1989; Giguere and Blais 1996)

- Consider auscultating the trachea during inflation of the ETT cuff and positive pressure ventilation, to detect the minimum occlusive volume to ensure a seal around the cuff. Palpation of the pilot balloon is not an indicator of the cuff pressure (Briganti *et al.* 2012).
- Position the ETT cuff in the cervical portion of the trachea
- Reassess the ETT cuff seal when moving the neck of the horse.
- Ensure adequate cleaning and rinsing of ETTs

Author's declaration of interests

The author has no conflicts of interests to declare.

Ethical animal research

Not required for this clinical commentary.

Source of funding

None.

Manufacturers' addresses

[1]Kruuse UK Ltd., North Yorkshire, UK.
[2]Smiths Medical, Hranice, Czech Republic.
[3]Mitutoyo, Kanagawa, Japan.
[4]Surgivet, Smiths Medical, Ohio, USA.

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Original Article

Post-partum uterine rupture: Standing repair in three mares using a laparoscopic technique

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Keywords: horse; laparoscopy; standing surgery; uterine rupture

Summary

Three mares underwent diagnostic laparoscopy because of suspicion of post-partum uterine ruptures. All three horses showed clinical signs of a uterine rupture between 1 and 3 days after parturition and underwent diagnostic laparoscopy. In all cases a full thickness uterine rupture could be detected and was sutured laparoscopically. Availability of suture material and surgeon experience were responsible for the surgical methods chosen for repair. In the first case, a hand-assisted laparoscopic approach was chosen for suturing the ruptured uterus, whereas in the other cases the approach was entirely laparoscopic. In the second case, extracorporeal knots were used for the repair and in the last case described a barbed loop suture was available for closure of the uterus. Two of three mares were alive for at least 12 months after surgery without any abdominal problems. One of these mares delivered a healthy foal 2 years after surgery. The remaining mare died 3 months after surgery but no necropsy was done. Laparoscopy should be considered for post-partum mares with signs of peritonitis to access the uterus and repair a rupture if it is accessible. A laparoscopic approach using intracorporeal knots or barbed sutures for the repair of the uterine rupture as well as a hand-assisted laparoscopic approach are feasible. The use of the barbed suture for intracorporeal closure makes the minimal invasive laparoscopic technique easier to perform.

Introduction

Full thickness uterine ruptures are the third most common cause of post-partum death in mares after urogenital haemorrhage and gastrointestinal ruptures (Dwyer 1993; Story 2007). It usually occurs in stage 2 of parturition or during dystocia. Ruptures are caused by forceful penetration of blunt appendages from the foal through the stretched uterine wall. In most cases, uterine ruptures are diagnosed about 1–3 days post-partum as the mares show depression, fever, mild abdominal discomfort with anorexia, and tachycardia (Javsicas *et al.* 2010). Peritoneal fluid cytology confirms suspicion of peritonitis. Definitive diagnosis can be made by transrectal or transvaginal palpation, although sometimes palpation of the rupture is not possible due to its location, e.g., cranially in the tip of the uterus horn or in combination with the large post-partum size of the uterus. If the cause of the clinical signs cannot be verified by palpation, ultrasonography, and/or haematology, diagnostic laparoscopy can be performed to evaluate the mare's gastrointestinal and urogenital tracts. Complications secondary to uterine rupture include peritonitis and herniation of abdominal organs through the uterine wall defect. Successful medical treatment using antibiotics, anti-inflammatories, and oxytocin therapy has been reported (Hassel and Ragle 1994; Javsicas *et al.* 2010). However, surgical repair of uterine ruptures has been recommended as the best treatment and it is mandatory in cases of gastrointestinal herniation. It was hypothesised that uterine rupture repair in the standing horse using a laparoscopic approach is feasible. A hand-assisted approach has been described (Cribb and Chenier 2012; McNally *et al.* 2012), however, a solely laparoscopic approach has not been reported. In the following cases, uterine ruptures were diagnosed and treated surgically using standing laparoscopy. To the authors' knowledge, there are no previous reports or studies describing the laparoscopic suturing of uterine ruptures using extracorporeal knots or barbed sutures in standing horses. In this study three different techniques are described, respectively, using a hand-assisted approach, a fully laparoscopic approach using intracorporal knots or barbed sutures.

Case 1

Case history

An 8-year-old Warmblood mare was referred to the equine clinic for supervised foaling. The mare was healthy, and delivery was uneventful. The placenta was fully expelled one hour after parturition. Three days later, the mare showed general depression and anorexia.

Clinical findings

The mare had a rectal temperature of 39.1°C and showed mild colic signs. A mild tachycardia (48 beats/min) was noted. Vaginal examination with a speculum revealed an open cervix and a mild dark brownish vaginal discharge. On transvaginal palpation, a uterine rupture could be palpated in the right horn (the gravid horn). Blood biochemical and haematological analysis revealed no changes except for a mild leukocytosis (12.6×10^9 cells/L; reference range [rr]: 7–10×10^9 cells/L). Abdominocentesis yielded a transparent orange fluid with a nucleated cell count of 150×10^9 cells/L (rr < 5×10^9 cells/L) and total protein concentration of 46 g/L (rr < 25 g/L). Microbiological culture was negative. In conjunction with the owner, it was decided to undertake diagnostic and therapeutic laparoscopy. Peri-operative antibiotic therapy was initiated using gentamicin (6.6 mg/kg i.v.)[3] and procaine penicillin G (22,000 IU/kg i.m.)[3].

As surgery was performed the same day, feed could not be withheld prior to the procedure. The foal was sedated and kept in the stables.

Standing sedation was achieved using intravenous boluses of detomidine hydrochloride (0.01 mg/kg)[1] and butorphanol tartrate (0.025 mg/kg)[1], and subsequently maintained by continuous intravenous infusion of detomidine hydrochloride (0.01 mg/kg)[1] in Lactated Ringer's solution, as described by van Dijk *et al.* (2002). The procedure for laparoscopic surgery was performed as described previously by Rijkenhuizen and Grinwis (1999). After abdominal exploration, a small full thickness rupture in the lateral wall of the right uterine horn (approximately 4 cm) was detected with the laparoscope. The decision was made to perform a hand-assisted laparoscopy. Instead of creating a second instrumental portal, a mini laparotomy was performed by creating a flank grid incision the size of the surgeon's hand. The cranial part of the uterine horn was then positioned in the right caudo-ventral portion of the abdominal cavity using grasping forceps. The uterus was partially exteriorised so the rupture in the uterine wall was extra-abdominal and held in position using a laparoscopic Babcock forceps (10 mm). The rupture site was flushed with 0.9%NaCl. The edges of the wound were slightly swollen and sharply debrided. The rupture was closed using polyglactin 910 (1USP)[2] in a double layer of continuous Cushing sutures. The extra-abdominal uterus was thoroughly lavaged prior to repositioning in the abdominal cavity.

The mini laparotomy wound was closed routinely. The transverse and oblique abdominal muscles were sutured independently with simple interrupted sutures (1 USP polyglactin 910)[2], the subcutaneous tissue was closed using 2/0 USP poliglecaprone[2] in a simple continuous pattern and, finally, the skin was closed using a continuous intradermal suture with 2/0 USP poliglecaprone[2]. One single interrupted suture with 2/0 USP poliglecaprone[2] was placed in the skin to close the remaining laparoscopic portal.

Post-operative care

Post-operative antibiotics and pain relief were provided for 3 days using once daily gentamicin (6.6 mg/kg i.v.),[3] procaine penicillin G (22,000 IU/kg i.m.)[3] and twice daily flunixin meglumine (1.1 mg/kg i.v.).[4,5]

The mare was monitored in the intensive care unit for one day with her foal alongside and then discharged because the mare was clinically healthy. Slight wound swelling occurred 2 days post-operatively. The mare and foal were discharged 5 days after surgery. Two years after surgery, the mare delivered a healthy colt foal without clinical problems.

Case 2

Case history

A 21-year-old Thoroughbred mare had delivered a male foal. During delivery, only one limb was palpable, and the foal had to be redirected into the birth canal as far as possible to reposition the other leg. Following this correction, the delivery proceeded normally. The placenta was expulsed within 1.5 h. Three hours later, the mare was found lying in lateral position and would not stand up. A uterine rupture was suspected. The mare was treated with procaine penicillin G (22,000 IU/kg i.m.)[3] and nonsteroidal anti-inflammatory drugs (flunixin meglumine [1.1 mg/kg i.v.][4], butorphanol tartrate [0.025 mg/kg i.v.][1]) and referred to the clinic.

Clinical findings

At the equine hospital, the horse was restless and showed signs of abdominal pain. A heart rate of 84 beats/min, respiratory rate of 16 breaths/min and a rectal temperature of 39.1°C were noted. Heart and lung auscultation sounded normal. The colour of the oral mucous membrane was reddish, and the capillary refill time was less than 2 s. The packed cell volume was 34% (rr 32–52%), total plasma protein concentration and lactate were 62 g/L (rr 46–69 g/L) and 2 mmol/L (rr 0.50–1.78 mmol/L), respectively. Leucocyte count was within normal limits. Ultrasound of the ventral abdomen revealed free fluid and a thickened nonmotile jejunum. Abdominal fluid retrieved via abdominocentesis was odourless, cloudy and had a red colour. Analysis yielded total nucleated cell count of 20×10^9 cells/L (rr < 5×10^9/L) and total protein concentration of 20 g/L (rr < 20 g/L).

Borborygmi were reduced bilaterally. No reflux was obtained following nasogastric intubation. Transrectal palpation was unremarkable. The horse had a perineal laceration of 5 cm. Transvaginal palpation revealed intrauterine jejunal loops, however, the rupture could not be reached. The following antibiotics were continued: procaine penicillin G (22,000 IU/kg i.m.)[3] and gentamicin (6.6 mg/kg i.v.)[3]. The foal appeared healthy.

Based on the findings of a uterine rupture with evisceration of jejunum, an emergency laparotomy under general anaesthesia was performed. A midline laparotomy was made, and after assessing the damage, the prolapsed jejunum (ca. 4 m) was manually reduced into the abdomen. The affected intestine was healthy and resection deemed unnecessary. The uterine rupture was about 15 cm in length, located dorsally in the right uterine horn and could not be reached for surgical closure via this approach. It was decided to leave the rupture for closure via a laparoscopic approach. The abdominal cavity was flushed with saline (20 L) and the incision was closed routinely. An intra-abdominal 6.4 mm PVC fenestrated drain was placed 2 cm to the right of midline and 20 cm caudal to the xyphoid cartilage through a 1 cm stab incision through skin and blunt perforation of peritoneum. The catheter was fixed with 0 USP polyamid using a Chinese-finger trap technique.

Post-operative broad-spectrum antibiotics procaine penicillin G (22,000 IU/kg i.m.)[3] and gentamicin (6.6 mg/kg i.v.)[3] and flunixin meglumine (1.1 mg/kg i.v.)[4] were continued for 13 days. Omeprazole (orally)[6] was also administered. Oxytocin (20 IE i.m.)[3] was injected every 2 h for 2 days to enhance uterine clearance and involution. Fluid therapy was instituted (Lactated Ringer's solution 2 mL/kg/h i.v.) for 2 days post-operatively. The horse had no signs of post-operative ileus and feed was provided within 24 h post-surgery, starting with small amounts of hay and the amounts were gradually increased over the following several days. On the first post-operative day, the mare was allowed free access to water. The mare was closely monitored, and blood analyses were performed twice daily. The rectal temperature remained between 37.7 and 38.2°C. Abdominal lavage with saline solution (10 L) was performed twice daily for 2 days. Nasogastric intubation was negative and borborygmi were present following the laparatomy. Gradually, the mare

became more active. Laparoscopic surgery was performed 6 days after the laparotomy.

Surgery

Laparoscopic preparation and anaesthesia were performed as described in Case 1. A 10 mm cannula was introduced on the right side for the laparoscope and a 5 mm cannula for instrumentation.

The abdomen was systematically examined visually and indicated that the mare was suffering from severe peritonitis, based on the dark brown coloured abdominal fluid with fibrin clots. The intestinal and abdominal walls were also reddish in colour, showing multifocal petechiae and ecchymoses, in addition to some fibrin clots locally. The motility of the intestines appeared normal.

The uterus showed normal post-partum enlargement, but with a thickened wall and local multifocal petechiae and ecchymoses. A rupture in the midbody uterine wall was visible dorso-laterally, about 15 cm cranial to the cervix, with a total length of approximately 8–10 cm. The edges of the rupture were swollen and slightly discoloured. The mucosa prolapsed slightly out of the uterus, but the tissue appeared viable and debridement was not considered necessary. Uterine palpation revealed that the originally palpated rupture was the same as the laparoscopically visible rupture (the fingers of the veterinarian became visible in front of the laparoscope). Although the prognosis was considered poor, the owner decided to continue surgery. With two needle holders, the uterine rupture was closed using an extra corporal knot tying interrupted nonperforating Lembert suture technique (polyglactin 910 USP 1)[2] (**Fig 1**). Closure was controlled by vaginal palpation.

The abdominal cavity was then lavaged with 6 L 0.9% NaCl, which was removed using a suction cannula attached to a vacuum pump. After desufflation, the portals were routinely closed.

Post-operative care

The laparotomy incision showed oedema formation during the first few days after surgery but was healed at the time of discharge as well as the laparoscopic portals.

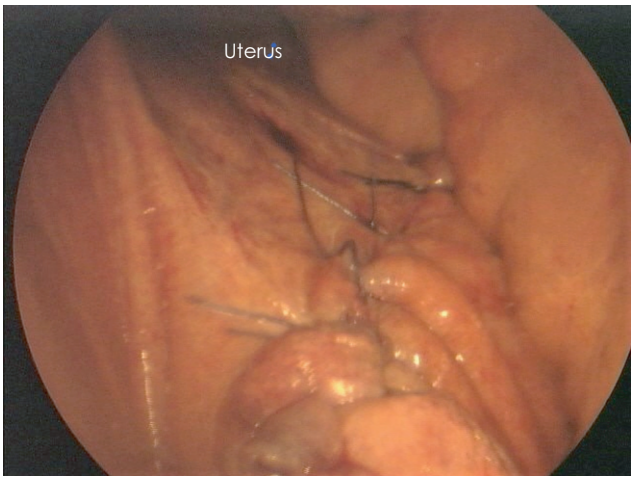

Fig 1: Case 2: Laparoscopic view of the right side of the abdominal cavity showing the sutured uterine rupture.

The mare recovered uneventfully and was discharged from the hospital 14 days after admission but still had some vaginal discharge. One week later, purulent vaginal discharge remained and the mare returned to the clinic for treatment. Transrectal examination revealed that the uterus was still enlarged, but no adhesion could be palpated at the site of the rupture. The cervix was open at a width of four fingers. Antiphlogistic therapy was initiated using NSAIDs (flunixin meglumine 1.1 mg/kg)[4]. The uterus was flushed once daily with saline solution (6 L). Uterine swab culture revealed a multiresistant *E. coli* and antibiotics were changed to ceftiofur (6.6 mg/kg i.m.),[7] based on the antibiogram. After 5 days, the horse was discharged for further treatment by the general practitioner (uterine lavage with ceftiofur[7]). Before discharge no further abdominocentesis was made. The mare died 3 months later and unfortunately no necropsy was done.

Case 3

Case history

A 12-year-old Warmblood mare (612 kg bodyweight) presented to the equine hospital for depression, recumbency, and inappetence following the uncomplicated delivery of a healthy foal 3 days previously. The placenta was fully expelled one hour after parturition. One day following parturition, the mare was slightly depressed, so the referring veterinarian treated her with an intravenous infusion of isotonic saline (10 L). Clinical signs diminished and both mare and foal did well. Three days later, the mare showed signs of colic, including pawing at the ground with the forelimb and lying down frequently. The mare defaecated regularly. The rectal temperature was 37.7°C and a red to brown vaginal discharge was observed. Transrectal examination revealed a displacement of the ascending colon to the nephrosplenic space without entrapment. The mare was treated medically with scopolamin butylbromid (5 mL/100 kg i.v.)[6] and metamizol (5 mL/100 kg i.v.)[3] but clinical signs of abdominal discomfort remained so the horse was referred.

Clinical findings

Upon presentation to the equine hospital, the mare was nervous but showed no signs of abdominal pain. A heart rate of 48 beats/min, respiratory rate of 12 breaths/min and a rectal temperature of 38.4°C were noted. Heart and lung auscultation were within normal limits. The colour of the oral mucous membranes was pink, and the capillary refill time was less than 2 s. The packed cell volume was 34%, total plasma protein concentration and lactate were 62 g/L and 2 mmol/L, respectively. Leucocyte count was also within normal limits. The foal appeared healthy.

Abdominal auscultation of the right and left quadrants revealed intermittent borborygmi. Displacement of the ascending colon into the nephrosplenic space with a mild obstipation of the ascending colon was found on transrectal examination with dry faeces in the ampulla recti and pink rectal mucous membranes. The left uterine horn was larger in size than the right uterine horn. Transabdominal ultrasonography showed good motility of the bowel and revealed that the intestines were no longer occluded the nephrosplenic space. A vaginal examination performed with a speculum revealed no injury. Brown, mucoid, odourless fluid was present within the vaginal vestibule. Two fingers could be passed through the cervix during transvaginal palpation. No other abnormalities

could be detected. The mare was administered intravenous saline at a rate of 3–4 L/h while she was box rested. Feed was withheld until the following day, but water was permitted.

As the mare showed no signs of abdominal discomfort for the first 8 h, 2 mL oxytocin (10 IE/mL)[3] was given intravenously to facilitate uterine involution. The mare remained comfortable throughout the night and defecated regularly. The following day, the horse developed ventral oedema. Transabdominal ultrasonography revealed no abnormalities. Abdominal fluid retrieved by abdominocentesis was odourless but had a dark yellow to red colour. Analysis yielded a total nucleated cell count of 11.2 × 10^9cells/L and a total protein concentration of 42 g/L. Vaginal examination revealed a more tightly closed cervix and the gloves used for examination were covered with old bloody clots. Because of the presence of intravaginal clots and the results of the analysis of the abdominal fluid, peritonitis secondary to uterine rupture was suspected for which conservative medical treatment was initiated. Intrauterine antibiotic therapy consisting of ceftiofur (25 mL)[7] was administered. The mare was treated systemically with procaine penicillin G (22,000 IU/kg intramuscularly)[3], gentamicin (6.6 mg/kg i.v.)[3] and flunixin meglumine (1.1 mg/kg i.v.)[4]. Intravenous fluid therapy with isotonic saline and intramuscular oxytocin were continued for 3 days. On the second day, repeat haematology revealed no abnormalities and the uterus was treated again locally (25 mL ceftiofur[7]). The uterine fluid retrieved was clear and odourless.

Antimicrobial and antiphlogistical therapy was continued. Rectal temperature remained within normal limits and the amount of vaginal discharge reduced progressively. The mare continued to lactate appropriately and both mare and foal were in a good body condition. After 7 days, medication was changed to oral enrofloxacin (5 mg/kg)[3] and flunixin meglumine (1.1 mg/kg)[4]. Both mare and foal were discharged on day 9 with medication to be administered for an additional 10 days. The owner was allowed to return the horse to pasture. At home, the horse was healthy and showed no further signs of fever or abdominal discomfort. However, after medication was discontinued, the mare gradually developed a fever over the two following days. Because her fever climbed above 40°C, the mare was referred again with her foal. In the equine hospital, re-examination of the abdomen and urogenital tract showed no abnormalities with the exception of fever (40.2°C) and continuous vaginal discharge of brown, odourless fluid. The size of the left uterine horn had declined. Abdominocentesis was repeated and fluid analysis revealed a total nucleated cell count of 120 × 10^9 cells/L and total protein concentration of 31 g/L. A sample from the abdominal fluid was collected for bacterial culture which identified *Streptococcus equi* subsp. *zooepidemicus* and Streptococcus spp. Antimicrobial and anti-inflammatory medications were initiated using ceftiofur [6.6 mg/kg i.m.][7] and flunixin meglumine [1.1 mg/kg i.v.][4]. After 3 days of treatment, the fever resolved.

Based on the clinical signs and abdominal fluid biochemistry analysis, a presumptive diagnosis of septic peritonitis due to uterine injury was made and diagnostic laparoscopy was recommended 27 days post-partum.

Surgery

Feed was withheld for 12 h with free access to water. Phenylbutazone (4.4 mg/kg)[8] was administered intravenously prior to laparoscopy. Laparoscopic preparation and anaesthesia were performed as described in Case 1. The foal was sedated with xylazine (1 mg/kg i.v.)[4] and placed in front of the mare restrained in stocks. The procedure for laparoscopic surgery was performed as described previously. For a better exploration and visualisation of the medial side of the left uterine horn, which was suspected to be affected because of its size, a 10 mm cannula was introduced on the right side for the laparoscope and a 5 mm cannula for instrumentation. Abdominal fluid was orange but clear without any signs of fibrin. The right uterine horn had involuted to almost its normal prepartum size. The right ovary was not observed to have any abnormalities. The right uterine horn was grasped with forceps to observe the medial side and no abnormalities were identified. After careful exploration of the right side, the laparoscopic examination was continued on the left side after creating similar portals on that side. The caudal peritoneum appeared inflamed over an area of 10 × 15 cm. The left uterine horn was also in the regression phase post-partum and had almost returned to its normal size. A full thickness rupture near the cranial tip of the left uterine horn could be visualised with a prolapse of uterine mucosa that was mildly swollen with hyperaemic edges (**Fig 2**). The length of the rupture was about 5–6 cm, running from dorsal to ventral. The lumen of the uterus could be entered using forceps, indicating a perforating rupture. A 10 mm cannula was introduced within the scope`s field of vision approximately 4 cm caudal and 8 cm distal to the laparoscope and directed caudo-ventrally to act as a second instrument portal. With the help of two needle holders, the uterine rupture was repaired using an intra-abdominal, Lembert suture technique in a running fashion with barbed loop suture (Stratafix 0 USP)[2], starting dorsally (**Fig 3**). After the rupture was prepared, the abdomen was desufflated, the laparoscope and instruments were removed, and the skin incisions for the portals on both sides of the abdomen were closed using two simple interrupted sutures (2/0 USP glycomer 631).[2]

Post-operative care

The horse was stall rested and post-operative antibiotics and pain relief were provided for 4 days using once daily ceftiofur (6.6 mg/kg i.m.)[7] and flunixin meglumine (1.1 mg/kg i.v.).[4]

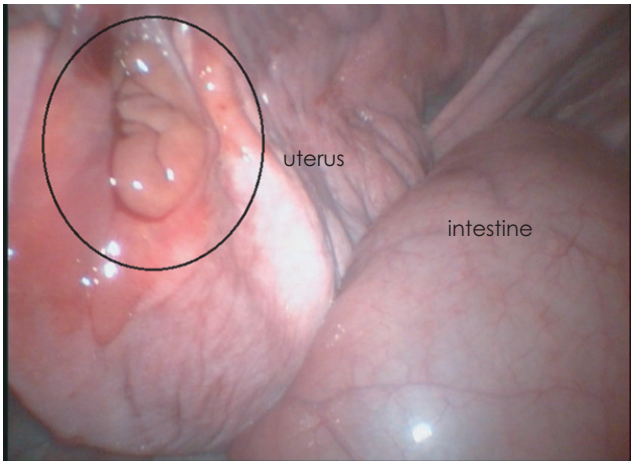

Fig 2: Case 3: Laparoscopic view of the ruptured uterus. The arrows point towards the rupture.

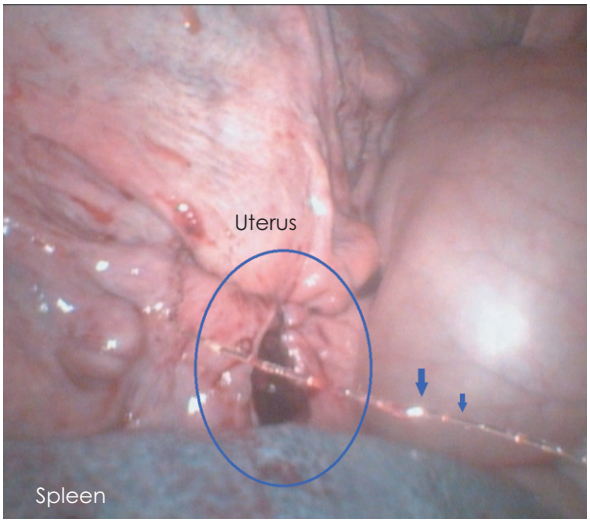

Fig 3: Case 3: Laparoscopic view on the partial sutured uterus. The laparoscopic forceps is tying the barbed suture. On the left the uterus with the rupture. On the right a part of the colon ascendens. The arrows point towards the barbed suture.

Food was withheld for 8 h following laparoscopy, and then the mare was fed mash and small amounts of wet hay (4 × 1.5 kg/day) in addition to free access to water. Clinical behaviour was good, and portals healed by primary intention. Post-operative haematology performed on the second day revealed no abnormalities. The horse was discharged 7 days post-operatively. Box confinement with daily hand-walks was advised for 2 weeks, followed by a gradual return to normal exercise. Sutures were removed 14 days post-operatively.

After 3 months, the owner was questioned about the horse by telephone and both mare and foal were healthy and without any clinical problems.

Discussion

Causes of peritonitis of mares in the peripartum period include either perforation or vascular compromise of the gastrointestinal or urogenital tracts (Javsicas *et al.* 2010). Damage to the uterus may be limited to the endometrium or myometrium or may be full thickness. Ruptures can appear either in the uterine body or in the uterine horn. Ruptures near the horn are the result of forceful movements of the foal's hindlimb whereas ruptures in the uterine body generally result from forceful penetration of blunt appendages through a stretched uterine wall during dystocia (Embertson 1999). Transvaginal palpation confirms uterine body ruptures, but only 24% of uterine horn ruptures are detected due to the large size of the post-partum uterus, thus making a definitive diagnosis of a uterine rupture difficult (Javsicas *et al.* 2010). During the first 1 to 3 days post-partum, mares with uterine ruptures have clinical signs such as depression, abdominal discomfort, fever, and tachycardia, as also described in the cases above. The combination of the presence of excessive peritoneal fluid during abdominal ultrasonography and a peritoneal fluid analysis with nucleated cell count >10 × 10^9 cells/L and a total protein concentration >25 g/L can confirm the suspicion of uterine ruptures (Javsicas *et al.* 2010). Other diagnostic techniques for uterine ruptures include hysteroscopy or contrast/methylene blue studies.

The mare in Case 3 presented to the equine hospital showing mild abdominal discomfort and a diagnosis of peritonitis was made because of peritoneal fluid analysis with 11.2 × 10^9/L (rr < 5 × 10^9 cells/L) leucocyte and total protein concentration of 42 g/L (rr < 25 g/L). Neither transrectal nor transvaginal examination could confirm uterine damage though vaginal discharge and peritonitis strengthened the suspicion. In Cases 1 and 2, the diagnosis was clear on the basis of the vaginal palpation.

Post-partum mares with peritonitis from a presumptive or confirmed uterine rupture can be treated medically or surgically having similar survival rates and foaling history (Javsicas *et al.* 2010). The mare in Case 3 was treated medically initially using antibiotics and antiphlogistics. The fever dissipated, and the horse no longer showed signs of discomfort. However, as soon as the medication was discontinued, the fever recurred, and the mare displayed colic signs. Based on the vaginal discharge and the abdominal fluid analysis, peritonitis following a uterine rupture was suspected and standing diagnostic laparoscopy was performed. At laparoscopy a full thickness uterine rupture was diagnosed in the cranial part of the left uterine horn and the rupture was closed using a barbed suture.

In previously reported cases, uterine ruptures have been closed under general anaesthesia using a caudal ventral midline celiotomy, a flank approach (Hassel and Ragle 1994) or hand-assisted laparoscopy (Cribb and Chenier 2012; Klohnen 2012; McNally *et al.* 2012). There is only one laparoscopy textbook that describes laparoscopy for the diagnosis and repair of uterine tears, but it does not provide any detailed information, about performing the surgery in the standing position and how to suture the rupture. Advantages of a ventral midline celiotomy include the ability to evaluate both uterine horns and the gastrointestinal tract and offer the opportunity to lavage the abdominal cavity. A disadvantage of this approach is the requirement for general anaesthesia and its associated complications. Economics or health status can also prohibit placing the horse under general anaesthesia. Furthermore, as described in Case 2, a ventral midline approach does not ensure access to the rupture for exploration or closure, depending on its location. A right or left sided flank approach may be performed if the side of the uterine rupture can be located and confirmed preoperatively.

Laparoscopy should be kept in mind for post-partum mares with peritonitis as it allows assessment of the uterus and the gastrointestinal tract for concomitant damage. It also allows the clinician to prepare a therapeutic plan. If laparoscopic closure of the rupture is not feasible, conversion to a ventral midline celiotomy can be performed with knowledge of the precise size and location of the rupture, thereby shortening the time of general anaesthesia.

The presented cases demonstrate that successful repair of uterine rupture can be achieved via minimally invasive techniques. Chronologically, the cases were approached differently because of the timespan. Initially a hand-assisted approach with exteriorisation of the uterine horn and closure of the rupture was chosen, which would now have been performed using a barbed suture, as described in Case 3. In the second case, interrupted, nonperforating sutures were used, which were knotted extra-abdominally, because barbed suture was not available at that time. The barbs on the surface

penetrate the tissue and lock them into place, so intra-abdominal knotting, which is time consuming, can be avoided.

Laparoscopy in the second case was postponed in order to let the mare recover from the abdominal surgery. Unfortunately, the mare had developed severe peritonitis, characterised by brown coloured abdominal fluid with fibrin clots. Earlier laparoscopic approach might have been preferable and potentially reduced the severity of the peritonitis. However, as mentioned before, successful medical treatment of a uterine rupture has been described. Conversely, as proven by Case 3, time does not seem to be a limiting factor. The uterine rupture as presented in Case 3 was repaired 2 months after giving birth and injuring the uterine wall. It is likely that antibiotic therapy was responsible for control of the peritonitis in this case.

Infection and peritonitis can be controlled with antibiotics and uterine lavage until the rupture heals by secondary intention. However, as Cases 2 and 3 show, there is a risk associated with delay of surgical intervention. The authors' collective opinion is that surgery should be recommended as soon as a uterine rupture is diagnosed or suspected because laparoscopic exploration offers the advantage of visualisation of the uterus, determining the cause of the peritonitis, and the opportunity of minimally invasive rupture closure without the risk of general anaesthesia.

As far as the authors consider, all uterine ruptures can be approached using standing laparoscopy techniques. Conversion from laparoscopy to laparotomy under general anaesthesia is always possible if needed. In the case of an intestinal prolapse through the rupture, an emergency midline laparotomy is advised, followed by laparoscopy when necessary. The feasibility of a laparoscopic approach is limited by the individual surgeon`s experience and expertise in laparoscopic suturing techniques.

Authors' declaration of interests

No conflicts of interest have been declared.

Ethical animal research

Clinical based study. The owners were informed prior to surgery. The guidelines for humane animal treatment were followed and comply with relevant legislation in the Netherlands and Germany where the study was conducted.

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Authorship

M. Diekstall and A. Rijkhuizen contributed to study design, study execution, data analysis and interpretation and preparation of the manuscript. C. Rohde contributed to the preparation of the manuscript. All authors gave their final approval of the manuscript.

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Review Article

Equine emergency upper airway management

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Keywords: horses; airway obstruction; tracheotomy; asphyxia; endoscopy

Summary

Respiratory distress due to acute upper respiratory tract obstruction is an uncommon emergency in equine practice. However, clinicians should be confident with the approach to this truly life-threatening scenario. Clinical signs are obvious at rest and include increased respiratory effort, loud respiratory noise and recumbency as asphyxiation progresses. Many cases of upper respiratory tract obstruction involve the pharynx or larynx, though obstruction in other regions of the upper respiratory tract and other causes of respiratory distress should be considered. Generally, the obstruction can be bypassed by placing a nasotracheal tube under endoscopic guidance or by making a temporary tracheotomy to ensure a patent airway. Following this stabilisation, further investigation into the cause of airway obstruction can be performed. Endoscopy is usually the most valuable diagnostic tool, though other imaging modalities can be useful. Further empirical treatment is often required, though the specific management will vary depending on the pathology present.

Introduction

Acute upper respiratory distress is an infrequently encountered emergency in equine practice (Mair and Lane 1996). However, it is important that practitioners are confident with the approach to this potentially life-threatening scenario, as prompt treatment is vital. This article will discuss some of the common causes of severe upper respiratory tract obstruction and the options for emergency management.

Clinical signs

Overt clinical signs of respiratory distress are typically present in cases of acute upper respiratory tract obstruction. They may include nasal flaring, reduced nasal airflow, an extended and low head position, and increased respiratory rate and effort (Dixon 1988). There is usually loud abnormal respiratory noise. In cases of upper respiratory tract obstruction cranial to the thoracic trachea, the degree of luminal reduction and respiratory noise is typically greatest during inspiration due to the negative transmural pressures in this phase of respiration (Rakesh *et al.* 2008). Severe cases may demonstrate cyanosis of the mucous membranes and affected horses are often distressed, and even recumbent as the degree of asphyxiation progresses (Abrahamsen *et al.* 1990). Examination may also demonstrate other localising signs such as lymphadenopathy, nasal discharge or evidence of trauma.

Differential diagnoses

There are many potential causes of acute respiratory distress, but the larynx and pharynx are the most common sites of obstruction. In some cases, clinical signs may readily implicate the affected region on initial physical examination, for instance in cases with obvious signs of trauma or facial swelling. This can be helpful in narrowing the list of differential diagnoses and may also be important for initial management (Mair and Lane 1990). It should be borne in mind that many cases presented with acute respiratory distress have actually had chronic disease for many weeks or months, which may have gone unnoticed by the owner but have now reached a 'crisis' point. Differential diagnoses for severe respiratory obstruction include:

Nasal cavity

To cause severe respiratory distress, bilateral nasal cavity obstruction is typically present. Causes may include:

- Trauma: Severe bilateral trauma may result in fractures of the maxilla, nasal and frontal bones with significant soft tissue swelling and oedema, which can disrupt the nasal cavity resulting in obstruction (Mudge and Bramlage 2007).
- Severe nasal congestion or inflammation: Oedema and swelling of the nasal mucosa and submucosa typically occur due to passive congestion and alterations in hydrostatic pressure within the nasal vasculature. This is most commonly observed during general anaesthesia where there is a low head position relative to the heart (especially in dorsal recumbency) and where anaesthetic agents may result in peripheral vasodilation (Lukasik *et al.* 1997; Clarke *et al.* 2014). It can also arise in conscious horses with a lowered head carriage, which can have a variety of causes such as central neurological disease or cervical pain. Severe bilateral jugular thrombophlebitis can restrict venous drainage and result in nasal congestion (Schwarzwald 2018). Generalised inflammation around the nose, such as following snake bites can also cause dyspnoea (Dickinson *et al.* 1996).
- Paranasal sinus disease (**Fig 1**): Both primary and secondary sinusitis can result in nasal cavity obstruction due to distention and medial displacement of the ventral and sometimes dorsal nasal conchae as they fill with fluid or solid sinus contents. If very distended, the nasal septum can be forced towards the contralateral nasal cavity and result in bilateral obstruction (Tremaine and Dixon 2001).
- Choanal atresia (**Fig 2**): The presence of a congenital membranous or bony division between the nasal cavity and pharynx is occasionally encountered in equine neonates. Cases with bilateral choanal atresia will

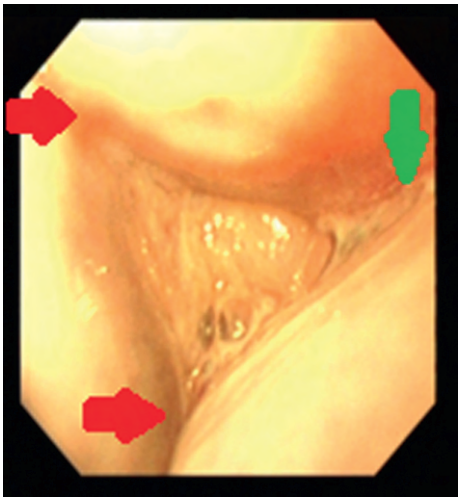

Fig 1: Endoscopic image showing complete obstruction of the middle (green arrow) and common (red arrows) nasal meatuses in a case of sinusitis. This is due to distension of the ventral concha and a soft tissue mass emerging from the sinuses and growing into the nasal cavity (centre of image).

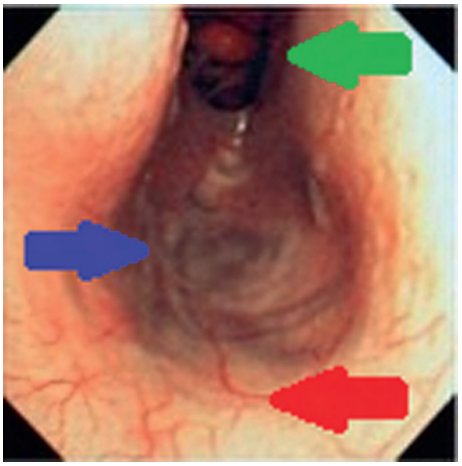

Fig 2: Endoscopic image of choanal atresia. The caudal aspect of the nasal cavity is visualised, with the ethmoturbinates located dorsally (green arrow) and the mucosa of the floor of the cavity ventrally (red arrow). A membranous division is present between the nasal cavity and the pharynx, obscuring the lumen (blue arrow).

demonstrate severe, often fatal respiratory distress immediately after foaling (James *et al.* 2006; Hawkins 2015).

- Neoplasia: Nasal cavity and paranasal sinus neoplasia can occasionally become sufficiently large to result in significant obstruction and respiratory distress (Head and Dixon 1999).

Pharynx

Respiratory distress arising from the pharynx may be a result of intraluminal obstruction or extraluminal compression:

- Trauma: Severe pharyngeal trauma is relatively infrequently encountered but can result in luminal obstruction and may involve foreign bodies (Sullivan and Parente 2003).
- Nasopharyngeal cicatrix syndrome: This syndrome is primarily reported in Texas, characterised by mucosal inflammation of the pharynx and larynx. Chronic cases often develop scarring which reduces the pharyngeal lumen (Norman *et al.* 2012).
- Pharyngeal foreign bodies: These are rare in horses but may occur by ingestion or in association with a penetrating wound (Kiper *et al.* 1992; Rush and Mair 2004b).
- Intraluminal mass: Differential diagnoses may include a neoplastic lesion, granuloma or cyst (Sullivan and Parente 2003). These cases often initially present with other clinical signs, such as dysphagia, nasal discharge and coughing. However, occasionally lesions may become large enough to result in a degree of respiratory obstruction (Rush and Mair 2004b).
- Extraluminal mass (**Figs 3** and **4**): Compression of the dorsal nasopharynx can arise due to an extraluminal disease process such as severe lymph node abscessation related to *Streptococcus equi var equi* ('Strangles') infection and guttural pouch haemorrhage, empyema, tympany or neoplasia (Sweeney 1996; Blazyczek *et al.* 2004).

Larynx

Laryngeal obstruction may be anatomical or functional and either primary or secondary to systemic disease.

- Subepiglottic cyst (**Fig 5**): Horses with a subepiglottic cyst may be asymptomatic, though common clinical signs include coughing, nasal discharge and increased respiratory noise (Aitken and Parente 2011; Salz *et al.* 2013). Acute collapse has been reported after swallowing of the cyst resulted in laryngeal obstruction and asphyxiation (Hay *et al.* 1997).
- Subepiglottic granuloma: Clinical presentations are often comparable to those of a subepiglottic cyst. Similarly, respiratory obstruction has been reported to be associated with swallowing the mass (Aitken and Parente 2011).

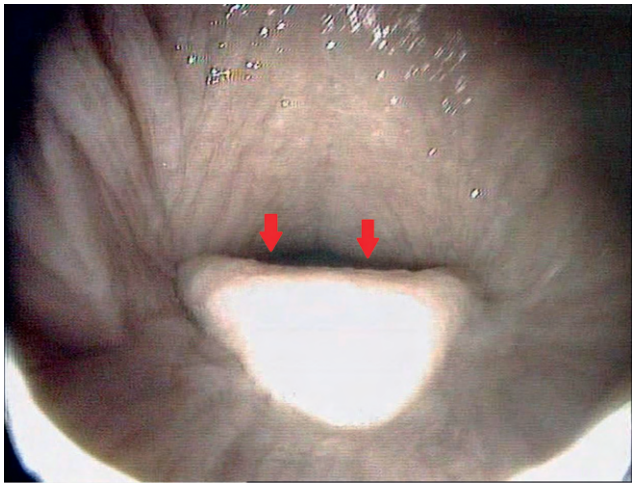

Fig 3: Endoscopic image of a horse with bilateral guttural pouch empyema. Note the ventral collapse of the dorsal pharynx (red arrows) reducing the pharyngeal lumen and obscuring visualisation of the rima glottidis of the larynx.

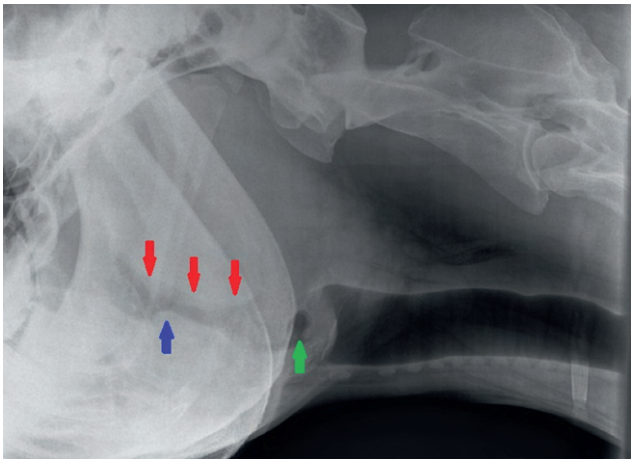

Fig 4: Radiograph of the caudal skull and cranial cervical region in a horse with severe abscessation within the guttural pouch following Streptococcus equi var equi. *infection. There is ventral displacement of the dorsal pharyngeal wall (red arrows) with a significant reduction in the radiolucent airway lumen. The tip of the epiglottis (blue arrow) and laryngeal ventricles (green arrow) are also readily identifiable.*

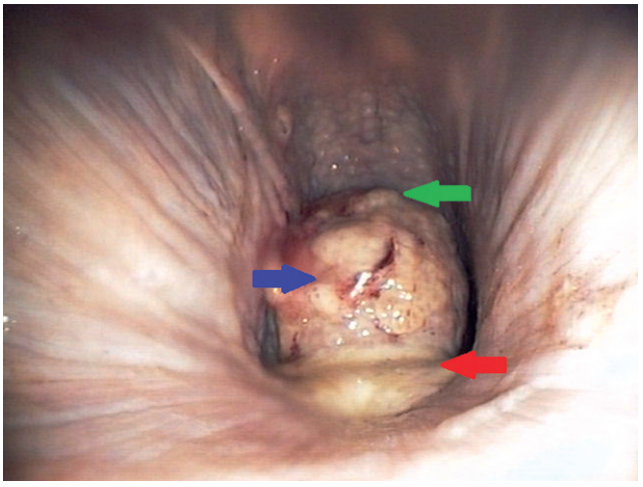

Fig 6: An endoscopic image of epiglottitis and associated subepiglottic inflammation. The epiglottis is partially retroverted, with the tip displaced dorsally (green arrow). There is marked inflammation of the epiglottis and subepiglottic tissue (blue arrow), which is adjacent to the caudal border of the soft palate (red arrow).

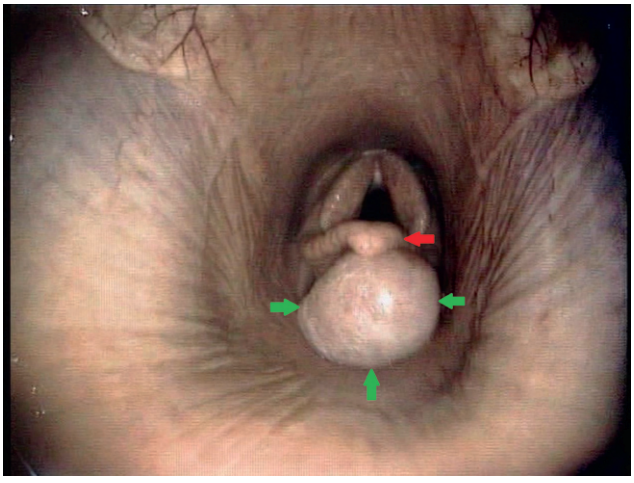

Fig 5: Endoscopic image of a subepiglottic cyst (green arrows). The epiglottis is displaced dorsally (red arrow). Asphyxiation has been reported in cases where the cyst is inhaled or swallowed resulting in airway obstruction.

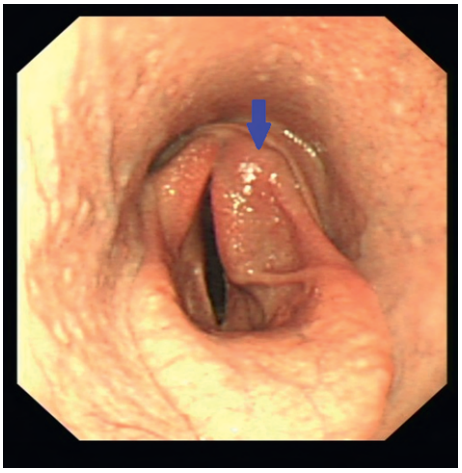

Fig 7: Endoscopic image of a horse with arytenoid chondritis. Note the generalised enlargement of the left arytenoid, which is displaced medially at rest (blue arrow).

- Epiglottitis (**Fig 6**): Inflammation of the epiglottal cartilage and mucosa is occasionally reported in racehorses with clinical signs of exercise intolerance and increased respiratory noise, though severe cases may demonstrate dyspnoea (Hawkins and Tulleners 1994; Davenport-Goodall and Parente 2003).
- Arytenoid chondropathy (**Fig 7**): Both unilateral and bilateral disease can result in significant reduction in the rima glottidis due to swelling and immobility of the affected arytenoid(s) (Fulton *et al.* 2012). An infectious process is usually implicated, though granulomatous tissue formation and generalised inflammation also contribute to the obstruction (**Fig 8**).
- Bilateral laryngeal dysfunction: Bilateral recurrent laryngeal dysfunction rarely occurs following general anaesthesia and may be associated with an extended head and neck positioning, or surgical manipulation of the recurrent laryngeal nerves (Abrahamsen *et al.* 1990; Dixon *et al.* 1993, 2001). Right-sided recurrent laryngeal neuropathy (RLN) has been reported to cause acute respiratory distress following a laryngoplasty for left-sided RLN (Canada *et al.* 2017). Bilateral laryngeal dysfunction may also occur in association with hepatic disease, toxicity (including lead and organophosphates) and hyperkalaemic periodic paralysis (Duncan and Brook 1985; Carr *et al.* 1996; Allen 2010)
- Laryngeal oedema: Endotracheal and nasotracheal intubation may result in laryngeal trauma and oedema, particularly on the medial aspect of the arytenoids (Trim 1984; Heath *et al.* 1989; Bradbury *et al.* 2008). Laryngeal

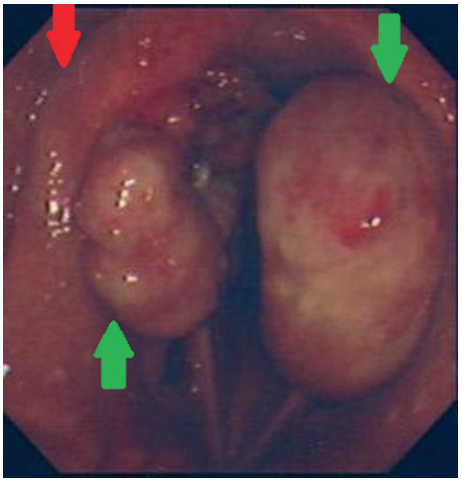

Fig 8: An endoscopic image of a horse with marked bilateral arytenoid chondropathy. Proliferative granulomatous tissue formation has formed on the medial aspects of both arytenoid cartilages (green arrows), obscuring the rima glottidis. Right arytenoid cartilage (red arrow).

surgery may also result in a degree of local inflammation (Cramp *et al.* 2014). Laryngeal swelling can also occur during anaphylactic reactions and may be combined with other respiratory tract pathology such as bronchoconstriction (Mealey and Long 2018).

- Laryngeal neoplasia: Neoplastic disease is rarely identified in the equine larynx but may result in reduction of the rima glottidis. A number of cellular origins have been reported in equine laryngeal neoplasia including squamous cell carcinoma, neuroendocrine tumours and lymphosarcoma (Jones 1994; van den Wollenberg *et al.* 2002; Rush and Mair 2004c; Koenig *et al.* 2012).
- Foreign body (**Fig 9**): Laryngeal foreign bodies are rare, as material is typically dislodged into the pharynx by coughing or passes through the rima glottidis to enter the trachea. Occasionally foreign bodies can get lodged in the laryngeal ventricles.

Trachea

The trachea is less commonly implicated but disease may be related to intraluminal obstruction or extraluminal compression.

- Tracheal collapse (**Fig 10**): Congenital tracheal deformities have been reported in horses and donkeys but are most commonly identified in Shetland ponies and miniature horses (Mair and Lane 1990; Aleman *et al.* 2008; Powell *et al.* 2010). Most cases present as mature animals with coughing and increased respiratory noise, though some may develop respiratory distress (Aleman *et al.* 2008). Disruption of the tracheal cartilages during tracheotomy procedure could predispose to tracheal collapse. Tracheobronchopathia osteochondroplastica has also been reported in a pony with acute onset tracheal collapse and rupture (Spanton *et al.* 2008).
- Trauma: Disruption of the tracheal cartilages can cause acute respiratory obstruction. Wounds are typically present, though in cases of blunt trauma subcutaneous emphysema may be the only localising sign. Dyspnoea is identified in some cases, usually due to inspiratory collapse of wound margins into the tracheal lumen (Mair and Lane 2005). Cervical cellulitis can progress to result in pyrexia, pneumomediastinum and pneumothorax (Caron and Townsend 1984; Stick 2012).
- Tracheal stenosis: Stenosis generally occurs as a rare complication following tracheotomy or tracheal wounds when scar tissue develops across the lumen (Stick 2012; Barnett *et al.* 2015). Excessive granulation tissue that develops at sites of tracheal surgery can also obstruct the lumen (Yovich and Stashak 1984).
- Tracheal foreign body: Plant material is the most frequently reported tracheal foreign body (Urquhart *et al.* 1981; Brown and Collier 1983; Bodecek *et al.* 2011). These objects can become lodged and result in paroxysmal coughing but are rarely large enough to cause respiratory obstruction. The foreign body may enter the bronchi and lead to pleuropneumonia in chronic cases (Ferrucci *et al.* 2010; Bodecek *et al.* 2011).
- Intraluminal mass: Neoplastic or granulomatous masses are a rare cause of tracheal obstruction (Lankveld 2001; Collins *et al.* 2005). Characteristic signs of luminal obstruction such

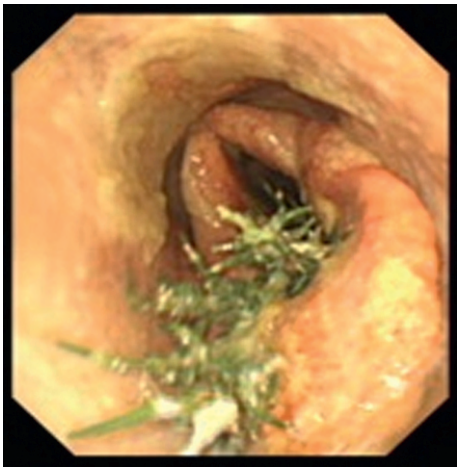

Fig 9: An endoscopic image of a laryngeal foreign body. Plant material is typically implicated in cases of pharyngeal, laryngeal and tracheal foreign bodies.

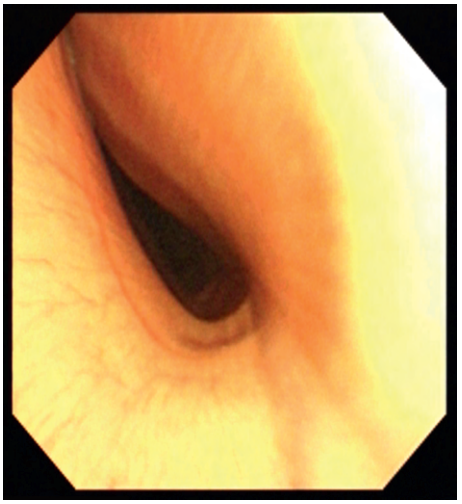

Fig 10: Endoscopic image of tracheal collapse due to congenitally abnormal tracheal cartilages.

as increased respiratory noise and effort are usually present.
- Extraluminal mass: Compression of the trachea by external masses is rare. Previous reports have implicated a variety of masses, including lipomas, lymph node abscessation and oesophageal diverticula (Yovich and Stashak 1984; Tessier *et al.* 1996; Gehlen *et al.* 2005).

Thoracic and systemic disease

Comparable signs of respiratory distress may also arise from intrathoracic disease, which typically requires a different approach to stabilisation and investigation. Consideration should be given to pathology that reduces the residual volume of the thorax or decreases the efficiency of gaseous exchange (Mair and Lane 1996). Potential differential diagnoses may include acute respiratory distress syndrome (ARDS), pneumonia, pneumothorax, diaphragmatic hernia and severe equine asthma syndrome (Mair and Lane 1989; Dixon *et al.* 1995; Boy and Sweeney 2000; Wilkins and Seahorn 2004). Smoke inhalation may result in a combination of upper respiratory tract, lower respiratory tract and systemic disease (Marsh 2007; McGorum 2017). Other systemic pathology such as toxicity and central nervous system disease may also present with respiratory signs (Mair and Lane 1996). Management of such cases is not discussed further in this article.

Initial management

If the upper respiratory tract is suspected to be the cause of respiratory distress, initial management procedures depend on the severity of distress and the demeanour of the horse at the time of examination. In most cases, there is time to perform endoscopy to ascertain the site of obstruction. If an endoscope is not readily available, or if the horse is very distressed, ataxic or even recumbent, emergency treatment should be instigated before diagnostics are performed. Horses can react violently to airway obstruction and may be difficult to restrain. Distress of the patient and increased respiratory effort can exacerbate airway inspiratory pressures, thus worsening the obstruction (McGorum 2017). Generally speaking, light sedation of the distressed patient is beneficial and in the authors' experience, does not make the obstruction worse.

Establishment of a patent airway is a key primary step. Insertion of a nasotracheal tube is a minimally invasive method of achieving an airway, though this is not possible in some circumstances (see section below) and requires an appropriately sized tube and usually, endoscopic guidance. In most first-opinion emergency situations, a quick and effective method of bypassing an upper airway obstruction and forming a patent airway is by performing a tracheotomy and placement of a temporary tracheostomy tube (Dixon 1988). This can be performed in the standing, recumbent or anaesthetised horse.

A temporary alternative to making a surgical tracheotomy is to pass a nasotracheal tube (**Fig 11**). Endoscopy is required to first see if the obstruction can be bypassed with the tube and also then greatly facilitates positioning of the tube. Examples of situations where a nasotracheal tube is useful include bilateral laryngeal paralysis, arytenoid chondritis, nasal occlusion due to sinus disease, pharyngeal collapse due to pharyngeal abscessation and some cases of epiglottic-related swelling, if

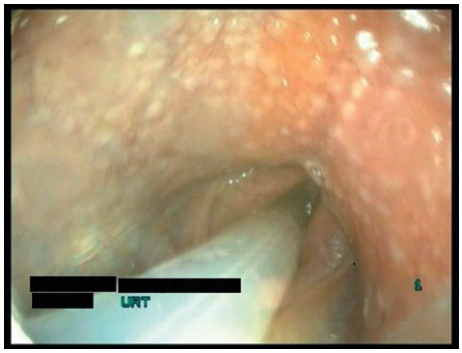

Fig 11: Endoscopic image of a larynx with a nasotracheal tube in place. Endoscopic guidance can be very helpful in placement of nasotracheal tubes. In this case the soft palate is permanently displaced dorsally.

the rima glottidis is accessible. These tubes are generally 50–60 cm long and 10–14 mm internal diameter, depending on the age and size of the horse. Using the biopsy channel of the endoscope to topically 'spray' the laryngeal and pharyngeal mucosa with 20–30 mL of lidocaine can reduce the occurrence of the swallowing and laryngospasm as the tube is passed through the pharyngeal/laryngeal lumen, though this step might not be required. Once in position, the tube can be taped to the horse's headcollar (**Fig 12**). This temporary solution allows the veterinarian time to discuss the situation with the client and also to make a surgical tracheotomy incision in a more controlled and sterile manner. In cases of nasal passage oedema, administration of intranasal phenylephrine may be sufficient to resolve passive congestion, though placement of a nasopharyngeal tube is sometimes required (Lukasik *et al.* 1997; Clarke *et al.* 2014).

Tracheotomy procedure

- Positioning the head in a normal resting position and sedating the horse optimise location of the tracheostomy

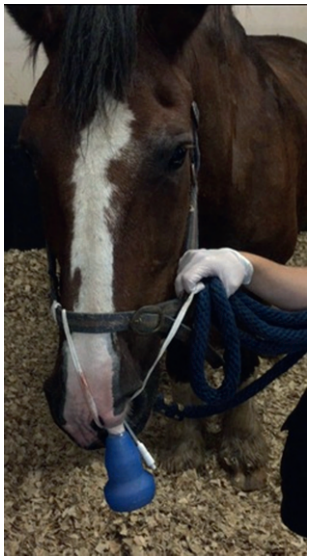

Fig 12: A horse with nasotracheal tube in place. Tape has been wrapped around the tube and secured to the headcollar.

and allow the procedure to be completed promptly. In very urgent cases, some of the preparatory steps may need to be omitted.

- The preferred location is the ventral midline at the junction between the upper and middle thirds of the neck (or around the 5th tracheal ring). The tracheal rings are palpable at this level. If the tracheotomy is positioned too high, the tube may be occluded when the horse flexes its head and neck. If positioned too low, there is thicker musculature covering the trachea which makes the tracheostomy procedure and replacement of the tube after cleaning more difficult. The oesophagus also courses lateral to the left side of the trachea in the mid-third of the neck and could be damaged at this location. Nonetheless, the position of the tracheotomy may need to be adapted in cases with tracheal pathology. It is preferable for the site to be clipped and aseptically prepared before surgery.
- Approximately 10 mL of local anaesthetic is infiltrated in a 10 cm long, linear pattern subcutaneously on the midline at the surgical site using a 21–23 G needle (**Fig 13**).
- A 6 cm linear skin incision is made on midline using a scalpel blade (**Fig 14**). The incision is then extended through the subcutaneous tissue to expose the paired sternothyrohyoideus muscles. The muscles are bluntly separated along the midline along the length of the incision, to expose the underlying trachea (**Fig 15**).
- Two cartilage rings in the centre of the incision are located and the annular ligament between the rings is identified. A scalpel blade is used to gently stab through the annular ligament, parallel to the cartilage rings (i.e. perpendicular to the skin incision; **Fig 16**). Audible air flow often occurs at this stage. The ligament incision is then extended 1.5 cm bilaterally, so that approximately one-third of the tracheal circumference is incised. If more than half of the tracheal circumference is incised, there is a small risk of long-term tracheal luminal stenosis due to mucosal stricture (Stick 2012). Several important neurovascular structures course along the dorsolateral aspect of the trachea and can be damaged by a very wide incision. The recurrent laryngeal nerve is the most ventrally positioned followed by the common carotid artery and the vagosympathetic trunk, which are located more dorsolaterally.
- The temporary tracheostomy tube should then be inserted into the trachea (**Figs 17** and **18**). A relatively small tube, for example a human tracheostomy tube (internal diameter 9 mm) is easier to place in an emergency and is usually preferable to larger tubes at this stage. Care should be taken to ensure the tube is not placed extraluminally into the subcutaneous tissue. Digital guidance is often sufficient to successfully place the tube. However, insertion of loop sutures using a nonabsorbable monofilament suture placed through the ventral midline of each tracheal ring on either side of the tracheotomy can assist in placement of the tube and readily identifies the site during future cleaning and tube replacement. There should be obvious air flow with respiration if the tube is positioned

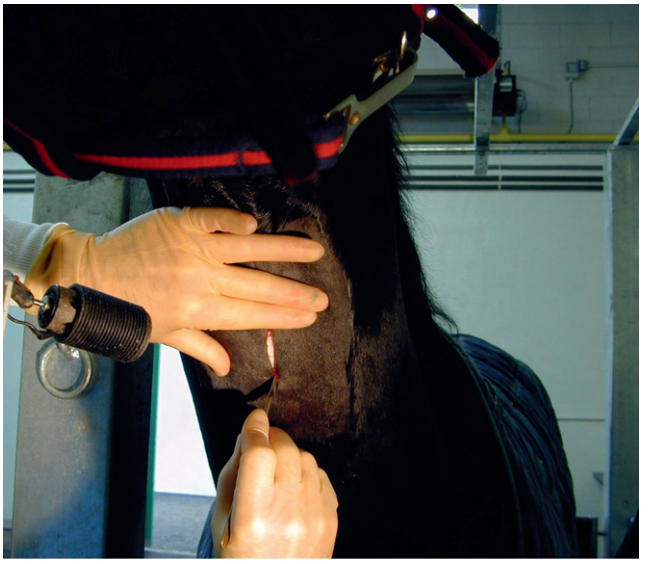

Fig 14: To begin the tracheotomy, a 6 cm linear skin incision is made on the ventral cervical midline using a scalpel blade.

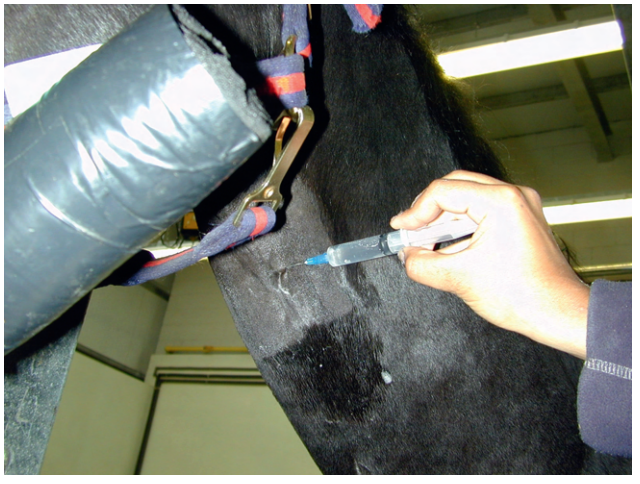

Fig 13: Prior to tracheotomy, approximately 10 mL of local anaesthetic is infiltrated in a 10 cm long, linear pattern subcutaneously on the midline at the surgical site using a 21–23 gauge needle.

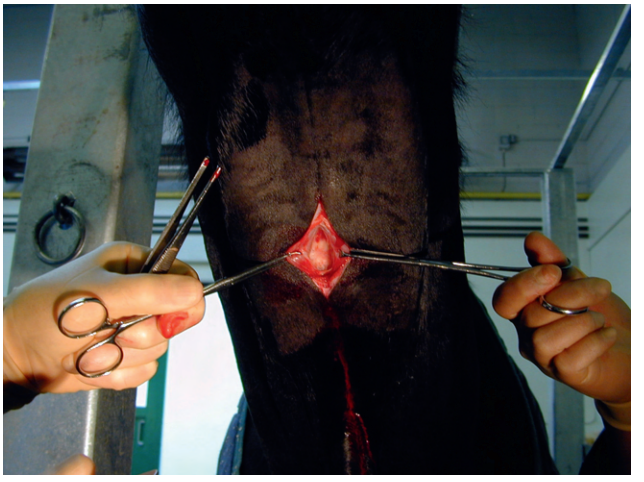

Fig 15: The paired sternothyrohyoideus muscles are exposed and bluntly separated along the midline to expose the underlying trachea.

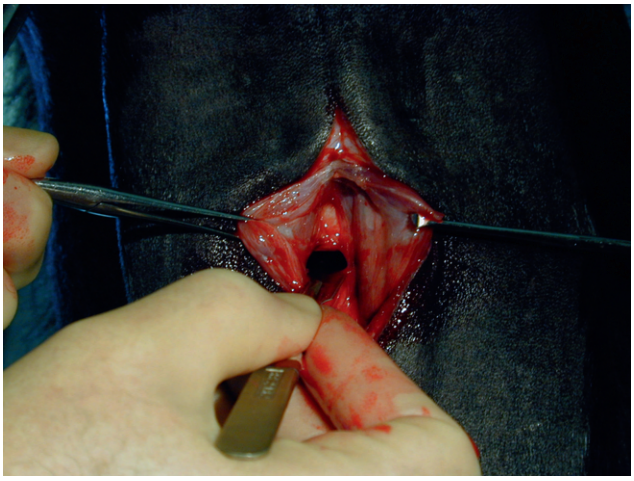

Fig 16: Two cartilage rings in the centre of the incision are located and the annular ligament between the rings is identified. A scalpel blade is used to stab through the annular ligament, parallel to the cartilage rings.

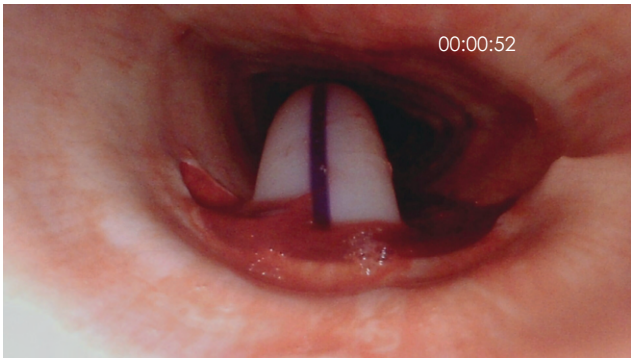

Fig 17: Endoscopic image of a 9 mm internal diameter tracheostomy tube in situ following emergency tracheotomy.

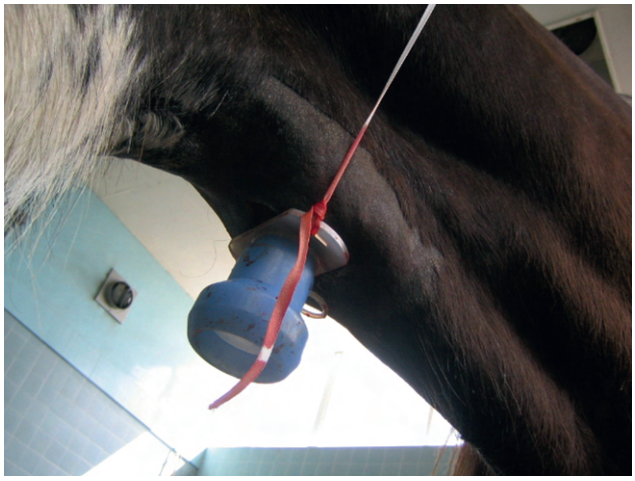

Fig 18: A horse with a temporary tracheotomy with a silicone tracheostomy tube in situ.

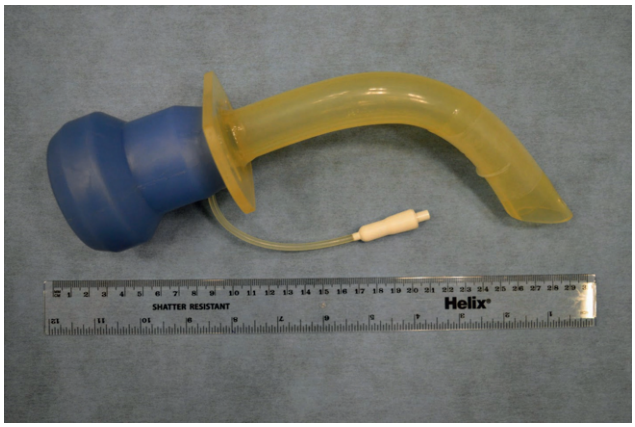

Fig 19: An example of a cuffed, semi-rigid silicone tracheostomy tube, with an internal diameter of approximately 17 mm, which is ideal for short- to medium-term use, including for anaesthesia.

correctly. The tube can then be secured with bilateral loop sutures using a nonabsorbable monofilament suture or by tying a loop of conforming bandage around the neck. In a field emergency situation, the clinician may not have a tracheotomy tube available. Simply making the incision in the annular ligament will allow some airflow, and the rings can be digitally held apart whilst a suitable tube-like structure is sourced.

Temporary tracheostomy tubes

A range of designs are available for use in a tracheotomy, including metal and plastic tubes. For horses, commercially available semi-rigid silicone tubes, typically with an internal diameter of approximately 17 mm are ideal for short to medium-term use (**Fig 19**). These tubes are also preferable for cases requiring inhalational anaesthesia as they often incorporate an inflatable cuff, a Murphy's eye and a funnel adaptor for attachment to a breathing circuit. In the emergency case, even a relatively small diameter tube (for example, a human tracheostomy tube with internal diameter 9 mm) is sufficient to alleviate respiratory distress. A small temporary tracheotomy pack (**Fig 20**) is an inexpensive and compact kit for ambulatory practitioners to carry in the car or to have prepared in locations around a clinic. If a purpose made tracheostomy tube is not available, improvised options can include a cut 10 or 20 mL syringe casing, a section of stomach tube, a clean section of hosepipe, or the cut handle of a 5-litre plastic container (Dixon 1988; Reed *et al.* 2006).

Management of the temporary tracheotomy

Tracheotomy sites rapidly accumulate secretions and exudate. Therefore, daily removal and cleaning of the tube and twice daily cleaning of the site are recommended (Stick 2012). Application of petroleum jelly onto the skin along the ventral cervical midline, caudal to the incision can minimise skin scalding and ease cleaning. Temporary occlusion of the tracheostomy tube can be performed to assess the degree of nasal airflow before it is removed. Once the tube is no longer required, it can be removed and the wound left to heal by secondary intention. This typically occurs within 3–4 weeks (Rush and Mair 2004a). Long-term cosmetic

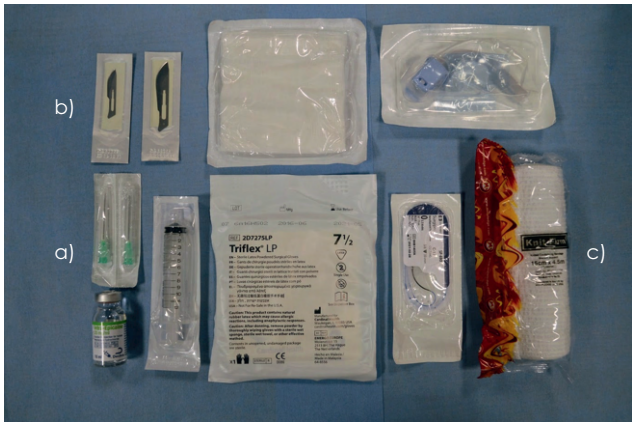

Fig 20: A compact temporary tracheotomy kit can easily be assembled for use in an emergency. This should include the important items required to prepare the surgical site and perform the procedure: a) Local anaesthetic, 21 gauge needles, a 10 mL syringe and sterile gloves. b) Scalpel blades, sterile swabs and a commercially available human temporary tracheostomy tube. c) Conforming bandage and 3.5 metric nonabsorbable suture material. Other items for preparation such as clippers and surgical scrub are usually readily available.

outcome is usually good, though a scar is sometimes visible or palpable at the surgery site.

Further investigation of emergency upper airway obstruction

Following stabilisation of the patient, further investigation can be performed to confirm diagnosis and guide additional management. Endoscopy is the most valuable procedure in the investigation of obstruction at all levels of the upper respiratory tract and some cases may be amenable to transendoscopic treatment. Radiography of the nasal cavity and paranasal sinuses is commonly used and is especially applicable for the assessment of trauma and neoplasia. Intraluminal gas can delineate foreign bodies and luminal obstruction on pharyngeal or tracheal radiographs but these would normally be more easily visualised on an endoscopic exam. Ultrasonography can also have applications in assessment of the pharynx, larynx and trachea. In some cases, advanced diagnostic imaging, such as computed tomography may be valuable. Obstruction secondary to systemic disease may require additional investigation of other body systems to evaluate the primary disease process.

Additional treatment

After stabilisation, additional therapy may include further empirical management such as oxygen insufflation. Beyond this, specific treatment protocols will vary depending on the pathology present but often require a combination of medical and surgical intervention. In many cases, referral to a hospital facility may be preferable to permit treatment and on-going management. Several patient and practical factors should be considered prior to travel. It is important that a patent airway has been established and steps have been taken to minimise the risk of recurrence of obstruction during travel. Other practical considerations include the availability of suitable transport, experience of the transporter and distance to the referral centre. Inspecting the horse compartment of the vehicle can be useful to address any features which may compromise airway patency, for example positioning of breast bars or ropes that could dislodge a tracheostomy tube. In this situation, it is usually preferable to travel the horse without feed being available.

Repeat obstruction (for example post-operatively) may be a risk in some patients, especially those with marked upper respiratory tract inflammation. In these cases, potent anti-inflammatory medications are important and may include systemic corticosteroids and nonsteroidal anti-inflammatory drugs and topical medication such as 'throat spray'– usually composed of dexamethasone, dimethyl sulphoxide and glycerol (Brandenberger *et al.* 2017).

Some cases of severe respiratory tract obstruction may result in the formation of negative pressure pulmonary oedema and even a degree of pulmonary haemorrhage (Abrahamsen *et al.* 1990). This may cause the production of a pink frothy nasal discharge and persistent dyspnoea, even following bypass of the primary obstruction. Further prompt treatment is imperative and may include oxygen insufflation, suction of fluid from the airways, furosemide, sedation, corticosteroids and nonsteroidal anti-inflammatory medication (Senior 2005).

Prevention

In a small number of cases, respiratory obstruction may be anticipated. This generally pertains to elective surgical procedures where intra- or post-operative obstruction is likely, for example after arytenoidectomy. Pre-emptive tracheostomy or nasotracheal intubation is preferable in these cases.

Conclusions

Acute upper respiratory tract obstructions are a relatively infrequently encountered emergency in equine practice. A wide spectrum of differential diagnoses can be implicated and it is important that the clinician is aware of these. However, a small number of methodical steps can result in successful management of the majority of these cases: establishing a patent airway is the most important component, typically by passage of a nasotracheal tube or via a surgical tracheotomy. Once the patient has been stabilised, the clinician has more time to evaluate the horse and arrange a referral if necessary or confirm the diagnosis and establish a treatment plan.

Authors' declaration of interests

No conflicts of interests have been declared.

Ethical animal research

No ethical review was performed for the preparation of this manuscript.

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Authorship

Both authors contributed to the article design and preparation of the manuscript. The final manuscript was approved by both authors.

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Outcome may also be related to the appearance of the keratoma on MRI. Mair and Linnenkohl (2012) described six horses requiring repeat debridement of which four were noted to have ill-defined lesions. In their case series, they also managed to perform follow-up MRI examinations in four cases. These cases were reported to have no clinical problems (lameness/recurrent abscesses). In all these cases, MRI features included an abnormal hoof wall structure with a mixed, heterogenous signal intensity protruding into the corium. These cases did not appear to have any further signal changes in the distal phalanx but it does highlight the potential problem of interpreting MRI after debridement has been performed (particularly if an MRI was not performed initially). The authors in that case series suggest that the use of MRI early in decision making is therefore preferable to provide a diagnosis and assist in surgical planning since some of these cases had a number of debridements performed prior to MRI evaluation which may have influenced image interpretation.

Notwithstanding, it is clear that advanced imaging, such as MRI, gives a clearer picture of the extent of the changes occurring within a foot containing a keratoma, particularly in relation to type and location. This information can be used for surgical planning regarding the approach and degree of debridement required as well as to inform the client of potential post-operative morbidity and outcome. Remember, forewarned is forearmed!

Author's declaration of interests

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Ethical animal research

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Correspondence

Letter to the Editor regarding 'What is the best treatment for mares with post-partum haemorrhage?' by P. Wilkins

Dear Editor,

I read with interest in your January 2020 issue the article by Dr Wilkins titled, 'What is the best treatment for mares with post-partum haemorrhage?' The topic of peripartum haemorrhage (PPH) has been of interest to me for several years and is a condition I have regularly encountered and treated as a stud farm veterinarian. I was thus surprised by the lack of substance and rather nebulous conclusions drawn by what is supposed to be a *Critically Appraised Topic*. First, the search criteria failed to include the terms 'periparturient', 'hypovolaemia(c)' and/or 'shock'. Including these key words would have cut a larger swath in capturing pertinent references. Secondly, the author failed to mention a key tenant of treatment: keeping these mares calm and quiet during the initial triage of PPH. Such treatment can be rendered in a multitude of ways and would include administration of a sedative or anxiolytic, removing external stimuli and performing the clinical exam in a calm yet efficient manner. Finally – but fully recognising my inherent bias – there was no reference to a clinical report published about an unusual case of PPH in which aggressive haemostatic support was apparently successful in treating rupture of the middle uterine artery during parturition (Scoggin and McCue 2006). In my experience, the scenario and treatments performed in this report closely mimicked that of an 'on-the-farm' case, with perhaps the exception of the whole blood transfusion. References included in that report, as well as those provided in a more thorough review from a past conference (Scoggin and McCue 2007), would indicate there is experimental and clinical evidence supporting the benefits of various haemostatic agents and therapies to support blood pressure and stabilise clot formation during hypovolemic crises in horses, as would occur with cases of PPH.

Since your publication reaches a wide audience, the purpose of this letter was to bear in mind that readers should be supplied with all pertinent information regarding PPH. Please note my comments are not meant to level hurtful criticism to the author or journal. Rather, they are meant to provide further perspective on a topic for which I have become very familiar with as an equine practitioner in an area of intensive breeding activity.

Thank you for the opportunity to voice my opinion and humour my concerns.

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Correspondence

Response to letter from Dr Scoggin regarding 'What is the best treatment for mares with post-partum haemorrhage?'

Dear Editor,

I would like to thank you for providing me with the opportunity to respond to Dr Scoggin's letter (Scoggin 2020). First, I would like to acknowledge Dr Scoggin's expertise in the topic of concern. Dr Scoggin is a thorough, talented and exceptional theriogenologist for whom I have tremendous respect. His listed publications on the topic of periparturient haemorrhage are certainly useful contributions to the literature (Scoggin and McCue 2006; Scoggin and McCue 2007). Not including them in the article that he takes to task was not a reflection of him or his contributions, but rather associated with the nature of the CAT article itself. Dr Scoggin's publications fall under the categories of case report and expert opinion, which become important as, while both are clinically useful, both are considered the lower levels of scientific evidence. My intention by stating this is not to denigrate those contributions but rather, to acknowledge their place in the pyramid of scientific evidence (Howick *et al.* 2011; Pinchbeck and Archer 2020). Expert opinion and case reports do provide a foundation for evidence-based hypothesis-driven studies and are useful in that regard. This is why EVE publishes these reports.

As background, I was asked to produce a CAT (Critically Appraised Topic) presentation on the topic at BEVA Congress in 2017, the topic question given as 'What is the best treatment for mares with post-partum haemorrhage?' with the PICO being: 'In mares affected by post-partum haemorrhage, is intensive medical therapy more effective than conservative therapy?' (Wilkins 2020). For those not familiar with CAT topics, they are intended to be a short summary of the *best* available evidence, created to answer a specific clinical question, the PICO. CATs are not extensive literature reviews but rather focus on the best evidence to answer the specific PICO question as determined by the guidelines. Typical parts of a CAT are as follows: the clinical question or PICO; the search strategy; a description of included articles; the methodological limitations (in a CAT usually presented in an evidence table); the clinical bottom line; a short reference list. PICO(S) is an acronym standing for Patient or Problem, Intervention, Comparison, Outcome (Study type). OCEBM Levels of Evidence are used as the guideline for determining evidence quality, with each article identified in the search categorised by level of evidence. These guidelines were used to create the CAT in question.

Here, then lies the crux of the matter. There was minimal to no high-quality evidence related to discovering a difference between intensive and conservative medical therapies. In fact, the summary stated at the beginning of the article still stands: 'Determining the "best" treatment for mares with post-partum haemorrhage is a challenge for equine practitioners. There have been many approaches described, some directly contradictory, with scant evidence supporting choices made for treatment. Information available from peer-reviewed literature may be biased as reports primarily originate from large private or university-based referral hospitals. There are no large breeding farm population-based studies or studies directly comparing treatments'. Rather than taking issue with the lack of inclusion of each available case report or opinion paper, the reader is directed to understand that the intention of this CAT was to motivate veterinarians associated with the care of these high-risk patients to perform high-quality hypothesis-driven investigations into the best management practices. I have my own way of managing these cases, when I was in private practice and when in academic referral practice, and those strategies have evolved over time with clinical experience, still is not 'best evidence', but certainly my opinion. I also made the important point that studies originating from referral institutions are probably biased towards survival of these mares, as the cases must be stable enough to survive the stress of transport to the referral facility and will not necessarily reflect those seen in farm situations. An extensive review of all available literature, including case reports and personal experience/opinion papers, is not possible with a CAT that requires examination of the best level of evidence. The CAT highlights the lack of large prospective multicentre, large retrospective or large case-control investigation studies into the bleeding mare problem. Because of this, we do not know what the best approach is as to follow: intensive or conservative therapy. It will take exceptional veterinarians, such as Dr Scoggin, performing high-level evidence studies to provide us with an answer to that particular clinical question.

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