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American Association of
Equine Practitioners, produced
in partnership with BEVA.

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Arthrotomy, curettage and medical management of septic arthritis and osteomyelitis of the temporomandibular joint in a horse

Prevalence of equine ulcerative keratomycosis in Colorado and association of environmental factors: A retrospective and descriptive study (2002–2017)

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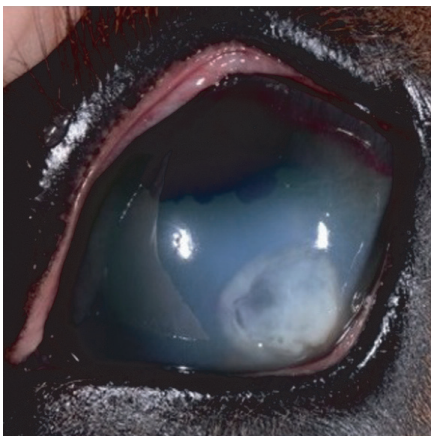


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American Association of Equine Practitioners

4033 Iron Works Parkway
Lexington, KY 40511
TEL (800) 443-0177 • (859) 233-0147
FAX (859) 233-1968
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Paul Ransdell, *Senior Development Officer*
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cross@aaep.org

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Amity Wahl, *Communications & Technology Coordinator*
awahl@aaep.org

Kristin Walker, *Membership & Event Services Coordinator*
kwalker@aaep.org

Elaine Young, *Development & Communications Coordinator*
eyoung@aaep.org

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Address advertising inquiries to Dana Kirkland (859) 233-0147 / dkirkland@aaep.org

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Meet 2021 AAEP President Dr. Scott Hay



Dr. Scott Hay

AAEP member. His father, Dr. William Hay, was a longtime member and mixed animal practice owner. His mother, Dorothy, was a stay-at-home mom to Scott and his older sister, Becky.

While in high school, Dr. Hay participated in rodeo—specifically team and calf roping—although basketball was his true passion. He attended Kansas State University intending to become a high school teacher and basketball coach, but after earning degrees in political science and history, he realized he wanted a career with horses. He spent the next two years fulfilling academic requirements before applying and being accepted to vet school at Kansas State University.

Shortly after receiving his veterinary degree in 1988, Dr. Hay started at Teigland, Franklin and Brokken. For the past 32 years, he has focused his practice on the day-to-day care of racehorses in south Florida while travelling to Thoroughbred auctions in the eastern half of the United States to consult on purchases. He took on additional practice management duties in 2000.



The AAEP is pleased to introduce Dr. Scott Hay as its 2021 president. Dr. Hay is president and managing shareholder of Fort Lauderdale, Florida-based racetrack practice Teigland, Franklin and Brokken DVMs (TFB Equine).

Born and raised in Ottawa, Kansas, Dr. Hay is a second-generation veterinarian and

Dr. Hay has been an AAEP member his entire professional career, citing the value of the educational offerings, networking and camaraderie that have enhanced his practice and enjoyment of veterinary medicine. A desire to become more involved with AAEP led to his consistent and effective volunteer leadership within the association over the past 15 years, upholding a commitment to organized veterinary medicine, particularly AAEP, that has been a hallmark of Teigland, Franklin and Brokken for more than half a century.



Dr. Hay serves on the AAEP's Educational Programs Committee, Finance & Audit Committee and as a veterinary spokesperson for the On Call program. He previously served on the board of directors from 2009-2011, as chair of the Racing Committee and as a member of the Professional Conduct & Ethics Committee.

Beyond AAEP, Dr. Hay serves on the Grayson-Jockey Club Research Foundation Advisory Committee and is a member and former chair of the Racing Medication and Testing Consortium's Scientific Advisory Committee.

Away from practice, Dr. Hay enjoys a relaxing round of golf and spending time with his three-year-old granddaughter, Cara, and his three adult children: Lindsay, a sports psychologist; Baylee, who's pursuing a business degree; and Kylee, who's working toward an education degree.

The challenges of 2020 have reinforced the importance of family, not just at home but also professionally among practice staff and the broader AAEP community. As Dr. Hay says of the AAEP, "there are so many things an organization of this magnitude helps with in your practice life."

These words are as true today during a global pandemic as in 1961, when practice founder Dr. M.B. Teigland assumed the reigns as AAEP's 7th president. The legacy of industry leadership established by Dr. Teigland and perpetuated by Dr. Ben Franklin in 2000 and Dr. Tom Brokken in 2006, continues this year with Dr. Hay serving as the fourth from his practice to lead the AAEP.

Annual convention attendees acquire new knowledge in a new format



It may have looked different out of necessity, but AAEP's reimagined 2020 Annual Convention & Trade Show in December continued the longstanding tradition of delivering practical clinical knowledge to enhance patient health and practice success.

At press time for this issue, nearly 2,600 veterinary professionals and students had taken advantage of the reduced registration rate to watch and claim CE at their own pace and on their own schedule. Registration closed Dec. 31, and all sessions remain available on-demand through June 30.

While the virtual format may have been a wildcard for some at the time they registered, attendees quickly adapted and enjoyed the format. In fact, it wasn't uncommon to see more than 200 attendees in some of the live Table Topics on Zoom, generating valuable discussion. As a member from Texas commented at the conclusion of the live Prime Time sessions, "I have participated now in six online conferences this year, and by far AAEP was the easiest to navigate, most streamlined, and most professional."

After a year that tested everyone's resiliency, we hope to see you in-person at the 2021 convention at the Music City Center in Nashville—although it's safe to say there will be a strong virtual component to the meeting.

Access Kester and Milne articles online

EVE and *EVJ* have released a virtual issue of the articles discussed during the Kester News Hour and referenced in the Milne Lecture. The articles are free access until Feb. 28 at <https://tinyurl.com/kest20>.

Continue earning CE credits

All educational sessions are available on-demand to attendees until June 30. For on-demand sessions, attendees answer a short quiz after watching the presentation video. Upon passing the quiz with a score of at least 70%, a CE certificate is automatically awarded and available to the attendee. Attendees can find copies of all CE certificates earned during convention by logging into the convention website, going to "My Account" and then selecting "CE Certificates" in the left-hand menu bar.

My Vet Rocks grand prize to Dr. Alfredo Sanchez-Londoño

During Opening Session of Convention Prime Time, the AAEP recognized Dr. Alfredo Sanchez-Londoño from Auburn University as recipient of the grand prize 2020 My Vet Rocks Award for the exceptional care he provides to

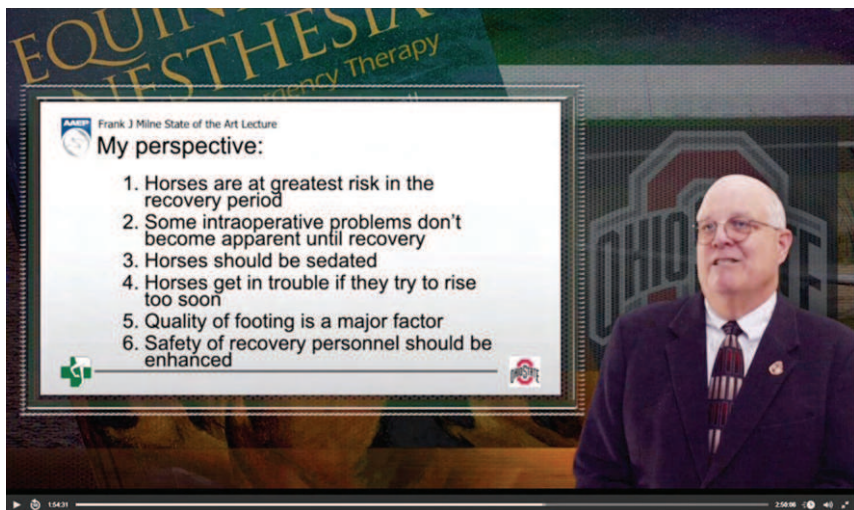


Dr. Alfredo Sanchez-Londoño

clients' horses. Dr. Sanchez-Londoño received complimentary registration to the virtual convention as well as a grand prize package provided by the AAEP and contest sponsor American Regent Animal Health.

The convention site is really easy to navigate—it is so convenient to have 'on demand' available, especially when there is a 5-hour time difference.

—Attendee from United Kingdom



During a Frank J. Milne State-of-the-Art Lecture universally praised by attendees, renowned equine anesthesiologist Dr. John Hubbell traced the development of modern anesthetic methods; discussed current best practices; and identified areas for improvement, including enhancing the safety of equine anesthesia in the future. Dr. Hubbell's paper is available in the Proceedings book, beginning on page 153.

8 receive annual awards

During Closing Session of Convention Prime Time, the AAEP honored seven members and one organization for outstanding contributions to the profession, association and equine industry:

The Lavin Cup – New Vocations, the largest racehorse adoption charity in the United States.

Distinguished Educator Award – Mentor – Dr. Stephen O’Grady, who has raised the standard of hoof care through instruction in basic and therapeutic farriery to veterinarians and students across the globe.

AAEP Research Award – Dr. Katrin Hinrichs, whose pioneering research in the field of equine assisted reproductive techniques (ART) has transformed the state of equine reproductive practice.

Distinguished Service Award (2) – Dr. Mary Scollay, longtime volunteer leader within the association and strident advocate for the welfare of racehorses and the integrity of racing; and Keith Kleine, tireless proponent for equine veterinary practice and the welfare of horses as AAEP’s director of industry relations.

Distinguished Life Member – Dr. Susan White, who has a legacy of exemplary and influential service on the board and numerous committees, councils and task forces during her four decades of volunteer leadership.

Sage Kester Beyond the Call Award –

Dr. Scott Palmer, who has an extensive history of exceptional service to the AAEP and an impactful commitment to equine welfare, in particular the health and safety of racehorses.



Dr. Scott Palmer

President’s Award – Dr. Sherry Johnson, who spearheaded AAEP’s first-ever online continuing education event as program chair of the Virtual CE Summer Series.



Dr. Rosemary Bayless

Fellows bestowed upon promising researchers

Drs. Rosemary Bayless and Rebecca Legere, doctoral candidates at North Carolina State University and Texas A&M University, respectively, were recognized during the Closing Session for exceptional research contributions.

Dr. Bayless received the AAEP Past Presidents’ Research Fellow for her research into innovative therapeutic strategies to reduce inflammation in horses by modulating neutrophil function. Meanwhile, Dr. Legere received the EQUUS Foundation Research Fellow for her investigation of aerosolized mRNA vaccination to protect foals from *Rhodococcus equi* infection.

The \$5,000 fellows are supported by monetary contributions from AAEP past presidents and in partnership between The Foundation for the Horse and the EQUUS Foundation.

Foundation awards scholarships of \$295,000

Two recent graduates and 14 students shared in scholarship awards of \$295,000 through the generosity of The Foundation for the Horse’s scholarship partners: Coyote Rock Ranch, Merck Animal Health, Oakwood Foundation Charitable Trust and Zoetis. See page XII for a list of recipients.

67th Annual AAEP Convention

Nashville

December 4-8, 2021



5 things to know about AAEP this month

1. U.S. members: Position yourself to help a client who could struggle to pay for veterinary care by enrolling in The Foundation's Vet Direct Safety Net at aaep.org/vet-direct-safety-net.
2. Help an affiliated equine rescue/retirement facility complete the application for free vaccines from the UHVR by Feb. 1 at tinyurl.com/uhvrc21.
3. Enjoy free access until Feb. 28 to all the *EVE* and *EVJ* articles highlighted during the Kester News Hour and cited in the Milne Lecture at tinyurl.com/kest20.
4. Shop the new AAEP Store for a variety of AAEP-logo apparel, including jackets, vests and pullovers at aaepshop.square.site.
5. Discover the benefits of becoming a "Proud Supporter" of The Foundation for the Horse by visiting foundationforthehorse.org/support/proud-supporter.

Nominate a distinguished researcher for the 2022 AAEP Milne Lecture

Deadline to nominate is January 29

Help determine the 2022 Frank J. Milne State-of-the-Art Lecturer by nominating an accomplished researcher by Jan. 29.

Created in 1997, the Milne Lecture recognizes an individual with a distinguished career in research and discovery, and who has presented and published their findings in a specific area of equine health. The lecture is intended to honor the accomplishments of the presenter and provide a meaningful learning experience to the AAEP membership. The lecture is a perspective on the state-of-the-art in the presenter's area of expertise.

Nominees should be an expert in their field with a track record of accomplishment and the ability to relate the topic to the audience. A nomination form must be completed and include qualifications and accomplishments of the nominee.

The award recipient will be determined by a subcommittee of the AAEP Educational Programs Committee in February and will then be presented to the board of directors for approval. The selected individual will deliver



Dr. Dean W. Richardson delivers the 2019 Milne Lecture on the topic of equine fracture repair.

their lecture and receive their award at the AAEP's 2022 Annual Convention in San Antonio, Texas.

A nomination form may be requested from Carey Ross, scientific publications coordinator, at cross@aaep.org. Completed forms must be returned to her by Jan. 29.

Share your research at the 2021 convention in Nashville

Help create a noteworthy experience for your colleagues by submitting a paper to be considered for presentation during the 67th Annual Convention at the Music City Center in Nashville, Tenn., Dec. 4–8.

Eligible for consideration are scientific papers, "how-to" papers, review papers, abstracts ≤ 250 words and The Business of Practice papers. All paper presentations are limited to 15 minutes with an additional 5 minutes for Q&A.

Submit papers by March 15 at https://s3.goeshow.com/aaep/annual/2021/AAEP_paper_submission.cfm. Authors should visit the site in advance to set up a profile and provide paper and author information before uploading

the paper when it is finished. Complete considerations and ethical guidelines are available in the General Instructions area of the site. The presenting author of selected papers will receive complimentary registration and a stipend to support travel to the meeting.

As an aid to private practitioners, first-time authors or members seeking guidance with their submission, AAEP offers a mentorship program in which experienced presenters are available to provide advice and direction. However, mentors are not responsible for rewriting or selecting material. Contact Carey Ross, scientific publications coordinator, at cross@aaep.org for a list of available mentors or with questions concerning educational paper submission.

Ethics in action



ETHICAL PRACTICE Every Day-Every Time

As an educational resource for members, the AAEP's Professional Conduct & Ethics Committee has compiled synopses of real-life ethical situations and issues addressed by the committee in recent years. The case series began in the November 2020 issue, and a different matter is being presented each month, with names omitted to protect the privacy of those involved.

Case of the month - January

"Dr. T" applied for AAEP membership. It was discovered that Dr. T had their license suspended by the state licensing board for animal cruelty for a period of one year and an additional probationary period of four years. The AAEP's Professional Conduct & Ethics Committee requested Dr. T provide an update as to the status of their license to practice veterinary medicine. No response was received.

Outcome: Dr. T's application for membership was denied.

ASSOCIATION

Taking steps toward a more diverse and inclusive profession

Work of diversity task force to accelerate in 2021

Societal events in 2020 prompted organizations and associations throughout the U.S. and elsewhere to take a deep look in the mirror, and the AAEP was no exception. With the composition of equine veterinary medicine being approximately 95% Caucasian compared to about 90% for general veterinary practice—both significantly higher than the overall U.S. population—is there more the AAEP could or should be doing to foster inclusivity within the association and equine practice?

To help answer that question, the board of directors at its summer meeting approved formation of a Diversity, Equity & Inclusion Task Force to provide recommendations to address deficiencies within the association and equine practice, as well as strategies for long-term commitment to these ideals.

The nine-person task force is chaired by Dr. Jean-Yin Tan and includes veterinary social worker Angie Arora along with the following AAEP members:

Dr. Rachel Cezar-Martinez
Dr. Elizabeth Charles
Dr. Liana Gonzalez
Dr. Eleanor Green
Dr. Aja Harvey
Dr. Rustin Moore
Dr. Mitchell Rode – Board Liaison

Although the task force is in its early stages, Dr. Tan emphasized the systematic approach to its organizational assessment, research and recommendations, which she hopes to provide to the board of directors by late spring or early summer.

"Our group is talking about what barriers there are to entering and staying in the veterinary profession from a race and ethnicity standpoint; and we also want to focus on gender, on sexuality, on people with disabilities and what barriers different groups from all types of circumstances face in the equine veterinary profession," said Dr. Tan. "We're really trying to identify what the issues are here, what can we do about it, and how can we get more on par with the general veterinary population and maybe even more on par with the general U.S. population."

AAEP President Dr. Scott Hay stressed the importance of the task force during the Closing Session of the virtual convention.

"Probably the most important issue we have facing us for our future is developing a successful approach to the diversity issues that affect many in equine practice," he said. "It's very easy to say that we are being inclusive of everyone, but I think we



Todd Korol

Dr. Jean-Yin Tan

have to look deeper. What are the real issues of diversity in an organization such as ours? What can we do differently to make sure everyone has opportunity? How can we work to make our organization and our profession as diverse as the general population? What are the blind spots that we never saw before?

"To try to get all of these questions answered, the AAEP has an appointed task force to look at diversity, equity and inclusion—or lack thereof—and to make absolutely certain that the organization is doing everything in its power to be inclusive of everyone!"

Road warrior wellness

Here are tips for living healthier if you're an ambulatory veterinarian

By Amy L. Grice, VMD, MBA

Ambulatory equine practitioners spend many hours of the day on the road, and many drive upwards of 35,000 miles each year. All this windshield time can pose a health risk due to the hours spent sitting, the difficulty in finding healthy food on the road, and the distraction while talking on the phone behind the wheel.

Despite these challenges, veterinarians can choose to have a healthier mobile lifestyle. Here are some tips.

Body and brain stiffness

As the years in practice accumulate, so do the various injuries and the consequent aches and pains. Because sitting in one position for 30-45 minutes can cause joints to stiffen up, when getting out of the truck, you might find yourself Grade IV/V lame! Consider doing some gentle stretches when you arrive at your destination.

If there are horses turned out in pastures that need simple procedures or examinations, consider walking out to where they are grazing to get a few limbering steps in.

Obviously, if they are horses that are difficult for their owners to catch or patients that resist veterinary attention, this is inadvisable. But the mental break of slowing down the rush and enjoying your surroundings outside on a beautiful spring day might bring you more relief than just an easing of your hip and knee pain. Having an opportunity to enjoy the small moments of your day can be uplifting.

Feeding the body

Lunch for road warriors is often limited to gas station hot dogs, drive-through burgers and fries, or slices

of pizza because most ambulatory doctors don't have time for a sit-down lunch unless it's behind the wheel. Consider packing a cooler or thermos with healthier food from home.

Grazing all day on yogurt, fruit, crackers with peanut butter or cheese, and leftover vegetables and steak from last night's dinner is better than fast food for maintaining a stable blood sugar and energy level. Better eating can also help you keep a healthy weight.

In the winter, a thermos full of chili or soup and a hunk of whole grain bread is a welcome midday meal. Just tuck in a blue surgery towel for a bib and spread one in your lap for the inevitable spills.

Always keep healthy snacks like nuts, dried fruit and popcorn in your truck for those unexpected late days when you're hungry enough to eat a stethoscope. If you pass a roadside stand selling tomatoes, strawberries or other munchable produce, treat yourself! It helps to keep a salt and pepper shaker in your center console and a roll of paper towels in the cab.

Feeding the joy

When you have many miles between calls, taking a break from your work is pleasant. Instead of making callbacks about lab work or rechecks, consider calling a friend for a visit or listening to a podcast about a topic that interests you. Catch up on global topics on National Public Radio or listen to your favorite music or a new audio book.

These mini-vacations can decrease your stress and increase your daily quotient of joy.



Safety first

Intense phone calls are a regular part of an equine veterinarian's life. When they occur, you should strongly consider pulling over to the side of the road, especially if you are in traffic. Distracted driving is very dangerous, and your life could change forever in a split second.

Never text while driving. Reading texts and emails while operating a large vehicle at 60 mph is foolhardy. Your loved ones are depending on you to arrive alive at the end of your day. Make it a new habit to check your phone every time you arrive at a destination, but not with every "ping." Set up a different ringtone for your emergency service so you know to answer. Safety on the road is essential for wellness.

Take-home message

Although ambulatory veterinarians have many challenges in living a healthy lifestyle, small changes can make a big difference in overall wellness.

Established to unite everyone who is dedicated to improving the health and well-being of horses, The Foundation for the Horse provides support for horses in need, relevant research and continued education for future equine veterinarians.

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Benefit: Mentorship program helps create vibrant and sustainable careers

Ask a question feature now available for those seeking specific advice

To help young equine veterinarians successfully navigate equine practice and find lasting professional fulfillment, the AAEP offers a mentorship program called Outrider to facilitate the creation of relationships between early-career AAEP members and members with more experience.

The program provides mentorship in the non-clinical areas of equine practice that are critical to long-term success and wellbeing, such as general career advice and supportive interpersonal relationships. The intent is not to provide specific case management advice.

The exact nature of the relationship between mentors and mentees is up to the pair; however, most conversations consist of phone calls, emails and/or text messages at least on a monthly basis. Pairings have a one-year term; both parties need to opt back into the relationship for it to continue. If one or both parties elect not to renew the relationship, each can return to the pool and receive a new match.

If you would prefer not to sign up for a full mentorship relationship but instead just need to seek advice on something, you can now submit a question in any of nine

areas such as contract negotiation, handling difficult clients, financial management and more. Your question will be directed to a veteran practitioner experienced in that area for a reply. To submit a question, visit aaep.org/mentoring-program and click the “Ask a Mentor a Question” button.

If you are in your first five years of practice and would like to find a mentor, register as a mentee at aaep.org/mentoring-program. After uploading your CV or work samples, you will be able to review a list of volunteer mentors and their background before requesting an engagement. You’ll negotiate and set expectations for time commitment up front so you both get the most value from your interactions.

If you are a veteran practitioner who would like to volunteer as a mentor to a new practitioner, register as a mentor at aaep.org/mentoring-program. You will then create your mentor profile by uploading your CV or work samples.

If you have questions about this benefit, contact Megan Gray, AAEP member concierge, at mgray@aaep.org or (859) 233-0147.

AAEP recognizes the service of outgoing member volunteers

The dedicated service of member volunteers is essential to fulfilling the AAEP’s mission. The AAEP thanks the following members whose volunteer service on the board of directors or on a council or committee concluded in 2020:

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Interns, student named case study contest winners

Two interns and a veterinary student were selected by the AAEP's Educational Programs Committee as the winners of the 2020 case study contest. The winners, with affiliations and case study titles, are:

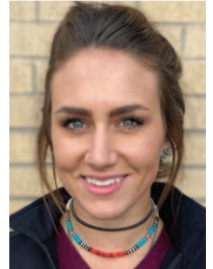
- Dr. Vicky Johnson, The Ohio State University class of 2020 and an intern at Rood & Riddle Equine Hospital in Saratoga, “Colic Secondary to Intestinal Pythiosis in a Thoroughbred Racehorse”
- Dr. Megan Palmisano, University of Florida class of 2020 and an intern at Rhinebeck Equine, “Urinary Bladder Transitional Cell Carcinoma”
- Hannah Carter, Mississippi State University class of 2022, “Degenerative Suspensory Ligament Desmitis in a Hereditary Equine Regional Dermal Asthenia Carrier”



Dr. Vicky Johnson



Dr. Megan Palmisano



Hannah Carter

As winners of the contest, each received complimentary registration to the AAEP's Virtual Convention & Trade Show along with \$500. The winning case studies are available as educational resources at aaep.org/case-studies.

INDUSTRY

AAEP Media Partner Profile: *EquiManagement*

EquiManagement
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EquiManagement is a proud AAEP Media Partner. *EquiManagement* is created for veterinarians, vet students and vet techs. It combines business, research and practitioner well-being content.

EquiManagement features a quarterly print magazine delivered with *EQUUS* to AAEP members, a frequently updated website, a veterinary equine health-related podcast (Disease Du Jour, brought to you by Merck Animal Health), and starting in 2021 The Business of Practice podcast (brought to you by Dechra). The magazine is also available as a downloadable PDF to our partners at NEAEP, BEVA, WEVA, NZEVA, AMMVEE, AVMA PLIT, ISELP, EPM Society and AAEVT.

Sign up online for *EquiManagement Update*, our monthly business/vet wellness newsletter, and *Research Reports* newsletter with peer-reviewed article summaries.



OUTRIDER

A mentoring program designed to **help young equine veterinarians** successfully navigate equine practice and find long-term professional fulfillment.

To learn how you can become a mentor or to register as a mentee, visit aaep.org/mentoring-program

The Foundation for the Horse awards nearly \$300,000 in scholarships

In recent months, 14 equine veterinary students and two veterinary school graduates of 2020 shared in scholarship proceeds of \$295,000 from The Foundation for the Horse and its scholarship program partners. Scholarship recipients were recognized Dec. 9 during Prime Time at the AAEP's 2020 Virtual Convention.

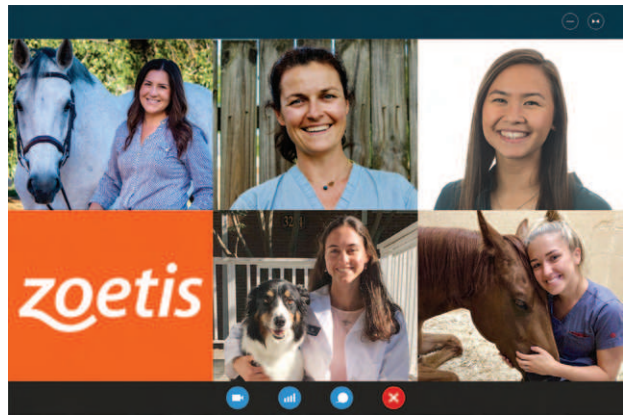
The award of scholarships to promising students and recent graduates pursuing careers in equine medicine is one important way in which The Foundation helps improve the welfare of horses. The scholarships help offset the cost of a veterinary education so that recipients can focus on patient care when entering practice.

The Foundation for the Horse sincerely thanks its scholarship program partners for their ongoing investment in horse health and the future of the profession.

Pictured clockwise from top left in each group:

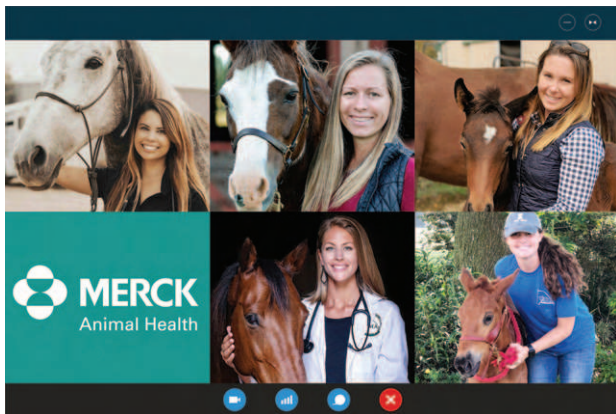
Five recent and future graduates received \$4,000 Zoetis scholarships:

- Dr. Sarah Freeman, *University of California, Davis*
- Dr. Meredith Frey, *Colorado State University*
- Gabriella Kawahisa Piquini, *Colorado State University*
- Adria Schlesman, *University of Pennsylvania*
- Sara Tufts, *North Carolina State University*



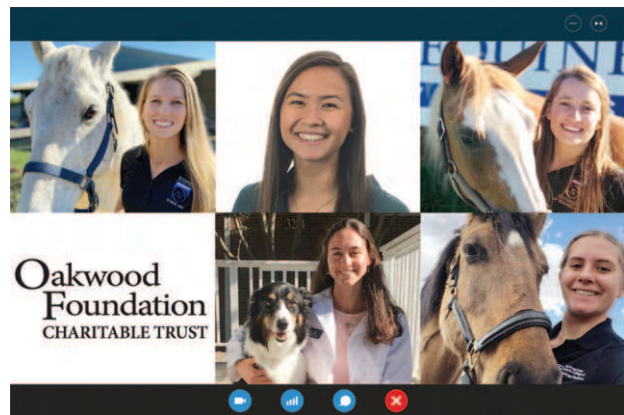
Five students received \$5,000 Merck Animal Health Scholarships:

- Briana Hamamoto-Hardman, *University of California, Davis*
- Bethanie Lewis, *North Carolina State University*
- Kendall Milkey, *University of Pennsylvania*
- Bailey Stolsworth, *University of Illinois*
- Katelyn Williams, *University of Georgia*



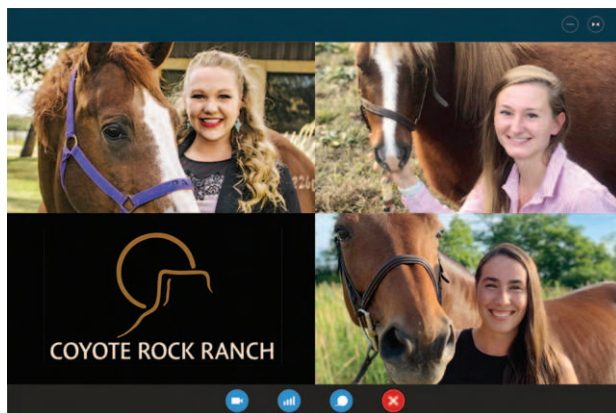
Five students received \$5,000 Oakwood Foundation Scholarships:

- Tara Doherty, *University of California, Davis*
- Gabriella Kawahisa Piquini, *Colorado State University*
- Virginia Logue, *University of Minnesota*
- Mikayla Swirski, *University of Saskatchewan*
- Sara Tufts, *North Carolina State University*



Three students received \$75,000 Coyote Rock Ranch Scholarships:


- Chelsea Folmar, *Texas A&M University*
- Kimberly Hildreth Martin, *University of Pennsylvania*
- Lindsay Seewald, *Cornell University*





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The following colleagues gave their time to peer review in the 12 months from October 2019 to October 2020, for which we are very grateful

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Highlights of recent clinically relevant papers

Cardiac arrhythmias in racehorses

This retrospective study by Celia Marr and colleagues in the UK, USA and Australia examined exercising ECG recordings for 245 Thoroughbred racehorses presenting with poor performance and/or respiratory noise at exercise.

Abnormal rhythms were found in 158 horses (64.5%); 110 (44.9%) of these had isolated premature depolarisations and 48 (19.6%) horses had complex tachydysrhythmias. Rhythm disturbances were most common during recovery from exercise (50% of horses).

Horses being exercised on a treadmill were 2.6 times more likely to have rhythm disturbances than those exercised overground, and National Hunt racehorses were 2.7 times more likely to have complex arrhythmias than horses engaged in flat racing. Exercise-associated upper respiratory tract (URT) obstruction was associated with the presence of rhythm disturbances. Horses with URT obstruction at exercise were twice as likely to have a rhythm disturbance than those with normal airway function.

Overall, 82% of horses raced again. There were no significant differences in the number of horses that returned to racing in the normal rhythm, isolated premature depolarisations or complex rhythm groups.

Genetic testing for PSSM2

P variant alleles (P2, P3 and P4) are currently used in commercial testing for type 2 polysaccharide storage myopathy (PSSM2) and myofibrillar myopathy (MFM). This study by Stephanie Valberg and colleagues in the USA aimed to compare frequencies of these alleles between 98 Warmblood and Arabian horses diagnosed with PSSM2/MFM by muscle histopathology, and 84 matched control horses.

There was no significant association between any P locus and a histopathological diagnosis of PSSM2 or MFM. The sensitivity for the P variants for predicting PSSM2/MFM was poor (<33%) for all P variants in both Warmbloods and Arabian horses. Frequencies of these P variants in modern, early domestic and Przewalski horses were determined from a public data repository. All P variants were present in early domestic horses and P2 was also present in the Przewalski horse, suggesting that they are unlikely to confer a disadvantage to health and fitness.

A careful history, physical examination, serum creatine kinase activity, PSSM1 genetic test, and, in the absence of PSSM1, muscle histopathology, represent more accurate and validated means to differentiate the many causes of exertional myopathies in horses. The P variants used in commercial genetic tests are not predictive of the presence or absence of PSSM2 or MFM.

Insulin dysregulation and obesity

This study by Justin Box and colleagues in Finland and the UK aimed to determine the insulin dysregulation (ID) status of a population of 128 purebred Finnhorses ≥ 3 years of age using an oral sugar test (OST) and compare phenotypes and management factors between ID and non-ID Finnhorses.

An online questionnaire regarding their horses' signalment, history, feeding, and exercise was used to recruit owners. Selected contributing stables were visited. Phenotypic markers of obesity and the weight of each horse were recorded. After fasting overnight, horses received 0.45 mL/kg bwt corn syrup per os. Serum samples before and at 60 and 90 min after syrup administration were analysed for insulin by chemiluminescent assay. Horses met ID criteria if insulin concentrations were ≥ 33 $\mu\text{U/mL}$ at T0, ≥ 66 $\mu\text{U/mL}$ at T60 or T90 or some combination thereof. Associations between phenotypic markers, feeding and exercise variables, and ID were examined using mixed effects logistic regression modelling.

Several phenotypic markers of obesity were significant on univariable analysis but in the final multivariable model, only obesity (body condition score ≥ 8) was associated with ID. Over half of the horses (60%) were considered overweight or obese whereas 16% were classified as having ID. Because obesity is associated with ID in cold-blooded type horses, objective monitoring of phenotypic markers by owners may be beneficial for health outcomes.

Intestinal helminth infections

In this prospective case-control study Heidrun Gehlen and colleagues in Germany, USA, Italy and the UK investigated the association between colic and intestinal helminth infection.

A total of 620 horses, of which 312 were colic patients, were studied. For each horse, a range of copromicroscopic, serological, and clinical data was obtained. A questionnaire which included details of previous anthelmintic treatment and husbandry was also used. The highest infection rates were seen for strongyles (41.8%), followed by *Anoplocephala perfoliata* and *Parascaris* spp. (both 0.8%), with no significant difference between the colic and non-colic groups. Real-time PCR showed a 1.1% *S. vulgaris* DNA prevalence. Higher seroprevalences were observed using *S. vulgaris* and *A. perfoliata* ELISAs, with 32.3% and 10.7%, respectively. No association concerning either serologic status was encountered with colic status. The shedding of strongyle eggs was associated with a 1.8-times increased risk of *S. vulgaris* seropositivity. Recent anthelmintic treatment was associated with the onset of colic, as animals who had received an anthelmintic during the previous week had a 2.4-times higher risk of signs of colic compared to those treated at least 8 weeks prior. Ponies were significantly less often affected by colic than Warmbloods. The high *S. vulgaris* and considerable *A. perfoliata* seroprevalences encountered in this investigation should prompt veterinarians, farm managers, and horse owners to maintain consequent and effective worm control measures.

Small intestinal mesenteric vessel occlusion

In this study Gessica Giusto and Marco Gandini from the University of Turin, Italy, compared the application of haemostatic clips and sliding knot ligatures to occlude equine mesenteric vessels.

In equine abdominal surgery, resection and anastomosis of strangulated intestine is a commonly performed procedure. Ligatures, vessel sealing devices and the ligate-divide stapler are commonly used for this purpose.

Portions of jejunum with 10 associated mesenteric vessels were collected from 12 horses at a local abattoir and divided into two groups. Portions of intestine were divided into two sections comprising five vessels each and assigned to Group A or Group B. Each vessel was occluded with a triple ligature. In Group A, vessels were ligated with three circumferential ligatures tied with a sliding knot with two overthrows. In Group B, three haemoclips were applied to occlude the vessels. The procedures were performed by the same experienced surgeon. Intestinal length, construction time and vessel leaking pressure were measured and compared between groups.

No significant difference was found in intestinal length (Group A 3.78 ± 0.43 m; Group B 3.04 ± 0.83 m [mean \pm SD]). The difference in construction time was significant (Group A 7.03 ± 0.34 min; Group B 2.40 ± 0.43 min [mean \pm SD]). No significant difference was found in the leaking pressure (Group A median 1000, IQ range 750–1050 mmHg; Group B median 1050, IQ range 800–1050 mmHg). The authors concluded that haemoclip application is comparable in terms of leaking pressure but quicker than sliding knots to apply.

Sidewinder gait

Sidewinder gait is characterised by walking with the trunk and pelvic limbs drifting to one side. This retrospective study by Monica Aleman and colleagues in the USA and UK reported causes, clinical and diagnostic features.

Cases at two institutions with sidewinder gait, neurological and orthopaedic examination, and diagnostic work-up or post-mortem evaluation were included. Descriptive statistics were performed.

Twenty-four horses (mean age 18.9 years) of various breeds and both sexes were included. Onset was acute ($n = 10$), subacute ($n = 6$), and insidious ($n = 8$). Electromyography and muscle biopsy supported neurologic disease and further aided in localising site of lesion in all horses. Neurologic causes included dynamic thoracolumbar spinal cord compression ($n = 5$), equine protozoal myeloencephalitis ($n = 4$, 2 confirmed and 2 presumed), thoracic myelopathy of unknown aetiology ($n = 4$), gliosis ($n = 2$), and thrombosis of thoracic spinal cord segments ($n = 1$). Non-neurologic causes included osteoarthritis of the coxofemoral joint ($n = 4$), multiple displaced pelvic fractures ($n = 2$), bilateral rupture of the ligamentum capitis ossis femoris ($n = 1$), and severe myonecrosis of multiple pelvic limb muscles ($n = 1$). Case fatality was 79%.

Sidewinder gait is usually seen in older horses and can have neurologic or musculoskeletal aetiologies. Electromyography can be used as a diagnostic aid to determine neurologic versus non-neurologic disease and further localise those of neurologic origin. The condition often has a poor prognosis for function and life.

Bacterial isolates in arytenoid chondropathy

In this retrospective cohort study Georgina Johnston and Jonathan Lumsden, based in Australia, describe the prevalence and antimicrobial susceptibility of bacterial isolates cultured from surgical specimens of infected arytenoid cartilage and granulomas.

Thirty-three Thoroughbred horses were identified from a search of clinical records for horses admitted to a referral hospital for arytenoid chondropathy surgery that had samples submitted for culture and sensitivity over a 14-year period. Descriptive analyses were performed.

In total, 56 bacterial isolates were obtained. Gram-positive bacteria (58%), Gram-negative bacteria (54%), and anaerobes (33%) were cultured from samples. Multiple bacteria were isolated in 58% of horses. *Streptococcus* spp. were the most common (32%), followed by *Enterobacteriaceae* (13%). Bacterial isolates were sensitive to ceftiofur (83%), ampicillin (64%), tetracycline (48%), enrofloxacin (45%), trimethoprim-sulfamethoxazole (41%), and gentamicin (18%). Multidrug resistance (MDR) was present in 44% of bacterial isolates.

A wide variety of bacteria was cultured, providing evidence that secondary opportunistic infection by common respiratory bacteria is likely a factor in arytenoid chondropathy. Multidrug resistance was higher than previously reported in equine respiratory samples. Trimethoprim-sulfamethoxazole had low effectiveness. Because culture and sensitivity testing is not available in the diagnosis of mild to moderate arytenoid chondropathy, the findings of this study may allow for more targeted broad-spectrum antimicrobial treatment to limit disease progression when the disease is first identified. The antimicrobial susceptibilities and MDR emphasise the importance of following current antimicrobial guidelines and highlight the requirement for surgical intervention in cases that do not resolve with initial antimicrobial therapy.

S. WRIGHT

EVE Editorial Office

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Editorial

The impact of COVID-19 on equine veterinary practice and mental wellbeing

Since the first cases of coronavirus disease 2019 (COVID-19) in Wuhan, China, in December 2019, pandemic illness has spread to millions of people worldwide and has been a great source of anxiety, distress and stress. At the time of writing this editorial (mid-October 2020), many countries are facing a second or third 'wave' of infections, and worldwide there have been around 40 million confirmed COVID-19 infections (in accordance with the applied case definitions and testing strategies in the affected countries), including over 1.1 million deaths. The pandemic has changed how individuals live their day-to-day lives due to the lockdown restrictions, requirements for quarantine and self-isolation, and social distancing measures implemented by most governments to minimise the spread of the virus (Pakpour and Griffiths 2020; Satici *et al.* 2020). The pandemic and its constant reporting in the media have increased distress-related psychological problems such as anxiety, depression and insomnia (Dong and Bouey 2020; Li *et al.* 2020). The pandemic also has an important economic aspect to it, with millions of people losing their employment, which is a source of great emotional distress (Kawohl and Nordt 2020; Nicola *et al.* 2020), not only to the people directly affected but also to numerous businesses (including veterinary businesses) that face potential downturns in their work as a result of the resultant financial recession. The COVID-19 pandemic continues to dominate the public health field. Although the initial panic caused by the pandemic may have mitigated to some extent, its effects (such as anxiety, stress, fear and uncertainty) will continue to linger for months or years ahead (Kanekar and Sharma 2020).

There is a growing global consensus that healthcare professionals, such as physicians and dentists, suffer high rates of anxiety, depression and psychological distress. In the current climate, mental distress, psychiatric illness and burnout inevitably worsen. Many will harbour fears over their own and their family's health (Imo 2017). Similar conditions apply to veterinarians. Mental ill health has also been shown to be prevalent in the veterinary profession, with high risk of occupational stress, burnout, poor psychological wellbeing and an elevated rate of suicide (Gardener and Hini 2006; Bartram *et al.* 2009; Hatch *et al.* 2011; Platt *et al.* 2012; Mastenbroek *et al.* 2013; Volk *et al.* 2018). The wellbeing of veterinary professionals is one of the most important issues facing our profession.

In this issue of Equine Veterinary Education, we publish the results of a survey that the British Equine Veterinary Association (BEVA) undertook of its members in June 2020, at the time of the period of lockdown during the first wave of the COVID-19 pandemic in the UK (Mair *et al.* 2021). The results suggest significantly lower levels of mental wellbeing among equine veterinary surgeons and equine veterinary nurses during the COVID-19 pandemic compared to the situation prior to the COVID-19 pandemic. In addition, equine veterinary nurses appeared to be more likely to report lower mental wellbeing than veterinary surgeons, and furloughed veterinary surgeons reported lower levels of mental wellbeing than veterinary surgeons that continued working during the

lockdown. The results are not surprising, but they highlight the importance for us all to recognise the further pressures that this pandemic is adding to our profession that already has significant issues with mental wellbeing.

Both local and national tools and resources to promote personal and professional wellbeing are vital to provide support for all members and of the profession. Practice teams, business owners, veterinary colleges, organisations and individuals all have important roles to play. There are a number of wellness and mindfulness programmes available to us, including the Mind Matters Initiative developed by the Royal College of Veterinary Surgeons (RCVS) (<https://www.rcvsmindmatters.org>) and wellness programmes run by the American Association of Equine Practitioners (AAEP) (<https://aaep.org/wellness>) and the American Veterinary Medical Association (AVMA) (<https://www.avma.org/resources-tools/wellbeing>). These are important resources that are particularly valuable during the acute phase of the pandemic.

The extent of the COVID-19 infections and the steps taken by national governments to control the pandemic have varied from country to country. Below is a brief summary of the impact of the pandemic on the equine veterinary sector in a number of different countries, as supplied by their national equine veterinary associations.

Australia (Holly Lewis, EVA)

Economic and government scenario

- Early on the Federal Agriculture Minister classified ALL veterinarians as essential service workers.
 - This announcement was extremely powerful in allowing veterinarians to continue to do their work, albeit with a comprehensive range of infection prevention protocols at clinics and in the field.
 - These protocols meant a burden of extra work that added stress to the job.
 - The Australian Veterinary Association, of which EVA is part, created a COVID-19 Working Group that provided information and insights into managing the pandemic. Their work did not go as far as advising vets what constituted 'essential work'; the definition of that was left broadly for individual veterinarians to decide. The individual vet's unique knowledge of the patient, animal ownership, diagnosis and location were thought to be the most important considerations.
- The racing industry was successful in lobbying that racing continued based on animal welfare. No spectators were allowed for many months.
- Sport horse activities were cancelled/postponed for many months, and major 3-day events cancelled completely.
- The Australian stud season commenced on 1 August, and the season has continued as normal with COVID-19 protocols in place.
 - The Australian Government Border Closure meant that international vets from UK, IRE, EU and NZ could not enter Australia for their normal 6-month rotations.

- EVA successfully lobbied hard with Federal Immigration Department to have VISAs and Border Force Permissions issued for these vets. A total of 29 vets were given entry permission.
- Regional mixed practice and clinic equine work continued as normal. Clinics with a small animal practice enjoyed a significant increase in canine and feline revenue. Pet owners who were in isolation and working from home devoted attention to their pets and made more vet visits.
- University vets had more student extramural pressure placed on their hospitals as many private clinics were unable to accept students under restricted COVID-19 protocols.
 - The 2020 graduate cohort (graduating in November) were worried that their extramural experience would be 'underdone'. Some graduation dates have been postponed allowing catch-up.
- Equine Research has been postponed in many places.
- EVA Conferencing (Bain Fallon), workshops and meetings have all been cancelled with extreme disappointment.
- In a Second Infection Wave, the State of Victoria (population 7 million) placed severe stage four lockdown restrictions including recreational horse movement.
 - This created high anxiety among many horse owners who asked vets to write exemptions for them, creating more stress.

Mental health

- There has been some regionalised stress in veterinarians due to:
 - Managing COVID-19 protocols has been a considerable burden.
 - Managing anxious clients in Victoria.
 - Sporting and social life being cancelled or curtailed.
 - General community seeking reassurance from health professionals including vets and nurses.
 - Not being able to travel.
- Tragically, two mid thirty-year-old equine vets committed suicide during the COVID-19 period.
- The association's mental health phone counselling service has experienced higher than average usage.

Belgium (Emmanuelle van Erck Westergren, BEPS)

These are the initial results of a survey of equine veterinary practitioners in Belgium:

- Over 70% of our respondents are in 100% general equine ambulatory practice.
- 84.6% said that the COVID crisis has had a mild to marked impact on their practice with 38% having had to handle more cases than during the same period last year, and 34% fewer cases. They have felt clients required more communication time than before.
- 53% of practices have had to furlough employees, and 40% have had to find temporary or long-term replacements.
- While 28% have found it difficult to manage from a professional perspective, only 16% have found the crisis to have had an impact on their personal lives.

Ireland (Thomas Austin, Vet Ireland)

COVID hit Ireland in spring 2020, and we all did our best to make the best of a bad situation. As we were classified as essential workers, we did our best to provide a limited socially distanced service to our clients. Most of us were happy to scan mares with nobody near us, but none of us were happy or knew how to treat a sick foal without being on top of each other. Large animal vets are tough people who do not admit defeat or give in easily. They certainly will not say they have a mental health issue easily. But we all had. Since we were all in bad form, we were all under pressure and we were all trying to cope as best we could. We counted ourselves blessed having an outdoor occupation but that did not stop us worrying about our parents, our children, our practices or pregnant staff.

Who knew what affect COVID had on pregnancy and yet many pregnant vets soldiered on. To my mind, they were among the heroes of the veterinary profession.

Splitting into team A and team B sounds wonderful but the logistics were awful, pulling people out of their comfort zones and getting them to do jobs that they do not normally do like a medic in a colic or a surgeon dripping a scouring foal.

But we survived. And now with the second wave, we go again, through gritted teeth and worse weather, we go again.

Cos it's what we do,
Cos we are equine vets,
And we will attend.

Norway (Jan Olav Berget, Norwegian Equine Veterinary Association)

Most Norwegian equine veterinarians work in solitary ambulatory practices or in smaller equine veterinary clinics combined with ambulatory work. On 12 March, the Norwegian Government implemented several severe measures to combat the COVID-19 outbreak. These included closure of day care centres, schools and universities, recommendations to work from home, travel restrictions, travel quarantine and social distancing. During March, the Norwegian Veterinary Association published guidelines on how to best protect against COVID-19 directed at small animal clinics and farm animal veterinarians. They did not give guidelines specifically aimed at equine veterinarians. Equine veterinarians were however, together with farm animal veterinarians, categorised as having a 'critical function' if they were in clinical work. This ensured that equine veterinarians could continue to work, with minor impact from various early local travel restrictions. Within the two weeks following 12 March, work could be performed mostly as normal, but routine calls were still not recommended. Advice on protection against COVID-19 was to maintain 2 m distance, proper hand hygiene before and after visits, and to use masks as deemed appropriate. We worked mostly alone and tried to keep the owners at some distance if possible. Veterinarians with small children had the opportunity to leave them in day care or at school if both parents had jobs defined as 'critical function'. Some tried to work at home in combination with helping children with schoolwork. The outcome of that practice was variable.

The negative economic impact on equine veterinarians has been quite small if we look at the whole period from

March to September. It seems to have been a normal breeding season, but equestrian events were cancelled for a long time. The sports suffer, but the veterinarians have been spared so far. The owners and trainers have had the time to look at and care for their horses, and that is one good thing to come out of the pandemic situation.

Overall, Norway has been lucky and had relatively few infected people (16,137) and deaths (278) from COVID-19 (mid October 2020) (Population 5.4 million).

Portugal (João Crespo, APMVE)

Portugal has four public Vet Schools and two private ones. This creates a huge input of young veterinarians every year to private practice, including equine practice. Portugal has roughly 100,000 registered equines with only 2800 competing under FEI regulations. Our market depends a lot on incoming horses for competitions, equine tourism and export of the Lusitano horse.

With the confinement measures implemented because of COVID-19, competitions were suspended and people were not allowed to travel. The three major incomes to the industry were shut down. With 150 veterinarians working with horses, there are three major areas: reproduction, sports' medicine and emergency care. The number of practices with more than one veterinarian is very limited, with the large majority working solo. During the first 4 weeks of confinement, the Veterinary Board was only allowing emergency care; this created a major drop in all services. Riding schools were not allowed to operate, some riding centres only allowed lunge work, and the National Federation shut down all shows. A lot of horses were put out to pasture. Everyone that worked in sports' medicine suffered major losses, on average over 70%. Only emergency work was being done. Because of the large number of practitioners, vets who do sports' medicine or reproduction work do not do emergency work.

When the restrictions on private practice were removed in May, reproduction work resumed with activity almost close to normal. Emergencies dropped because horses were used to the new management and shows only started in July. With summer and the end of confinement, a lot of activity started, and work returned to almost normal levels, since tourism this year dropped significantly.

Overall, COVID-19 created significant losses for the equine veterinary sector, more significant for vets undertaking more specialised work.

Spain (Miguel Llorca, AVEE)

Despite our efforts, we could not convince the Government and authorities to change clinical activity reduction from 'urgent treatment' to 'compulsory or necessary attention'. Regarding the financial impact, we cannot accurately evaluate it. It has been estimated that there was about 20% reduction, but this 'almost' recovered during the summer. We are now very concerned about what will happen in 2021, with an inevitable deep depression predicted.

Sweden (Lena Malmgren, SVF)

There was a decrease in the number of patients in the beginning of the pandemic, but it returned to normal levels

after a while. Since we did not have 'a lock down' in Sweden, the horse owners could visit clinics and the vets were able to visit the stables, 'business as usual'. Only a few practices have been forced to close down.

The bigger hospitals have had problems with the staff; that is, when people develop mild respiratory symptoms, the staff must stay at home. So, this has created much more work for the healthy staff. Some big hospitals have booked fewer patients to be able to deal with this problem, that is less profit.

It seems that the interest in horse sport has increased, that is something you can do at home, and you can be outdoors. The riding schools have been able to continue with their activities. I am working as a stud vet, and we were worried that horse owners would not cover their mares this year; however, the interest in breeding has been high.

We have no 'special hygiene protocols' for equine practice. We follow the guidelines from the authorities, that is social distancing, washing/disinfection of hands, stay at home if you have symptoms and no big crowds with people.

So far, we have not seen an impact on equine health/welfare. However, the future is uncertain. In the longer run, it might be a problem if unemployment increases, and then, it might be a problem for the horse owners to keep and pay for a horse.

Switzerland (Simone Castella-Studer, SVPM)

A survey was undertaken by the society of Swiss Veterinarians to understand the impact of COVID-19 in the months of March and April 2020. 63% of the practices reported a reduced turnover by 14%. This applied mostly to the small animal sector, while in the large animal sector no great difference was noticed, and in 9% there was an increase in turnover. No definite information of the effect on mental wellbeing could be identified.

From talks with associates and discussions with other veterinarians, we can say that vets in Switzerland have been only slightly affected by the coronavirus pandemic and could conduct their daily business in a relatively normal way.

USA (David Frisbie, AAEP)

While we did not do extensive surveying of the membership, our general sense from conversations with practitioners over the last few months was that business was impacted during the early phase of the pandemic when most of the country was on lockdown and only essential services were allowed. As we moved into summer and early fall, business seemed to somewhat rebound, and many members are reporting being as busy as they have ever been. From a mental wellness standpoint, equine practitioners have felt the impact like the rest of society, and there are challenges, particularly with parenting. The AAEP Wellness Committee has tried to bridge that gap by arranging a series of frequent 'Wellness Meet-ups' as a forum for members to stay connected with one another and share strategies for coping with these challenges.

T.S. MAIR^{†,*}  and E. LOCKETT[‡]

[†]Bell Equine Veterinary Clinic, Maidstone, Kent; and

[‡]Royal College of Veterinary Surgeons, London, UK

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Case Report

Successful treatment of two horses after perforation of the small intestine by fine wireD. E. Crosby* , J. Wise and B. J. Hilbert 

School of Animal and Veterinary Sciences, Charles Sturt University, Wagga Wagga, New South Wales, Australia

*Corresponding author email: dcrosby@csu.edu.au

Keywords: horse; perforation; small intestine; wire; foreign body**Summary**

This report describes the successful surgical management of two horses with fine wire penetration of the small intestine. The first case was a 5-week-old Thoroughbred colt foal that was referred to the Charles Sturt University, Veterinary Clinical Centre (VCC), because it was dull and in-appetent. The colt had not recently passed faeces or responded to treatment with flunixin meglumine and a paraffin oil and electrolyte drench. On examination at the VCC, the foal was dull. Nasogastric intubation retrieved 4.5 L of reflux. Sonographic examination of the abdomen revealed distended loops of small intestine. An abdominal radiograph revealed some metallic objects in the abdomen but interpretation of the images was challenging. An exploratory laparotomy revealed an adhesion between two adjacent loops of jejunum (**Fig 1**). Dissection of the adhesion revealed a central focus of septic, necrotic tissue and a short length of fine wire which had perforated the jejunum. The affected area of jejunum was flushed with sterile saline and diluted 10% povidone iodine before being replaced into the abdomen and the peritoneal cavity was lavaged with warm sterile saline. The midline laparotomy incision was closed in a routine fashion. The foal made an uncomplicated recovery from the surgical procedure and as an adult horse has gone on to start in over 20 races.

The second case was a 2-year-old Thoroughbred gelding that had been referred to the VCC after the referring veterinarian had detected distended loops of small intestine on examination of the abdomen per rectum. At the VCC the

referring veterinarian's findings were confirmed and, as the horse still had intermittent bouts of severe abdominal pain, it was decided to investigate further by exploratory laparotomy. On entering the abdomen a dense band of tissue was adhered to the cranial aspect of the midline incision (**Fig 2**). This adhesion extended from the serosal edge of a loop of jejunum and was causing a small intestinal obstruction. A fine wire was embedded within the adhesion and this was removed. A small defect in the intestinal wall was oversewn using 2/0 polydioxanone in a continuous Cushing pattern and the laparotomy incision was closed in routine fashion. The horse made an uncomplicated recovery and 8 months after surgery was back in race training for 8 weeks but was yet to start in a race.

Key points

- Intestinal complications after ingestion of fine wire occur infrequently in horses and may only become obvious when an exploratory laparotomy is undertaken.
- Even in foals and small horses, current methods of abdominal imaging are not reliable for detecting fine wire in and around the gastrointestinal tract.
- We report a successful outcome after fine wire penetration of the small intestine in two horses and this is in contrast to other reported cases that have been associated with a poor prognosis.

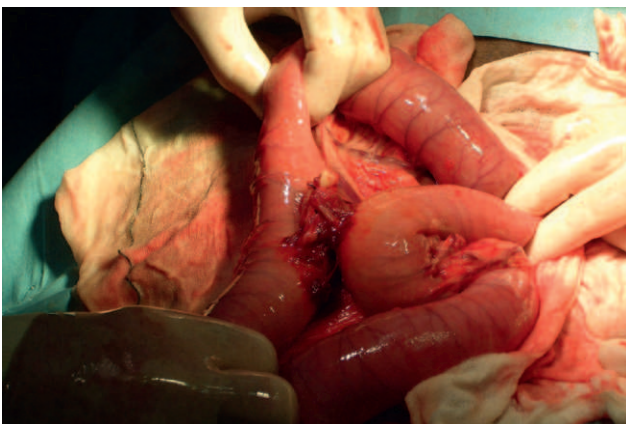


Fig 1: Adhesion between adjacent loops of jejunum in Case 1.



Fig 2: Dense adhesion between the jejunum and body wall in Case 2.



Case Report

Arthrotomy, curettage and medical management of septic arthritis and osteomyelitis of the temporomandibular joint in a horse

J. Balducci[†] , J. Ruby[‡], C. Hall[§] and J. Williams^{†*}

[†]Department of Large Animal Medicine, University of Georgia College of Veterinary Medicine; [‡]Department of Veterinary Biosciences and Diagnostic Imaging, University of Georgia College of Veterinary Medicine, Athens; and [§]Central Georgia Equine Services, Fort Valley, Georgia, USA

*Corresponding author email: jarred@uga.edu

Keywords: horse; TMJ; septic; osteomyelitis; arthrotomy; sequestrum

Summary

Osteomyelitis has been reported within the temporomandibular joint (TMJ) but is a rare occurrence in horses and often requires invasive surgery if surgical treatment is pursued. A 1-year-old Quarter Horse gelding presented with an 8-week history of a draining sinus tract caudodorsal to the right eye. During the 8-week period prior to presentation, the wound was surgically debrided twice and the patient had been

administered a variety of antimicrobials, NSAIDs and antifungal therapy. Given the history, physical examination and initial radiographic findings with needle placement into the draining tract, the patient was diagnosed with a chronically infected TMJ secondary to osteomyelitis. Diagnosis and surgical planning were facilitated through computed tomography (CT) (**Fig 1**). Based on the results of the CT scan, a targeted approach via a small arthrotomy for surgical debridement was performed. The caudoventral aspect of the right zygomatic process of the temporal bone was debrided with a bone curette, removing multiple pieces of necrotic bone and soft tissue until healthy bone was encountered. Bacterial aerobic culture of excised bone from within the joint revealed growth of *Staphylococcus aureus*. Post-operatively, local and targeted debridement of the affected regions of the mandibular condyle and temporal bone was continued. At one-year follow-up, the patient was eating normally, pain free and back in training. This case reports the successful management of septic osteomyelitis and arthritis within a diarthrodial joint.

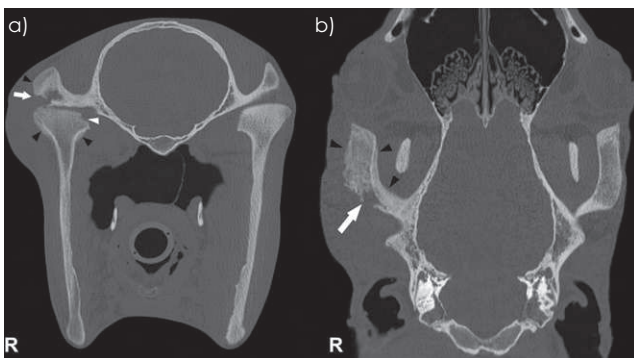


Fig 1: Transverse and reconstructed dorsal computed tomographic image of the skull at the level of the TMJ. In the transverse view (a), there is moderate lysis and sclerosis along the mandibular fossa, articular surface of the zygomatic process (white arrow) and articular margin of the condylar process of the mandible (white arrowhead). There is locally extensive smooth periosteal reaction (black arrowheads). The right TMJ is narrowed compared to the left TMJ, and the soft tissues centred over the right TMJ are moderately enlarged. In the reconstructed dorsal plane (b), there is irregular lysis and sclerosis of the right zygomatic process of the temporal bone (white arrow) with smooth periosteal reaction (black arrowheads).

Key points

- Septic osteomyelitis of the temporomandibular joint is a rare occurrence in horses.
- Computed tomography is a very useful diagnostic technique in further evaluating the extent of the disease within the temporomandibular joint.
- This case reports the successful management of septic osteomyelitis and arthritis in the temporomandibular joint with a targeted, noninvasive arthrotomy and curettage coupled with medical management.



Case Report

Retrograde intussusception of the descending colon secondary to multiple colonic hamartomas in a neonatal foalS. Mejia^{†‡*} , S. D. A. Hurcombe[‡], D. H. Rodgerson[†], L. M. Cassone[§] and N. M. Slovis[†][†]Hagyard Equine Medical Institute, Lexington, Kentucky; [‡]Cornell Ruffian Equine Specialists, Cornell University, Elmont, New York; and [§]University of Kentucky Veterinary Diagnostic Laboratory, Lexington, Kentucky, USA*Corresponding author email: santiagomhvet@gmail.com**Keywords:** horse; hamartoma; intussusception; colic; foal**Summary**

A neonatal Thoroughbred filly presented with a 3-h history of abdominal pain and distension that failed to respond to medical treatment. Diagnostic evaluation, including abdominal ultrasound, barium enema and proctoscopy, was suggestive of atresia coli. Exploratory laparotomy revealed a pedunculated mass in the wall of the diaphragmatic flexure of the ascending colon. The hamartoma was attached to a smaller hamartoma by a fibrous pedicle originating from the descending colon. The histologic features of both masses were identical as densely packed papillary projections and cysts lined by well-differentiated colonic mucosal epithelium, supported by a layer of loose fibrous connective tissue and underlain by smooth muscle. These histologic features fulfil all criteria of colonic hamartomas.



Fig 1: Retrograde intussusception of the descending colon (yellow arrows) to the small colon (black arrow).

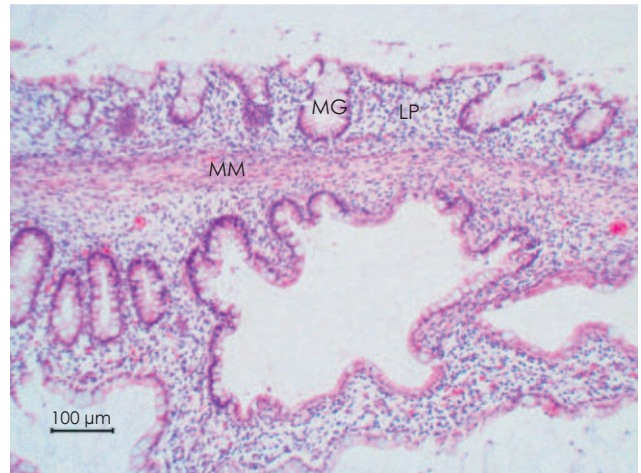


Fig 2: Photomicrograph of the ascending colon hamartoma. Normal colonic mucosal constituents: Mucosal glands (MG) lined by well-differentiated columnar and goblet cells; lamina propria (LP); and muscularis mucosae (MM). =100 ×, haematoxylin and eosin.

The descending colon had intussuscepted retrograde into the ascending colon along the fibrous band. The filly was subjected to euthanasia due to poor prognosis (Figs 1 and 2).

Key points

- Congenital defects such as atresia coli/ani can mimic the signs of meconium impaction, but are far less common; however, congenital gastrointestinal lesions need to be considered a possible cause of colic signs in a newborn foal.
- Hamartomas are benign tumours originating from mature cells within the tissue of origin, which often have an abnormal distribution or overgrowth of additional cellular elements.
- Retrograde intussusception is the telescoping of the bowel inside itself, progressing from distal to proximal, rather than the commoner proximal to distal direction and is a rare occurrence in horses.



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Clinical Commentary

Retrograde intussusception of the descending colon in a neonatal foal

D. E. Freeman* 

College of Veterinary Medicine, Large Animal Clinical Sciences, University of Florida, Gainesville, Florida, USA

*Corresponding author email: freemand@ufl.edu

The report of a retrograde intussusception of the descending colon in a neonatal foal and the thorough review of related topics by Mejia *et al.* (2021) describes a highly unusual case. Small colon intussusceptions are rare in horses and are then reported usually in post-partum broodmares, possibly related to stage 4 rectal or small colon prolapse (Ross *et al.* 1988). A hamartomatous polyp has been described as a cause of small colon obstruction and tenesmus in a 2-day-old Standardbred foal (Colbourne *et al.* 1996) but without causing an intussusception.

In this report, a foal developed a reverse intussusception apparently induced by oral traction on the connecting stalk between two intraluminal hamartomas. Although intussusceptions are considered common in foals and can even be clinically silent (Abraham *et al.* 2014), young age pre-disposition for the clinical disease is far from rigid, and horses over a wide age range can be affected (Fig 1). Many intussusceptions in mature horses (Fig 1) are caused by an obvious mucosal or intramural change that provides a lead point for the intussusceptum to enter the intussusciptum in an aboral direction (Boulton and Williamson 1984).

The mechanism by which the intussusception developed in this case can only be presumed, but I question whether abnormal motility was responsible (Mejia *et al.* 2021). The large colon of the adult horse is capable of propulsion and retro propulsion, motility patterns designed to retain solid particles in the colon for microbial digestion (Sellers *et al.* 1979). Whether or not this mature motility pattern is established in neonatal foals is unknown, but foals can rapidly establish a

microbiome (Costa *et al.* 2016), which might require early development of a special motility pattern to support it. Possibly, this normal retro propulsion or retrograde motility in the large colon (Sellers *et al.* 1979) drew on the connecting stalk orad so that the small colon was drawn into the unusual reverse intussusception. As the large colon was obstructed by the intussusception, the resulting distention could have stretched its wall and possibly applied even more oral traction on the small colon hamartoma. This process could create a vicious cycle of events, ending with an irreducible intussusception. A simpler explanation is that normal small colon peristalsis passed in an aboral direction over the tethered hamartoma in its lumen, progressively drawing more small colon in a telescoping manner into a reverse intussusception.

The authors did not propose any surgical correction in this case, presumably because the intussusception was irreducible for reasons that could only be learned through hindsight (Mejia *et al.* 2021). Even with the benefit of hindsight, surgical options would seem limited, although some might be worth consideration. Obviously, any such speculation about surgery cannot supersede the authors' assessment of the prospects for a satisfactory outcome.

From personal experience with obstruction of the transverse colon by fibrous foreign bodies in young horses (Boles and Kohn 1977), the author has treated one such case with similar challenges to the subject case (Mejia *et al.* 2021). In that case, a large mass of string and rubber from ingested conveyor belt material used for paddock fencing obstructed the right dorsal colon (Boles and Kohn 1977). A segment had detached from that mass and migrated into the small colon, while retaining a string-like connection to the parent portion (Fig 2). The small colon was impacted by this floater fragment so that both ends of the transverse colon were firmly obstructed (Fig 2). Neither the parent fragment in the right dorsal colon nor the small fragment in the small colon could be exteriorised for enterotomy. An enterotomy in the right dorsal colon oral to the large obstructing mass allowed access to the connecting cord between the impactions. Transecting that cord blindly in the lumen of the right dorsal colon with Mayo scissors released both masses so they could be removed through separate colotomies.

The subject of this commentary differed from the above case by attachment of the hamartomas to the affected colon segments. One could speculate that simple transection of the connecting stalk through a small enterotomy in the wall of the large colon could be a critical step. This simple correction would allow reduction of the intussusception but would leave the two primary lesions intact in the small and large colons. In these locations, the lesions would be expected to develop concurrently with the affected organ and growth would cease when that organ had reached its adult size (Mejia *et al.* 2021). The risk of complications with

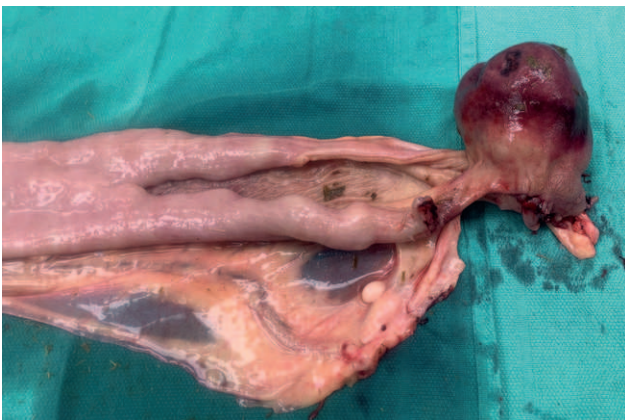


Fig 1: An intraluminal poorly differentiated sarcoma, either a gastrointestinal stromal tumour or leiomyosarcoma, that caused an ileocecal intussusception in a 21-year-old Quarter Horse gelding. After jejunocecostomy, the transected end of ileum was opened to display the lead point of the intussusception within its lumen.

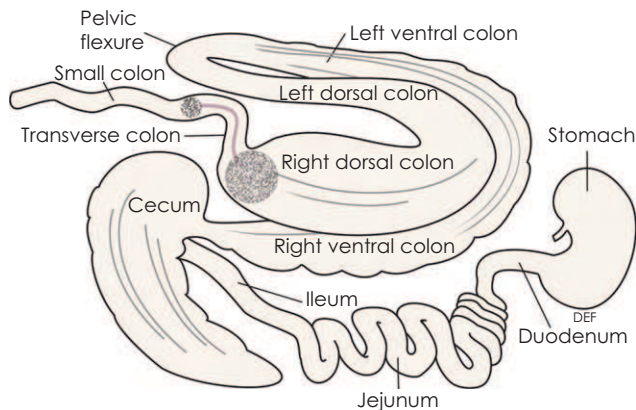


Fig 2: Manner by which two connected foreign bodies, one in the right dorsal colon and one in the small colon, obstructed both ends of the transverse colon. Intraluminal transection of the connection allowed their removal through two enterotomies.

these lesions would exist as long as they were in place but only the authors were in a position to judge that risk based on their intraoperative and necropsy findings.

Resection of the hamartomas would depend on the extent of attachment of the lesions to the colon walls, and this information was not clear. Apparently, the same cord that connected the masses to each other also provided attachment to the intestinal segments (Mejia *et al.* 2021). In a previously reported hamartoma in the small colon of a foal, the mass was attached to the mucosa by a long slender cord (Colbourne *et al.* 1996) that would be amenable to transection with a haemostatic method. Such a point of attachment in both sites would facilitate removal of the masses from the large and small colons, whereas a broader base of attachment might require a partial or complete resection and anastomosis in one or both segments.

Some readers might not share the authors' view that colic surgery in foals carries a relatively guarded prognosis (Mejia *et al.* 2021), based on a more recent study than those cited (MacKinnon *et al.* 2013). In that study, the outcome in those foals treated surgically was similar to those treated medically for different types of colic (MacKinnon *et al.* 2013). Colic surgery in foals can be complicated by certain comorbidities and such immature animals could be prone to perioperative sepsis and other diseases that could lead to a poor result, despite a successful surgery. However, the effect of these diseases on outcome might be less than expected (MacKinnon *et al.* 2013).

Contamination is always a concern with enterotomy or enterectomy, as the authors mentioned (Mejia *et al.* 2021). The foal of this report was 8 hours old, which could be

sufficient time ex-utero to allow it to develop some microbial flora in its large intestine (Costa *et al.* 2016). However, this process does require time and some oral interaction with the dam and environment, which might have been limited in this case. Also, draping and packing methods can protect the adjacent serosal surfaces (Hubert *et al.* 2000). Possibly, other methods for surgical treatment could be effective, and considering these options is an exercise that could provide some direction for handling similar cases in the future.

Author's declaration of interests

No conflicts of interest have been declared.

Ethical animal research

Not applicable to this commentary.

Source of funding

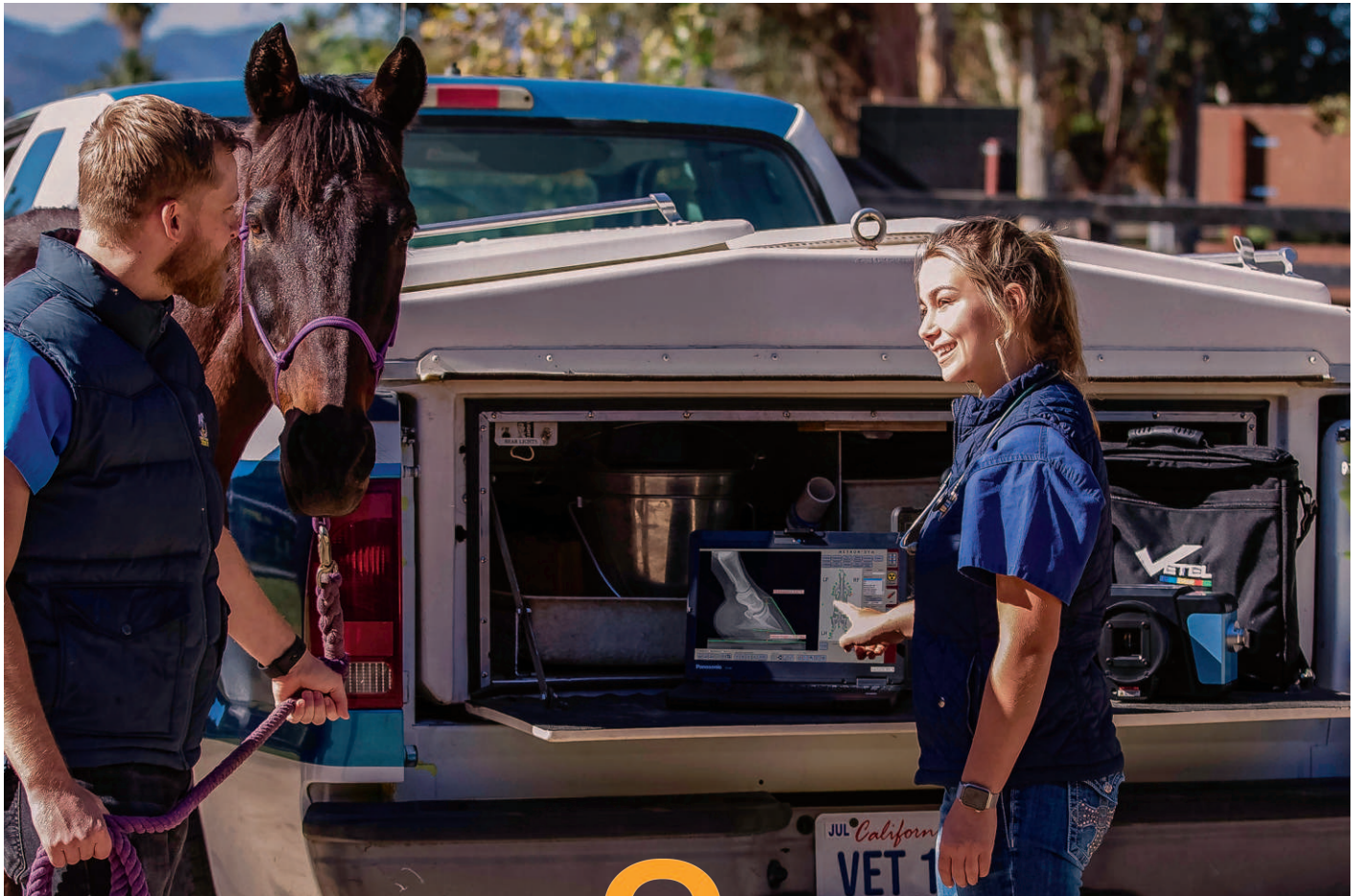
None.

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Original Article

Mental wellbeing of equine veterinary surgeons, veterinary nurses and veterinary students during the COVID-19 pandemic

T. S. Mair^{†*} , D. R. Mountford[†], R. Radley[†], E. Lockett[‡] and T. D. Parkin[§] 

[†]British Equine Veterinary Association, Cambridgeshire; [‡]Royal College of Veterinary Surgeons, London; and [§]School of Veterinary Medicine, College of Medical, Veterinary and Life Sciences, University of Glasgow, Glasgow, UK

*Corresponding author email: tim.mair@btinternet.com

Keywords: COVID-19; lockdown; mental wellbeing; pandemic

Summary

The rapid global spread of COVID-19 necessitated changes to national behavioural patterns and working practices, including self-isolating, maintenance of social distancing and lockdowns. These steps are likely to have had consequences for mental health and wellbeing.

Objectives: To assess the mental wellbeing of equine veterinary surgeons, equine veterinary nurses and veterinary students during the COVID-19 pandemic and the associated lockdown in the UK in June 2020.

Study design: Electronic survey.

Methods: The survey was run between 6 June 2020 and 14 June 2020, and consisted of 22 closed and open questions, including the 14-item scale Warwick-Edinburgh Mental Wellbeing Scale (WEMWBS). The questionnaire was distributed through email via the British Equine Veterinary Association (BEVA) membership database.

Results: A total of 451 responses were received. The mean scores for the WEMWBS for veterinary surgeons, veterinary nurses and veterinary students were 47.17, 39.53 and 44.29 respectively. These compare to 48.08 and 46.38 for equine veterinary surgeons and nurses respectively in the 2019 RCVS survey of the profession. The WEMWBS results indicated lower levels of mental wellbeing in equine veterinary nurses/student veterinary nurses and veterinary students, compared to equine veterinary surgeons, as well as in furloughed equine veterinary surgeons compared to working equine veterinary surgeons.

Main limitations: Risk of self-selection bias and reporting bias. Low numbers of veterinary nurse respondents.

Conclusions: There were lower levels of mental wellbeing among equine veterinary surgeons and equine veterinary nurses during the COVID-19 pandemic compared to the situation prior to the COVID-19 pandemic. Equine veterinary nurses appeared to be more likely to report lower mental wellbeing than veterinary surgeons, and furloughed veterinary surgeons reported lower levels of mental wellbeing than veterinary surgeons that continued working during the lockdown.

Introduction

COVID-19 spread rapidly around the world following its initial appearance in China in December 2019, and on 11 March 2020, the World Health Organization declared the situation as a pandemic (World Health Organization 2020a). The rapid global spread of the disease necessitated significant changes to national behavioural patterns and working practices, including

Clinical relevance

- Veterinary employers should be aware of the negative impact that pandemics, such as the COVID-19 pandemic, have on the mental wellbeing of equine veterinary surgeons, nurses and students.
- Strategies to support the veterinary team, especially veterinary nurses, during pandemics may help to improve mental wellbeing.
- Restrictions to normal working practices, such as furloughing team members, can further affect their mental wellbeing, for which added support could be beneficial.

self-isolating, maintenance of physical distancing ('social distancing') and lockdowns (Galea *et al.* 2020). While these steps are critical to mitigate the spread of highly contagious diseases in immunologically naive populations, they will likely have contributed to negative consequences for mental health and wellbeing in both the short and long term. Sudden outbreaks of disease have been associated with a higher prevalence of depression, lower mental wellbeing and other associated psychological problems (Ahmed *et al.* 2020; Xiang *et al.* 2020; Zhang *et al.* 2020), and the World Health Organization has also recognised that self-isolation/social distancing measures may result in people becoming more anxious, angry, stressed, agitated and withdrawn (World Health Organization (2020b)). A key risk factor for both anxiety and depression is perceived isolation (Santini *et al.* 2020), and social network structures, social support and participation in social activities are recognised as being associated with better mental wellbeing (Cornwell and Laumann 2015). It is therefore possible that the recent restrictions placed on the UK population owing to the COVID-19 pandemic may have had unintentional consequences on the state of mental wellbeing of the UK public (Smith *et al.*, 2010).

Mental ill-health has been shown to be prevalent in the veterinary profession, with high risk of occupational stress, burnout, poor psychological wellbeing and an elevated rate of suicide (Gardener and Hini 2006; Bartram *et al.* 2009; Hatch *et al.* 2011; Platt *et al.* 2012; Mastenbroek *et al.* 2014; Volk *et al.* 2018). The added impact of the COVID-19 pandemic and the associated stresses associated with strategies to reduce the spread of infection (including social distancing, lockdown, furloughing, etc) may have had further negative effects of the mental wellbeing of veterinary surgeons, veterinary nurses and veterinary students. The aims of this study were to assess the mental wellbeing of these

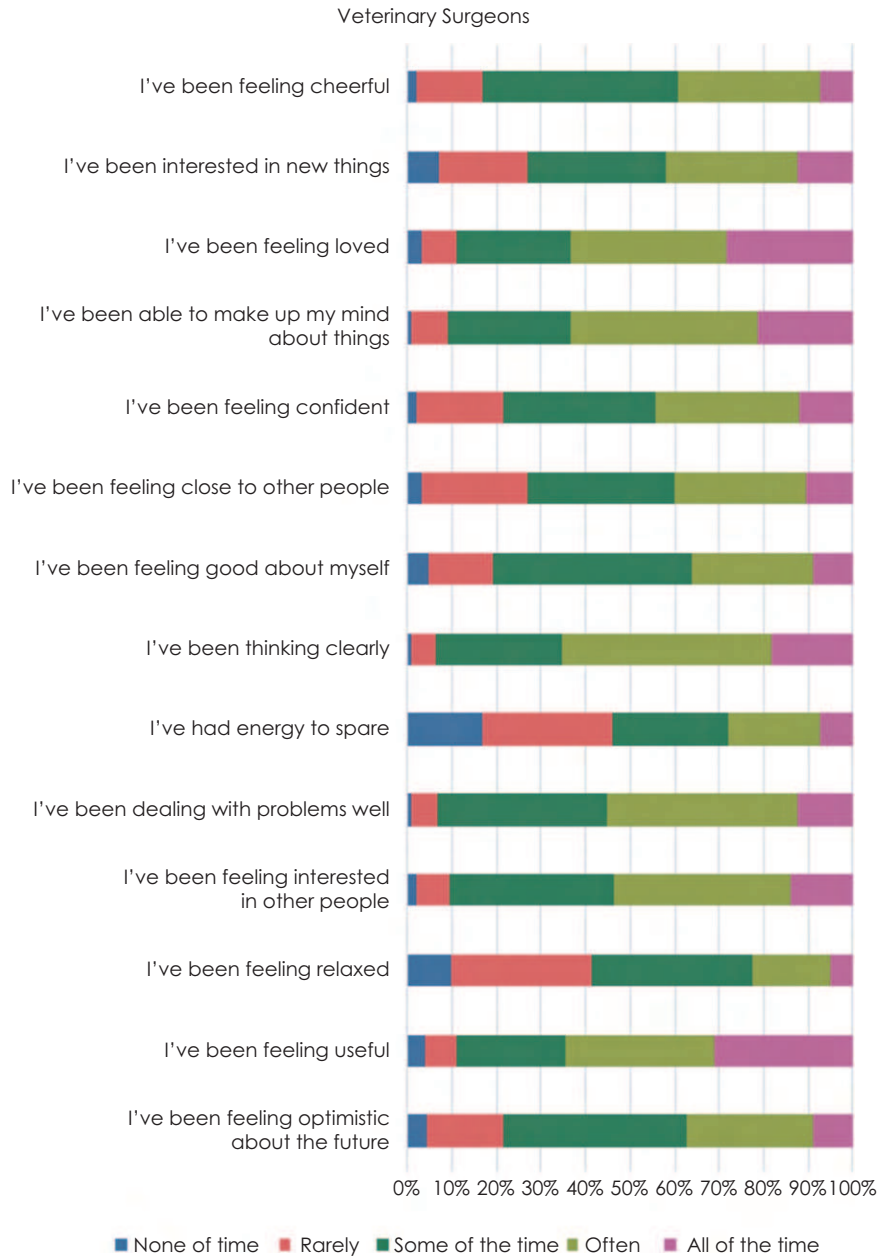


Fig 1: Results of the 14 items of the Warwick-Edinburgh Mental Wellbeing Scale for veterinary surgeons.

groups within the equine veterinary sector during the period of COVID-19 lockdown in the UK in June 2020.

Materials and methods

An online questionnaire was created using Dotdigital¹ (**Supplementary Item 1**). It consisted of 22 closed and open questions, including the 14-item scale Warwick-Edinburgh Mental Wellbeing Scale (WEMWBS). A user licence was obtained for use of the WEMWBS (registration ID: 519329420). Participants could choose to not answer any questions, and no incentives were offered. The questions were designed to assess participants' experiences over the previous 2 weeks; they were part of a larger survey of the

impact of COVID-19 on equine veterinary practices that was launched on 6 June 2020 and closed on 14 June 2020. The questionnaire was distributed through email via the British Equine Veterinary Association (BEVA) membership database and was open to veterinary surgeons, veterinary nurses, veterinary students and practice administrators/managers.

Data analysis

This article focuses on a sub-selection of the respondents' data.

The results of the 14 individual items of the WEMWBS for veterinary surgeons and veterinary nurses, and the mean total scores, were compared to the results for equine

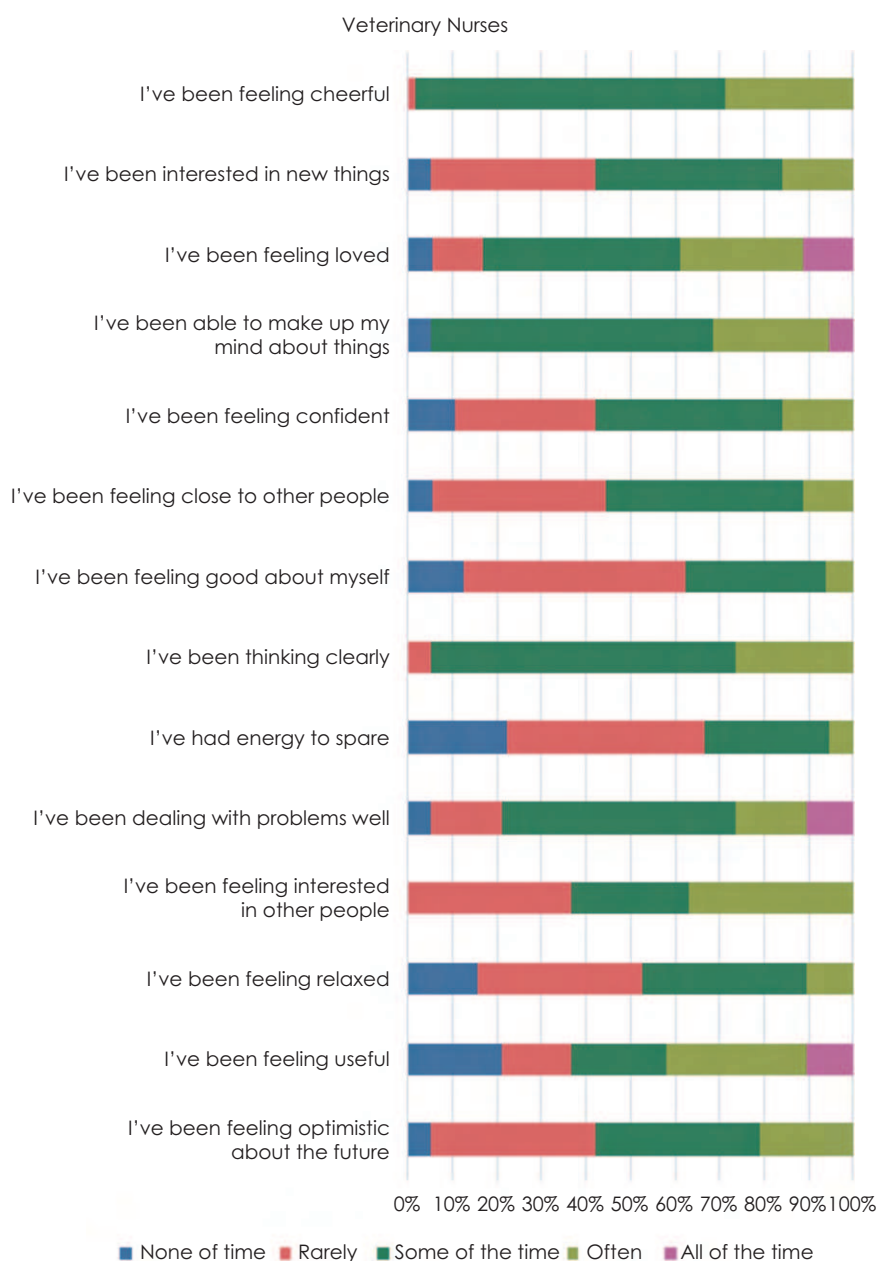


Fig 2: Results of the 14 items of the Warwick-Edinburgh Mental Wellbeing Scale for veterinary nurses.

veterinary surgeons and equine veterinary nurses from the 2019 survey of the veterinary profession (RCVS 2019). For comparison of results within the current study and with those of the 2019 survey of the veterinary profession, the sum of the frequencies of 'none of the time' and 'rarely' responses and the sum of the frequencies of 'often' and 'all of the time' responses were calculated for equine veterinary surgeons and equine veterinary nurses. Comparisons of the results of the current survey between veterinary surgeons and veterinary nurses, and between veterinary surgeons who were still working (full-time or part-time) and veterinary surgeons who had been furloughed were also undertaken. Chi-square

or, where appropriate, Fisher Exact tests and two proportions tests were conducted using Minitab 18.1². Two proportions tests were used to identify if differences observed were due to fewer respondents stating that they were 'positive' in their responses or more respondents stating that they were 'negative' in their responses.

Results

A total of 451 responses were received, comprising 377 equine veterinary surgeons, 41 equine veterinary students, 20 veterinary nurses/student veterinary nurses, 11 practice

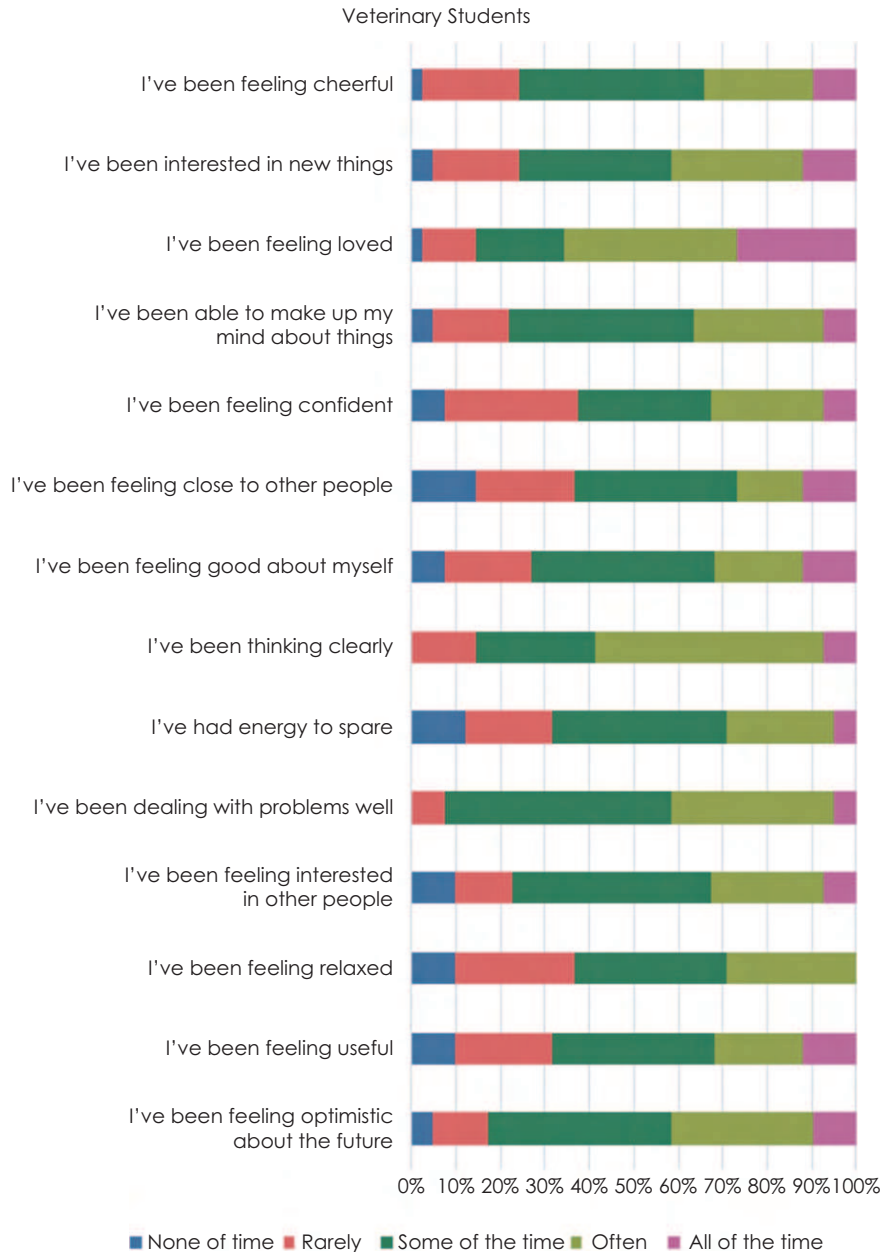


Fig 3: Results of the 14 items of the Warwick-Edinburgh Mental Wellbeing Scale for veterinary students.

administrators/managers/receptionists and 2 others. The gender of respondents included 275 (61.0%) females, 173 (38.4%) males and 3 respondents (0.6%) who preferred not to say; the veterinary surgeons included 210 (55.7%) females and 165 (43.8%) males (2 (0.5%) preferred not to say). The age ranges were recorded for 440 respondents: 18–24 years 34 (7.7%), 25–34 years 120 (27.3%), 35–44 years 95 (21.6%), 45–54 years 95 (21.6%), 55–64 years 66 (15.0%) and over 65 years 30 (6.8%). Of the 377 veterinary surgeons, 303 (80.4%) worked in the UK, 41 (10.9%) worked in an EU/EEA/EFTA country (including 6 in the Republic of Ireland), 30 (7.9%) worked outside of the UK/EU, and country not specified in 3 (0.8%). The type of workplace where veterinary surgeon respondents worked predominantly included independent, stand-alone

practices in 202 (53.5%), practices being part of a corporate group in 104 (27.5%), veterinary schools (clinical role) in 31 (8.2%), charity sector in 11 (2.9%), industry in 5 (1.3%) and others in 24 (6.3%). The type of work undertaken by veterinary surgeon respondents included equine only in 325 (86.2%), mixed practice in 42 (11.1%) and other in 10 (2.7%). The majority of veterinary surgeon respondents reported that they were working full-time (249/377, 66.0%), with 57 (15.1%) working part-time, 36 (9.5%) furloughed, 8 (2.1%) self-isolating/shielding, 9 (2.4%) unemployed, 3 (0.8%) on leave (e.g. parental or sickness), 2 (0.5%) on a career break, 2 (0.5%) retired and 11 (2.9%) other (including 5 furloughed for part of the 2-week period). The hours worked in the previous 2 weeks by the veterinary surgeon

TABLE 1: Results of the 14 items of the WEMWBS for veterinary surgeons in the 2019 survey of the profession (RCVS 2019) compared with the current survey

WEMWBS items	Survey of the profession 2019			Current survey		Chi-square test of those responding 'none of the time' or 'rarely' vs. 'often' or 'all of the time' P value	Proportion of respondents answering 'often' or 'all of the time'		Proportion of respondents answering 'rarely' or 'none of the time'		
	Number of respondents answering 'none of the time' or 'rarely'	Number of respondents answering 'often' and 'all of the time'	Number of respondents answering 'none of the time' or 'rarely'	Number of respondents answering 'often' and 'all of the time'	Survey of the veterinary profession 2019 (%)		Current survey (%)	Survey of the veterinary profession 2019 (%)	Current survey (%)	Two proportions test P value	Two proportions test P value
I've been feeling optimistic about the future	89	251	79	138	46.7	37.3	16.6	21.4	0.004	NS	
I've been feeling useful	35	353	41	239	65.7	64.4	6.5	11.1	NS	0.02	
I've been feeling relaxed	180	137	151	83	25.7	22.7	33.8	41.3	NS	0.02	
I've been feeling interested in other people	68	303	34	196	56.7	53.7	12.7	9.3	NS	NS	
I've been dealing with problems well	44	295	25	203	55.1	55.3	8.2	6.8	NS	NS	
I've had energy to spare	220	126	170	103	23.6	27.9	41.1	46.1	NS	NS	
I've been thinking clearly	23	237	23	237	68.0	65.1	5.2	6.3	NS	NS	
I've been feeling good about myself	81	264	70	132	49.3	36.3	15.1	19.2	<0.001	NS	
I've been feeling close to other people	101	257	98	145	48.0	40.1	18.9	27.1	0.02	0.004	
I've been feeling confident	61	291	80	164	54.4	44.3	11.4	21.6	<0.001	<0.001	
I've been able to make up my mind about things	28	406	33	233	75.9	63.3	5.2	9.0	<0.001	0.004	
I've been feeling loved	91	293	40	231	54.9	63.5	17.0	11.0	0.01	0.009	
I've been interested in new things	54	360	99	154	67.2	42.1	10.1	27.0	<0.001	<0.001	
I've been feeling cheerful	62	291	62	144	54.6	39.1	11.6	16.8	<0.001	0.003	

NS, not significant.

TABLE 2: Results of the 14 items of the WEMWBS for veterinary nurses/student veterinary nurses in the 2019 survey of the profession (RCVS 2019) compared with the current survey

WEMWBS Items	Survey of the profession 2019		Current survey		Chi-square test of those responding 'none of the time or rarely' vs. 'often' or 'all of the time' Significance (P value)
	Number of respondents answering 'none of the time' or 'rarely'	Number of respondents answering 'often' and 'all of the time'	Number of respondents answering 'none of the time' or 'rarely'	Number of respondents answering 'often' and 'all of the time'	
I've been feeling optimistic about the future	17	26	8	4	NS
I've been feeling useful	6	39	7	8	0.01
I've been feeling relaxed	31	8	10	2	NS
I've been feeling interested in other people	7	33	7	7	0.03
I've been dealing with problems well	3	42	4	5	0.01
I've had energy to spare	36	11	12	1	NS
I've been thinking clearly	4	41	1	5	NS
I've been feeling good about myself	14	29	10	1	0.001
I've been feeling close to other people	17	26	8	2	0.03
I've been feeling confident	8	37	8	3	0.001
I've been able to make up my mind about things	6	48	1	6	NS
I've been feeling loved	14	35	3	7	NS
I've been interested in new things	8	46	8	3	<0.001
I've been feeling cheerful	7	41	2	5	NS

NS, not significant.

TABLE 3: Results of the 14 items of the WEMWBS comparing veterinary surgeons and veterinary nurses/student veterinary nurses

WEMWBS Items	Veterinary surgeons		Veterinary nurses/student veterinary nurses		Fisher exact test of those responding 'none of the time or rarely' vs. 'often' or 'all of the time' Significance (P value)
	Number of respondents answering 'none of the time' or 'rarely'	Number of respondents answering 'often' and 'all of the time'	Number of respondents answering 'none of the time' or 'rarely'	Number of respondents answering 'often' and 'all of the time'	
I've been feeling optimistic about the future	79	138	8	4	NS
I've been feeling useful	41	239	7	8	0.005
I've been feeling relaxed	151	83	10	2	NS
I've been feeling interested in other people	34	196	7	7	0.003
I've been dealing with problems well	25	203	4	5	0.01
I've had energy to spare	170	103	12	1	0.04
I've been thinking clearly	23	237	1	5	NS
I've been feeling good about myself	70	132	10	1	<0.001
I've been feeling close to other people	98	145	8	2	0.02
I've been feeling confident	80	164	8	3	0.01
I've been able to make up my mind about things	33	233	1	6	NS
I've been feeling loved	40	231	3	7	NS
I've been interested in new things	99	154	8	3	NS
I've been feeling cheerful	62	144	2	5	NS

NS, not significant.

respondents was reported to be normal in 183 (49.0%), increased in 95 (25.5%) and decreased in 95 (25.5%) (not reported in 4). Of the 20 veterinary nurses/student nurses, 11 (55.0%) were working full-time, 3 (15.0%) were working part-time, 3 (15.0%) were furloughed, 2 (10.0%) were unemployed, and 1 (5.0%) was self-isolating/shielding. Of

450 respondents, 201 (44.7%) reported that since the onset of the COVID-19 pandemic they had personally known someone (e.g. family member, colleague or client) who had suffered from confirmed or suspected COVID-19, and a further 18 (4.0%) reported that they believed that they themselves had been infected.

TABLE 4: Results of the 14 items of the WEMWBS for veterinary surgeons who were working compared with veterinary surgeons who were furloughed

WEMWBS Items	Working veterinary surgeons		Furloughed veterinary surgeons		Chi-square test of working veterinary surgeons versus furloughed veterinary surgeons Significance (P value)
	Number of respondents answering 'none of the time' or 'rarely'	Number of respondents answering 'often' and 'all of the time'	Number of respondents answering 'none of the time' or 'rarely'	Number of respondents answering 'often' and 'all of the time'	
I've been feeling optimistic about the future	56	124	15	7	0.001
I've been feeling useful	5	227	26	6	<0.001
I've been feeling relaxed	128	63	15	10	NS
I've been feeling interested in other people	26	158	6	20	NS
I've been dealing with problems well	15	172	7	15	0.003
I've had energy to spare	148	77	11	17	0.006
I've been thinking clearly	16	200	5	20	NS
I've been feeling good about myself	49	113	12	10	0.02
I've been feeling close to other people	74	118	17	13	NS
I've been feeling confident	51	148	20	8	<0.001
I've been able to make up my mind about things	18	200	13	14	<0.001
I've been feeling loved	33	186	4	29	NS
I've been interested in new things	86	122	10	19	NS
I've been feeling cheerful	50	122	7	15	NS

NS, not significant.

The results of the 14 items of the WEMWBS for veterinary surgeons, veterinary nurses and veterinary students are shown in **Figs 1–3**. The overall mean score for the WEMWBS for the veterinary surgeons in the current survey was 47.17; this compares to 48.08 in the 2019 survey of the profession results for veterinary surgeons (RCVS 2019). The overall mean score for the WEMWBS for the equine veterinary nurses/student veterinary nurses in the current survey was 39.53; this compares to 46.38 in the 2019 survey of the profession results for equine veterinary nurses (RCVS 2019). The overall mean score for the WEMWBS for the veterinary students in the current survey was 44.29; there were no available data for veterinary students prior to COVID-19 to compare with.

A comparison of the results of the WEMWBS for veterinary surgeons in the current survey with the results for equine veterinary surgeons from the 2019 survey of the profession (RCVS 2019) is summarised in **Table 1**. The chi-square test showed significant differences between the sums of the numbers of responders answering 'none of the time' or 'rarely' to those responding 'often' or 'all of the time' for the two surveys for 9 of the 14 WEMWBS items. The two proportions test showed significant differences in the proportions of respondents answering 'often' and 'all of the time' between the two surveys for 8 items, and significant differences in the proportions of respondents answering 'rarely' and 'none of the time' for 8 WEMWBS items (6 items had significant differences in both of the two proportions test results).

A comparison of the results of the WEMWBS for veterinary nurses/student veterinary nurses in the current survey with the results for equine veterinary nurses from the 2019 survey of the profession (RCVS 2019) is summarised in **Table 2**. The chi-square test showed significant differences between the numbers of responders answering 'none of the time' or

'rarely' to those responding 'often' or 'all of the time' for the two surveys for 9 of the WEMWBS items.

A comparison of the results of the WEMWBS for veterinary surgeons compared with veterinary nurses/student veterinary nurses is summarised in **Table 3**. The Fisher exact test showed significant differences between the numbers of responders answering 'none of the time' or 'rarely' to those responding 'often' or 'all of the time' for the veterinary surgeons and veterinary nurses/student veterinary nurses for 7 of the items.

A comparison of the results of the WEMWBS for veterinary surgeons working in the previous two weeks and veterinary surgeons who were furloughed in the previous two weeks is shown in **Table 4**. The chi-square test showed significant differences between the numbers of responders answering 'none of the time' or 'rarely' to those responding 'often' or 'all of the time' for the veterinary surgeons and veterinary nurses/student veterinary nurses for 7 of the items.

Discussion

The results of this study indicate that the COVID-19 pandemic and its associated lockdown and related strategies to reduce the spread of COVID-19 (such as social distancing and furloughing) have had negative effects on the mental wellbeing of equine veterinarians and equine veterinary nurses, as assessed by comparison of the WEMWBS scores of the current survey and those of the 2019 survey of the profession (RCVS 2019). This is perhaps not surprising since the UK population has not been exposed to this type of pandemic or required to undertake such drastic public health control measures in modern history. In addition, our results imply lower levels of mental wellbeing during the COVID-19 lockdown in equine veterinary nurses/student veterinary nurses and veterinary students, compared to

equine veterinary surgeons, as well as lower levels of mental wellbeing in furloughed equine veterinary surgeons compared to working equine veterinary surgeons.

The World Health Organization describes positive mental health (which is frequently used interchangeably with the term mental wellbeing) as being 'the foundation for wellbeing and effective functioning for both the individual and the community' and defined it as a state 'which allows individuals to realise their abilities, cope with the normal stresses of life, work productively and fruitfully and make a contribution to their community' (World Health Organization 2004). The 14-item WEMWBS was developed to enable the monitoring of mental wellbeing at a population level (Tennant *et al.* 2007; Fat *et al.* 2017). The scale estimates mental wellbeing both in terms of feeling good and functioning well and has been validated for use in the veterinary profession (Bartram *et al.* 2011). Individual items are scored on a Likert scale from 1 (none of the time) to 5 (all of the time), and a total score is calculated by summing the 14 item scores (the minimum score is therefore 14 and the maximum is 70). The WEMWBS does not have a precise 'cut off' level to divide the population into those who have 'good' and those who have 'poor' mental wellbeing. However, some studies have suggested that a mean score below 41-44 corresponds to possible depression, and 60 and above can be used to identify the top 15% of scores, indicating high mental wellbeing (Bianco 2012). Scores between 43 and 59 have been used to denote average mental wellbeing in other studies (Ahmed *et al.* 2020). In the present study, the mean total scores for equine veterinary surgeons and veterinary students fell within this range for 'average' mental wellbeing, whereas the scores for equine veterinary nurses fell into the 'possible depression' group. However, these results must be interpreted with extreme caution because of the very low numbers of respondents, especially for equine veterinary nurses/student veterinary nurses, and the associated risk of significant bias in the results. Furthermore, detailed research into this area would be required before any firm conclusions can be reached.

There is a limited body of literature to which one can refer to inform effective policy and practice in order to support the emotional wellbeing alongside the reduction in risk of exposure to contagion (Smith *et al.*, 2010). To the best of our knowledge, this is the first study that has addressed the impact of COVID-19 on the mental wellbeing of veterinary surgeons. Several studies around the world have used the WEMWBS (in addition to other tools) to document negative impacts of the COVID-19 pandemic on mental health and wellbeing of the general public (Smith *et al.* 2010; Rolland *et al.* 2020), and higher rates of anxiety, depression, alcohol use disorder, and lower mental wellbeing in the general population during the COVID-19 epidemic have been reported in several countries (Ahmed *et al.* 2020).

Findings of the current study should be interpreted in light of its limitations. Firstly, there may have been self-selection bias in this online survey, with those people with poorer mental wellbeing more likely to complete the survey. Secondly, the participants were asked to self-report on their mental wellbeing, potentially introducing reporting bias. Furthermore, the current survey and the 2019 survey of the veterinary profession (RCVS 2019) were distributed in different ways, so they may not have targeted precisely the same population of veterinary surgeons and nurses. There were also

very small numbers of veterinary nurses responding to the survey.

In conclusion, the results of the present study indicate lower levels of mental wellbeing among equine veterinary surgeons and equine veterinary nurses during the COVID-19 pandemic compared to the situation prior to the COVID-19 pandemic. The reasons for this have not been elucidated but might include fear of getting ill or family and friends getting ill, feelings of social isolation due to lockdown measures, anxiety about the viability of veterinary businesses going forwards, and the potential effects of the pandemic on the economy in general. Equine veterinary nurses appeared to be more likely to report low mental wellbeing than veterinary surgeons. In addition, furloughed veterinary surgeons reported lower levels of mental wellbeing than veterinary surgeons that continued working during the lockdown. Interventions to improve mental wellbeing and ensure emotional safety should focus on these groups during the current COVID-19 pandemic and in similar scenarios in the future.

Authors' declaration of interests

No conflicts of interest have been declared.

Ethical requirements

British Equine Veterinary Association.

Source of funding

None.

Authorship

T. Mair, D. Mountford and R. Radley were responsible for the study design and study execution. All authors were involved with the data analysis and interpretation, preparation of the manuscript and final approval of the manuscript.

Manufacturers' addresses

¹Dotdigital <https://dotdigital.com/features/landing-pages-forms/>
²Minitab

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Supporting information

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

Supplementary Item 1. BEVA Covid-19 impact survey 2.

Original Article

Prevalence of equine ulcerative keratomycosis in Colorado and association of environmental factors: A retrospective and descriptive study (2002–2017)

B. B. Martabano, M. de Linde Henriksen*  and C. C. Powell*Department of Clinical Sciences, Comparative Ophthalmology, College of Veterinary Medicine and Biomedical Sciences, Colorado State University, Fort Collins, Colorado, USA***Corresponding author email: michala.henriksen@colostate.edu***Keywords:** horse; ulcerative keratomycosis; corneal ulceration; Colorado; wind speed

Summary

Equine ulcerative keratomycosis is relatively commonly presented to teaching hospitals in North America, with a prevalence from 24 to 86%. Horses in Colorado may have lower risk due to the dry mountain climate, but data are lacking. This study aimed to determine the prevalence of ulcerative keratomycosis amongst horses with ulcerative keratitis presented to Colorado State University Veterinary Teaching Hospital (CSU-VTH) ophthalmology service and to evaluate environmental factors (season, temperature, humidity, wind speed and elevation) associated with ulcerative keratomycosis in Colorado. A database search identified horses with ulcerative keratitis presented to the ophthalmology service at CSU-VTH from January 2002 to August 2017. Sixty-one horses met the inclusion criteria of a corneal cytology and/or culture or histopathology at the time of diagnosis; cases lacking that were excluded. Environmental factors at the boarding sites, including season, temperature, humidity, wind speed and elevation and clinical outcomes for fungal cases, were recorded. Prevalence of fungal infection amongst equine ulcerative keratitis was 16.4% (10/61), suggesting that CSU-VTH has considerably fewer ulcerative keratomycosis cases than other veterinary teaching hospitals in North America. Spring (50%, 5/10) and fall (40%, 4/10) had the highest prevalence of fungal ulcerative keratitis in Colorado. Only one case was reported in summer (10%, 1/10); no horses were positive (0%, 0/10) in winter. Only wind speed seemed to influence the development of ulcerative keratomycosis with higher wind speeds associated with greater rates of fungal involvement ($P = 0.047$). Other environmental factors did not show a detectable association (all P -values >0.05). Outcomes were variable. It was concluded that horses from the area of CSU-VTH appear to be at lower risk for ulcerative keratomycosis than from the areas around other North American veterinary teaching hospitals that have reported data. Most horses with keratomycosis in this area present in the spring and fall.

Introduction

The published prevalence of fungal involvement in equine ulcerative keratitis in the United States varies by institution, with three veterinary schools reporting data to date (Moore *et al.* 1983; Moore *et al.* 1995; Andrew *et al.* 1998; Utter *et al.* 2009; Gilger 2013). Keratomycosis appears to be most common in the southeastern United States, with the highest

published prevalence at the University of Florida at 84.6% (33/39) of equine ulcerative keratitis cases having evidence of fungal infection (Andrew *et al.* 1998). The lowest prevalence was previously reported by the University of Pennsylvania at 24% (10/41) (Utter *et al.* 2009). University of Missouri indicated ulcerative keratomycosis in 38–43% of their equine ulcerative keratitis cases (Moore *et al.* 1983; Moore *et al.* 1995). Keratomycosis (ulcerative and stromal abscess) generally presents seasonally, dependent upon geographic location. In the northeastern United States, horses with ulcerative keratomycosis predominantly present during the summer and early fall (Gaarder *et al.* 1998; Utter *et al.* 2010; Ledbetter *et al.* 2013), while in southeastern regions, keratomycosis is more frequent in late fall to winter or without seasonal effects (Coad *et al.* 1985; Andrew *et al.* 1998; Proietto *et al.* 2016). Seasonal presentation is suspected to be related to fluctuations in temperature and humidity (Henriksen *et al.* 2014a; Proietto *et al.* 2016). To the authors' knowledge, the risk for keratomycosis in horses living at higher elevations and drier climates of the western part of United States such as Colorado has not been evaluated. Environmental studies demonstrate that moisture (humidity) and moderate temperatures (15 to 40°C) promote fungal growth, while low humidity and extreme temperature changes have inhibitory effects (Talley *et al.* 2002). High elevation specifically has not been implicated as a factor reducing fungal growth (Weir 1918; Talley *et al.* 2002; Meier *et al.* 2010), and in one study, a positive correlation was found between elevation and environmental fungal growth (Talley *et al.* 2002). We are unaware of studies examining fungal growth at different elevations and risk of infection.

No studies have evaluated the prevalence of ulcerative keratomycosis in horses from northern Colorado. This retrospective study was performed to evaluate the prevalence of ulcerative keratomycosis in horses presented to the Colorado State University Veterinary Teaching Hospital (CSU-VTH) ophthalmology service and to describe the correlation with season, temperature, humidity, wind speed and elevation. Age differences between ulcerative keratomycosis versus non-fungal related ulcerative keratitis, as well as treatment plan and clinical outcome for horses with ulcerative keratomycosis presented to CSU-VTH were also evaluated and compared with data from other veterinary teaching hospitals. Since CSU-VTH is located in northern Colorado (Fort Collins), 1500 metres above sea level with a dry climate compared to other reported localities, we

hypothesised that the prevalence of ulcerative keratomycosis at CSU-VTH be lower than that reported at veterinary teaching hospitals in other areas of the United States.

Materials and methods

This was a retrospective descriptive study. Medical records from equine cases presented to the ophthalmology service at CSU-VTH were electronically searched from January 2002 to August 2017. To be included in the study, horses were required to have a complete ophthalmic examination performed by the ophthalmology service at CSU-VTH and a clinical diagnosis of 'corneal ulceration' or 'ulcerative keratitis'. Horses with accessible results for corneal cytology and/or corneal culture (aerobic, anaerobic and/or fungal) and/or histopathology (enucleation or keratectomy) in the medical record were included; all diagnostic tests were not performed in all cases. Cytology evaluation was performed either by the clinical pathology service at CSU-VTH, the ophthalmologist (board-certified) or the ophthalmology resident on the case. Diff-quick stain¹ was used for cytology samples stained and analysed by the ophthalmology service, whereas Giemsa stain² was used for samples submitted to the clinical pathology service. Culture samples were submitted to CSU Veterinary Diagnostic Laboratories (CSU-VDL) and analysed by the Bacteriology Laboratory. Corneal tissue samples collected from surgical cases were submitted in formalin 10% solution² and processed by the pathology laboratory at CSU-VDL. The histopathology samples were stained with Haematoxylin and Eosin³ for tissue evaluation and Gomori Methenamine Silver stain² to look for fungal organisms. The histopathology samples were evaluated by board-certified anatomic pathologists at CSU-VDL. Data collected from each record included signalment, age of the horse, previous treatment, date of presentation associated with ulcer diagnosis, boarding location, cytology and/or culture results, medication regimen, clinical outcome and date of outcome. Outcome for horses with ulcerative keratomycosis was categorised as 1) healed with medical therapy alone, 2) surgical correction (keratectomy and conjunctival graft versus enucleation) after failure of medical therapy or 3) unknown if the case was lost to follow-up. Excluded from the study were horses presented to CSU-VTH with 'corneal ulceration' or 'ulcerative keratitis' lacking a complete ophthalmic examination performed by the ophthalmology service or diagnostic tests, such as cytology, culture or histopathology.

Environmental factors

The following data were obtained: (1) date of presentation to establish the season as follows; spring (March, April and May), summer (June, July and August), fall (September, October and November) and winter (December, January and February); (2) The average temperature (Celsius) for the month of presentation; (3) The ambient humidity (%) for the month of presentation; (4) Average wind speed (m/s) for the month of presentation; and (5) Elevation (metres) for the location of the weather station from which environmental data were collected. The Weather Underground online database was used as the source of the environmental data. The date of presentation and zip code for the location of the housing facility of the horse were used as the search criteria on the Weather Underground homepage⁴.

Data analysis

The age, sex and breed of each horse were recorded. Median \pm standard deviation (s.d.) and range for age were calculated for horses with ulcerative keratomycosis and non-fungal related ulcerative keratitis horses. The prevalence of ulcerative keratomycosis and non-fungal related ulcerative keratitis was calculated. Non-fungal related ulcerative keratitis horses were further subdivided into bacterial-related ulcerative keratitis, and non-infected ulcerative keratitis, and the prevalence of each were determined. The mean \pm s.d. for the environmental factors of temperature, humidity, wind speed and elevation were calculated for ulcerative keratomycosis and non-fungal related ulcerative keratitis. The seasonal occurrence for each condition was characterised. Excel Microsoft was used to characterise the descriptive data. The Mann-Whitney U test was used to identify differences between the ages of each group and differences between the environmental factors for ulcerative keratomycosis versus non-fungal related ulcerative keratitis. A significance level of 0.05 was used for test of differences ($P < 0.05$ was deemed significant).

Results

Nine-hundred and thirty-five horses were examined by the CSU-VTH ophthalmology service from 2002 to 2017. Two-hundred and forty-two case records were reviewed based on the search terms of corneal ulceration and ulcerative keratitis. Sixty-one cases fit the total inclusion criteria, including 26 mares, 32 geldings and 3 stallions. The following breeds were represented: Quarter Horse ($n = 24$), Thoroughbred ($n = 10$), Appaloosa ($n = 7$), American Paint horse ($n = 8$), Fox Trotter ($n = 3$), Pony ($n = 2$), Mule ($n = 1$), Miniature horse, Arabian ($n = 1$), Fjord horse ($n = 1$) and undocumented breeds ($n = 4$). Mean \pm s.d. for the age (in years) of ulcerative keratomycosis cases was 13 ± 8 years and for non-fungal related ulcerative keratitis cases was 11 ± 8 years, which were not statistically significantly different ($P = 0.490$).

Ten of 61 horses (16.4%, 10/61) were diagnosed with ulcerative keratomycosis, three of which were co-infected with bacteria (4.9%, 3/61). The overall prevalence of ulcerative keratomycosis amongst all CSU-VTH equine ophthalmology patients was 1.1% (10/935). Non-fungal related ulcerative keratitis was found in 83.6% cases (51/61), including bacterial-related ulcerative keratitis (63.9%, 39/61) and non-infectious aetiology (19.7%, 12/61). Corneal cytology was performed in 87% of cases (53/61). Nine out of the 10 horses (90%) that were diagnosed with ulcerative keratomycosis in this study were positive for fungal hyphae on their cytology (**Table 1**). Bacterial culture was performed in 46% of cases (28/61), with positive growth in 71% (20/28). Fungal culture was performed in 20% of cases (12/61), with positive growth in 16% (2/12). Fungal ulcerative keratitis was identified on corneal histopathology in one case (1/61, 1.6%). **Table 2** shows the specific bacterial and fungal aetiologies identified by culture, and **Figure 1** shows the gross appearance of the eyes from four horses with infectious ulcerative keratitis.

Outcome for the 10 horses with ulcerative keratomycosis was as follows: 40% healed (4/10), 30% were enucleated (3/10) and 30% were lost to follow-up (3/10). Three of the four cases (75%) that healed received medical and surgical

TABLE 1: Fungal equine ulcerative keratitis (EUK) cases (n = 10)

Signalment	Cytology	Culture	Treatment	Outcome
1 17-year-old Fox Trotter gelding	Fungal hyphae with cocci	-	Medical: ofloxacin*, hypertonic saline [†] , neopolybac [‡] , betadine [§] , flunixin meglumine [¶]	Lost to follow-up after 12 days hospitalisation
2 25-year-old Appaloosa gelding	Fungal hyphae	Fungal: <i>dematiaceous</i> fungus	Medical: natamycin**, betadine, ofloxacin, serum ^{††} , fluconazole ^{‡‡} , atropine ^{§§} , neopolybac, flunixin meglumine	Healed
3 17-year-old Quarter Horse gelding	**Corneal histopathology: fungal hyphae consistent with <i>Aspergillus</i> sp.	-	Medical: ofloxacin, serum, atropine, oral doxycycline ^{¶¶} , oral flunixin meglumine*** Surgical: conjunctival graft	Enucleated
4 3-year-old Thoroughbred gelding	Fungal hyphae with bacteria	Aerobic: <i>Bacillus</i> sp. Fungal: no growth	Medical: ofloxacin, serum, atropine, oral doxycycline, oral flunixin meglumine	Enucleated
5 6-year-old Quarter Horse gelding	Fungal hyphae	-	Medical (24 h): voriconazole ^{†††} , atropine, serum Surgical: conjunctival graft	Healed
6 11-year-old Quarter Horse gelding	Branching septate fungal hyphae with neutrophils	Fungal culture: <i>Aspergillus</i> sp, <i>Cladosporium</i> sp. Aerobic: no growth	Medical: ofloxacin, voriconazole, serum, atropine, oral doxycycline, oral fluconazole ^{‡‡‡} , oral flunixin meglumine Surgical: conjunctival graft followed by SIS and amnion due to graft dehiscence	Healed
7 16-year-old Quarter Horse gelding	Fungal hyphae	-	Medical: ofloxacin, voriconazole, serum, atropine, SSD ^{§§§} , oral doxycycline, flunixin meglumine	Enucleation
8 20-year-old American Paint gelding	Branching fungal hyphae with cocci	-	Medical: ofloxacin, voriconazole, serum, atropine, flunixin meglumine	Lost to follow-up
9 1-month-old Thoroughbred mare	Rare yeast and fungal hyphae	Aerobic: no growth Anaerobic: no growth	Medical: ofloxacin, cefazolin, serum, atropine, flunixin meglumine	Lost to follow-up
10 8-year-old Quarter Horse gelding	Septate and branching fungal hyphae	-	Medical: ofloxacin, cefazolin, voriconazole, serum, atropine, flunixin meglumine Surgery: conjunctival graft	Healed

*Ofloxacin 0.3% ophthalmic solution, Akorn Inc., Lake Forest, Illinois, USA

[†]Hypertonic saline 5% ophthalmic solution, Bausch & Lomb, Bridgewater, New Jersey, USA

[‡]Neopolybac (Neomycin-Polymyxin B- Bacitracin) ophthalmic ointment, Bausch & Lomb, Bridgewater, New Jersey, USA

[§]Betadine 5% ophthalmic solution, Brockton, Massachusetts, USA

[¶]Flunixin meglumine 50 mg/ml injectable solution, Merck, Kenilworth, New Jersey, USA

**Natamycin 5% ophthalmic suspension, Alcon, Fort Worth, Texas, USA

^{††}Serum, autologous serum taken from the horse itself

^{‡‡}Fluconazole 2 mg/mL

^{§§}Atropine 1% ophthalmic solution, Bausch & Lomb, Bridgewater, New Jersey, USA

^{¶¶}Oral doxycycline 100 mg tablets, Alvogen, Pine Brook, New Jersey, USA

***Oral flunixin meglumine 1500 mg paste, Merck, Kenilworth, New Jersey, USA

^{†††}Voriconazole 1% ophthalmic solution, Stokes compounding pharmacy, Mt Laurel, New Jersey, USA

^{‡‡‡}Oral fluconazole 100 mg tablets, Pfizer, New York, New York, USA

^{§§§}SSD (Silver Sulfadiazine 1% Cream), Dr. Reddy's laboratories, Princeton, New Jersey, USA

treatment (keratectomy followed by a conjunctival graft placement), while one received only medical treatment (25%, 1/4). The three horses that were enucleated received no medical treatment at CSU-VTH except for post-enucleation treatment. The owners of these horses elected enucleation after the initial ophthalmic examination due to financial concerns and a poor prognosis for healing without aggressive medical treatment and likely surgery. Signalment, cytology results, culture results, treatment and outcome for the 10 fungal ulcerative keratomycosis horses are detailed in **Table 1**.

The seasonal presentation of all ulcerative keratitis horses was as follows (most to least); fall 36% (22/61) > summer 34% (21/61) > spring 21% (13/61) > winter 8% (5/61). Seasonal presentation of only ulcerative keratomycosis horses was (most to least) spring 50% (5/10) > fall 40% (4/10) > summer 1% (1/10) > winter 0% (0/10). Seasonal presentation of non-fungal related ulcerative keratitis horses was (most to least) summer 39% (20/51) > fall 35% (18/51) > spring 16% (8/51) > winter 10% (5/51).

No differences were found between the groups for any environmental factor in the spring season (temperature;

TABLE 2: Bacterial and fungal culture isolates

Bacterial isolates	Number of cases with positive growth on culture (n)
<i>Streptococcus zooepidemicus</i>	9
Non-haemolytic <i>Streptococcus</i>	3
<i>Bacillus</i> species	2
<i>Chryseiomonas luteola</i>	1
<i>Morgenella morgani</i>	1
<i>Penicillium</i> species	1
<i>Proteus mirabilis</i>	1
<i>Providencia stuartii</i>	1
<i>Pseudomonas aeruginosa</i>	1
<i>Pseudomonas fluorescens</i>	1
<i>Pseudomonas mendocina</i>	1
Coagulase negative <i>Staphylococcus</i>	1
<i>Staphylococcus intermedius</i>	1
<i>Streptococcus constellatus</i>	1
Alpha haemolytic <i>Streptococcus</i>	1
No growth	8
Total	34

Fungal isolates	Number of cases with positive growth on culture (n)
<i>Aspergillus</i> species	1
<i>Cladosporium</i> species	1
Dematiaceous fungus	1
Total	3

P = 0.271, humidity; P = 0.271, wind speed; P = 0.242 and elevation; P = 0.465). No P-values could be calculated for summer, fall and winter because of insufficient numbers of keratomycosis cases in those seasons. When all seasonal data were added together in a cumulative analysis, there was a significant difference in wind speed (P = 0.047), with the ulcerative keratomycosis horses being associated with areas of higher wind speed compared to all other ulcerative keratitis horses in this study. No other differences could be found between the groups for environmental conditions (temperature; P = 0.535, humidity; P = 0.542 and elevation; P = 0.289).

Discussion

This study evaluated the prevalence of fungal infection amongst equine ulcerative keratitis cases presented to CSU-VTH's ophthalmology service over a 15-year period. The historical clinical impression was of relatively low rates of fungal infection; however, data were lacking for objective evaluation. The prevalence of fungal involvement in equine ulcerative keratitis at veterinary teaching hospitals has been reported by the University of Florida at 84.6% (Andrew *et al.* 1998), the University of Pennsylvania's New Bolton Center at 24% (Utter *et al.* 2009) and the University of Missouri at 43% in 1983 (Moore *et al.* 1983) and 38% in 1995 (Moore *et al.* 1995). In our study, the prevalence of 16.4% at CSU-VTH is considerably lower than the three other veterinary teaching hospitals' reported data.

We also found that ulcerative keratomycosis cases constituted only 1.1% of the equine ophthalmology patients presented to the CSU-VTH during the study period. This also is lower than other veterinary teaching hospitals, which have reported a range from 2 to 8.62% (Peiffer 1979; McLaughlin

et al. 1992; Grahn *et al.* 1993; Andrew *et al.* 1998; Galán *et al.* 2009; Reed *et al.* 2013). Reviewing the literature, the University of California-Davis had the lowest prevalence at 2% of their equine ophthalmology cases presenting with ulcerative keratomycosis (Reed *et al.* 2013) whereas the University of Cordoba (Spain) had the highest prevalence at 8.62% (Galán *et al.* 2009). California and Colorado both have a dry climate, whereas Cordoba, Spain is known for its high temperatures and humidity⁴.

Proietto and colleagues evaluated environmental risk factors for 390 cases of equine deep stromal abscesses presented to the University of Florida (Proietto *et al.* 2016). Deep stromal abscesses are a form of non-ulcerative keratitis in horses with a likely fungal aetiology (Henriksen *et al.* 2014b). The Proietto *et al.* study found a positive correlation between horses presented with deep stromal abscess and high wind speed, whereas they did not find any association between deep stromal abscess and temperature or humidity (Proietto *et al.* 2016). Our study also found a correlation between wind speed and ulcerative keratomycosis. Higher wind speed will increase the risk of flying material, potentially containing hyphae, that could traumatise the cornea, thereby increasing the risk for ulcerative keratomycosis. It should therefore be recommended to collect cytology samples as well as performing aerobic and fungal cultures from ulcerative keratitis lesions diagnosed following high winds or a storm in Colorado or any other areas with risk of fungal infection; presumptive treatment with a topical antifungal medication such as voriconazole 1% ophthalmic solution may be warranted while awaiting test results.

We found that ulcerative keratomycosis most commonly presents to CSU-VTH in the spring and fall, with no cases presented in the winter months. The effect of season on the presentation of keratomycosis (ulcerative and non-ulcerative/stromal abscesses) cases has been evaluated in multiple studies (Coad *et al.* 1985; Barton 1992; Grahn *et al.* 1993; Andrew *et al.* 1998; Andrew *et al.* 2003; Galán *et al.* 2009; Henriksen *et al.* 2014a). In the southeastern United States, the prevalence of equine keratomycosis is lowest in the summer and more prevalent in the winter and spring (Coad *et al.* 1985; Andrew *et al.* 1998; Henriksen *et al.* 2014b; Proietto *et al.* 2016), while more temperate northern regions see an increase in keratomycosis cases in the late summer and fall (Gaarder *et al.* 1998; Utter *et al.* 2009; Ledbetter *et al.* 2013; Sherman *et al.* 2017). Soil temperatures of 25–30 degrees Celsius are ideal for bacterial and fungal growth in soil (Pietikäinen *et al.* 2005). Fungal growth is impaired at higher temperatures, more so than bacteria (Pietikäinen *et al.* 2005). This effect of temperature on fungal and bacterial growth fits with the typical seasonal pattern of ulcerative keratitis cases – with fewer cases in the summer in the south and more cases in the north. At CSU-VTH, the overall prevalence of ulcerative keratitis cases was highest in the summer (35%, 21/61) and fall (36%, 22/61), whereas the ulcerative keratomycosis cases tended to present in the spring (50%, 5/10) and fall (40%, 4/10). The fungal presentation at CSU-VTH fits with optimal local temperature and humidity parameters for fungal growth for the area of CSU-VTH (Pietikäinen *et al.* 2005). Considering temperature, humidity, wind speed and elevation in the 'All cases' group (Fig 2), temperature is lower, but wind speed seems to be higher in the winter. This is not surprising since CSU-VTH is located at the foothills of the Rocky Mountains and winters in the Rockies are associated with cold weather and snowstorms.

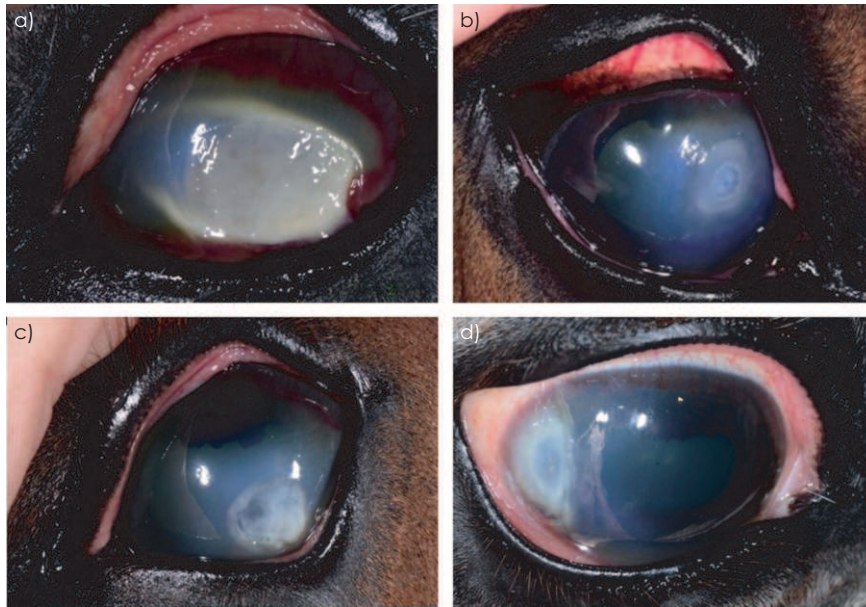


Fig 1: Four equine infectious ulcerative keratitis cases. a) a horse with ulcerative keratomycosis encompassing 60% of the corneal surface. The surface of the ulcer is soft (melting/keratomalacia), and corneal vascularisation is infiltrating the cornea 360 degrees around the limbus. Fungal hyphae were found with cytology. **b)** another horse with ulcerative keratomycosis with an ulcer in the axial aspect of the cornea incorporating 20% of the corneal surface. The ulcer is surrounded by a 3 mm halo of cellular infiltration. Only mild corneal vascularisation is infiltrating the cornea from the dorsal limbus. The pupil is dilated due to atropine treatment. Fungal hyphae were found by cytology. **c)** a horse with infectious ulcerative keratitis positive for *Pseudomonas aeruginosa* by culture. The ulcer is located in the ventral aspect of the cornea taking up 30% of the corneal surface. The ulcer has severe cellular infiltration and keratomalacia (melting). Corneal vascularisation can be appreciated in the dorsal aspect of the cornea. **d)** a horse with infectious ulcerative keratitis culture positive for *Staphylococcus epidermidis* (Coagulase Negative Staph). The ulcer is located in the temporal aspect of the cornea taking up 30% of the corneal surface. The ulcer has severe cellular infiltration and has 20% stromal loss with a dark central aspect – indicating loss of tissue and risk of perforation. Corneal vascularisation can be appreciated in the dorsal and temporal aspect of the cornea.

Difficulties with transportation could also depress the case load and result in low numbers of ulcerative keratitis presentations during the winter months (total n = 5).

Andrew *et al.* (2003) evaluated the conjunctival flora in a herd of horses from Florida and determined that fungus was found at the highest frequency during the fall and winter months, which correlated to the time of year when most fungal cases present to equine hospitals in the southern United States (Andrew *et al.* 2003). Other factors, such as housing (pasture vs. stall), have been evaluated, and there is a significant increase of fungal organisms in the conjunctiva of horses housed in stalls (Whitley *et al.* 1983; Moore *et al.* 1988; Rosa *et al.* 2003). A future study of normal conjunctival flora in horses from the area around CSU-VTH may further elucidate differences in prevalence of bacterial and fungal agents amongst infectious ulcerative keratitis and potentially account for the decreased prevalence of fungal infection. Future climate changes and their impact on the prevalence of ulcerative keratomycosis in horses from the area around CSU-VTH should also be considered. We would be interested in repeating our retrospective study in 10 years to see if the climate changes have had an impact on infectious agents in horses presented to CSU-VTH with infectious ulcerative keratitis.

Of the 10 horses with fungal ulcerative keratitis presented to CSU-VTH, only one resolved with medical therapy (**Table 1**). Three horses were enucleated due to the severity of their ulcerative keratomycosis; three horses had keratectomy and conjunctival graft performed subsequent to failure of medical

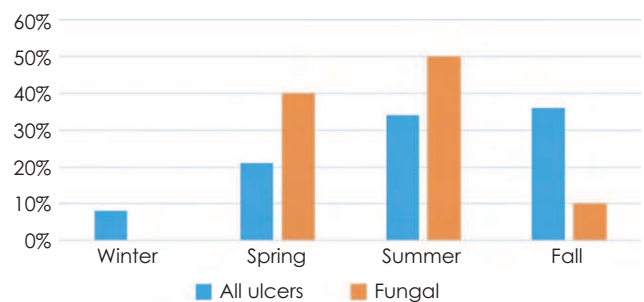


Fig 2: An overview of all ulcerative keratitis cases (all ulcers) and fungal ulcerative keratitis cases (fungal) presented to Colorado State University's Veterinary Teaching Hospital from 2002 to 2017. Notice that the winter months have a noteworthy low number of ulcerative keratitis cases presented to CSU-VTH, and no ulcerative keratomycosis cases were presented in the winter months in this time period.

therapy; and three horses were lost to follow-up. The outcome of ulcerative keratomycosis varies but is generally good, with early aggressive and appropriate medical treatment with topical antifungal medication. Positive outcomes for healing and retention of vision with topical antifungal medication have been reported to be as high as 89–100% (Andrew *et al.* 1998; Utter *et al.* 2010). Our study showed a poor recovery rate for the ulcerative keratomycosis cases presented to CSU-VTH when only medical

management was used, but the data should be interpreted with caution due to the small sample size of ulcerative keratomycosis cases in our study. It could be speculated that no treatment with a topical antifungal medication such as voriconazole 1% prior to presentation at CSU-VTH could be the underlying cause for the poor outcome of the ulcerative keratomycosis horses in our study. A general belief amongst general equine practitioners that keratomycosis in horses is a rare condition in northern Colorado could potentially be the reason why general practitioners choose not to start complicated corneal ulceration cases on an antifungal medication. This study shows that keratomycosis can also occur in horses in this region and fungal infection should be considered when a horse has an infected corneal ulcer, especially in the spring and fall months and/or after a severe storm or high wind speeds. Diagnostic tests such as cytology and culture, as well as topical antifungal medication, are recommended for these horses.

Conclusion

The prevalence of ulcerative keratomycosis in horses presented to CSU-VTH is considerably less than reported by other veterinary teaching hospitals. Spring and fall are the most common seasons for horses to present with ulcerative keratomycosis at CSU-VTH, and there seems to be a low risk for ulcerative keratomycosis in the winter months. Keratomycosis should be considered in horses with ulcerative keratitis following a severe storm or high wind speeds.

Authors' declaration of interests

No conflicts of interest have been declared.

Ethical animal research

This is a retrospective study of horses admitted to Colorado State University Veterinary Teaching Hospital (CSU-VTH). All owners of horses admitted to CSU-VTH have signed a client consent form that gives permission to use information regarding their horse diseases in future studies.

Authorship

This study was performed as an ophthalmology internship project for Dr Martabano with Dr Henriksen as her internship mentor. Drs Henriksen and Martabano have been involved with study design as well as data analysis and interpretation. All three authors have been involved with preparation of the manuscript and final approval of the manuscript.

Manufacturers' addresses

¹Thermo Fisher Scientific, Waltham, Massachusetts, USA.

²Cardinal Health, Denver, Colorado, USA.

³MilliPor Sigma, Burlington, Massachusetts, USA.

⁴www.wunderground.com/history/airport/

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Review Article

Application and indications of magnetic resonance imaging and computed tomography of the equine head

G. Manso-Díaz^{†‡*} , O. Taeymans[§], J. M. García-López[¶]  and R. Weller[‡]

[†]Hospital Clínico Veterinario Complutense, Universidad Complutense de Madrid, Madrid, Spain; [‡]The Royal Veterinary College, Hatfield, Hertfordshire, UK; [§]Dick White Referrals, Cambridgeshire, UK; and [¶]Department of Clinical Sciences, Cummings School of Veterinary Medicine, Tufts University, North Grafton, Massachusetts, USA

*Corresponding author email: gmanso@ucm.es

Keywords: horse; magnetic resonance imaging; computed tomography; head; imaging; skull

Summary

The equine head is an anatomically highly complex area affected by a range of disorders, making the diagnosis of head conditions challenging. Imaging techniques play a crucial role in the diagnostic work-up of head disorders. Tomographic imaging methods, such as computed tomography (CT) and magnetic resonance imaging (MRI) are particularly useful in avoiding problems associated with superimposition of multiple structures in this highly complex region. Both techniques are becoming more widely available in equine medicine. However, the choice between CT and MRI for imaging the equine head is not always straightforward. Each modality has advantages and disadvantages in terms of practicality, costs and diagnostic value for particular problems. The aim of this review is to describe the application of CT and MRI for imaging the equine head and to provide a practical guide for their use in different anatomical structures and clinical indications. This should allow the equine practitioner to make an informed decision on which modality to choose.

Introduction

The equine head anatomy is highly complex, comprising parts of the respiratory, alimentary and nervous systems, in addition to musculoskeletal structures, confined in a relatively small space (König and Liebich 2010). Therefore, many different disorders of potentially major clinical importance can affect the head and result in a wide range of clinical signs, making the diagnosis of these conditions often challenging. Information obtained from physical examination is often insufficient to reach a conclusive diagnosis, hence the valuable role of diagnostic imaging techniques (Tucker and Farrell 2001; Lane 2013).

Advanced imaging modalities, such as computed tomography (CT) and magnetic resonance imaging (MRI), have become more widely available in equine referral institutions. Both modalities are tomographic techniques, producing a stack of image slices and thus avoiding superimposition of structures, which is the major limitation of traditional radiography.

The aim of this article is to provide a review of the use and main indications of MRI and CT for imaging the horse's head.

Basic principles

Computed tomography and MRI are based on fundamentally very different technical principles and both have their advantages and disadvantages.

Computed tomography

Computed tomography is an x-ray-based technique, where an x-ray tube is arranged across multiple detectors within the circle of a CT gantry. This arrangement rotates around the patient while sending out a narrow slice of x-rays whilst the patient is moved through the gantry (in some set-ups the gantry is moved in relation to the patient). This produces a volume of data that gets reconstructed into a stack of thin cross-sectional slices in transverse plane (Fig 1). Being a volume however, data can be displayed in whichever plane using post-processing multiplanar reconstruction software on the workstation or remotely on any off-line computer equipped with medical imaging viewing software (DICOM viewer). Similar to radiographs, different structures appear in varying shades of grey on the resulting image based on their radiodensity (i.e. degree of beam attenuation). On CT, this degree of attenuation can be quantified using Hounsfield Units (HU), which has water as a reference value of 0 HU. Unlike radiographs, CT has the added advantage that each pixel has its own density value, which is not affected by the summation of densities through superimposition or the thickness of the tissue as is the case in radiography. The use of different post-processing filters or windows makes it possible to 'enhance' specific tissues and match their attenuation values to the available shades of grey of the computer monitor (256). Most acquisitions are reconstructed at minimum in a 'bone window' and a 'soft tissue window' (Fig 1).

Computed tomography of the equine head can be performed either with the horse under general anaesthesia or with the horse standing (usually under sedation; Fig 2) (Barbee *et al.* 1987; Solano and Brawer 2004; Kinns and Pease 2009; Saunders *et al.* 2011; Dakin *et al.* 2014; Porter and Werpy 2014). Two different CT set-ups are used for scanning in standing position: either the horse moves in relation to the static CT gantry with the help of an air skate mounted platform or the CT gantry moves in relation to the patient (Saunders *et al.* 2011; Dakin *et al.* 2014; Porter and Werpy 2014). In both scenarios the gantry opening has to be adjusted to the horse's height either by elevating the CT in relation to the horse or lowering the horse in relation to the CT.

Magnetic resonance imaging

Magnetic resonance imaging images are the result of the stimulation of magnetised tissues by radio waves and capturing the returning radio waves from the stimulated tissues. Depending on the type of emitted radio wave (duration,

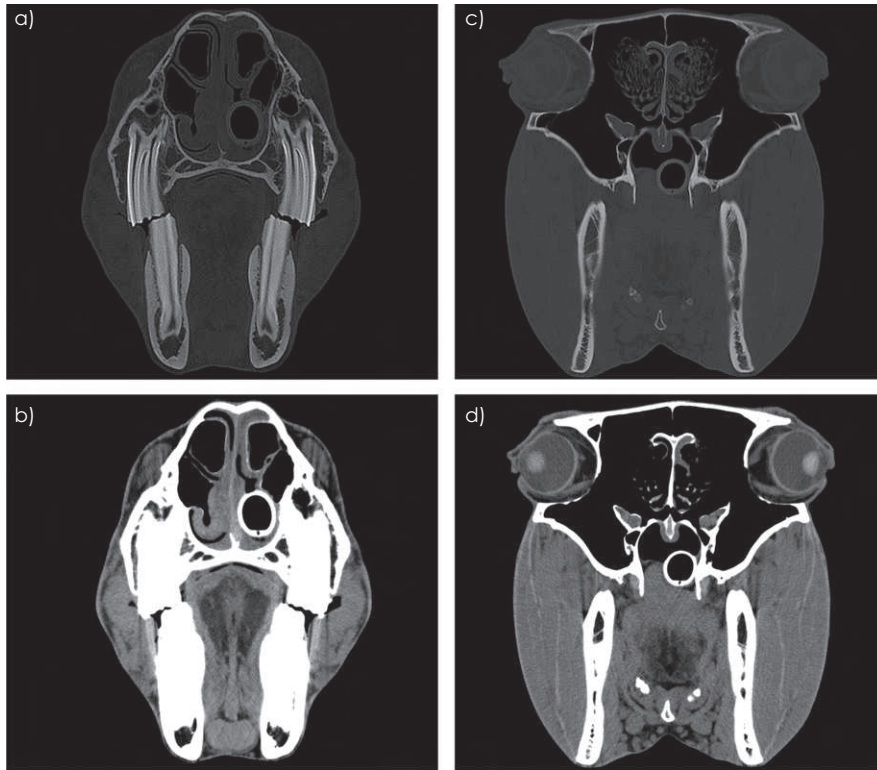


Fig 1: Transverse computed tomographic images at the level of the second maxillary cheek teeth (07s) (a,b) and the orbit (c,d) using bone (a,c) and soft tissue (b,d) windows.



Fig 2: Positioning of the horse for performing a computed tomography examination of the head under general anaesthesia (a,b) and in standing position (c,d).

phase, frequency) and the time at which the returning wave is captured, different sequences can be obtained. The sequences selected for head examinations in horses usually follow the protocols used in small animals, including T2-weighted, T1-weighted, fluid attenuation inversion recovery (FLAIR), T2*-weighted gradient-recalled echo (GRE) and single-tau inversion recovery (STIR) (Fig 3). Depending on the selected sequence, different tissues appear in different shades of grey based on their molecular composition. This results in a high contrast resolution (ability to differentiate tissue types) which represents the main advantage of MRI. Besides different sequences, MRI studies usually include several different acquisition planes, including transverse, dorsal and sagittal planes (Fig 4). A separate acquisition is needed for each different sequence, as well as for each different plane, making MRI studies considerably more time-consuming than CT acquisitions. Computed tomography scanning times are around 30–60 s, depending on the parameters used, with a set-up time of around 15 min for a standing scan. On the contrary, each MRI sequence lasts approximately 3–5 min. A basic, routine, MRI examination therefore takes at least 40–50 min (set-up time of 10–15 min).

Equine head MRI examinations can only be performed with the horse anaesthetised (Fig 5) (Kraft and Gavin 2001; Tucker and Farrell 2001; Werpy 2007; Murray 2011). Correct positioning of the horse in the MRI gantry can be challenging in short-necked, large horses, as well as in very small horses. The main measurements to consider when planning performing a head MRI in a horse include the length of the neck and the distance between the shoulders. This limitation is a big issue when imaging the brain, where in some

instances the caudal aspect of the cerebellum and medulla oblongata may not be included in the field of view (Fig 6) (Tucker and Holmes 2011).

The use of contrast media in the equine head

Further enhancement of structures can be achieved by using contrast media in both modalities. Contrast-enhanced images provide better tissue delineation and differentiation, thereby improving diagnostic capabilities (Fig 7). Iodinated nonionic contrast media are the most commonly used in CT, while organic chelates of gadolinium are used in MRI (Nelson *et al.* 2017). These media can be administered intravenously or intra-arterially, depending on the application.

The recommended intravenous dose of iodinated (I) contrast for CT is 600–880 mg I/kg bodyweight and gadolinium for MRI is 0.01 mmol/kg body weight, which in a 500 kg standard adult horse would significantly increase the costs of the procedure. Minimising the volume of contrast administered is desirable to reduce cost. The use of an intra-arterial route in CT studies allows administration of a low-dose of contrast in a targeted area, which represents less than 50% of the intravenous dose. Studies have shown similar degrees of soft tissue enhancement compared with systemic intravenous administration (Carmalt and Montgomery 2015; Crijns *et al.* 2016). In MRI, different doses have been described in the literature based on empirical experiences (Ferrell *et al.* 2002; Werpy 2007; Judy 2011). Halving the dose to 0.005 mmol/kg body weight resulted in similar subjective lesion detection compared to the full dose and has therefore been proposed as an appropriate dose in clinical settings (Saveraid and Judy 2012).

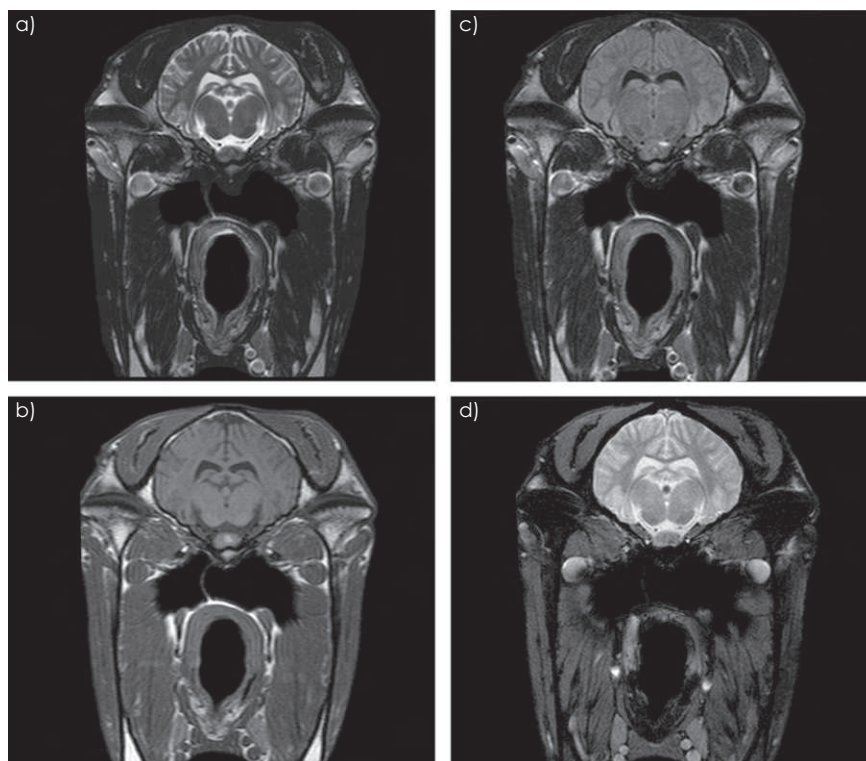


Fig 3: Comparison of different transverse magnetic resonance sequences of the head at the level of the temporomandibular joint. a) T2-weighted; b) T1-weighted; c) FLAIR and d) T2*-weighted gradient-recalled echo.

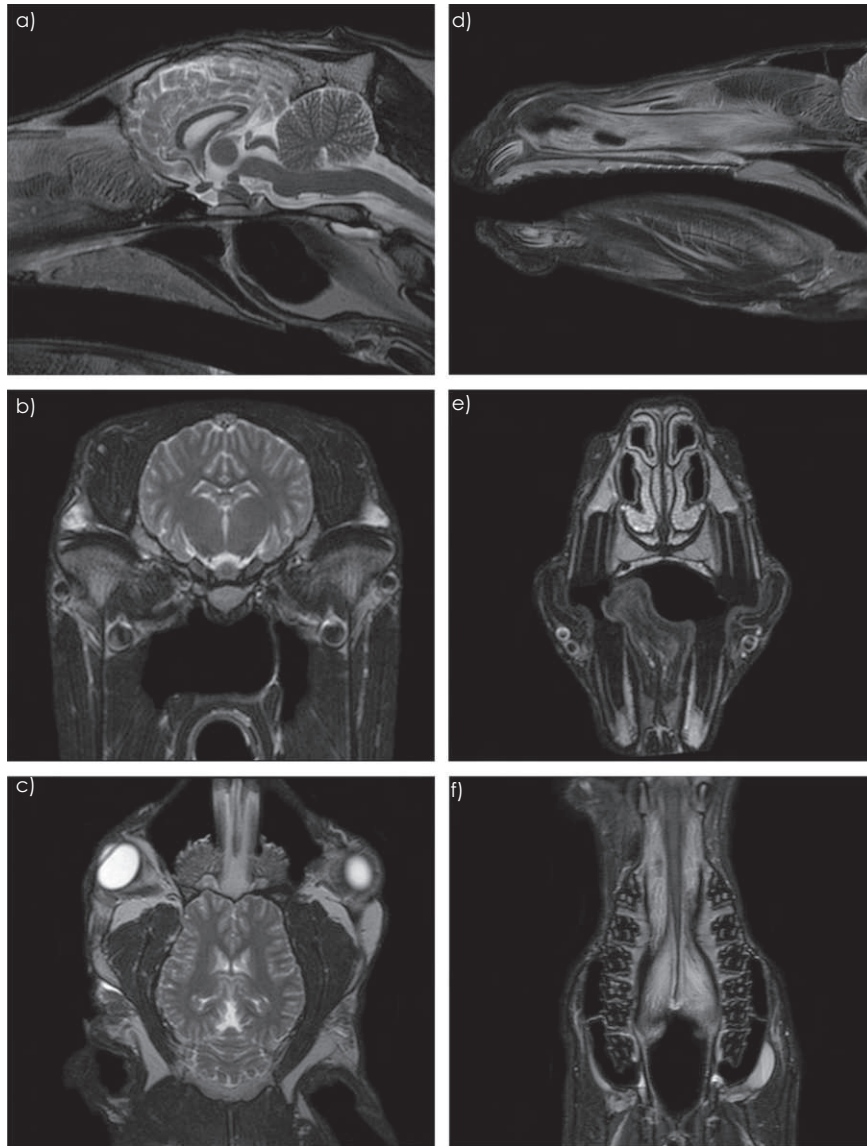


Fig 4: T2-weighted magnetic resonance images of the head at the level of the brain (a–c) and the nasal passages (d–f) on sagittal (a, d), transverse (b,e) and dorsal (c,f) planes.

Costs implications

Both imaging modalities are substantially more expensive than, for example, radiographs. Performing a procedure under general anaesthesia carries a considerable increase in costs due to the anaesthesia itself, but also due to the additional expenses of hospitalisation and the length of the procedure. The purchase cost of CT and MRI scanners differs as well, with MRI scanners generally being more expensive to buy, to install and maintain. Due to the need for general anaesthesia, duration of examination, duration of hospitalisation and equipment overheads, MRI examinations are generally more expensive than CT examinations.

Choice of MRI or CT for the equine head

The choice between CT and MRI for imaging the equine head is not always straightforward. A tentative clinical

diagnosis based on a thorough clinical examination is paramount in deciding which modality may be the most useful. Other considerations, such as the risk of general anaesthesia, finances and logistics, will also influence the decision.

Imaging of the nasal passages and paranasal sinuses

Radiographic diagnosis of disorders of the nasal passages and paranasal sinuses in the horse is challenging due to the anatomical complexity of this region and the inherent lack of soft tissue contrast. In some cases, no radiographic abnormalities can be detected at all or pathologies cannot be differentiated since their radiographic features are very similar. A recent study described low to moderate sensitivity for radiographic identification of sinusal disease (Manso-Díaz



Fig 5: Positioning of the anaesthetised horse for performing a magnetic resonance examination of the head.

et al. 2015b). Depending on the sinus affected, it can however yield a high specificity. The lowest sensitivity using radiographs was seen in the sphenopalatine (16.7%) and the ventral conchal (43.5%) sinuses (Manso-Díaz *et al.* 2015b). In comparison MRI and CT can show the different sinus compartments and their anatomical variations in great detail thanks to the tomographic characteristics of the images they produce (Arencibia *et al.* 2000; Smallwood *et al.* 2002; Probst *et al.* 2005; Brinkschulte *et al.* 2013; Kaminsky and Bienert-Zeit 2014; Tucker *et al.* 2016). Therefore, identification of individual sinus involvement can be better performed using either tomographic technique. Magnetic resonance imaging is superior to CT for soft tissue structures depiction, such as mucosal lining or the nasal plexus, especially on T2-weighted images; whereas CT produces images of high quality of the thin osseous walls of the paranasal sinuses (Kaminsky *et al.* 2016) and provides very high detail of the anatomy of the nasal conchae and their bullae (Kaminsky and Bienert-Zeit 2014; Liuti *et al.* 2016).

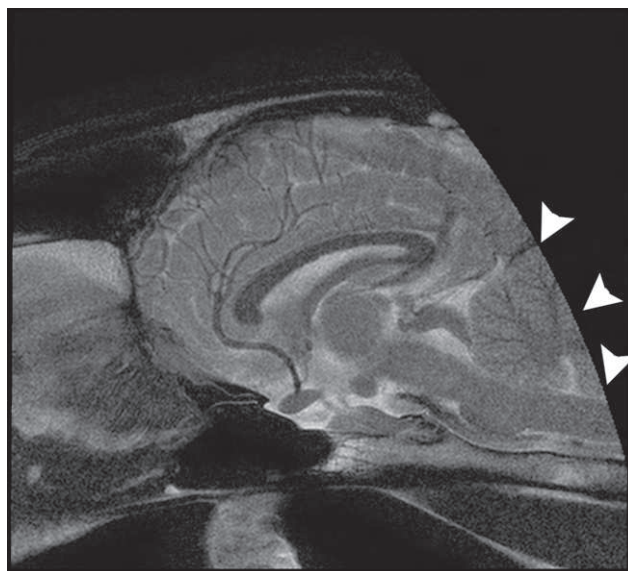


Fig 6: Sagittal T2-weighted magnetic resonance image of the brain in which the caudal part of the cerebellum and the medulla oblongata has not been included in the field of view due to the size of the patient (arrowheads).

Mild alterations of the mucosal lining of the nasal passages and paranasal sinuses may represent the only finding of sinusitis and they are only visible with MRI or CT unlike radiology. These alterations are characterised by thickening of the mucosa, changes in signal intensity in T2-weighted images on MRI and mild enhancement after contrast injection (Manso-Díaz *et al.* 2015b). Computed tomography might then be better in cases of subtle lysis of the thin sinusal bony walls, which is typically observed in chronic sinusitis, expansile masses, ethmoid haematomas or tumours (Cehak *et al.* 2008; Barker *et al.* 2013).

Both modalities are superior to radiography in identifying the nature of the disease, for example diagnosing sinusal cysts, progressive ethmoid haematomas, abscesses, neoplasia or sinusitis (Fig 8) (Robertson *et al.* 2002; Henninger *et al.* 2003; Annear *et al.* 2008; Barnett *et al.* 2008; Bischofberger *et al.* 2008; Cilliers *et al.* 2008; Veraa *et al.* 2009a; Cissell *et al.* 2012; Textor *et al.* 2012; Tessier *et al.* 2013; Maischberger *et al.* 2014; Fjordbakk *et al.* 2015; Manso-Díaz *et al.* 2015a,b). In cases of homogenous soft tissue masses being surrounded by fluid, e.g. a sinus cyst with secondary sinusitis, CT may show similar attenuation values for both, making differentiation between them difficult (Fig 8c,g). Measuring the HU may help to characterise tissues of different attenuation, such as the sinus fluid and the cystic content. Injection of intravenous contrast medium may also improve lesion delineation on CT. Moreover, the use of an intra-arterial route versus intravenous route would potentially allow evaluation of further lesions that are characterised by increased blood flow. In comparison, MRI evaluation of images have higher soft tissue contrast, resulting in different signal intensities for each type of soft tissue and fluid making it easier to delineate soft tissue masses (Manso-Díaz *et al.* 2015a).

The high bony detail of CT images is particularly useful for assessing the osseous canals that cross the nasal passages and paranasal sinuses, such as the infraorbital canal and the

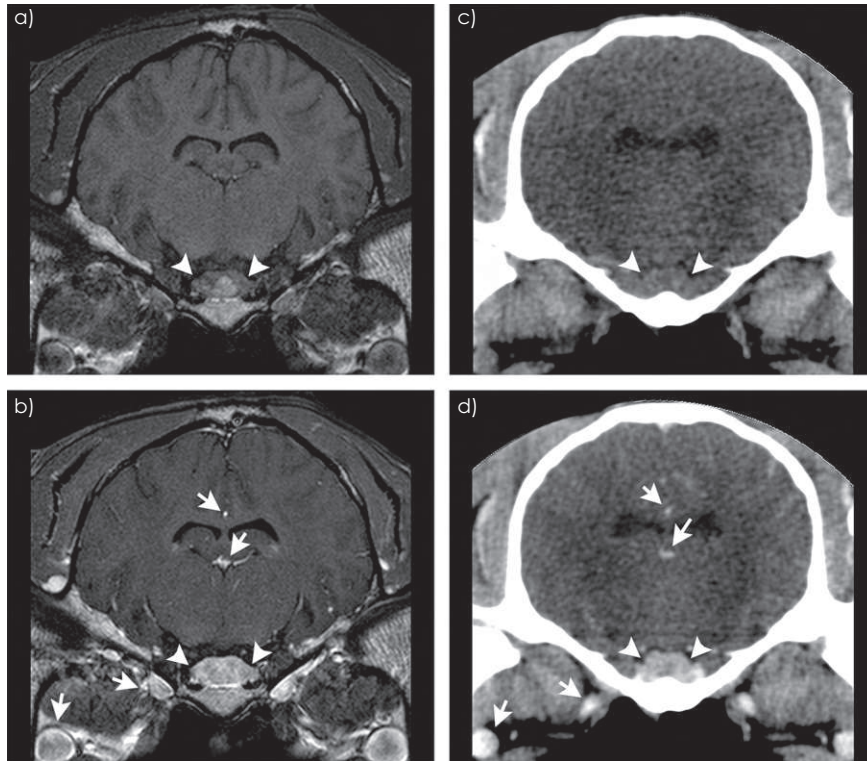


Fig 7: Transverse T1-weighted magnetic resonance (a,b) and computed tomographic (c,d) images of the brain at the level of the pituitary gland. Note the enhancement of the pituitary gland (arrowheads) and blood vessels (arrows) on postcontrast images (b,d) compared with the precontrast images (a,c).

nasolacrimal duct (Kaminsky *et al.* 2016). The first is of clinical importance as lesions of the infraorbital nerve can be associated with headshaking (Roberts *et al.* 2009; Fiske-Jackson *et al.* 2012). However, mild changes within the nerve are difficult to detect on CT images, whereas MRI will potentially show them (Beltran *et al.* 2016). Computed tomography can also delineate the osseous anatomy of the nasolacrimal duct and it is possible to assess the patency of its lumen by injecting contrast medium (dacryocystography) (Nykamp *et al.* 2004). Diseases of the nasolacrimal duct commonly manifest themselves as an obstruction. Several causes can lead to such an obstruction and radiography may be able to identify the cause, however, cross sectional modalities, specially CT, can delineate this duct without superimposition of surrounding structures (Cleary *et al.* 2011; Rached *et al.* 2011; Manso-Díaz and Taeymans 2012). Nonetheless, MRI should be considered as a potential alternative for the evaluation of the nasolacrimal duct (Manso-Díaz *et al.* 2015c).

Either MRI or CT will be required when radiographic findings are inconclusive. In the majority of conditions CT is commonly preferred due to shorter scan times, better availability, as well as the possibility of performing the CT examination in the standing patient (Kinns and Pease 2009; Dakin *et al.* 2014; Kaminsky *et al.* 2016). The latter avoids the necessity for general anaesthesia, both decreasing risks and costs (Dakin *et al.* 2014). Another main advantage of shorter scan times with CT results in the possibility of performing both procedures, CT acquisition and surgery, under the same general anaesthetic. However, limited MRI protocols using 3D

GRE sequences could equally decrease the anaesthesia time and would eliminate the necessity of acquiring sequences in different planes by using multiplanar reconstructions. These could be considered as a good alternative where CT is not readily available. An important word of caution is however warranted when combining imaging and surgery during the same anaesthetic, as this will inevitably lead to interpretation errors when reading a large number of images under time pressure. In this respect, MRI is better as the images become gradually available after each sequence, with an average number of images in the range of a few hundred, whilst CT results in hundreds to thousands of images obtained at once.

Imaging of dental disease

Approximately 22% of horses with sinonasal disease have underlying dental disease (Tremaine and Dixon 2001), as there is a close relationship between maxillary cheek teeth and the paranasal sinuses. Radiography is the imaging technique of choice for evaluating dental structures in equine general practice, as it can be performed under field conditions. This technique has moderate sensitivity (76%) and high specificity (90%) for diagnosis of periapical infections (Townsend *et al.* 2011). However, radiographic signs detectable in the early stages of apical infection (e.g. widening of the periodontal space and loss of the lamina dura) are less reliable (Townsend *et al.* 2011). Moreover, assessment of the internal tooth anatomy cannot be achieved with radiography. Computed tomography is able to distinguish with high detail the internal structures of the

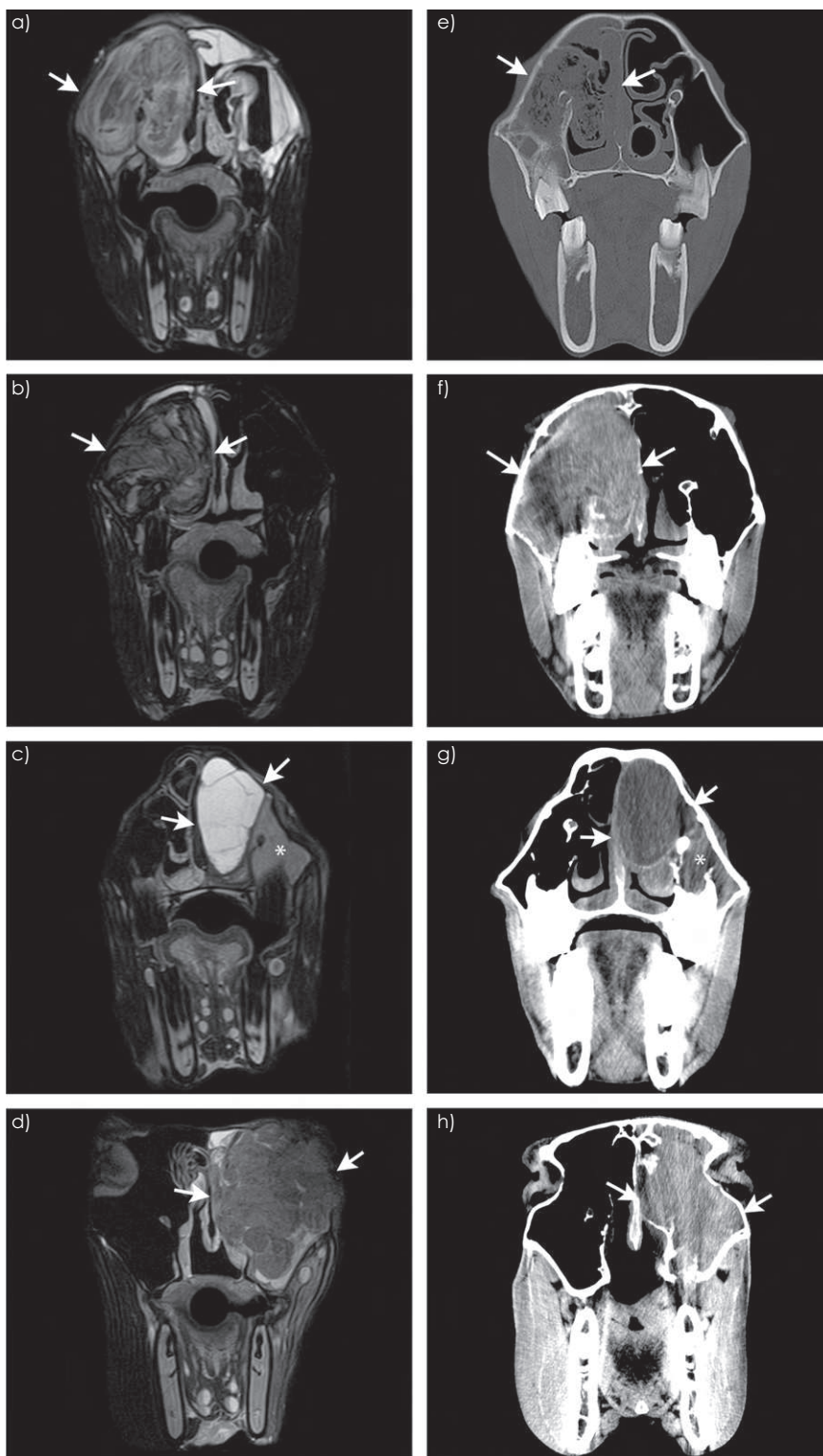


Fig 8: Comparison of transverse T2-weighted magnetic resonance (a–d) and computed tomographic (e–h) images of different sinonasal diseases. a and e show the presence of inspissated pus in the right paranasal sinuses (arrows), in (a) there is also moderate fluid accumulation in the left side. An ethmoid haematoma is seen in the right paranasal sinuses in b and f (arrows), causing deviation of the nasal septum towards the left side. In c and g, a sinus cyst (arrows) is identified within the left paranasal sinuses surrounded by secondary sinusitis (asterisk). d and h) show two different examples of neoplasia within the left paranasal sinuses (arrows).

tooth and its surrounding structures, and is therefore considered the gold standard for detecting lesions of the enamel, infundibulum, pulp cavity, root, lamina dura, periodontal space and alveolar bone (Fig 9a,b) (Henninger *et al.* 2003; Veraa *et al.* 2009b; Windley *et al.* 2009; Bühler *et al.* 2014). A recent study compared radiographic, CT and histological features of maxillary cheek teeth with apical infection, showing a 97% agreement between CT diagnosis and the presence of pathological changes in the extracted teeth, confirming the high diagnostic accuracy of CT (Liuti *et al.* 2018). Not all dental tissues can be visualised with MRI due to their molecular composition. Magnetic resonance imaging relies on the presence of mobile hydrogen atoms which are restricted in enamel, dentin, cement and cortical bone. The same principle is applied to air, which is lacking hydrogen atoms, resulting in dark areas (signal voids) in the oral cavity and paranasal sinuses. The lack of signal is a limiting factor in the use of MRI for assessing these structures (Fig 9b,d) (Gerlach *et al.* 2013; Schoppe *et al.* 2017). Magnetic resonance imaging can depict certain dental diseases, such as advanced pulpitis, periapical infections and large fractures (Fig 10) (Manso-Díaz *et al.* 2015a). Studies using a 9.7 T magnet show that very specific sequences (e.g. ultra-short spin echo time and zero spin echo time) are able to depict both soft and hard (enamel, dentin and cementum) dental tissues in extracted equine and human teeth, but clinical application of this is currently not realistic (Hövenner *et al.* 2012).

Imaging assessment following loss or removal of a tooth is often necessary and can present a challenge. Presence of small dental fragments, maxillary or mandibular fractures, sequestra formation or the development of oronasal or oromaxillary sinus fistula are common. Computed tomography has been proposed to be the most useful imaging modality to identify the problem, its extent and aid in pre-surgical planning (Manso-Díaz *et al.* 2015b; Hargreaves and Dixon 2018).

Imaging of the skull

Trauma to the head is relatively common in horses and, therefore, skull fractures are often identified. They are difficult to assess on radiographs because of the complex morphology of the skull bones and overlapping of numerous structures. Therefore, numerous tangential views are usually required (Gibbs and Lane 1987; Ramirez *et al.* 1998; Ramirez and Tucker 2004; Gerding *et al.* 2014). In addition, involvement of the surrounding soft tissues (e.g. eye globe or brain) cannot be detected on radiographs. Ultrasonography is a useful imaging tool for evaluating the bone surface, therefore in some instances can be used for diagnosing skull fractures, specially to the most superficial bones. Although most skull fractures can be diagnosed radiographically, CT is superior in identifying the exact extent and configuration of osseous changes, and allows detailed assessment of the involved structures, such as the infraorbital canal, nasolacrimal duct, cranial nerve foramina, calvarium, temporomandibular joint, teeth or airways (Crijs *et al.* 2019). Although MRI is very sensitive at identifying bone marrow lesions, flat bones and petrous temporal bones are shown as black areas due to signal void on MRI. Subtle lesions affecting these bones are therefore difficult to identify on MRI (Scrivani 2013). The presence of gas within the airways (paranasal

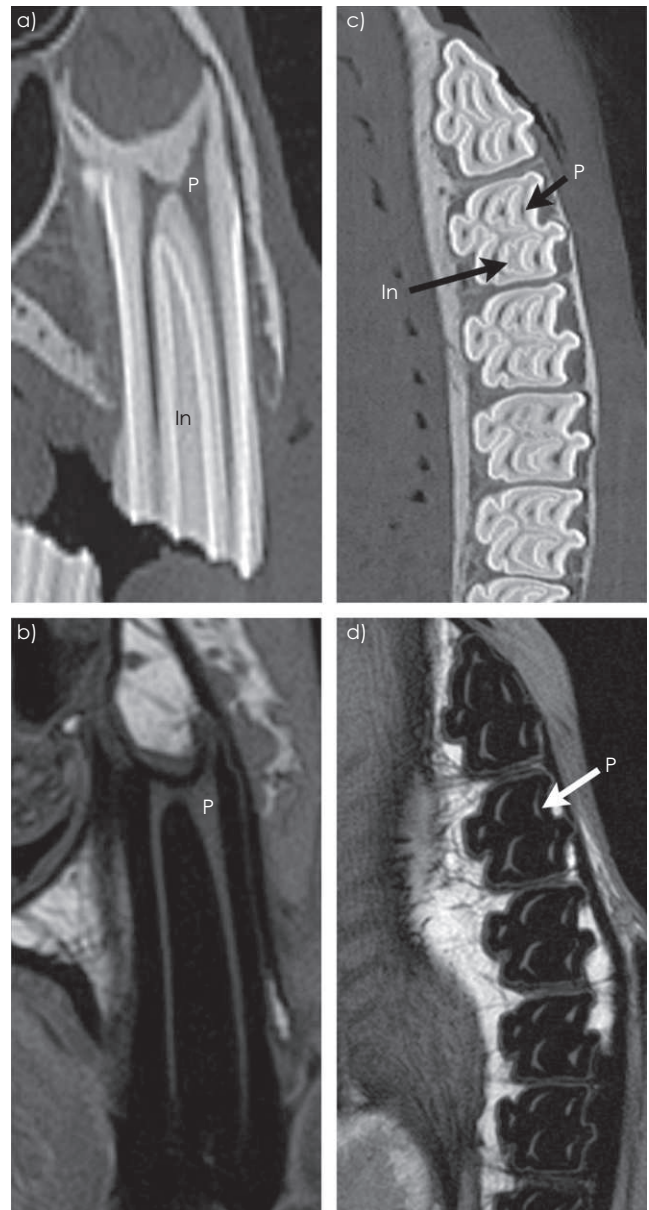


Fig 9: Transverse (a and b) and dorsal (c and d) computed tomographic (CT) (a and c) and T1-weighted magnetic resonance (MR) (b and d) images of the maxillary cheek teeth. In CT images distinction of the different dental tissues is possible, while in MR images enamel, dentin, cement, lamina dura and air are hypointense (dark). P-pulp cavity; In-infundibulum.

sinuses, pharynx and guttural pouches) surrounding these flat bones complicate detailed assessment of osseous structures with MRI even further. Hence CT is considered the method of choice for the assessing osseous structures of the head (Manso-Díaz *et al.* 2015b; Crijs *et al.* 2019).

Imaging of the temporomandibular joint

Computed tomography and MRI anatomy of the temporomandibular joint (TMJ) has been extensively studied (Rodríguez *et al.* 2008, 2010). Both modalities allow a thorough examination of most structures in this area.



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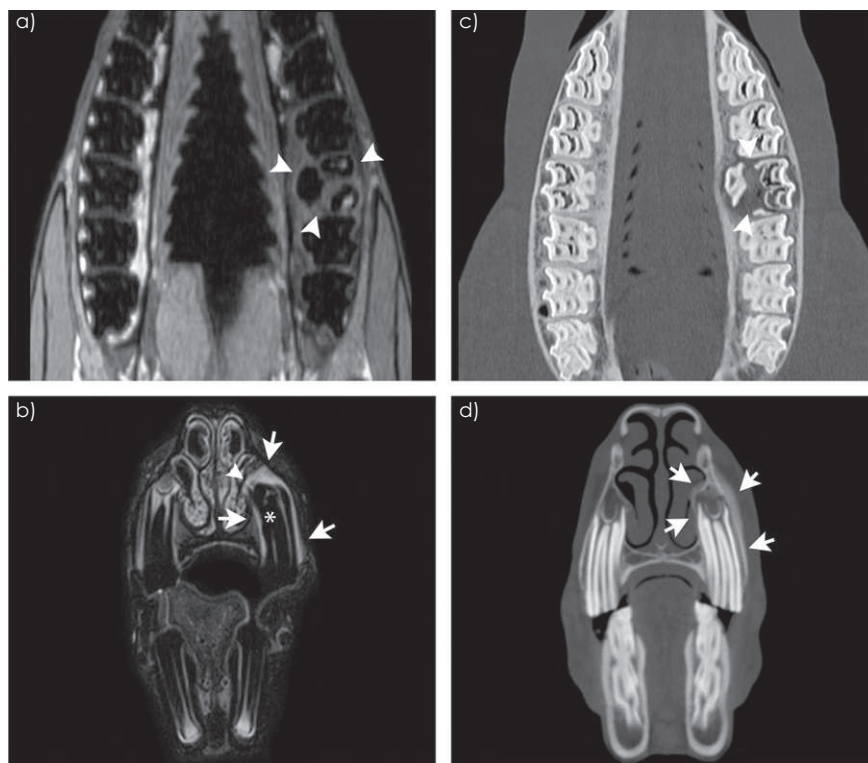


Fig 10: Comparison of magnetic resonance (a,b) and computed tomographic (CT) (c,d) images of different dental diseases. a) Dorsal T1-weighted image of the maxillary arcade with a comminuted crown fracture of 109 (arrowheads). b) Transverse T2-weighted image of the nasal passages, there is a hyperattenuating band surrounding the crown and apices of 207 (arrows) and the left ventral nasal concha is partially obliterated by the root (arrowheads), consistent with periapical infection. There is loss of visualisation of the pulp cavity of 207, representing pulpitis (asterisk). c) Dorsal CT image of the maxillary arcade with a sagittal fracture of 208 (arrowheads). d) Transverse CT image of the nasal passages, there is widening of the periodontal space of 207 and moderate smooth periosteal reaction (arrows), consistent with periapical infection.

Computed tomography is an excellent method for detailed assessment of the bony structures, but poorly delineates the soft tissue structures associated with the TMJ, such as the articular disc (Rodríguez *et al.* 2008). Conversely, MRI is considered the best modality to evaluate the articular cartilage, the articular disc and synovial pouches (Rodríguez *et al.* 2010). Understanding the anatomy and anatomical variations of this region is essential for establishing the clinical significance of imaging findings. A recent study described that the TMJ undergoes age-related remodelling, both in terms of shape and CT attenuation alterations early in life. Presence of hypoaattenuating regions consistent with osseous cyst-like lesions in the mandibular condyle and linear hyperattenuating regions consistent with soft-tissue mineralisation within the articular disc can be found in asymptomatic horses. The latter is highly correlated with age and the clinical significance of these changes is unknown (Carmalt *et al.* 2016).

Intra-articular TMJ disease has been reported as a cause of facial pain and dysphagia in horses, with published studies primarily reporting septic arthritis (Barnett *et al.* 2014). Osteoarthritis can also be identified in this joint but is very infrequently reported as clinically relevant. Other diseases affecting the TMJ include trauma (fracture or subluxation) or neoplasia (Manso-Díaz *et al.* 2015b). Use of advanced imaging techniques (MRI and CT) is recommended when TMJ

pathology is suspected (Smyth *et al.* 2017) since the diagnostic value of radiography is limited (Fig 11).

Imaging of the temporo-hyoid apparatus

The hyoid apparatus consists of a series of small and thin bones that suspend the tongue from the temporal bone. Computed tomography allows assessment of each hyoid bone as well as their junctions. Although it is possible to evaluate the hyoid apparatus using MRI, CT is considered the gold standard (Chalmers *et al.* 2006; Hilton *et al.* 2009). Temporohyoid osteoarthropathy (THO) is the most common disease affecting this area, however, trauma (fracture or subluxation) or congenital abnormalities have also been previously reported (Manso-Díaz *et al.* 2015b; Dixon *et al.* 2017a). A significant association between horse's age and the presence of bilateral degenerative changes within the temporohyoid articulation has been observed, which may predispose horses to the development of THO (Naylor *et al.* 2010b). Main CT features associated to THO include: osseous proliferation of the stylohyoid bone and temporohyoid articulation, thickening of the ceratohyoid bone and proliferation of its articulation, fracture of the petrous temporal and stylohyoid bones, fluid accumulation within and remodelling of the tympanic bulla, as well as narrowing and mucosal thickening within the external ear canal (Hilton *et al.* 2009).

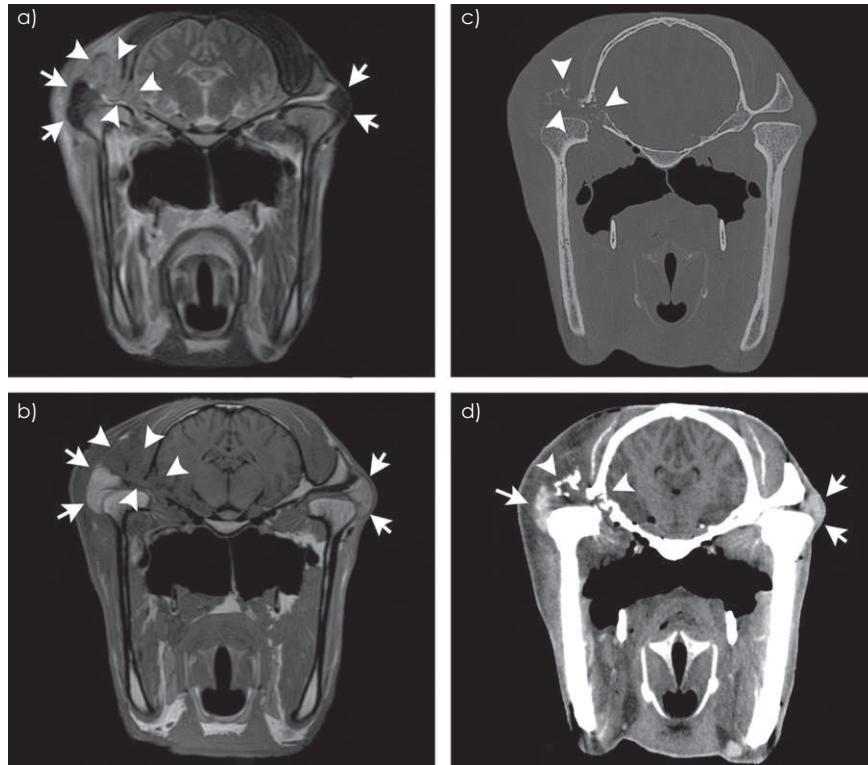


Fig 11: Comparison of transverse T2-weighted (T2W) (a) and T1-weighted (T1W) (b) magnetic resonance and bone (c) and soft tissue (d) windows computed tomographic (c,d) images of a grey horse. There is a parotid carcinoma that caused severe lysis of the temporal bone (arrowheads), bone destruction is better evaluated with CT, however soft tissue involvement is better seen with MRI. Multiple melanomas (arrows) are also identified; they are hypointense on T2W and hyperintense on T1W magnetic resonance images and show high attenuation values on computed tomography images.

Magnetic resonance imaging has been used in selected cases of temporo-hyoid disease. Observed abnormalities included fluid accumulation adjacent to the proximal portion of the stylohyoid bone and wall of the guttural pouch, consistent with haemorrhage or inflammation, structural changes of the middle and inner ear and evidence of fracture of the stylohyoid or petrous temporal bone (Walker *et al.* 2002). This imaging modality may be preferred when further evaluation of the inner ear, peripheral nerves and the brain is needed (Fig 12).

Intracranial imaging

Intracranial lesions are relatively uncommon in the horse and the diagnostic value of radiography and ultrasonography is usually very limited. Notable exceptions are the identification of pneumocephalus with radiographs and hydrocephalus in neonates with ultrasound (Dunkel *et al.* 2012; Archer 2014).

Intracranial lesions may either have an intra-axial, extra-axial or intraventricular localisation (Divers 2006). Extra-axial disorders are localised outside the brain parenchyma, the most common examples in equine practice include trauma with extradural haemorrhage, abscesses and tumours, e.g. pituitary masses, melanomas or intracranial extension of orbital or nasal tumours (Feige *et al.* 2000; Robertson *et al.* 2002; Covington *et al.* 2004; Dyson *et al.* 2007; Matiasek *et al.* 2007; Beccati *et al.* 2011; Morressey *et al.* 2011; De Zani *et al.* 2013; Johns *et al.* 2014; Maischberger *et al.* 2014). The most common intraventricular lesions are cholesterol

granulomas. Although MRI has higher soft tissue contrast resolution than CT, both imaging modalities can potentially depict these types of lesions (Fig 13a,b,e,f). The use of contrast medium is however necessary for detailed classification, delineation of the lesion and assessing its relationship with the surrounding tissues in both modalities (Fig 7). Magnetic resonance imaging might show associated changes within the brain, such as oedema or malacia, which are not clearly identifiable using CT; whereas if the lesion involves osseous structures, CT would be able to better delineate them (Fig 13c,d,g,h).

Intra-axial lesions comprise pathologies localised within the brain parenchyma and are very uncommon in horses. Computed tomography would likely fail showing these type of lesions (Lacombe *et al.* 2010), and MRI should therefore be considered as the gold standard in studying the equine brain parenchyma (Fig 13d,h) (Manso-Díaz *et al.* 2015a).

The vast majority of horses with recurrent seizure-like activity and normal neurological examination do not have visible MRI abnormalities (Manso-Díaz *et al.* 2015a). Therefore, cryptogenic epilepsy is the most likely differential diagnosis in these cases (Lacombe *et al.* 2012, 2014). Although MRI findings are negative in most of these cases, performing MRI is still a vital part of their work-up, as it helps ruling out morphological causes for seizures, such as tumours.

Cranial nerve abnormalities are also uncommon in horses, and only a few references describing lesions within the optic and trigeminal nerve are available (Manso-Díaz *et al.* 2015a; Beltran *et al.* 2016). Recent studies compared CT and MRI for

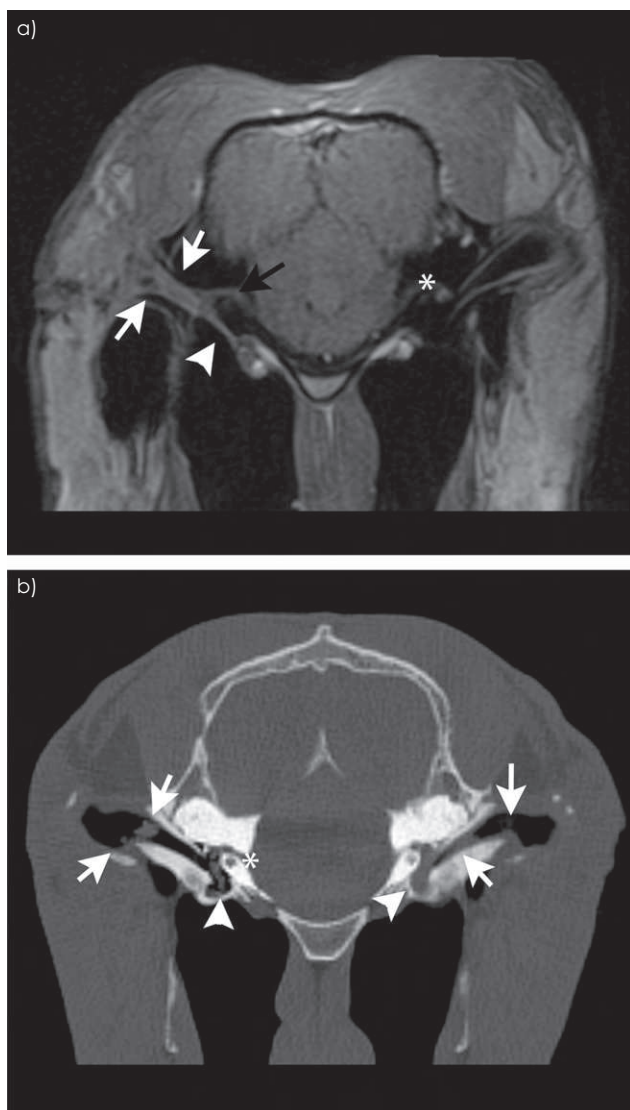


Fig 12: Transverse T1-weighted post-contrast magnetic resonance (a) and computed tomographic (b) images at the level of the internal acoustic meatus (asterisks) of two different horses with otitis externa (white arrows) and media (arrowheads). The right facial nerve on image a shows mild diffuse contrast enhancement (black arrow), consistent with facial neuritis.

anatomical identification of normal cranial nerves and concluded that MRI allowed for excellent visualisation of most cranial nerves, whereas CT allowed for detailed visualisation of the osseous canals and foramina and occasionally the nerves themselves (Gonçalves *et al.* 2015; Dixon *et al.* 2017b). The transverse plane was found to be the most useful plane and the acquisition of MRI high-definition sequences with thin slice thickness improved nerve identification (Fig 12) (Dixon *et al.* 2017b).

Imaging of extracranial soft tissues

Extracranial soft tissue disorders of the head are relatively common and they usually involve the tongue, salivary glands, lymph nodes, pharynx and orbit (Dixon 1991; Dixon *et al.* 2014).

Ultrasound is often the first imaging method employed for assessing these structures. The use of CT and MRI is usually restricted to masses that need further evaluation for diagnostic or treatment planning purposes. Compared with ultrasound, CT and MRI provide better coverage of the entire lesion on the images (larger field of view), allow using multiple imaging planes (or even 3D models) and allow visualisation of tissues covered by gas or bone (Fig 14b,d) (Ramirez and Tucker 2004; Wollanke *et al.* 2006; Gerlach *et al.* 2007; van den Top *et al.* 2007; Jakesova *et al.* 2008; Pekarkova *et al.* 2009; Naylor *et al.* 2010a; Schneider *et al.* 2010; Santos *et al.* 2012; Bienert-Zeit *et al.* 2014; McConnell *et al.* 2014). The use of contrast media aids in determining the exact lesion demarcation and assessment of potential invasion into the surrounding tissues.

The orbit includes the globe, nerves and extraocular muscles that are surrounded by extraorbital fat, which provides good contrast and allows differentiation of soft tissue orbital structures on CT. Both CT and MRI can be used for evaluation of orbital cellulitis or abscesses, optic neuritis, neoplasia and orbital trauma. They are especially useful for assessing retrobulbar space-occupying lesions, as they allow detailed characterisation of the mass, but also provide significant diagnostic and prognostic information by determining the presence of nasal or intracranial extension (Fig 14a,c). These techniques also allow evaluation of intraocular structures such as identifying lens luxation, intraocular haemorrhage, retinal detachment and loss of normal shape or air within the eye suggesting a ruptured globe (Ramirez and Tucker 2004). Computed tomography is advantageous over MRI in that it has a greater ability to detect osseous abnormalities and is superior at providing information for planning orbital surgery (Gerding *et al.* 2014). MRI provides better overall resolution of the retrobulbar tissues but may fail to detect defects in cortical bone or soft-tissue mineralisation.

Conclusions

Magnetic resonance imaging can be considered the gold standard for studying the central nervous system, including the brain and cranial nerves, as well as the extracranial soft tissues, including the orbit, lymph nodes, blood vessels, muscles and salivary glands. Magnetic resonance imaging may also be adequate for studying the nasal passages and paranasal sinuses, and it is particularly useful for differentiating space-occupying lesions, as its high contrast resolution allows good differentiation of different soft tissue types. Diagnostic usefulness of MRI in cases of dental disease is limited to lesions involving the pulp cavity, the periodontal space, the lamina dura and the bone marrow of the surrounding alveolar bone.

Computed tomography can be considered the gold standard for studying the skull bones, the temporomandibular joint, the temporohyoid articulation and teeth. It is also adequate for studying the nasal passages and paranasal sinuses, being particularly useful for identifying subtle nasal and sinus osseous wall lesions. Computed tomography can identify intraventricular and extra-axial brain lesions, however, the diagnostic value of CT in cases of intra-axial lesions is limited. Extracranial soft tissue lesions can be identified with CT, but with less detail than with MRI.

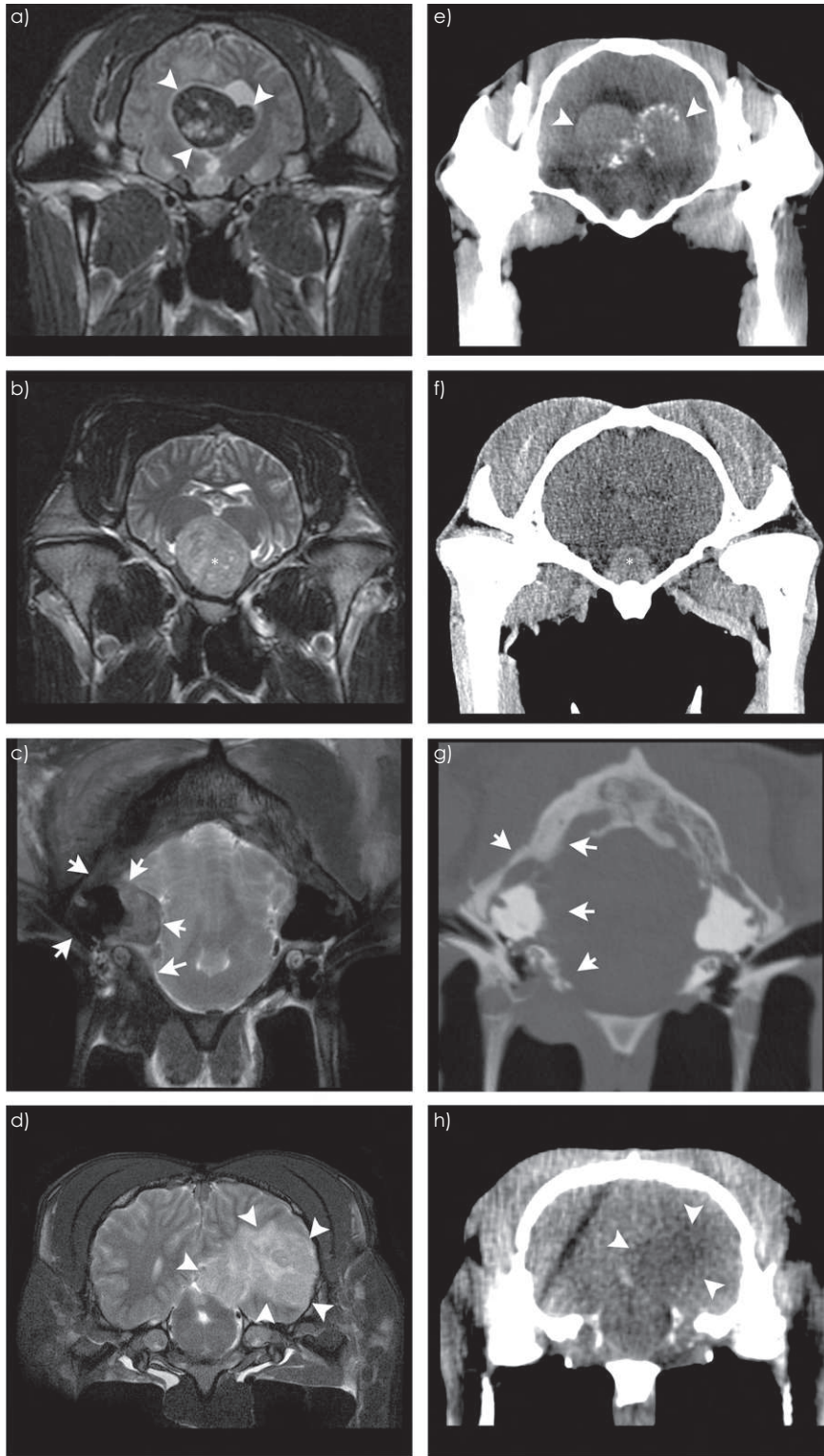


Fig 13: Comparison of transverse T2-weighted magnetic resonance (MR) (a–d) and computed tomographic (CT) (e–h) images of different intracranial diseases. a and e show two different cases of cholesterol granulomata (arrowheads) within the lateral ventricles and secondary obstructive hydrocephalus. In b and f there is moderate to severe enlargement of the pituitary gland (asterisks), consistent with macroadenoma. c and g compare the MR and CT images of the same horse with an extra-axial mass involving the temporal bone and compressing the cerebellum (arrows). The horse from d and h had a head trauma and developed diffuse intra-axial brain oedema (arrowheads). (a- Courtesy of Dr Sue Dyson, The Animal Health Trust).

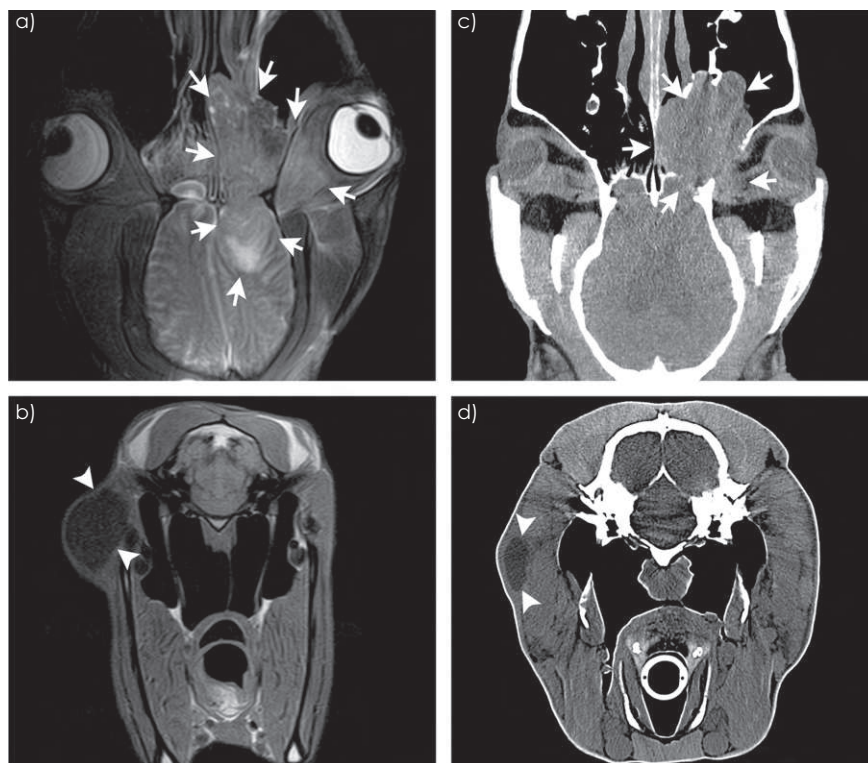


Fig 14: Dorsal (a,c) and transverse (b,d) T2-weighted (a) and T1-weighted (b) magnetic resonance and computed tomographic (c,d) images. a and c show two different ethmoidal neoplasia involving the orbit and the brain (arrows). b and d) show two different parotid mucoceles (arrowheads).

Authors' declaration of interests

No conflicts of interest have been declared.

Ethical animal research

This is a review article; recourse to ethical bodies was not undertaken.

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All authors were involved in the writing and reviewing of the manuscript. All authors approved the final version of the manuscript.

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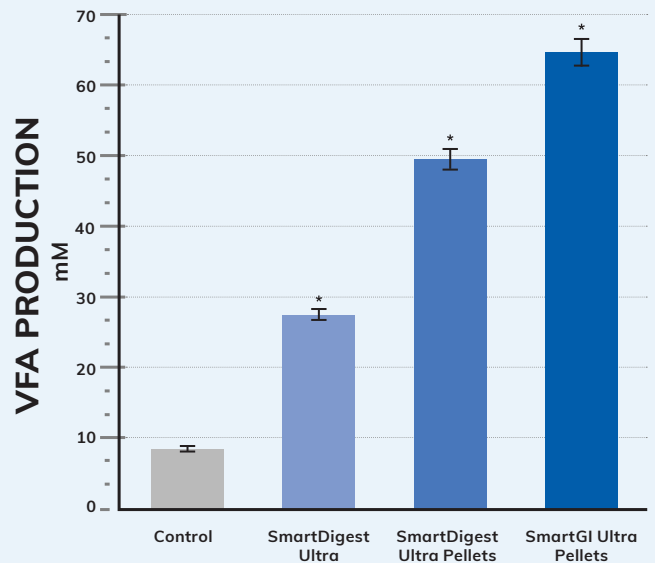
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Review Article

Diagnosis, management and prognosis of small colon impactions

R. Reid Hanson*  and J. Schumacher 

Department of Clinical Sciences, JT Vaughan Teaching Hospital, Auburn University, Auburn, Alabama, USA

*Corresponding author email: hansorr@auburn.edu

Keywords: horse; small colon; rectum; impaction; management

Summary

Common causes of obstruction of the small colon and rectum include diffuse faecal impaction, enterolithiasis, faecalithiasis, phytobezoar, trichobezoar, phytotrichobezoar, phytoconglobate, foreign body, intramural haematoma and retained meconium. Poor dentition, poor-quality hay, lack of adequate water, parasite damage and lack of exercise are risk factors for the development of small colon impactions. Clinical signs of small colon obstruction develop slowly because a large space proximal to the obstruction allows ingesta, gas and fluid to accumulate. Medical management of horses with faecal impaction of the small colon involves improvement of hydration, stimulation of colonic motility, softening the impaction by the administration of osmotic laxatives or lubricants, and control of pain. Surgical intervention is indicated when medical management fails to resolve the impaction or when intractable pain and a deteriorating cardiovascular status ensues.

Introduction

Diffuse small colon faecal impaction is the most common pathological condition of the small colon except in regions with a high incidence of enterolithiasis. In several retrospective studies, diffuse faecal impaction was diagnosed in 1.9–2.5% of all horses admitted for signs of abdominal pain (Ruggles and Ross 1991; Dart *et al.* 1992; Rhoads 1999). Poor dentition, poor-quality hay, lack of water, parasite damage and lack of exercise are risk factors for the development of small colon impactions (Edwards 1992; Schumacher and Mair 2002; Frederico *et al.* 2006). The increased incidence of diffuse faecal impaction during the cooler part of the year observed in some studies may be the result of inadequate water consumption or change of feed as horses are transitioned from pasture to hay (Ruggles and Ross 1991; Rhoads 1999). Horses older than 15 years, American Miniature Horses, and ponies were at an increased risk in several studies, but age, breed, and sex were not significant risk factors in other reports (Tennant *et al.* 1972; Dart *et al.* 1992; Rhoads 1999).

Enterolith obstruction of the small colon (**Fig 1**) accounts for up to 35% of small colon diseases in areas such as California where the incidence of enterolithiasis is high (Blue 1979; Dart *et al.* 1992; Hassel *et al.* 1999; Cohen *et al.* 2000). The small colon is occasionally focally obstructed by a faecalith, phytobezoar, trichobezoar, phytotrichobezoar, or phytoconglobate. Faecaliths are discrete concretions of inspissated faecal material that form because of poor-quality diet, poor mastication, or reduced water consumption (Keller and Horney 1985; McClure *et al.* 1992). The condition occurs

most commonly in ponies in late fall when grass has low nutritional value and is high in lignin and, because the weather is cool, water consumption is reduced. Small colon faecaliths most commonly occur in ponies and American Miniature Horses, especially those <1 year or more than 15 years of age (Boles and Kohn 1977; Dart *et al.* 1992; Ragle *et al.* 1992). Bezoars are combinations of concretions of magnesium ammonium phosphate crystals and plant material (phytobezoars), hair (trichobezoars) or a combination of plant and hair (phytotrichobezoars) (Livesey 1990; Schumacher and Mair 2002). Phytobezoars, or 'oat stones' are most often composed of matted 'oat hairs'. They are permeated with magnesium ammonium phosphate crystals to form calculi that are relatively light and have an uneven, furrowed, velvet-textured surface (**Fig 2a,b**). Phytoconglobates are concretions of matted plant residues formed into balls. Phytoconglobates occur most commonly in young horses and in horses with poor dentition. The smooth surface of phytoconglobates and bezoars may allow them to obstruct the lumen for relatively long periods without causing severe damage to the mucosa.

Foreign materials involved in obstruction of the small colon include halters, ropes, hay nets, mops (**Fig 3a,b**), plastic bags, bailing twine, and rubberised fencing (Getty *et al.* 1976; Boles and Kohn 1977; Gay *et al.* 1979; Schmitt *et al.* 1999). Obstruction of the small colon with foreign material occurs generally in young horses because they are less



Fig 1: Clusters of enteroliths obstructing the small colon. Enterolith obstruction of the small colon accounts for up to 35% of small colon diseases in areas such as California where the incidence of enterolithiasis is high.

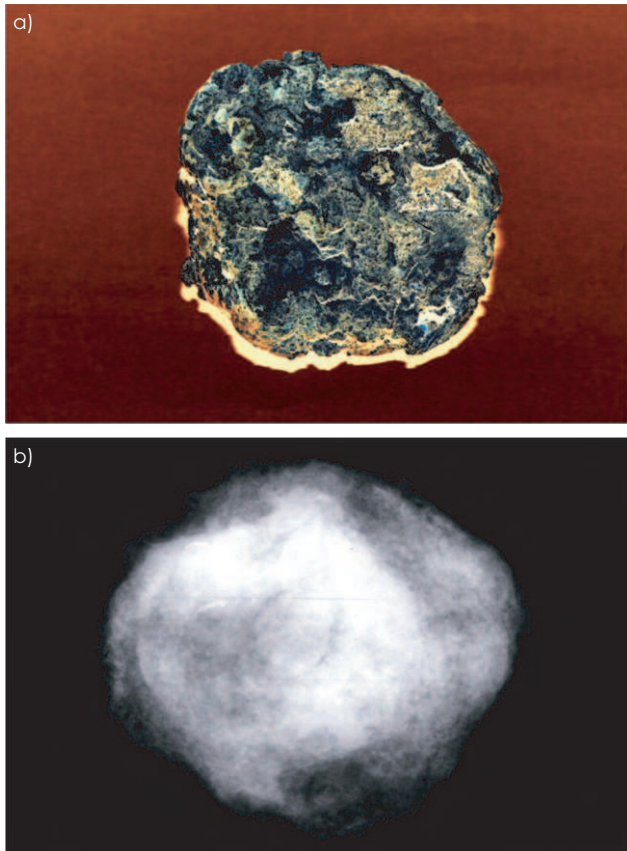


Fig 2: a) Phytobezoar removed from small colon. These stones are relatively light and have an uneven, furrowed, velvet-textured surface. b) Radiograph of the phytobezoars in (a) reveals a radiodense calculus permeated with magnesium ammonium phosphate crystals form radiodense calculi. Phytobezoars, or 'oat stones' are most often composed of matted 'oat hairs'. They are permeated with magnesium ammonium phosphate crystals to form calculi that are relatively light.

discriminate in their eating habits (Boles and Kohn 1977; Dart *et al.* 1992). While residing in the large colon, foreign material becomes layered with mineral precipitate increasing its bulk and often forming irregular projections that can cause pressure necrosis when the material moves to the small colon.

An intramural or submucosal haematoma (**Fig 4**) is an uncommon, idiopathic lesion of the small colon (Spiers *et al.* 1981; Pearson and Waterman 1986; Edwards 1992). Haemorrhage within the intestinal wall may occlude the intestinal lumen and dissect along the submucosa producing intestinal necrosis. The condition occurs most commonly in old horses. Histology has not revealed the cause, and the source of haemorrhage contributing to the formation of mural haematoma is not usually evident during gross or microscopic examination of resected colon (Schumacher and Mair 2002).

Meconium impaction is a common cause of abdominal pain in newborn foals. Meconium impaction occurs more frequently in males (because of their narrower pelvis), weak newborns and foals born at more than 340 days of gestation (Fisher *et al.* 1987; Madigan and Goetzman 1990; White 1990; Edwards 1997). Foals that fail to ingest colostrum are prone to meconium impaction because colostrum promotes



Fig 3: a) Plication of the small colon due to an obstruction from a mop. Foreign materials involved in obstruction of the small colon include halters, ropes, hay nets, mops, plastic bags, baling twine, and rubberised fencing. b) The mop was removed from the small colon via a small colon enterotomy. Obstruction of the small colon with foreign material occurs generally in young horses because they are less discriminate in their eating habits.

gastrointestinal motility and has a laxative effect (Rakestraw and Hardy 2012). Signs of abdominal pain caused by meconium impaction usually appear between the first 12–96 h of life (Madigan and Goetzman 1990; Edwards 1997).

Diagnosis

Horses with diffuse faecal impaction of the small colon initially show signs of mild abdominal pain followed by increasing signs of pain. Abdominal pain progresses slowly after colonic obstruction because of the large space proximal to the obstruction available for accumulation of ingesta, gas and fluid. The heart rate is often only mildly to moderately elevated. Leukopenia with a left shift is common in horses with diffuse faecal impactions of the small colon, but serum biochemical and peritoneal fluid values are typically within



Fig 4: Intramural haematoma obstructing the lumen of the small colon. An intramural or submucosal haematoma is an uncommon, idiopathic lesion of the small colon caused by haemorrhage beneath the mucosa.

normal ranges (Ruggles and Ross 1991; Edwards 1992). Loops of tubular, firm, digesta-filled intestine, and oedematous or rough rectal mucosa, can be identified during a transrectal abdominal examination. Serosanguinous fluid can sometimes be seen on the rectal sleeve or manure pulled from the rectum. A single tenia identified during the examination confirms small colon as the segment of intestine involved (Keller and Horney 1985; Livesey 1990; Ruggles and Ross 1991; Edwards 1992). Transabdominal ultrasonography revealing distended, amotile small colon with a thickened wall (>8 mm) and a lumen filled with hyperechoic ingesta may assist in the diagnosis especially when signs of abdominal pain occur in horses too small to allow abdominal palpation per rectum. For horses large enough to rectally palpate, small colon impactions are usually easily diagnosed by palpating firm coils of colon near the pelvic inlet (Freeman *et al.* 2001).

Findings of diarrhoea, fever, leukopenia, and irritated rectal mucosa suggests that colitis may predispose some horses to small colon impaction, possibly because of disturbance in motility (Dart *et al.* 1992; Frederico *et al.* 2006). Gastrointestinal stasis and inflammation associated with small colon impaction may predispose horses to colitis (Wiley *et al.* 1988; Ruggles and Ross 1991).

Enteroliths, faecaloliths, phytobezoars, trichobezoars, and phytotrachobezoars can block passage of faeces yet allow passage of gas and intestinal lubricants, such as mineral oil. Affected horses typically exhibit numerous episodes of minor colic, most likely from intermittent obstruction in the large colon before the obstruction enters the small colon. If the obstruction is too large to be passed, it often becomes wedged either in the transverse colon or the proximal portion of the small colon (Blue 1979). An obstruction within the small colon typically causes complete obstruction and affected horses tend to show signs of more severe abdominal pain than horses with partial or intermittent obstruction of the transverse or right dorsal colon. Evidence of an obstruction in the proximal portion of the small colon is usually not palpable during transrectal abdominal examination. Loops of gas-filled small colon may be recognised, however, if the enterolith is lodged in the middle or distal portions of the small colon. For horses with an intramural haematoma the rectum is usually devoid of faeces, but various amounts of clotted blood may

be found during transrectal examination (Schumacher and Mair 2002).

Radiography can be used to confirm a suspicion of enterolithiasis. Enteroliths in the large colon are more easily identified radiographically than an enterolith in the small colon. Severe gas distention in the large or small colon causes compression and distortion of intra-abdominal organs that negatively impacts the sensitivity of radiographic diagnosis of enterolithiasis (Yarbrough *et al.* 1994; Maher *et al.* 2011; Kelleher *et al.* 2014). Additional limitations include underexposure of the small colon with the use of analogue radiographs. Digital radiographs can compensate for underexposure by image processing mechanisms that allow for change in contrast after the image is acquired. The absence of a radiographic diagnosis does not preclude the presence of an enterolith.

Increasing abdominal distention and signs of pain, tachycardia, with leukopenia and an increase in peritoneal fluid protein concentration and nucleated cell count are often found in horses with complete obstruction of the small colon. Pressure necrosis can occur at the site of the obstruction and in these cases, surgery should be strongly considered when the aforementioned values increase.

Signs of meconium retention include tail swishing, restlessness, straining to defaecate, and abdominal distention due to gas accumulation. As the condition progresses, the foal develops signs of more severe colic, such as repeated recumbency, rolling, lying upside down, and abdominal distention (Madigan 1987). Meconium can usually be identified either by plain or contrast abdominal radiography, by ultrasonography or by digital rectal examination. Following appropriate sedation and restraint of the foal, a 28–30 French Foley catheter with a 30 mL bulb is placed into the rectum, the bulb slowly inflated, and up to 20 mL/kg of 30% weight/volume barium is administered by gravity flow. Contrast radiography is reportedly 100% sensitive and specific for identifying mechanical obstructions of the transverse and small colon in foals younger than 30 days of age (Fischer and Yarbrough 1995). Radiographically, meconium appears as granular contents in the small colon and rectum, with fluid or gas-distended intestine proximal to the obstruction.

Medical treatment

Medical management of horses with diffuse faecal impaction of the small colon involves improving hydration, softening the impaction by the administration of osmotic laxatives or lubricants and controlling pain. Intravenous administration of large amounts fluids (2–3 times the maintenance volume) has been recommended to hydrate and soften a small colon impaction (Ruggles and Ross 1991; Frederico *et al.* 2006), but over-hydration, in one study was shown to merely cause excessive urination without an increase in intraluminal fluid (Lester *et al.* 2013). Enteral fluids (2–4 L every 4–6 h) are more likely to hydrate a small colon impaction and have the additional benefit of initiating a gastrocolonic reflex, whereby gastric distention stimulates contractile activity of the colon (Clark and Becht 1987; Freeman *et al.* 1992).

Oral laxatives such as mineral oil (5–10 mL/kg every 12 h), dioctyl sodium sulfosuccinate (50 mg/kg in 6 L of water), or magnesium sulfate (1 g/kg in 6 L of water) administered to adult horses by nasogastric tube are commonly administered to soften the impaction. Magnesium sulfate can be

administered once daily for 2–3 days if the horse is well hydrated (Henninger *et al.* 1992; Prange *et al.* 2019).

Enemas can be administered to soften the impaction (Fig 5). Because of the risk of perforating the small colon, caution should be exercised when administering an enema to a standing horse (Ruggles and Ross 1991; Rhoads 1999). The horse should be adequately sedated and restrained. Enemas should not be performed under pressure and the return of flow should not be prevented. The procedure is most effective if epidural anesthesia has been administered

because it prevents straining and allows more fluid to be administered.

Flunixin meglumine (0.25 mg/kg 3 times a day, or 1.1 mg/kg twice a day i.v.) can be administered to treat endotoxaemia and to control pain. Epidural morphine (0.1 mg/kg in diluted in 30 mL saline and administered slowly) can help to control pain in horses with small colon impaction (Zimmel 2003). Antibiotics may be indicated for horses with small colon impaction that have signs of septicaemia, severe leukopenia, or concurrent diarrhoea (Ruggles and Ross 1991). Cryotherapy using ice-filled boots should be initiated before clinical signs of laminitis (heat in the feet, a bounding digital pulse and pointing or favouring the affected limb) develop (van Eps and Pollitt 2006). The feet should be maintained in ice boots to a level above the fetlock until heart rate, and mucous membrane capillary refill time and colour are normal and immature neutrophils and neutrophils with toxic change are no longer present on bloodwork.

Most foals with meconium impaction respond to medical therapy that includes judicious use of analgesics, i.v. fluid therapy, oral laxatives (4–8 oz. mineral oil administered via a nasogastric tube; 1–2 oz. of milk of magnesia) and enemas. For an enema, warm water is mixed with a mild liquid detergent (e.g. Palmolive; 1/2 teaspoon liquid detergent added to 500 mL water)¹. Commercial phosphate (Fleet®)² enemas can also be administered.

A 4% acetylcysteine enema solution has been recommended for treatment of retained meconium (Madigan and Goetzman 1990; Pusterla *et al.* 2004). The foal is sedated with diazepam (0.2–0.4 mg/kg i.v.) and placed in lateral recumbency. A 30-French Foley catheter with a 30 mL bulb is inserted about 2.5–5 cm into the rectum. The balloon is slowly inflated to avoid damaging the rectum. Between 100 and 200 mL of 4% acetylcysteine solution is administered slowly by gravity flow and retained for 30–45 min (Madigan 1987). This procedure can be repeated, if necessary, up to three times over a 24-h period. Acetylcysteine cleaves the disulfide bonds in the mucoprotein molecules and decreases the tenacity of the meconium. The 4% solution is hypertonic and will cause some loss of fluid into the bowel, an action which may help detach the meconium from the bowel wall (Pusterla *et al.* 2004). The efficacy of acetylcysteine enemas has been reported to be excellent (Madigan 1987; Pusterla *et al.* 2004). Occasionally, repeated enemas can result in significant mucosal irritation and persistent straining beyond the resolution of the meconium impaction, thereby confounding the assessment of treatment success.

Surgical treatment

Surgical intervention for diffuse faecal impaction is indicated when medical management fails, the abdomen distends, cardiovascular deterioration is detected, or an increase in the nucleated cell count and concentration of total protein in the peritoneal fluid indicates a decrease in intestinal viability (Dart *et al.* 1992; Edwards 1992; Rhoads 1999). When palpated through the celiotomy, small colon is easily identified as a distended tube with a single antimesenteric taeneal band, with or without the usual sacculations (Fig 6). After the small colon is exteriorised through a ventral midline celiotomy, the impaction is broken apart by intraluminal lavage with warm water administered by a stomach tube introduced rectally. The tube is inserted through the anus by



Fig 5: Administration of an enema to a horse using an enema bell.

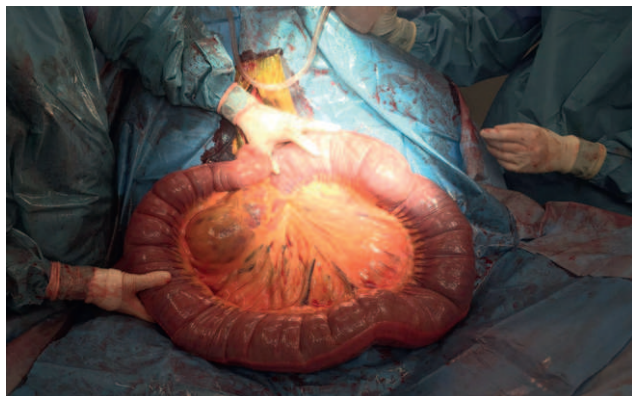


Fig 6: When palpated through the celiotomy, small colon is easily identified as a distended tube with a single antimesenteric taeneal band, with or without the usual sacculations.



Fig 7: After the small colon is exteriorised through a ventral midline celiotomy, it is broken apart by intraluminal lavage with warm water administered by a stomach tube introduced rectally. The tube is inserted through the anus by an assistant and manipulated transmurally by the surgeon until the tube reaches the impaction.

an assistant (**Fig 7**) and manipulated transmurally by the surgeon until the tube reaches the impaction. The surgeon's hand closes the lumen of the small colon over the tube caudal to the impaction to allow water distention around the distal extent of the impaction (**Fig 8**). To break up the distal portion of the impaction, the impaction is gently massaged as water is administered through the tube. The exercises are repeated working orad until the impaction is relieved. Extreme care should be used during manipulation of the small colon to avoid rupture of the colon. To decrease mechanical damage to the serosa during the massage, the small colon can be coated with carboxymethylcellulose (Ruggles and Ross 1991). If the impaction cannot be relieved by intraluminal lavage combined with external massage, a small colon enterotomy on the antimesenteric teniae can be performed. Lavage is used to evacuate the impacted faecal material through the enterotomy. Small colon resection and

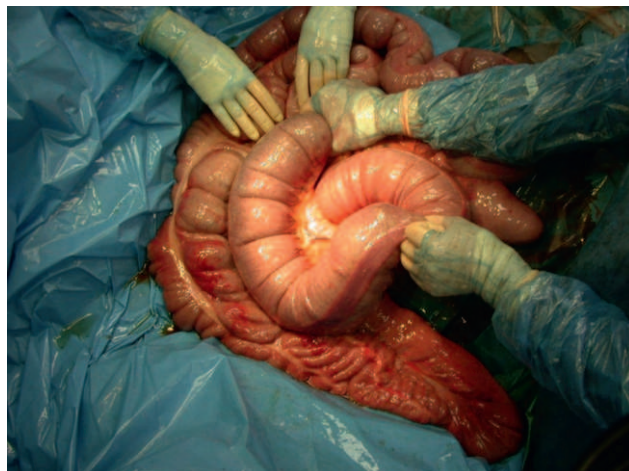


Fig 8: The surgeon's hand closes the lumen of the small colon over the tube caudal to the impaction to allow water distention around the distal extent of the impaction. To break up the distal portion of the impaction, the impaction is gently massaged as water is administered through the tube.

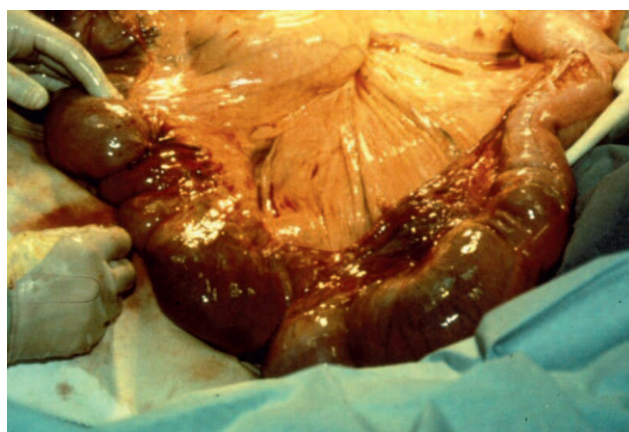


Fig 9: Small colon resection and anastomosis is necessary if there is mural ischaemia or thrombosis of the mesenteric vessels that supply the small colon.

anastomosis is necessary if there is mural ischaemia or thrombosis of the mesenteric vessels that supply the small colon (**Fig 9**). An end to end anastomosis in two layers using polyglactin 910 is used. A simple continuous pattern in the submucosa is used in the first layer followed by a continuous Cushing pattern in the serosa for the second layer (**Fig 10**). This pattern creates an ideal seal without excessive inversion of the anastomosis that could lead to post-operative obstruction of the small colon (**Fig 11**) (Hanson *et al.* 1988). If a significant quantity of ingesta is found in the large colon, large colon evacuation through an enterotomy minimises early post-operative recurrence of impaction in the oedematous and inflamed small colon. Because large colon displacement or volvulus may occur secondary to gas distention proximal to the impaction in some horses, the

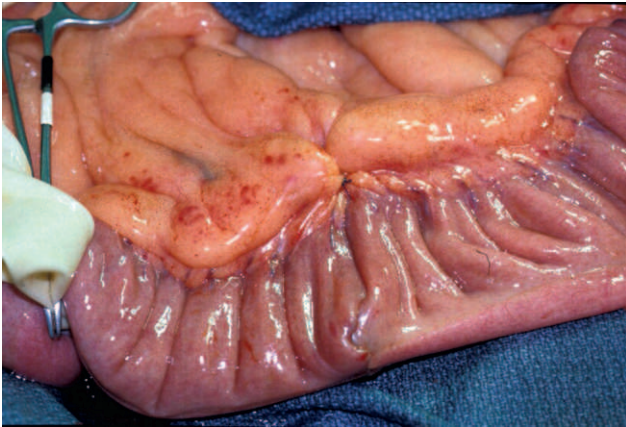


Fig 10: Two-layer closure arrow of the small colon following resection. A simple continuous pattern in the submucosa is used in the first layer followed by a continuous Cushing pattern in the serosa for the second layer.

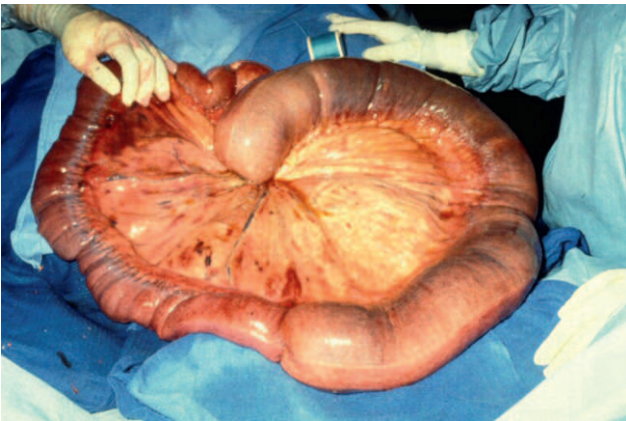


Fig 11: Impaction of the small colon at the anastomosis site due to excessive inversion of the anastomosis layers and firm faecal mass proximal to the anastomosis.

position of the large colon should be determined before closure of the celiotomy incision.

Treatment of horses in pain due to impaction of the small colon caused by an enterolith (**Fig 12a,b**), faecalith, phytobezoar, trichobezoar, phytotrichobezoar, phytoconglobate, foreign body or intramural haematoma involves surgical removal of the obstruction through an antimesenteric enterotomy or retropulsion and removal through a large colon enterotomy (Hassel *et al.* 1999). The obstruction should be manoeuvred distally or proximally so the enterotomy site can be made in a healthier portion of the intestine. Longitudinal enterotomies made through the antimesenteric tenia of the small colon are superior to incisions made adjacent to the tenia regarding ease of closure, larger luminal diameter after closure (**Fig 13a** and **b**), and less interruption of the blood supply. An enterotomy performed through the antimesenteric tenia results in less haemorrhage and less inflammation, and sutured tenial incisions are stronger than sutured incisions adjacent to the tenia at 96 h (Edwards 1997; Schumacher and Mair 2002). Obstructions found in the

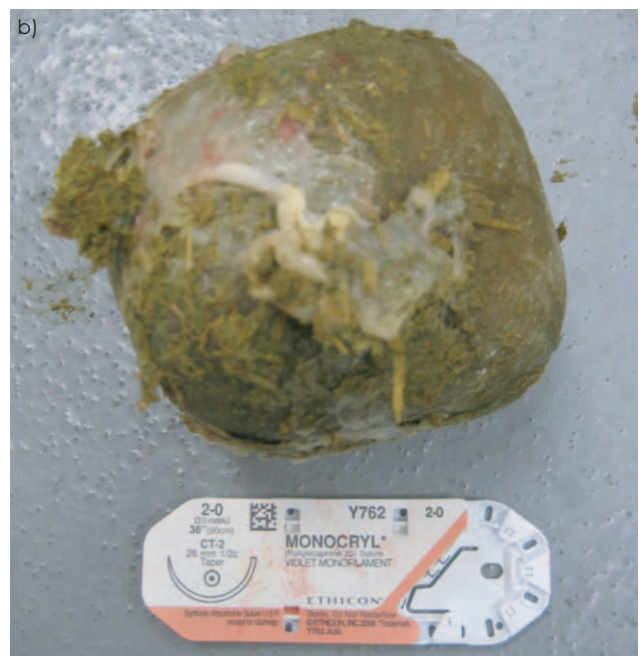


Fig 12: a) Enterolith within the small colon causing transmural necrosis of the small colon intestinal layers. Removal involves surgical removal of the obstruction through an antimesenteric enterotomy or retropulsion and removal through a large colon enterotomy. b) Faecalith removed from small colon.

proximal portion of the small colon often must be repelled into the right dorsal colon and then into the left dorsal colon for removal through an enterotomy. Retro propulsion with lavage can be accomplished by retrograde infusion of water into the small colon. To repel an enterolith proximally, a stomach tube is inserted into the rectum and passed into the small colon. The tube is guided to the obstruction by the surgeon and, while the small colon is occluded by holding it tightly to the tube, warm water is infused into the intestine until the lumen expands to a size large enough to allow the enterolith to move orally. The obstruction is then repelled into the left dorsal colon where it can be removed safely via an enterotomy site remote from the abdominal cavity.

If removing an obstruction in a retrograde fashion is not successful, the tube is inserted through a pelvic flexure enterotomy and advanced aborally to the obstruction. Warm water is introduced to distend the small colon orad to the enterolith, while the intestine distal to the obstruction is

manually occluded. The obstruction is then massaged in an oral direction. Care must be taken during distention and manipulation of the small colon, since pressure necrosis can make the bowel susceptible to rupture. A parainguinal approach to the abdomen may provide access to the enterolith for removal at the site of obstruction in cases where the enterolith cannot be dislodged, and its location prohibits exteriorisation through a ventral midline incision (Barrett and Munsterman 2013).

A complete examination of the large intestine, especially the right dorsal and transverse colon, is strongly recommended following the removal of a stone through a small colon enterotomy as, in one study, almost half of the horses with enteroliths in the small colon had additional stones in the large or transverse colons (Hassel *et al.* 1999; Pierce *et al.* 2010). To limit the risk of an impaction at the small colon enterotomy site, evacuation of the large colon through a pelvic flexure enterotomy may be indicated to decrease the amount of faecal material passing through the small colon in the immediate post-operative period.

A linear foreign body may cause plication of the small colon leading to ischaemia or mechanical damage of the intestinal wall and complicating its removal. Over-sewing or even resection and subsequent end-to-end anastomosis of ischaemic or damaged small colon might be necessary (Boles and Kohn 1977; Gay *et al.* 1979; Schmitt *et al.* 1999). The post-surgical prognosis should be comparable to the outcome after enterolith removal, unless small colon segments are devitalised and require resection. In these cases, the risk for post-operative complications is higher and long-term survival less likely (de Bont *et al.* 2013). An intramural haematoma is recognised at surgery as a dense, circumscribed mass free in the lumen or attached to the wall of the small colon; they can usually be removed through an enterotomy (Fig 14).

Surgical intervention of meconium impaction should be considered if medical therapy is unsuccessful, especially in the face of persistent pain unresponsive to analgesics, persistent tachycardia, progressive abdominal enlargement, or increase in peritoneal fluid protein and or nucleated cell count.

Broad-spectrum antibiotics should be administered perioperatively for 24 h and nonsteroidal anti-inflammatory drugs are continued post-operatively for 3–5 days depending on the surgical findings and post-operative condition of the horse. Post-operatively, horses should be slowly re-introduced to feed. Feeding a complete pelleted diet for several weeks may help prevent re-impaction (Prange *et al.* 2010).

Prognosis

Survival after medical therapy for feed impaction of the small colon is reported to be good to excellent (72–100%), and survival after surgical therapy is reported to be fair to excellent (47–95%) (Ruggles and Ross 1991; Dart *et al.* 1992; Edwards 1992; Rhoads 1999). Horses whose large colon was not evacuated during surgery are more likely to develop post-operative pain (Ruggles and Ross 1991). Horses treated surgically were more likely to have positive faecal culture of *Salmonella* spp. than horses treated medically (Rhoads 1999). The cause of the high incidence of salmonellosis in horses with impaction of the small colon treated surgically is unknown. Post-operative antibiotic therapy may increase the



Fig 13: a) First layer of small colon enterotomy closure with a simple continuous in the antimesenteric taenial band. Longitudinal enterotomies made through the antimesenteric tenia of the small colon are superior to incisions made adjacent to the tenia regarding ease of closure, larger luminal diameter after closure, and less interruption of the blood supply. b) Second layer of the small colon enterotomy is closed with a continuous Cushing pattern.



Fig 14: Intramural haematoma causing obstruction and full thickness splitting of the small colon intestinal layers. Only the mucosal layer remains intact. They can usually be removed through an enterotomy.

risk of developing salmonellosis by altering gastrointestinal flora (Ruggles and Ross 1991; Prange *et al.* 2010). Other common complications of small colon impaction treated medically or surgically are jugular thrombophlebitis, fever, laminitis, peritonitis, and recurrent impaction. Horses treated surgically may have additional complications of incisional infection, incisional hernia, and intestinal adhesions (Dart *et al.* 1992; Edwards 1992; Rhoads 1999).

The cardiovascular health of the horse and the integrity of the affected area of intestine are factors that determine the prognosis for survival of horses undergoing surgery for enterolithiasis. Horses recovering from surgery for transverse and small colon enterolithiasis have a good to excellent prognosis for short (88–96.2%) and long-term survival (up to 92.5%) (Hassel *et al.* 1999; Cohen *et al.* 2000; Pierce *et al.* 2010). In one study, horses treated surgically for small colon enterolithiasis were more prone to complications than horses treated surgically for an enterolith in the large colon (Hassel *et al.* 1999), but in other studies there was no difference in the incidence of complications (Taylor *et al.* 1979; Cohen *et al.* 2000).

To minimise the recurrence of enterolithiasis, feeding areas should be free of gravel and debris or elevated from the ground, and grass hay rather than legume hay should be fed. Colonic pH below 6.6 tends to prevent the formation of enteroliths. Decreasing the amount of hay, adding cider vinegar (one cup twice daily) and increasing the amount of grain in the diets tends to decrease colonic pH (Schumacher and Mair 2002; Rakestraw and Hardy 2012).

The prognosis for short-term survival of horses treated surgically for faecalithiasis, phytobezoar-, trichobezoar, phytotrichobezoar, or phytoconglobate is excellent (Scharner *et al.* 2015). For horses treated surgically for a foreign body in the small colon, the prognosis should be comparable to the outcome after enterolith removal, unless small colon segments are devitalised and require resection and anastomosis. In these cases, the risk for post-operative complications is higher and long-term survival decreased (Prange *et al.* 2010). Seven of 43 horses undergoing small colon resection and anastomosis did not survive to discharge from the hospital in one retrospective study (de Bont *et al.* 2013). The prognosis a horse treated for an



Fig 15: Post-mortem photo revealing adhesions of multiple segments of small colon following resection and anastomosis 6 weeks post-operatively.

intramural haematoma is good if the entire lesion can be removed (Schumacher and Mair 2002).

Post-operative complications involving adhesion formation (**Fig 15**) are common after gastrointestinal surgery of neonates (Vatistas *et al.* 1996; Cable *et al.* 1997). Eight of 28 foals that failed to respond to medical therapy for meconium impaction required surgery; two of these were eventually euthanised as a result of colic caused by serosal adhesions (Hughes *et al.* 1994). Minimal handling of the bowel in surgery along with topical administration of 1% sodium carboxymethylcellulose during bowel manipulation may reduce adhesion formation.

Conclusion

Surgical intervention for faecal impaction is indicated in horses when medical management fails, the abdomen distends, cardiovascular deterioration is detected, or an increase in the nucleated cell count and concentration of total protein in the peritoneal fluid indicates loss of intestinal viability. Large colon displacement or volvulus can occur secondary to small colon impaction. Survival after medical therapy is reported to be good to excellent and survival after surgical therapy is reported to be fair to excellent if the cardiovascular health of the horse and the integrity of the affected area of intestine are good.

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Manufacturers' addresses

¹Colgate Palmolive, New York, New York, USA.

²Prestige Consumer Healthcare, Greenburgh, New York, USA.

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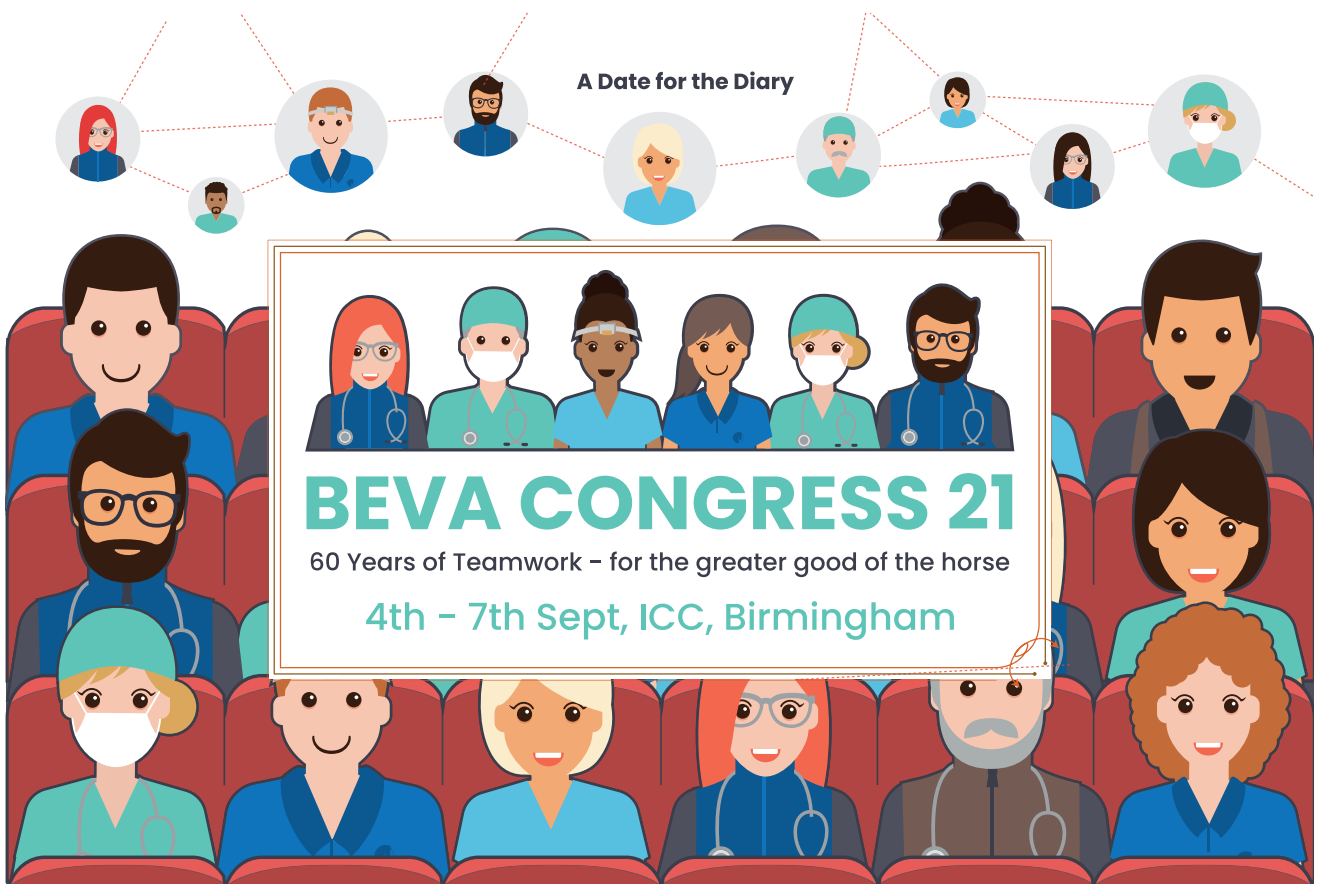
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¹ Pehkonen J, Karma L, Raekallio M. Behavioral Signs Associated with Equine Periapical Infection in Cheek Teeth. *Journal of Equine Veterinary Science*. 2019;77:144-150.