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AAEP® EQUINE VETERINARY EDUCATION

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BEVA

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

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Success Story: Shorter work week, salary boost spark hiring spree at venerable practice

Evisceration in a Thoroughbred gelding following application of a topical chemotherapy agent for the treatment of sarcoids

Endotracheal tube obstruction due to cuff overinflation or cuff herniation in small equids: A case series

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References:
[1] Brendemuehl JP, Kopp K, Altman J. Uterine Inflammatory Response to Frozen Semen is attenuated by Oral Supplementation of a Blend of Omega-3 Fatty Acids (Algal DHA and Flax Seed) in Susceptible and Resistant Mares. Submitted to Theriogenology. [2] Brendemuehl JP, Altman J, Kopp K. Influence of dietary algal N-3 fatty acids on breeding induced inflammation and endometrial cytokine expression in mares bred with frozen semen. J Equine Vet Sci. 2014; 34(1): 123-124. [3] A.M. Adkin, A.V. Muniz, C.J. Mortensen, L.K. Warren. Maternal fatty acid supplementation influences memory and learning ability in yearling and 2-year-old horses. J Equine Vet Sci. 2015; 35: 418-436. [4] A.M. Adkin, L.K. Warren, C.J. Mortensen, J. Kivipelto. Maternal supplementation of docosahexaenoic acid and its effect on fatty acid transfer to the foal (longitudinal study). Equine Vet Sci. 2013; 33: 321-329. t[5] A.M. Adkin, L.K. Warren, and C.A. McCall. Effect of maternal docosahexaenoic acid supplementation on behavior and cognitive development in nursing foals. J Equine Vet Sci. 2013; 33: 321-399.

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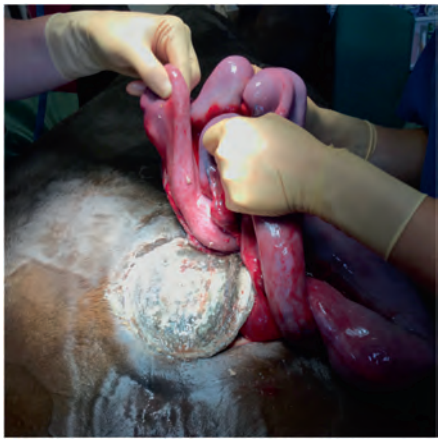

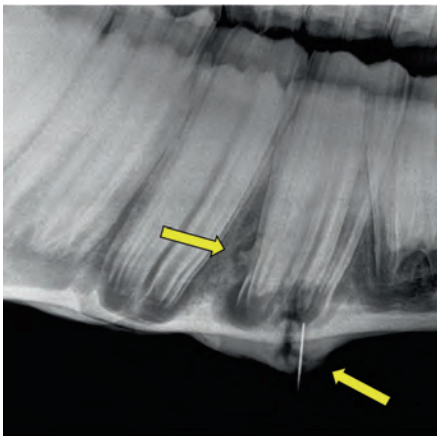

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Cover photo by Dr. Ruth Sobeck.

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

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

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Success Story: Shorter work week, salary boost spark hiring spree at venerable practice

In an increasingly competitive labor market, many new equine practitioners are specifically seeking employment with practices that are adapting their operations to prioritize professional growth, personal well-being and sense of belonging among staff. One practice reaping the rewards of recently implemented changes is Teigland, Franklin and Brokken, DVMs, Inc. (TFB Equine), an 18-doctor Thoroughbred practice based in Fort Lauderdale, Fla., with divisions in New York and Maryland.

TFB Equine recently shifted to a shorter, 5-day work week—a bold step for a predominantly racetrack practice in an environment that demands coverage 7 days per week. Together with an increase in starting straight-salary compensation exceeding $100,000 and continued focus on integrating new associates into a structured environment as valued team members, the practice recently pulled off the largest hiring spree in its 75+ year history.

The innate appeal of its changes resulted in three 2023 graduates signing on with the practice. According to TFB Equine President and Managing Shareholder Dr. Scott Hay, the new horse doctors are helping spread the current workload for the benefit of its entire veterinary staff as well as securing the future of the practice as several veterinarians creep closer to retirement.

"We want to make our practice an attractive place to work, and to recruit younger members into the practice, we felt like a 5-day work week was an integral part of the equation along with a better salary," said Dr. Hay. "It's important to be able to recruit people because we're competing against not only other equine practices that are taking steps to improve their work environments to lure new veterinarians but small animal practices that generally can offer greater salaries and more flexible work schedules."

Dr. Hay chats with consignors at a Thoroughbred auction.

AAEP TRANSFORMING EQUINE PRACTICE

TFB Equine has structured its new 5-day work schedules around the live racing schedules of the tracks it services to ensure full coverage every single day. Although some of the practice's veterinarians may have weekends off, time off is weighted toward tracks' "dark" days on which they don't race—usually early in the week.

Two of its new associates previously came through the practice as externs. Although not easy to host a steady stream of students who shadow or extern, Dr. Hay said it's a valuable investment of time to keep the pipeline of future candidates open.

"It's important for externs to see how you practice and get a feel for their comfort level with the way the practice is run, the way the practice approaches medicine, the way the practice treats its people, the way work schedules are put together, and how they would fit in and be respected as opposed to just being a second wave of labor."

Although handling routine tasks that may require less experience and client interaction is a rite of passage for any new veterinarian, Dr. Hay said the practice shows its respect to the younger associates through supportive mentorship on a rotational basis among more established colleagues as well as prioritizing involvement in client and case management.

"We have certain clients that are very accepting of practitioners who are just starting out, so we tend to place new hires with those clients," he said. "In addition, although we don't have a lot of emergencies, we do have regular working hours emergencies like covering races and dealing with lacerations or colics or injuries. Introducing younger vets into those types of situations—with some mentoring of course—and having them handle those caseloads in front of clients is rewarding to the veterinarian and builds confidence with the client."

By reimagining its practice model around a shorter work week and taking the necessary steps to make it a reality, TFB Equine is strengthening employee well-bring, assuring practice longevity and giving its new associates an important leg up on what it hopes are long and satisfying careers in equine practice.

5 things to know about AAEP this month

1. Save $200 by registering for the in-person AAEP Annual Convention by Aug. 31 at convention.aaep.org. A virtual option is also available.
2. Reserve your spot in one or more of the small group labs being offered at the annual convention in San Diego by registering at convention.aaep.org.
3. Seeking a fresh start or new opportunity? Check out the latest job openings in the AAEP Career Center at jobs.aaep.org.
4. Memorialize a client's horse and have your gift matched by Zoetis through The Foundation's Equine Memorial Program. Learn more at foundationforthehorse.org/support/memorial-giving.
5. Newer practitioners: Raise your clinical, business and wellness game by claiming one of only 60 spots at the wet labs-focused Foundational Skills in Equine Practice CE meeting at aaep.org/meetings.

Resources to facilitate productive internships now available

Recent AAEP data indicates that over 70% of the new equine graduates in a given year elect to do an internship. While not a requirement, many new graduates feel they might benefit from participating in an internship program for additional work on clinical skills and client interactions.

The Internship Subcommittee is developing resources to assist both prospective interns and host practices. One such resource is the internship core competencies document on the next page, which is a comprehensive list of skills an intern should be able to perform at the conclusion of the internship.

Visit aaep.org/internships for additional resources, including a Green Flags/Red Flags checklist to help internship seekers find the right opportunity along with an Entrustable Professional Activities document to regularly assess and provide feedback to interns.

Emergency coverage, compensation headline upcoming Virtual Round Table schedule

Two pillars of the AAEP's Commission on Equine Veterinary Sustainability and tips for treating your youngest patients will be in the spotlight as Virtual Wednesday Round Tables press on in July and August.

Each month's Round Tables feature one clinical and one non-clinical topic and are held on the second and fourth Wednesday of every month through October. The sessions are free for AAEP members; simply register in advance through AAEP Anywhere at aaepanywhere.org.

Following is the upcoming schedule of sessions through August. Please note that the session originally scheduled for August 9 is instead being held August 16.

July 26: Utilizing Relief Veterinarians for Emergency Coverage
August 16: Compensation Subcommittee: How Revenue Drives Compensation
August 23: Treating Neonates (or Foals) in the Field

If unable to attend a live 90-minute Round Table, you can watch a recording of the session on-demand through AAEP Anywhere, the association's free-to-members online learning platform. On-demand sessions are available approximately 48 hours following the live sessions and include links to external resources. CE credit is not offered for the Round Tables.

The AAEP thanks its Virtual Wednesday Round Table sponsors:

AAEP | 2022 INTERNSHIP CORE COMPETENCIES

CLINICAL REASONING

Intern will be able to:

- Collect and interpret history
- Create prioritized problem and differential list
- Develop appropriate diagnostic and treatment plan, incorporating individual case and client factors
- Triage cases based on urgency
- Recognize biosecurity and zoonotic disease concerns and incorporates into plan, promoting health and safety of people (team members and clients), patients and the environment
- Recognize limitations of personal knowledge, skill, and resources and consults as needed

TECHNICAL COMPETENCY

Intern will be able to:

- Perform veterinary procedures and post-procedural care defined by technical skills list
- Promote and develop comprehensive wellness and preventive care plans

COMMUNICATION SKILLS

Intern will be able to:

- Listen attentively and communicate professionally
- Adapt communication style to colleagues, team members, and clients
- Prepare documentation appropriate for intended audience
- Develop a financial estimate and communicate financial options regarding plan with client
- Solicit, respect, and integrate contributions from others
- Function as leader or team member, as needed, based on context and experience

PROFESSIONALISM

Intern will be able to:

- Conduct themselves in an ethical and professional manner
- Manage time efficiently
- Reflect on personal actions and respond to feedback
- Engage in self-directed career planning
- Recognize wellbeing of self and others
- Demonstrate inclusivity and cultural competence

SELF-DIRECTED SCHOLARSHIP

Intern will be able to:

- Perform literature searches and use textbooks to analyze data critically, and apply clinically where relevant
- Integrate, adapt and apply knowledge and skills in clinical case management
- Disseminate knowledge and practices to stakeholders

Adapted from: AAVMC Working Group on Competency-Based Veterinary Education. Molgaard LK, Hodgson JL, Bok HGJ, Chaney KP, Ilkiw JE, Matthew SM, May SA, Read EK, Rush BR, Salisbury SK (2018) Competency-Based Veterinary Education: Part 1 – CBVE Framework. Washington, DC. American Association of Veterinary Medical Colleges.

Coming in August *EVE*: Convention registration kit

The AAEP's 69th Annual Convention returns in late November to sunny San Diego, Calif., for the first time in 15 years. A virtual option will also be available. In support of the meeting, the convention registration kit will be inserted in the August issue of *EVE*.

The kit will feature the complete educational program, including hands-on lab offerings; social events listing; trade show information; registration and hotel information; and more.

Register for the meeting and labs, book your hotel and view the most current convention information at convention.aaep.org.

San Diego Tourism Authority

Set sail to San Diego for sun and science with your AAEP family this November.

Practice Life podcast looks at progress of Student, Internship subcommittees

The Student and Internship subcommittees of the AAEP's Commission on Equine Veterinary Sustainability move in parallel in many respects by seeking to increase the number of students entering equine practice and then getting them started on the right foot through a productive internship for those interested in pursuing that path into practice. Several of the co-chairs of these two subcommittees recently spoke about their progress and goals with AAEP Practice Life podcast co-hosts Drs. Jessica Dunbar and Mike Pownall.

Participating in the discussion were Drs. Jackie Christakos and Sarah Reuss, co-chairs of the Internship Subcommittee; and Dr. Rhonda Rathgeber, co-chair of the Student Subcommittee.

The Student Subcommittee has created a speakers bureau in which AAEP members visit veterinary schools to discuss the positive changes occurring in equine practice. They are also working to expand the Essential Skills Workshop offerings and increase relations with student faculty advisors at the veterinary schools; and they will be encouraging participation at the annual convention and getting the word out about early-career mentoring opportunities such as Decade One and Starting Gate.

Meanwhile, the Internship Subcommittee completed a survey of interns from the previous five years that provided valuable data to explore. The subcommittee has created internship best practices guidelines to help spark productive conversations between practices and interns. These guidelines served as the basis for creation of an internship red flags/green flags document. The subcommittee is currently working on a standardized application for students as well as program listing standards to help students compare internship opportunities on an apples-to-apples basis.

AAEP TRANSFORMING EQUINE PRACTICE

During a discussion of revelations from their subcommittee work to date, Dr. Reuss indicated that practices can boost their standing with prospective interns without a significant outlay of capital.

"For a lot of the students and prospective interns, [salaries and work hours] aren't even the first things they want to talk about. A lot of it is more culture and mentorship support … things that practices can just look at internally and, again, it doesn't mean they have to go out and build a whole new hospital facility with a bunch of toys to recruit interns, but if they can just show their culture across the board from their staff to their veterinarians to their front office to how they're dealing with externs and interns, it can be really game-changing for them and without necessarily a huge financial input."

Download or listen to the 36-minute episode at podcast.aaep.org or on iTunes.

Dr. Patrick McCue to examine state of repro practice during Milne Lecture

Dr. Patrick McCue

Innovation and discovery have provided the knowledge and resources for practitioners to overcome ever-evolving challenges to optimal fertility in mares and stallions, increasing the efficiency and success of client breeding programs.

During his Nov. 30 Frank J. Milne State-of-the-Art Lecture, "Historical Perspectives in Equine Reproduction: Pioneers in the Age of Discovery," renowned theriogenologist Dr. Patrick McCue will trace significant advancements in equine reproduction over the past half-century, leading to analysis of the current state-of-practice in the field. Acquire valuable advice to enhance your diagnosis, treatment and management of stallions, mares and neonates, and be inspired to contribute to the advancement of knowledge in equine reproduction.

Dr. McCue is the Iron Rose Ranch Professor of Equine Theriogenology at Colorado State University, where he has served on faculty since 1994. Dr. McCue coordinates the clinical Stallion and Mare Services at the Equine Reproduction Laboratory and attends to dystocias, high-risk pregnancies and other reproduction cases at the Veterinary Teaching Hospital.

He is the author or co-author of 10 books or eBooks and over 400 refereed publications, textbook chapters, scientific proceedings, and/or abstracts. Among Dr. McCue's accolades are the 2017 Theriogenologist of the Year award from the American College of Theriogenologists and the 2022 Lifetime Achievement Award from the European Symposium on Equine Reproduction.

Elevate your skills at convention labs

Whether refreshing a lapsed skillset or perfecting new techniques to keep pace with modern advances in veterinary procedures, one thing is clear: Practice makes perfect. On Wednesday, Nov. 29, opening day of the annual convention, optimize patient health and client satisfaction with hands-on training and expert support in core areas of equine health.

The following labs are being offered during each of three 2-hour sessions: 10:00 a.m.–Noon, 1:00–3:00 p.m., and 3:30–5:30 p.m.

- Calling All Colics: Responding Effectively to the Dreaded "Colic Symptom" Call
- Take the Reins of Reproduction: Optimizing Stallion Breeding with Advanced Techniques
- It's Not in the Shoulder: Performing Venograms and Applying Hoof Casts for the Mobile Practitioner
- What's My Aim? Mastering Image-Guided Injection Techniques

Each lab is limited to 12 participants at a cost of $275 per session. Registration is on a first-come basis at convention.aaep.org or by phone at (859) 233-0147. Convention labs tend to fill quickly so early registration is encouraged.

Mourning two of our own: Drs. Mark Crisman and Stephen Soule

Dr. Stephen Soule

Dr. Stephen Soule

AAEP Honor Roll member Dr. Stephen Soule, FEI sport horse veterinarian who practiced at Palm Beach Equine Clinic in Wellington, Fla., died May 25 at the age of 75.

After receiving his veterinary degree from the University of Pennsylvania in 1973, Dr. Soule interned at the New Bolton Center. He served as a state veterinarian in Pennsylvania and as a United States Equestrian Team Veterinarian since 1978. Dr. Soule published in various industry journals and lectured at numerous conferences and events. An AAEP member since 1974, Dr. Soule served on the Horse Show, Purchase Exam and Equine Insurance committees throughout the 1980s and 90s.

Dr. Mark Crisman

Dr. Mark Crisman

Dr. Mark Crisman, senior veterinarian, equine technical services for Zoetis since 2010, died May 20 in his hometown of Blacksburg, Va. He was 69.

Dr. Crisman joined Zoetis following 23 years at the Virginia-Maryland College of Veterinary Medicine, where he served as a professor, section chief of equine medicine and surgery, and director of the molecular diagnostics lab. Dr. Crisman authored or co-authored over 85 refereed publications and book chapters, and his research interests included immunology, pharmacology, and inflammation associated with equine metabolic syndrome. In 2020, he was selected to serve on the board of the Horses and Humans Research Foundation as vice president of scientific advisors.

He received his veterinary degree from the University of Warsaw, Poland in 1984 and achieved diplomate status with the American College of Veterinary Internal Medicine in 1990. A longtime AAEP member, Dr. Crisman served on the Abstract Review, Identification and Student Faculty Advisors committees.

53 members attain Honor Roll status

Acknowledging the longstanding commitment to the veterinary medical profession, the association and the horse, the AAEP conferred Honor Roll status upon 53 veteran members during the preceding 12 months. The Honor Roll membership category is reserved for members who have reached the age of 70 and have maintained an AAEP membership for 40 years. Congratulations to the following members who attained this milestone between July 1, 2022, and June 30, 2023:

Eric J. Abrahamsen, DVM DACVA, Kalamazoo, MI
Mary Ragan Adams, DVM, Fort Collins, CO
Renee Aguirre-Hall, MVZ, Monterrey, Nuevo León, Mexico
Jim L. Alexander, DVM, Peoria, AZ
Mimi Arighi, DVM, Lincoln, CA
Linda Lee Barton, VMD, Harpswell, ME
Judith A. Bechtum, DVM, Webster, MN
Richard L. Bowman, DVM, Fargo, ND
Loren A. Brandt, DVM, Niles, MI
Connie C. Brown, DVM, Versailles, KY
Alfred B. Caudle, DVM, Watkinsville, GA
John D. Chappell, DVM, Cowpens, SC
Andrew R. Clark, DVM, MBA, Aiken, SC
John M. Donecker, VMD, MS, Reidsville, NC
Gary M. Doxtater, DVM, Norge, VA
Andrea E. Floyd, DVM, Evington, VA
Brendan W. Furlong, MVB, MRCVS, Oldwick, NJ
Fred B. Gardner, DVM, Garnett, KS
Allen M. Garst, DVM, Walkersville, MD
Michael W. Giacopuzzi, DVM, Somis, CA
Glenn P. Gillard, VMD, Boynton Beach, FL
Dan M. Gillen, DVM, Loomis, CA
Dee M. Gragg, DVM, Oklahoma City, OK
Marta E. Granstedt-Volkmann, DVM, Simi Valley, CA
Daniel J. Haskins, DVM, Stanwood, WA
C. Tom Hill, DVM, Baker City, OR
Andris J. Kaneps, DVM, Beverly, MA
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Josephine A. Magurn, DVM, Goodview, VA
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Dickson D. Varner, DVM, College Station, TX
Michael D. Williams, DVM, Big Bend, WI
Peggy S. Williams, DVM, Pataskala, OH
Larry A. Wohlford, DVM, Southern Pines, NC

Benefit: Enlist colleagues' expertise in AAEP's online communities

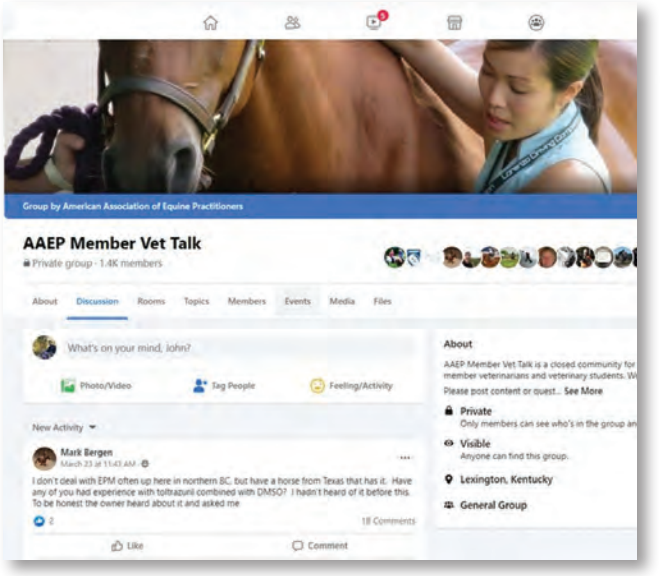
Whether seeking advice on a difficult case, perplexed by an ethical dilemma, or wanting to offer support or guidance, you can draw upon the collective expertise of the membership through the AAEP's online communities.

One component of this complimentary benefit of your membership is the Rounds, which are online forums centered on specific topics and an ideal way to share ideas and knowledge with colleagues. You may subscribe to any of the following Rounds:

Business Education
Complementary & Alternative Medicine
Dentistry
Equitarian
Infectious Disease
New Practitioner
Performance Horse
Podiatry
Public Auction
Purchase Exam
Racing
Reproduction/Perinatology
Solo Practitioner
Wellness & Family Life

You may also subscribe to the General Discussion List, which is open to all topics of interest. To join any of the discussions, visit communities.aaep.org/home.

In addition to the Rounds, the AAEP Member Vet Talk community on Facebook is another forum to solicit or offer case advice or simply share content relevant to equine medicine. More than 1,600 members participate in AAEP Member Vet Talk. To join this AAEP members-only community, simply search for the group on Facebook.



Members in the News

Dr. Jerry Black

AHC honors Dr. Jerry Black

AAEP Past President and Distinguished Life Member Dr. Jerry Black received the American Horse Council's 2023 Hickey Award June 5 during the AHC Conference and National Issues Forum in Denver, Colo. Named in honor of past AHC president James J. Hickey, the award is presented to an individual who has been a great supporter of the horse industry and the AHC.

Dr. Black is a visiting professor at Texas Tech School of Veterinary Medicine and emeritus professor and Wagonhound Land and Livestock Chair in Equine Sciences at Colorado State University, from which he received his veterinary degree. His extensive industry service includes AHC board chair from 2016–2019, AAEP president in 2002, and terms as either chair or member of more than 20 different AAEP councils and committees.

Dr. Rebecca Bishop

AAEP researchers awarded by Morris Animal Foundation

Among 10 new fellowship studies funded by Morris Animal Foundation are a pair of projects by AAEP members Drs. Rebecca Bishop and Shune Kimura.

Dr. Bishop's project studies proteins and the genetic makeup of the peritoneal fluid as a first step toward a diagnostic test to help predict which horses are at higher risk for colic surgery complications. Dr. Kimura's project seeks to determine the feasibility of using a currently available veterinary drug as a treatment for systemic inflammatory response syndrome (SIRS), a serious immune response disorder in horses.

Dr. Shune Kimura

Dr. Bishop, a Ph.D. candidate at the University of Illinois, received her veterinary degree from the Cummings School of Veterinary Medicine at Tufts University in 2017. She received the 2022 AAEP Past Presidents' Research Fellow awarded by The Foundation for the Horse for her research into gastrointestinal diseases of horses.

Dr. Kimura, a Ph.D. candidate at the University of Georgia, earned his veterinary degree in 2017 from Tuskegee University. In February, he received the Storm Car Career Development Award from Grayson-Jockey Club Research Foundation for his research into SIRS.

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Equine Veterinary Education

RESEARCH HIGHLIGHTS

Highlights of recent clinically relevant papers

CROSS-COUNTRY HORSE FALL RISK FACTORS

This retrospective cohort study by Heather Cameron-Whytock and co-workers in the UK aimed to identify risk factors for horse falls, which are the leading cause of rider fatality.

Sixteen riders and 69 horse fatalities were recorded at equestrian eventing competitions in the last 10 years. In this study, British Eventing competition data (January 2005 to December 2015) were analysed. Descriptive statistics followed by univariable logistic regression to identify risk factors for inclusion in a multivariable logistic regression model were conducted. A total of 749,534 cross-country starts were analysed for association with the risk of horse falls.

Sixteen risk factors were identified including: higher event levels, higher dressage penalties and higher number of days since horses' last start. For example, horse and rider combinations competing at BE100 (OR 1.64, CI 1.37–1.96), Novice (OR 3.58, CI 3.03–4.24), Intermediate (OR 8.00, CI 6.54–9.78), Advanced (OR 12.49, CI 9.42–16.57) and International (OR 4.63, CI 3.50–6.12) all had a higher risk of having a horse fall in comparison to combinations competing at BE90 level. Riders that had a horse fall during their previous start (OR 2.39, 1.62–3.53) were more likely to fall during their current start. Horses competing in their first start (OR 2.06, 1.36–3.12) were more likely to have a horse fall than horses that had started in the previous 1–14 days. Furthermore, for every additional 10 dressage penalties awarded to a horse and rider combination, there was a higher risk of a horse fall (OR 1.20, CI 1.12–1.28).

The authors concluded that these study results can be used by sports governing bodies to inform policy which has the potential to reduce the risk of injury and fatality to sports participants.

SALMONELLA SAMPLING

In this study, Jose Goni and co-workers in the United States aimed to determine the optimal pooling technique to maintain high sensitivity of Salmonella *spp. culture using spiked samples, and to demonstrate the efficacy of this protocol on clinical submissions.*

This study included one *Salmonella*-negative horse from a university herd and 19 hospitalised horses. *Salmonella*-free faecal samples were spiked with different amounts of *Salmonella* spp. (10^2, 10^3, 10^4 and 10^5 colony forming units [cfu]) and homogenised to evaluate pooled samples. Five individual faecal samples were collected from 19 hospitalised horses. Ten-gram aliquots of each individual sample were combined to make a pooled sample. Both individual and pooled samples were cultured for *Salmonella* spp. The identity of bacterial isolates was confirmed by matrix-assisted laser desorption-ionisation time of flight mass spectrometry.

A 10^2 cfu concentration of *Salmonella* spp. could be recovered from a spiked *Salmonella*-free faecal sample. Homogenisation protocols indicated that the addition of 20 mL of broth to the pooled sample improved recovery, whereas homogenisation time did not. Of the 19 horses tested, 5 were positive for *Salmonella*. In all instances, *Salmonella* spp. were recovered from the faecal pool as well as individual samples. Pooling of 5 faecal samples for *Salmonella* culture is a sensitive and cost-effective diagnostic approach to detect horses that are shedding the organism.

CYANOACRYLATE MESH CLOSURE

In this retrospective study, Janine Astrid Terschuur and co-workers in the UK assessed the use of topical 2-octyl cyanoacrylate (2-OCA) mesh to close laparotomy incisions in horses.

Three methods of skin closure were used following laparotomy for acute colic, including metallic staples (MS), suture (ST) and cyanoacrylate mesh (DP). Postoperative complications were recorded following contact with owners 3 months after surgery. For each method of closure, the rates of surgical site infection (SSI) and herniation were recorded, as well as surgical time and treatment costs, including those for incisional complications. Chi-square testing and logistic regression modelling were used to assess differences between the groups.

A total of 110 horses were included (45 DP, 49 MS, 16 ST). The overall rate of SSI was 15.5% (8.9% DP, 18.4% MS, 25% ST). Incisional hernias developed in 21.8% of cases (8.9% DP, 34.7% MS, 18.8% ST). The median total treatment cost did not differ significantly between groups. No significant differences in the rate of SSI or overall cost were demonstrated between treatment groups. However, MS was associated with a higher rate of hernia formation than DP or ST.

Despite the increased capital cost, 2-OCA proved to be a safe skin closure method in horses and was no more expensive than DP or ST after factoring in visits to remove sutures/staples and treat infections.

OSTEOCHONDRAL FRAGMENT REMOVAL

In this retrospective observational study, Janna Goldkuhl and co-workers in Germany assessed the prevalence of cartilage injury in the equine metacarpo–/metatarsophalangeal joint and its association with fragment size, location, age and lameness.

Clinical records including radiographs of 823 metacarpo–/metatarsophalangeal joints (640 horses) that underwent arthroscopic fragment removal were reviewed. Fragment size, intra-articular fragment location and cartilage injury score were recorded. Presence of synovitis was retrospectively evaluated in 157 joints.

Cartilage injury was present in 28.8% (95% CI 25.8–32.0) of joints. Lameness was not associated with fragment location or fragment size. Fragment size was not associated with cartilage injury. Age (OR 1.35, 95% CI 1.22–1.48) and lameness (OR 5.03, 95% CI 2.27–11.68) were associated with cartilage injury as well as fragment location (palmar/plantar, OR 0.22, 95% CI 0.13–0.38), with dorsal fragments being more likely to be associated with cartilage lesions than palmar/plantar fragments. There was a significant association between age and mean cartilage score ($b = 0.18$, 95% CI 0.14–0.22).

These results show no association between radiographic fragment size, presence of synovitis and cartilage injury. The likelihood of a joint presenting with cartilage lesions increases with dorsal fragmentation, lameness and older age. Early fragment removal, especially in joints with dorsal fragmentation, could be beneficial to avoid future cartilage injuries in equine athletes.

BLOOD GASES DURING RECOVERY

In this study, Kelsey Fisher and co-workers in the United States compared PaO_2 and $PaCO_2$ in horses recovering from general anaesthesia maintained with either apneustic anaesthesia ventilation (AAV) or conventional mechanical ventilation (CMV).

Ten healthy adult horses were anaesthetised in dorsal recumbency with isoflurane in oxygen [inspired oxygen fraction = 0.3 initially, with subsequent titration to maintain $PaO_2 \geq 85$ mmHg (11.3 kPa)] and ventilated with AAV or CMV according to predefined criteria [10 mL/kg bwt tidal volume, $PaCO_2$ 40-45 mmHg (5.3–6.0 kPa) during CMV and < 60 mmHg (8.0 kPa) during AAV]. Horses were weaned from ventilation using a predefined protocol and transferred to a stall for unassisted recovery. Arterial blood samples were collected and analysed at predefined timepoints. Tracheal oxygen insufflation at 15 L/min was provided if $PaO_2 < 60$ mmHg (8.0 kPa) on any analysis. Time to oxygen insufflation, first movement, sternal recumbency and standing were recorded.

Between modes, PaO_2 was significantly higher immediately after weaning from ventilation and lower at sternal recumbency for AAV than for CMV. No $PaCO_2$ differences were noted between ventilation modes. All horses ventilated with CMV required supplemental oxygen, whereas three horses ventilated with AAV did not. Time to first movement was shorter with AAV. Time to oxygen insufflation was not different between ventilation modes.

Although horses ventilated with AAV entered the recovery period with higher PaO_2, this advantage was not sustained during recovery. Fewer horses required supplemental oxygen after AAV; however, the use of AAV does not preclude the need for routine supplemental oxygen administration in horses recovering from general anaesthesia.

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REFERENCES

Cameron-Whytock, H.A., Parkin, T.D.H., Hobbs, S.J., Brigden, C.V. & Bennet, E.D. (2023) Towards a safer sport: risk factors for cross-country horse falls at British Eventing competition. *Equine Veterinary Journal*, Epub ahead of print. Available from: https://beva.onlinelibrary.wiley.com/doi/10.1111/evj.13934

Fisher, K., Dodam, J., Bailey, J., Thombs, L., Hodgson, D. & Bukoski, A. (2023) Arterial blood gas tensions during recovery in horses anesthetized with apneustic anesthesia ventilation compared with conventional mechanical ventilation. *Journal of Veterinary Anaesthesia Analgesia*, Epub ahead of print. Available from: https://doi.org/10.1016/j.vaa.2023.01.004

Goldkuhl, J.E.C., Zablotski, Y., Sill, V., Jahn, W., Lorenz, I., Brunk, J. et al. (2023) Evaluation of cartilage injury in horses with osteochondral fragments in the metacarpo–/metatarsophalangeal joint: a study on 823 arthroscopies. *Equine Veterinary Journal*, Epub ahead of print. Available from: https://beva.onlinelibrary.wiley.com/doi/10.1111/evj.13937

Goni, J.I., Hendrix, K. & Kritchevsky, J. (2023) Recovery of *salmonella* bacterial isolates from pooled fecal samples from horses. *Journal of Veterinary Internal Medicine.*, 37(1), 323–327. Available from: https://doi.org/10.1111/jvim.16586

Terschuur, J.A., Coomer, R.P.C., Handel, I., Pressanto, M.C. & McKane, S.A. (2023) Benefits of cyanoacrylate mesh closure following exploratory laparotomy in horses. *Veterinary Record*, Epub ahead of print. Available from: https://doi.org/10.1002/vetr.2732

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Equine Veterinary Education BEVA AAEP

CASE REPORT

Long-term monitoring with an implantable loop recorder detects multiple episodes of paroxysmal atrial fibrillation after electrical cardioversion in a Warmblood horse

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Summary

Atrial fibrillation (AF) is a pathological arrhythmia affecting performance horses and is termed paroxysmal (pAF) when self-terminating to sinus rhythm. Little is known about pAF as its sporadic nature makes it difficult to diagnose. Therefore, continuous electrocardiographic monitoring devices, such as implantable loop recorders (ILR), are necessary to detect the time of onset and episode duration. This case report presents the detection of pAF in a 9-year-old Warmblood horse after successful transvenous electrical cardioversion (TVEC). An ILR continuously monitored the heart rhythm over 28 months and detected 12 episodes of pAF of which two episodes were associated with reduced performance, while others occurred asymptomatically at rest. The estimated episode duration ranged from 6 min to 46.5 h. The antiarrhythmic drug sotalol (2 mg/kg bwt BID PO) was given prior to TVEC and then for 4 weeks. As episodes continued to occur, sotalol was prescribed for another 4 weeks, 6 months after TVEC. Continuous monitoring after TVEC allows for detection of AF recurrence and identification of AF burden, approximate time of onset and possible identification of trigger events. Early diagnosis and antiarrhythmic treatment may prevent a progression to persistent AF.

KEYWORDS
horse, AF recurrence, atrial arrhythmia, heart rhythm monitoring, insertable cardiac monitor, sotalol

INTRODUCTION

Paroxysmal atrial fibrillation (pAF) is a pathological arrhythmia that can appear spontaneously without clinical disease and is self-terminating usually within 7 days (Hindricks et al., 2021; Kjeldsen et al., 2022). The arrhythmia may be triggered by spontaneous ectopic firing or increased automaticity and is sustained by an abnormal substrate (e.g. atrial dilation or fibrosis) (Decloedt et al., 2020). The presence of pAF causes atrial remodelling and promotes the progression of the arrhythmia; however, the pathophysiologic pathways are not fully understood (Kjeldsen et al., 2022).

Paroxysmal AF is primarily reported in racehorses, with an estimated incidence of up to 4.9% (Nath et al., 2021; Slack et al., 2015), as overt clinical signs such as sudden loss of speed ease recognition of possible arrhythmic horses, but clinical signs may be subtle or even unnoticeable in horses performing at a less intense level.

Novel methods for early diagnosis of pAF include computational analyses of sinus rhythm (SR) ECG (Alexeenko et al., 2020;

Huang et al., 2020) and the use of insertable cardiac monitoring devices such as implantable loop recorders (ILR) (Buhl, Hesselkilde, et al., 2020; Buhl, Nissen, et al., 2020). The ILR continuously monitors the patient's heart rhythm with two electrodes and with an incorporated AF detection algorithm, it detects R–R interval deviations and whether a P wave is present between the two R waves to generate an AF evidence score (Pürerfellner et al., 2014).

Here, we report a case with multiple pAF episodes following TVEC, detected by an ILR, which had been monitoring continuously for 28 months. The characteristics of the pAF episodes are described based on the registrations from the ILR. This is accompanied by a description of how the ILR can be used to monitor AF in horses.

CASE DETAILS

History

In October 2019, a 9-year-old Danish Warmblood dressage gelding was diagnosed with persistent AF and was referred for transvenous electrical cardioversion (TVEC) after one unsuccessful attempt of cardioversion with quinidine sulphate.

Clinical findings and treatment

Upon arrival, a clinical examination, bloodwork (biochemistry and haematology), ECG and echocardiography were performed. The horse was diagnosed with AF and trivial pulmonic and tricuspid regurgitation. The atrial fibrillatory rate (AFR) from the surface ECG (Televet, Kruuse) was 440 fibrillations per minute (fpm). Two days prior to cardioversion treatment with sotalol (Sotalol, Viatris Aps, 2 mg/kg bwt BID PO) was initiated, which was continued for 4 weeks to minimise the recurrence risk (Broux et al., 2018), the horse underwent TVEC according to existing procedures (McGurrin et al., 2005). Cardioversion was successful after the second shock at 125 J, and the horse recovered uneventfully from anaesthesia.

Implantation of loop recorder

After recovery from anaesthesia, an ILR (Reveal LINQ; Medtronic A/S) was implanted on the left thoracic side between the fifth and sixth costae at the level of the shoulder joint as previously described (Buhl, Hesselkilde, et al., 2020) (Figure 1). A single dose of flunixin (Finadyne; MSD Animal Health, 1.1 mg/kg bwt IV) was given and no antibiotics were used. After the implantation procedure, a programming device (CareLink Programmer 2090; Medtronic A/S) was used to program the ILR for AF detection with the following settings: *AF detection 'ON-AF only'*, detection sensitivity '*Balanced sensitivity'*, ectopy rejection '*Nominal*', detection threshold *'0.035 mV'*, recording threshold *'All episodes'* and a symptomatic episode duration of 7.5 min (Medtronic, 2017). In case of AF recurrence, the ILR records episode time and date of estimated onset and the duration of AF, which then can be extracted from the ILR after manual interrogation with the 2090 programmer (Buhl, Hesselkilde, et al., 2020; Buhl, Nissen, et al., 2020). The ILR is automatically programmed to record a 2-min ECG from episode detection and is able to store 59 min of ECG in total corresponding to 30 episodes. However, when the storage is full, an episode can be stored with episode information as text only and no ECG. After interrogation, the storage space of the ILR is cleared. The owner received a patient assistant (Medtronic, 2017), which is a remote that can activate the ILR in case the horse expresses clinical signs. By activating the ILR, an ECG is immediately recorded and stored on the ILR, nonetheless manual interrogation is necessary to extract the episode.

Follow-up examinations with ECG and echocardiography

Three days after cardioversion, a follow-up cardiac examination including a 3-lead ECG, echocardiography (Table 1) and interrogation of the ILR, was performed. The ECG confirmed the horse was in SR; however, several second-degree atrioventricular blocks (2AVB) were observed, and often with a repetitive pattern of two

FIGURE 1 (a) Subcutaneous insertion of a loop recorder (left top corner) with provided introducer. (b) Closing of skin with staples. (c, d) after skin healing, the loop recorder is barely visible and usually does not cause any discomfort or problems in relation to rider equipment.

TABLE 1 Echocardiographic and electrocardiographic measurements before TVEC, 3 days and 2 years after TVEC.

Measurement	Before TVEC	3 days after TVEC	2 years after TVEC
Heart rhythm	AF	SR	SR
$LAD_{llx\text{-}max}$ (500)	14.0 cm	12.6 cm	12.1 cm
LAA_{max} (500)	96.2 cm^2	98.1 cm^2	92.0 cm^2
LAA_{min} (500)	77.9 cm^2	76.2 cm^2	73.6 cm^2
LAAp (500)	[a]	78.0 cm^2	82.0 cm^2
LA FAC_{active}	[a]	2.25%	10.25%
LVIDd (500)	11.8 cm	11.6 cm	12.1 cm
LVIDs (500)	6.9 cm	6.9 cm	6.2 cm
LV FS	40%	40%	40%
P wave duration	[a]	204 ms	179 ms
PR-interval	[a]	498 ms	403 ms
Mean HR	40 bpm	39 bpm	36 bpm

Note: All echocardiographic measurements are allometrically scaled to a bodyweight of 500 kg (500).

Abbreviations: AF, atrial fibrillation; bpm, beats per minute; FAC, fractional area change; HR, heart rate; LAA, left atrial area; LAD_{llx}, left atrial diameter (left long axis); LV FS, left ventricular fractional shortening; LVID(d/s), left ventricular internal diameter in systole or diastole; SR, sinus rhythm; TVEC, transvenous electrical cardioversion.

[a]Measurements are not obtainable during AF. All examinations were performed by the same operator.

consecutive P waves being blocked, followed by three or four conducted beats. The echocardiographic examination revealed signs of atrial stunning with increased left atrial diameter (LAD) and left atrial area (LAA) while the fractional area change (FAC_{active}) was decreased to only 2.25%. Furthermore, the ILR had not detected any AF episodes.

Two years later, a second follow-up examination was performed with ECG and echocardiography. The ECG showed SR with occasional 2AVB. Comparing the echocardiographic measurements from the examination 3 days post TVEC with the examination 2 years later, the values were normalised (Table 1).

Results from the implantable loop recorder

Interrogation of the ILR was performed ad hoc and six times in total during the 28-month monitoring period. The ILR indicated 184 alerts, of which 77 included an ECG recording, and the remaining only included a text file. The 77 ECG recordings originated from 12 episodes of pAF (Table 2). Two of these were symptomatic, as the owner noticed tiredness during riding (Figure 2). As SR was not observed between the two symptomatic episodes and they were 1 day apart, it should most likely be considered one single episode of pAF. All ECGs from these alerts were analysed manually to confirm AF. The detected episode duration varied from 6 min to 46.5 h, with periods between the episodes lasting 4–245 days. Most episodes were detected during the daytime and one in the evening. Because of low battery status, the ILR was replaced with another device after 24 months. The preparation and aftercare for the replacement procedure was identical to the above-mentioned insertion procedure. A small incision of 1 cm was made horizontally on the most dorsal part of the ILR through the skin and the thin fibrotic pocket. The old ILR could easily be removed and the new was inserted in the same pocket, hereafter the skin was closed with two staples. The signal from the ILR was checked, and the amplitude was the same as the previous ILR.

As pAF episodes continued to occur 6 months after TVEC (episode #4) sotalol (2 mg/kg bwt BID PO) was administered for 4 weeks. Hereafter no episodes were registered for 8 months where a new episode occurred (episode #5) (Table 2), which was the longest duration between two episodes. No episodes occurred during sotalol treatment. At the time of writing this paper, the horse is in SR with sporadic episodes of pAF.

DISCUSSION

This case is the first to report the diagnosis of pAF by use of an ILR after successful electrical cardioversion to SR and describes how the ILR can be used to monitor the AF burden in a Warmblood horse with pAF.

No specific pattern of the AF burden was observed during the 28-month period. In this time frame, no progression to persistent AF was observed. In theory progression to persistent AF could have been hypothesised, presuming that the horse already had an abnormal substrate to maintain persistent AF. Previous studies have shown that only a few days of AF may cause atrial remodelling, which resulted in an abnormal substrate that promotes AF (De Clercq et al., 2008; Hesselkilde et al., 2019). Nevertheless, early electrical and functional remodelling can be reversed to some degree when the patient returns to normal SR, which may explain why this patient never generated a substantial substrate to maintain persistent AF (De Clercq et al., 2008). In human patients with pAF many never progress into persistent AF, and progression is associated with increased age, and increased cardiac remodelling such as increased atrial size (Hindricks et al., 2021).

Ectopic triggering from the myocardial sleeves of the pulmonary veins often causes pAF in human patients (Haïssaguerre et al., 1998). Similar mechanisms have been reported in a horse (Linz et al., 2020). Spontaneous firing induces an electrical signal that travels the atria and can result in short runs of AF, but with the lack of a suitable substrate, the electrical activity terminates and returns to normal SR. Autonomic tone and interchangeable sympathetic/parasympathetic stimuli may promote triggering signals during daytime (Linz et al., 2019), which could explain why the estimated onset of pAF was predominantly during the daytime. Although, pAF in horses has also been recorded in the nighttime (Buhl, Nissen, et al., 2020) where vagal activity is assumed to predominate.

TABLE 2 Data collected by the implantable loop recorder (ILR).

Episode no.	Episode detection date (dd.mm.yy)	Time of estimated onset (hh:mm)	Duration (hours, minutes)	Days since previous episode
TVEC	6.11.19	10:00	—	—
# 1	28.2.20	12:20	25 h 52 min	115
# 2	5.4.20	13:43	SYMPTOM	37
# 3	6.4.20	16:11	SYMPTOM	[a]
# 4	23.4.20	12:54	46 h 32 min	17
# 5	24.12.20	13:38	46 h	245
# 6	4.1.21	11:04	7 h 50 min	11
# 7	19.3.21	11:22	28 h 30 min	74
# 8	26.8.21	10:16	27 h 42 min	160
# 9	30.8.21	10:46	6 min	4
# 10	13.9.21	10:42	23 h 28 min	14
# 11	9.10.21	8:20	6 min	26
# 12	11.2.22	20:27	43 h 38 min	125
Total			Range 6–46:32	Range 4–245

Note: The ILR provides information on the detection date (dd.Mm.Yy) and time of estimated onset (hh:mm), duration of episodes (hours minutes). Furthermore, days since previous episodes are included in this table.

Abbreviations: TVEC, transvenous electrical cardioversion.

[a]Episode #2 and #3 could be considered one single episode as they appear only 1 day apart; however, they are listed as two separate episodes as they are recorded as SYMPTOM episodes. SYMPTOMS are episodes of 7.5 min recorded when a patient assistant is activated by the owner.

Paroxysmal AF has primarily been reported in racing horses without underlying cardiac conditions, with an incidence up to 4.9% diagnosed by use of short-term ECG recordings (Nath et al., 2021; Slack et al., 2015). When using ILR a much higher frequency of 33% has been reported (Buhl, Nissen, et al., 2020). This suggests that continuous monitoring with ILR allows diagnosis of even short episodes and thus increasing the detection frequency of the arrhythmia. However Buhl, Nissen, et al. (2020) only included 12 horses all with poor performance, which might also explain the higher prevalence in their study.

In the current case, two of 12 episodes were recorded as symptom episodes when the owner activated the ILR with the patient assistant due to reduced performance during riding. However, it is uncertain if exercise was the trigger of pAF or if pAF was already present during riding as the transition from SR to AF was not observed, nor was AF onset recorded by the ILR at any other time points. Motion artefacts limited the arrhythmia detection of the ILR during exercise. A similar limitation of the ILR has previously been reported (Buhl, Nissen, et al., 2020).

Several clinical factors have been associated with the risk of recurrence including previous unsuccessful attempt of cardioversion, reduced LA FAC, mitral regurgitation, longer AF duration and increased AFR (Buhl et al., 2022; Decloedt et al., 2015; Reef et al., 1988; Vernemmen et al., 2020). This case went through one unsuccessful attempt of cardioversion with quinidine and had an AFR of 440 fpm, which is above the level of 380 fpm that is associated with increased risk of recurrence (Buhl et al., 2022). The atrial contractile function was assessed by atrial area measurements obtained from 2D echocardiography; however, more advanced techniques such as Tissue Doppler Imaging or 2D speckle tracking provides additional information about the myocardial function (Eberhardt et al., 2020; Schwarzwald et al., 2007). These methods need to be validated in horses examined in AF. Interestingly, the longest duration between episodes (245 days) was following the second treatment of sotalol. As a class III antiarrhythmic drug, sotalol prolongs the atrial and ventricular effective refractory period and lowers the heart rate, decreasing the risk of re-entry and recurrence of AF (Broux et al., 2018; Decloedt et al., 2018). However, it also prolongs the QT-interval, which increases the risk of dangerous ventricular arrhythmias (Decloedt et al., 2018); therefore, sotalol should be used with care and only mild exercise was recommended during treatments. As this case was a patient at risk of AF recurrence, we decided on a 4-week treatment period with sotalol, but it is uncertain if a shorter treatment period or no treatment at all would have resulted in the same AF burden.

At no time did the horse show any signs of discomfort from the ILR. The ILR was programmed to detect 'AF only', based on the patient's history of persistent AF and our previous experience with using ILR for AF detection (Buhl, Hesselkilde, et al.,2020; Buhl, Nissen, et al., 2020). As the ILR is developed for human purposes, the normal heart rate in horses and frequent 2AVB may be misinterpreted as asystole or bradycardia. One part of the ILR algorithm uses P wave detection to rule out AF, but in horses the P wave can be difficult to detect, as the small electrodes are only a few centimetres apart. Also, movement artefacts easily affect the ILRs ability to sense correctly. These factors can affect the ILR's ability to detect AF correctly, including the registered time of onset and duration. This should be considered when using ILRs in horses. Therefore, all

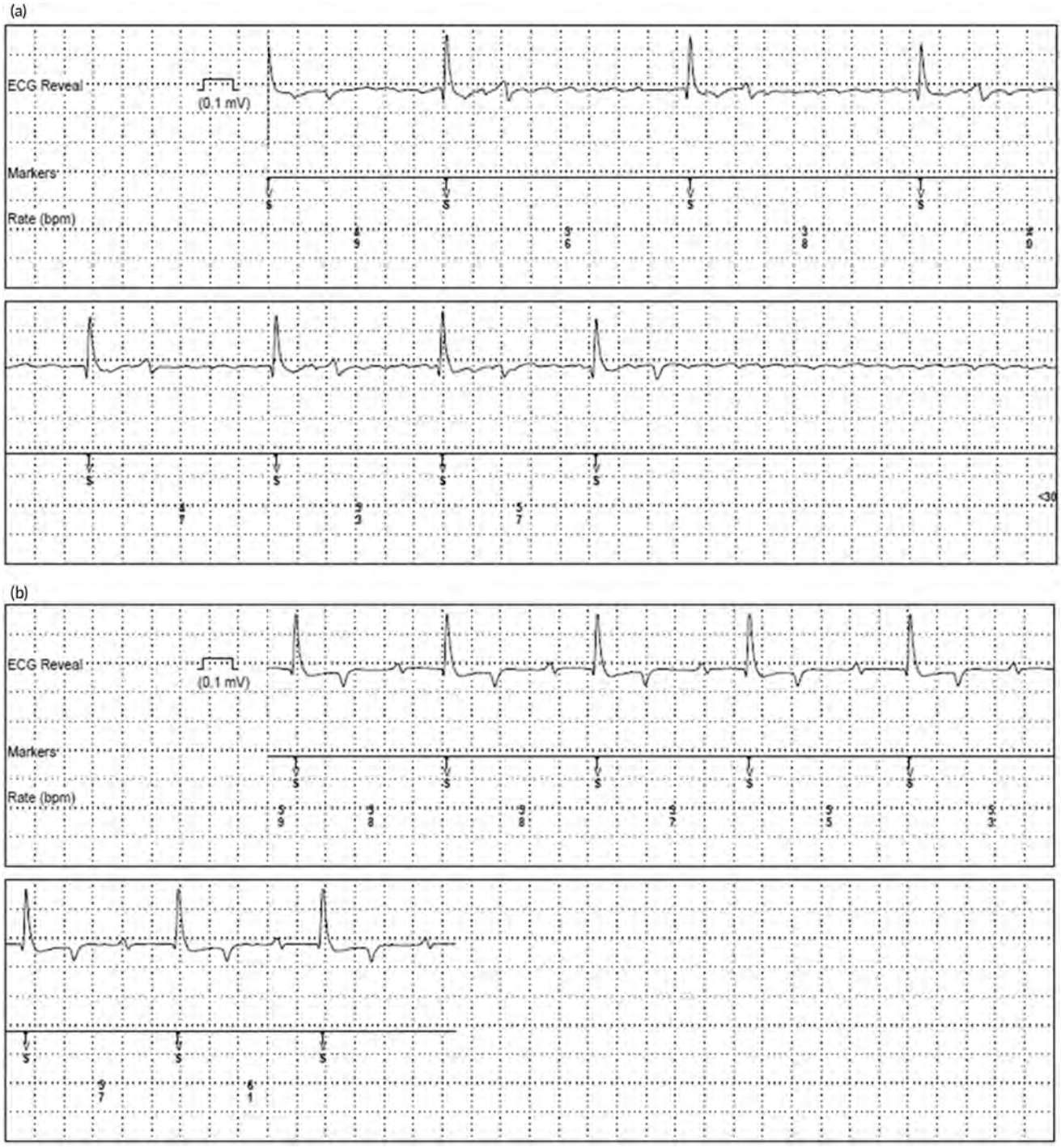

FIGURE 2 (a) ECG of paroxysmal atrial fibrillation detected by the implantable loop recorder. Bottom line shows heart rate in beats per minutes (Bpm). VS, ventricular sensing, (b) ECG showing sinus rhythm from the same patient.

ECGs were analysed manually. In humans, the Reveal LINQ diagnostic sensitivity to detect AF episodes is 97.3% (Sanders et al., 2016). Nevertheless, future studies investigating the sensitivity and specificity of insertable monitoring devices for AF detection in horses are needed.

The ILR was replaced after 2 years as it ran low on battery. As the ILR has a storage and battery limitation, frequent interrogation is necessary to ensure that ECGs are stored. Human patients get their ILR implanted in ambulatory clinics and are assigned a home monitor, which automatically transfers data from the ILR via a 3G network to an online storage system accessible by their doctor. Hopefully, this could be the future in equine medicine to overcome the logistic issues related to interrogations. The ILRs are expensive and factors such as economy, age and performance level should be considered in every case. Currently, insertable cardiac monitoring devices in horses have mostly been used for research purposes and are not yet easily available in clinical settings. As pAF appears sporadically, it might not be detected during short ECG recordings

(2/4/7 days), and this is where continuous monitoring devices become beneficial.

This report demonstrates how an ILR can be applied in horses at risk of AF recurrence or cases with reduced performance of unknown cause. Continuous monitoring of pAF episodes can be useful to follow the AF burden and add valuable information in case of disease progression. If monitored closely, the ILR has the potential to facilitate early intervention if medical and/or electrophysiological techniques can be proven to prevent recurrence of persistent AF in the future.

AUTHOR CONTRIBUTIONS

All authors have contributed to the clinical management of the horse and contributed to the data interpretation. All authors have approved the final manuscript.

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We would like to thank the owner of the horse for allowing us to present this case.

CONFLICT OF INTEREST

The Reveal LINQs were reused for scientific purposes with approval by Medtronic.

ETHICS STATEMENT

No ethical review required for a case report.

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REFERENCES

Alexeenko, V., Fraser, J.A., Bowen, M., Huang, C.L.H., Marr, C.M. & Jeevaratnam, K. (2020) The complexity of clinically-normal sinus-rhythm ECGs is decreased in equine athletes with a diagnosis of paroxysmal atrial fibrillation. *Scientific Reports*, 10, 6822.

Broux, B., De Clercq, D., Decloedt, A., Vera, L., Devreese, M., Gehring, R. et al. (2018) Pharmacokinetics and electrophysiological effects of sotalol hydrochloride in horses. *Equine Veterinary Journal*, 50, 377–383.

Buhl, R., Hesselkilde, E.M., Carstensen, H., Fenner, M.F., Jespersen, T., Tfelt-Hansen, J. et al. (2020) Detection of atrial fibrillation with implantable loop recorders in horses. *Equine Veterinary Journal*, 53, 397–403.

Buhl, R., Hesselkilde, E.M., Carstensen, H., Hopster-Iversen, C., Loon, G., Decloedt, A. et al. (2022) Atrial fibrillatory rate as predictor of recurrence of atrial fibrillation in horses treated medically or with electrical cardioversion. *Equine Veterinary Journal*, 54, 1013–1022.

Buhl, R., Nissen, S.D., Winther, M.L.K., Poulsen, S.K., Hopster-Iversen, C., Jespersen, T. et al. (2020) Implantable loop recorders can detect paroxysmal atrial fibrillation in Standardbred racehorses with intermittent poor performance. *Equine Veterinary Journal*, 53, 955–963.

De Clercq, D., van Loon, G., Tavernier, R., Duchateau, L. & Deprez, P. (2008) Atrial and ventricular electrical and contractile remodeling and reverse remodeling owing to short-term pacing-induced atrial fibrillation in horses. *Journal of Veterinary Internal Medicine*, 22, 1353–1359.

Decloedt, A., Broux, B., De Clercq, D., Deprez, P., Van Steenkiste, G., Vera, L., Ven, S., & van Loon, G. (2018) Effect of sotalol on heart rate, QT interval, and atrial fibrillation cycle length in horses with atrial fibrillation. *Journal of Veterinary Internal Medicine*, 32(2), 815–821. https://doi.org/10.1111/jvim.15055

Decloedt, A., Schwarzwald, C.C., De Clercq, D., Van Der Vekens, N., Pardon, B., Reef, V.B. et al. (2015) Risk factors for recurrence of atrial fibrillation in horses after cardioversion to sinus rhythm. *Journal of Veterinary Internal Medicine*, 29, 946–953.

Decloedt, A., Van Steenkiste, G., Vera, L., Buhl, R. & van Loon, G. (2020) Atrial fibrillation in horses part 1: pathophysiology. *Veterinary Journal*, 263, 105521.

Eberhardt, C., Mitchell, K.J. & Schwarzwald, C.C. (2020) Quantification of left atrial wall motion in healthy horses using two-dimensional speckle tracking. *Journal of Veterinary Cardiology*, 30, 32–43.

Haïssaguerre, M., Jaïs, P., Shah, D.C., Takahashi, A., Hocini, M., Quiniou, G. et al. (1998) Spontaneous initiation of atrial fibrillation by ectopic beats originating in the pulmonary veins. *The New England Journal of Medicine*, 339, 659–666.

Hesselkilde, E.Z., Carstensen, H., Flethøj, M., Fenner, M., Kruse, D.D., Sattler, S.M. et al. (2019) Longitudinal study of electrical, functional and structural remodelling in an equine model of atrial fibrillation. *BMC Cardiovascular Disorders*, 19, 228.

Hindricks, G., Potpara, T. & Dagres, N. (2021) 2020 ESC guidelines for the diagnosis and management of atrial fibrillation developed in collaboration with the European Association for Cardio-Thoracic Surgery (EACTS). *European Heart Journal*, 42, 373–498.

Huang, Y.H., Alexeenko, V., Tse, G., Huang, C.L.-H., Marr, C.M. & Jeevaratnam, K. (2020) ECG restitution analysis and machine learning to detect paroxysmal atrial fibrillation: insight from the equine athlete as a model for human athletes. *Function*, 2, zqaa031.

Kjeldsen, S.T., Nissen, S.D., Buhl, R. & Hopster-Iversen, C. (2022) Paroxysmal atrial fibrillation in horses: pathophysiology, diagnostics and clinical aspects. *Animals*, 12, 698.

Linz, D., Elliott, A.D., Hohl, M., Malik, V., Schotten, U., Dobrev, D. et al. (2019) Role of autonomic nervous system in atrial fibrillation. *International Journal of Cardiology*, 287, 181–188.

Linz, D., Hesselkilde, E., Kutieleh, R., Jespersen, T., Buhl, R. & Sanders, P. (2020) Pulmonary vein firing initiating atrial fibrillation in the horse: oversized dimensions but similar mechanisms. *Journal of Cardiovascular Electrophysiology*, 31, 1211–1212.

McGurrin, M.K.J., Physick-Sheard, P.W. & Kenney, D.G. (2005) How to perform transvenous electrical cardioversion in horses with atrial fibrillation. *Journal of Veterinary Cardiology*, 7, 109–119.

Medtronic. (2017) Reveal Linq product specifications. Available from: https://europe.medtronic.com/content/dam/medtronic-com/xd-en/hcp/documents/Diagnostics/reveal-LINQ-ICM-specifications.pdf [Accessed 9th May 2022].

Nath, L.C., Elliott, A.D., Weir, J., Curl, P., Rosanowski, S.M. & Franklin, S. (2021) Incidence, recurrence, and outcome of postrace atrial fibrillation in thoroughbred horses. *Journal of Veterinary Internal Medicine*, 35, 1111–1120.

Pürerfellner, H., Pokushalov, E., Sarkar, S., Koehler, J., Zhou, R., Urban, L. et al. (2014) P-wave evidence as a method for improving algorithm to detect atrial fibrillation in insertable cardiac monitors. *Heart Rhythm*, 11, 1575–1583.

Reef, V.B., Levitan, C.W. & Spencer, P.A. (1988) Factors affecting prognosis and conversion in equine atrial fibrillation. *Journal of Veterinary Internal Medicine*, 2, 1–6.

Sanders, P., Pürerfellner, H., Pokushalov, E., Sarkar, S., Di Bacco, M., Maus, B. & Dekker, L.R.C. (2016) Performance of a new atrial fibrillation detection algorithm in a miniaturized insertable cardiac monitor: Results from the reveal LINQ usability study. *Heart Rhythm*, 13(7), 1425–1430. https://doi.org/10.1016/j.hrthm.2016.03.005

Schwarzwald, C.C., Schober, K.E. & Bonagura, J.D. (2007) Methods and reliability of echocardiographic assessment of left atrial size and mechanical function in horses. *American Journal of Veterinary Research*, 68, 735–747.
Slack, J., Boston, R.C., Soma, L.R. & Reef, V.B. (2015) Occurrence of cardiac arrhythmias in Standardbred racehorses. *Equine Veterinary Journal*, 47, 398–404.
Vernemmen, I., De Clercq, D., Decloedt, A., Vera, L., Van Steenkiste, G. & van Loon, G. (2020) Atrial premature depolarisations five days post electrical cardioversion are related to atrial fibrillation recurrence risk in horses. *Equine Veterinary Journal*, 52, 374–378.

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Equine Veterinary Education

CLINICAL COMMENTARY

Implantable loop recorders for detecting arrhythmia in horses: Research tool or diagnostic technique?

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Keywords: arrhythmia, atrial fibrillation, electrocardiography, event recorder, horse, syncope

PAROXYSMAL ATRIAL FIBRILLATION IN HORSES

Paroxysmal atrial fibrillation (AF) has been associated with poor performance in equine athletes but diagnosing this arrhythmia can be daunting (Kjeldsen, Nissen, et al., 2022; Nath et al., 2021). The case report of Kjeldsen, Jensen, et al. (2023) describes the use of an implantable loop recorder (ILR) to detect multiple episodes of paroxysmal AF in a Warmblood dressage horse after successful transvenous electrical cardioversion. Paroxysmal AF is defined as AF which spontaneously converts to sinus rhythm within 24–48 h (Reef et al., 2014) up to 5 days (van Loon, 2019). Paroxysmal AF is most commonly described immediately after exercise in poor performing or non-finishing racehorses. A prevalence of 0.29% was found among horses racing in Japan Racing Association-sanctioned races, with an overall frequency of 0.03% (1 in 3333 race starts) (Ohmura et al., 2003). In 92.7% of these AF episodes, the arrhythmia converted to sinus rhythm within 24 h without medical treatment. In a retrospective study among Thoroughbreds racing in Hong Kong, the overall incidence of postrace AF was 4.9 per 100 horses registered to race during the study period, with an incidence of 2.7 per 1000 starts (Nath et al., 2021). In Standardbred racehorses, the frequency of AF was 2.0% among non-finishers and slow finishers (Slack et al., 2015). Due to its self-limiting and temporary nature, the actual prevalence of paroxysmal AF is difficult to determine and the arrhythmia is probably underdiagnosed. As for other exercise-associated arrhythmias, the reproducibility of exercising electrocardiography (ECG) should be taken into account when exercise testing is performed to diagnose paroxysmal AF as a potential cause of poor performance. Previous research has suggested that multiple exercise tests may be needed to detect the presence of arrhythmias, although the exercising rhythm was more consistent than the postexercise rhythm (Navas de Solis et al., 2016). Computer-based analysis of the ECG in sinus rhythm has also been proposed as a screening tool for paroxysmal AF, based on complexity analysis with two estimators (Alexeenko et al., 2020) or restitution analysis combined with a machine learning algorithm (Huang et al., 2022). Although these analyses might be a potential screening tool for paroxysmal AF, the diagnosis cannot be confirmed by these techniques alone. Continuous rhythm monitoring using an implantable loop recorder (ILR) therefore seems to be an interesting diagnostic technique.

IMPLANTABLE LOOP RECORDERS

The use of ILRs has been described in horses for the detection of AF and pathological bradyarrhythmias (Buhl, Hesselkilde, et al., 2021; Buhl, Nissen, et al., 2021; Lyle et al., 2010; Nissen et al., 2022). An ILR is a small subcutaneously implanted device which continuously monitors the ECG and analyses the cardiac rhythm. In case of predefined arrhythmic events, short ECG snapshots are recorded and stored. ILR implantation in horses is feasible, minimally invasive and safe (Buhl, Hesselkilde, et al., 2021). However, the anatomical location is crucial for optimal detection of arrhythmias. The implant site at the sixth left intercostal space at the level of the shoulder joint resulted in the best signal quality with high R wave amplitudes and high R/T amplitude ratio. ILRs have been used to detect paroxysmal AF in racehorses with intermittent poor performance (Buhl, Nissen, et al., 2021). In that study, paroxysmal AF was diagnosed in 4/12 Standardbreds with decreased performance. Remarkably, only two episodes occurred during competition while the other episodes occurred during training or at rest. However, a major limitation of ILRs is the presence of motion artefacts and insufficient ECG quality during exercise. Exercise-associated paroxysmal AF may still be diagnosed as the ILR can detect arrhythmias immediately after exercise (Buhl, Nissen, et al., 2021), but the application

of ILRs to detect exercise-associated ventricular arrhythmias is limited. In contrast, ILRs might be useful in clinical patients with suspected pathological bradyarrhythmias or unexplained collapse (Keen, 2020). In one horse with collapse, the ECG obtained during two syncopal episodes did not reveal arrhythmias or abnormal complexes which led to a presumed diagnosis of neurocardiogenic syncope by increased vasodepressor activity (Lyle et al., 2010). In another case suffering from multiple collapses, the ILR revealed episodes with consecutive second-degree atrioventricular blocks generating pauses of over 5 s duration (Nissen et al., 2022). However, no recordings during collapse were obtained due to lack of battery power.

RESEARCH TOOL OR DIAGNOSTIC TECHNIQUE?

Kjeldsen, Jensen, et al. (2023) suggest that ILRs may be useful for early diagnosis of recurrent AF after cardioversion. Close follow-up of these patients is indeed important as the recurrence rate of AF after electrical or pharmacological cardioversion is up to 40% (Decloedt et al., 2015; Premont et al., 2022; Vernemmen et al., 2022). Timely detection of recurrence is crucial to prevent atrial myocardial remodelling and to ensure horse and rider safety as AF can cause high heart rates and abnormal ventricular activation during exercise, which has been associated with collapse or in rare cases sudden death (Decloedt et al., 2020). However, the ILR used in this case report required manual interrogation to extract the data. Although the owner did receive a patient assistant which could activate the ILR in case the horse expressed clinical signs, interrogation of the ILR with advanced equipment by a veterinarian was necessary to confirm the rhythm during a symptomatic episode. Interrogation of the ILR was performed six times over a 28-month monitoring period, which implies that episodes of paroxysmal AF or even recurrence of persistent AF could potentially remain unnoticed for months. Early diagnosis of AF recurrence in equine athletes may be achieved more easily using other methods such as heart rate monitoring to evaluate heart rate variability (Broux et al., 2018; Broux, De Clercq, Decloedt, Ven, et al., 2017). The automatically calculated RMSSD (root mean squared successive differences in RR interval) at rest, walk and trot was significantly higher during AF compared with sinus rhythm. These data can be visualised and interpreted by the owner, and abnormal results may prompt immediate follow-up diagnostics by the veterinarian. Recently, Nath et al. (2022) also demonstrated the applicability of a smartphone electrocardiography device for distinguishing AF from sinus rhythm. Although the device cannot be applied during exercise, smartphone ECG recordings can be used as a diagnostic technique during the immediate post-exercise period and allow a definite diagnosis of AF. Another option could be the use of equine fitness trackers which record a single lead ECG in addition to other parameters such as heart rate (Ter Woort et al., 2023). However, these wearable devices are not suitable for long-term monitoring at rest.

Continuous rhythm monitoring with recording and early detection of arrhythmic events can be achieved using an ILR with remote monitoring, which automatically transfers data to an online storage system accessible by the veterinarian. Depending on the manufacturer, recent ILRs transmit data to an online server on a daily basis which sends a message to the clinician in case of arrhythmia detection. The use of such a system was recently described in horses, using a Biomonitor II with home monitoring (Biotronik) which allowed immediate detection of paroxysmal AF (van Loon, 2021). In human medicine, the use of cardiac implantable electronic devices with remote monitoring has expedited timely recognition of ILR-detected arrhythmias (Slotwiner et al., 2015). On the other hand, the burden of erroneous alert transmissions is high, with up to 59.8% false-positive alerts (O'Shea et al., 2021). The specificity of ILR arrhythmia detection in horses remains to be determined, but the presence of artefacts or physiological arrhythmias may result in false positive diagnoses (Buhl, Hesselkilde, et al., 2021). Erroneous alerts were common in the horses monitored by our clinic, mainly due to bradycardia alerts in case of second degree atrioventricular block. Adjusted automated analysis and artificial intelligence may overcome this hurdle, allowing timely detection of clinically relevant arrhythmias without burdensome workflow for the veterinarian.

However, the question arises whether early detection of paroxysmal AF is clinically relevant in equine athletes, as treatment options are limited. Kjeldsen, Jensen, et al. (2023) suggest that early detection of paroxysmal AF is important to initiate antiarrhythmic treatment and prevent the development of persistent AF. Episodes of paroxysmal AF may result in electrical, contractile and structural remodelling of the atrial myocardial tissue, which could in turn give rise to progression to persistent AF (Hesselkilde et al., 2019). Antiarrhythmic treatment may be useful to reduce the presence and duration of paroxysmal AF episodes and counteract harmful atrial remodelling. In the case report of Kjeldsen, Jensen, et al. (2023), the longest duration between episodes of paroxysmal AF (8 months) was after a 4-week treatment with 2 mg/kg bwt sotalol administered orally. Although it is unsure whether there was a causal relationship between sotalol treatment and the absence of AF episodes in the following months, the use of sotalol has been suggested as a strategy to reduce the risk of AF recurrence after cardioversion (Decloedt et al., 2021). As a class III antiarrhythmic drug, sotalol prolongs the atrial and ventricular effective refractory period and lowers heart rate, thereby decreasing the risk of re-entry and recurrence of AF (Broux, De Clercq, Decloedt, Vera, et al., 2017; Decloedt et al., 2018). However, the drug also prolongs the QT interval and therefore Kjeldsen, Jensen, et al. (2023) only recommended mild exercise during sotalol treatment. In addition, sotalol is listed on the FEI prohibited substances list as controlled medication and a withdrawal time must be observed before competing (Fédération Equestre Internationale, 2022). Therefore, prolonged use of sotalol in equine athletes is not possible. Furthermore, evidence for the effect of sotalol on AF recurrence is currently lacking as no randomised controlled clinical trial has been performed. Other antiarrhythmic

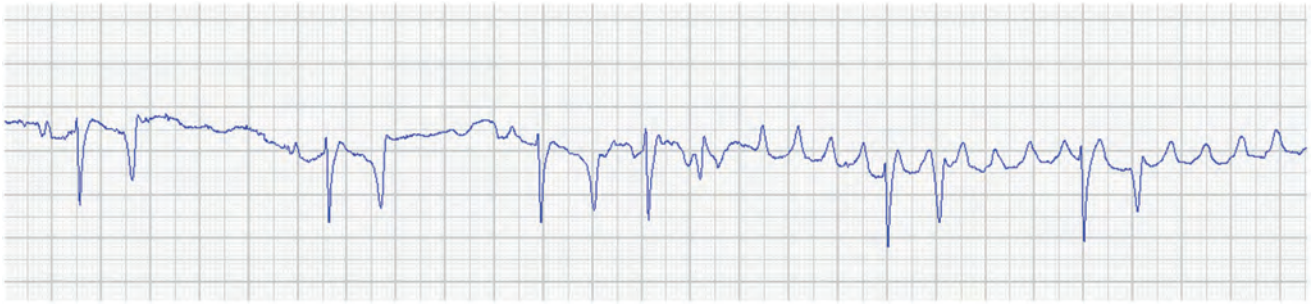

FIGURE 1 Modified base-apex ECG (10 mm/mV, 25 mm/s) showing the onset of atrial tachycardia in a 4-year-old Warmblood stallion at 48 h after successful transvenous electrical cardioversion of atrial fibrillation.

drugs such as propafenone, amiodarone and phenytoin (Decloedt et al., 2015; Dicken et al., 2012) have been proposed but so far almost no clinical data are available.

While the medical treatment options are limited, an ILR could potentially record the onset of atrial fibrillation and elucidate the underlying mechanism. For example, Figure 1 shows a modified base-apex ECG recording of a 4 year old Warmblood stallion at 48 h after transvenous electrical cardioversion of AF. In this horse, recurrence was initiated by an episode of atrial tachycardia. When atrial tachycardia is confirmed as the underlying trigger for developing AF, treatment by 3D electro-anatomical mapping and radiofrequency catheter ablation could be a successful treatment strategy (Van Steenkiste et al., 2022).

CONCLUSION

Implantable loop recorders allow continuous monitoring of the cardiac rhythm and facilitate detection of arrhythmias in equine patients. The current limitations of ILRs include the presence of motion artefacts which impede detection of exercise-associated arrhythmias, the lack of early arrhythmia detection when manual interrogation is necessary and the burden of false-positive alerts in case of remote monitoring. ILRs are therefore very useful to study the pathophysiology of equine arrhythmias such as paroxysmal AF, but remote monitoring is required to allow early diagnosis and treatment of this arrhythmia. ILRs are also useful to detect or exclude pathological bradyarrhythmias in horses with a history of collapse and to detect whether the initiating mechanism of AF recurrence after cardioversion is atrial tachycardia as these horses may benefit from radiofrequency ablation.

CONFLICT OF INTEREST

No conflicts of interest to declare.

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REFERENCES

Alexeenko, V., Fraser, J.A., Bowen, M., Huang, C.L.H., Marr, C.M. & Jeevaratnam, K. (2020) The complexity of clinically-normal sinus-rhythm ECGs is decreased in equine athletes with a diagnosis of paroxysmal atrial fibrillation. *Scientific Reports*, 10, 6822. Available from: https://doi.org/10.1038/s41598-020-63343-7

Broux, B., De Clercq, D., Decloedt, A., Ven, S., Vera, L., van Steenkiste, G. et al. (2017) Heart rate variability parameters in horses distinguish atrial fibrillation from sinus rhythm before and after successful electrical cardioversion. *Equine Veterinary Journal*, 49, 723–728.

Broux, B., De Clercq, D., Decloedt, A., Vera, L., Devreese, M., Gehring, R. et al. (2017) Pharmacokinetics and electrophysiological effects of sotalol hydrochloride in horses. *Equine Veterinary Journal*, 50, 377–383.

Broux, B., De Clercq, D., Vera, L., Ven, S., Deprez, P., Decloedt, A. et al. (2018) Can heart rate variability parameters derived by a heart rate monitor differentiate between atrial fibrillation and sinus rhythm? *BMC Veterinary Research*, 14, 320.

Buhl, R., Hesselkilde, E.M., Carstensen, H., Fenner, M.F., Jespersen, T., Tfelt-Hansen, J. et al. (2021) Detection of atrial fibrillation with implantable loop recorders in horses. *Equine Veterinary Journal*, 53, 397–403.

Buhl, R., Nissen, S.D., Winther, M.L.K., Poulsen, S.K., Hopster-Iversen, C., Jespersen, T. et al. (2021) Implantable loop recorders can detect paroxysmal atrial fibrillation in Standardbred racehorses with intermittent poor performance. *Equine Veterinary Journal*, 53, 955–963.

Decloedt, A., Broux, B., De Clercq, D., Deprez, P., Van Steenkiste, G., Vera, L. et al. (2018) Effect of sotalol on heart rate, QT interval, and atrial fibrillation cycle length in horses with atrial fibrillation. *Journal of Veterinary Internal Medicine*, 32, 815–821.

Decloedt, A., Schwarzwald, C.C., De Clercq, D., Van der Vekens, N., Pardon, B., Reef, V.B. et al. (2015) Risk factors for recurrence of atrial fibrillation in horses after cardioversion to sinus rhythm. *Journal of Veterinary Internal Medicine*, 29, 946–953.

Decloedt, A., Van Steenkiste, G., Vera, L., Buhl, R. & van Loon, G. (2020) Atrial fibrillation in horses part 1: pathophysiology. *Veterinary Journal*, 263, 105521. Available from: https://doi.org/10.1016/j.tvjl.2020.105521

Decloedt, A., Van Steenkiste, G., Vera, L., Buhl, R. & van Loon, G. (2021) Atrial fibrillation in horses part 2: diagnosis, treatment and prognosis. *Veterinary Journal*, 268, 105594. Available from: https://doi.org/10.1016/j.tvjl.2020.105594

Dicken, M., Gordon, S.J. & Mayhew, I.G. (2012) The use of phenytoin in two horses following conversion from atrial fibrillation. *New Zealand Veterinary Journal*, 60, 210–212.

Hesselkilde, E.Z., Carstensen, H., Flethoj, M., Fenner, M., Kruse, D.D., Sattler, S.M. et al. (2019) Longitudinal study of electrical, functional and structural remodelling in an equine model of atrial fibrillation. *BMC Cardiovascular Disorders*, 19, 228.

Fédération Equestre Internationale. (2022) Equine prohibited substances list. Available from: https://inside.fei.org/sites/default/files/2022%20Prohibited%20Substances%20List.pdf [Accessed 3rd January 2023].

Huang, Y.H., Lyle, J.V., Ab Razak, A.S., Nandi, M., Marr, C.M., Huang, C.L.H. et al. (2022) Detecting paroxysmal atrial fibrillation from normal sinus rhythm in equine athletes using symmetric projection attractor reconstruction and machine learning. *Cardiovascular Digital Health Journal*, 3, 96–106.

Keen, J.A. (2020) Pathological bradyarrhythmia in horses. *Veterinary Journal*, 259–260, 105463. Available from: https://doi.org/10.1016/j.tvjl.2020.105463

Kjeldsen, S.T., Jensen, M., Sorensen, C.T., Hopster-Iversen, C. & Nissen, S.D. (2023) Long-term monitoring with an implantable loop recorder detects multiple episodes of paroxysmal atrial fibrillation after electrical cardioversion in a warmblood horse. *Equine Veterinary Education*, 35, 340–346. https://doi.org/10.1111/eve.13745

Kjeldsen, S.T., Nissen, S.D., Buhl, R. & Hopster-Iversen, C. (2022) Paroxysmal atrial fibrillation in horses: pathophysiology, diagnostics and clinical aspects. *Animals*, 12, 698. Available from: https://doi.org/10.3390/ani12060698

Lyle, C.H., Turley, G., Blissitt, K.J., Pirie, R.S., Mayhew, I.G., McGorum, B.C. et al. (2010) Retrospective evaluation of episodic collapse in the horse in a referred population: 25 cases (1995–2009). *Journal of Veterinary Internal Medicine*, 24, 1498–1502.

Nath, L.C., Elliott, A.D., Weir, J., Curl, P., Rosanowski, S.M. & Franklin, S. (2021) Incidence, recurrence, and outcome of postrace atrial fibrillation in thoroughbred horses. *Journal of Veterinary Internal Medicine*, 35, 1111–1120.

Nath, L.C., Forbes, G., Elliott, A.D., Tomren, V., Ryan, A. & Franklin, S.H. (2022) Application of an electrocardiography device (iECG) for heart rhythm analysis after exercise in thoroughbred horses. *Australian Veterinary Journal*, 100, 114–120.

Navas de Solis, C., Green, C.M., Sides, R.H. & Bayly, W.M. (2016) Arrhythmias in thoroughbreds during and after treadmill and racetrack exercise. *Journal of Equine Veterinary Science*, 42, 19–24.

Nissen, S.D., Saljic, A., Kjeldsen, S.T., Jespersen, T., Hopster-Iversen, C. & Buhl, R. (2022) Cartilaginous intrusion of the atrioventricular node in a quarter horse with a high burden of second-degree AV block and collapse: a case report. *Animals*, 12, 2915. Available from: https://doi.org/10.3390/ani12212915

Ohmura, H., Hiraga, A., Takahashi, T., Kai, M. & Jones, J.H. (2003) Risk factors for atrial fibrillation during racing in slow-finishing horses. *Journal of the American Veterinary Medical Association*, 223, 84–88.

O'Shea, C.J., Middeldorp, M.E., Hendriks, J.M., Brooks, A.G., Harper, C., Thomas, G. et al. (2021) Remote monitoring of implantable loop recorders: false-positive alert episode burden. *Circulation. Arrhythmia and Electrophysiology*, 14, 1048–1050.

Premont, A., Balthes, S., Marr, C.M. & Jeevaratnam, K. (2022) Fundamentals of arrhythmogenic mechanisms and treatment strategies for equine atrial fibrillation. *Equine Veterinary Journal*, 54, 262–282.

Reef, V.B., Bonagura, J., Buhl, R., McGurrin, M.K., Schwarzwald, C.C., van Loon, G. et al. (2014) Recommendations for management of equine athletes with cardiovascular abnormalities. *Journal of Veterinary Internal Medicine*, 28, 749–761.

Slack, J., Boston, R.C., Soma, L.R. & Reef, V.B. (2015) Occurrence of cardiac arrhythmias in Standardbred racehorses. *Equine Veterinary Journal*, 47, 398–404.

Slotwiner, D., Varma, N., Akar, J.G., Annas, G., Beardsall, M., Fogel, R.I. et al. (2015) HRS expert consensus statement on remote interrogation and monitoring for cardiovascular implantable electronic devices. *Heart Rhythm*, 12, E69–E100.

Ter Woort, F., Dubois, G., Tansley, G., Didier, M., Verdegaal, L., Franklin, S. et al. (2023) Validation of an equine fitness tracker: ECG quality and arrhythmia detection. *Equine Veterinary Journal*, 55, 336–343. https://doi.org/10.1111/evj.13565

van Loon, G. (2019) Cardiac arrhythmias in horses. *Veterinary Clinics of North America: Equine Practice*, 35, 85–102.

van Loon, G. (2021) Implantable devices: loop recorders, neurostimulators and pacemakers. In: BEVA interactive cardiology workshop, UK, 19 November 2021 (online due to Covid).

Van Steenkiste, G., Boussy, T., Duytschaever, M., Vernemmen, I., Schauvlieghe, S., Decloedt, A. et al. (2022) Detection of the origin of atrial tachycardia by 3D electro-anatomical mapping and treatment by radiofrequency catheter ablation in horses. *Journal of Veterinary Internal Medicine*, 36, 1481–1490.

Vernemmen, I., Van Steenkiste, G., Dufourni, A., Decloedt, A. & van Loon, G. (2022) Transvenous electrical cardioversion of atrial fibrillation in horses: horse and procedural factors correlated with success and recurrence. *Journal of Veterinary Internal Medicine*, 36, 758–769.

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References:
[1] Nogradi N, Couetil LL, Messick J, Stochelski MA, Burgess JA. Evaluation of an Omega-3 Fatty Acid Containing Feed Supplement in the Management of Horses with Chronic Lower Airway Inflammatory Diseases. J Vet Intern Med 2015; 29:299-306.
[2] Couetil LL, Cardwell J.M, Gerber V, Lavoie J.-P, Leguillette R, Richard E.A. Inflammatory Airway Disease of Horses. ACVIM Consensus Statement J of Vet Intern Med 2016; 30:503-515 p. 508-510.

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Equine Veterinary Education

CASE REPORT

Recurrence of conjunctival exuberant granulation tissue in a pony

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Summary

A 22-year-old pony mare was presented at the Equine Hospital of the Faculty of Veterinary Medicine with a pedunculated exuberant granulation tissue (EGT) located at the lateral bulbar conjunctiva of the right eye. The granulation tissue, diagnosed by histology, grew over three and a half weeks after a superior and inferior Gundersen inlay flap procedure. The pony's underlying ocular pathology was diffuse corneal oedema, suspected to be related to immune-mediated keratitis affecting the endothelium. Despite several surgical resections, topical corticosteroid treatment, intralesional injection of methylprednisolone acetate and electrosurgical cauterisation, the combination of a ligature at the peduncle base of the mass, intralesional injection of methylprednisolone acetate and removal of the facemask seemed to be the most efficient treatment. The mass did not recur after 33 months of follow-up. Similar healing tissue has been reported, secondary to surgical ophthalmic procedures in human medicine, in which it is called a conjunctival pyogenic granuloma (CPG).

KEYWORDS
horse, conjunctival exuberant granulation tissue, Gundersen inlay flap, immune-mediated keratitis, intralesional injection

INTRODUCTION

Granulation tissue is normally present in wounds healing by the second intention. This healing phase is followed by contraction and epithelialisation. Exuberant granulation tissue (EGT) in horses is common and mostly affects the distal limbs.

The exact cause of EGT remains unknown in horses but many factors can contribute to its formation, including amongst others: weak acute inflammatory response followed by chronic inflammation of the wound, mechanical stress and oxygen levels (hypoxia) (Theoret & Wilmink, 2016). The localisation of the wound at the distal limb, and its challenging immobilisation associated with the absence of tissue and vascular support, increase the risk of EGT formation (Theoret & Wilmink, 2016).

In human medicine, tissues arising from an excessive healing response in the ocular conjunctiva are misnamed conjunctival pyogenic granuloma (CPG), although neither infectious nor histologically granulomatous (Ferry, 1989). The CPG is a benign vasoproliferative inflammatory response composed of granulation tissue (Jordan et al., 2001) and although mainly associated with surgical sites (DeMaria et al., 2018; Espinoza & Lueder, 2005; Ferry, 1989; Nair et al., 2020; Oke et al., 2017; Wu et al., 2017) or chronic stress, (DeMaria et al., 2018; Ferry, 1989; Lin et al., 2002; Oke et al., 2017; Wu et al., 2017) no aetiology was determined for some cases (Ferry, 1989; Lee et al., 2019). Conjunctival pyogenic granuloma is usually self-limiting or easily treated medically with corticosteroids (Espinoza & Lueder, 2005); however, in some instances, medical control can be challenging (Wu et al., 2017), and surgical excision can be indicated (DeMaria et al., 2018; Espinoza & Lueder, 2005; Wu et al., 2017).

To the authors' knowledge, recurrent conjunctival EGT has not previously been reported on the conjunctiva in horses.

CASE HISTORY

A 22-year-old female pony weighing 182 kg was presented at the Equine Hospital of the Université de Montréal for a right blue eye and loss of vision. A board-certified veterinary ophthalmologist

performed a complete bilateral ophthalmic examination (Data S1) and the corneal lesion was compatible with immune-mediated keratitis affecting the endothelium of the right eye (Gilger et al., 2005; Matthews & Gilger, 2009).

Because topical and systemic treatment for 1 week was not successful (Gilger et al., 2005), a superficial keratectomy and Gundersen inlay flap were performed, to improve corneal oedema and vision, and to prevent secondary corneal ulceration (Giannikaki et al., 2020; Rodriguez Galarza & McMullen, 2020; Scherrer et al., 2017) (Data S2). The treatment attempted before the surgery included topical 5% hypertonic saline (four times daily; MURO 128®, Bausch & Lomb), topical 1.5% diclofenac (three times daily, Sandoz Canada Inc.) and daily oral dexamethasone (15 mg for 3 days, 10 mg for 3 days then 5 mg for 6 days; Dominion Veterinary Laboratories Ltd.). The topical post-operative treatments were administered via a subpalpebral lavage system (SLS) (MILA International Inc.) placed in the medial fornix of the right lower eyelid (Giuliano et al., 2000), four times daily until the recheck including 0.3% tobramycin (Sandoz Canada Inc.), 5% hypertonic saline and autologous serum. The 1% atropine (Isopto-atropine®, Alcon Canada Inc.) was administered once daily, for three and a half weeks, until the recheck. A facemask with rigid eye protection (Eye Saver Kit, Jorgensen Laboratories Inc.) was used while the SLS remained in place.

Three and a half weeks following surgery, the owner noted a mass growing in the lateral canthus of the right eye, which was further evaluated. Besides the graft integration characterised by conjunctival vessels from upper and lower graft invading the cornea, a 1-cm diameter round, pink, smooth pedunculated mass originating from the site of the bulbar conjunctival flap was visible (Figure 1a).

Medical, surgical treatments and outcome

To avoid an incomplete eyelid closure and secondary corneal lesions, the mass was surgically excised at its base using Stevens scissors under general anaesthesia (intravenous xylazine (0.1 mg/kg bwt) and butorphanol (0.02 mg/kg bwt; Torbugesic®, Zoetis) premedication and intravenous ketamine (2.2 mg/kg bwt, Narketan®, Vetoquinol) and propofol (0.55 mg/kg bwt) induction, PropoFlo28®, Zoetis) (Data S3). The topical treatment included: 1.5% diclofenac three times daily for 1 week, 0.3% tobramycin three times daily and 5% hypertonic saline four times daily until the recheck. Atropine and serum were discontinued while the conjunctival graft was being integrated into the cornea.

Two weeks after the first surgical excision, the mass recurred and surgical excision was performed 1 week later. Surgical excision performed as previously described was combined with electrosurgical cauterisation (ForceTriad™ Energy Platform, Medtronic Canada Minimally Invasive Therapies) and the base of the mass was infiltrated with methylprednisolone acetate (16 mg). The mass recurred a second time, 2 weeks after the second surgical excision. Topical 0.1% dexamethasone (Maxidex®, Novartis Pharma Canada Inc.) was prescribed three times daily for 2 weeks. Because of the progression of the size, although slower than at the first recurrence, the mass was infiltrated with methylprednisolone acetate (12 mg) under standing sedation (intravenous xylazine; 0.4 mg/kg bwt). One month after this last injection, the mass increased significantly (especially in the last 2 weeks), and the horse was reassessed.

By that time (fifteen and a half weeks after the conjunctival graft), the SLS was removed and a non-sterile elastic tape was firmly tied at the base of the mass until the mass turned reddish black (Figure 2). The mass and its peduncle were infiltrated with 18 mg of methylprednisolone acetate, on standing sedation (intravenous xylazine; 0.4 mg/kg bwt). The facemask was removed.

The day after the placement of the non-sterile elastic tape, the mass detached from its peduncle. The pony was reevaluated a week later, and the mass did not recur; 8 mg of methylprednisolone acetate was injected in the free-rising peduncle (5 × 5 mm), on standing sedation (intravenous xylazine; 0.55 mg/kg bwt). The corneal oedema was moderate, and the pony returned to its previous function as a riding school pony.

The exuberant granulation tissue did not recur 33 months after the last injection of methylprednisolone acetate.

Diagnosis: Histopathological findings

The mass was histologically analysed after each surgical excision by an ACVP and ECVP-certified pathologist (MOBB).

Macroscopically, the submitted mass was round, white, smooth and firm; it measured 1.3 × 1.1 × 0.5 cm. Histologically, the mass consisted of fibrovascular tissue composed of fibroblasts oriented parallel to the surface, with perpendicularly-oriented blood vessels, which were lined by plump, reactive endothelial cells. The fibrous tissue was denser at the core of the mass, where mild lymphocytic infiltrates were observed. The surface of the mass was partially covered by a stratified squamous epithelium, which was sometimes eroded and multifocally ulcerated, exposing necrotic tissue moderately infiltrated by neutrophils and covered with a fibrinoleucocytic exudate (Figure 1b,c). Gram and PAS stains did not reveal bacteria or fungi. This histopathologic description was compatible with granulation tissue.

Bacterial culture was not performed as the clinical presentation (absence of ocular discharge) did not suggest an infectious process.

DISCUSSION

Aside from granulation tissue, the differential diagnosis for a conjunctival mass includes a squamous cell carcinoma (Giuliano, 2017), subconjunctival *Setaria equina* nodule (Regnier et al., 2019), foreign body granuloma (less likely considering the absence of a mucopurulent ocular discharge), and sarcoid (Theoret & Wilmink, 2016). Furthermore, like EGT in veterinary medicine, CPG in human medicine can resemble squamous cell carcinomas or be associated with this tumour (Herwig-Carl et al., 2019), justifying the need for histopathological evaluation to differentiate the two lesions and provide

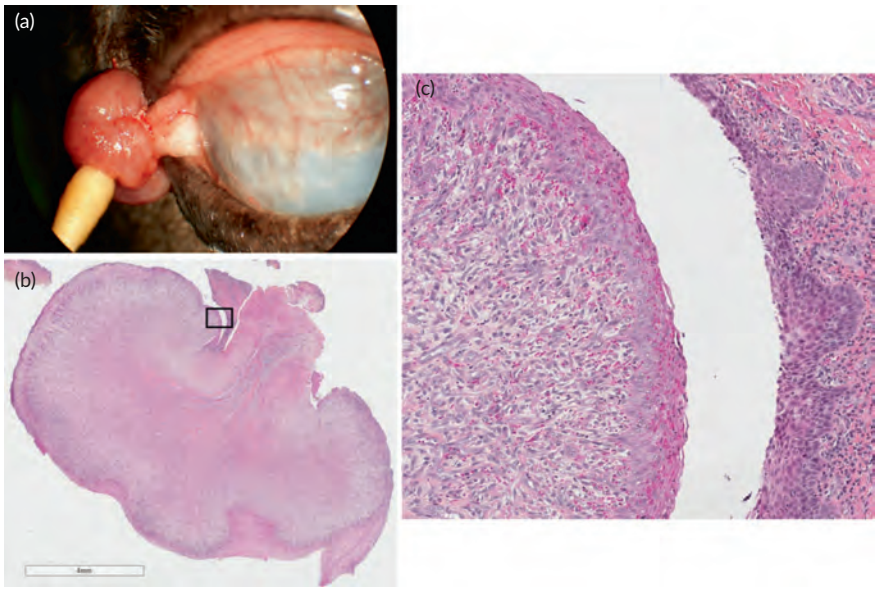

FIGURE 1 (a) Photograph of the 1-cm diameter round, pink, smooth pedunculated mass at the lateral canthus of the right eye. The corneal oedema and superior Gundersen inlay flap are visible. (b) Histologic section of the mass stained with haematoxylin phloxine saffron (HPS) (bar = 4 mm). The black square is magnified and represented in the next picture. (c) Histologic section of the mass stained with HPS (×5 magnification) showing the tissue organisation of the exuberant granulation tissue, partially covered by an eroded epithelium.

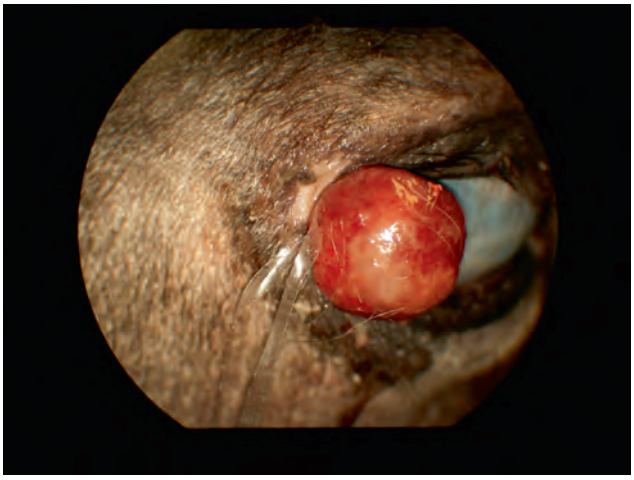

FIGURE 2 Photograph of the mass at the second recurrence. The non-sterile elastic tape was firmly tied at the base of the mass until the mass turned reddish black.

the appropriate treatment. In the current case, a squamous cell carcinoma was initially suspected because of the localisation, fast growth and the appearance of the mass.

According to the authors' knowledge, a bulbar conjunctiva location has not been reported in other animal species, and this is the first case report describing recurrent conjunctival exuberant granulation tissue in a horse. In human medicine, CPG grows because of an excessive healing response. The exact aetiology remains undetermined in some cases (Ferry, 1989; Lee et al., 2019). Such lesions can be localised on the tarsal or bulbar conjunctiva (DeMaria et al., 2018; Wu et al., 2017). In our case, the bulbar conjunctival EGT grew at the lateral canthus. Subconjunctival suture of the lateral canthus rubbing on the bulbar conjunctiva could have contributed to the development and growth of the conjunctival EGT. However, at the first recheck (24 days after the surgery), no subconjunctival suture was visible at the conjunctival aspect of the lateral canthus. According to the manufacturer, the resorption time of polyglactin 910 is 56–70 days, therefore, after the first and the second mass removal (24 and 46 days after the initial surgery, respectively), the incompletely resorbed suture knot could have rubbed on the bulbar conjunctiva through the palpebral conjunctiva. Although never observed in the authors' personal experience, the subconjunctival suture (and the knot's size) may be considered as a predisposing factor for the occurrence of a conjunctival EGT as, when the non-sterile elastic tape was firmly tied at the base of the mass on day 107 after the initial surgery, the subconjunctival suture should have been completely resorbed, and the mass did not recur at that time.

Conjunctival dissection could be a predisposing factor for conjunctival EGT in this study, as in human surgery. Although, the conjunctiva was dissected at 120° dorsally and 120° ventrally, the conjunctival EGT occurred only in the dorsolateral aspect of the bulbar conjunctiva.

In human medicine, 90% of CPG cases are effectively treated with topical corticosteroids (Espinoza & Lueder, 2005). In the current study, topical or intralesional injections of corticosteroids alone were not successful.

Conjunctival flora in healthy horses is mostly composed of gram-positive bacteria, with a lower proportion of gram-negative bacteria, and fungi (Gemensky-Metzler et al., 2005; LaFrentz et al., 2020; Moore et al., 1988). Healthy eyes represent an

unfavourable environment for the growth and invasion of fungi because of the normal ocular surface flora, lacrimal flow, and mechanical movement of the eyelids (Gould et al., 2021). These defence mechanisms explain why ocular infections are uncommon unless anatomic barriers are compromised (Gould et al., 2021). Colonisation by fungi can occur after corneal trauma, particularly when corticosteroids are administered (Gould et al., 2021) and the use of long-term corticosteroids is believed to increase the risk of secondary fungal and bacterial infections (Gaarder et al., 1998; McMullen Jr. & Fischer, 2017; Nasisse & Nelms, 1992). Subconjunctival corticosteroid injection is used in severe cases of equine recurrent uveitis when the topical treatment is not sufficient (Gilger & Hollingsworth, 2017). In horses, subconjunctival injections of methylprednisolone can lead to abscess and granuloma formation (Gilger & Hollingsworth, 2017) and osseous metaplasia (Donaldson et al., 2012). The exact incidence of side effects specifically associated with the subconjunctival injection is not reported in the veterinary literature; in the current case, the cornea was intact, the fluorescein test was negative, and the graft was integrated into the cornea when the subconjunctival injections were administered, and no associated side effects were observed.

Medically uncontrolled CPG is reported in the human literature and surgical removal is recommended in those cases (DeMaria et al., 2018; Espinoza & Lueder, 2005; Wu et al., 2017). The treatment of EGT in horses is based on the management of the causal factors or consists of removing the exuberant tissue if it is already present. The most commonly used treatments in veterinary medicine include surgical resection (Fretz et al., 1983; Theoret & Wilmink, 2016) and topical short-acting corticosteroids (Barber, 1990). In this case, a recurrence of the tissue occurred despite these two treatments.

In this case, ligation led to ischaemic necrosis by cutting off the blood flow of the tissue and prevented the recurrence of the CPG. In farm animals, rubber rings can be used for castration and tail docking (Dinniss et al., 1997; Sutherland & Tucker, 2011). Both procedures are considered painful, and injection of local anaesthetic is recommended (Dinniss et al., 1997; Sutherland & Tucker, 2011). In our case, local anaesthesia could have been considered, but the tissue was considered insensitive based on clinical observations. Furthermore, the discomfort associated with ligation, if present, was short-lived as the mass fell away the following day. Injection of methylprednisolone acetate at the base of the peduncle was performed to control the potential inflammatory response from the viable peduncle secondary to this necrotic process.

In human medicine, ligature using suture, rubber band ligation or metal clip have been used to treat ulnar polydactyly, haemorrhoids and skin tags (acrochordon) (Patillo & Rayan, 2011; Schonauer et al., 2021; Shanmugam et al., 2005;). For haemorrhoids, rubber band ligation is considered less painful than surgical excision (Shanmugam et al., 2005). Surgical excision is considered for grade III haemorrhoids or in cases of recurrence after rubber band ligation (Shanmugam et al., 2005). In our case, surgical excision was chosen first and, after two recurrences, rubber band ligation was considered and successfully performed.

In conclusion, the conjunctival ETG in our case likely developed secondary to the conjunctival surgery with dissection and chronic stress induced by the palpebral conjunctival suture could not be excluded. Mechanical ligation at the base of the pedunculated mass associated with the removal of the facemask, and intralesional injection of long-acting corticosteroids were efficient to stop the recurrence of the conjunctival exuberant granulation tissue.

AUTHOR CONTRIBUTIONS

A. Bessonnat and M. Vanore contributed to the study design, study execution, data analysis and interpretation, and preparation of the manuscript. M-O. Benoit Biancamano contributed to study execution, data analysis and interpretation, and preparation of the manuscript. All authors gave their final approval of the manuscript.

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CONFLICT OF INTEREST

None of the authors has a conflict of interest with the submission. No financial support was received for this submission.

ETHICS STATEMENT

All procedures were in compliance with the Association for Research in Vision and Ophthalmology (ARVO) statement for the Use of Animals in Ophthalmic and Vision Research.

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REFERENCES

Barber, S.M. (1990) Second intention wound healing in the horse: the effect of bandages and topical corticosteroids. *Proceedings of the American Association of Equine Practitioners*, 35, 107–116.

DeMaria, L.N., Silverman, N.K. & Shinder, R. (2018) Ophthalmic pyogenic granulomas treated with topical timolol-clinical features of 17 cases. *Ophthalmic Plastic & Reconstructive Surgery*, 34, 579–582.

Dinniss, A.S., Mellor, D.J., Stafford, K.J., Bruce, R.A. & Ward, R.N. (1997) Acute cortisol responses of lambs to castration using a rubber ring and/or a castration clamp with or without local anaesthetic. *New Zealand Veterinary Journal*, 45, 114–121.

Donaldson, D., Matas, M. & Stewart, J. (2012) Osseous metaplasia in the conjunctiva of a horse presenting with recurrent ulcerative keratitis. *Equine Veterinary Education*, 24, 4–7.

Espinoza, G.M. & Lueder, G.T. (2005) Conjunctival pyogenic granulomas after strabismus surgery. *Ophthalmology*, 112, 1283–1286.

Ferry, A.P. (1989) Pyogenic granulomas of the eye and ocular adnexa: A study of 100 cases. *Transactions of the American Ophthalmological Society*, 87, 327–343 discussion 343-327.

Fretz, P.B., Martin, G.S., Jacobs, K.A. & McIlwraith, C.W. (1983) Treatment of exuberant granulation tissue in the horse evaluation of four methods. *Veterinary Surgery*, 12, 137–140.

Gaarder, J.E., Rebhun, W.C., Ball, M.A., Patten, V., Shin, S. & Erb, H. (1998) Clinical appearances, healing patterns, risk factors, and outcomes

of horses with fungal keratitis: 53 cases (1978-1996). *Journal of the American Veterinary Medical Association*, 213, 105–112.

Gemensky-Metzler, A.J., Wilkie, D.A., Kowalski, J.J., Schmall, L.M., Willis, A.M. & Yamagata, M. (2005) Changes in bacterial and fungal ocular flora of clinically normal horses following experimental application of topical antimicrobial or antimicrobial-corticosteroid ophthalmic preparations. *American Journal of Veterinary Research*, 66, 800–811.

Giannikaki, S., Escanilla, N., Sturgess, K. & Lowe, R.C. (2020) A modified technique of keratoleptynsis ("letter-box") for treatment of canine corneal edema associated with endothelial dysfunction. *Veterinary Ophthalmology*, 23, 930–942.

Gilger, B.C. & Hollingsworth, S.R. (2017) Diseases of the uvea, uveitis, and recurrent uveitis. In: Gilger, B.C. (Ed.) *Equine ophthalmology*, 3rd edition. Ames, Iowa: John Wiley & Sons, Inc., pp. 380–401.

Gilger, B.C., Michau, T.M. & Salmon, J.H. (2005) Immune-mediated keratitis in horses: 19 cases (1998-2004). *Veterinary Ophthalmology*, 8, 233–239.

Giuliano, E. (2017) Diseases of the adnexa and nasolacrimal system. In: Gilger, B.C. (Ed.) *Equine ophthalmology*, 3rd edition. Ames, Iowa: John Wiley & Sons, Inc., pp. 197–251.

Giuliano, E.A., Maggs, D.J., Moore, C.P., Boland, L.A., Champagne, E.S. & Galle, L.E. (2000) Inferomedial placement of a single-entry subpalpebral lavage tube for treatment of equine eye disease. *Veterinary Ophthalmology*, 3, 153–156.

Gould, D., Dewhurst, E. & Papasouliotis, K. (2021) Clinical microbiology and parasitology. In: Gelatt, K.N. (Ed.) *Veterinary ophthalmology*, 6th edition. Hoboken, New Jersey, USA: John Wiley & Sons, Inc., pp. 293–348.

Herwig-Carl, M.C., Grossniklaus, H.E., Muller, P.L., Atzrodt, L., Loeffler, K.U. & Auw-Haedrich, C. (2019) Pyogenic granuloma associated with conjunctival epithelial neoplasia: Report of nine cases. *The British Journal of Ophthalmology*, 103, 1469–1474.

Jordan, D.R., Brownstein, S., Lee-Wing, M. & Ashenhurst, M. (2001) Pyogenic granuloma following oculoplastic procedures: an imbalance in angiogenesis regulation? *Canadian Journal of Ophthalmology*, 36, 260–268.

LaFrentz, S., Abarca, E., Mohammed, H.H., Cuming, R. & Arias, C.R. (2020) Characterization of the normal equine conjunctival bacterial community using culture-independent methods. *Veterinary Ophthalmology*, 23, 480–488.

Lee, Y., Hyon, J.Y. & Jeon, H.S. (2019) Conjunctival pyogenic granuloma: Cases with undetermined etiologies. *Korean Journal of Ophthalmology*, 33, 483–484.

Lin, C.J., Liao, S.L., Jou, J.R., Kao, S.C., Hou, P.K. & Chen, M.S. (2002) Complications of motility peg placement for porous hydroxyapatite orbital implants. *The British Journal of Ophthalmology*, 86, 394–396.

Matthews, A. & Gilger, B.C. (2009) Equine immune-mediated keratopathies. *Veterinary Ophthalmology*, 12(Suppl 1), 10–16.

McMullen, R.J., Jr. & Fischer, B.M. (2017) Medical and surgical management of equine recurrent uveitis. *The Veterinary Clinics of North America. Equine Practice*, 33, 465–481.

Moore, C.P., Heller, N., Majors, L.J., Whitley, R.D., Burgess, E.C. & Weber, J. (1988) Prevalence of ocular microorganisms in hospitalized and stabled horses. *American Journal of Veterinary Research*, 49, 773–777.

Nair, A.G., George, R.J., Natarajan, S. & Jain, V. (2020) Topical timolol for the treatment of conjunctival pyogenic granulomas: Outcomes and effect on intraocular pressure. *Indian Journal of Ophthalmology*, 68, 2170–2174.

Nasisse, M.P. & Nelms, S. (1992) Equine ulcerative keratitis. *The Veterinary Clinics of North America. Equine Practice*, 8, 537–555.

Oke, I., Alkharashi, M., Petersen, R.A., Ashenberg, A. & Shah, A.S. (2017) Treatment of ocular pyogenic granuloma with topical timolol. *JAMA Ophthalmology*, 135, 383–385.

Patillo, D. & Rayan, G.M. (2011) Complications of suture ligation ablation for ulnar polydactyly: A report of two cases. *Hand (N Y)*, 6, 102–105.

Regnier, A., Martin, C., Semin, M.O., Lienard, E., Geffre, A., Douet, J.Y. et al. (2019) Subconjunctival nodule due to Setaria equina erratic migration in a horse: First case report. *Veterinary Ophthalmology*, 22, 921–927.

Rodriguez Galarza, R.M. & McMullen, R.J., Jr. (2020) Descemet's membrane detachments, ruptures, and separations in ten adult horses: Clinical signs, diagnostics, treatment options, and preliminary results. *Veterinary Ophthalmology*, 23, 611–623.

Scherrer, N.M., Lassaline, M. & Miller, W.W. (2017) Corneal edema in four horses treated with a superficial keratectomy and Gundersen inlay flap. *Veterinary Ophthalmology*, 20, 65–72.

Schonauer, F., Guastafierro, A., Grasso, E., Izzo, S., Nicoletti, G.F. & D'Andrea, F. (2021) Ligaclip for preauricular skin tags in the newborn. *European Journal of Pediatric Surgery*, 31, 273–275.

Shanmugam, V., Thaha, M.A., Rabindranath, K.S., Campbell, K.L., Steele, R.J. & Loudon, M.A. (2005) Rubber band ligation versus excisional haemorrhoidectomy for haemorrhoids. *Cochrane Database of Systematic Reviews*, 201.

Sutherland, M.A. & Tucker, C.B. (2011) The long and short of it: A review of tail docking in farm animals. *Applied Animal Behaviour Science*, 135, 171–191.

Theoret, C. & Wilmink, J. (2016) Exuberant granulation tissue. In: *Equine Wound Management*, 3rd edition. Hoboken, New Jersey: John Wiley & Sons, Inc, pp. 369–384.

Wu, D., Qian, T., Nakao, T., Xu, J., Liu, Z., Sun, X. et al. (2017) Medically uncontrolled conjunctival pyogenic granulomas: correlation between clinical characteristics and histological findings. *Oncotarget*, 8, 2020–2024.

SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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Equine Veterinary Education

CLINICAL COMMENTARY

Solving an eye condition by looking to the rear

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It is rare to read a modern scientific publication that describes a surgical technique used on human anal haemorrhoids for the management of an ocular disorder in a horse, but Bessonnat et al. (2023) describe the use of ligation, as described for haemorrhoids, for the treatment of recurrent ocular exuberant granulation tissue in a pony that was unresponsive to traditional therapies.

Exuberant granulation tissue is an uncommon complication after corneal surgery in horses and usually develops at the harvest site of the conjunctival graft in the bulbar conjunctiva. As thoroughly described by the authors, exuberant granulation tissue in horses generally responds well to topical or local injection of corticosteroids, with or without tissue resection. In the pony described in this case report, the granulation tissue originally developed after a conjunctival graft surgery (Gunderson flap) was performed for the management of presumed endothelial immune-mediated keratitis. The granulation tissue was large, exuberant, and recurred twice despite standard-of-care therapy (i.e. use of topical and local steroid injection and resection using electrosurgical cauterisation). Following the two recurrences, the authors elected to use a ligature tape applied to the base of the pedunculated granulation tissue, as described for the treatment of severe haemorrhoids in humans. Following the ligation, the pedunculated granulation tissue turned reddish-black and spontaneously detached within 24 h after the ligation procedure. Following this technique, the eye recovered uneventfully and the granulation tissue did not recur during the 33-month follow-up period. The authors are applauded for their outside-of-the-box approach to effectively treat this case, despite venturing for inspiration to an anatomic location of the body whose surgical techniques are not commonly translated to the treatment of diseases of the eye.

Recurrent periocular masses are common in horses, but these lesions are generally neoplastic. Periocular squamous cell carcinoma is a common example. Therefore, it is important that any mass removed from a horse's eye be examined histologically to definitively determine the underlying cause, if possible. The surgeon must differentiate granulation tissue from squamous cell carcinoma, lymphoma, and parasitic granulomas, among other causes. Most non-responsive or recurrent masses are simply the result of a misdiagnosis of the lesion and subsequent inappropriate treatment of the underlying cause(s). Specific and aggressive adjunctive therapy is needed to manage periocular neoplasia for example, and ligation or resection alone will result in the recurrence of the mass in greater than 50% of the cases, depending on the specific underlying neoplasia. Further work is needed to determine the frequency of occurrence of exuberant granulation tissue after ocular surgery in the horse, in comparison to neoplasia, but in my experience, the development of granulation is relatively uncommon and generally responds well to steroidal therapy.

Prevention of granulation tissue around the eye after surgery can usually be accomplished by complete closure of the conjunctiva during surgery. It is common to not close the conjunctiva at the harvest site during surgery when surgeons are trying to reduce overall anaesthesia time, but doing so will minimise the development of granulation tissue. Furthermore, minimising the use of topical irritating substances, such as 5% sodium chloride or topical lidocaine, or procedures, such as a sub-palpebral lavage catheter, may also reduce the development of conjunctival granulation tissue. Finally, the use of small-sized sutures will minimise knot size and reduce conjunctival irritation (and thus the frequency of developing granulation tissue), especially when using braided absorbable sutures. Further studies are needed to determine the causes and prevention of granulation tissue in the horses' eyes.

This case report also demonstrates the need for careful and thorough communication with the horse owner prior to surgery. Discussing the pros and cons of a salvage procedure such as Gunderson flaps are needed when managing chronic ocular diseases in horses such as endothelial immune-mediated keratitis. The described goal of the Gunderson flap procedure in the horse of this case report was to improve corneal oedema and vision and to prevent the development of corneal ulceration. Excessive corneal oedema from lack of corneal endothelial cell function results in the

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development of epithelial bullae. Fluid-filled bullae are easily ruptured by the horse leading to corneal ulceration, exposure of corneal nerve endings, and ocular discomfort. Although there was limited clinical description provided in the case report, no ocular discomfort was described in the horse (and pre-operative images were not provided). However, the horse required repeated procedures to manage the complications after surgery. The post-operative images (see figure 1a in the article) indicate a limited resolution to the corneal opacity but if the Gunderson flap helped prevent the development of corneal ulceration (which is not described for the 33 months after surgery), then this procedure likely prevented ocular discomfort despite the need for repeated surgeries to manage the granulation tissue that developed. Again, thorough client communication is needed prior to surgery to discuss these possible complications, such as the development of granulation tissue, and the possible need for further procedures if they develop.

This case report effectively describes an uncommon corneal surgical complication in horses, the development of exuberant granulation tissue, the histologic diagnosis, appropriate therapy and an interesting, if unconventional, method to manage a rare case of unresponsive, recurrent granulation tissue of a pony's eye. This case report accentuates the need for histologic confirmation on masses removed from a horse's eye and the need for thorough communications with the owner prior to surgery to discuss the pros, cons and possible complications of ocular salvage procedures in the horse.

CONFLICT OF INTEREST STATEMENT

No conflicts of interest have been declared.

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Equine Veterinary Education

CASE REPORT

Endotracheal tube obstruction due to cuff overinflation or cuff herniation in small equids: A case series

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Summary

Adequate inflation of the endotracheal tube (ETT) cuff is important to avoid leakage of anaesthetic gases or aspiration of gastric contents and to allow positive pressure ventilation. However, overinflation or herniation of the cuff can cause tracheal mucosal damage and in rare cases even obstruction of the ETT. ETT obstruction due to the cuff itself may be an underrecognised phenomenon in equine practice and we aim to create awareness with this retrospective case series (n = 3). Cases identified between 2014 and 2021 with (partial) ETT obstruction due to cuff overinflation or cuff herniation at the Utrecht University Equine Clinic were selected. Anaesthesia records were examined and presented. Two cases occurred in foals and one in a pony. In each case, high airway pressure was encountered and no or minimal thoracic excursions were visible. In all three cases, cuff deflation led to immediate normalisation of ventilation parameters. When presented with an intubated patient that is difficult to ventilate and high airway pressures exist, ETT cuff overinflation or herniation should be considered as a possible cause; rapid cuff deflation should be included in algorithms for management of ventilation failure due to suspected airway obstruction.

KEYWORDS
horse, cuff herniation, cuff overinflation, cuff pressure, endotracheal tube obstruction

INTRODUCTION

Endotracheal intubation in horses is a routine procedure to deliver inhalant anaesthetics and oxygen, maintain airway patency and to facilitate positive pressure ventilation. Inflation of the endotracheal tube (ETT) cuff provides a seal between the tube and the trachea, preventing leakage of gases and fluids. Underinflation of the cuff can result in pulmonary aspiration of orogastric contents, while leakage of anaesthetic gases can result in contamination of the room. On the other hand, overinflation of the ETT cuff in horses can lead to tracheal mucosal damage (Heath et al., 1989; Holland et al., 1986; Touzot-Jourde et al., 2005), tracheal necrosis (Wylie et al., 2015) and even tracheal perforation (Saulez et al., 2009). Overinflation should therefore also be avoided. Despite the importance of avoiding under and overinflation, no best practice guidelines for ETT cuff inflation or recommended cuff pressure ranges for horses currently exist.

An underrecognised and rare complication of cuff overinflation is ETT obstruction due to the cuff itself. This may be either due to pressure-induced luminal collapse of ETTs, or due to herniation of the cuff, which then obstructs the ETT outflow including the Murphy eye. There are several case reports in human medicine describing ETT obstruction due to cuff overinflation (Davis et al., 2011; Hofstetter et al., 2010; Zenga et al., 2018) and cuff herniation (Barker & Stotz, 2013; Bar-Lavie et al., 1995; Kumar et al., 2021), but only two reports of cuff herniation in veterinary medicine

(Bergadano et al., 2004; Richardson & McMillan, 2017). The possibility of ETT obstruction secondary to cuff overinflation may be an underrecognised phenomenon in equine practice, but it can be life-threatening if not identified and resolved timely. Therefore, we aim to create awareness of this potential problem with this retrospective case series.

CASE 1

A 4-year-old Shetland pony mare weighing 142 kg was presented for experimental bilateral stifle surgery (DEC 2014.III.11.098). The pony was premedicated with detomidine (Domosedan, 9 μg/kg bwt, Orion Pharma) and butorphanol (Dolorex, 18 μg/kg bwt, MSD Animal Health) and then induced with midazolam (Midazolam, 0.1 mg/kg bwt, Actavis) and ketamine (Narketan, 2.1 mg/kg bwt, Vetoquinol) intravenously (IV) via a 14-gauge catheter (Mila International). Supplemental oxygen was provided intranasally (5 L/min; FiO_2 ~0.25) and the pony was hoisted on a surgical table in dorsal recumbency. Seven minutes from the start of induction, the pony was intubated without difficulty with a pretested 14 mm internal diameter silicone ETT tube (Kruuse). The low-volume-high-pressure (LVHP) cuff was inflated as deemed adequate to the anaesthetist by assessing syringe back-pressure; cuff pressure was not measured or recorded. Spontaneous respiration was initially observed by thoracic movements. Five minutes later, head-and-neck movements were observed by the anaesthetist in training and three consecutive top-ups of midazolam and ketamine were given IV (0.01 mg/kg bwt midazolam and 0.46 mg/kg bwt ketamine each). The anaesthetist did not note an obstructive breathing pattern, but a supervisor was called to assist. When the supervisor arrived 1 min later, movement was judged as 'tracheal tugging' (agonal gasping), oral mucous membranes were pale and cyanotic, ictus cordis (apical impulse rate) was 130 beats/min, and eyelid and corneal reflexes were absent. The pony was rushed into theatre and connected to a small animal circle system; flow rate and time controlled intermittent positive pressure ventilation (IPPV) (Mallard Large Animal Ventilation System Model 2800-P, Mallard Medical) was immediately started with 18 breaths/min and gas flow of 100% oxygen. Pulse oximetry and ECG monitoring were started using a multiparameter monitor (Datex Ohmeda S/5, GE Healthcare). Heart rate was 121 beats/min, peripheral oxygen saturation (SpO_2) was 56% and end-tidal carbon dioxide partial pressure ($EtCO_2$) was 5.4 kPa (40.5 mmHg). It was immediately noticed that the anaesthetic machine did not deliver an adequate tidal volume (only 300 ml, measured by movement of the bellow) and that the inspiratory pressure was very high (maximum pressure of 80 cm H_2O). The capnogram showed only a minimal triangular trace. The ETT cuff was rapidly deflated and immediately the anaesthetic machine could deliver an adequate tidal volume (1.2–1.5 L) with an inspiratory pressure of 24 cm H_2O. SpO_2 increased to 84 and 98% in the next few minutes and in this time frame, heart rate decreased to 60 beats/min. The cuff was reinflated to minimal occlusive volume by listening at the mouth during a positive pressure breath and by observation of a normal capnogram waveform. IPPV was continued with a tidal volume of 8–10 ml/kg and 18 breaths/min. Isoflurane (IsoFlo, Zoetis) in 100% oxygen was started at return of slow palpebral reflex and nystagmus. The physiological status of the pony was at this point deemed sufficient in regard to the inclusion criteria of the experiment and the pony was prepared for surgery. Crystalloid infusion was initiated at approximately 6 ml/kg/h IV (Ringer Fresenius, Fresenius Kabi). Thirty minutes after induction, placement of an invasive arterial line for blood gas analysis and blood pressure measurement was unsuccessful. Heart rate was 58 beats/min, SpO_2 99% and variable pulse wave amplitude was visible on the plethysmogram. A fluid bolus of 10 ml/kg (Fresenius Kabi) was administered IV and a continuous rate infusion (CRI) of dobutamine (Dobutamine, 0.25 μg/kg/min, Hameln Pharma) was started. Heart rate decreased to 44 beats/min and an arterial line was successfully placed in the right facial artery. Mean arterial pressure (MAP) was 79 mmHg; the results of arterial blood gas analysis are presented in Table 1 (further arterial blood gas analysis results were in line with the last arterial blood gas results). For the remainder of anaesthesia, the fraction of inspired oxygen was decreased to 0.65–0.77 as dictated by the experimental study protocol (Calero Rodriguez et al., 2021) and SpO_2 remained 99%–100%. Total anaesthesia time was 187 min. Recovery was prolonged, and the pony was hypothermic, but stood well after 30 min. Buprenorphine (Buprecare, 6 μg/kg bwt, AST Farma) and meloxicam (Metacam, 0.6 mg/kg bwt, Boehringer Ingelheim) were administered IV for post-operative analgesia. Inspection of the ETT after extubation did not reveal any obvious abnormalities with overinflation. Fifteen hours after anaesthetic induction, clinical examination

TABLE 1 Arterial and venous blood gas results of Case 1.

	41 min after induction arterial	89 min after induction arterial	Reference (arterial)
pH	7.341	7.346	7.35–7.45
$PaCO_2$	45.6	49.8	35–45 mmHg
PaO_2	415.1	419.5	>90 mmHg
$HCO3^-$	24.1	26.6	20–28 mmol/L
BE	−1.9	0.2	−3 to +3 mmol/L
SBC	22.9	26.6	20–28 mmol/L
Sat	99.8	99.8	>95%
Ht	0.3	0.28	0.3–0.43 L/L
Na^+	136.5	134.9	135–150 mmol/L
K^+	3.0	3.27	3.0–5.9 mmol/L
Ca^{++}	1.24	1.29	1.4–1.7 mmol/L
Cl^-	101	98	96–107 mmol/L
Glucose	7.1	7.0	3.9–5.6 mmol/L
Lactate	4.08	4.04	0.7–1.2 mmol/L
FiO_2	0.93	0.94	

Abbreviations: BE, base excess; Ht, haematocrit; $PaCO_2$, partial pressure of arterial carbon dioxide; PaO_2, partial pressure of arterial oxygen pressure; Sat, saturation; SBC, standard bicarbonate.

revealed paroxysmal tachyarrhythmia (50–70 beats/min); an ECG was recorded and showed sinus arrhythmia with ST elevation. The tachyarrhythmia and ST elevation resolved in the next 24 h. The pony made a full recovery, and a subsequent anaesthesia 4 months later was uneventful.

CASE 2

A 10-day-old 78 kg Dutch Royal Warmblood colt was presented for resection of infected umbilical remnants. The foal was premedicated with detomidine (Domosedan, 13 μg/kg bwt, Orion Pharma) and morphine (Morfine HCL, 0.13 mg/kg bwt, Centrafarm) and then induced with diazepam (Diazepam, 0.06 mg/kg bwt, Centrafarm) and ketamine (Narketan, 2.8 mg/kg bwt, Vetoquinol) IV via a 14G catheter (Mila International). Oxygen was provided via nasal line (5 L/min; FiO_2 ~ 0.25) and the patient was placed on a surgical table in dorsal recumbency. The patient was intubated without apparent difficulty with a pretested 14 mm internal diameter silicone ETT tube (Kruuse) and the LVHP cuff was inflated to a pressure of 140 mmHg at unknown volume using a manometer (DS54 DuraShock Hand Aneroid, Welch Allyn). In theatre, the foal was connected to a small animal circle system and flow rate and time controlled IPPV (Mallard Medical) was started at 18 breaths/min. A maximum tidal volume of 550 ml was obtained at an inspiratory peak pressure of 27 cm H_2O. A pulse oximeter and ECG were attached (Datex Ohmeda S/5, GE Healthcare). No abnormal capnogram waveform was noted with an $EtCO_2$ of 5.8 kPa (43.5 mmHg), but only minimal thoracic excursions were visible. The cuff was deflated and reinflated until audible air leakage just disappeared. Hereafter, the tidal volume immediately increased to 1200 ml at the same inspiratory peak pressure of 27 cm H_2O (ventilator flow rate was unchanged). Arterial saturation (SaO_2) increased from 96.7% to 99.7% (the corresponding increase in arterial partial pressure of oxygen was not recorded; Table 2). Isoflurane (Isoflo, Zoetis) in 100% oxygen was started and the foal was prepared for surgery. Hypotension (MAP 47 mmHg) was treated with dobutamine (Dobutamine, 0.25 μg/kg/min, Hameln Pharma) IV to maintain MAP >60 mmHg. Total anaesthesia time was 169 min. After extubation, the ETT cuff appeared normal, yet haemorrhagic fluid was visible in the ETT lumen and the foal developed a mild stridor, which did not improve after placement of a nasal tube. Oxygen flow at 10 L/min was administered via a nasal line. Recovery was calm and the stridor did not worsen, nor was laboured breathing observed. The day after surgery the stridor had disappeared, and thoracic auscultation did not reveal respiratory abnormalities.

TABLE 2 Arterial blood gas results of Case 2.

	38 min after induction	72 min after induction	Reference (arterial)
pH	7.340	7.354	7.35–7.45
$PaCO_2$	42.4	47.7	35–45 mmHg
PaO_2	93.1		>90 mmHg
$HCO3^-$	21.7	24.4	20–28 mmol/L
BE	−3.3	−0.1	−3 to +3 mmol/L
Sat	96.7	99.7	>95%
Ht		0.27	0.3–0.43 L/L
Na^+	139.1	136.9	135–150 mmol/L
K^+	3.16	3.03	3.0–5.9 mmol/L
Ca^{++}	1.27	1.27	1.4–1.7 mmol/L
Cl^-	116	106	96–107 mmol/L
Glucose	8.3	6.7	3.9–5.6 mmol/L
Lactate	3.89	3.16	0.7–1.2 mmol/L
FiO_2	0.6	0.93	

Abbreviations: BE, base excess; Ht, haematocrit; $PaCO_2$, partial pressure of arterial carbon dioxide; PaO_2, partial pressure of arterial oxygen pressure; Sat, saturation; SBC, standard bicarbonate.

CASE 3

A 1-month-old male Dutch Royal Warmblood foal weighing 85 kg was presented for umbilical resection due to omphalophlebitis. The foal was premedicated with detomidine (Domosedan, 18 μg/kg bwt, Orion Pharma) and morphine (Morfine HCL, 0.12 mg/kg bwt, Centrafarm) and induced with diazepam (Diazepam, 0.06 mg/kg bwt, Centrafarm) and ketamine (Narketan, 2.4 mg/kg bwt, Vetoquinol) IV via a 14G catheter (Mila International). The foal was lifted onto the surgical table and placed in dorsal recumbency with nasal oxygen supplementation (5 L/min; FiO_2 ~ 0.25). Endotracheal intubation with a pretested 14 mm internal diameter silicone ETT tube (Kruuse) was attempted but was unsuccessful. Placement of a pretested 12 mm internal diameter silicone ETT tube (Kruuse) was successful and the LVHP cuff was pressurised to 200 mmHg at unknown volume using a manometer (DS54 DuraShock Hand Aneroid, Welch Allyn). The foal was moved to the theatre and connected to a small animal circle system. Volume controlled IPPV (Sfinx, Veterinary Technics) was started with isoflurane (Isoflo, Zoetis) in 100% oxygen. Continuous pulse oximetry and ECG monitoring was initiated (Datex Ohmeda S/5, GE Healthcare). Anaesthetic gas leakage was detected, and cuff pressure was noted to have dropped well below 200 mmHg; the cuff was reinflated to 220 mmHg at this time. Hereafter, minimal thoracic excursions were seen despite high airway pressures (maximum pressure of 80 cm H_2O), and it was impossible for the anaesthetic machine to deliver more than 250–300 ml tidal volume. Heart rate was 92 beats/min, SpO_2 was 97%, $EtCO_2$ was 5.0 kPa; no obvious abnormalities in the capnogram waveform were noted. The ETT cuff was deflated, and normal thoracic excursions were immediately visible. The cuff was reinflated to minimal occlusive volume as judged by capnogram waveform, audible gas leakage and absence of detectable isoflurane smell. $EtCO_2$ was now 9 kPa and IPPV was started again with a tidal volume of 1.3 L at a rate of 24 breaths/min. $EtCO_2$ decreased within a few minutes and the respiratory rate was decreased to 11 breaths/min. The results of arterial blood gas analysis are presented in Table 3 (further arterial blood gas analysis results were in line with the last arterial blood gas results). The remainder of

TABLE 3 Arterial blood gas analysis results of Case 3.

	15 min after induction	32 min after induction	Reference (arterial)
pH	7.301	7.350	7.35–7.45
$PaCO_2$	56.4	49.5	35–45 mmHg
PaO_2	394.5	421.2	>90 mmHg
$HCO3^-$	27.2	26.9	20–28 mmol/L
BE	−0.4	0.6	−3 to +3 mmol/L
SBC	24.2	25.1	20–28 mmol/L
Sat	99.8	99.8	>95%
Na^+	138.7	138	135–150 mmol/L
K^+	3.17	2.95	3.0–5.9 mmol/L
Ca^{++}	1.47	1.45	1.4–1.7 mmol/L
Cl^-	103	107	96–107 mmol/L
Glucose	11.3	10.1	3.9–5.6 mmol/L
Lactate	2.54	2.27	0.7–1.2 mmol/L
FiO_2	0.85	0.95	

Abbreviations: BE, base excess; $PaCO_2$, partial pressure of arterial carbon dioxide; PaO_2, partial pressure of arterial oxygen pressure; Sat, saturation; SBC, standard bicarbonate.

anaesthesia was uneventful. Total anaesthesia time was 105 min and recovery was smooth. Visual inspection of the ETT after extubation did not reveal any obvious abnormalities.

DISCUSSION

In the equine scientific literature, reports of cuff-related ETT obstruction are rare. Endotracheal tube obstruction due to the ETT cuff can be caused by either cuff overinflation, resulting in excessive pressure effectively obliterating the lumen of the ETT, or cuff herniation, where the cuff extends beyond the opening of the ETT, obstructing gas flow. The two case reports available in veterinary medicine (equine and canine) both describe ETT obstruction due to cuff herniation (Bergadano et al., 2004; Richardson & McMillan, 2017). In the human medical literature, in addition to case reports on ETT obstruction due to cuff herniation, several authors also reported ETT obstruction due to collapse of the ETT lumen secondary to excessive external pressure exerted by an overinflated ETT cuff (Davis et al., 2011; Hofstetter et al., 2010; Zenga et al., 2018). Our case series highlights several clinically relevant aspects of cuff-related ETT obstruction in ponies and foals.

First, it appears that size and ETT material properties matter (Briganti et al., 2012; Davis et al., 2011; Dobrin & Canfield, 1977). In the three cases presented here, cuff overinflation may either have caused inward collapse of the ETT lumen or may have contributed to cuff herniation. Cuff overinflation causing the inner lumen of the ETT to collapse was shown to occur in some brands of polyvinyl chloride (PVC) ETTs used for small animal anaesthesia but not in other brands, and this difference was suggested to be due to PVC quality and therefore compliance of the ETT wall (Davis et al., 2011). Silicone ETTs, such as are commonly used in equine anaesthesia, are even more compliant than PVC ETTs (Briganti et al., 2012; Dobrin & Canfield, 1977). This is particularly true in tubes with a smaller inner diameter, and this affects both the wall strength and the elastic properties of the ETT cuff (Briganti et al., 2012; Dobrin & Canfield, 1977). While cuff herniation in PVC ETTs does not occur even at high intracuff pressures (Hofstetter et al., 2010), no comparable study has been done for silicone ETT cuffs. In the veterinary case reports where cuff herniation occurred (Bergadano et al., 2004; Richardson & McMillan, 2017), ETT cuff pressure was not measured, and it is therefore impossible to determine if cuff overinflation contributed to herniation in those cases as well. Alternatively, cuff herniation can also occur at normal cuff pressures due to manufacturing issues (Barker & Stotz, 2013; Bergadano et al., 2004; Kao et al., 2005). All three cases of ETT obstruction due to cuff overinflation in the current case series involved small size animals (one Shetland pony and two Warmblood foals). It would appear that a small internal diameter silicone ETT (<16 mm) is a possible risk factor for ETT obstruction secondary to cuff overinflation.

Secondly, in all cases, the cuff problem manifested as difficult ventilation, characterised by reduced gas flow and increased respiratory effort, or low delivered tidal volume despite high peak inspiratory pressures during IPPV. This agrees with previous observations reported in human (Barker & Stotz, 2013; Bar-Lavie et al., 1995; Davis et al., 2011; Hofstetter et al., 2010; Justiz & Mayhew, 2007; Kumar et al., 2021) and veterinary (Bergadano et al., 2004; Richardson & McMillan, 2017) literature on ETT obstruction. The sequelae can be severe, as severe hypercapnia and hypoxaemia can develop in minutes if critical hypoventilation is not promptly recognised and the problem resolved. Prompt diagnosis is likely hindered by the fact that shortly after intubation and having verified air flow prior to cuffing, the anaesthetist is unlikely to consider the possibility of luminal obstruction of the ETT thereafter. Also, while kinking or accumulation of secretions may be more common causes of ETT obstruction (Divatia & Bhowmick, 2005), ETT obstruction due to cuff overinflation or herniation is a less likely scenario, making it harder for the anaesthetist to quickly identify and correct the problem. Furthermore, cuff position and shape are dynamic and influenced by, among other things, changes in head-and-neck position (Brimacombe et al., 1999) and ETT displacement. Case 1 illustrates how failure to identify an obstructive breathing pattern can lead to an erroneous assumption of insufficient depth of anaesthesia, with critical time wasted on correcting this presumed problem. Importantly, when induction and intubation are performed outside the operating room under clinical observation only, the lack of monitoring and connection to an anaesthetic machine immediately after intubation may contribute to delay in identifying partial or complete airway obstruction. Continuous patient monitoring like pulse oximetry, capnography, spirometry, changes in peak inspiratory pressure and ECG could help alert the anaesthetist to the issue but is usually only initiated in the operating theatre. In Case 1, critical hypoventilation during the intervening period caused severe tachycardia, tachyarrhythmia and critical

desaturation that could have ended with hypoxic organ damage and death; the near-total airway obstruction could also have resulted in negative pressure pulmonary oedema. Difficult ventilation was likewise not identified in the second case until the foal was connected to the anaesthetic machine, IPPV was started, and a low tidal volume was observed despite high peak airway pressures. When the cuff was identified as the cause of ETT obstruction and difficult ventilation, rapid cuff deflation led to immediate return of normal ventilation parameters. In none of the cases post obstruction pulmonary oedema was noticed, which may be due to the short duration of the insult, although in Cases 2 and 3, this may also have been due to a lack of specific post anaesthetic monitoring instituted. The management of difficult ventilation due to ETT obstruction is an emergency situation where early diagnosis and intervention is vital; therefore, rapid cuff deflation should be included in the anaesthetist's algorithm for management of inspiratory dyspnoea in horses (Figure 1).

Thirdly, no recommended cuff pressure range is known for different diameter equine silicone ETTs, meaning achievement of adequate ETT inflation and cuff seal remains a balancing act, and more art than science. While underinflation may lead to leakage and potential aspiration, excessive pressure exerted on the tracheal mucosa as a result of cuff overinflation can lead to mucosal ischaemia and tracheal wall damage. Tracheal capillary perfusion pressure decreases when ETT cuff pressures over 30 cm H_2O were used in rabbits (Nordin et al., 1977) and humans (Seegobin & van Hasselt, 1984), but this was in PVC ETTs fitted with high-volume low-pressure cuffs. In horses, silicone tubes with LVHP cuffs are more commonly used. In these, intracuff pressure does not accurately reflect tracheal wall pressure. In these tubes, intracuff pressure is affected by the cuff's elastic properties and geometry (Dobrin & Canfield, 1977; McGinnis et al., 1971; Sultan et al., 2011). The foal in Case 2 developed a stridor after extubation, which may have been caused by transient laryngeal hemiplegia or tracheal wall damage due to temporarily excessive transmural pressure; however, it is also possible that haemorrhage was secondary to tissue damage incurred during traumatic intubation with a relatively large size ETT. In the foals of Cases 2 and 3, a cuff pressure of 140 to 200 mmHg (190–270 cm H_2O) was used to seal the trachea. In adult horses, an ETT cuff pressure of more than 80 cm H_2O provided a seal sufficient to prevent liquid leakage around the LVHP cuff of a 30 mm internal diameter silicone ETT size (Touzot-Jourde et al., 2005). The 30 mm ETT has a thicker wall and larger diameter, meaning the cuff needs less inflation and deformation to actuate a seal than a 26 mm ETT. In our hospital, we routinely inflate the cuff on a size 26 ETT for adult horses to 200 mmHg (270 cm H_2O) to prevent gas leakage, without apparent difficulties in ventilation. However, in these foals, like in the pony of case one, cuff deflation immediately resulted in restoration of normal ventilation parameters, and there was no

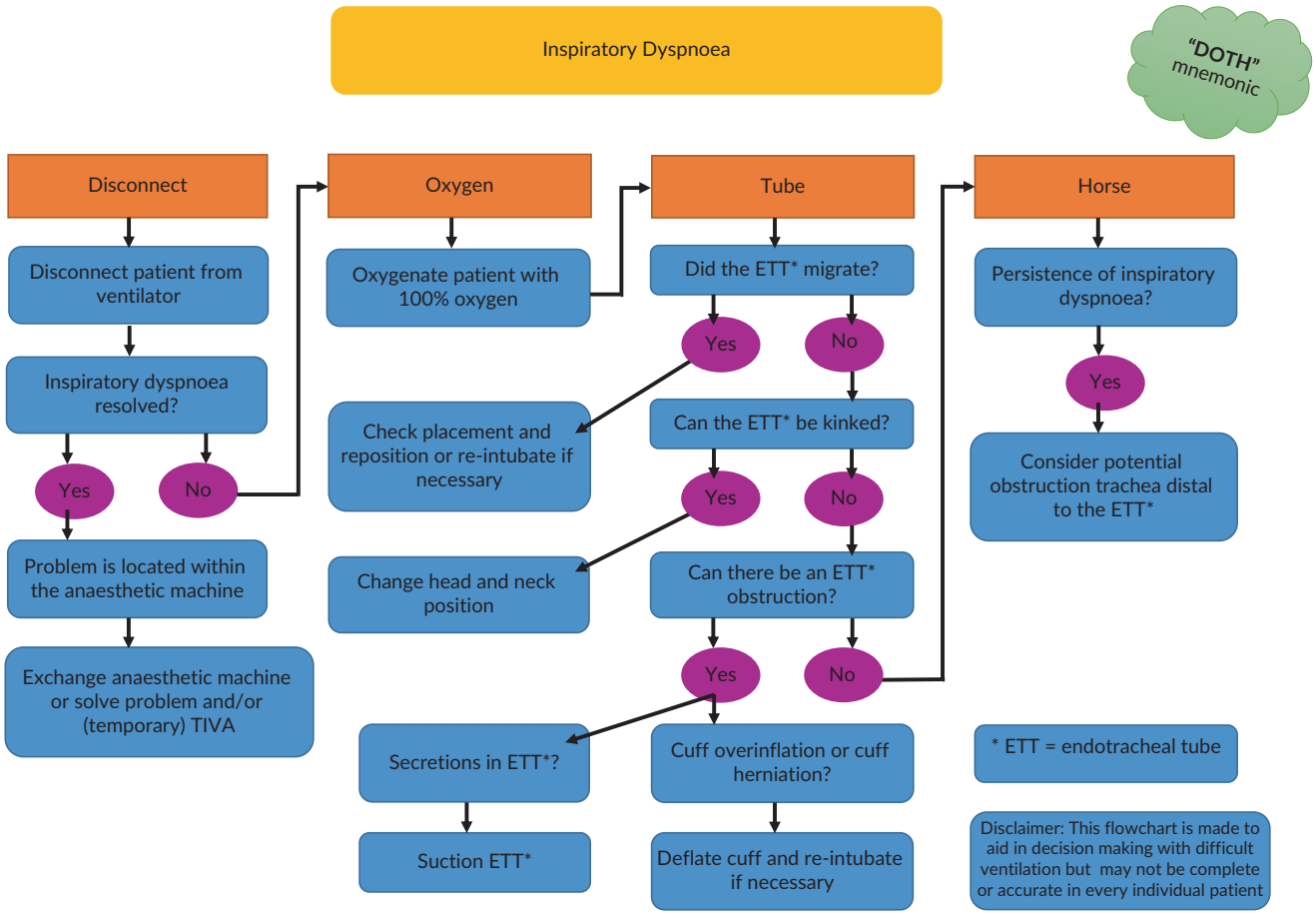

FIGURE 1 Algorithm for management of inspiratory dyspnoea.

recurrence of difficult ventilation after reinflating the same ETT cuff to minimal occlusive volume. We currently lack scientific data for recommended intracuff pressure ranges for different size silicone tubes. Since overinflation is more common than underinflation with most of the routinely used cuff inflation techniques other than pilot balloon palpation (Briganti et al., 2012; Khan et al., 2016; Sathish Kumar & Young, 2002; White et al., 2020), and tracheal mucosal wall damage is also pressure dependent (Touzot-Jourde et al., 2005), ETT cuff pressure measurement is recommended to avoid post-operative complications (Briganti et al., 2012; Hockey et al., 2016; Khan et al., 2016; Sengupta et al., 2004; Sultan et al., 2011; Touzot-Jourde et al., 2005).

In conclusion, ETT obstruction is a potentially life-threatening condition that requires prompt recognition and removal of the underlying cause to prevent morbidity and mortality. When presented with an intubated pony or foal that is difficult to ventilate and high airway pressures are observed, compression of the ETT lumen due to cuff overinflation or obstruction of gas flow due to cuff herniation should be considered as possible causes. Rapid cuff deflation should be included in algorithms for management of difficult ventilation. While cuff pressure measurement may reduce the risk of overinflation and associated tracheal mucosal injury, it may not protect against cuff herniation, and close observation of respiratory pattern and/or airway pressures (if IPPV is supplied) is imperative following ETT cuff inflation. More research is necessary to provide an evidence-based recommendation on a safe range of ETT cuff pressure for different size silicone ETTs used in horses.

AUTHOR CONTRIBUTIONS

Both authors contributed to study design, study execution, data analysis and interpretation and preparation of the manuscript. Furthermore, both authors have approved the final version of the manuscript.

CONFLICT OF INTEREST

No conflicts of interest have been declared.

ETHICS STATEMENT

The procedures described in this case report involved informed client consent. These were clinical cases presented to our hospital for surgery and ethical review was not required.

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REFERENCES

Barker, I.R. & Stotz, M. (2013) Cardiorespiratory arrest secondary to tracheostomy cuff herniation. *BML Case Reports*, 2013, bcr2013200304. Available from: https://doi.org/10.1136/bcr-2013-200304

Bar-Lavie, Y., Gatot, A. & Tovi, F. (1995) Intraoperative herniation of a tracheostomy tube cuff. *The Journal of Laryngology and Otology*, 109, 159–160.

Bergadano, A., Moens, Y. & Schatzmann, U. (2004) Two cases of intraoperative herniation of the endotracheal tube cuff. *Schweizer Archiv für Tierheilkunde*, 146, 565–569.

Briganti, A., Portela, D.A., Barsotti, G., Romano, M. & Breghi, G. (2012) Evaluation of the endotracheal tube cuff pressure resulting from four different methods of inflation in dogs. *Veterinary Anaesthesia and Analgesia*, 39, 488–494.

Brimacombe, J., Keller, C., Giampalmo, M., Sparr, H.J. & Berry, A. (1999) Direct measurement of mucosal pressures exerted by the cuff and non-cuff portions of tracheal tubes with different cuff volumes and head and neck positions. *British Journal of Anaesthesia*, 82, 708–711.

Calero Rodriguez, A.C., de Grauw, J.C. & van Loon, J.P.A.M. (2021) Effect of different inspired fractions of oxygen on F-shunt and arterial partial pressure of oxygen in isoflurane-anaesthetized and mechanically ventilated Shetland ponies. *Veterinary Anaesthesia and Analgesia*, 48, 930–934.

Davis, D., Murphy, J., Pop, R. & Szmuk, P. (2011) Airway obstruction due to endotracheal tube's lumen collapse secondary to cuff. *Anesthesia and Analgesia*, 112, 1511–1512.

Divatia, J.V. & Bhowmick, K. (2005) Complications of endotracheal intubation and other airway management procedures. *Indian Journal of Anaesthesia*, 49, 308–318.

Dobrin, P. & Canfield, T. (1977) Cuffed endotracheal tubes: mucosal pressures and tracheal wall blood flow. *American Journal of Surgery*, 133, 562–568.

Heath, R.B., Steffey, E.P., Thurmon, J.C., Wertz, E.M., Meagher, D.M., Hyyppa, T. et al. (1989) Laryngotracheal lesions following routine orotracheal intubation in the horse. *Equine Veterinary Journal*, 21, 434–437.

Hockey, C.A., van Zundert, A.A.J. & Paratz, J.D. (2016) Does objective measurement of tracheal tube cuff pressures minimise adverse effects and maintain accurate cuff pressures? A systematic review and meta-analysis. *Anaesthesia and Intensive Care*, 44, 560–570.

Hofstetter, C., Scheller, B., Hoegl, S., Mack, M.G., Zwissler, B. & Byhahn, C. (2010) Cuff overinflation and endotracheal tube obstruction: case report and experimental study. *Scandinavian Journal of Trauma, Resuscitation and Emergency Medicine*, 18, 18.

Holland, M., Snyder, J.R., Steffey, E.P. & Heath, R.B. (1986) Laryngotracheal injury associated with nasotracheal intubation in the horse. *Journal of the American Veterinary Medical Association*, 189, 1447–1450.

Justiz, A. & Mayhew, J. (2007) Kinking of an endotracheal tube within the trachea: a rare cause of endotracheal tube obstruction. *Journal of Clinical Anesthesia*, 19, 75–81.

Kao, M., Yu, Y., Liu, H., Tsai, S., Lin, S. & Huang, Y. (2005) Airway obstruction caused by endotracheal tube cuff herniation during creation of tracheal stoma. *Acta Anaesthesiologica Taiwanica*, 43, 59–62.

Khan, M.U., Khokar, R., Qureshi, S., Al Zahrani, T., Aqil, M. & Shiraz, M. (2016) Measurement of endotracheal tube cuff pressure: instrumental versus conventional method. *Saudi Journal of Anaesthesia*, 10, 428–431.

Kumar, M., Sinha, C., Kumar, A., Mithun, R. & Pattanayak, A. (2021) Cuff herniation as the cause of right main stem bronchus obstruction following tracheostomy. *Journal of Clinical Anesthesia*, 70, 110188.

McGinnis, G.E., Shively, J.G., Patterson, J.G. & Magovern, G.J. (1971) An engineering analysis of intratracheal tube cuffs. *Anesthesia and Analgesia*, 50, 557–564.

Nordin, U., Lindholm, C.E. & Wolgast, M. (1977) Blood flow in the rabbit tracheal mucosa under Normal conditions and under the influence of tracheal intubation. *Acta Anaesthesiologica Scandinavica*, 21, 81–94.

Richardson, E. & McMillan, M. (2017) A case of airway obstruction caused by probable nasotracheal tube cuff herniation in a horse. *Veterinary Anaesthesia and Analgesia*, 44, 191–192.

Sathish Kumar, S. & Young, P.J. (2002) Over-inflation of the tracheal tube cuff: a case for routine monitoring. *Critical Care*, 6, 37.

Saulez, M.N., Dzikiti, B. & Voigt, A. (2009) Traumatic perforation of the trachea in two horses caused by orotracheal rupture. *Veterinary Record*, 164, 719–722.

Seegobin, R.D. & van Hasselt, G.L. (1984) Endotracheal cuff pressure and tracheal mucosal blood flow: endoscopic study of effects of four large volume cuffs. *British Medical Journal (Clinical Research Ed.)*, 288, 965–968.

Sengupta, P., Sessler, D.I., Maglinger, P., Wells, S., Vogt, A., Durrani, J. et al. (2004) Endotracheal tube cuff pressure in three hospitals, and the volume required to produce an appropriate cuff pressure. *BMC Anesthesiology*, 92, 8.

Sultan, P., Carvalho, B., Rose, B.O. & Cregg, R. (2011) Endotracheal tube cuff pressure monitoring: a review of the evidence. *Journal of Perioperative Practice*, 21, 379–386.

Touzot-Jourde, G., Stedman, N.L. & Trim, C.M. (2005) The effects of two endotracheal tube cuff inflation pressures on liquid aspiration and tracheal wall damage in horses. *Veterinary Anaesthesia and Analgesia*, 32, 23–29.

White, D., Makara, M. & Martinez-Taboada, F. (2020) Comparison of four inflation techniques on endotracheal tube cuff pressure using a feline airway simulator. *Journal of Feline Medicine and Surgery*, 22, 641–647.

Wylie, C.E., Foote, A.K., Rasotto, R., Cameron, I.J. & Greet, T.R.C. (2015) Tracheal necrosis as a fatal complication of endotracheal intubation. *Equine Veterinary Education*, 21, 170–175.

Zenga, J., Galaiya, D., Choumanova, I. & Richmon, J.D. (2018) Endotracheal tube obstruction caused by cuff hyperinflation. *Anesthesiology*, 129, 581.

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

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Equine Veterinary Education

CASE REPORT

Intravesical foreign body causing a cystolith in a gelding

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SUMMARY

A 4-year-old gelding was referred to the clinic with a history of haematuria and stranguria after exercise. Transrectal examination and endoscopy of the urinary bladder revealed the presence of a cystolith. Surgery under general anaesthesia was scheduled for the removal of the bladder stone. A 12-cm laparotomy incision through the caudal ventral midline was performed to localise the bladder. The right part of the bladder wall was severely thickened and the right lateral ligament of the bladder appeared tensed and fibrotic, which made the mobilisation of the bladder extremely difficult. A second 6- to 7-cm incision was made just cranial to the right external inguinal ring and allowed the exteriorisation of the apex of the bladder. At removal, the stone appeared to be a foreign body (a 4×3 cm piece of red plastic with two attached rubber bands), which was covered with a calcium carbonate layer (Figure 1). A control endoscopy was performed under sedation 3 days after surgery and showed mild inflammation and good healing of the cystotomy. The horse was discharged from the hospital. Two years later, the owner reported no recurrence of the clinical signs and explained that the horse was born in a breeding stable where he did not show complications after birth such as patent urachus or other umbilical abnormalities. The horse spent his youth at a second centre where he was castrated by a veterinarian who stated to have never used anything other than sutures while castrating. The authors hypothesised that the route of entry of the foreign body found in the bladder was migration either from the umbilicus or the spermatic cord. The exact origin of the foreign body remains unknown, as there are no elements in the history of the horse that leads to a logical explanation.

FIGURE 1 Foreign body covered with a layer of calcium carbonate found in the urinary bladder of the gelding

KEYWORDS
horse, cystolithiasis, foreign body, intravesical, urolithiasis

Key points

- Endoscopy of the urinary bladder is key in order to evaluate the amount, nature and size of the cystoliths.
- The modified parainguinal approach provides the ideal parainguinal laparotomy incision location, which can be useful in cases where the mobilisation of the bladder is limited.
- Migration of a foreign body into the urinary bladder of a gelding, although very uncommon, should not be neglected.

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Equine Veterinary Education BEVA AAEP

CASE REPORT

Botryomycosis-like discospondylitis of the thoracic spine in a Friesian horse with severe bilateral pelvic limb ataxia and paresis

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SUMMARY

An 8-year-old Friesian gelding was presented with severe bilateral hindlimb ataxia and paresis of 2 weeks duration. Only lordosis was noted during static clinical examination, and during movement, only the pelvic limbs were abnormal with severe ataxia (grade III/IV) and hypermetria. Transcranial magnetic stimulation (TMS) was performed as an ancillary test to confirm spinal cord involvement, and the latency times of the pelvic limbs were severely elongated (>60s). The latency times of the thoracic limbs were within normal limits. The clinical neurological examination and the TMS findings suggested a spinal cord lesion between T2 and the lumbar region with involvement of the sensory (ataxia) and motor (paresis) pathways. Radiographic examination confirmed the neurolocalisation and revealed a large osteolytic lesion at the T10–T11 intervertebral disc space. Due to the severe ataxic condition of the horse and the extent of the radiographic abnormalities, a poor prognosis was given. In agreement with the owners, the horse was euthanised. Post-mortem examination revealed a discospondylitis with abscess formation and histological presence of pyogranulomatous inflammation with coccoform bacteria rimmed by Splendore-Hoeppli material. *Staphylococcus aureus* was identified by bacteriological examination. This case report describes the clinical presentation, imaging features and post-mortem findings with a Friesian gelding presenting with severe bilateral hindlimb ataxia and paresis caused by compression and degeneration of the spinal cord due to a botryomycosis-like thoracic discospondylitis.

KEYWORDS
horse, botryomycosis, spinal ataxia, Splendore-Hoeppli

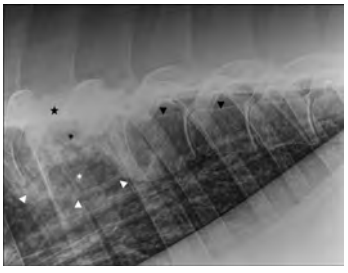

FIGURE 1 Left-to-right lateral projection of the thoracic vertebrae. The intervertebral disc space between T10 and T11 is no longer identifiable (black asterisk), with a large region of osteolysis (white asterisk), bordered by bridging new bone formation (white arrowheads) and loss of delineation of the dorsal cortices of the vertebral bodies (black star), compared with the ones of T12 and T13 (black arrowheads).

Key points

- Botryomycosis is an uncommon chronic bacterial pyogranulomatous infection of cutaneous and, rarely of visceral origin, that can rarely invade the osseous tissues.
- The clinical neurological examination and the ancillary transcranial magnetic stimulation (TMS) test indicated ataxia and paresis respectively; they were complementary, indicated spinal cord involvement and resulted in correct neurolocalisation between T2 and the lumbar region.
- Botryomycosis-like infection should be considered in the differential diagnosis of focal expansile bone lesions demonstrating diffuse osteolysis, sclerosis and interrupted bone margins.

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Equine Veterinary Education BEVA AAEP

CASE REPORT

Evisceration in a Thoroughbred gelding following application of a topical chemotherapy agent for the treatment of sarcoids

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SUMMARY

An 18-year-old Thoroughbred gelding was presented following evisceration of the jejunum. A topical caustic chemotherapy agent (AW5-LUDES cream) had been applied to several suspected sarcoids, including one on the ventral abdomen with the most recent application 6 weeks previously. The gelding was bright and alert on arrival with normal clinical parameters and had an abdominal bandage in place.

Following induction of general anaesthesia, the bandage was removed to reveal a 15 cm diameter necrotic full-thickness segment of the body wall including a necrotic sarcoid on the ventral caudal midline abdomen (Figure 1). Direct communication with the peritoneal cavity was present on the left side of the lesion from which approximately 1m of jejunum had eviscerated. The exposed jejunum was moderately contaminated, and there was serosal inflammation and haemorrhage within the mesentery. The body wall adjacent to the defect was devitalised with a 10cm diameter segment of compromised tissues, contaminated with maggots. Due to the degree of contamination, and necrosis of the skin and muscular tissue, treatment by debridement and closure using a mesh device was recommended, and the owner was advised of a guarded prognosis owing to potential risks of peritonitis, infection of the implant and wound dehiscence. Due to limited finances and the guarded prognosis, the owner elected to euthanise the horse.

There is limited published information about the outcomes and complications of treatment of skin tumours such as sarcoids with caustic chemotherapy agents. This case report describes a serious complication following treatment with one such caustic chemotherapy cream (AW5-LUDES) and highlights one of the risks associated with using such agents on the ventral midline. Unfortunately, the poor prognosis associated with the extensive necrosis of the body wall, despite the rapid application of first aid and referral, led to the owners' decision to euthanise the horse rather than attempt treatment.

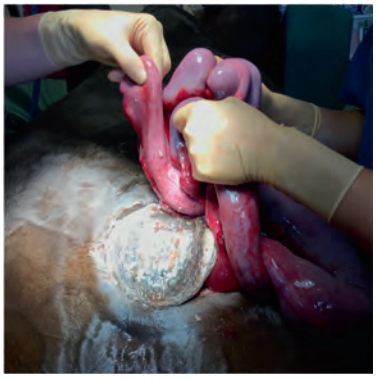

FIGURE 1 Approximately 1m of jejunum eviscerated through the abdominal defect.

Key points

- Evisceration is a previously unreported complication of AW5-LUDES application to the ventral abdomen.
- Caustic chemotherapy agents should be used with extreme caution in regions where uncontrolled tissue necrosis could have catastrophic results.
- The full effects of tissue necrosis may not be evident until 6 weeks after the application of the caustic chemotherapy agent.

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Equine Veterinary Education

CASE REPORT

The use of prostaglandin applied in Bai Hui Acupoint on mare reproductive efficiency

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SUMMARY

Prostaglandin $F_{2\alpha}$ ($PGF_{2\alpha}$) is one of the most frequently used drugs in mares for pharmacologic manipulation of the oestrous cycle. $PGF_{2\alpha}$ induces luteolysis, leading to early oestrus return, and reduced dioestrus phase and interovulatory intervals. Interestingly, mares are more sensitive to $PGF_{2\alpha}$ than other domestic species. Even with lower doses, there are adverse and inconvenient side effects for animals and breeders. Recently, acupuncture has been an alternative to decrease the $PGF_{2\alpha}$ dose for mares. Applying lower doses of $PGF_{2\alpha}$ at specific acupoints is as efficient as the regular dose. The aim this study was to analyse the reproductive performance and oestrous characteristics in embryo recipient and donor mares using different doses at the Bai Hui—an acupoint located on the dorsal midline, whose region of effect encompasses many nerve trunks, nerve endings and vascular networks. For this study, 76 Quarter Horse mares had daily rectal palpation and transrectal ultrasonography to check oestrus start, and during oestrus follicle growth was monitored for ovulation detection. Six days after ovulation (D0), the mares were examined for the presence of a corpus luteum (CL), and randomly assigned to 3 experimental groups: Control (CTR; $n = 20$) with 5 mg $PGF_{2\alpha}$ IM administration (Dinoprost Trometamina, Lutalyse®, 1 ml, Zoetis); Bai Hui 5 mg $PGF_{2\alpha}$ (BH5; $n = 24$) with 5 mg (1 ml) at the Bai Hui acupoint; and Bai Hui 2.5 mg $PGF_{2\alpha}$ (BH2.5; $n = 32$) with 2.5 mg (0.5 ml) at the Bai Hui acupoint. For the application the needle (21 gauge, 0.8 × 30 mm) was inserted vertically into the lumbosacral joint. Results showed no differences in uterine oedema, pregnancy rate or body condition score among the groups. However, oestrous expression was lower ($p < 0.001$) in both BH groups. The application and ovulation was shorter in BH5 compared with CTR ($p = 0.042$). Results indicated BH5 and BH2.5 as viable alternatives to the IM administration.

KEYWORDS
horse, corpus luteum, luteolysis, ovulation, reproduction, acupuncture

Key points

- The affinity of $PGF_{2\alpha}$ for CL in horses is roughly 10 times greater, with a clearance rate and a dose five times lower than that required to induce luteolysis effectively.
- The side effects observed after the application of $PGF_{2\alpha}$ in mares are inconvenient for both animals and owners.
- The use of acupuncture, a traditional Chinese medicine technique, has been identified as an interesting alternative in the veterinary field, including equine medicine.

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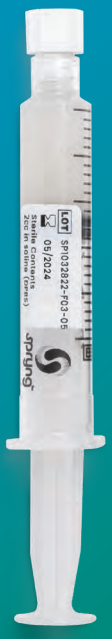

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Equine Veterinary Education BEVA AAEP

CASE REPORT

Septal myocardial abscess in a Thoroughbred mare

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SUMMARY

An 11-year-old multiparous Thoroughbred mare was presented with a history of acute colic. On presentation, a transient improvement in abdominal pain had been seen following administration of flunixin meglumine, but the mare was profoundly depressed. The horse had hypothermia (36.8°C) and increasing tachypnoea (60 breaths/min) and tachycardia (100 beats/min). Conjunctival and oral mucous membranes appeared pale. Cardiac auscultation revealed an arrhythmia with variable intensity, but no heart murmurs. An increased packed cell volume (57%) and leucocytosis (15,400/μl) were identified on haematological evaluation. Nasogastric intubation yielded no reflux, and transcutaneous abdominal ultrasonography did not reveal any abnormal findings that contribute to abdominal pain. On initial examination, transthoracic echocardiography revealed no abnormalities. Electrocardiography revealed monomorphic ventricular tachycardia (VT) at a rate of 211 beats/min with R-on-T phenomenon occasionally and made a presumptive diagnosis of idiopathic VT. Therefore, the mare was treated with lidocaine. VT was temporally converted to normal sinus rhythm and heart rate decreased to 70 beats/min with intermittent premature ventricular depolarisations after starting therapy. Echocardiography performed 2 days later revealed a hypoechoic spherical area within the muscular part of the intraventricular septum. It appeared to protrude into the left ventricular cavity on left parasternal long axis 2-chamber view. Unfortunately, the mare died suddenly as the result of ventricular fibrillation. Post-mortem examination confirmed the presence of an encapsulated abscess in the intraventricular septum. *Staphylococcus aureus* and *Staphylococcus chromogenes* were isolated from the lesion. This was thought to be responsible for the arrhythmia seen in this case. This is the first case of a septal myocardial abscess in a horse and demonstrates that it should be considered as a cause of ventricular tachycardia.

KEYWORDS
horse, arrythmia, echocardiography, electrocardiography, septal myocardial abscess

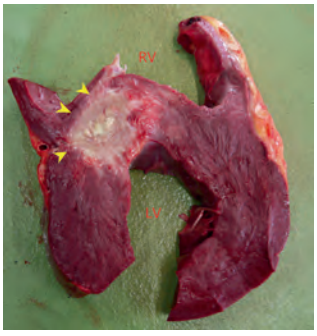

FIGURE 1 Post-mortem appearance of a cross-section through the ventricles. The abscess (yellow arrows) was located in the ventricular septum.

Key points

- Septal myocardial abscess is rare in horses and can cause ventricular tachycardia.
- For the diagnosis of the interventricular septum abscess, repeat transthoracic echocardiography is useful.
- Empirical antimicrobial therapy should be considered in cases of idiopathic ventricular arrhythmia where there is evidence of a septic process and myocardial infection cannot be ruled out.

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Equine Veterinary Education

CASE REPORT

Diagnosis and management of spermiostasis in a Shetland stallion

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SUMMARY

A 16-year-old, 143 kg Shetland stallion was presented to the Equine Theriogenology Service at the University of Illinois Veterinary Teaching Hospital for a semen evaluation and cooling test. The stallion produced foals by live covering mares during the previous breeding seasons but never had semen collected before the presentation. Upon arrival, a complete physical examination revealed all parameters to be within normal limits, and both testes had normal consistency and were present in the scrotum. Semen collection was performed with a Missouri artificial vagina while the stallion mounted a Shetland oestrus mare. The first semen collection yielded an ejaculate containing 73 billion total sperm, and necrozoospermia, with 67% sperm having detached heads. These results warranted nine serial additional semen collections. There was no evidence of ampullary plugs in the semen filter throughout the collections. The expected daily sperm output (DSO) and actual DSO were determined to estimate spermatogenic efficiency. Gel-free semen volume was stabilised after the first collection. A gradual increase in sperm motility after the third semen collection was noted. The percentage of morphologically normal sperm gradually increased after collection 1 and remained greater than 60% starting from the collection 3. Sperm concentration decreased after collection 5 and stabilised between collections 8 and 10. In addition to sperm concentration stabilising, the percentage of detached heads declined remarkably. The spermatogenic efficiency range was from 182% to 240%, which is consistent with the clinical diagnosis of spermiostasis. A semen cooling test determined that a sodium caseinate cholesterol-loaded cyclodextrin extender was the most suitable semen extender. The stallion returned for a semen freezing test 2 months after the initial presentation. Total and progressive motilities were 73% and 67%, respectively, the morphology evaluation revealed 90% of morphologically normal sperm and 5% of sperm with detached heads. Satisfactory post-thaw semen motility and thermal longevity were measured. Total and progressive motility remained above 30% after 120 min. This article describes a clinical case of spermiostasis in a Shetland stallion successfully resolved by repeated semen collections.

KEYWORDS
horse, asthenozoospermia, ejaculatory dysfunction, necrozoospermia, sperm accumulator, teratozoospermia

Key points

- This case describes the first reported case of spermiostasis in a pony breed.
- High-spermatogenic efficiency was consistent with spermiostasis, which was successfully resolved by serial semen collections.
- Normospermia was obtained 60 days post-initial presentation while the stallion was regularly pasture breeding mares.

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Equine Veterinary Education

ORIGINAL ARTICLE

Dental health and management practices of donkeys in the UK: What should we be considering?

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Funding information
The Donkey Sanctuary; Donkey Sanctuary

Summary

Background: Several studies have shown dental disease to have a high prevalence and severity in donkeys. Limited studies have assessed the possible relationships between poor dental health and the management and health care of donkeys.

Objective: The aim of this study was to identify relationships between dental health and current management of donkeys in the UK and to provide recommendations to improve practices to help donkey welfare.

Study design: Observational cross-sectional survey.

Methods: A total of 596 donkeys surrendered to The Donkey Sanctuary (TDS) over a period of 30 months were included. Analysis was performed on three categories of information: entrance information submitted by previous owners and welfare professionals, pre-admission clinical examination records and arrival medical examination data.

Results: No statistically significant differences were identified between dental health and provision of bedding, or diet types. Agreement between external professionals and experienced TDS staff was weak in reference to recognition of dental pathology, age and body condition score (BCS). Over 25% of donkeys with severe dental pathology also had poor BCS (1–1.5). The majority of donkeys had no indication of previous dental examination.

Main limitations: Entrance information was not gathered and recorded in a structured manner.

Conclusions: Regular prophylactic dental care seems to have poor uptake amongst the owners of the study population, but this is perhaps, in part, aligned to the nature of the sanctuary. Owners are yet to take dental health into consideration when allocating a diet or bedding types to their donkeys, presenting a risk of colic/choke in those fed long fibres with an inability to process them adequately. The Donkey Sanctuary should continue to offer accessible means of education to reach both professionals and owners alike, and this may be well served by the implementation of the new, online, Donkey Academy.

KEYWORDS
horse, dental, dentistry, donkey, welfare

INTRODUCTION

The latest data observe an increase in global donkey numbers over the last 20 years, to more than 50 million (Norris et al., 2021). According to the Central Equine Database in 2019, there are 27,592 donkeys in the UK. However, these figures relate to donkeys registered with valid passports. Approximately one third of intakes to The Donkey Sanctuary (TDS) did not have a valid passport in a recent study (Barrio Fernandez et al., 2020) and hence would not be registered with the Central Equine Database. The current number of donkeys at TDS is 6233, with 4089 on farms and 2144 in monitored guardian homes, leaving just over 21,000 donkeys in private homes.

The prevalence of dental disease in donkeys has been found to be in the region of 73–93% and is identified as the second most common clinical condition after diseases of the hoof (Cox et al., 2010; du Toit et al., 2008, 2009a; Rodrigues, Araújo, et al., 2013; Rodrigues, Dixon, et al., 2013). Indeed, Rodrigues, Dixon, et al. (2013) noted a disease prevalence of 83% in the cheek teeth of donkeys of all ages with an absence of previous dental treatment, and du Toit et al. (2009a) noted a figure of 73% in living donkeys, rising to 93% at *post-mortem*. The literature seems to suggest that intervention makes a positive difference in disease prevalence, but donkeys are still suffering high levels of oro-dental disease towards the end of their lives.

Cox et al. (2010) suggest that 86% of TDS guardian homes provided their donkeys with at least annual dental examinations. Moreover, 45% of the same donkey owners surveyed, indicated knowledge that their donkeys had some degree of dental disease, yet internal audit data suggest that the prevalence of dental disease in donkeys returning from guardianship to be in the region of 77% (Cox et al., 2010; Lilly, 2013).

Routine prophylactic dental assessment has long been promoted specifically in donkeys by TDS and is driven by the experiences of the clinical team and in field research. Yet, key studies emphasise a high prevalence of disease, despite claims of regular intervention (Cox et al., 2010; du Toit et al., 2009a; Grint et al., 2015; Lilly, 2013; Rodrigues & Lilly, 2019). The literature indicates that the recognition of dental pathologies is poor and that regular intraoral assessment and prophylactic treatment should be provided for all equids (Cox et al., 2010; du Toit et al., 2009a, 2009b; Grint et al., 2015; Lilly, 2013; Rodrigues & Lilly, 2019).

Dental disease shares relationships with other systemic conditions, and indeed in donkeys, it is a recognised risk factor for impaction colic, the prevalence of which is about 17% (~10% in horses), with a mortality risk found to be higher than in other equids at 51% (Cox et al., 2007, 2009; du Toit et al., 2009b; Hillyer et al., 2001; Mellor et al., 2001; Tinker et al., 1997).

This relatively high incidence and mortality rate may indicate unsuitable feeding practices and a failure to recognise colic in donkeys in the early stages. Additionally, dental disease has been shown to influence body condition score (BCS), which in turn has been shown to affect morbidity and mortality (Cox et al., 2007, 2009; du Toit et al., 2008).

Dental disease in donkeys presents a major welfare concern, and consideration for feeding practices in conjunction with regular intraoral examination is indicated by these observations.

From the literature reviewed, it is apparent that there may be conflicting evidence between best practice messaging and the reality of management practices for donkeys in the UK.

MATERIALS AND METHODS

This cross-sectional study focuses on data yielded from three main areas:

1. Entrance information from surrendered equids processed through the New Arrivals Unit of TDS, Sidmouth (UK) for a period of 30 months.
2. Pre-admission medical (PAM) data for the above donkeys. The PAM is conducted by external veterinary surgeons on equids destined to travel to TDS and consists of a full clinical and intraoral examination, and the date of the last dental examination.
3. Admission medical (AM) data for the above donkeys. The AM is performed upon arrival at TDS and includes a full clinical examination performed by a veterinary nurse, with a more thorough examination by a vet if there were medical concerns. Intraoral examination was performed within the next 2–4 weeks of arrival by BEVA/BVDA qualified Equine Dental Technicians.

The New Arrivals Unit provides the necessary initial care for equids upon arrival and sees intakes spend about 6 weeks isolated from the main herd to undergo the AM and further health screening such as dental examination, faecal samples, weight checks, full haematology and biochemistry screening, and other testing if required.

Entrance information

The main author assessed the arrival records for donkeys entering the New Arrivals Unit at TDS during the study period. The information recorded included age (as per passport, or according to the owners where no date of birth was available), reason for relinquishment, post-code, duration of ownership, vaccination status, presence of microchip, deworming history, diet and management (including bedding, routine and number of friends/companions), BCS using the standard TDS 1–5 scale (Evans & Crane, 2018), with the modification of using half points, previous medical history and last recorded dental examination (including dental charts and or clinical notes).

Pre-admission examination

It is TDS policy that every donkey over 20 years of age should receive a full PAM examination prior to departure from their location. Donkey Welfare Advisors provide specific photographs of all equids

TABLE 1 Estimated age of donkeys (years) at admission medical (AM) stratified by AM dental grade

Dental grade	*n*	Mean	SD	Q1	Median	Q3	Min	Max
None	13	13.92[bc]	9.58	6.0	10.0	21.5	5	36
1	274	7.34[a]	5.31	4.0	6.0	10.0	0	28
2	83	11.16[b]	6.63	6.0	10.0	15.0	3	30
3	69	12.77[b]	7.53	7.0	10.0	16.5	2	35
4	22	16.82[c]	7.04	11.0	17.5	23.0	6	27
5	20	21.2[d]	6.88	20.0	21.5	25.0	2	30
Total	481	9.96	7.14	5.0	8.0	14.0	0	36

Note: Significance of Kruskal–Wallis test, $p < 0.001$.

Different superindexes in the same column indicate significant differences taking into account the paired Mann–Whitney test ($p < 0.050$).

prior to relinquishment. The New Arrivals Unit vet evaluates the photographs, and in conjunction with the medical history, a decision is reached regarding the need for a PAM examination for donkeys under the age of 20 years.

The pre-admission intraoral examination was detailed on the PAM examination form, with the allocation of a dental health grade applied retrospectively by the main author, based on a grading system developed by TDS (Lilly, 2015).

Dental health was subsequently catalogued by the New Arrivals Unit vet as acceptable (grades 1–2) or pathological (3–5). Grades 1–2 include equids with good, normal, age-related dental health and those with very minor pathology (deemed easily correctable with no impact on pain or function), whereas grades 3–5 include multiple, moderate, severe and very severe pathology, respectively, with grades 4 and 5 often presenting wider impacts on function, pain and systemic disease.

The purpose of the grading system was not to be prescriptive with indicators, but to give a general guide to the potential types and severities of intraoral findings in each grade. Not all conditions at noted grades may be observed, and professionals are encouraged to grade the overall general health of the mouth, considering all observations, on a scale of 1–5.

Admission medical details

It is TDS policy that each equid undergoes an AM examination. Examination was undertaken by a Registered Veterinary Nurse or a vet within 24 h of arrival and completed using an admissions form.

Accurate age information is important to enable planning for the post-New Arrivals Unit relocation of the equid to a suitable location for their likely needs. It may also preclude equids from consideration for the guardian scheme (temporary or permanent relocation of the equid to an individual home assessed as suitable by TDS). Age estimation using the incisor teeth was performed at arrival. Post-admission intraoral examination included the designation of a live dental health grade and was either performed within the first 2–4 weeks or upon arrival if concerns were raised (either via PAM, AM or by New Arrivals Unit staff).

General management (bedding and diet) within New Arrivals Unit remained identical or like that used in the previous home for at least the first night unless it presented a detrimental risk to health.

Statistical analysis

Data were collected in a Microsoft Access 2016 database; then, they were further exported for statistical analysis with IBM SPSS 19.0 for Windows®. Categorical variables (as BCS, dental grades, type of diet, type of bedding, type of origin and time since last dental visit) were described using absolute (*n*) and relative frequencies (%). Continuous variables were described using mean, median, standard deviation, quartiles and ranges depending on normality of distribution. The associations between dental grades with another categorical variable were assessed using Pearson's Chi-square test (χ^2) if less than 20% of expected frequencies were lower than 5; in other cases, we used Fisher's s exact test (*F*) for 2×2 contingency tables and Likelihood Ratio test (LR) for rest of the cases. These tests assessed if there were statistically significant differences between the expected frequencies and the observed frequencies (McHugh, 2013). Additionally, dependence between categories of analysed variables was confirmed by calculating the adjusted standardised residuals (ASR); under the null hypothesis that the two categorical variables are independent and assuming a confidence level of 0.95, an ASR of more than 1.96 indicated that the number of cases in that cell was significantly greater than would be expected if the null hypothesis were true. An ASR that was <1.96 indicated that the number of cases in that cell was significantly fewer than would be expected if the null hypothesis were true, and in consequence, the category was underrepresented (Agresti, 2002). The alpha error was set at 0.05.

Some animal data were missing from the information database; therefore, the initial n number does not match for all the studied variables.

RESULTS

During the study period, 596 donkeys from all over the UK were surrendered to TDS, from those the majority admitted were geldings (53.0%), followed by mares (31.5%) and stallions (15.4%).

Of the 596 donkeys, 48.7% ($n = 290$) had a PAM examination performed by an external veterinary practice, 46.0% ($n = 274$) did not receive a PAM examination, and just 5.4% ($n = 32$) received a partial PAM. Dental examination with an equine dental speculum

was requested in all of the 290 PAM; however, in 54.8% ($n = 159$) of those, the attending veterinary practice did not provide a dental examination report or dental chart. On partial PAM examination, only 1 of 32 cases received a dental examination. Therefore, out of the 596 donkeys, PAM dental reports were available for 132 animals.

Despite the median age (Table 1) of the population being reasonably young, nearly half were deemed to require a PAM examination prior to transportation.

Dental health and age

There was a positive association between age and the severity of dental disease, and dental grade increasing with age ($p < 0.001$). Donkeys with a dental grade of 1 had a mean age of 7.34 years and were significantly younger than those with grades 2–5. Donkeys with dental grades of 2 and 3 were similar ages (mean 11.16 and 12.77, respectively). Donkeys with a dental grade of 4 were significantly older than those with grades of 1–3. Donkeys with a dental grade of 5 had a mean age of 21.2 years and were significantly older than those with a dental grade of 1–4 (Table 1).

Dental grade and BCS

Statistically significant differences were noted between admission dental grade and admission BCS (Table 2, $p = 0.007$). It was observed that 25.8% of donkeys with severe dental pathologies (grade 5) were in poor condition. However, it was also identified that 15.9% of donkeys with a pathological dental grade (grade 3) were classified as obese. Moreover, donkeys with moderate-to-severe dental disease (grades 4 and 5) have reduced probability of having an adequate BCS (2.5–3.5; 32.3% and 29.0%).

Dental health and diet

Statistically significant differences were found between pre-admission diet and dental grade of donkeys at admission with regard to donkeys having access to grass ($p = 0.045$) and the use of chopped forage feed ($p = 0.018$) (Table 3). A significant number of donkeys were identified with pathological dental grades that had access to restricted grazing (17.7%) compared with those without dental disease. There were also significant numbers of donkeys with no significant dental disorders that were on chopped feed (34.0%). Interestingly, 17.9% of nongeriatric donkeys (those under 20 years of age) were found to receive cereal grain compound feed, reducing to 8% in geriatric donkeys.

Dental health and bedding

No statistically significant differences were found between the type of pre-admission bedding and dental grade at admission ($p = 0.291$) (Table 4).

Dental health and origin

There were significant differences found between AM dental grade and type of origin (Table 5; $p = 0.001$); donkeys with better dental health came from Donkey Sanctuary holding bases, with 76% allocated a dental grade of 1, and only 1% with severe dental disease (grade 5). However, the poorest dental health scores corresponded to New Arrival donkeys and Returning guardian donkeys, with 11.1% of New Arrivals and 17.2% of Returning guardian allocated grades 4 and 5.

Dental health and PAM/AM

More than half of the donkeys (55.7%) had an admission dental grade of 1, compared with 66.7% at PAM. 25.1% of donkeys arrived with pathological dental grades (3–5; Table 6).

Statistically significant differences were found between dental grades at PAM and AM (Table 7, $p < 0.001$). A total of 101 donkeys were considered to have an acceptable dental grade at PAM; from those, there were a total of 38 donkeys that showed pathological

TABLE 2 Admission body condition score (BCS) stratified by admission dental grades

		BCS					
Dental grades	***n***	**None**	**≤1.5**	**(1.5, 2.5)**	**(2.5, 3.5)**	**(3.5, 4.5)**	**>4.5**
1	320	1.6%	1.3%	9.7%	53.8%	27.2%	6.6%
2	110	1.8%	1.8%	3.6%[a]	58.2%	28.2%	6.4%
3	82	1.2%	1.2%	4.9%	54.9%	22.0%	15.9%[b]
4	31	6.5%[b]	6.5%	12.9%	32.3%[a]	25.8%	16.1%
5	31	0.0%	6.5%	25.8%[b]	29.0%[a]	29.0%	9.7%
Total	574	1.7%	1.9%	8.9%	52.3%	26.7%	8.5%

Note: Significance of likelihood ratio test, $p = 0.007$.

[a]Observed proportion significantly lower than expected ($p < 0.050$).

[b]Observed proportion significantly higher than expected ($p < 0.050$).

TABLE 3 Type of diet and admission dental grades (categorised)

Diet	*n*	Dental grades categories		*p*
		Acceptable (1–2) (n = 347)	Pathological (3–5) (n = 124)	
Grass	374	80.4%	76.6%	0.045[a]
Restricted grazing	57	10.1%[b]	17.7%[c]	
Hay	356	73.5%	81.5%	0.076[a]
Straw	206	42.1%	48.4%	0.224[a]
Haylage	41	9.8%	5.6%	0.159[a]
Chopped forage feed	146	34.0%[c]	22.6%[b]	0.018[a]
Fibre compound feed	129	29.1%	22.6%	0.162[a]
Cereal grain compound feed	82	18.4%	14.5%	0.322[a]
Supplement balancer	20	4.9%	2.4%	0.240[a]

[a]Significance of Pearson's Chi-squared test.

[b]Observed proportion significantly lower than expected ($p > 0.050$).

[c]Observed proportion significantly higher than expected ($p < 0.050$).

TABLE 4 Types of bedding stratified by dental grade (categorised)

Bedding	Dental grade categories	
	Acceptable (1–2) (*n* = 341)	Pathological (3–5) (*n* = 115)
Straw	58.7%	56.5%
Shavings	15.5%	20.9%
No bedding	7.9%	11.3%
Other	8.8%	7.0%
Rubber matting	5.9%	4.3%
Dust-extracted wood fibre	1.5%	0.0%
Rubber matting + Straw	1.2%	0.0%
Rubber matting + Shavings	0.3%	0.0%
Straw + Shavings	0.3%	0.0%

Note: Significance of likelihood ratio test, $p = 0.291$.

dental grades when examined at AM (Table 7). Finally, the agreement between PAM dental grades and admission dental grades was found to be weak (k = 0.270).

Dental health and dental history

There was considerable variability in the scheduling of dental examination for the 29% (*n* = 187) of donkeys who had received previous assessment (Table 8). There was no significant correlation between dental grade and date of previous examination. Timing of the last dental examination varied from just over 1 week up to 15 years, with an average of 1.3 years.

DISCUSSION

Dental grade and age

The data support the widely accepted principle that equid dental disease increases in prevalence and severity with advancing age. A particularly interesting observation is the range of ages found not only in the acceptable dental health grade scores (dental grade 1) but also those at the opposite end of the scale, with dental health scores of 4 and 5. The age range for grade 1 at AM is 0.1–28 years of age, whilst the range for grades 4 and 5 was 2–33 years of age, meaning that it is possible for geriatric donkeys to reach old age with comfortable and disease-free, functional dentition. Conversely, it is interesting that there are instances of juvenile donkeys with severe and very severe dental disease, highlighting a need for regular examination from a young age.

The results agree with those of du Toit et al. (2009a) and Rodrigues, Dixon, et al. (2013), whereby a significant deterioration in dental health seems to first occur around the ages of 10–15 years old. The results support the need for regular intraoral examination by a suitably trained professional, and that thorough intraoral examination should be undertaken for PAM. Additionally, if equid dentistry is considered prophylactic, intraoral examinations need to commence from an earlier age.

Dental grade and BCS

The results show that both BCS and dental health grade are often underestimated by external partners. Consequently, donkeys with more severe grades of dental health (4 or 5) were typically found to

TABLE 5 Distribution of admission dental grade of donkeys by type of origin

		Admission dental grade				
Type of origin	***n***	**1**	**2**	**3**	**4**	**5**
New arrival	394	52.3%[a]	21.3%	15.2%	4.8%	6.3%
DS HB (NA)	96	76.0%[b]	9.4%[a]	8.3%	5.2%	1.0%[a]
Return guardian	58	46.6%	20.7%	15.5%	8.6%	8.6%
DS HB (RG)	11	27.3%	18.2%	36.4%[b]	18.2%	0.0%
From DAT	15	73.3%	20.0%	6.7%	0.0%	0.0%
Total	574	55.7%	19.2%	14.3%	5.4%	5.4%

Note: Significance of likelihood ratio test, $p = 0.001$.

DS HB (NA), Donkey Sanctuary holding base (New arrival); DS HB (RG), Donkey.

Sanctuary holding base (Return Guardian); DAT, Donkey Assisted Therapy centre.

[a]Observed proportion significantly lower than expected ($p < 0.050$).

[b]Observed proportion significantly higher than expected ($p < 0.050$).

TABLE 6 Dental grades at pre-admission medical (PAM) and admission medical (AM)

Dental grade	**Pre-admission (*n* = 132)**	**Admission (*n* = 574)**
1	66.7%	55.7%
2	12.1%	19.2%
3	14.4%	14.3%
4	4.5%	5.4%
5	2.3%	5.4%

have a poorer BCS at admission. Interestingly, dental disease was also correlated to donkeys identified as overweight, which may allude to inappropriate feeding practices. Additionally, dental disease often goes undiagnosed until the latter stages, and therefore donkeys presenting with excess body condition, especially coupled with a lack of oro-dental signs, risk following suit.

Dental grades appear to progressively worsen as they move away from optimal BCS. It would, therefore, be reasonable to assume that donkeys with a low BCS may have dental disease that negatively affects the ability to masticate the available diet, consequently causing a reduction in BCS, or a failure to maintain, or increase bodyweight (du Toit et al., 2009b). A more challenging finding to explain is that donkeys with high BCS also seem predisposed to moderate-to-severe levels of dental disease. Whilst it is likely that this is related to the diet provided, the data yielded from dietary assessment suggest that fewer geriatric donkeys, donkeys with pathological dental grades and/or those that are overweight, receive higher incidences of energy-dense feeds. In fact, the only difference in dietary provision indicates that more overweight donkeys and more donkeys with pathological dental grades are provided with restricted grazing, leaving the authors to assume that the volume of the remaining dietary feedstuffs is likely to be high, although this was unrecorded. If grass restriction comes from reduced time spent grazing, then perhaps these donkeys still managed to consume a high volume of grass, as indicated by Wood (2010) and Burden and Bell (2019).

Body condition score in donkeys with acceptable dental health scores generally tended to be greater than 2.5, but less than 4.5. Interestingly, these donkeys had the highest prevalence of short-chopped fibre, fibre compound feed and cereals, which may explain the increased BCS (Smith & Burden, 2013).

Donkeys with high BCS are not being managed effectively for weight loss irrespective of dental health. These results suggest that it is possible for donkeys with poor dental health to obtain a calorie intake in excess of their calorie expenditure, and therefore, higher BCS should not be an indicator of acceptable dental health. Thorough intraoral examinations should therefore be performed in all donkeys regardless of BCS (Barrio Fernandez et al., 2020; Smith & Burden, 2013).

Diet

Donkeys have evolved to browse and graze highly fibrous plants of poor nutritional quality (Pearson et al., 2001). Diets should therefore be fibre-based, and feedstuffs high in starches and sugars should be strictly avoided (Burden et al., 2013).

A diet based on fibrous forages with controlled access to grass (especially in places such as the UK where grass is abundant) is reportedly sufficient for most donkeys (Burden, 2012).

One of the challenges with donkeys living in the UK is to ensure that they are receiving enough bulk to satisfy their appetite, whilst not oversupplying energy, which will lead to considerable weight gain (Burden et al., 2013). Our results suggest that weight gain may be irrespective of dental health.

Statistically significant differences were found between origin region and straw diet. It was observed that many donkeys from the West Midlands had straw as part of their diet (67.3%), whilst there were fewer from Scotland (19.0%), Northern Ireland (0.0%)

TABLE 7 Agreement of dental grades at pre-admission and admission

	Pre-admission dental grade						
Admission dental grade	***None* (*n* = 181)**	**1 (*n* = 86)**	**2 (*n* = 15)**	**3 (*n* = 19)**	**4 (*n* = 5)**	**5 (*n* = 3)**	**Total (*n* = 309)**
1	*65.2%*	48.8%[a]	6.7%[b]	5.3%[b]	0.0%	0.0%	52.4%
2	*14.9%*	18.6%	26.7%	5.3%	0.0%	0.0%	15.5%
3	*10.5%*	19.8%	33.3%	42.1%[a]	0.0%	0.0%	15.9%
4	*3.9%*	7.0%[b]	13.3%	26.3%	100.0%[a]	0.0%	8.1%
5	*5.5%*	5.8%[b]	20.0%	21.1%	0.0%	100.0%[a]	8.1%

Note: Significance of likelihood ratio test, $p < 0.001$ (excluding animals without pre-admission medical [PAM] dental grade).
Cohen's Kappa coefficient = 0.270 ($p < 0.001$).
[a]Observed proportion significantly higher than expected ($p < 0.050$).
[b]Observed proportion significantly lower than expected ($p < 0.050$).

TABLE 8 Time since last dental examination (days) stratified by AM dental grade

AM dental grade	*n*	Mean	SD	Q1	Median	Q3	Min	Max
None	7	326.9	668.0	71	83	120	13	1840
1	87	409.4	389.1	124	315	525	8	2006
2	41	492.3	439.4	140.5	337	734	15	1811
3	25	636.6	750.7	152.5	365	741.5	8	2785
4	12	732.7	1510.8	213.5	276.5	505.25	13	5497
5	15	481.7	542.9	127	272	746	73	2108
Total	187	481.41	605.35	126	303	592	8	5497

Note: Significance of Kruskal–Wallis test, $p = 0.208$.

and the North-West (25.5%) with a straw component. This is an interesting finding, as straw should be always given as part of a donkey's healthy diet, unless there are concerns with regard to dental disease (Burden, 2012; Burden et al., 2013; Burden & Bell, 2019). Additionally, the aforementioned regions offering less dietary straw offered straw bedding in an average of 50% of cases. This may suggest that supplies of straw are available, but perhaps, there is a misconception regarding the feeding of such foodstuffs. Some donkeys were fed dietary fibre from more than one source, commonly both hay and straw. Hay may be considered comparatively more energy dense than straw, and although it appears to be more palatable than straw, it must be fed with caution where appropriate (Burden, 2012; Burden et al., 2013; Burden & Bell, 2019; Smith & Burden, 2013).

Impaction colic in horses with dental disease is correlated with long fibre presence in the large colon, caused by compromised ability for adequate mastication (Brosnahan & Paradis, 2003). Consequently, faecal fibre length is also an indicator of oro-dental health, pain and masticative function, despite perhaps more commonly in cases with significant dental disease (Hummel et al., 2008; Johnson et al., 2017; Ralston et al., 2001; Rodrigues, Ferreira, et al., 2013).

Dental disease and feeding management have been implicated as risk factors for impaction colic, hyperlipaemia and gastric ulceration in donkeys (Burden et al., 2008; Cox et al., 2007, 2009; du Toit, 2008), as well as in other equids (Cohen et al., 1999; Hillyer et al., 2002; Hudson et al., 2001; Tinker et al., 1997; White, 1997).

Strategies to successfully manage donkeys with dental disease where dental function allows include reducing the fibre length of available feedstuffs (Burden, 2012; Burden & Bell, 2019; Thiemann & Sullivan, 2019). Although other authors do not recommend the use of short fibre (du Toit & Dixon, 2022), in our experience, the use of such products in cases with sufficient dental function has directly contributed to a reduction in colic, hyperlipaemia and gastric ulceration cases, in addition to optimising quality of life in our resident herds (Burden et al., 2010; Burden, 2012; Burden & Bell, 2019; Thiemann & Sullivan, 2019).

Diet choice in the study group does not seem to be influenced by dental disease, and this finding would indicate that owners are not taking dental health into consideration when choosing a specific diet for their donkeys. This finding could also have an impact on donkey BCS, as diets with reduced fibre length in donkeys with good dentition can increase the risk of obesity, particularly if they include ingredients to increase palatability (Burden, 2012; Burden et al., 2013; Burden & Bell, 2019). Furthermore, it may be considered a profound negative impact on welfare in donkeys with poor dental health who are allocated long fibre diets, which may lead to life-limiting colic episodes and or hyperlipaemia (Burden et al., 2010, 2013; Cox et al., 2009; Thiemann & Sullivan, 2019).

Bedding

Similar to diet, it seems that owners are not taking dental health into account when making their choices for the provision of bedding materials. Dried cereal plant stalks such as straw is essentially edible bedding. In the authors' experiences, donkeys may not necessarily preferentially eat straw bedding in circumstances where other more palatable feedstuffs are available. However, donkeys have evolved to consume highly fibrous plants with reduced nutritional content, and so the drive to eat such bedding cannot be ignored. Additionally, whilst straw is an agricultural by-product of cereal production, inevitably a variable quantity of grain is typically present. The grain content encourages foraging and also the consumption of bedding material.

Consumption of straw bedding is not usually an issue in donkeys with acceptable dental health; in fact, feeding and bedding on straw are usually encouraged in healthy donkeys. The provision of straw bedding to donkeys with impaired dental function, however, may result in catastrophic systemic consequences such as impaction colic or hyperlipaemia (Burden et al., 2010; Cox et al., 2009).

Dental health and time since last dental

It is disappointing that 71% of donkeys had no indication of previous dental examination in their lifetime. The results show that there are no significant differences between the date of the previous dental examination and the dental grade on admission, suggesting that owners may not understand their donkeys' dental conditions, or the need for regular intervention. When we looked at origin and dental grade, however, those donkeys coming from a holding base who had received recent and regular dental treatment from a qualified professional had better dental health scores and, in particular, had less incidences of pathological dental health. This combined data suggest the following considerations: firstly, perhaps there is an issue with the quality of the treatment provided. Other than being 'vet or EDT', the specific service provider was not recorded, so it is unclear as to their training, qualifications and experience. There is also the possibility that donkeys requiring specialist interventions were not referred for such treatment, and hence improved dental health scores were not achieved. Furthermore, the date of previous dental examinations was provided by the owners; therefore, the reliability of the information may be uncertain. Additionally, equine dental specialists advocate for six to 12 monthly examinations and the study population had an overall average of 16 months (range of 8 days to 15 years); the lack of regular intervention reduces the opportunity to slow down or prevent more severe dental disease (The Equine Dental Clinic, 2021). Indeed, in-house dental audits demonstrated that it takes less than 5 years for donkeys with good dental health scores to drop into the pathological range (Lilly, 2013). And finally, it is difficult to reverse dental disease once it is established, and this is further confounded by inadequate treatment scheduling. Conversely, those donkeys with severe dental health conditions, such as multiple hypodontia and or senile excavation, are unlikely to improve dental health score even with regular and or specialist intervention.

Given the variability in scheduling, the authors conclude that owners do not consider the dental health status (of which they may not be aware), and or age of their donkeys, in the provision of regular dental examinations. It is common that clinical signs of dental disease in donkeys are under-reported (du Toit & Dixon, 2011; Rodrigues & Lilly, 2019).

Donkeys are a prey species and accordingly display different behaviour to horses. Often described as stoic and less inclined to demonstrate clinical signs of many disorders, such predator avoidance behaviour does not diminish the experiences of pain and suffering (Evans & Crane, 2018).

Indeed, Van Dierendonck et al., 2020 suggested that far more subtle signs of tightening of the eyelid(s) and nostril dilation are sensitive weighting factors for positive identification of head-related (including oro-dental) pain under the EQUUS-DONKEY-FAP tool (Van Dierendonck et al. (2020)).

The results suggest that typically older and geriatric donkeys should receive more frequent dental examinations owing to the greater prevalence of dental disease. Consequently, significant differences should have been seen in time since last dental examination and age. This finding leads us to believe that geriatric companion donkeys may not be being presented for treatment regularly enough. Indeed, it was observed that geriatric donkeys had a higher mean of 604.33 days since their last dental examination, versus 457.92 days since their last dental examination in younger donkeys. This is a very interesting finding and highlights the need for further awareness among owners, carers, UK veterinary practices and EDTs with regard to donkey dentistry.

Equid dentistry is considered prophylactic, and so regular opportunity for high-quality examination is necessary (Rodrigues, Dixon, et al., 2013; Rodrigues, Ferreira, et al., 2013; Rodrigues & Lilly, 2019), and this needs to be actively received by owners and professionals alike. Regular high-quality intervention could reduce the number of donkeys suffering from undiagnosed, severe and preventable dental disease.

In the study by Grint et al. (2015), it seems that owners and vets associate signs of dysmastication as clear signalment of oro-dental pain, which TDS reports to correlate poorly with dental disease in donkeys (du Toit et al., 2009a; Evans & Lilly, 2020). The same study suggested that just 58% of donkey owners have been on a training course for ownership, and 97% read about care/ownership in books (Grint et al., 2015). There is an opportunity, therefore, for identification of resources that donkey owners engage with, with a view to collaborating on sound alternatives.

Severe dental disease can be very difficult to treat, and even irreversible in the latter stages, reinforcing the importance of thorough intraoral examination and prophylactic treatment. Whilst severe dental disease is difficult to treat, steps should be made to address pain, disease and function; equilibration, diastema treatment, extractions and long-term pain relief are examples of good practice that would aid donkeys with marked dental disease.

For cases where dental disease is severe, and welfare is affected, the animal's quality of life must be evaluated, and euthanasia may be considered. These animals should preferably be highlighted at the owner's property before movement. The need for treatment or euthanasia should be discussed prior to arrival at TDS to avoid prolonged suffering and to manage owner expectations. The Donkey Sanctuary should aim to further educate vets and deliver global welfare advice with regard to donkeys with severe dental disease and concerns regarding their quality of life and welfare.

PAM versus AM grade

The agreement between PAM dental grades and admission dental grades was found to be weak (k = 0.270). This suggests dental disease is more likely to be underestimated, or not recognised at PAM. Whilst this is concerning, it would seem logical that this would be the case when the prevalence of dental disease in donkeys is high.

These results further support the requirement for all donkeys, and especially those over the age of 20 years, to have regular dental examination with a full mouth speculum, mirror and light source. Donkeys with dental disorders should be afforded more regular oral examinations than the timescales proposed for equids with what would be considered routine oro-dental health (Rodrigues & Lilly, 2019). Whilst the results indicate that professionals engaging in intraoral examinations require adequate training and proficiency for successful recognition of donkey dental health, it is also noted that under 30% of intakes had any kind of dental history. It is imperative, therefore, that owners and carers are educated in the need for primary healthcare management of their donkeys.

CONCLUSION

From the data collected, the authors have identified a variety of areas for improvement in terms of management systems for donkeys with reference to dental health. The basic principles of nutrition, bedding and the provision of dental care appear saturated with conflicting and misunderstood realities; not taking dental pain and function into account when providing feed or bedding, providing supplemental foods for donkeys with good BCS and dental health, and not providing regular and high-quality dental assessments for example.

Failing to take dental health into consideration when allocating diet or bedding types presents an unacceptable risk of colic/choke in donkeys fed long fibres with an inability to process them sufficiently. Conversely, it seems more common to offer supplemental feeds to donkeys with good dental health which may attribute to higher BCS scores.

The data show that recognition of oro-dental pathologies in donkeys by owners and professionals is deficient. Accordingly, it may be presumed by the high prevalence of disease that the treatment of dental pathologies in donkeys is also lacking both in terms of frequency of scheduling and quality.

It is clear that the issues surrounding donkey management, especially in terms of dental health, are multifactorial. Owners have an appetite for information, but without knowing the sources, it is possible that this fails to be evidence-based, and accordingly, owners continue to miscalculate the requirements of donkeys.

We cannot ignore the role that professionals play not only in the recognition and treatment of dental disease but also in communication of disorders, their wider impacts and the countermeasures that can be taken.

RECOMMENDATIONS

Grint et al. (2015) found that just over half of owners undertook dedicated training prior to acquiring donkeys, so it would be reasonable to offer high-quality, accessible and widely available programmes to owners using the most up-to-date and evidence-based materials. This will be well served by the online learning platform 'The Donkey Academy'.

Most donkey owners used textbooks to understand the requirements of their equids. Accordingly, it would be justifiable to produce evidence-based texts of best practice which are in turn regularly reviewed and updated.

Courses and literature should support regular professional interventions, from qualified and insured service providers. Those providing dental examination and treatment to donkeys need to be performing examinations earlier and more frequently throughout their life, and with greater proficiency. Donkeys with conditions outside of the remit and or skills of the professional should be referred on to those who are able to provide appropriate and relevant, humane care.

AUTHOR CONTRIBUTIONS

E. Barrio Fernández contributed to the study design, data collection, data analysis, interpretation, preparation and approval of the manuscript. I. de Blas Giral contributed to data collection, study analysis, interpretation and approval of the manuscript. G. Lilly contributed to the preparation and approval of the manuscript. J.B. Rodrigues contributed to the preparation and approval of the manuscript. F.J. Vázquez Bringas contributed to the study design, study interpretation and approval of the manuscript.

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CONFLICT OF INTEREST

No conflicts of interests have been declared.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

ETHICAL APPROVAL

This study was approved by The Donkey Sanctuary ethical committee. https://www.thedonkeysanctuary.org.uk/what-we-do/knowledge-and-advice/research/our-research-aims

INFORMED CONSENT

Donkeys were owned by The Donkey Sanctuary.

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REFERENCES

Agresti, A. (2002) *Categorical data analysis*, 2nd edition. Wiley: New York.

Barrio Fernandez, E.B., de Blas Giral, I., Thiemann, A. & Vázquez Bringas, F.J. (2020) Demography, preventative healthcare and reason for relinquishment of donkeys to an equine charity in the UK (2013-2015). *Equine Veterinary Journal*, 53(2), 324–330.

Brosnahan, M.M. & Paradis, M.R. (2003) Demographic and clinical characteristics of geriatric horses: 467 cases (1989-1999). *Journal of the American Veterinary Medical Association*, 223(1), 93–98.

Burden, F. (2012) Practical feeding and condition scoring for donkeys and mules. *Equine Veterinary Education*, 24, 589–596.

Burden, F. & Bell, N. (2019) Donkey nutrition and malnutrition. *The Veterinary Clinics of North America. Equine Practice*, 35(3), 469–479.

Burden, F., du Toit, N. & Thiemann, A. (2013) Nutrition and dental care of donkeys. *In Practice*, 35(7), 405–410.

Burden, F.A., Hazell-Smith, E. & Trawford, A.F. (2010) Nutritional risk factors for the development of hyperlipaemia in a population of donkeys. In: Ellis, A.D., Longland, A.C., Coenen, M. & Miraglia, N. (Eds.) *The impact of nutrition on the health and welfare of horses*. Netherlands: Wageningen Academic Publishers, 234.

Burden, F.A., Thiemann, A.K., Trawford, A.F. & Gallagher, J. (2008) Gastric ulcers in donkeys: prevalence and effect of diet. [poster]. 9th international equine colic research symposium, 15th-18th June, Liverpool.

Cohen, N.D., Gibbs, P.G. & Woods, A.M. (1999) Dietary and other management factors associated with colic in horses. *Journal of the American Veterinary Medical Association*, 215, 53–60.

Cox, R., Burden, F., Gosden, L., Proudman, C.J., Trawford, A.F. & Pinchbeck, G.L. (2009) Case control study to investigate risk factors for impaction colic in donkeys in the UK. *Preventive Veterinary Medicine*, 92, 179–187.

Cox, R., Burden, F., Proudman, C., Trawford, A. & Pinchbeck, G. (2010) Demographics, management and health of donkeys in the UK. *The Veterinary Record*, 166(18), 552–556.

Cox, R., Proudman, C.J., Trawford, A.F., Burden, F. & Pinchbeck, G.L. (2007) Epidemiology of impaction colic in donkeys in the UK. *BMC Veterinary Research*, 3, 1.

du Toit, N. (2008) An anatomical, pathological and clinical study of donkey teeth. [doctoral dissertation, University of Edinburgh].

du Toit, N., Burden, F. & Dixon, P. (2009a) Clinical dental examinations of 357 donkeys in the UK. Part 1: prevalence of dental disorders. *Equine Veterinary Journal*, 41(4), 390–394.

du Toit, N., Burden, F. & Dixon, P. (2009b) Clinical dental examinations of 357 donkeys in the UK. Part 2: epidemiological studies on the potential relationships between different dental disorders, and between dental disease and systemic disorders. *Equine Veterinary Journal*, 41(4), 395–400.

du Toit, N. & Dixon, P. (2011) Common dental disorders in the donkey. *Equine Veterinary Education*, 24(1), 45–51.

du Toit, N. & Dixon, P.M. (2022) Treatment strategies for equine periodontitis. In: Easley, J., Dixon, P. & du Toit, N. (Eds.) *Equine dentistry and maxillofacial surgery*. Newcastle upon Tyne: Cambridge Scholars Publishing, 494.

du Toit, N., Gallagher, J., Burden, F.A. & Dixon, P.M. (2008) Post mortem survey of dental disorders in 349 donkeys from an aged population (2005-2006). Part 2: epidemiological studies. *Equine Veterinary Journal*, 40(3), 209–213.

Evans, L. & Crane, M. (Eds.). (2018) Appendix 3: Body scoring. In: *The clinical companion of the donkey*, 1st edition. Leicestershire: Matador.

Evans, L. & Lilly, G. (Eds.). (2020) *Clinical history. Clinical companion of donkey dentistry*. Leicestershire: Matador.

Grint, N.J., Murrell, J.C. & Whay, H.R. (2015) Investigating the opinions of donkey owners and veterinary surgeons towards pain and analgesia in donkeys. *Equine Veterinary Education*, 27(7), 365–371.

Hillyer, M.H., Taylor, F.G. & French, N.P. (2001) A cross-sectional study of colic in horses on thoroughbred training premises in the British Isles in 1997. *Equine Veterinary Journal*, 33, 380–385.

Hillyer, M.H., Taylor, F.G.R., Proudman, C.J., Edwards, G.B., Smith, J.E. & French, N.P. (2002) Case control study to identify risk factors for simple colonic obstruction and distension colic in horses. *Equine Veterinary Journal*, 34, 455–463.

Hudson, J.M., Cohen, N.D., Gibbs, P.G. & Thompson, J.A. (2001) Feeding practices associated with colic in horses. *Journal of the American Veterinary Medical Association*, 219, 1419–1425.

Hummel, J., Fritz, J., Kienzle, E., Medici, E.P., Lang, S., Zimmermann, W. et al. (2008) Differences in fecal partical size between free-ranging and captive individuals of two browser species. *Zoo Biology*, 27(1), 70–77.

Johnson, C., Williams, J. & Phillips, C. (2017) Effect of routine dentistry on fecal fiber length in donkeys. *Journal of Equine Veterinary Science*, 57, 41–45.

Lilly, G. (2013) Donkey dental health audit of intakes between 01/01/10 and 31/01/13. Internal Donkey Sanctuary report. Unpublished.

Lilly, G. (2015) Donkeys, dentistry and welfare. Guest lecture, BEVA/BVDA joint vet and EDT seminar. Hadlow manor hotel, Kent; august 4, 2015.

McHugh, M.L. (2013) The chi-square test of independence. *Biochemical Medicine*, 23(2), 143–147.

Mellor, D.J., Reid, S.W.J., Love, S., Walker, R. & Gettinby, G. (2001) Sentinel practice-based survey of the management and health of horses in northern Britain. *The Veterinary Record*, 149, 417–423.

Norris, S.L., Little, H.A., Ryding, J. & Raw, Z. (2021) Global donkey and mule populations: figures and trends. *PLoS One*, 16(2), e0247830. Available from: https://doi.org/10.1371/journal.pone.0247830

Pearson, R.A., Archibald, R.F. & Muirhead, R.H. (2001) The effect of forage quality and level of feeding on digestibility and gastrointestinal transit time of oat straw and alfalfa given to ponies and donkeys. *The British Journal of Nutrition*, 85, 599–606.

Ralston, S.L., Foster, D.L., Divers, T. & Hintz, H.F. (2001) Effect of dental correction on feed digestibility in horses. *Equine Veterinary Journal*, 33(4), 390–393.

Rodrigues, J., Araújo, S., Sanroman-Llorens, F., Bastos, E., San Roman, F. & Viegas, C. (2013) A clinical survey evaluating the prevalence

of incisor disorders in Zamorano-Leonés and Mirandês donkeys (Equus asinus). *Journal of Equine Veterinary Science*, 33(9), 710–718.
Rodrigues, J., Dixon, P., Bastos, E., San Roman, F. & Viegas, C. (2013) A clinical survey on the prevalence and types of cheek teeth disorders present in 400 Zamorano-Leonés and 400 Mirandês donkeys (*Equus asinus*). *The Veterinary Record*, 173(23), 581–581.
Rodrigues, J., Ferreira, L., Bastos, E., San Roman, F., Viegas, C. & Santos, A. (2013) Influence of dental correction on nociceptive test responses, fecal appearance, body condition score, and apparent digestibility coefficient for dry matter of Zamorano-leonés donkeys (*Equus asinus*). *Journal of Animal Science*, 91(10), 4765–4771.
Rodrigues, J. & Lilly, G. (2019) Dental disorders of donkeys. *The Veterinary Clinics of North America. Equine Practice*, 35(3), 529–544.
Smith, D.G. & Burden, F. (2013) Practical donkey and mule nutrition. In: Geor, R.J., Coenen, M. & Harris, P. (Eds.) *Equine applied and clinical nutrition: practical donkey and mule nutrition*. Philadelphia: Saunders, pp. 304–316.
The Equine Dental Clinic. (2021) *Routine dentistry*. Available at URL: https://equinedentalclinic.co.uk/services/routine-dental-care/ Accessed: December 12th, 2021
Thiemann, A. & Sullivan, R. (2019) Gastrointestinal disorders of donkeys and mules. *The Veterinary Clinics of North America. Equine Practice*, 35(3), 419–432.
Tinker, M.K., White, N.A., Lessard, P., Thatcher, C.D., Pelzer, K.D., Davis, B. et al. (1997) Prospective study of equine colic incidence and mortality. *Equine Veterinary Journal*, 29, 448–453.
Van Dierendonck, M., Burden, F., Rickards, K. & van Loon, J. (2020) Monitoring acute pain in donkeys with the equine Utrecht University scale for donkeys composite pain assessment (EQUUS-DONKEY-COMPASS) and the equine Utrecht University scale for donkey facial assessment of pain (EQUUS-DONKEY-FAP). *Animals*, 10(2), 354.
White, J.L.N. (1997) Risk factors associated with colic. In: Robinson, N. (Ed.) *Current therapy in equine medicine*, 4th edition. Philadelphia: W.B. Saunders, pp. 174–179.
Wood, S.J. (2010) Some factors affecting the digestible energy requirements and dry matter intake of mature donkeys. PhD Thesis, Edinburgh University.

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Rice, M. & Henry, T. (2018) Standing intraoral extractions of cheek teeth aided by partial crown removal in 165 horses (2010–2016). *Equine Veterinary Journal*, 50, 48–53. Available from: https://doi.org/10.1111/evj.12727
Tremaine, W.H. (2004) Oral extraction of equine cheek teeth. *Equine Veterinary Education*, 16, 151–158. Available from: https://doi.org/10.1111/j.2042-3292.2004.tb00287
Tremaine, W.H. (2007) Local analgesic techniques for the equine head. *Equine Veterinary Education*, 19, 495–503.

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Equine Veterinary Education BEVA AAEP

ORIGINAL ARTICLE

Reducing chronic back pain and inflammation in horses using a commercial herbal liniment

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SUMMARY

Background: Back pain in horses, regardless of the underlying cause, is a common condition that can result in poor performance. The field veterinarian has limited noninvasive treatment options for reduction of back muscle soreness. This study was designed to evaluate effectiveness of a commercially available herbal, nonheating liniment (Sore No More Performance Ultra, Arenus), in reducing pain and inflammation in horses with mild back pain.

Objectives: Focus on a standardised area of the lumbar back region to evaluate effects of an herbal liniment over 44 days using pressure algometry to determine pain response and thermographic measurement of surface temperature to evaluate inflammation.

Study design: A randomised complete block design was used. Eighteen mature stock horses were evaluated for back pain and randomly assigned to treatment group (herbal liniment or control solution).

Methods: All horses maintained similar light work 5 days per week in a university equestrian programme for 44 days. Evaluation of the back was standardised by identifying the lumbar region, and pain and inflammation assessed weekly with force gauge pressure readings and thermal images.

Results: All horses displayed a decrease in pain scores over the first 3 weeks of the study, but the control group saw a rise in pain scores at Day 23. Pain scores on the left side of the back were significantly lower in the liniment group than the control group at Day 30.

Main limitations: Number of horses available for the study was limited. Daily exercise of the horses used represented typical use of mature lesson horses, however, was not standardised for the entirety of the 44-day trial.

Conclusions: Standardised evaluation procedures using pressure algometry and thermography found that Sore No More Performance Ultra herbal liniment had some effect on thermography (inflammation) and pain response of the back, with improvements shown at 23–30 days.

KEYWORDS
horse, back pain, herbal liniment, pressure algometry, thermography

Clinical relevance

- A commercially available herbal liniment gel (Sore No More Performance Ultra, Arenus) was found to reduce back muscle inflammation (assessed by thermal pattern) and pain response (evaluated by pressure algometry) when applied daily to horses participating in a university riding programme.
- Algometry and thermography were shown to be a reliable method of standardising evaluation of pain and inflammatory responses, respectively, in horses with back pain.
- Daily use of herbal liniments such as the one used in this study may provide a noninvasive treatment option for horses with back pain.

RACHEL YOUNGBLOOD, DVM
Brazos Valley Equine, Salado

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1 Data on file.

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

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

4 Kim DY, Taylor HW, Moore RM, Paulsen DB, Cho DY. Articular chondrocyte apoptosis in equine osteoarthritis. The Veterinary Journal 2003; 166: 52-57.

5 McIlwraith CW, Frisbie DD, Kawcak CE, van Weeren PR. Joint Disease in the Horse.St. Louis, MO: Elsevier, 2016; 33-48.

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Equine Veterinary Education

ORIGINAL ARTICLE

Sensitivity and specificity of 3 Tesla magnetic resonance imaging and multidetector computed tomographic tenography to identify artificially induced soft tissue lesions in the equine cadaveric digital flexor tendon sheath

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SUMMARY

Background: A common cause of lameness in horses is tenovaginitis of the digital flexor tendon sheath (DFTS). Ultrasound and contrast tenography have become frequently used diagnostic tools for abnormalities in the DFTS but are considered insufficiently accurate in describing specific lesions.

Objectives: To determine sensitivity and specificity of computed tomographic tenography (CTT) and 3 Tesla magnetic resonance imaging (MRI) to detect artificial lesions within the DFTS.

Study design: Blinded laboratory study.

Methods: Using an arthroscopic hook knife, lesions (10–20 mm long, 3–5 mm deep) ($n = 52$) were created tenoscopically in the superficial digital flexor tendon (SDFT), deep digital flexor tendon (DDFT), manica flexoria (MF) and proximal scutum in 19 distal limb specimens. MRI and CTT were performed and images reviewed. Sensitivity and specificity were calculated for each modality and compared.

Results: Computed tomographic tenography and magnetic resonance imaging identification of SDFT and MF lesions showed similar sensitivity (75% vs. 85%, respectively; $p = 1$) and specificity for MF lesions (96% for both). SDFT lesions specificity was similar for CTT versus MRI (85% vs. 77%, respectively; $p = 0.88$). For DDFT lesions, MRI sensitivity (62%) was higher compared to CTT (38%), although not statistically significant ($p = 0.58$). MRI specificity (92%) was lower than CTT (96%, $p = 1$). Lesions in the proximal scutum were more frequently identified by MRI compared to CTT (sensitivity: 93% vs. 57%, $p = 0.17$; specificity: 96% vs. 100%, $p = 1$).

Main limitations: Artificial, small lesions were assessed. Incomplete arthroscopic portal seal resulted in pressure loss and contrast leakage.

Conclusions: Sensitivity and specificity of both modalities are good to excellent for the diagnosis of most artificially created lesions. CTT performed similar to MRI in detecting SDFT and MF lesions. MRI showed higher sensitivity for the diagnosis of DDFT and proximal scutum lesions. The results indicate a future application of CTT for diagnosis of DFTS pathologies, whenever suspecting MF tears.

KEYWORDS
horse, computed tomographic tenography, digital flexor tendon sheath, MRI

Clinical relevance

- Standing CT tenography performed similarly to high field MRI in detecting soft tissue lesions within the digital flexor tendon sheath, however, it negates the need for general anaesthesia.
- Horses with suspected manica flexoria tears or longitudinal SDFT tendon tears, where diagnosis using conventional imaging is difficult, would be suitable candidates to undergo CT tenography in the diagnostic work-up.
- Standing CT tenography will facilitate preoperative planning in cases where a manica flexoria resection is needed and may potentially decrease the need of tenovaginoscopy as a purely diagnostic procedure.

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Equine Veterinary Education BEVA AAEP

REVIEW ARTICLE

Complications of equine cheek teeth extractions

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Summary

Due to the length of the reserve crown and roots of equine cheek teeth, especially in young horses, their extraction (exodontia) can be a challenging procedure with the potential for many types of post-extraction complications to develop. The prevalence of post-extraction complications is greatly influenced by the exodontia technique used, with unacceptably high levels of complications with the traditional repulsion technique and conversely, low levels of complications with oral extraction performed by skilled operators. Recent objective studies on post-exodontia problems in horses have also highlighted some risk factors for the development of post-extraction problems including exodontia of rostral mandibular teeth in young horses, and exodontia of teeth with apical infections. The recent recognition that some nonhealing post-extraction equine alveoli suffer from a disorder very similar to dry socket in humans, may help clinicians to recognise, treat and possibly help prevent this disorder.

INTRODUCTION

Historical aspects of equine cheek teeth exodontia techniques and extraction complications

The type and prevalence of equine post-dental extraction problems are closely related to the dental extraction (exodontia) technique used as reviewed by Dixon et al. (2009), Earley et al. (2013), Caramello et al. (2020), Kennedy et al. (2020), Henry et al. (2022) and Reardon (2022). Oral extraction in conscious, cast horses restrained by ropes, or under chloroform anaesthesia, or occasionally in standing horses restrained by twitches and leg ropes were widely practiced in the 1800s and early 1900s (Easley, 2022), with obvious welfare problems in nonanaesthetised horses. Nevertheless, many excellent equine oral extraction instruments and oral speculums were developed at those times. In the mid-1900s, for reasons unknown to the author, the practice of cheek teeth repulsion under chloroform and later, halothane general anaesthesia largely replaced oral extraction and became the standard equine cheek teeth exodontia technique (Figure 1). The repulsion technique, with its very high reported complication rate of up to 67% (Dixon et al., 2000) or 80% (Caramello et al., 2020) remained the standard cheek tooth exodontia technique until the 1990s.

The use of the (standard) lateral buccotomy cheek teeth exodontia technique in the late 1900s caused a reduced prevalence but a different range of post-operative complications (O'Neill et al., 2011), as well as always requiring general anaesthesia with its attendant costs and risks. The advent of effective and safe equine sedation drugs facilitated the (re)introduction of standing oral extraction in the 1990s (Tremaine, 2004; Dixon et al., 2005) using similar oral speculums and extraction instruments developed over 100 years previously. The later introduction of effective regional local anaesthetic techniques (Tremaine, 2007) further enhanced oral extraction techniques, which remains the current equine exodontia technique of choice.

However, oral exodontia requires the presence of a sufficiently strong clinical crown on the affected tooth. The development of less invasive exodontia techniques for teeth with incomplete clinical crowns, including minimally invasive (Steinmann pin) repulsion, minimally invasive transbuccal technique (MITT) [also termed minimally invasive transbuccal extraction (MTE)] and intraoral dental sectioning have reduced the prevalence of post-extraction problems of teeth with an incomplete clinical crown as compared to the standard repulsion technique (Caramello et al., 2020; Kennedy et al., 2020; Langeneckert et al., 2015). Regardless of the exodontia technique that is used, post-extraction problems can still occur even following careful extractions by skilled veterinarians (Rice & Henry, 2018;

Gergeleit & Bienert-Zeit, 2020; Kennedy et al., 2020) and the costs of treating some post-extraction complications can exceed the initial costs of exodontia.

Post-extraction alveolar management

Apical infection (Figure 2) is the most common indication for cheek teeth exodontia, being the reason for 62% of 428 extractions in a recent study (Kennedy et al., 2020). Exodontia of apically infected teeth causes a bacteraemia with potential pathogens, including anaerobes (Kern et al., 2017). Many clinicians administer preoperative antibiotics (e.g. penicillin and an aminoglycoside) to help prevent the rare spread of bacteria from infected teeth to distant sites, which can cause infections such as meningitis (Arndt et al., 2021; Bach et al., 2014). When infection of the supporting bones is present, longer-term post-extraction antibiotic therapy is justified. There is less consensus on the use of post-extraction antibiotic therapy in routine exodontia cases.

Following exodontia, the alveolus should be digitally and visually examined (using a dental mirror or oral endoscope), as should the apical aspect of the extracted tooth to ensure that no dental fragments remain in the alveolus. If any doubt remains, and always following repulsion techniques or where the apex of the tooth is not intact, post-extraction radiography should be performed to ensure that no intra-alveolar dental (or alveolar bone fragments) remain. Any such identified fragments should be immediately removed digitally or using long, right-angled equine dental picks with adjustable heads or long-nosed, slim fragment forceps under visual guidance, and with use of suction of intra-alveolar blood to allow visualisation of mandibular alveoli. If suitable instruments are unavailable, high-pressure lavage of the alveolus using an equine dental syringe may remove unattached bone or dental fragments. Formation of a new blood clot should now be encouraged, if necessary, by alveolar curettage.

Optimal post-extraction healing will occur in an alveolus that did not have significant pre-existing alveolar bone infection, which has not sustained excessive exodontia-related alveolar bone damage, does not contain dental or bone fragments and which contains a large post-extraction blood clot. The alveolar blood clot should be protected from masticatory forces and food impaction by placing packing material (e.g. polysiloxane, acrylic or surgical swabs [gauze] impregnated with antibiotics, honey or dilute antiseptics) in the more occlusal (e.g. one third) aspect of the alveolus. Excessively deep alveolar packing will mechanically reduce or even prevent alveolar healing. Some clinicians have used antibiotic-impregnated surgical swabs in the more occlusal half of the alveolus to help treat existing and help control post-operative alveolar bone infection and these swabs are invariably retained at re-examination 1–2 weeks later (Kennedy et al., 2020). The risk of bacterial antibiotic resistance development must be considered with such local antibiotic therapy. The use of surgical swabs soaked in concentrated antiseptic solutions such as povidone iodine may risk causing chemical irritation and delayed alveolar healing.

Post-extraction, the alveolus should be actively managed until healing is complete or near complete

No large objective studies have determined which post-extraction alveolar management is optimal. However, anecdotal evidence indicates that just placing packing material in the alveolus following exodontia and allowing this material to spontaneously dislodge later, is unsatisfactory. This is especially true following exodontia of apically infected Triadan 06–08 mandibular cheek teeth in younger horses (Gergeleit & Bienert-Zeit, 2020; Kennedy et al., 2020). Instead, the post-extraction alveolus should be actively managed until healing is complete or near complete. The alveolar packing inserted immediately post-extraction should be removed about 7–10 days later, and the alveolus digitally examined to assess if it is lined by smooth (developing granulation) tissue over all its surfaces. Rough areas of exposed bone such as caused by alveolar sequestration or *dry socket* are readily

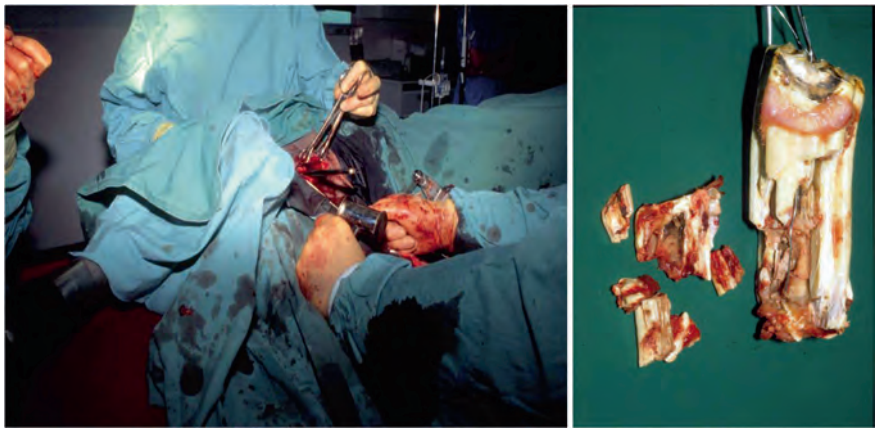

FIGURE 1 The left image shows a maxillary cheek tooth being repelled under general anaesthesia. The right image shows typical damage to a repulsed tooth, with its apical area extensively fractured that predisposes to retention of dental fragments.

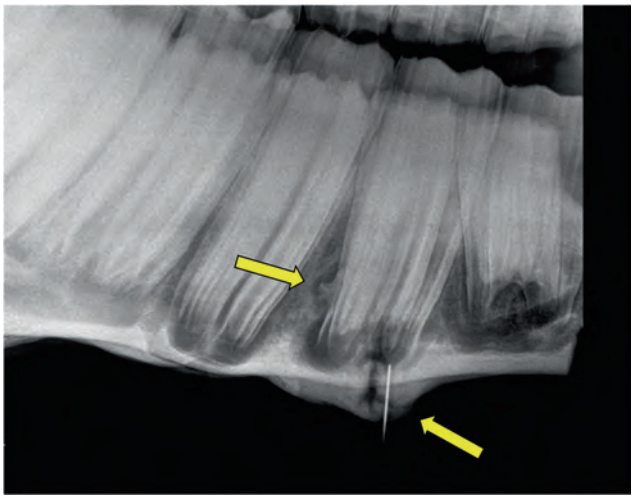

FIGURE 2 Radiograph of an apically infected mandibular Triadan 08 in a young horse where a thin metallic probe has been inserted into a ventral draining tract. Note the extensive bone changes at the caudal and apical aspects of the alveolus (arrows). Exodontia of this tooth has an increased risk of post-extraction problems as this is a rostral mandibular cheek tooth, is apically infected and this is a young horse.

palpated and if these bony areas are loose (i.e. are sequestrae rather than dry socket), they should be removed digitally or using picks, with some sequestrae taking 3–4 weeks to become loose.

If the alveolus appears to be healing normally at this first re-examination, it should be gently lavaged, without dislodging the blood clot. The occlusal aspect of the alveolus should be repacked (using less packing material on this occasion) and the alveolus re-examined 1–2 weeks later to further assess alveolar healing and, in particular, for evidence of delayed sequestration. As noted, the most rigorous management is needed following extraction of younger mandibular teeth with apical infection and such cases should have repeated alveolar examinations until healing is very advanced.

POST-EXTRACTION DISORDERS

Damage to adjacent teeth

Due to the normal angulations and curvatures of the cheek teeth reserve crowns in the rostro-caudal plane, and/or due to improper repulsion punch placement, the punch may damage adjacent teeth (Dixon et al., 2000), unless its position and angulation in the *rostro-caudal plane* is carefully monitored by intraoperative radiography during repulsion. Damage to adjacent teeth can less commonly occur due to wrong positioning of cheek teeth separators; when sectioning of teeth with damaged clinical crowns or during dental luxation using an elevator and mallet during MITT. Damage to a tooth that does not involve the pulp (endodontic system) or its apical blood supply will usually not cause any clinical problem. Exposure of dental pulp may become sealed off with tertiary dentine, but if this does not occur, then pulpar and later apical infection will develop. If the apical blood supply of adjacent teeth is iatrogenically damaged, this will cause death of the tooth that may not be evident for many months or years, with possible development of an apical infection or fracture of the devitalised tooth.

TRAUMATIC ALVEOLAR DAMAGE

Movement of the punch in a *medial or lateral plane* during repulsion may markedly damage the alveolus and supporting bones. When repulsing a mandibular cheek tooth, the punch may penetrate or even fracture the mandible, lingually or buccally to the tooth. When repulsing a mandibular cheek tooth, once a tract has been made to the apex of the affected tooth (along its eruption path), a pointed Steinmann pin should be replaced with a similar sized blunt pin. Placement of the blunt pin under repeated radiographic guidance and possibly palpating the dental apex with the pin can help place it on the affected tooth apex to allow its repulsion. Similarly, when repulsing a maxillary cheek tooth, the punch may penetrate or fracture the hard palate or the buccal aspect of the adjacent maxillary bone. Such damage can predispose to sequestration, osteomyelitis and/or local soft tissue infection. Alveolar damage can also occur during dental pick extraction of fractured teeth.

Due to the angulation of the caudal cheek teeth reserve crowns and the presence of the facial crest, it is not possible to perform the MITT extraction on all cheek teeth positions. Additionally, when teeth are being elevated (loosened) with a transbuccal elevator and mallet, the elevator will always cause local alveolar bone damage. Additionally, the angle of introduction of the elevator into the alveolar spaces is not always optimal and can cause local alveolar bone damage due to the restriction of having to use a single cannula site. Further details on this and other exodontia technique are given by Henry et al. (2022).

Partial crown removal (partial coronectomy) facilitates mesio-distal (rostro-caudal) dental crown movement when using cheek teeth separators (Rice & Henry, 2018). Intraoral sectioning of teeth is useful when extracting teeth with dilacerated (diverging) roots or apical hypercementosis – both of which will cause difficult or even prevent extraction. It is also useful when extracting teeth with damaged clinical crowns. The use of long dental burrs for the above procedures carries a risk of causing direct traumatic or thermal (if using nonwater-cooled equipment) alveolar bone damage that can cause delayed sequestration and infection of the injured bone.

RETENTION OF DENTAL FRAGMENTS

Standard repulsion of apically infected teeth tends to drive the punch into the diseased (less mineralised) apex and adjacent reserve crown and can cause peripheral fragments of the reserve crown to fracture off and remain attached to the alveolar wall (Figure 1). These fragments need to be identified (including by routine post-extraction clinical and radiographic examinations following repulsion) and

then removed, else they will likely result in a nonhealing alveolus. Dental fragments, except for long mandibular roots in mature horses (Figure 3) are less commonly retained following other exodontia techniques.

DAMAGE TO FACIAL NERVES, VASCULATURE AND PAROTID DUCT

The standard lateral buccotomy extraction technique has largely been discontinued due to its invasive nature, necessitating long incisions in the cheeks and/or supporting bones with risk of damaging buccal nerve branches, facial vasculature or the parotid salivary duct and always requiring general anaesthesia. There is a low risk of such damage with a carefully performed MITT.

INFRAORBITAL NERVE DAMAGE

Damage to the infraorbital canal and its nerve can occur during maxillary cheek tooth repulsion, especially in young horses where the infraorbital canal sits immediately medio-dorsal, or dorsal to the apical aspect of the alveolus. In many young horses, it is difficult to understand how such nerve damage is avoided during a standard repulsion. If the infraorbital nerve is damaged by repulsion techniques, clinical signs may occur within hours in a proportion of horses and can include violent headshaking, distress and rubbing (even excoriating) the ipsilateral nostril off adjacent structures. Such cases usually do not respond to corticosteroid, nonsteroidal anti-inflammatory, or opiate therapy, but may respond in the short-term to acetylpromazine therapy. Thankfully, most of such cases show spontaneous resolution of clinical signs within 1–2 weeks of nerve injury. However, some cases of trigeminal damage can cause longer term headshaking (Ogden et al., 2023). Infraorbital nerve damage is much less likely following Steinmann pin repulsion, but long-term signs of clinical trigeminal neuropathy can very rarely occur following use of this technique.

SURGICAL SITE INFECTION

Due to their inevitable contamination with dental pathogens, infection of trephine repulsion sites is common (Caramello et al., 2020) but usually self-limiting. Prolonged nonhealing of cutaneous repulsion tracts should prompt an examination for the presence of intra-alveolar dental or bone fragments, or of saliva or food from oral leakage. Local infection and delayed healing can occur at standard buccotomy wounds (O'Neill et al., 2011) but rarely at MITT sites.

SEQUESTRATION OF ALVEOLAR WALL

The most common complication following oral extraction is sequestration of segments of alveolar bone with or without concurrent alveolar infection. Kennedy et al. (2020) found alveolar sequestration to be the most common post-extraction problem and was identified in 38/428 cheek teeth extractions (including with 343 oral extractions). Clinical signs of alveolar disease were present in 17 of these cases (4% of 428 cases) but in 15 cases (3.5%) the (usually smaller) sequestrate that were detected on routine post-extraction alveolar examinations did not cause a detectable clinical problem (Kennedy et al., 2020). Giegert and Bienert (2021) found a 6.6% (20/302 cases) prevalence of clinical post-extraction complication with *mandibular* cheek teeth oral extractions, with 18 of 20 complications being alveolar sequestration and infection, including sequestration of the complete alveolar wall.

Due to the great length (up to 9 cm long) of equine cheek teeth reserve crowns, high and prolonged mechanical forces are required

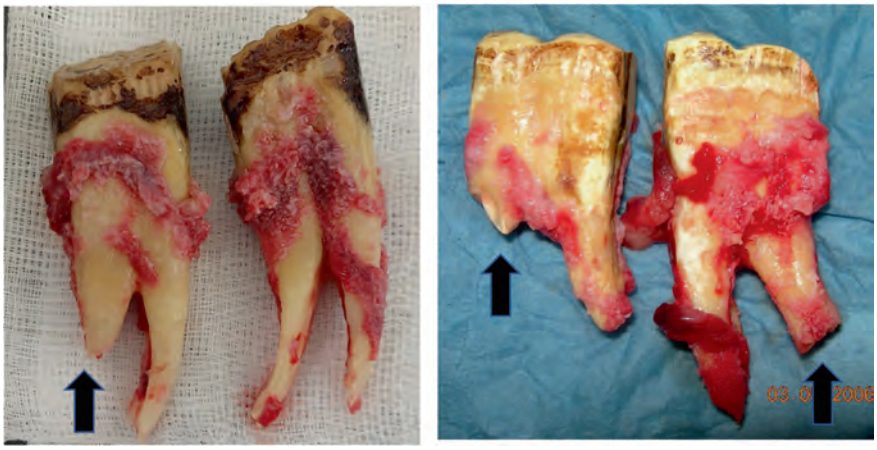

FIGURE 3 These extracted Triadan 10 mandibular cheek teeth are from two mature horses that had bilateral Triadan 10 developmental displacements and long-term periodontal disease. Exodontia of these teeth with long curved tapering roots resulted in fracture of one caudal (distal) root in the teeth as shown in the left image and of one rostral (mesial) and one caudal (distal) root as in the teeth shown in the right image.

to break down their periodontal membranes. High forces are also required to deform the layer of dense bone (i.e. bundle bone or cribriform plate – radiologically termed the *lamina dura [denta]*) that lines the alveolus and compress it into the underlying spongy bone to enlarge the periodontal space and so allow dental movement and later extraction (Figure 4). This necessary alveolar bone deformation can cause it to fracture deeply and/or may disrupt its local blood supply. The partial coronectomy technique (Rice & Henry, 2018) may less traumatically create additional intra-alveolar space to facilitate extraction.

Fragments of fractured alveolar bone may be detected immediately following exodontia if the fractured bone segment is displaced by exodontia forces. More commonly, alveolar fragments are recognised a week or more later (Figure 5), especially if caused by extraction-induced loss of blood supply to a local area of fractured alveolar bone. The presence of alveolar sequestrae prevents alveolar healing and can act as a nidus of infection, often leading to alveolar infection and even to osteomyelitis of the supporting bones (Figure 6). Such infected alveoli are usually malodorous and on digital palpation have areas of exposed bone and/or contain loose sequestrae. Alveolar sequestration occurs more commonly in mandibular as compared to maxillary cheek teeth, as is also the case in human dentistry (Chiapasco et al., 1993), possibly related to differences in the thickness and rigidity of the mandibular bones and their blood supply. The effects of gravity in retaining alveolar bone sequestrae and infected exudate in mandibular as compared to maxillary alveoli may also be significant.

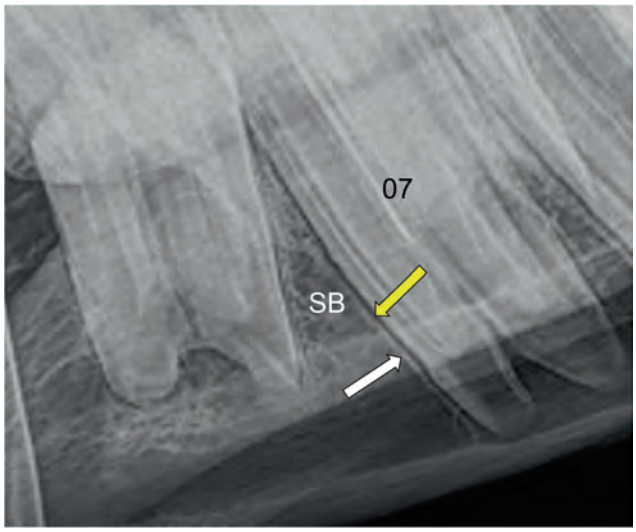

FIGURE 4 This radiograph of normal rostral mandibular cheek teeth in a young horse has the periodontal space rostral to the Triadan 07 indicated by a yellow arrow. The adjacent lamina dura (bundle bone or cribriform plate) (white arrow) overlies the larger expanse of spongy bone (SB).

ALVEOLAR BONE INFECTION AND OSTEOMYELITIS OF THE SUPPORTING BONES

The most common indication for equine cheek teeth exodontia is infection of the tooth apex that is usually caused by mixed anaerobic bacterial infections (with concurrent infection of some or all pulp horns, the adjacent periodontal membranes and alveolar bone). Extraction-related damage to the alveolar bone may facilitate more extensive bone infection by these pathogens to develop. Consequently, post-extraction complications are higher following extractions of apically infected as compared to fractured teeth without clinical apical infection (Kennedy et al., 2020) and especially in horses with pars pituitary intermedia dysfunction. Concurrent alveolar sequestration is common with alveolar and supporting bone infections and it may not be possible to determine which of these complications came first (Figure 6).

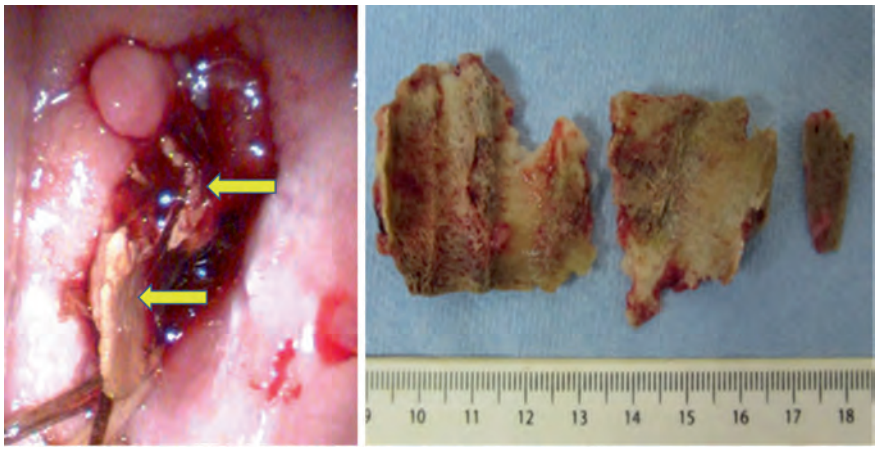

FIGURE 5 The left image shows a nonhealing, post-extraction alveolus with thin alveolar sequestrae (arrows) visible in its lumen. A small granuloma-type lesion is present on the top left of this image. The right image shows some of the sequestrae that were removed from this alveolus.

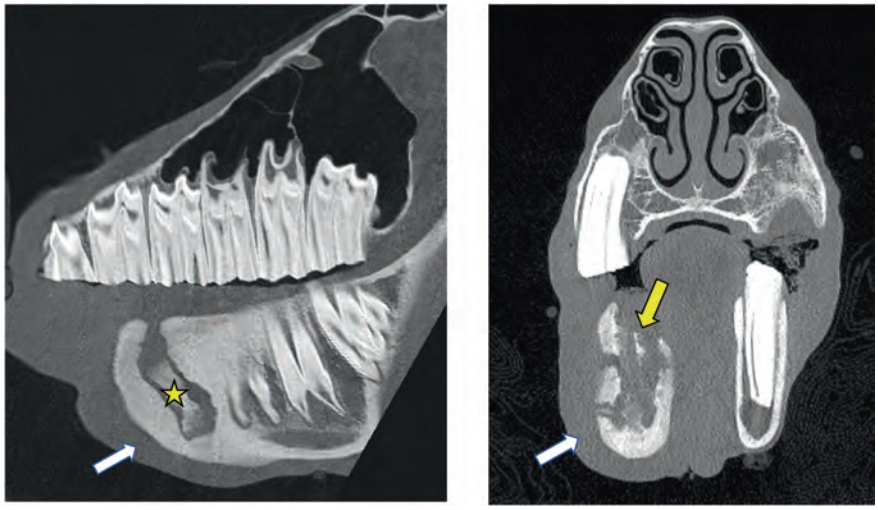

FIGURE 6 Left: This parasagittal CT image is of a horse with alveolar osteomyelitis and sequestration following exodontia of 408. Note the gross soft tissue swelling overlying the affected alveolus (white arrow), alveolar thickening and remodelling and a large sequestrum of its lateral wall (star). Right: This transverse CT image of the same case in a slightly different plane also shows the overlying soft tissue swelling (white arrow), gross alveolar wall remodelling and an intra-alveolar sequestrum (yellow arrow). The alveolus of (maxillary) Triadan 208 which underwent exodontia the previous year is fully healed.

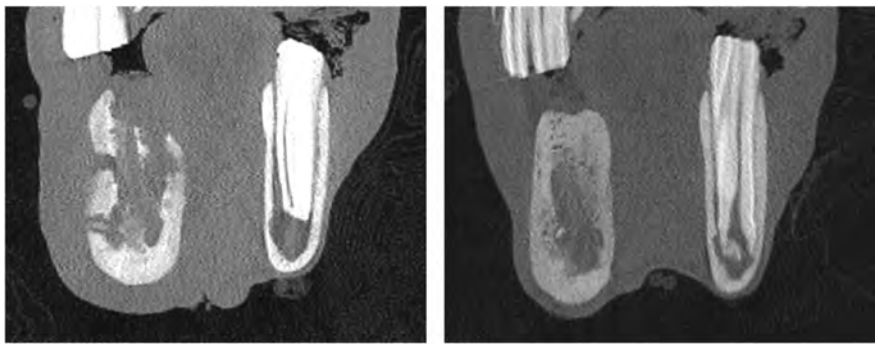

FIGURE 7 The left image shows the mandible in Figure 6 with post-exodontia osteomyelitis, sequestration, overlying soft tissue swelling and widespread alveolar bone changes. The right CT image of this same site was obtained 8 months later, when the infection had resolved. It shows a shortened mandible with reformation of its walls and the 408 alveolar lumen filled with osteoid material.

If the supporting mandibular or maxillary bones are swollen and painful on palpation, the alveolus is obviously infected and will usually contain malodorous exudate. Systemic and possibly local antibiotic therapy should be administered to such cases along with removal of sequestrae and alveolar lavage followed by packing. Repeat examinations, even weeks later may show development of new sequestrae that also must be removed. Because many of the bacteria involved in dental infections are partial or full anaerobes and possibly 50% cannot be conventionally cultured, broad-spectrum antimicrobial treatment that is effective for anaerobic infections should be administered to such cases. Further examinations including imaging to assess the degree of bone infection and detect new sequestrae should also be performed until the alveolus has complete granulation tissue cover that indicates alveolar healing (Figure 7).

ORO-MAXILLARY, ORO-NASAL AND ORO-CUTANEOUS FISTULAE FORMATION

The presence of a food-containing nasal discharge following exodontia is indicative of an oro-nasal (Figure 8) or oro-maxillary (Figure 9) communication and likewise the presence of food or saliva at a repulsion site indicates the presence of an oro-cutaneous communication. Rarely, an apically infected tooth will develop necrosis of the apical aspect of its alveolus and following routine oral extraction, an oro-sinus/nasal communication will immediately be obvious in such cases. By necessity, repulsion always damages the apical aspect of the alveolus and if the alveolar packing is lost before the damaged alveolar apex has healed, this causes oro-maxillary, oro-nasal or oro-cutaneous tracts that eventually may epithelialise and become fistulae. This is in total contrast to nonrepulsion techniques that preserve

the integrity of the alveolar apex. Damage to the alveolar apex is especially marked when a traditional (large) dental punch is used, and one study showed an 11% prevalence of oro-maxillary or oro-nasal fistulation following repulsion (Caramello et al., 2020). In contrast, the careful use of a fine punch (e.g. a 5-mm diameter Steinmann pin) seldom causes fistulae, especially if it is inserted through a pre-existing apical draining tract.

When loosening maxillary cheek teeth using the MITT technique, care must be taken that the dental elevator is not punched too far in an apical direction, or at a later stage of MITT, that the drill bit does not penetrate the apex of the alveolus into the overlying sinus or nasal cavity. Greatly varying prevalences of oro-maxillary fistulae have been reported following MITT from 29% (Caramello et al., 2020), 26% (Reichert et al., 2014) to 2% (Langeneckert et al., 2015).

For treatment of these communications or fistulae, the tracts need to be lavaged of food and debrided of any epithelial lining. A more robust barrier, for example, an acrylic alveolar prosthesis, can be placed between adjacent teeth to prevent further alveolar food ingress into the alveolus until it heals (Dixon, 2020).

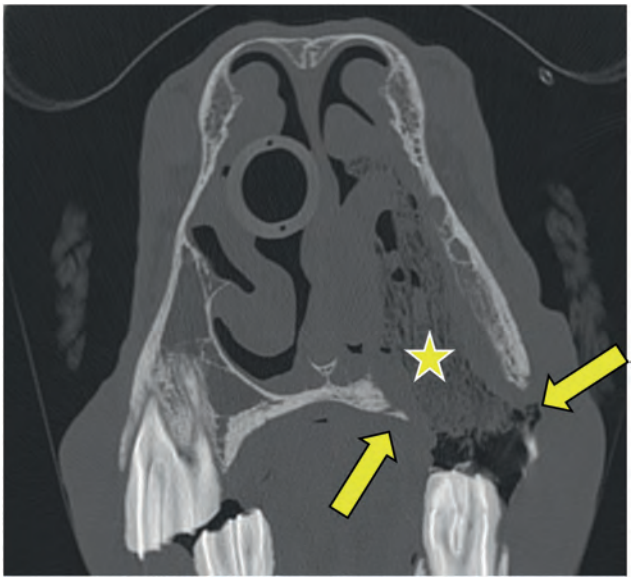

FIGURE 8 This transverse CT image taken following exodontia of 206 shows a large oro-nasal fistula filled with food (arrows). There also is almost total loss of the surrounding alveolus and of some of its supporting bone that will make repair of this fistula very problematic (figure courtesy of Dr Eric Parente).

NONHEALING ALVEOLUS WITH EXPOSED ALVEOLAR BONE ('DRY SOCKET')

The presence in a nonhealing alveolus of exposed, often tan-coloured, alveolar bone that *remains firmly attached* to the remaining alveolar bone and which remains vital beneath the usually discoloured exposed layer, is termed *dry socket* (Figure 10). Dry socket is the most common (and a very painful) post-exodontia problem in humans where it is usually caused by absence of an adequate intra-alveolar blood clot that should protect the exposed alveolar bone. Dry socket has only recently been recognised in horses (Horbal et al., 2019; Kennedy et al., 2020), but possibly all nonhealing alveoli without obvious infection or sequestrae could be considered to be affected by this disorder. Such alveoli, that are often painful, need repeated monitoring and packing to cover the exposed alveolar bone. It may take many weeks for the superficial alveolar bone layer to be shed or resorbed and the underlying healthy bone to then become covered in granulation tissue to allow alveolar healing.

CONTINUATION OF UNILATERAL NASAL DISCHARGE

The failure of dental sinusitis cases to resolve following exodontia may be related to one of the above described alveolar disorders but is much more likely to be caused by a residual sino-nasal problem

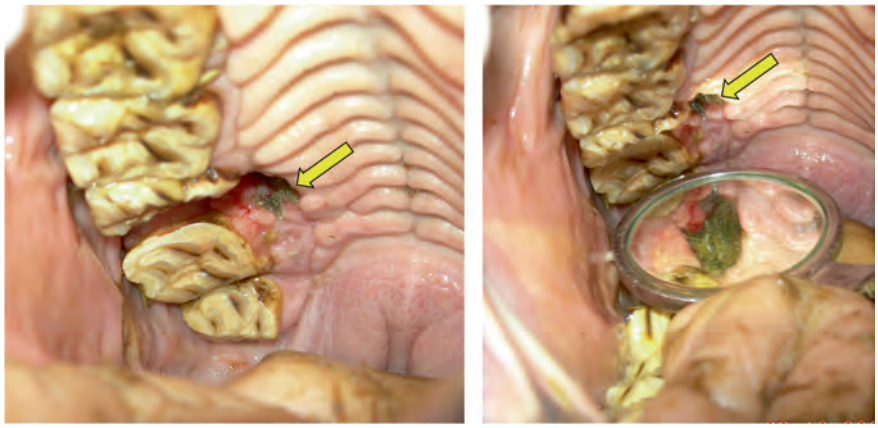

FIGURE 9 These intraoral images show a large oro-maxillary (oro-sinus) fistula at the site of a repulsed 109 (arrows). The dental mirror in the right image shows the fistula to be filled with forage. This neglected fistula is expanding in a palatal direction and will be increasingly difficult to treat.

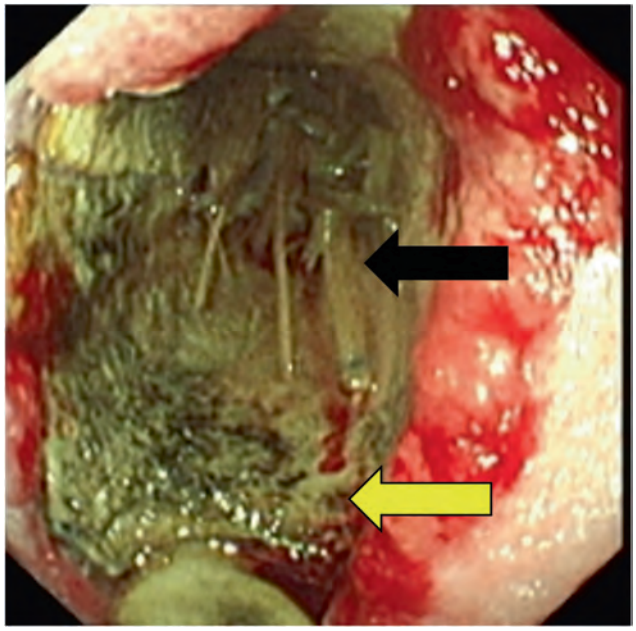

FIGURE 10 This oral endoscopic image shows a nonhealing alveolus that contains no blood clot, has exposed, discoloured porous-appearing bone over much of its surface (yellow arrow) and some forage fibres visible (black arrow). Healthy granulation tissue is only present at the occlusal aspect of the alveolus. Such alveoli need assessment to determine if the exposed bone is loose (i.e. is an alveolar sequestrum) or whether it is affected by 'dry socket' as was the case for this alveolus.

(Dixon et al., 2021). Such cases should have the affected alveolus examined and, if it contains sequestrae and/or is infected, or if it has a communication with the sinus, these disorders should be treated. However, the more likely causes for nonresponse of dental sinusitis are the presence of inspissated exudate or bone sequestrae in the affected sinuses or intercurrent nasal disease including nasal conchal bulla infections (Dixon et al., 2020, 2021).

CONFLICT OF INTEREST

No conflicts of interest have been declared.

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REFERENCES

Arndt, S., Kilcoyne, I., Heney, C.M., Wong, T.S. & Magdesian, K.G. (2021) Bacterial meningitis after dental extraction in a 17-year-old horse. *The Canadian Veterinary Journal*, 62, 403.

Bach, F.S., Bodo, G., Kuemmerle, J.M., Bienert-Zeit, A., Hainisch, E.K. & Simhofer, H. (2014) Bacterial meningitis after sinus surgery in five adult horses. *Veterinary Surgery*, 43, 697–703.

Caramello, V., Zarucco, L., Foster, D., Boston, R., Stefanovski, D. & Orsini, J. (2020) Equine cheek tooth extraction: Comparison of outcomes for five extraction methods. *Equine Veterinary Journal*, 52, 181–186. Available from: https://doi.org/10.1111/evj.13150

Chiapasco, M., De Cicco, L. & Marrone, G. (1993) Side effects and complications associated with third molar surgery. *Oral Surgery, Oral Medicine, and Oral Pathology*, 76, 412–420.

Dixon, P., Dacre, I., Dacre, K., Tremaine, W., McCann, J. & Barakzai, S. (2005) Standing oral extraction of cheek teeth in 100 horses (1998-2003). *Equine Veterinary Journal*, 37, 105–112. Available from: https://doi.org/10.2746/0425164054223822

Dixon, P.M. (2020) Treatment of equine oro-nasal and oro-maxillary fistulae. *Equine Veterinary Education*, 32, 471–478.

Dixon, P.M., Barnett, T.P., Morgan, R.E. & Reardon, R.J. (2020) Computed tomographic assessment of individual paransal sinus compartment and nasal conchal bulla involvement in 300 cases of equine sinonasal disease. *Frontiers in Veterinary Science*, 7, 580356.

Dixon, P.M., Hawkes, C. & Townsend, N. (2009) Complications of equine oral surgery. *Veterinary Clinics of North America. Equine Practice*, 24, 499–514.

Dixon, P.M., Kennedy, R., Poll, K., Barakzai, S. & Reardon, R.J.M. (2021) A long-term study of sinoscopic treatment of equine paranasal sinus disease: 155 cases (2012–2019). *Equine Veterinary Journal*, 53(5), 979–989.

Dixon, P.M., Tremaine, W.H., Pickles, K., Kuhns, L., Hawe, C., McCann, J. et al. (2000) Equine dental disease part 4: A long-term study of 400 cases: apical infections of cheek teeth. *Equine Veterinary Journal*, 32, 182–194. Available from: https://doi.org/10.2746/042516400776563581

Earley, E.T., Rawlinson, J.E. & Baratt, R.M. (2013) Complications associated with cheek tooth extraction in the horse. *Journal of Veterinary Dentistry*, 30, 220–235.

Easley, J. (2022) Milestones in equine dentistry. In: *Equine dentistry and maxillofacial surgery*, 1st edition. Newcastle-upon-Tyne UK: Cambridge Scholars Publishing, pp. 2–10.

Gergeleit, H. & Bienert-Zeit, A. (2020) Complications following mandibular cheek tooth extraction in 20 horses. *Frontiers in Veterinary Science*, 7, 504. Available from: https://doi.org/10.3389/fvets.2020.00504

Henry, T., Stoll, M. & Rice, M. (2022) Equine exodontia. In: *Equine dentistry and maxillofacial surgery*, 1st edition. Newcastle-upon-Tyne UK: Cambridge Scholars Publishing, pp. 519–552.

Horbal, A., Reardon, R.J.M., Froydenlund, T., Jago, R.C. & Dixon, P.M. (2019) Head and neck abscessation and thrombophlebitis following cheek tooth extraction in a pony. *Equine Veterinary Education*, 31, 523–529. Available from: https://doi.org/10.1111/eve.12900

Kennedy, R., Reardon, R.J., James, O., Wilson, C. & Dixon, P.M. (2020) A long-term study of equine cheek teeth post-extraction complications: 428 cheek teeth (2004-2018). *Equine Veterinary Journal*, 52, 811–822. Available from: https://doi.org/10.1111/evj.13255

Kern, I., Bartmann, C.P., Verspohl, J., Rohde, J. & Bienert-Zeit, A. (2017) Bacteraemia before, during and after tooth extraction in horses in the absence of antimicrobial administration. *Equine Veterinary Journal*, 49, 178–182. Available from: https://doi.org/10.1111/evj.12581

Langeneckert, F., Witte, T., Schellenberger, F., Czech, C., Aebischer, D., Vidondo, B. et al. (2015) Cheek tooth extraction via a minimally invasive transbuccal approach and intradental screw placement in 54 equids. *Veterinary Surgery*, 44, 1012–1020.

Ogden, N., Thomas, H., Carslake, H. & Kane-Smyth, J. (2023) Trigeminal neuropathy in two horses following trauma to the infraorbital and mental nerves. *Equine Veterinary Education*, 35, e303–e310. https://doi.org/10.1111/eve.13700

O'Neill, H.D., Boussauw, B., Bladon, B.M. & Fraser, B.S. (2011) Extraction of cheek teeth using a lateral buccotomy approach in 114 horses (1999–2009). *Equine Veterinary Journal*, 43, 348–353.

Reardon, R. (2022) Exodontia complications and treatments. In: *Equine dentistry and maxillofacial surgery*, 1st edition. Newcastle-upon-Tyne UK: Cambridge Scholars Publishing, pp. 553–566.

Reichert, C., Conze, P., Roetting, A.K. & Bienert-Zeit, A. (2014) Approaches to cheek teeth removal after failed oral extraction in 23 horses. *Pferdeheilkunde Equine Medicine*, 30, 532–540.

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