EQUINE VETERINARY EDUCATION/AMERICAN EDITION | VOLUME 32 NUMBER 1 | JANUARY 2020

AAEP®

EQUINE VETERINARY EDUCATION

American Edition | January 2020

BEVA

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

IN THIS ISSUE:

Perspectives from an Equine Expert Panel on

Clodronate Use in Horses

DISCUSSION TOPICS

Clinical Experience

Case Selection

Short-Term Efficacy

Long-Term Efficacy

Safety

On May 14, 2019, a group of 12 leading experts in equine veterinary medicine participated in a panel to discuss their cross-disciplinary experiences and opinions on the use of clodronate in horses.

To learn more, please visit:

EquineClodronate.com

PANELISTS

Academia

Myra Barrett
DVM, DACVR

Chris Kawcak
PhD, DVM, DACVS, DACVSMR

Sarah le Jeune
DVM, DACVS, DACVSMR

Ashlee Watts
PhD, DVM, DACVS

English Performance

Kent Allen
DVM

Robert Boswell
DVM

Marc Koene
DVM

Richard Markell
DVM, MRCVS, MBA

Western Performance

Billy Maupin
DVM

Steven Colburn
DVM

Chris Ray
DVM, DACVS

Josh Zacharias
DVM, DACVS, DACVSMR

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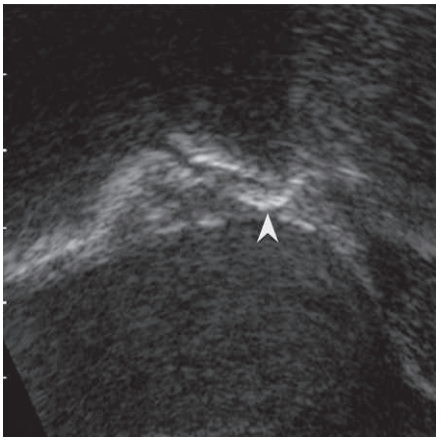

AAEP NEWS In this issue

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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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Meet 2020 AAEP President Dr. David Frisbie

Dr. David Frisbie

The AAEP is pleased to introduce Dr. David Frisbie as its 2020 president. Dr. Frisbie is a professor in the College of Veterinary Medicine and Biomedical Sciences at Colorado State University.

Dr. Frisbie was born in Minneapolis, Minnesota, and raised with five older stepsiblings on a small island in Lake Minnetonka. The Frisbies were one of just a few families that lived year-round on the island, which, in the early days, was only accessible by rope ferry.

His father, Darrell, started as a professional race car driver and retired as vice president of a gravel company. His mother, Vera, was an accountant. Each of Dr. Frisbie's siblings raced cars professionally at some point in their careers, but he had his sights set on becoming a veterinarian from a young age, influenced in part by his Golden Retriever "Buddy," who became an all-time high-point champion field trial dog.

Dr. Frisbie grew up fishing, snowmobiling and playing hockey. He wasn't exposed to horses until age 12 during summers spent on a South Dakota cattle ranch owned by family friends.

Following high school, Dr. Frisbie attended the University of Wisconsin, where there was considerable enthusiasm around its new vet school. A year after earning his bachelor's in biochemistry, Dr. Frisbie entered vet school in 1988 with an interest in cattle and a family connection to a potential small animal career. He discovered an interest in equine medicine during his third year, when he scrubbed in on an arthroscopy with Dr. Bill Lindsey and emerged thinking it was the coolest thing he'd ever seen.

Following a preceptorship at Littleton Equine Medical Center, Dr. Frisbie was accepted for a surgery internship at Cornell University, where he embarked on research into therapeutics for musculoskeletal and joint disease.

He expanded his research while completing a large animal surgery residency and a master's degree in joint pathobiology at Colorado State, where he would join the faculty as an assistant professor of equine surgery in 1999.

Dr. Frisbie's research into musculoskeletal treatments and pathogenesis include translational and novel therapeutics such as stem cells and other biologic treatments influencing veterinary and human health. He founded one of the first regenerative therapies focused on improving treatments for horses; and he created and described innovative, minimally invasive orthopaedic techniques.

In addition to his teaching, research, mentoring and other responsibilities at Colorado State, Dr. Frisbie co-founded one of the first veterinary-owned and veterinary specialist-run rehabilitation facilities. He also partnered in one of the first sports medicine practices focused on the Quarter Horse show world and served six years as the official veterinarian for the AQHA World Show Series.

Dr. Frisbie met his wife, equine radiologist Dr. Myra Barrett, at a mutual friend's birthday party, and the couple was married in 2005. They have two daughters: Siena, 9, and Sydney, 4. Both daughters pleasure ride and are avid skiers, each having started on the slopes at age 2.

In his spare time, Dr. Frisbie enjoys skiing and mountain biking. He raced mountain bikes for a couple of years, achieving several podium placings, but gave up competitive racing three years ago to focus on bringing the university's C. Wayne McIlwraith Translational Medicine Institute from concept to reality as its interim director of operations and founding director.

Dr. Frisbie has been an AAEP member since 2001 and calls the association the most altruistic organization he's ever been involved with. He served as chair of the Educational Programs Committee, his contributions to which earned him the President's Award in 2011. He also served on the board of directors from 2013-15.

He credits AAEP with helping him be more successful—both professionally and personally—and he looks forward to working toward solutions that create similar opportunities and outcomes for all, especially for younger members of the profession.

In breaking family tradition with his career focus on horsepower of the hooved variety, Dr. Frisbie has contributed substantially to the health and wellbeing of horses, and the practice of veterinary medicine.

Practitioners descend from Denver with new knowledge, skills and connections

Offering science-backed solutions to the clinical challenges of everyday practice along with resources and strategies to strengthen emotional resilience and personal wellbeing, the AAEP's 65th Annual Convention drew 5,443 veterinary professionals, students, guests and exhibitors from 37 countries to Denver, Colo., Dec. 7-11.

The 137.5 hours of available CE included an expanded slate of wet and dry labs at which more than 200 practitioners refined techniques and learned new skills. In addition, attendees established and expanded important professional connections at numerous networking and social events; and they shopped for their next practice investment among the 340 trade show exhibitors.

We hope to see you at the 2020 convention in Las Vegas, if not sooner at one of our summer meetings listed on page XI.

Keynote: Change lens to benefit from gender differences in workplace

Although men and women work and communicate in ways that are different and can cause "hiccups" in life, it's important that each gender view these differences through a new set of lenses and that differences be valued, appreciated and preserved, according to keynote speaker Tammy Hughes *(pictured above)*.

According to Hughes, men and women reach goals in the same way but in different places. While men tend to be goal focused and sort things out internally, women tend to be process focused and solicit others' input early on. Similarly, men tend to excel when fixated on a singular task while women have a natural propensity for multi-tasking, which men can view as being too scattered despite the goals being accomplished successfully.

Even non-verbal communication is often misinterpreted. For instance, a head nod means "yes" to men and "I'm hearing what you're saying" to women but not necessarily agreement.

According to Hughes, successful companies create a culture where differences are understood and the working style of each gender is honored: "When both are allowed to work out of their strengths, productivity goes up."

Milne Lecture examines current and future of fracture repair

Achieving harmony of mechanics and biology is essential to fixing fractures, according to Dr. Dean W. Richardson, whose Frank J. Milne State-of-the-Art Lecture explored the difficulties and possibilities of surgical repair of major bone and joint injuries.

Dr. Richardson encouraged practitioners to avoid common emergency management errors when confronted with a fracture. These include shipping a horse in a loose box; using a splint that is too heavy, inadequately attached, not close enough to the limb or too padded; not considering the mechanics and anatomy of the injury; and panicking. For unstable fractures, he recommends more splinting instead of more padding. When in doubt, add another splint and place the splint over the opened part of the fracture. Be sure to use non-elastic tape such as duct tape or packing tape.

Dr. Richardson closed with a glimpse into the future of equine orthopedic surgery. These include advancements in body management, including improvements to sling management and other anti-gravity techniques; custom-made 3D implants designed specifically for the horse as opposed to the human implants currently used; pain management, especially paravertebral and liposomal local anesthetics; and superior imaging, which will be the standard of care and make difficult surgeries easier but won't prevent inferior thinking or bad technique.

Dr. Richardson's Milne Lecture paper is available on the convention app and in the *Proceedings* book beginning on page 86.

Access Kester and Milne articles online

EVE and *EVJ* have released a virtual issue of the articles discussed during the Kester News Hour and referenced in the Milne Lecture. The articles are free access through early March at https://tinyurl.com/kest19.

Annual awards bestowed on four

Three members and an industry collective improving the lives of horses in transition were honored during the Dec. 10 President's Luncheon:

Distinguished Educator Award – Academic:
Dr. David Wilson
Distinguished Educator Award – Mentor:
Dr. Terry Swanson
The Lavin Cup: The Right Horse Initiative
President's Award: Dr. Katie Flynn

Promising researchers receive fellows

Colorado State University Ph.D. students Dr. Lynn Pezzanite and Dr. Sherry Johnson were recognized for exceptional equine research contributions.

Dr. Pezzanite received the AAEP Past Presidents' Research Fellow for her exploration of new methods to treat multi-drug resistant infections. Meanwhile, Dr. Johnson received the EQUUS Foundation Research Fellow for her research into new approaches to tendon injury rehabilitation in horses. Respectively, the $5,000 fellows are supported by monetary contributions from AAEP past presidents and in partnership between The Foundation for the Horse and the EQUUS Foundation.

The 2020 officers were installed during the President's Luncheon. From left: Dr. Emma Read, vice president; Dr. Lisa Metcalf, treasurer; Dr. Scott Hay, president-elect; Dr. David Frisbie, president; and Dr. Jeff Berk, immediate past president.

Foundation scholarships exceed $360,000

Four recent graduates and 13 students shared in scholarship awards of $366,000 through the generosity of four of The Foundation for the Horse's scholarship partners: Coyote Rock Ranch, Merck Animal Health, Oakwood Foundation Charitable Trust and Zoetis.

Foundation gifts reach $77,000

Between the Collegiate Challenge, Vet Story Night, My Mentor giving and contributions at The Foundation for the Horse booth in the trade show, $77,000 was raised for the welfare of horses.

Report your CE credits

Convention attendees are reminded to report their continuing education credits using the CE form included in the packet received at registration. If you misplaced this form, you may request a replacement from Kristin Walker at (859) 233-0147 or kwalker@aaep.org.

5 things to know about AAEP this month

1. 2019 convention attendees may access complimentary archived recordings of educational sessions beginning in mid- to late January at aaep.digitellinc.com/aaep.
2. Access *EVJ* and *EVE* articles from Kester News Hour and the Milne Lecture at no charge through early March at https://tinyurl.com/kest19.
3. *Proceedings* books were mailed in early January to members who did not attend the annual convention.
4. Help an affiliated equine rescue/retirement facility complete the application for free vaccines from the UHVRC by Feb. 1 at uhvrc.org.
5. If your practice involves ophthalmology, podiatry or sport horses, make plans to attend one of the AAEP's 2020 summer CE meetings. Learn more at aaep.org/meetings.

Reward a distinguished researcher with a 2021 Milne Lecture nomination

Deadline to nominate is January 31

Nominate an accomplished researcher for the 2021 Frank J. Milne State-of-the-Art Lecture, a traditional highlight of the annual convention.

The lecture is a perspective on the state-of-the-art in the presenter's area of expertise and is intended to honor the accomplishments of the presenter and provide a meaningful learning experience to the AAEP membership.

A nomination form may be requested from Carey Ross, scientific publications coordinator, at cross@aaep.org. The form must be completed, including qualifications and accomplishments of the nominee, and returned by Jan. 31, 2020.

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

Share your research at the 2020 convention in Vegas

It's the Entertainment Capital of the World and you could be there this December by submitting a paper to be considered for presentation during the 66th Annual Convention in Las Vegas, Nev., Dec. 5–9.

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

Submit papers at https://s3.goeshow.com/aaep/annual/2020/AAEP_paper_submission.cfm. Authors should visit the site in advance to set up a profile and provide paper and author information before uploading the paper when it is finished. Complete considerations and ethical guidelines are available in the General Instructions area of the site.

The presenting author of selected papers will receive complimentary registration and a stipend to support travel to the meeting.

On air: *EVE* and *EVJ* podcasts

New episodes of the *Equine Veterinary Education* podcast and the *EVJ in Conversation* podcast offer deeper looks into recently published papers.

In the *EVE* podcast, Dr. Natasha Lean discusses the paper "Standing repair of an articular dorsal medial oblique fracture of the proximal third metacarpal bone in a racing Standardbred"; and Dr. Eugenio Cillan Garcia discusses the paper "Standing repair of a proximal, incomplete, articular fracture of the third metatarsal bone." Download or listen to the 22-minute episode at equineveterinaryeducation.podbean.com.

The *EVJ* podcast features discussions of lameness with Drs. Sue Dyson and René van Weeren. The podcast is linked to the "Practical uses of quantitative gait analysis" virtual issue published in *EVJ* and containing 17 open access articles. The 23-minute episode is accessible at evj.podbean.com.

2013 Milne Lecturer Dr. Sue Dyson discusses lameness on the December issue of the EVJ in Conversation *podcast.*

AAEP recognizes the service of outgoing member volunteers

The dedicated service of member volunteers is essential to fulfilling the AAEP's mission. The AAEP thanks the following members whose volunteer service on the board of directors or on a council, committee or Round concluded in 2019:

Board of Directors
Dr. Leslie Easterwood
Dr. Margo Macpherson
Dr. Tracy Turner

Foundation Advisory Council
Dr. Mark Baus
Dr. Duane Chappell
Dr. Reynolds Cowles, Jr.
Dr. Elizabeth Fish

Welfare & Public Policy Advisory Council
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Dr. Lauren Lamb
Dr. Sara Langsam
Dr. Craig Lesser
Dr. Joe Rumsey
Dr. Bernadette Smith
Dr. Brad Tanner

AAEP mourns the passing of Dr. Chris House

Dr. Chris House

The AAEP in late November learned of the passing of former BEVA President Dr. Chris House. Although he was not an AAEP member, Dr. House served as BEVA president in 2009, coinciding with the AAEP presidency of Dr. Harry Werner. The two equine welfare advocates were pivotal to the creation of the International Forum for Working Equids (IFWE).

After several years of support from BEVA and AAEP, the IFWE was taken over by The Donkey Sanctuary and eventually ran its course. However, the initiative planted the seed for the importance of a federation of interested parties for the welfare of working equids. Today, with The Donkey Sanctuary and World Horse Welfare as the primary players, the International Coalition for Working Equids is going strong, which, according to Dr. Werner, "is a wonderful and enduring legacy for these long underserved animals and a tribute to Chris' noble vision."

AAEP Working For You

In addition to the president and/or other officers who represented the association at industry meetings, the AAEP extends its appreciation to the following members who volunteered time and expertise for AAEP programs or on behalf of the AAEP during the period May–December 2019:

AAEP On Call
Dr. Kathleen Anderson – *Black Eyed Susan Stakes from Pimlico; TVG.com Haskell Invitational from Monmouth Park*
Dr. Jeff Blea – *Breeders' Cup World Championships from Santa Anita Park*
Dr. Ryan Carpenter – *Awesome Again Stakes from Santa Anita Park*
Dr. Luis Castro – *Whitney Stakes from Saratoga Race Course; Fourstardave Handicap from Saratoga Race Course; and Travers Stakes from Saratoga Race Course*
Dr. Kevin Dunlavy – *Thurby from Churchill Downs; Stephen Foster Handicap from Churchill Downs; Shadwell Turf Mile Stakes from Keeneland*
Dr. Celeste Kunz – *Hambletonian from Meadowlands; Pennsylvania Derby from Parx Racing*
Dr. Sara Langsam – *Belmont Gold Cup Invitational from Belmont Park; Belmont Stakes from Belmont Park; Belmont Derby & Oaks from Belmont Park; Jockey Club Derby & Oaks from Belmont Park*
Dr. Keith Latson – *Kentucky Derby from Churchill Downs; Preakness Stakes from Pimlico; Belmont Stakes from Belmont Park*
Dr. Nick Meittinis – *Preakness Stakes from Pimlico*
Dr. Foster Northrop – *Kentucky Derby from Churchill Downs*
Dr. Scott Palmer – *Breeders' Cup World Championships from Santa Anita Park*
Dr. Al Ruggles – *Kentucky Oaks from Churchill Downs; Juddmonte Spinster Stakes from Keeneland; Breeders' Cup World Championships from Santa Anita Park*

Ask the Vet
Dr. Alison Cornwall – *Nutrition*
Dr. Carol Gillis – *Lameness Rehabilitation*
Dr. Gary Hanes – *Wound Care & What to Expect When the Vet Arrives*
Dr. Lynn Martin – *Lower Respiratory Disease*
Dr. Michael St. Blanc – *Lameness in the Sport Horse*
Dr. Elizabeth Thompson – *Dentistry*
Dr. Alina Vale – *Equine Welfare*

Essential Skills Workshops (Dentistry)
Dr. Chris Blevins – *Utah State University*
Dr. Lynn Caldwell – *University of California, Davis*
Dr. Jon Gieche – *Michigan State University*
Dr. Robert Gregory – *University of California, Davis*
Dr. Gordon Plotts – *Washington State University*
Dr. Elizabeth Schilling – *Western University*
Dr. Bruce Whittle – *Washington State University and Utah State University*

Essential Skills Workshops (Podiatry)
Dr. Lindsey Boone – *University of Georgia*
Dr. Steve Naile – *Tufts University*

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Dr. Nat White
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Dr. Karen Wolfsdorf

American Horse Council Annual Meeting
Dr. Tom Lenz

AMMVEE Congress
Dr. Tracy Turner

Association of Racing Commissioners International Meeting
Dr. Jeff Blea

AVMA House of Delegates Meeting
Dr. Stuart Brown
Dr. Rebecca Stinson

AVMA Veterinary Wellbeing Summit
Dr. Rob Franklin

Racing Medication and Testing Consortium Meeting
Dr. Jeff Blea

U.S. Equestrian Federation Meeting
Dr. Stephen Schumacher

U.S. Animal Health Association Meeting
Dr. Katie Flynn
Dr. Nat White

Improve practice culture and management with workplace wellbeing certification

By Rob Franklin, DVM, DACVIM

Dr. Rob Franklin

Managing people is tough, even more so when you are highly stressed and physically depleted after long hours of hard work. Managing our own care along with that of our patients and our team can often become an out of touch goal. As practitioners, we're constantly challenged by a wide range of non-veterinary issues that, quite honestly, we are ill-prepared to handle. We need simple, straightforward tools that provide both perspective and resources to handle these issues, care for ourselves and keep life flowing Kumbaya style.

Let's consider a few examples of problems we deal with in our profession:

First, we have a practice that needs caring for. There are people working with and for us who rely on us to steward a safe, fulfilling and, hopefully, enjoyable work environment. The practice culture that we develop can only come from a top-down leadership approach where we identify key attributes that everyone agrees are important, and then we walk those out day in and day out. Culture development is a constant process that requires foresight and a modicum of persistent energy. There is a certain level of self-care needed to make sure we are contributing in a positive manner and not being irritable, unhealthy, sad, mad, depressed or burned-out, any of which will ruin any attempt to build good company culture. Remember, if the cabin experiences a loss of pressure and the oxygen mask is deployed, you must put your own mask on first before attempting to help those around you. Company culture is one of the most important ways to attract and retain key employees and team members; it also allows practice owners to enjoy their own workplaces.

Second, consider how we provide feedback to our team or even how we receive it from our clients. Feedback is vital to personal wellbeing and company culture. We all need to know how we are doing—it is the same reason we call our clients to enquire about how their horse is doing after we treat it. Did we make the correct diagnosis? Did we prescribe the correct treatment? Did we show compassion when dealing with their animal? We rely on this feedback to adjust our future visits and assessments of similar cases. We also must be adequately prepared to accept feedback from our clients, especially when things don't follow an expected course. Our team members also crave feedback—and not the kind that comes from the silent treatment or throwing instruments across the operating room. Giving effective feedback lets them know they are safe and cared for by their team leader, regardless of their performance. There happens to be an entire art to asking for, receiving and giving feedback, and doing it the right way is as important as doing it at all.

Third, conflicts arise in practice, even among the happiest of teams and with the best of clients. We can address the conflict in a professional manner that builds trust or in a destructive manner that costs us valuable relationships. Part of conflict resolution is establishing effective boundaries on what we will or will not do for others. Unclear boundaries allow others to infringe on our sanctuary zones and cause us to become emotionally upset or physically spent. Learning to set boundaries, say "no" and handle conflicts well can be some of the most powerful skills you can master.

Company culture is one of the most important ways to attract and retain key employees and team members; it also allows practice owners to enjoy their own workplaces.

Fourth, suicide rates in our profession are obscene. We've heard of colleagues—and sometimes friends and family—ending their lives, and we feel helpless. What can we do to help those facing such desperation and hopelessness? Everyone needs basic CPR-type skills to know how to interact with someone contemplating suicide. This involves more than referring them to a telephone hotline.

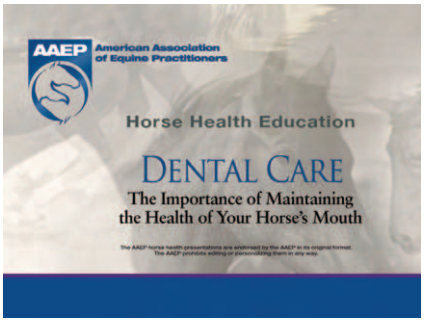
Finally, our profession and the world have become more diverse and we need to understand how to operate appropriately in this new landscape. Whether it is race, religion, gender or any other "difference," it is imperative that we understand how to navigate these waters safely to maintain a non-threatening work environment and non-judgmental client relations.

Fortunately, the AVMA has developed the Workplace Wellbeing Certificate Program, an online short course

continued on page X

Dr. Franklin of Fredericksburg, Texas, is chair of the AAEP's Wellness Subcommittee and owner of or partner in multiple equine and small animal practices in Texas.

Benefit: Save time on client education with AAEP PowerPoints



Owner education events can be a great venue to improve the daily care of client horses, strengthen client relations and introduce yourself to prospective clients. While the food and beverage menus are up to you, AAEP has shouldered much of the preparation by creating PowerPoint presentations on pertinent equine healthcare topics.

As a benefit of your membership, you can download any of the following 18 presentations. Each contains the most current information on the topic so that your clients receive fundamental knowledge that will help them maintain the health of their horses as well as recognize and respond to warning signs of different ailments and diseases.

- Colic
- Dental Care
- Disaster Preparedness
- Emergency Care
- Equine Herpesvirus (EHV)
- Foal Growth
- Foaling Mare and Newborn
- Hay Quality and Nutrition
- Immunizations
- Internal Parasites
- Lameness Exams
- Laminitis
- Neurology
- Overweight Horse
- Poisonous Plants
- The Expectant Mare
- The Older Horse
- Understanding Equine Strangles

These presentations may be downloaded from aaep.org/dashboard/clienteducation/presentations. For additional information about the owner education PowerPoints and other benefits of your AAEP membership, contact Megan Gray, member concierge, at mgray@aaep.org.

Welcome new members, and congratulations recent graduates

New Members:

Julia W. Bentley, DVM, Amherst, MA
Lisa Dauten, DVM, Litchfield, CT
Charles Hall, DVM BSc MSc, Erin, ON, Canada
Cecilia Lavigne, DVM, Shaftsbury, VT
Yoko Nakamae, DVM, Charlottetown, PE, Canada
Emily Christine Nietrzeba, DVM MPH, Auburn, CA
Sean Victor Peck, DVM, Carson City, NV
Jorge Luis Sanclemente, DVM, Pullman, WA
Gary R. Shelton, DVM, Elkton, FL
Jeff Wells, DVM, Evergreen, CO
Jessica Werner, DVM, East Dummerston, VT
Edwina Joanna Alington Wilkes, BVSc MPharm FANZCVS, Wagga Wagga, NSW, Australia

Recent Graduates:

Gabrielle Care, DVM, Blacksburg, VA
Madalyn Kalscheur, DVM, Lambertville, NJ
Amy McBirney, DVM, Morgan Hill, CA
Erin Pinnell, DVM, Columbus, OH
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Improve practice culture and management, continued

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Highlights of recent clinically relevant papers

Dorsal fetlock chip fractures

Arthroscopy is considered the treatment of choice for dorsal osteochondral chip fractures of the metacarpo/metatarsophalangeal (MCP/MTP) joints in the racehorse. This retrospective study by Pieter Ramzan and Claire Wylie compared the surgical (SX) and non-surgical (non-SX) management of MCP/MTP joint dorsal chip fractures in racing Thoroughbreds in the UK.

Medical records from 2006 to 2014 were reviewed to identify Thoroughbred racehorses that were diagnosed with MCP/MTP dorsal osteochondral chip fractures by radiography. In total, 98 horses met the inclusion criteria (70 non-SX, 28 SX), with chip fractures predominantly involving the forelimbs (n = 92, 93.9%) and considered to be clinically active in 86.7% of cases (n = 85).

Overall, 70 horses were managed non-surgically (71.4%) and 28 underwent surgery (28.6%). Significantly more SX horses had a reported ongoing problem associated with the affected joint than non-SX horses; however, there was no significant difference between non-SX and SX horses with respect to the number of intra-articular medications of affected joint per month of follow-up. The proportion of horses racing post-diagnosis was not significantly different between the two groups (78.6% non-SX vs. 85.7% SX). The median time to first start following diagnosis for non-SX (106 days) was significantly shorter than for SX (203 days).

Non-surgical management may be a valid treatment option for some cases of metacarpo/metatarsophalangeal joint dorsal chip fracture.

Horse-owners' perceptions of exotic diseases

In this UK-based study, Kelsey Spence and colleagues investigated horse-owners' perceptions of, and attitudes towards, exotic diseases.

This study describes horse-owners' perceptions of the term 'exotic disease', and their attitudes towards their risk of being affected by an exotic disease. Data was collected from 423 horse-owners using two open-ended survey questions.

Horse-owners perceived exotic diseases as (1) belonging somewhere else, and (2) a dangerous threat to their horse(s). The term 'exotic' was associated with being foreign, non-native, and out-of-place in the UK. Attitudes towards exotic disease risk were summarised into four categories: (1) responsible horse-owners prevent disease, (2) horse-owners need support to stop disease spread, (3) risk depends on proximity to the 'risky' horse, and (4) some risk is inevitable. A 'responsible' owner was aware of health hazards and took actions to protect their horse from disease. Reliance on others, including stakeholders, to uphold disease prevention in the community led to feeling vulnerable to disease threats. When evaluating risk, horse-owners considered which horses were the 'riskiest' to their horse's health (horses that travelled, participated in competitions, or were simply unfamiliar) and avoided situations where they could interact. Despite undertaking disease prevention measures, the perceived uncontrollable nature of exotic diseases led some owners to feel an incursion was inevitable.

The authors concluded that without accounting for horse-owners' perceptions of, and attitudes towards, exotic diseases, recommendations to increase preparedness may be ineffective. Improved communication among stakeholders in the industry may help to clarify expectations for exotic disease-specific prevention measures. A collaborative approach among horse-owners and stakeholders is recommended to improve disease preparedness within the industry.

Right dorsal displacement of the large colon

In this study from the University of Wisconsin-Madison, USA, Jennifer Whyard and Sabrina Brounts compared post-operative complications and survival in horses with right dorsal displacement of the large colon (RDD) and horses with other non-strangulating large colon (NSLC) lesions.

Data relating to horses undergoing exploratory laparotomy were obtained from medical records and further data was obtained from an owner questionnaire. Of the 137 horses in this study, 67 (49%) had RDD and 70 (51%) had NSLC lesions. Post-operative complications were experienced by 28 horses with RDD (42%) and 27 horses with NSLC lesions (39%). The horses with RDD showed more severe complications than the horses with NSLC lesions. Horses with RDD were found to be more likely to develop colic in the short term, but not in the long term, and were more likely to have a second laparotomy. No significant difference in short- or long-term survival was found between groups. Major post-operative complications in the RDD group did not influence short- or long-term survival.

EIPH in endurance horses

In this study Iciar Tarancón and colleagues in Spain assessed the prevalence of exercise-induced pulmonary haemorrhage (EIPH) among elite endurance horses after competition in a long-distance race.

Bronchoalveolar lavage fluid samples collected from 20 endurance horses at 3–8 days (sample A) and 36–38 days (sample B) after the race (100 km in 1 day [n = 3], 70 km/day for 2 days [n = 12], or 100 km/day for 2 days [n = 5]) were cytologically examined for the presence of hemosiderophages. Samples from 12 control horses (nonexercised or minimally exercised age-, breed-, and trainer-matched horses from the same environment) were collected at the same time as sample B was obtained from matched endurance horses and similarly examined. Horses with bronchoalveolar lavage fluid samples in which >1% of identified cells were hemosiderophages were considered to have evidence of EIPH.

Of 20 endurance horses, 9 (45%) and 10 (50%) had cytologic evidence of EIPH in samples A and B, respectively. Evidence of EIPH was present in 6 of 20 (30%) horses at both sample collection times, 3 (15%) at the first sample time only, and 4 (20%) at the second sample time only. Only one of 12 control horses had cytologic evidence of EIPH.

The prevalence of EIPH in these elite endurance horses (45–50%) was higher than previously reported estimates for poor-performing endurance horses; however, differences in

criteria for identification of EIPH should be considered when comparing findings between studies.

Electrical nerve stimulation for headshaking

This international, multi-centre study by Veronica Roberts and colleagues in the UK investigated the use of percutaneous electrical nerve stimulation for idiopathic trigeiminal-mediated headshaking.

Horses were included in analyses if they were diagnosed with trigeminal-mediated headshaking by exclusion of all other possible causes of the clinical signs and received EquiPENS™ neuromodulation between August 2013 and November 2017.

Each horse received an initial course of three procedures, with the first two procedures performed 3–7 days apart, and the third procedure 10–14 days after the second. A total of 530 procedures were performed on 168 horses, with 53% (n = 72) of horses going into remission following the initial course. The median duration of remission was 9.5 weeks (range 2 days–156 weeks and ongoing). Horses were significantly more likely to go into remission at the end of the first course if they went into remission after the first procedure and second procedures. Complications were reported in 8.8% (n = 47) of procedures, with worsening of clinical signs being the most frequently reported. In all but one case, complications were mild and transient, without self-trauma. No predictors for outcome were determined.

Headshaking and the infraorbital canal

This retrospective cross-sectional study by Ralph Edwards and colleagues in The Netherlands aimed to describe the computed tomography (CT) anatomy and variations of the infraorbital canal in horses with local disease processes and normal horses, and to examine associations between those findings and headshaking.

Computed tomography scans were reviewed and morphological changes of the infraorbital canal were described. Presence of changes was then tested for association with headshaking prevalence, presence of disease processes in the region of the infraorbital canal, age, and sex.

Of the 218 horses included in this study, 42 (19%) had headshaking and 97 (45%) had CT lesions in the region of the infraorbital canal. Morphological changes to the bone of the infraorbital canal were found in 121 horses (56%) and included: increased mineralisation (n = 39, 18%), decreased mineralisation (n = 89, 41%), deformed shape (n = 51, 23%), displaced position (n = 43, 20%), and disruption (n = 11, 5%). All changes of the infraorbital canal significantly increased in frequency with the presence of adjacent disease. Increased mineralisation and disruption of the infraorbital canal were significantly associated with headshaking in horses with adjacent disease; the latter only reached significance after exclusion of dentally immature horses. No other changes were significantly associated with the presence of headshaking. No association was found between headshaking and the age or sex of the horse.

Acute kidney injury

In this retrospective cohort study, Victoria Savage and colleagues in the UK evaluated the prevalence of acute kidney injury (AKI) in hospitalised horses, risk factors associated with AKI, and the effect of AKI on short-term survival.

Adult horses hospitalised for >2 days from which a minimum of two measurements of serum creatinine concentration were available were identified from clinical records. Horses were grouped according to their baseline serum creatinine concentration and change in serum creatinine concentration from baseline. The associations between signalment, diagnosis, and treatment variables, and the presence of azotaemia or AKI were assessed using multinomial logistic regression. The relationship between these conditions and survival to discharge was evaluated.

Of the 325 horses included in the study 14 (4.3%) had azotaemia at baseline and 48 (14.8%) developed AKI. There were no significant associations between investigated risk factors and development of AKI. The presence of azotaemia and AKI did not significantly affect survival to discharge.

The prevalence of AKI in this population of hospitalised horses is similar to that reported in dogs and humans; however, in this study population, there was less impact on morbidity and short-term survival.

S. WRIGHT
EVE Editorial Office

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Editorial

Evaluating evidence for new therapies in equine medicine

"*I believe in evidence. I believe in observation, measurement, and reasoning, confirmed by independent observers. I'll believe anything, no matter how wild and ridiculous, if there is evidence for it. The wilder and more ridiculous something is, however, the firmer and more solid the evidence will have to be*." Isaac Asimov

In the 1923, the US Department of Agriculture Special Report on Diseases of the Horse, A. Liutard M.D.V.M. offered a warning to owners of horses with arthritis, 'He will do well to be on his guard against the patented "cures" which the travelling horse doctor may urge upon him and withhold his faith from the circular of the agent who will deluge him with references and certificates. It is possible that nostrums may in some exceptional instances prove serviceable, but the greater number of them are capable of producing only injurious effects'. Pursuing novel interventions is fuelled by our desire to improve our patient's quality of life. Some prove ineffective, some have a small impact and a few have such a large and obvious impact that they may be referred to as parachute treatments. The latter being a tongue in cheek reference to the fact that experimental evidence is not required to prove that parachutes save lives. Few treatments in fact are parachutes with obvious overwhelming benefit. Many that were thought to be have not stood up to scrutiny. Novelty alone is not evidence of efficacy. It is natural to want to be 'first on the block', and most practitioners do not want to be the last to adopt a new therapy. We tend to be overly optimistic when assessing new therapies; in fact the novelty bias is well reported. Even in clinical trials a novelty or 'wish' bias can overestimate the effectiveness of a new therapy by as much as 27% (Persaud). When rigorously tested, novel therapies demonstrate superiority over standard care only a little more than half the time and only a few new treatments are substantially better than their predecessor (Djulbegovic *et al.* 2012).

In veterinary medicine the criteria for a novel therapy has been defined as one of the following: a completely original therapy, one that has only been used by a small number of veterinarians, one that has only been applied to a small number of animals of a particular species, a novel combination of previously accepted therapies or utilising an accepted therapy on a condition for which it was not previously indicated (Yeates 2016). This leaves us two significant questions regarding the introduction of novel therapies. What type and quality of evidence is considered adequate to incorporate the novel therapy into practice? Where does the burden of proof for efficacy and safety lie?

When considering the quality of therapeutic evidence, the randomised controlled trial (RCT) remains the gold standard (Cohen 2011). It involves an experimental study where an intervention is compared to a control group, usually a placebo or standard of care. By randomly allocating subjects to one of the two groups and masking both the provider and recipient to which subjects received the intervention, the impact of several biases and potential confounding variables are diminished. Without randomisation and blinding, observed treatment effects could be due to a true causal relationship, confounders or chance. In pre – post treatment studies with no control group, attribution of a treatment effect may be due to regression to the mean, selection bias or simply an animal that was going to improve on its own. The lack of randomised controlled trials in equine medicine has been addressed (Mair and Cohen 2003). Reasons for this may be difficulty in recruiting subjects, overall cost and concerns about equipoise, meaning there is a genuine concern among experts over whether a treatment is effective. Since most equine interventional evidence lacks a control group, relies on subjective or surrogate outcomes, is rarely replicated and is based on small sample sizes, we must accept that our evidence for therapeutic efficacy is weak. If we wish to improve the evidentiary basis for our interventions, we will have to convince members of the equine industry that RCTs are a worthwhile investment that benefits both the horse and the horse owner in the long run. Perhaps pragmatic trials comparing the new therapy to current practice and recruiting subjects from multiple practices can offer an alternative. Outcomes from pragmatic trials are more generalisable and applicable to everyday practice than traditional RCTs. However, they have the potential to suffer from biases introduced due to a lack of randomised allocation and blinding. Routinely collecting and aggregating health data from equine hospitals and primary care facilities have the potential to offer a cost-effective and practical way to assess novel therapies in randomised trials (McCord *et al.* 2018).

Without quality evidence for an intervention, horses serve as uncontrolled and often poorly monitored experimental subjects. New therapies are based on plausible theoretical evidence that the therapy will improve the condition which it addresses. Excitement and optimism grow, and momentum ensues. Early perceived success and buzz lead to more frequent use of the therapy, the so-called bandwagon effect. This frequently leads to less incentive for further research even as the potential for adverse effects increases. Once adopted and accepted, it takes exceptional evidence or significant adverse effects to reverse course. Significant evidence in human medicine and some in veterinary medicine reveals that even when quality evidence refutes claims, these therapies are not readily abandoned. Some examples in equine medicine would include the use of isoxsuprine for navicular disease, the use of cimetidine (Helle 2012) in the prevention of melanoma and the continued use of nitroglycerin in the treatment of laminitis. Medical reversal occurs when a widely held medical practice is found to have no benefit and possibly causes harm to patients (Prasad *et al.* 2012). In equine medicine, medical reversal is not well documented since very few, if any, therapies are subjected to large scale clinical trials. Without high quality evidence prior to the introduction of a novel therapy, the likelihood of medical reversal increases. This leads to significant financial waste and sometimes emotional distress. A unique and challenging aspect of equine medicine is the use of unproven therapies in competitive horses. Often the indications for these therapies are short term performance benefits with unknown long-term health consequences. Many of these therapies address orthopaedic issues and fall into the

'orthopaedic triad' described by Dr John Bergfeld of the Cleveland Clinic (Howard 2018). The triad consists of a famous athlete, a famous doctor and an unproven heavily hyped therapy. We can substitute well-known horse for the famous athlete. The question of responsibility for the burden of proof of efficacy is not as clear cut as what qualifies as evidence of therapeutic efficacy but it is no less important.

The fundamental principle of medicine is *Primum non nocere* first do no harm. Even a treatment that is shown later to neither cause harm nor impart benefit can deplete finite financial and industry resources, limiting future resources for clinical research. There is little financial incentive to conduct studies that challenge current practice. However, there is an argument that the burden of proof should be on those who profit from an intervention (Prasad and Cifu 2012). Certainly, the individual practitioner has some responsibility for evaluating the evidence that the intervention she is recommending is effective. However, since most practitioners are not trialists they should not bear complete responsibility. The practitioner should evaluate the evidence from investigators, regulatory agencies and specialty organisations before making a decision, giving sceptical consideration to promotional evidence. Most importantly, the practitioner should be willing to abandon a practice if compelling evidence refutes its efficacy. In summary, as practitioners, we are responsible for understanding the available evidence for a treatment such that when a client asks 'How do you know that it works'? We have an answer.

Medicine advances incrementally with occasional bursts of discovery interspersed along the labourious march. The financial incentives for a veterinarian to adopt a novel therapy can be formidable, even when the evidence is inconclusive. Anecdotes and testimonials are a starting point, not evidence. A sprinkling of caution mixed with the inevitable optimism of discovery is prudent.

It is important to maintain professional credibility by rigorously assessing the evidence. We serve both patients and customers. Customers have demands, but our oath is to our patients. If we are not cautious, an asymmetry develops where the perceived benefit accrues to the customer while the horse bears the major burden of risk. Where the evidence is strong, make that clear and where it is equivocal or nonexistent, do not embellish. Evidence will help deconstruct the spin and separate the signal from the noise. It is tempting to jump on the novel treatment bandwagon but without evidence the ride is potentially treacherous.

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Case Report

Unilateral malignant melanoma of the adrenal gland with metastatic spread to the thorax in a horse

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Keywords: horse; adrenal gland; immunohistochemistry; malignant melanoma; thoracic metastasis

Summary

A 7-year-old grey horse that had a history of inappetence, weight loss, weakness, dyspnoea, coughing and intermittent colic was examined post-mortem. A melanoma, confirmed histologically, was found in the right adrenal gland and had eroded into the posterior vena cava. Thoracic metastases were also identified. The skin, including the legs, trunk and perineum was normal with no evidence of melanomas. This was considered to be a primary, malignant melanoma, a novel finding in the adrenal gland of the horse.

Introduction

Melanocytic neoplasms have been reported to account for 4–19% of the total number of equine cutaneous tumours (Seltenhmmer *et al.* 2004). Melanomas are common, slow-growing skin tumours, most commonly seen in grey horses (Johnson 1998). Many reports have estimated that as many as 80% of grey horses older than 15 years of age will develop dermal melanomas (Johnson 1998; MacGillivary *et al.* 2002; Moore *et al.* 2013; Phillips and Lembcke 2013). Although, the majority of melanomas behave as benign tumours, many of these histologically benign cutaneous melanomas may eventually metastasise and, therefore, should be considered as potentially malignant (MacGillivary *et al.* 2002; Metcalf *et al.* 2013). MacGillivary *et al.* (2002) reported the prevalence of metastatic melanoma to be approximately 14% in 101 horses which were diagnosed with cutaneous melanoma; however, this was a referral population and this prevalence rate is unlikely to be the same in the general horse population. There are several individual case reports that describe malignant melanoma located in different regions, such as the thorax (Milne 1986; Murray *et al.* 1997), retrobulbar space (Sweeney and Beech 1983), the third and lower eyelids (Rizk 2012; Albanese *et al.* 2015), foot (Honnas *et al.* 1990; Floyd 2003), vertebrae *(Traver et al.* 1977; Schott *et al.* 1990), peripheral nerves and skeletal muscles (Kirker-Head *et al.* 1985), and the oesophagus (Caston and Fales-Williams 2010). The purpose of this report is to describe a case of apparent primary melanoma in the adrenal gland with metastatic spread, in a young horse.

Case history

A 7-year-old male horse had been purchased 2 years previously from a local farm. It was normal on clinical examination. Insidious weight loss was noticed 11 months after arrival of the horse. One month later, obvious inappetence and weakness were evident, at which time the horse was referred for further examinations and treatment. On presentation, the heart and respiratory rates and rectal temperature were normal. The volume, colour and frequency of urination were normal, but the faeces appeared dry. The horse was treated symptomatically and returned to the herd. However, after a further month, he was presented again for inappetence, weakness, respiratory distress and coughing. On thoracic auscultation, the lung sounds were muffled in the dorso-cranial region, and tachypnoea and tachycardia were evident. The horse was not pyrexic. He was treated again symptomatically with antibiotics and corticosteroids, and his daily exercise programme was halted. Within 4 months after the onset of the clinical disease, despite the above treatments, the horse continued to lose weight and became weaker; the coughing and dyspnoea worsened. In addition, mild to moderate, intermittent colic developed. Terminally, the horse developed severe respiratory distress and he subsequently died.

Post-mortem and histopathology findings

Immediately after death, the horse was submitted for post-mortem examination. Grossly, the skin, including the most common sites of suspected primary melanoma (perineal skin; base of tail; external genitalia; limbs and trunk), was normal. In the abdominal cavity, a large darkly pigmented mass, 8 × 6 × 3 cm, surrounded the anterior pole of the right kidney, in the region of the right adrenal gland (**Figs 1** and **2**), and a large thrombus, 6 × 5 × 4 cm, extended from the mass into the posterior vena cava (**Fig 1**). In the thorax bilaterally from the thoracic inlet to the level of the 7th ribs, scattered firm dark red/black masses were present on the parietal pleura (**Fig 3**). Also, a round, black mass, 3 × 2 × 2 cm, was found adjacent to the thoracic aorta. The remaining organs including lymph nodes, liver, spleen, kidney, lung, eyes, guttural pouch and salivary glands were all grossly normal.

Samples of different organs including the adrenal gland, liver, spleen, kidney, lung, aortic lymph node and pleural metastases were collected for histology and immuno-histochemistry (IHC). Bleached control tissues were also included for assessing the effect of bleaching on melanin tissue antigen. Potassium permanganate was used in the bleaching method. S-100 protein (S-100, clone rabbit anti human[1]), melanoma marker HMB-45 (Anti-melanosome, clone HMB45[1]), chromogranin A (Chromogranin A, clone DAK-A3[1]) and synaptophysin (Synaptophysin, clone 27G12[2]) were used in IHC staining.

Fig 1: Gross post-mortem appearance of the equine malignant melanoma. Highly pigmented adrenal gland (red arrow); tumour thrombus, vena cava (blue arrow).

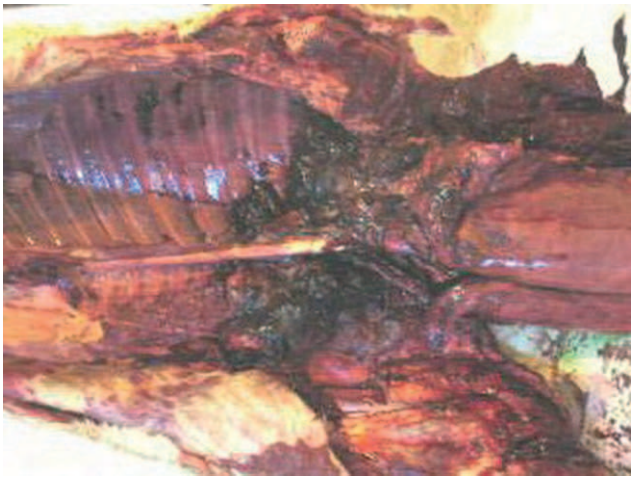

Fig 3: Gross post-mortem appearance of the malignant melanoma in the thoracic cavity. Darkly pigmented metastatic tumour masses attached to the chest wall.

Fig 2: Gross post-mortem appearance of the malignant melanoma of the right adrenal gland (after fixation).

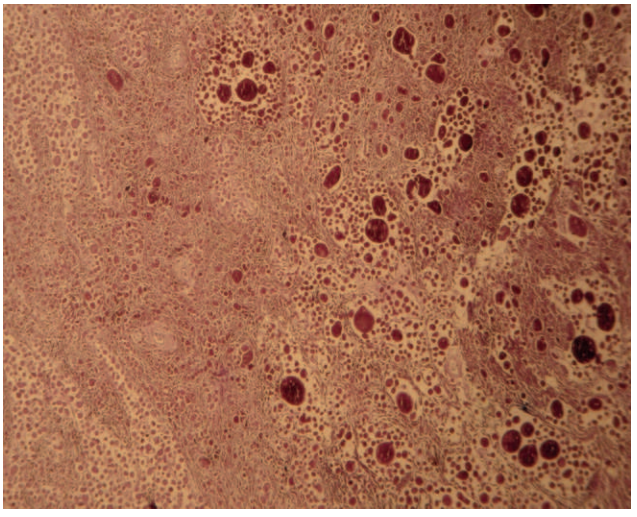

Fig 4: Photomicrograph showing the malignant melanoma of the right adrenal gland. Tumour cells have variable morphology. Bleached and stained by Mayer haematoxylin, ×100.

Samples were fixed in 10% neutral buffered formalin for microscopic examination. Tissues were processed and embedded in paraffin wax after fixation for 48–72 h, sectioned at 4–5 μm and stained with Haematoxylin & eosin (H&E). Another set of identical sections of the highly melanin-containing tissues were bleached first, followed by Mayer haematoxylin staining. Darkly pigmented samples including the adrenal gland, pleural metastases and the aortic lymph node were bleached followed by IHC using aforementioned antibodies. The IHC-stained sections counterstained with Mayer haematoxylin. Control sections of darkly pigmented samples were also immunostained.

The cells in the adrenal mass consisted of nests of variable sized, epithelioid cells containing melanin, with an interstitial, fine, fibrovascular stroma (**Fig 4**). These anaplastic melanocytes contained intracytoplasmic black/dark brown granules. Bleaching of tissue sections removed the dark pigments and allowed better evaluation of cellular and nuclear details. Tumour cells exhibited variation in nuclear morphology with prominent nucleoli. There were some giant cells with large nuclei, enclosing one or more nucleoli. Few mitotic figures were seen. The nuclear and cytoplasmic appearance of the cells in the pleural metastases and the aortic lymph node was similar to those in the adrenal gland. Histological examination of the visceral organs revealed multiple small metastatic foci in the liver, spleen, kidney and lung.

Melanin bleaching followed by IHC staining of samples of the adrenal mass, pleural metastases and the aortic lymph node were strongly positive for S-100 protein and melanoma marker HMB-45. However, IHC stains for neuroendocrine markers, chromogranin A and synaptophysin, were negative.

Discussion

In the present case a black, pigmented mass was detected in the right adrenal gland of a 7-year-old grey horse with invasion of the adjacent posterior vena cava and metastasis to the thorax. Smaller lesions were found, histologically, in the liver, spleen, lung and kidney. A diagnosis of malignant melanoma was made, based on histological and IHC examination. Erosion of neoplastic thrombus into the vena cava is a characteristic of adrenal tumours in other species (Capen 2002). Thus, in the absence of detectable lesions in the other common primary sites of melanoma in the horse, the adrenal gland was considered to be the primary site in this animal, with extension into the vena cava. A primary adrenal origin can be explained by the fact that adrenal medullary blasts and melanoblasts, similar to the nervous system and the skin, are of neuroectodermal origin. Therefore, ectopic melanocytes can exist in this location and develop metaplasia and malignant transformation, leading to the emergence of a melanoma (Carstens *et al.* 1984). However, primary melanoma of the adrenal gland is rare, as demonstrated by the very few cases described in the literature (Gonzalez-Saez *et al.* 2011), whereas metastatic spread of malignant tumours to the adrenal glands is relatively commonly seen in people with lung, breast, gastric carcinomas and malignant melanoma (Carstens *et al.* 1984).

In the current case, expression of melanoma and neuroendocrine markers were used to confirm the diagnosis of melanoma. Routine IHC staining procedures, in which tissue sections are bleached with melanin followed by immunostaining, could cause loss of antigen. Hongwu and Wengiao (2015) treated melanin-containing and melanin-free samples with three bleaching methods: trichloroisocyanuric acid (TCCA), potassium permanganate and potassium dichromate. Their results demonstrated that all three bleaching methods efficiently bleached melanin but also partially destroyed tissue antigen. However, according to Orchard and Calonje (1998), antigens S100, HMB-45, NKIC3, CD34 and L26 are relatively unaffected by application of a modified potassium permanganate/oxalic acid melanin bleaching procedure. In the current case, by reduction of bleaching time, the antigen degradation rate decreased to an acceptable level, so that sufficient antigens were preserved after bleaching.

Equine melanocytic tumours are generally expansive in nature and clinical signs may manifest only when the size of the tumour compromises the function of affected organs (Pasco and Summers 1981). In the present case, the clinical signs were considered to be related to the lesion in the thorax similar to those reported by Mair and Brown (1993), and the presence of the abdominal mass may have contributed to the colic.

To the author's knowledge this is the first report of an equine malignant melanoma potentially originating in the adrenal gland. A comprehensive post-mortem examination failed to identify an origin in other tissues commonly associated with melanoma in the horse (Capen 2002; Goldschmidt and Hendrick 2002), and therefore, the adrenal gland was considered to be the primary site.

Author's declaration of interests

No conflicts of interest have been declared.

Ethical animal research

The animal was treated in compliance with the guidelines of Animal Welfare Committee of the Research Deputy of Razi Vaccine and Serum Research Institute, Karaj, Iran.

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[2]Novocastra, Newcastle upon Tyne, UK.

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Case Report

Use of negative pressure wound therapy in three horses with open, infected olecranon bursitis

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Keywords: horse; negative pressure wound therapy; olecranon bursitis; infection; granulation tissue

Summary

This article describes the clinical use of negative pressure wound therapy (NPWT) in three horses with an open and infected subcutaneous olecranon bursa, in which prior surgical excision followed by primary closure was unsuccessful. The wounds filled in rapidly with granulation tissue and contracted during therapy. All wounds subsequently went on to heal without complications. The use of NPWT was well tolerated in all three horses and facilitated healing in a difficult area.

Introduction

Negative pressure wound therapy (NPWT) has been researched and used clinically in people and small animals. There is a single report describing its use in a horse (Gemeinhardt and Molnar 2005). Many terms have been employed to describe negative pressure wound therapy (NPWT) including vacuum-assisted closure and sub-atmospheric wound dressing. In this article, the term NPWT will be used for consistency with the recent literature.

There is a significant body of research in the human medical literature on the effects of NPWT without a clear consensus as to the specific effects at the molecular level (Glass *et al.* 2014). The removal of exudate, the increase in blood flow to the wound, and the formation of granulation tissue are recognised effects of NPWT (Pitt and Stanley 2014). A systematic review of the potential effects concluded that NPWT induces an anti-inflammatory cytokine profile in the wound bed combined with mechanical and chemoreceptor cell signalling effects on angiogenesis, remodelling of the extracellular matrix, and granulation tissue formation (Glass *et al.* 2014).

In small animal veterinary medicine several articles have been published regarding both the clinical use and efficacy of NPWT. Two clinical investigations of canine wounds managed with NPWT revealed that there was an associated learning curve in the application and management of the technology but also satisfaction with the final healing outcomes (Ben-Amotz *et al.* 2007; Pitt and Stanley 2014). Furthermore, two clinical controlled studies observed beneficial effects when open wounds and free skin grafts were managed with NPWT in dogs (Demaria *et al.* 2011; Stanley *et al.* 2013). The use of NPWT was also compared with a silver coated foam dressing on experimental open canine wounds and revealed that NPWT halved the healing time compared with foam dressings and that both had faster healing times compared with conventional bandages (Nolff *et al.* 2015). There is one published report of NPWT use in a horse in the English veterinary literature and it is mentioned elsewhere without specific details (Gemeinhardt and Molnar 2005; Pitt and Stanley 2014). A large equine neck wound was treated with NPWT and a satisfactory healing in a faster time than expected was noted. The NPWT system was applied with a continuous negative pressure of −125 mmHg for 27 days with dressing changes every 3–4 days (Gemeinhardt and Molnar 2005).

The goal of this descriptive case series is to report the clinical use of NPWT following surgical excision of chronic, infected, open, subcutaneous olecranon bursitis. In the horse open olecranon bursitis is known to have a prolonged healing response because of the anatomical location and movement (Honnas *et al.* 1995). Complete surgical excision is recommended as management with drainage and wound care is commonly inadequate to effect healing (Honnas *et al.* 1995). The treatment with NPWT of three horses with open, draining subcutaneous olecranon bursitis in which the skin was unable to be closed by primary intention after excision are described.

Case details: history and clinical findings

Case 1

A 5-year-old Warmblood gelding presented to the equine hospital for an olecranon bursitis of the right elbow. The gelding had been previously admitted to the hospital 4 months earlier for an acute swelling of the right forelimb. At that time he had undergone physical, radiographic and ultrasonographic examinations. The final diagnosis was an infected, subcutaneous olecranon bursa and an associated cellulitis of the limb. The infected bursa had been lanced with a small stab incision of approximately 2 cm in length, drained under standing sedation, and the horse had been placed on systemic antimicrobials (oral trimethoprim-sulphonamide for 10 days). A culture and sensitivity were not performed. The swelling of the limb had rapidly resolved and the horse was discharged with instructions for continued care of the drainage and restricted exercise. When the horse returned 4 months later, it had a large, open, draining, subcutaneous bursitis of the right olecranon. The open wound was approximately 12 cm by 8 cm in size. The exposed tissue appeared necrotic and purulent drainage was present. At this time the limb was not swollen and there was no overt lameness.

Case 2

A 20-year-old Quarter Horse mare presented to the hospital for an open, draining subcutaneous olecranon bursitis of the right forelimb that had been present and increasing in size over several years. The bursitis was not noted to have been opened or drained but rather developed an associated wound from trauma due to being swollen and protruding (**Fig 1**). The mare was in good general health and no lameness was present. The distal limb was not swollen. The open wound of the subcutaneous olecranon bursa was 15 cm by 10 cm in size with exposed necrotic tissue and purulent drainage.

Case 3

A 17-year-old Warmblood mare presented for an infected subcutaneous olecranon bursitis that had been opened and drained by the referring veterinarian several months previously. The opening had gradually enlarged and failed to heal. On presentation there was a 10 cm by 10 cm enlargement of the olecranon bursa and surrounding skin with an open wound in the skin of 3 cm by 5 cm on the palmar aspect with necrotic tissue and purulent drainage. No overt lameness was present and the distal limb was not swollen.

Surgery

In all three cases the skin and tissue surrounding the olecranon bursa was thickened, indurated, and firm. The open wounds in the skin were large and this, combined with the inelastic nature of the skin, eliminated the possibility to perform a neat lateral surgical excision and primary closure (Honnas *et al.* 1995). However, the fact that the subcutaneous olecranon bursitis had caused a gradual enlargement of the bursa and overlying skin dictated that surgical excision was necessary to prevent recurrent trauma and to foster a healing response. All horses had been treated at home for several months with standard wound care by the referring veterinarians and in all cases the infected bursa had continued to enlarge.

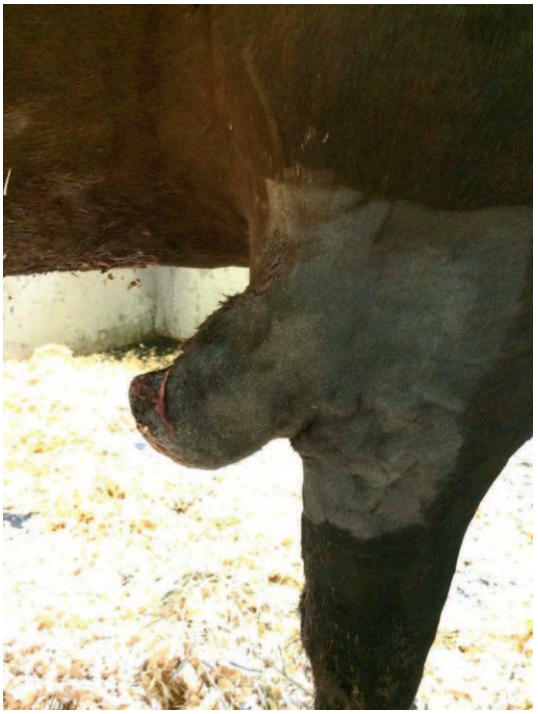

Fig 1: The enlarged olecranon bursa of Horse 2. The open draining portion was directly palmar and therefore not visualised in this picture.

All horses were administered systemic broad spectrum antimicrobials and anti-inflammatory medications immediately prior to surgery and these were continued for 3 days post-operatively. Antimicrobicals were administered to prevent bacteraemia from manipulation of chronically infected tissues and to limit reinfection of healthy underlying tissue. Intravenous sedation for standing surgery was administered and an inverted U block with 2% lidocaine injected subcutaneously was performed proximally and to either side of the bursa. The infected tissue and skin were then resected preserving as much healthy skin as possible but excising all of the infected tissue. In all three cases the skin was initially opposed proximally with a small opening left for drainage ventrally and a stent bandage applied. Horses were then kept on box rest and the stent bandage was changed every 2 days. Substantial purulent exudate was noted at the time of bandage change in all cases with potential maceration of the wound edges. In all three cases the suture line dehisced at 5–7 days and the skin retracted open once more. The result was an open circular wound with a concavity in the interior where all the abnormal tissue had been removed.

Negative pressure wound therapy was then applied to all three horses in an attempt to improve and shorten the healing time. The skin surrounding the surgical sites had already been clipped for surgery but was reclipped and shaved to remove all the hair to facilitate a secure attachment of the apparatus to the skin. The wound was cleaned and a silver impregnated foam (V.A.C. granufoam silver™)[1] was cut to the size of the wound and inserted into the wound. The surrounding skin was then sprayed with an adhesive spray (Vi-Drape®)[2] and the adhesive drape applied to seal the area. A small hole was then cut in the adhesive drape over the foam and the suction cup and tubing applied (**Fig 2**). The tubing was then attached to the vacuum pump unit (V.A.C. TracPad™, V.A.C. Freedom)[1] and the suction turned on. If a seal had not been obtained, additional adhesive drape was applied to the site. The vacuum pump and canister were suspended from a ceiling hook that was usually employed for fluid therapy administration (**Fig 3**). Horses were monitored and maintained on continuous therapy at −125 mmHg for the first 24 h and then intermittent therapy with 5 min on, 2 min off, with a negative pressure of −125 mmHg for the remainder of the therapy. The dressing was changed every 3–4 days until the wound had filled in with healthy granulation tissue to the level of the skin. Sedation was not required for bandage changes. The subjective impression was that all wounds started with a small amount of superficial infection post-surgery as noted by purulent drainage on the stent bandages and this improved rapidly with the NPWT therapy. At the time of the first bandage change at 3–4 days the wounds had healthy, red granulation tissue present. No irritation of the surrounding healthy skin was noted during therapy.

Outcome

All horses tolerated the NPWT very well. No discomfort was noted during use and horses moved freely around the stall.

Fig 2: The same horse as Fig 1 (Horse 2) with the abnormal tissue excised and the NPWT therapy applied. A distal limb bandage has been placed and it supports the adhesive dressing placed above it.

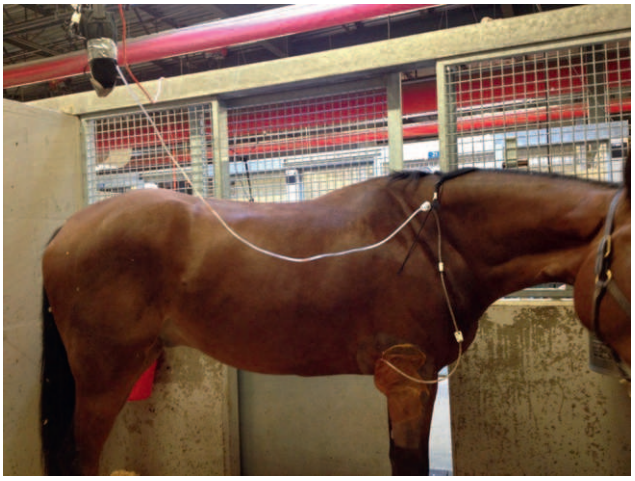

Fig 3: Horse 1 with the NPWT applied in the stall. The apparatus and canister are attached firmly to the fluid hook in the stall with duct tape thereby allowing the horse to move freely in the box. The suction line is attached to the mane and then descends to the wound site. A sticky adhesive dressing and generous applications of adhesive spray are employed to seal the periphery of the wound to maintain continuous negative pressure. No distal limb bandage was used in this horse.

The clinical outcome was satisfactory as all the wounds filled in completely with healthy granulation tissue and contracted significantly during the NPWT therapy. Horse 1 had the NPWT for a total of 11 days, Horse 2 for 12 days total (**Fig 4**) and Horse 3 for 22 days. Nonsteroidal anti-inflammatories and antibiotics were not given throughout the duration of the NPWT therapy for the first two horses. Oral antimicrobial therapy with trimethoprim-sulphonamide was given in Horse 3 for the duration of treatment at the medically trained owners insistence. The application of the NPWT did require a learning curve and the first horse required several early changes of the bandage due to loss of suction. However the application became easier with time and the latter two horses maintained their bandage without difficulty. No horse was noted to lie down during the hospital stay although they were not cross-tied to prevent this from happening.

Horses were all discharged shortly after the NPWT was removed as the wounds were judged to be sufficiently healed to no longer require intensive care (**Fig 4**). Instructions were given to continue with box rest for 2 weeks after discharge from the hospital followed by a slow return to athletic activity if desired.

Follow-up conversation with the referring veterinarians 2 years after the horses had left the hospital revealed that all the wounds had completely healed without difficulty or recurrence of the bursitis. A small scar was visible at the site of the bursitis in all cases and in Horse 2 hair had failed to regrow at the site of the bursitis (**Fig 5**). Horses had returned to their intended use as pleasure riding horses.

Discussion

This is the first study to describe the successful application and tolerance of NPWT in a case series in horses. There are several interesting points that can be raised. First, the use of NPWT therapy was very well tolerated with no signs of discomfort or pain. Discomfort has been observed in human subjects with NPWT although this finding is not consistent (Borgquist *et al.* 2010; Ren *et al.* 2017). Discomfort during therapy does not appear to be an important consideration in horses based on these three adult horses. Second, a learning curve was noted for the ability to obtain a good seal around the wound as has been reported in other veterinary studies. We observed that the use of a razor to remove small hairs in addition to clipping, careful cleaning of the surrounding skin, drying the skin, and the application of an adhesive spray to enhance stickiness, all appeared to help to maintain the seal. Complete coverage by adhesive spray (Vi-Drape®)[2] on the surrounding skin as well as allowing time for the spray to air-dry prior to application of the adhesive drape was also perceived to be important to obtain a long-lasting seal. Third, no problems of irritation of the surrounding skin were identified with the repeated applications of the adhesive spray or drapes (**Fig 4**). The site was unable to be covered by a protective bandage but occasionally a lower limb support bandage was placed along the most ventral aspect of the dressing to help maintain it in place (**Fig 2**).

The choice of the amount of pressure and the initial period of continuous negative pressure followed by intermittent negative pressure was influenced by studies in dogs and communications with small animal surgeons. The choice of −125 mmHg is common to most small animal studies (Pitt and Stanley 2014; Nolff *et al.* 2015). A continuous negative pressure was used for the first 24 h to accustom the horse to the apparatus and then changed to an intermittent negative pressure as some studies have shown this to be advantageous with improved granulation tissue formation (Borgquist *et al.* 2010; Malmsjo *et al.* 2012; Stanley 2017). The choice to change the dressing every 3–4 days was also based on use in small

animals and the fact that the canister would often be full of discharge at or around 72 h of use (Stanley 2017). The use of intermittent or continuous negative pressure and the amount of negative pressure requires further study in the horse.

A silver impregnated foam was placed in the wounds as all three were chronically infected. The horses did not have clinical signs of cellulitis around the wound area and antibiotics were not routinely administered or judged to be necessary. As the NPWT removes the discharge, it provides excellent drainage. At the time of the first dressing change after NPWT was started (3–4 days after NPWT and around 8–10 days after surgery) the wounds appeared healthier with red granulation tissue starting to appear (**Fig 4**). This may have been coincidental with increasing time after surgery, however the subjective impression of improvement in the appearance of the superficial infection with NPWT remained strong. Studies have been performed evaluating the effect of NPWT on infection and are controversial. Some studies show a potential enhanced bacterial clearance and diminished infection whilst other studies show higher bacterial numbers with NPWT (Moues *et al.* 2004; Weed *et al.* 2004; Lalliss *et al.* 2010; Demaria *et al.* 2011). Silver impregnated foams are reported to enhance the removal of bacteria when used with NPWT (Stinner *et al.* 2011; Stanirowski *et al.* 2015). The effect of NPWT on equine infected wounds remains to be elucidated as does the effect of different foams. In a recent study of different foams and NPWT in an equine ex vivo wound model, silver impregnated foam was effective at reducing Pseudomonas infection but not MRSA (Van Hecke *et al.* 2016). In that study polyvinyl alcohol foam was the most effective in reducing both types of bacteria in the wounds. The effect of foam type on different bacterial populations and wound healing with NPWT requires further study in horses prior to any recommendations being made as to the optimal foam to be used.

There were no control horses with which to compare these three horses so the results are purely subjective in nature. The granulation tissue which formed in the wounds during NPWT was solid and red, healthy in appearance, and healing progressed rapidly. This is subjective and no horses were treated with surgery and traditional wound care after dehiscence to provide a comparison. Primary surgical excision has been used successfully in four reported cases and by the authors themselves but these three horses had particularly advanced and chronically infected, open bursitis and primary surgical excision had failed (Honnas *et al.* 1995).

The healing of subcutaneous olecranon bursitis can be impeded when the horse lies down repeatedly and re-traumatises the area with a hoof. These horses were not routinely cross-tied but did not show an inclination in the hospital for repeated or prolonged episodes of recumbency. Cross-tying or tying to an overhead wire to prevent recumbency could be considered if the dressing was repeatedly disrupted by this activity. The use of the overhead hook, normally employed for fluid administration in our hospital, to suspend the NPWT apparatus and canister facilitated its application and allowed the horses to move

Fig 4: The progression of healing with NPWT for Horse 2 from the first bandage change. A progressive decrease in size is noted with the appearance of granulation tissue. At the end of 14 days there is obvious wound contraction and progression of epithelialisation at the periphery.

Fig 5: A follow-up photograph of Horse 2, 2 years after discharge showing a scar and lack of hair regrowth at the site of the olecranon bursitis.

about the stall without twisting and eventually kinking the tubing. We have also attached the apparatus and canister to a surcingle when treating other wounds which also worked well. Using the fluid hook avoided potential damage to the suction apparatus by rolling.

The cost of the treatment could not be compared with conventional therapy as there were no control horses. The length of therapy was judged to be quite short (11, 9 and 22 days) compared with memory of other similar cases and bandage changes were limited to every 3–4 days. Cost was not thought to be a limiting factor in the application of the NPWT. As antibiotics and anti-inflammatories were discontinued in two horses and sedation was not required for bandage changes the costs of maintaining the NPWT was minimal. The foam dressing and new canister and tubing were the most important costs. Several studies concerning the cost effectiveness of NPWT have been performed in the human medical field with some finding substantial cost savings with NPWT compared with traditional dressings (Liu *et al.* 2017) while some found comparable costs (Heard *et al.* 2017).

Recently the development of a NPWT system with the ability to allow instillation of topical wound therapies is thought to benefit wound healing even further than NPWT alone (Kim *et al.* 2015; Gupta *et al.* 2016). Investigation of this development in horses is warranted given the positive results in other species.

The fact that two of the three horses had an iatrogenic opening made by a veterinarian in order to drain a presumptively infected subcutaneous olecranon bursitis which then expanded to a large wound and failed to heal is also worthy of mention. While it is likely that in both horses an attempt was made to place the drainage incision laterally and of a small size, in both cases it progressed to a large open wound probably as a result of repeated trauma. This area is prone to repeated trauma during recumbency and there is marked movement and tension on the skin during flexion of the elbow. A prior publication also reported failure of healing with open drainage and medical management (Honnas *et al.* 1995). The treatment of a closed subcutaneous olecranon bursitis that is inflamed with clinical signs suggestive of infection should potentially be limited, at least initially, to medical management alone. If drainage of an infected closed bursitis is necessary then potentially the placement of an active suction drain with primary closure of the incision at the time of removal may be one option. Endoscopic debridement and lavage could also be considered as this has been extensively employed for treatment of calcaneal septic bursitis. Cultures were not performed in these horses and potentially needle aspiration and culture of the bursa would be recommended at the time of initial presentation to guide appropriate antimicrobial use.

The application of NPWT to the equine wounds in this study permitted rapid progression of a healthy appearing granulation tissue and marked contraction similar to clinical reports of beneficial effects of NPWT therapy in small animals in a clinical context (Ben-Amotz *et al.* 2007; Demaria *et al.* 2011; Pitt and Stanley 2014). Studies in dogs have also commented on the increased speed of healing in comparison to conventional bandaging (Nolff *et al.* 2015). The equine wounds reported here were large, deep, chronically infected wounds in a challenging site and the final clinical outcome was judged to be excellent. The installation and management of the NPWT apparatus became easier with time and experience. The use of NPWT in horses has merit and deserves further study based on the clinical experience gained with these three horses.

Authors' declaration of interests

No conflicts of interest have been declared.

Ethical animal research

Not applicable.

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Authorship

All authors contributed to the study execution and final approval. Y. Elce prepared the manuscript and S. Laverty contributed to its development.

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Case Report

Small intestinal adenomatous polyps resulting in chronic obstruction in a 3-year-old Quarter Horse gelding

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Keywords: horse; adenomatous polyp; colic; ultrasound; tumour

Summary

A 3-year-old, Quarter Horse gelding was admitted to Kansas State University Veterinary Health Center with a primary complaint of colic. The horse had a 3-month history of recurrent colic and progressive weight loss. On physical examination, the horse was quiet, alert and responsive. The horse's mucous membranes were pink and capillary refill time was 2 s. His rectal temperature was 37.6°C (99.6°F), heart rate was 56 beats/min and respiration rate was 16 breaths/min. Rectal palpation revealed an approximately 5 cm dilated, firm, tubular, mass traversing from left caudal abdomen to mid abdomen. Nasogastric intubation obtained 6 L net reflux. A 5 cm diameter small intestinal intraluminal mass was detected by abdominal ultrasound. Complete blood count, serum chemistry and peritoneal fluid analysis were performed and all results were unremarkable. The horse was humanely euthanised due to pain and financial constraints. Post-mortem examination and histopathology revealed a 15 × 5 × 5 cm polyp with multiple smaller satellite polyps that obstructed the distal duodenum. Colic was considered secondary to small intestinal obstruction and luminal distension caused by the adenomatous polyps. To the authors' knowledge, this is the first report to include ultrasound images of a small intestine adenomatous polyp that caused small intestinal obstruction and colic in a 3-year-old horse.

Introduction

Small intestinal neoplasia has been previously described in domesticated species including the horse. Intestinal neoplasia in the horse is uncommon; however, it has been reported to be the cause of severe gastrointestinal disease and death. Small intestinal tumours are reported to cause obstruction, alter intestinal motility, and cause protein losing enteropathy in horses (Patterson-Kane *et al.* 2000; Watt *et al.* 2001; Gold *et al.* 2006; Moran Muñoz *et al.* 2008). Adenomatous polyps are benign neoplastic lesions composed of tubular, villous or tubulovillous intestinal epithelial proliferations. Adenomatous polyps have been reported in the intestinal tract of cattle, sheep, cats, dogs, horses and humans (Patterson-Kane *et al.* 2000; Saulez et al. 2004; Furness *et al.* 2013). In humans, villous adenomas are most commonly found in the duodenum (Levine and Kaplan 1996). A definitive diagnosis of small intestinal neoplasia is usually made post-mortem or histologically. The objective of this paper is to describe the history, clinical examination findings, diagnostic ultrasound images, post-mortem and histological findings of a 3-year-old Quarter Horse gelding diagnosed with small intestinal adenomatous polyps.

Case history

A 3-year-old, Quarter Horse gelding (363 kg) was admitted to the Kansas State University Veterinary Health Center with a primary complaint of colic. The horse had a 3-month history of recurrent colic and progressive weight loss. The horse had been housed in a 7.3 × 7.3 m (24 × 24 ft) run and was routinely turned out on brome pasture. He was fed quality brome grass hay and pelleted feed and was ridden 2–3 times/week. The horse had never showed signs of colic while ridden. The horse was administered a 10 mg/kg bwt dose of fenbendazole (Panacur) 2 months prior to presentation. The horse had been showing intermittent colic signs for 3 months prior to presentation and the colic episodes responded to an unknown amount of flunixin meglumine (Banamine) administered intramuscularly by the owner.

Physical examination

The gelding was quiet, alert and responsive with a body condition score 5/9 (Henneke *et al.* 1983). Mucous membranes were pink and capillary refill time was 2 s. The horse's rectal temperature was 37.6°C (99.6°F), the heart rate was 56 beats/min and the respiration rate was 16 breaths/min. Auscultation of the heart and lungs revealed no abnormalities. Abdominal auscultation revealed increased borborygmi and the horse's abdomen did not appear grossly distended. Rectal examination revealed an approximately 5 cm diameter firm, tubular mass traversing from left caudal abdomen to mid abdomen that was associated with the small intestine. Nasogastric intubation obtained 6 L net reflux.

Clinical diagnostics

All haematological and serum biochemical results were within reference ranges. Peritoneal fluid analysis revealed a normal total nucleated cell count of 1.2×10^9/L (rr <1.5–5.0 $\times 10^9$/L) and total protein of 0.3 g/L (rr <0.1–0.2 g/L) (Brownlow *et al.* 1981). Abdominal ultrasound revealed a small intestinal luminal mass in the cranial ventral abdomen 10 cm cranial to the umbilicus and 5 cm to the right of midline as shown in **Figure 1**. The mass was heterogeneous in appearance with a distinct hyperechoic wall with a hypoechoic intraluminal center.

Differential diagnosis

A clinical diagnosis was made of a small intestinal intraluminal mass causing secondary intestinal obstruction. The ultrasound and rectal findings supported our clinical diagnosis. Differential diagnoses included small intestinal foreign body,

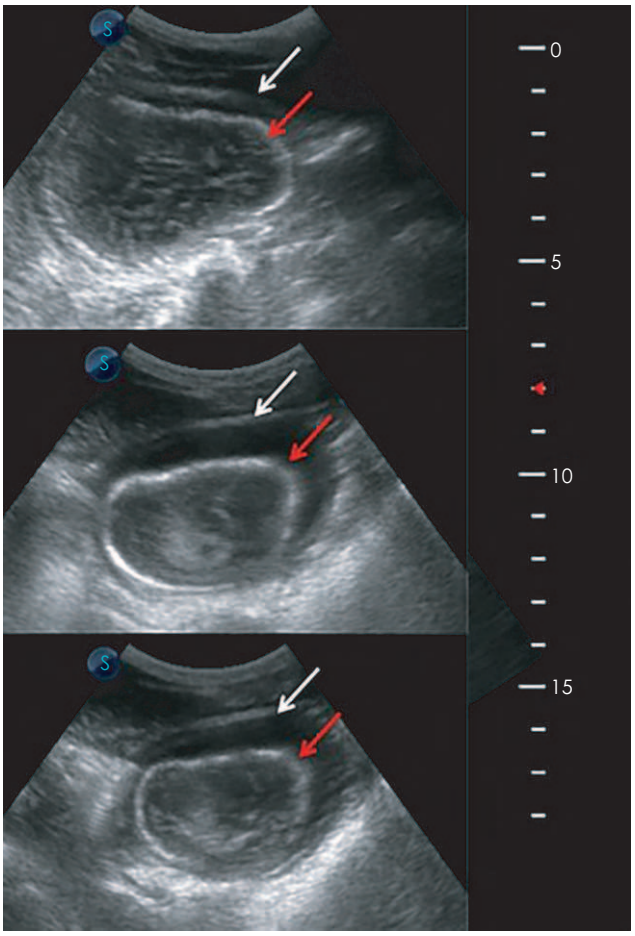

Fig 1: Intraluminal 5 cm diameter mass with a heterogeneous appearance. Hyperechoic small intestinal wall (white arrow) is clearly distinct from the heterogeneous intraluminal mass (red arrow).

intussusception and neoplasia. The ultrasound images did not appear as the previously reported description of a small intestine intussusception (Fontaine-Rodgerson and Rodgerson 2001). This made foreign body and neoplasia the top two differential diagnoses.

Recommendations and treatments

Exploratory celiotomy was recommended on the basis of the horse's lack of response to analgesia, physical examination and ultrasound findings. However, the owner declined this recommendation. The horse was managed conservatively. Total nasogastric reflux was 17 L over the next 12 h. The horse started to show signs of colic 8 h after the initial presentation and was administered 7 mg detomidine intravenously (Dormosedan) (0.02 mg/kg bwt) (Jöchle 1989). The horse continued to show signs of colic and the owner elected humane euthanasia due to financial constraints. The horse was submitted for necropsy.

Gross finding post-mortem

Necropsy revealed an enlarged segment of proximal jejunum measuring 15 cm with occasional serosal petechiae (**Fig 2a**). Approximately 1 m aborally from the pylorus, at the junction of the distal duodenum and proximal jejunum, there was a 15 × 5 × 5 cm pedunculated dark red polypoid ulcerated mass occluding the intestinal lumen (**Fig 2b**). There were multiple smaller polypoid masses ranging from 1 to 5 cm in length with 1–2 cm diameter adjacent to the larger polypoid mass. The polyps were distributed with one immediately oral, four were 5 cm oral, and two immediately aboral to the large polypoid mass. The large polypoid mass was dark red and congested. The mucosa was ulcerated on the distal end and partially adhered to the intestinal mucosa. The small polyps were tan to pinkish red on the surface. On cut section, the polyps had thickened yellow gelatinous material (oedema) within the mucosa. In addition, the mucosa had multifocal dark red areas with mineralisation. Approximately 10 cm oral to the large polypoid mass, there were multifocal 1–5 cm, linear, mucosal ulcers along the mesenteric side of the intestinal lumen. Throughout the entire length of the jejunum the mucosal surface had both scattered and diffuse areas of haemorrhage. There were no significant gross lesions noticed in any other tissues.

Histopathology

The intestinal mucosa of the distal duodenum and proximal jejunum were multifocally elevated into polypoid masses and the masses were lined by normal mucosal epithelium. The submucosa was markedly expanded by oedema (**Fig 2c**). The mucosa lining the polyps was hyperplastic characterised by multifocal areas of proliferation configured in a branching pattern. The mucosa lining the largest polypoid mass was ulcerated and the submucosa contained infiltrates of lymphocytes, plasma cells, and macrophages. The submucosal glands showed moderate goblet cell hyperplasia (**Fig 2d**) with moderate oedema in the deep submucosa admixed with small numbers of mixed inflammatory cells and occasional mineralisation. There were no significant microscopic lesions noticed in the ileum, caecum, or large colon.

Discussion

This case report describes the clinical and post-mortem diagnosis of intestinal adenomatous polyps resulting in colic due to chronic obstruction in a 3-year-old Quarter Horse gelding. Small intestinal tumours occur uncommonly and are typically a diagnosis of exclusion; however, in this case abdominal ultrasonography improved the clinical diagnosis (Reef 2012). Horses with intestinal neoplasia usually present for colic and/or a history that includes progressive weight loss, decreased appetite, intermittent colic, diarrhoea, or fever (Taylor *et al.* 2006).

Following full clinical examination in this case differentials included neoplasia, foreign body and small intestinal intussusception, because of the history, clinical examination findings and transudative peritoneal fluid (Fontaine-Rodgerson and Rodgerson 2001). The ultrasound provided key information on forming a clinical diagnosis of intraluminal neoplasia and an exact location for the cause of colic. The ultrasound images of the intraluminal polyp had a distinct hyperechoic luminal margin with a round heterogeneous intraluminal mass located centrally. This is in contrast with previous reports of intussusception where the classical ultrasound description is of a distinct hypoechoic ring which is the intussuscipiens surrounding a distinct hyperechoic centre which is the intussusceptum that was not observed in this case (Fontaine-Rodgerson and Rodgerson 2001). To the

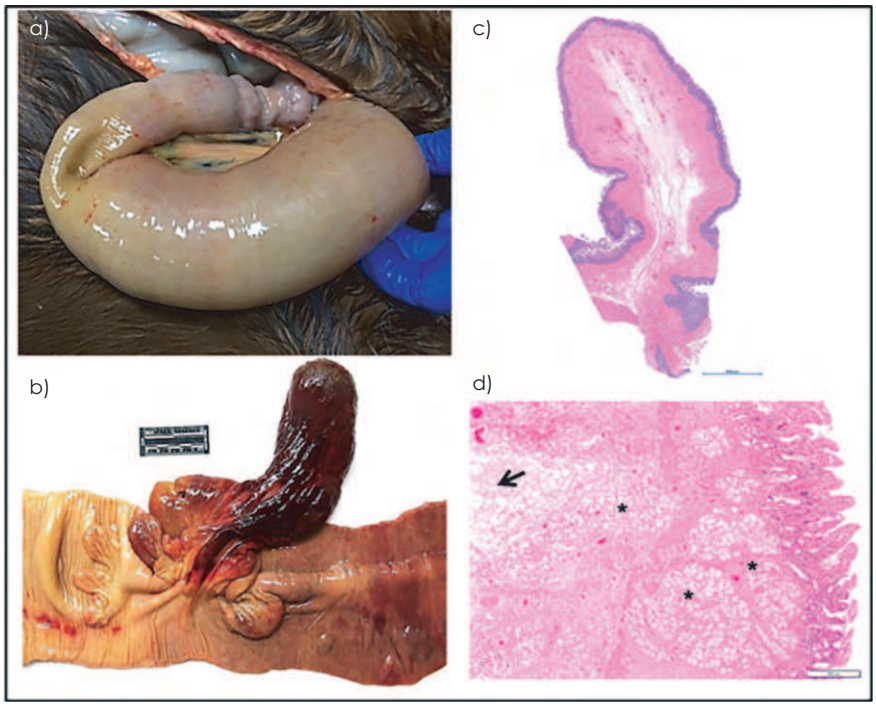

Fig 2: Gross and microscopic image of a distal duodenal polypoid mass. a) In situ image of the exteriorised aboral portion of the luminal mass in the proximal jejunum. A clear demarcation can be visualised between the markedly distended and normal jejunum. b) Jejunal lumen showing a pedunculated dark red mass arising from the mucosa. Similar smaller polypoid masses are located oral and aboral to the large polypoid ulcerated mass. c) The mucosa is elevated into a polypoid mass with submucosa continuing into the polyp. The submucosa is expanded by oedema. d) Higher magnification (40×) of the polypoid mass showing mucosal hyperplasia, submucosal oedema (arrow) with submucosal mucosal glandular hyperplasia (asterisks).

authors' knowledge, this is the first case report to include an ultrasound image of a small intestinal adenomatous polyp in the horse.

On gross and microscopic examination, the mucosa was elevated and continuous with the normal mucosal epithelium forming multiple elevated polypoid masses. The mucosal epithelium showed occasional branching with no evidence of infiltration into the submucosa. The features identified by gross and microscopic examination were consistent with intestinal mucosal adenomatous polyps causing mechanical obstruction in the distal duodenum as previously reported (Patterson-Kane *et al.* 2000).

In contrast to previous cases of intestinal neoplasia, no protein losing enteropathy was identified in this case (Datt and Usenik 1975; Colbourne *et al.* 1996; Gold *et al.* 2006; Taylor *et al.* 2006; Moran Muñoz *et al.* 2008), suggesting that not all intestinal polyps are associated with weight loss and protein losing enteropathy. However, the mechanical obstruction caused by growing polyps can result in colic; hence, it is important to rule out polyps as one of the differential diagnoses. In cats diagnosed with adenomatous polyps, chronic abdominal pain, vomiting, and melena have been described (MacDonald *et al.*1993). The history of this particular horse having chronic episodes of colic parallels the clinical signs of gastrointestinal abnormalities associated with adenomatous polyps in other species. The clinical findings were consistent with obstruction and a likely surgical lesion. Intestinal polyps have been reported in foals to cause bowel obstruction and intussusception. To the author's knowledge, it is currently unknown whether intestinal neoplasia is congenital in the horse (Colbourne *et al.* 1996; Gold *et al.* 2006). In horses, intestinal adenomatous polyps may occur spontaneously or as part of one of several large intestinal inherited syndromes (Patterson-Kane *et al.* 2000). In this case, it could not be determined whether or not this 3-year-old Quarter Horse gelding's intestinal neoplasia was congenital or acquired.

In summary, small intestinal tumours occur uncommonly in horses and are typically diagnosed on post-mortem examination. However, as in this particular case, ultrasonography can prove to be valuable in distinguishing a small intestinal intraluminal polyp from a small intestinal intussusception. The ante-mortem clinical diagnosis of small intestinal intraluminal neoplasia was confirmed by gross and histopathological examination. The neoplasia was identified as a small intestinal adenomatous polyp. Ultrasonography is a valuable diagnostic tool to utilise in horses exhibiting progressive intermittent signs of colic, especially in young horses.

Authors' declaration of interests

No conflicts of interest have been declared.

Ethical animal research

This case report passes ethical review.

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Authorship

All authors provided equal contributions to the manuscript.

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Clinical Commentary

Use of transabdominal ultrasonography in the acute abdomen: Has it really revolutionised our colic work-ups?

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Keywords: horse; colic; ultrasonography

Colic is one of the most economically important diseases affecting the horse industry and one of the most common reasons why horses present to a veterinarian as an emergency. It is the leading cause of death in equids between the ages of 1 and 20 years (National Animal Health Monitoring System (NAHMS) 2017). The equine practitioner is familiar with the routine colic work-up, which generally at minimum includes a physical exam, rectal exam and nasogastric intubation. While the majority of horses with signs of colic will respond to medical management, it is extremely important for the primary veterinarian to determine whether the horse can be treated medically, or if a recommendation for referral to a surgical facility should be made.

The decision for surgery is primarily based on the degree of abdominal pain, its ability to be controlled by medication and the results of examination and diagnostic tests. While uncontrollable pain alone can be reason enough to elect for exploratory laparotomy, if a horse's comfort can be maintained then gastrointestinal specific tests should be performed and interpreted in an attempt to formulate an appropriate treatment plan. Does the horse have distended small intestine or significant gas distention of the large intestine on rectal exam? Does the horse have excessive gastric fluid? Does abdominocentesis yield fluid with abnormal parameters? The equine surgeon may be presented with a clear-cut case for surgery but it is not always that simple. The patient may be too small to safely undergo a rectal exam or the rectal exam may be unremarkable; no gastric reflux may be present; an abdominocentesis may not yield any fluid to evaluate or could be within normal reference ranges. When presented with a scenario such as this, the surgeon must look to ancillary diagnostic tests to determine the best course of action for the patient.

One of the earliest articles reporting the use of ultrasound in equine internal medicine was by Byars and Halley (1986). Their list of gastrointestinal diseases that could be evaluated included mostly those of the liver and spleen, but also included peritoneal effusions, ileus, and bowel displacements and distention, however specific conditions were not described in detail.

Klohnen *et al.* (1996) first reported on the evaluation of the use of transabdominal ultrasound in the equine colic patient. They determined that it was accurate for detecting small intestinal abnormalities and allowed quicker surgical intervention when other diagnostics were unremarkable. These authors did however state that abdominal ultrasound cannot identify the primary small-intestinal lesion. Although not the aim of the study, the authors did observe that horses having primary large-intestinal lesions did have large colon walls that were subjectively more distended and hyperechoic as compared with clinically normal horses; however, at that time they stated that other than for nephrosplenic entrapments, abdominal ultrasonography was non-diagnostic for primary large colon lesions.

Since then, the quality of the ultrasound machine has drastically improved and clinicians have become more experienced. Numerous articles have since been written on the subject, including review articles describing the complete abdominal ultrasound procedure to date (le Jeune and Whitcomb 2014), the development of the fast localised abdominal sonography of horses (FLASH) protocol (Busoni *et al.* 2006), articles covering specific ultrasonographic findings relating to specific diseases (Bernard *et al.* 1989; Santschi *et al.* 1993; Taintor *et al.* 2004; Abutarbush 2006; Buchanan *et al.* 2006; Grenager and Durham 2011; Ness *et al.* 2012; Nielsen *et al.* 2016; Manso-Díaz *et al.* 2018), and articles analysing the accuracy of ultrasonography in the colic patient (Beccati *et al.* 2011; Naylor 2015; Cribb and Arroyo 2018).

le Jeune and Whitcomb (2014) presented a nice review of how to perform a thorough abdominal ultrasound examination in the acute colic patient and provided very high quality images of common gastrointestinal abnormalities that could be present. Busoni *et al.* (2006) described the FLASH protocol. The goal of this protocol is to quickly evaluate a colic patient by evaluating seven different topographical locations. The mean time to complete the evaluation was 10.7 min and clinicians could successfully complete the protocol even without extensive ultrasound experience. The FLASH protocol was able to detect free abdominal fluid and abnormal intestinal loops. When dilated turgid small intestinal loops were found using this protocol, it had positive and negative predictive values of requirement for surgery at 88.89% and 81.48% respectively. Fairburn (2017) reviewed the literature to determine whether a fast scan (the FLASH protocol) has comparable sensitivity and specificity to a detailed exam for finding small and large intestinal lesions requiring surgery. It was concluded that the FLASH examination was indeed comparable, although some limitations in data precluded the ability to fully assess large intestinal conditions. The one concern was whether the FLASH technique would miss some cases of right dorsal displacement of the large colon due to the viewing window being more dorsal than the location of the vessels, which are often near the costochondral junction of the right body wall.

Very specific ultrasonographic findings and how they relate to a definitive diagnosis have been described throughout the literature including left dorsal displacement of the large colon (Santschi *et al.* 1993), small intestinal

intussusception (Bernard *et al.* 1989), ceco-colic intussusception (Taintor *et al.* 2004), pyloric-duodenal intussusception (Buchanan *et al.* 2006), large colon displacement (Grenager and Durham 2011; Ness *et al.* 2012), large colon volvulus (Abutarbush 2006), ascarid burden (Nielsen *et al.* 2016), pedunculated lipomas (Manso-Díaz *et al.* 2018), and described in this issue, the visualisation of a small intestine adenomatous polyp causing intestinal obstruction (Younkin *et al.* 2020). Due to the depth of the adult equine abdomen there are obviously some limitations to the true completeness of the exam. Some of these specific findings are reliably assessed (such as large colon wall thickness and ability to visualise the left kidney). Encountering a specific finding such as an intussusception or the exact cause of a strangulation or luminal obstruction (i.e. lipoma or polyp), while exciting and can obviously support a decision for surgery (or euthanasia), in my experience, is usually rare.

The ultimate question, of course, is whether or not an ultrasound examination can truly help the clinician make a sound decision regarding the need for surgery. As an equine surgeon I can say *yes*, there have been times that my standard colic work-up is relatively unremarkable (e.g. occasional mild discomfort, no significant findings on rectal exam, no net reflux obtained, bloodwork within reference interval, no fluid yielded on abdominocentesis) and then an abnormal ultrasound examination (e.g. a single loop of thickened, partially distended, amotile small intestine) is what led me to recommend surgery for the patient, which had an early strangulating lesion that was correctable. A review of the literature finds studies that have attempted to answer this question scientifically. Beccati *et al.* (2011) performed a retrospective analysis of numerous colic cases that received ultrasound exams prior to surgery. They concluded that ultrasonography can help to distinguish between small and large intestinal lesions: finding small intestinal loops that are completely distended (round shape) and lacking motility is highly related to a definitive diagnosis of strangulating obstruction, while finding partially distended small intestinal loops (square shape) with reduced or normal contractility is related to a large intestinal lesion. Increased peritoneal free fluid, reduced duodenal motility, and a completely distended appearance of the small intestinal loop with absent motility was significantly associated with a small intestinal strangulating lesion. Failure to visualise the left kidney was significantly associated with renosplenic entrapment of the large colon. A thickened appearance (>5 mm) and absent motility of the large intestine were found to be significantly associated with a strangulating volvulus of the large colon while absent motility of the large colon and failure to visualise small intestine was shown to be significantly associated with a non-strangulating volvulus of the large colon. Naylor (2015) and Cribb and Arroyo (2018) each reviewed the literature to report the accuracy of ultrasonography for predicting various gastrointestinal diseases by analysing statistics, including sensitivity, specificity, positive predictive values, and negative predictive values. Their findings were very similar to the retrospective analysis of Beccati *et al.* (2011).

To conclude, I whole-heartedly believe that transabdominal ultrasound has completely changed the colic work-up over the last few decades. It has made it more complete, allows for quicker recognition of small intestinal distention and wall thickening, can find a pocket of peritoneal fluid for successful abdominocentesis, and can assess motility of small and large intestine. This information can help expedite the decision for surgical intervention for the benefit of the patient. There are still cases of surgical colic that I do not believe require an ultrasound examination, especially if the horse is so violently painful that it would be dangerous. I also believe that the 'routine field colic' does not generally require an ultrasound examination, unless there are findings that need further evaluation, in which case it is no longer 'routine'. In regards to finding a *specific* diagnosis via ultrasound, I think that it is very interesting and extremely helpful to find a surgical lesion pre-operatively, however other than leading to faster progression to euthanasia in horses without a surgical option, it will not likely change the clinical course in those that do. This does not mean that a clinician should not be on the lookout for such a finding, especially as the literature has continued to be expanded by them, however during the emergency ultrasound evaluation I think that the main focus should be on evaluating the horse for surgical need. If a definitive diagnosis can be quickly found it will help direct the clinical course but I do not think a prolonged amount of time should be spent trying to locate one of these specific findings if the horse has a surgical option and the colic work-up and/or general ultrasound findings are directing towards that recommendation. I commend the authors of this accompanying case report (Younkin *et al.* 2020) for discovering a rare lesion ultrasonographically and reporting it for the benefit of expanding the literature.

Author's declaration of interests

No conflicts of interest have been declared.

Ethical animal research

Not applicable.

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Case Report

A novel approach for palatal cyst ablation in a horse

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Keywords: horse; palatal cyst; tracheostomy; laser; respiratory noise

Summary

An 18-month-old Welsh Cob was referred to a university teaching hospital for investigation of abnormal respiratory noise at rest. Video-endoscopy revealed persistent displacement of the soft palate with bilateral 2–3 cm diameter raised areas on either side of the midline. Neither trans-nasal nor oral approaches allowed sufficient visualisation of the caudal soft palate for diagnosis or treatment. Latero-lateral radiographs showed a blunted, thickened caudal edge of the soft palate consistent with a palatal cyst. Two palatal cysts were thermally ablated with a transendoscopic diode laser via temporary tracheotomy. The horse recovered uneventfully and resolution of the displacement was evident on follow-up endoscopy 11 months later. This report documents a novel surgical approach to the caudal aspect of the soft palate.

Introduction

Palatal cysts have previously been reported as a cause of abnormal respiratory noise, increased respiratory effort, and dysphagia secondary to persistent dorsal displacement (DDSP) of the soft palate in the horse (Koch and Tate 1978). Respiratory noise is commonly exacerbated by exercise and is usually noted on both inspiration and expiration (Salz *et al.* 2013). Cystic structures involving the upper respiratory tract (URT) of equines are most usually found in the subepiglottic tissues. Less frequently they occur in the dorsal nasopharynx and may distort the architecture between the two (Palmer 2003). Dysphagia, persistent coughing and aspiration pneumonia have also been reported as sequelae to subepiglottic cysts (Salz *et al.* 2013).

It has been proposed that there is an association between these cysts and the embryonic remnants of the thyroglossal and craniopharyngeal ducts (Kelmer *et al.* 2007), and they are thought to be a congenital defect (Fulton *et al.* 2012). Acquired cystic structures in the upper respiratory tract have also been reported as sequelae to inflammation and or trauma (Sullivan and Parente 2003). They have also been reported in older horses, as an incidental finding, with no history of upper respiratory tract problems and their aetiology is unknown (Aitken and Parente 2011). Surgical removal by conventional surgical approaches via laryngotomy, pharyngotomy, transoral or transnasal approaches as well as transendoscopic laser ablation has been described (Koch and Tate 1978; Haynes *et al.* 1990; Tulleners 1991; Blikslager and Tate 2000; Sullivan and Parente 2003; Fulton *et al.* 2012).

Lasers have a number of applications in the horse including resection of cutaneous masses (McCauley *et al.* 2002) and within the URT including laryngeal ventriculectomy, cordectomy and resection of subepiglottic tissue causing epiglottic entrapment (Palmer 2003). Transendoscopic laser surgery of the equine upper respiratory tract has many proposed advantages, especially in racehorses, because of the noninvasive nature of surgery, avoidance of general anaesthesia, and the relatively rapid return to work (Palmer 2003).

Removal of subepiglottic cysts have been reported using conventional surgical approaches via laryngotomy or pharyngotomy incisions, oral approaches, or transendoscopically with an Nd:Yag or diode laser or transendoscopic instruments such as snares (Fulton *et al.* 2012).

This case report describes the use of a retrograde endoscopic approach via a tracheotomy for further evaluation and treatment of bilateral palatal cysts using a diode laser in a horse.

Case history

An 18-month-old, 346 kg, Welsh Cob gelding was presented to the Philip Leverhulme Equine Hospital for further investigation of respiratory noise at rest. The noise was reported to worsen when the horse was excited and intermittent coughing had been evident when the gelding had been eating. Intermittent nasal discharge containing ingesta had also been noted. The clinical signs had been present since the purchase of the gelding 2 months previously. No pre-purchase examination had been performed. Clinical examination at rest was unremarkable and thoracic auscultation did not reveal any abnormalities. A mild inspiratory and slightly louder expiratory noise was audible during this examination.

Endoscopy of the upper respiratory tract was performed per nasum with the horse standing and under sedation (xylazine, 0.4 mg/kg bwt and butorphanol 0.014 mg/kg bwt intravenously [i.v.]). This revealed persistent DDSP. The epiglottis could not be visualised at any stage even when swallowing was induced. The dorsal border of the soft palate appeared to project dorsally on either side of the midline (**Fig 1**). No abnormalities of the guttural pouches were evident on endoscopic examination.

Latero-lateral radiographic projections were performed centred on the larynx. These demonstrated an abnormal appearance to the caudal border of the soft palate which had a blunted, bulbous 'match-head' appearance, consistent with the appearance of a soft palate cyst (Haynes *et al.* 1990) (**Fig 2**). The epiglottis was positioned ventrally relative to the soft palate but appeared to be of normal shape and length.

A provisional diagnosis of bilateral palatal cysts was therefore made. It was not clear how much palatal tissue was on the ventral aspect of the soft palate as they could not be visualised. This led to concern about potentially

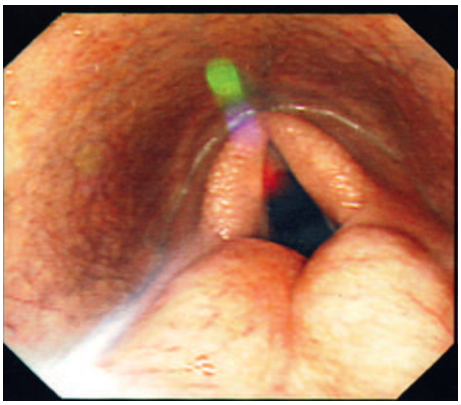

Fig 1: Trans-nasal video-endoscopic view of the larynx showing persistent dorsal displacement of the soft palate and bulging of the soft palate on either side of the midline.

Fig 2: Latero-lateral radiograph centred on the larynx. The caudal border of the soft palate can be seen as rounded with a 'match-head' type appearance.

ablating the cysts from the dorsal aspect of the soft palate due to the risk of creating a fistula in the soft palate. An oral endoscopic examination was performed using a flexible endoscope with a dental gag in place but this failed to provide sufficient visualisation of the caudal portion of the soft palate. It was elected to perform further evaluation and likely video-endoscopic laser-assisted surgical drainage and ablation of the cyst linings using a retrograde endoscopic approach via a temporary tracheotomy as a standing procedure under sedation.

Surgical technique and immediate post-operative period

The horse was medicated with acetylpromazine (Calmivet[1]) (0.02 mg/kg bwt intramuscularly [i.m.]), flunixin meglumine (Meflosyl[2]) (1.1 mg/kg bwt i.v.) and procaine benzylpenicillin (Depocillin[3]) (10 mg/kg bwt i.m.). Sedation was achieved with the use of xylazine (Virbaxyl[4]) (0.5 mg/kg bwt i.v.) and butorphanol tartrate (Torphasol[5]) (0.02 mg/kg bwt i.v.) and further incremental doses of xylazine (0.2 mg/kg bwt i.v.) were administered as required. The ventral midline of the trachea and mandible and proximal cervical region was clipped and was aseptically prepared. Mepivacaine (intra-epicaine[6]) (approximately 10 mL) was infiltrated subcutaneously around the proposed incision site. A vertical incision was made through the skin at the junction between the upper and middle thirds of the cervical region (as per a routine approach for tracheostomy) and the annular ligament between adjacent tracheal rings was sharply transected in a transversely, sufficient for placement of a 9 mm diameter flexible videoendoscope (Q240 Olympus[7]). The endoscope was easily introduced via the incision and was advanced rostrally and proximally to the level of the larynx to allow visualisation of the caudal border of the soft palate.

This confirmed the presence of two cystic structures positioned adjacent to each other on the caudal border of the soft palate (**Fig 3**). An endoscopic injection needle (Olympus[7]) was inserted via the biopsy channel. The needle was used to puncture each cyst, without apparent discomfort to the horse, and thick mucoid material was seen to drain from the site of puncture. Mepivacaine (approximately 20 mL) was infiltrated over the caudal border of the soft palate via the endoscopic biopsy channel and each cyst was then fenestrated using the diode laser set at 15 W (Vet Art 810 diode laser, 600 µm diameter fibre, Kruuse[8]). This action debulked the cysts and created a portal for insertion of the laser fibre into the cystic cavity up to the most rostral aspect (each cyst was approximately 3 cm in length). The laser was then set to 10 W and the fibre was gently withdrawn as the laser was activated with the aim of creating sufficient thermal damage to ablate the cyst lining without causing severe thermal necrosis of the soft palate. An estimated total of 500 joules (J) of energy was used (approximately 250 J per cyst). This was performed quickly and uneventfully without the requirement for additional instrumentation. The scope was withdrawn and the tracheotomy incision was allowed to heal by second intention. The horse was placed on a 7-day course of trimethoprim sulphonamides (Trimediazine[1]) (30 mg/kg bwt per os q. 12 h) and phenylbutazone (Equipalazone[6]) (4.4 mg/kg bwt per os q. 12 h for 3 days followed by 2.2 mg/kg bwt per os q. 24 h for 2 days).

The gelding recovered uneventfully following surgery and an immediate reduction in the degree of respiratory noise

Fig 3: Video-endoscopic view of the soft palate from the caudal aspect. This view shows two cystic structures on the caudal edge of the soft palate.

was noted. No coughing or nasal discharge was evident during eating.

Follow-up endoscopy was performed per nasum Day 5 post-operatively where DDSP was still evident. The soft palate, however, appeared to have a more normal dorsal outline apart from a dorsal protuberance on the right side. Repeat latero-lateral radiographs were also performed and these showed a normal outline to the caudal border of the soft palate (**Fig 4**). The gelding was discharged from the hospital 6 days post-operatively.

Outcome

Re-evaluation was performed at 4 weeks and again at 11 months post-operatively. The owners reported that the gelding had been much livelier and no respiratory noise, coughing or nasal discharge had been evident. Follow-up endoscopic examination at both 4 weeks and 11 months was performed pernasum and revealed the soft palate to be normally positioned relative to the epiglottis and the soft palate was normal in appearance (**Fig 5**).

Discussion

This report describes an unusual case of bilateral palatal cysts and to the authors' knowledge this is the first description of laser ablation using a retrograde approach via a tracheotomy. This novel approach provided excellent visualisation of the caudal portion of the soft palate and may be a useful method of assessing the upper respiratory tract and accessing lesions for laser treatment when a conventional approach provides insufficient visualisation or surgical access utilising transendoscopic instruments.

Lasers have expanded veterinary surgical capability by facilitating minimally invasive surgery, allowing access to areas that would otherwise be unreachable and by interacting with tissue in ways that conventional instruments could not (Sullins 2002). The first veterinary use of a laser was reported in 1972 (Blikslager and Tate 2000). The development of commercially available and affordable lasers that can deliver thermal energy via flexible fibres has enabled a variety of transendoscopic surgical procedures to be developed. The minimally invasive nature of transendoscopic surgery has meant that laser has gained large-scale popularity for upper respiratory tract surgery (Orsini 2002). URT

Fig 4: Latero-lateral radiographic projection of the larynx after drainage and laser ablation of the cysts. A sharp, normal caudal border of the soft palate can be seen.

Fig 5: Trans-nasal video-endoscopic view of the larynx at follow-up (11 months) showing a normal position of the soft palate and epiglottis. There was no residual deformity of the soft palate.

conditions that have been treated using transendoscopic lasers include: ablation of ethmoid haematomas and resection of masses (Sullins 2012), congenital or acquired tissue webs in the nasal passages, pharynx and larynx (Orsini 2002); stimulation of fibrosis of the caudal soft palate in horses with DDSP (Sullins 2012); correction of epiglottic entrapment (Parente 2002), resection of vocal cords (Ducharme *et al.* 2002), laryngeal ventricles and aryepiglottic folds (Orsini 2002); fenestration of the guttural pouch for management of tympany or to assist in the removal of chondroids (Sullins 2012); removal of subepiglottic and other cysts in the URT (Cramp *et al.* 2014) and resection of tissue in foals with choanal atresia (Ducharme 2012).

Palatal cysts are relatively uncommon, with few reports in the literature (Koch and Tate 1978; Haynes *et al*. 1990) and in this case, due to the young age of the horse, they were considered most likely to be congenital. More commonly cystic structures occur in the subepiglottic region and are usually congenital, being reported most frequently in young Thoroughbred and Standardbred racehorses (Fulton *et al.* 2012). Acquired cysts may develop as a sequela to inflammation or trauma (Sullivan and Parente 2003) but this is less common. Diagnosis in this group is potentially a function of their requirement for large aerobic capacity and the frequent nature of endoscopic examinations at an early age rather than being due to a specific breed predisposition, diagnosis being made most frequently at endoscopic examinations preceding yearling sales (Salz *et al.* 2013). Concomitant epiglottic entrapment has been reported in 20% (Tulleners 1991) and 36% (Salz *et al.* 2013) of cases according to two reports. Endoscopically cysts are visualised as pink and smooth, round to oval mucosal covered masses that sit below the epiglottis and are usually to one side of the midline (Fulton *et al.* 2012). In some cases, stimulation of swallowing or elevation of the epiglottis is needed to visualise the cysts (Blea and Arthur 2003). In this case, the cysts had a similar appearance but were difficult to fully evaluate without radiography and the ability to directly visualise the caudal border of the soft palate in detail.

Surgical approaches via laryngotomy or pharyngotomy have been described to access masses in the URT (Haynes *et al.* 1990; Robertson 2007) and Robertson (2007) advocated surgical excision en bloc or drainage following excision of the caudal margin of the soft palate for

treatment of palatal cysts. However, these reports listed a number of complications such as creation of palatal defects including fenestrations (Haynes *et al.* 1990; Parente 2011) and development of soft palate dysfunction post operatively (Robertson 2007). Previously described oral approaches and the use of endoscopic elevators did not provide sufficient visualisation for either treatment or diagnosis in this case. In this case, visualisation of the caudal border of the soft palate endoscopically was superior to a larnyngotomy or pharyngotomy and the ability to use a surgical laser enabled a minimally invasive approach to be taken. This minimally invasive approach resulted in no post-operative complications developing.

It was not clear if laser ablation of the cyst lining would prevent recurrence of cyst formation but follow-up over a reasonable time period confirmed that this appeared to have been successful. Surgical removal of subepiglottic cysts has been reported to be up to 100% successful in a review of 15 cases over 14 years by Salz *et al.* (2013). In the latter study, no horses were reported to have recurrence of cysts after removal. Both contact and noncontact ablation of subepiglottic cysts has been described (Palmer 2003). In this case, the cysts were perforated prior to contact laser ablation in part as a diagnostic aid to confirm their cystic nature and this enabled the lining of the cystic cavities to be directly accessed, with the aim of minimising the thermal energy and risk of thermal necrosis to adjacent tissues. A nonsurgical, intralesional, formalin treatment has been reported. This was done in the standing sedated horse and required multiple treatments (Dougherty and Palmer 2008). In this case, formalin was considered but was not attempted due to concerns about the potential for palatal necrosis to occur.

Another potential surgical approach to the larynx has been described for treatment of arytenoid chondritis. In a case series by Sullins (2002), horses had an endoscope positioned per nasum to view the arytenoid cartilage. A flexible laser fibre was then inserted through a cannula that had been placed through a one centimetre incision through the cricothyroid membrane. The chondritis lesion on arytenoid cartilage was then vaporised under endoscopic guidance (Sullins 2002). The latter approach could have been used in this case, particularly if instruments had been needed to assist treatment but a tracheostomy incision was easy to perform using minimal equipment and is associated with few complications and in this case worked well.

The novel use of a tracheotomy incision for the passage of the endoscope allowed visualisation for confirmation of diagnosis, access for surgical instrumentation and laser fibres to be passed transendoscopically for treatment. A tracheotomy incision is more invasive but this commonly performed procedure carries a low risk of complications when correctly performed and heals well by secondary intention.

Authors' declaration of interests

No conflicts of interest have been declared.

Ethical animal research

No ethical review was required as single case report.

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Antimicrobial stewardship policy

The horse was given perioperative antibiotics. No critically important antibiotics were used in this study.

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Authorship

D. C. Archer performed the initial case work-up, case treatment and follow-up examinations. M. Sinovich prepared the manuscript with the help of P. G. Kelly and D. C. Archer. All authors reviewed and approved the final manuscript prior to submission.

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[4]Virbac, Woolpit, Bury St Edmunds, Suffolk, UK.
[5]Animal Care, York, UK.
[6]Dechra, Hadnall, Shrewsbury, Shropshire, UK.
[7]Olympus, Southend-On-Sea, Essex, UK.
[8]Kruuse, Sherburn in Elmet, Leeds, UK.

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Clinical Commentary

Deciphering and treating dysphagia in young horses

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Keywords: horse

The authors of 'A novel approach for palatal cyst ablation in a horse' in this issue of *Equine Veterinary Education* (Sinovich *et al.* 2020) should be commended for bringing this thoughtful approach to a palatal problem to the readership. There are several components of this report that are worthy of further discussion.

An epiglottic and/or palatal problem should be near the top of the differential diagnosis list whenever a horse has a clinical history of abnormal respiratory noise and coughing, particularly if associated with eating. If the animal is very young or not active, an abnormal respiratory noise may not be that evident, and too often only lower respiratory disease is considered when an animal coughs. Yet, coughing should not be overlooked as a clinical sign associated with upper respiratory abnormalities (Aitken and Parente 2011). Fortunately, the functional compromise that precipitates the coughing is most often secondary to structural abnormalities that can be seen on upper airway endoscopy. In the neonate, the most common palate problem would be a cleft palate that would result in dysphagia and evidence of aspiration with milk at the nares. Depending on the size of the cleft and the scrutiny by the owners, these horses may not be recognised as having a problem until they are older. Similarly, it is somewhat surprising in this case report that this horse was not evaluated until it was 18 months of age. It is likely that these palatal cysts were congenital and this animal would have had difficulty from the time it was born. Palatal cysts are very uncommon, but large cysts or other soft tissue masses associated with the subepiglottic region can cause dysphagia and persistent displacement of the soft palate resulting in subclinical aspiration and coughing (**Fig 1**). Fortunately, because there is no underlying neuromuscular dysfunction, resolving the structural problem (as was achieved in this case report) should yield complete resolution.

That situation is very different from the horse that has an underlying neuromuscular problem that is causing a primary functional inability of the oropharynx resulting in the dysphagia and possibly persistent palate displacement. Dysphagia, presumably secondary to pharyngeal dysfunction, associated with hypoxic ischaemic encephalopathy or neuropathy has been documented in neonates (Holcombe *et al.* 2012). Most foals will resolve the pharyngeal dysfunction over time with just supportive therapy and prevention of aspiration. Yet,

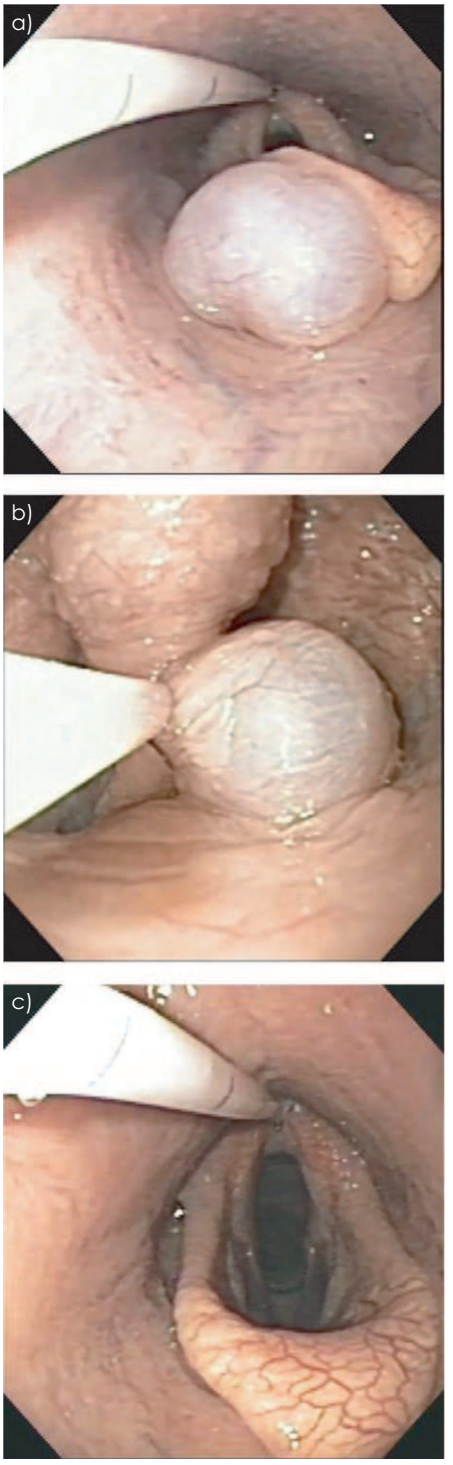

Fig 1: a) Endoscopic view of a neonate with dysphagia. A large subepiglottic cyst is evident. A naso-oesophageal feeding tube is in place. b) Endoscopic view of the oropharynx with the foal under anaesthesia in dorsal recumbency. A transendoscopic diathermic loop is being employed to transect the cyst. c) The 1-day post-operative endoscopic view showing minimal swelling. The naso-oesophageal tube that is still present was removed several hours later.

complete resolution that would allow high level performance as an adult is less likely. In adults, the more common cause for such a condition in the horse is neural insult from fungal disease within the guttural pouch (**Fig 2**). While treatment of the fungal infection can be instituted and effective, sufficient resolution of the neural disease may require an extended period of time and again could be incomplete (Virgin *et al.* 2016). There is some evidence that a tie-forward procedure may be beneficial in those horses that persist to have some pharyngeal dysfunction and dysphagia (Dobesova *et al.* 2012). Despite having an obvious structural abnormality of the palate that could account for the clinical signs demonstrated in the case reported here, the authors did rule out any evidence of neural insult associated with guttural pouch disease.

Upper airway endoscopic examination is usually the first diagnostic tool used to arrive at a diagnosis when a horse is presented with these problems. Generally, it is not advised to use any sedatives during the endoscopic examination in which the clinician wants to make some assessment of function (Lindegaard *et al.* 2007). I suspect the authors only used sedation in this gelding because of behavioural concerns. Stimulating swallowing during an endoscopic examination can be helpful in seeing evidence of dysphagia as well as seeing subepiglottic cysts that can move between the oro- and nasopharynx. If the palate is persistently above the epiglottis despite multiple stimulated swallows, a lateral radiograph (as was performed in this case report) can yield valuable information about any structural abnormalities associated with the epiglottis or palate. An open mouth view to provide more air contrast within the oropharynx can provide better detail to the soft tissue structures. If an abnormality of the epiglottis is suspected sedation, topical anaesthetic and manipulation of the palate/epiglottis via long equine laryngeal/pharyngeal forceps can be used to determine the abnormality. Infrequently entrapment of the epiglottis can precipitate persistent displacement of the palate, or the ventral surface of the epiglottis can be very abnormal and result in significant performance problem or dysphagia while appearing normal on the dorsal surface. Persistent displacement of the soft palate 5 days after surgery in the case reported here was likely disappointing to the authors. Not performing any further

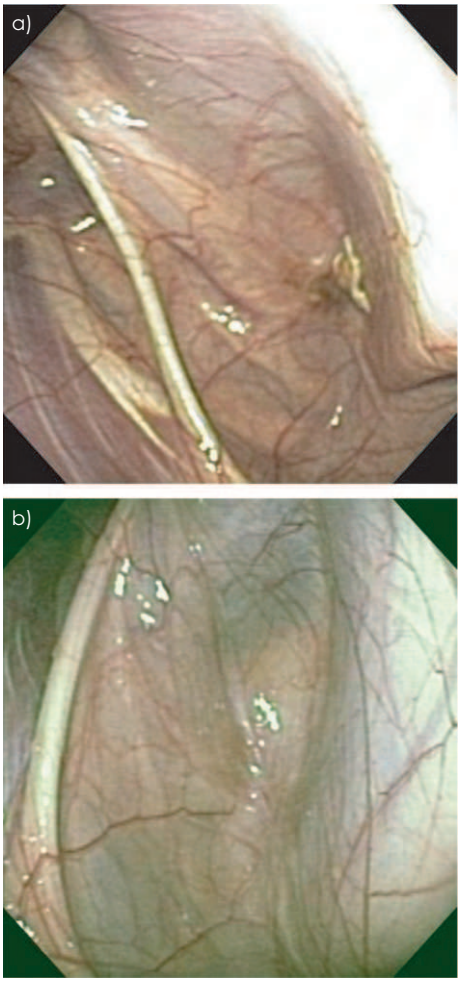

Fig 2: a) Fungal plaque in the ventral medial aspect of the right guttural pouch (near the pharyngeal branch of the vagus nerve) of a horse with evidence of palate displacement and dysphagia. b) Resolution of the fungal plaque coincided with eventual resolution of the dysphagia.

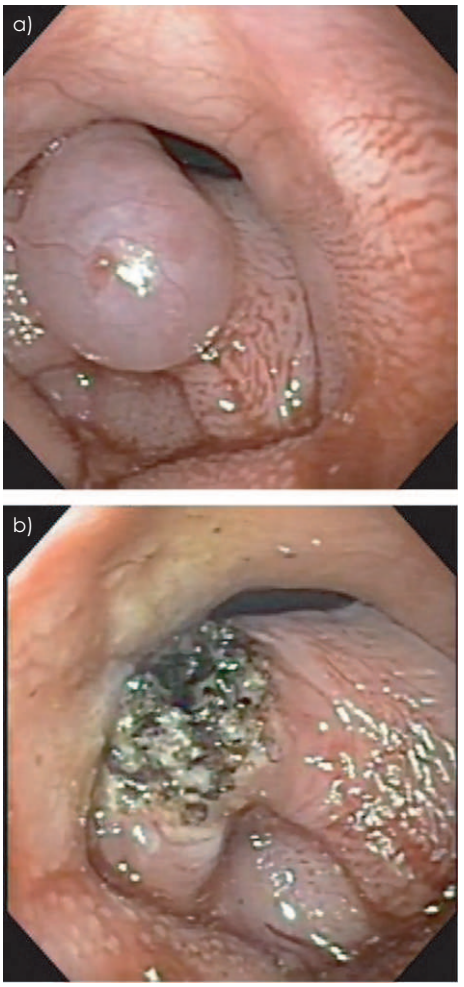

Fig 3: a) Endoscopic view through a laryngotomy of a large palatal cyst prior to laser ablation and b) after laser ablation in a foal in dorsal recumbency. The foal was able to replace her palate to normal position 1 day after surgery.

intervention was wise since the persistent displacement was most likely a result of continued palatal inflammation that resolved with further time.

The caudal approach to the palate edge can be achieved via laryngotomy or tracheotomy. Given the horse's age, the tracheotomy approach made good sense and allowed the procedure to be performed standing. If this condition were evident in a neonate, keeping the foal still enough to complete the procedure without complications would have been a challenge. An alternative approach to consider would be i.v. anaesthesia, dorsal recumbency and approaching the caudal palate transendoscopically through a laryngotomy (**Fig 3**) (Parente 2011).

Application of laser energy to a cystic structure has been reported in animals (Blikslager *et al.* 1993; Gemensky-Metzler *et al.* 2004) and has two significant advantages. The first is the minimally invasive approach to get a fibre to the surgical site which limits the complications associated with a more open approach surgery. Second, more importantly, it enables targeted destruction of the cystic tissue with minimal impact on adjacent tissue. While some cystic structures can be isolated and resected from the underlying normal tissue, these palatal cysts cannot, and thus resection of the cystic structures with standard surgical instruments in this horse would have resulted in irreparable damage to the palate. The amount of laser energy to employ is not well established. Considering effective cyst destruction essentially requires the intracellular fluid of the cells lining the cyst to boil, the amount of energy required is likely less than we would estimate, and distribution of the energy may be enhanced if some application can be achieved prior to cyst rupture. The amount of energy used by the authors is valuable information. As reported, 250 joules/cyst was enough to effectively destroy the cysts. We could speculate that less energy may have been just as effective and resulted in less post-operative soft palate inflammation with a quicker correction of palate position. While impossible to accurately measure under these conditions laser fluence, which includes the surface area over which the energy is applied, is another component of the procedure that should be considered when critically evaluating the efficacy of a laser procedure.

Author's declaration of interests

No conflicts of interest have been declared.

Ethical animal research

Not applicable.

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Original Article

Transrectal ultrasonographic examination of the sacroiliac joints of the horse: Abnormal findings and lesions

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Keywords: horse; ultrasonography; pelvis; sacroiliac joint; osteoarthritis

Summary

Transrectal ultrasonography is a useful technique for the assessment of sacroiliac osteoarthrosis because of the ventral localisation of lesions. Comparison between the right and left side is essential. Due to the deep localisation of the sacroiliac joints, other imaging modalities have limitations for diagnosing osteoarthrosis. A grading system from 1 to 4 is suggested in order to classify the severity of lesions based on the shape of the articular margins and architecture of the ventral sacroiliac ligament. Abnormal ultrasonographic findings should be correlated with clinical manifestations.

Introduction and indications

Sacroiliac pain in horses is a common cause of poor performance and lack of power in the hindlimbs (Jeffcott *et al.* 1985; Denoix 1998; Dyson and Murray 2003). Diagnostic analgesic techniques have been described (Haussler 2010) but their use is limited in routine practice because of a lack of specificity and sensitivity (Dyson and Murray 2003; Denoix 2016). Therefore, localisation of the source of pain remains challenging (Denoix 1998). In the last two decades, exploration of the pelvis has improved with imaging techniques and a better knowledge of sacroiliac injuries has been gained.

Transrectal ultrasonography is a useful technique to evaluate the sacroiliac joints considering the ventral localisation of osteoarthritic lesions (Jeffcott *et al.* 1985; Dalin and Jeffcott 1986a; Haussler 2004; Denoix 2016). A clear evaluation of soft tissues abnormalities and abnormalities of the bone surface can be achieved with this technique (Denoix 1999; Bergman *et al.* 2013). Moreover, it is widely available and affordable in field practice and reliable information can be obtained with a minimum of training and practice. Therefore, transrectal ultrasonographic examination of the lumbosacroiliac area can be included in the routine approach to diagnose the cause of low back or sacroiliac pain (Denoix *et al.* 2006, 2007). In our centre, it is performed systematically in the context of a locomotor check-up of sport and racehorses and/or when back pain is present (Denoix *et al.* 2006, 2007). It is also indicated whenever an injury is suspected in sacroiliac area because of:

- Abnormal conformation of the pelvis: pelvic asymmetry and/or atrophy of the *gluteus medius* muscle; nevertheless, a lot of horses affected with sacroiliac injuries do not present any atrophy (Denoix *et al.* 2005; Denoix and Coudry 2005);
- Manifestations at physical examination: pain on palpation and pressure on the sacroiliac area; racing trotters are commonly more sensitive than other horses over the lumbosacroiliac area (Denoix 2016), and can demonstrate marked sinking (flexion) of the hindlimbs when putting pressure over the *tuber sacrale* (Denoix and Coudry 2005);
- History of trauma to the pelvis, like a fall: an acute pelvic fracture or a luxation may be present;
- Clinical features affecting all disciplines including: lack of propulsion, poor action and back stiffness (Tucker *et al.* 1998; Erichsen *et al.* 2002; Dyson and Murray 2003; Haussler 2004; Denoix *et al.* 2005; Denoix and Coudry 2005; Engeli *et al.* 2006); mild chronic hindlimb lameness may be present;
- Negative responses to diagnostic analgesia such as nerve blocks or intrasynovial blocks of the hindlimb, ruling out a lesion on the limb;
- Scintigraphic findings in the pelvis: detection of increased radiopharmaceutical uptake indicating active bone remodelling over the sacroiliac area**.** In a study made on 33 horses comparing nuclear scintigraphy and transrectal ultrasonography in the detection of sacroiliac abnormalities, Coudry *et al.* showed a good correlation (77%–51/66) between the two techniques (Coudry *et al.* 2006). Radiation capture from the sacroiliac joint is also limited by the thick *gluteus medius* muscle which causes attenuation.

The technique and normal images of the sacroiliac joints have already been described (Tallaj *et al.* 2019). Therefore, the aims of this paper are to present the abnormal findings and the types of lesions of the sacroiliac joint which can be detected with ultrasonography, as well as a grading system for characterising the severity of osteoarthritic lesions.

Abnormal findings and lesion types

Abnormal ultrasonographic findings encountered at the ventral aspect of the sacroiliac joint include mainly (Denoix 1998; Denoix and Coudry 2005; Denoix *et al.* 2006):

- Marginal remodelling of the periarticular borders and/or periarticular osteophytes of the sacral and/or ilium wings (caudal border of the auricular surface of the sacrum and/or caudal auricular margin of the ilium);
- Periarticular bony proliferation with modelling of the sacral or iliac wing often associated with a reduction of the sacroiliac joint space;
- Ventral sacroiliac ligament desmopathy with thickening and reduction and/or alteration of echogenicity of the ventral sacroiliac ligament;
- Ventral sacroiliac ligament enthesopathy with bone remodelling at the attachment on the bone surface, especially at the iliac insertion;

- Ventral sacroiliac ligament rupture with dislocation of the sacroiliac joint and increased distance between sacrum and ilium;
- Traumatic or fatigue fracture of the sacral or iliac wing imaged as an interruption of the hyperechogenic bone surface of the wing and echogenic spot deep to the bone surface.

Lesion grades

Osteoarthritic lesions are most commonly found in race, sport and pleasure horses. Their severity can present huge variations between cases. In order to compare the left and right sides of the same horse, to get an idea of the severity of the findings to be correlated with the clinical or athletic manifestations, and to correlate with other imaging modalities as well as to follow the disease process, a scale of the sacroiliac joints lesions has been established, from 0 (absence of lesion) to 4 (severe bone remodelling of the sacroiliac joint margins) (Denoix 2016) (**Figs 1-5; Table 1**).

Osteoarthritis of the sacroiliac joints is a chronic condition. Therefore, identification of changes in the severity of lesions needs a careful and accurate ultrasonographic follow-up of the horse. Changes in the bone surface and joint margins alter the ventral sacroiliac ligament because of its anatomic location between the sacrum and ilium. Very severe bone alteration of echogenicity and shape can be seen when an iliac wing stress fracture involves the sacroiliac joint margins (**Fig 6**). Dislocation of the sacroiliac joint has been diagnosed after a fall resulting in a complete rupture of the ventral sacroiliac ligament (**Fig 7**).

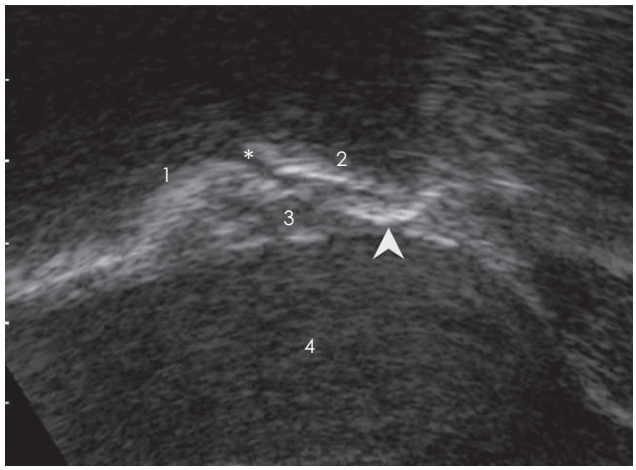

Fig 2: Parasagittal ultrasound scan of the sacroiliac joint of a horse (female) with a grade 1 osteoarthrosis (cranial is to the left). Joint margins are mildly irregular (arrow head). 1: sacral wing; 2: iliac wing; 3: ventral sacroiliac ligament; 4: cranial gluteal artery and vein; *sacroiliac joint space.

Discussion

Indications

Sacroiliac joint osteoarthritis is a common condition that should be considered in the differential diagnosis of clinical disorders attributed to the lumbosacroiliac or upper hindlimb area. Observations at physical and dynamic examination are rarely specific but asymmetry of the pelvis and muscle atrophy are indications to perform a complete ultrasound

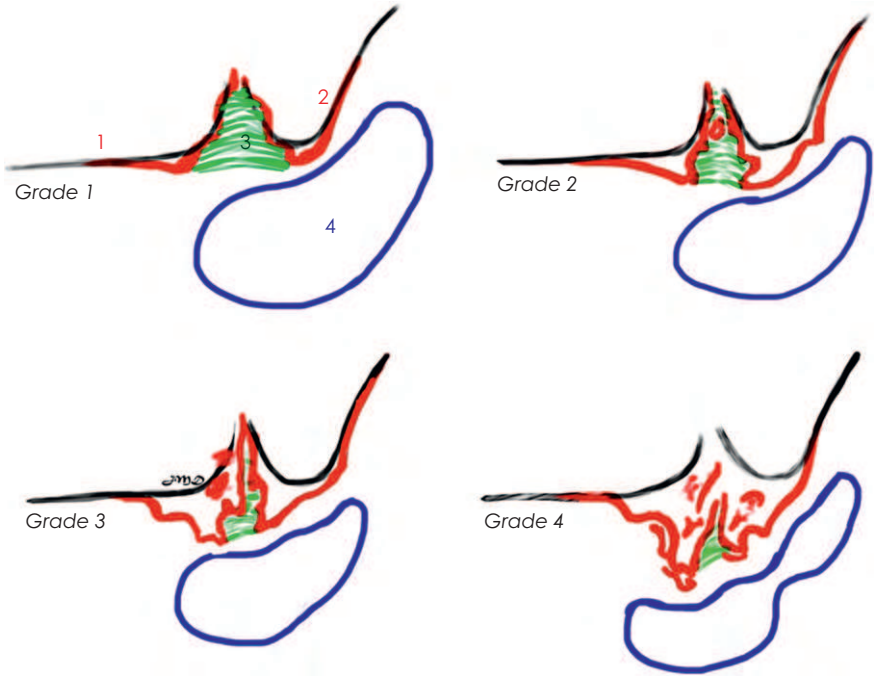

Fig 1: Schematic drawings of the pathological appearance of the ventral aspect of the sacroiliac joint (cranial is to the left) showing the grading system from 1 to 4 according to the severity of bone modelling and remodelling of sacral and iliac wings. 1: sacral wing; 2: iliac wing; 3: ventral sacroiliac ligament; 4: cranial gluteal vein.

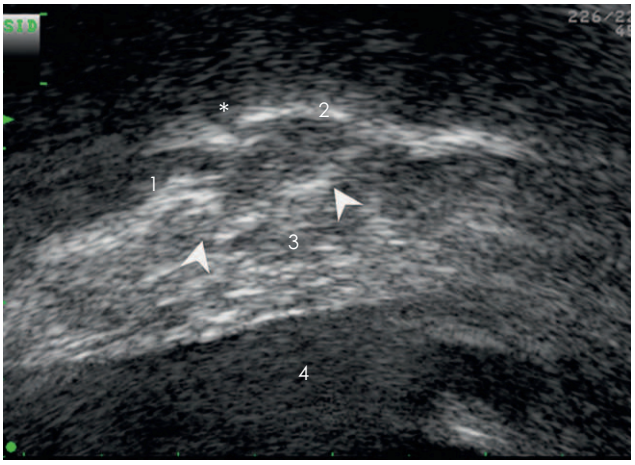

Fig 3: Parasagittal ultrasound scan of the sacroiliac joint (cranial is to the left) of a horse (female) with a grade 2 osteoarthrosis. Moderate periarticular proliferation is imaged on the sacral and iliac wings (arrow heads). The ventral sacroiliac ligament presents a heterogeneous echogenicity. 1: sacral wing; 2: iliac wing; 3: ventral sacroiliac ligament; 4: cranial gluteal artery and vein; *sacroiliac joint space.

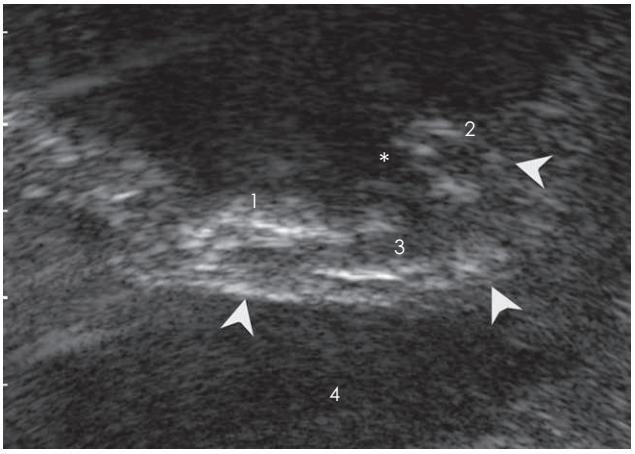

Fig 4: Parasagittal ultrasound scan of the sacroiliac joint (cranial is to the left) of a horse (gelding) with a grade 3 osteoarthrosis. The sacral and iliac wings present marked alteration of their shape (arrow heads). 1: sacral wing; 2: iliac wing; 3: ventral sacroiliac ligament; 4: cranial gluteal artery and vein; *sacroiliac joint space.

assessment of the area (Denoix and Coudry 2005). Musculature and symmetry of the pelvis are better assessed at walk than on the standing horse, because of the symmetrical left and right movements of the area at walk (Denoix and Coudry 2005). Inspection of the pelvis may highlight nonspecific signs such as unilateral or bilateral muscle atrophy (*gluteus medius* muscle). Atrophy in the femoral area (*gluteofemoralis* muscle) is uncommon but more specific for sacroiliac disease (Denoix and Coudry 2005; Denoix 2016). Nevertheless, a lot of horses affected with sacroiliac injuries do not present any atrophy (Denoix *et al.* 2005). Pelvic asymmetry can also be associated with a wider sacroiliac joint space (Erichsen *et al.* 2002; Denoix 2016). Palpation and pressure on the sacroiliac area are useful to

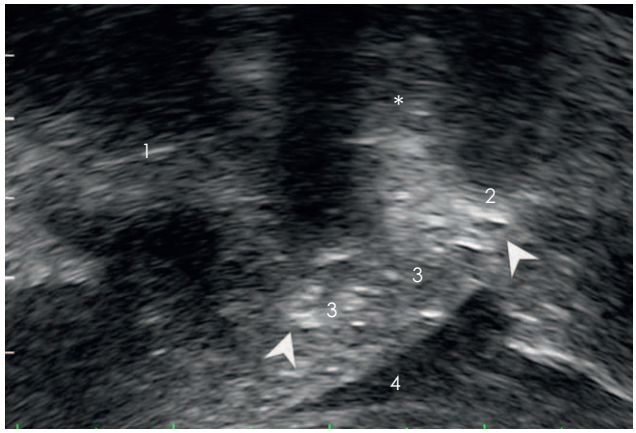

Fig 5: Parasagittal ultrasound scan of the sacroiliac joint (cranial is to the left) of a horse (gelding) with a grade 4 osteoarthrosis. Joint margins present severe irregularities of the bone surface with an altered shape of the sacral and iliac wings (arrow heads). The ventral sacroiliac ligament presents a severely heterogeneous echogenicity. 1: sacral wing; 2: iliac wing; 3: ventral sacroiliac ligament; 4: cranial gluteal artery and vein; *sacroiliac joint space.

evaluate pain. Racing trotters are commonly more sensitive than other discipline horses over the lumbosacroiliac area (Denoix and Coudry 2005; Denoix *et al.* 2005). The most common clinical features of affected horses are lack of engagement and/or propulsion, mild chronic hindlimb lameness, poor action and back stiffness (Tucker *et al.* 1998; Erichsen *et al.* 2002; Dyson and Murray 2003; Haussler 2004; Denoix *et al.* 2005; Engeli *et al.* 2006; Haussler 2010; Denoix 2016). Each discipline displays specific manifestations. Sport horses usually demonstrate asymmetry at canter (or disunited canter) with difficulties changing leads, alteration of jump style or refusing jumps, poor engagement, reluctance and lack of power on short turns or fighting the rider. Thoroughbreds show stiff or short gaits and trotters have commonly irregular gaits at high speed and/or on turns and a curved or oblique attitude in the sulky (Denoix *et al.* 2005; Denoix 2016). These troubles are commonly worse when the horse is ridden (Dyson and Murray 2003) or driven (Denoix 2016). Obvious lameness and acute pain are not typically observed in horses affected by chronic sacroiliac injuries (Denoix and Coudry 2005), unless an acute pelvic fracture or a luxation is present (Haussler 2004; Denoix 2016). For these reasons, ultrasonographic examination of the pelvis should be routinely performed in horses suspected of back or pelvis pain or with low-grade hindlimb lameness.

The clinical significance of sacroiliac joint disorders is difficult to assess because of high prevalence in the presumed normal horse population (Haussler and Stover 1998; Haussler 2004). In our centre, grade 1 and 2 lesions of the sacroiliac joint margins are observed ultrasonographically in more than 50% of horses presented for a locomotor check-up. Grade 3 or 4 lesions are found in horses presenting athletic manifestations. Sacroiliac pain is not easily evaluated in horses and differential diagnosis with lumbosacral pain is difficult (Denoix *et al.* 2005). It can occur alone or in conjunction with thoracolumbar pain as well as hindlimb or forelimb lameness (Dyson and Murray 2003; Tomlinson *et al.* 2003).

TABLE 1: Grading and description of the most common ultrasonographic findings of the sacroiliac joint

Grade	Articular margins	Modelling = change of shape of the adjacent bones (sacral and iliac wings)	Ventral sacroiliac ligament	Enthesophytes
1	Mild irregular joint margins	Mild modelling	No change	Mild enthesophytes
2	Moderate irregular joint margins	Moderate modelling	Heterogeneous sacroiliac ligament	Moderate enthesophytes
3	Marked irregular joint margins	• marked modelling • superficial bone echogenic spots	Fibrosis and/or atrophy of the ventral sacroiliac ligament	Marked enthesophytes
4	Severe irregular joint margins	• severe modelling • deep bone echogenic spots	Fibrosis and/or atrophy of the ventral sacroiliac ligament	Severe enthesophytes

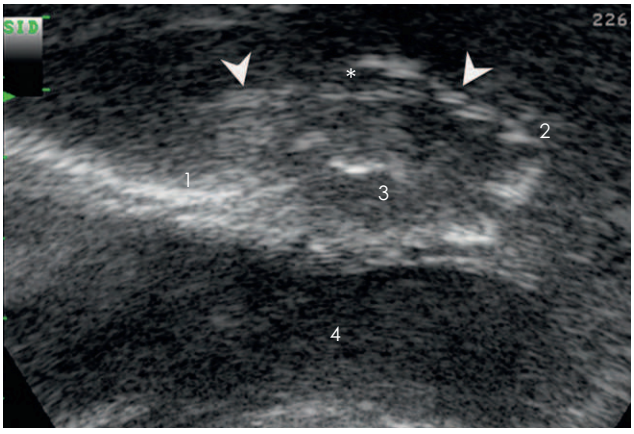

Fig 6: Parasagittal ultrasound scan of the sacroiliac joint (cranial is to the left) of a horse (male) with a fatigue fracture of the caudal margin of the iliac wing involving the sacroiliac joint (arrow heads = fracture plane). 1: sacral wing; 2: iliac wing; 3: ventral sacroiliac ligament; 4: cranial gluteal artery and vein; *sacroiliac joint space.

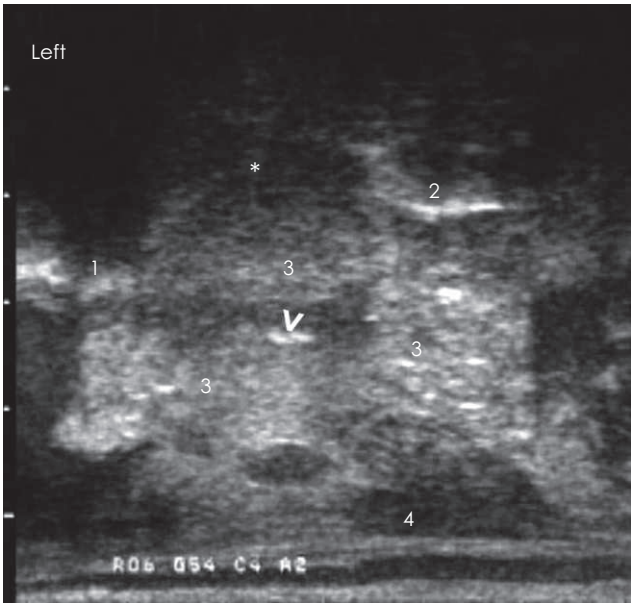

Fig 7: Parasagittal ultrasound scan of the sacroiliac joint of a steeple-chaser filly showing a rupture of the ventral sacroiliac ligament and dislocation of the sacroiliac joint (cranial is to the left). 1: sacral wing; 2: iliac wing; 3: ruptured ventral sacroiliac ligament with a haematoma filling the joint space; 4: cranial gluteal artery and vein (collapsed); *enlarged sacroiliac joint space; >bone fragment.

Technique

A good knowledge of descriptive and topographical anatomy is essential to perform an adequate transrectal ultrasound examination of the sacroiliac joints. Inadequate positioning of the probe can lead to misinterpretation or over diagnosis because of the poor orientation of the ultrasound beam. Moreover, care must be taken when manipulating the probe in the rectum in order to preserve the rectal wall and mucosa. A quiet environment is required. Sedation of nervous horses may be necessary.

Comparative imaging

Radiography is a valuable technique to identify pelvic and coxofemoral fractures but it has nevertheless major limitations to assess the lumbosacroiliac area. Although the transrectal ultrasound technique has some anatomical limitations since it does not enable visualisation of the interosseous sacroiliac ligament, the internal structures of the joint and the subchondral bone, it was found adequate in the evaluation of sacroiliac injuries because of their ventral and caudal localisation. Nuclear scintigraphy is a noninvasive and useful technique to identify sacroiliac injuries and to evaluate the clinical relevance of lesions (Tucker *et al.* 1998; Dyson *et al.* 2003a,b; Haussler 2010). In the past, nuclear scintigraphy was considered as the gold standard (Erichsen *et al.* 2002; Dyson *et al.* 2003a). Dorsal and oblique views of the pelvis are usually performed and enable a good evaluation of the sacroiliac joints (Tucker *et al.* 1998; Erichsen *et al.* 2002). A complete and precise scintigraphic assessment of lumbosacroiliac area requires four views of the pelvis: a dorsal horizontal symmetric view extending from L3 to the tail, a dorsocaudal symmetric view, parallel to the sacrum, extending from the iliac crest to the tuber ischiae, and two left and right dorsolateral 45° oblique views (Denoix *et al.* 2006). Indeed, oblique views are more useful as the camera is placed parallel to the sacroiliac joint plane. An increased radiopharmaceutical uptake (IRU) indicates active bone remodelling. In a study made on 33 horses comparing nuclear scintigraphy and transrectal ultrasonography in the

detection of sacroiliac abnormalities, Coudry *et al.* (2006) showed a good correlation (77% - 51/66) between the two techniques. A marked IRU in nuclear scintigraphy without abnormal ultrasonographic findings was observed in 20% (13/66) of sacroiliac joints, and abnormal ultrasonographic findings without any IRU detected in the sacroiliac area in 3% (2/66) of sacroiliac joints. These results show that ultrasonographically abnormal sacroiliac joints are highly correlated with active bone remodelling in the area and related to clinical features. Nevertheless, nuclear scintigraphy can be limited for diagnosing chronic diseases. Uptake from sacroiliac joint is also reduced by the thick *gluteus medius* muscle which causes attenuation. In the future, computed tomography performed with large diameter machines will probably complement soft tissue and physiological imaging.

Aetiopathogenesis and pathological findings

Sacroiliac joint lesions can have traumatic or more often degenerative origins (Jeffcott *et al.* 1985; Haussler and Stover 1998). Osteoarthritis is the most common pathological finding in horses affected by sacroiliac pain although its clinical significance remains unclear (Haussler 2004).

In 1986, Dalin and Jeffcott reviewed the gross morphology and morphometric features of sacroiliac joints of 41 horses without any history of low back pain (Dalin 1984; Dalin and Jeffcott 1986a,b). They showed that pathological findings are due to cartilaginous degeneration progressing with advancing age. Age-related changes were previously suspected as mean age of horses with abnormal sacroiliac joints is higher than horses with normal sacroiliac joints (Rooney 1977). However, another study did not confirm this tendency (Haussler *et al.* 1999). The iliac surface is more prone to degenerative changes than the sacral surface, and at a lower age. This observation is consistent with findings in human subjects for which sacral hyaline cartilage has a better capacity to resist degenerative changes than iliac fibrocartilage (Dalin and Jeffcott 1986a). A suggested mechanism of degenerative changes is that shearing forces are higher than compressive forces on the sacroiliac joint, leading to a decreased turnover of the synovial fluid and thereby nutritional dysfunction (Dalin and Jeffcott 1986a). Moreover, the presence of higher contact forces on low-motion joints than high-motion joints may predispose sacroiliac joints to osteoarthritis (Haussler 2004). Pooling of biomechanical and anatomical data revealed that osteoarthritis lesions are mainly located at the caudomedial joint margin (Jeffcott *et al.* 1985; Dalin and Jeffcott 1986a,b; Haussler *et al.* 1999; Haussler 2004; Denoix 2016). Correlation between sacroiliac joint degenerative injuries and chronic sacroiliac ligament desmopathy with lack of stability of the joint has been discussed in the past (Rooney 1977; Jeffcott *et al.* 1985; Haussler *et al.* 1999).

Ultrasonographic findings indicative of degenerative lesions include modification of the bone surface shape (bone remodelling) of the sacrum and/or ilium, periarticular osteophytes of the auricular surfaces, and narrowing of the joint space (Denoix 1998; Denoix *et al.* 2006). The ventral sacroiliac ligament size and/or echogenicity can be modified (desmopathy, enthesopathy or even rupture). The grading system described in this paper is helpful to classify the severity of bone remodelling lesions, based on the severity of periarticular proliferation and modelling of the sacrum and/or ilium (Denoix 2016). Severity of lesions and clinical manifestations are not necessarily correlated. A horse's tolerance of lesions depends greatly on the discipline. For example, trotters have low tolerance of sacroiliac injuries compared with sport horses and Thoroughbreds because of the very specific biomechanical stresses applied to the pelvis at high-speed trot. Rooney also showed that Standardbreds are more affected and earlier in life by sacroiliac joint arthropathy than Thoroughbreds because of differences in biomechanics of gaits (Rooney 1977).

In a necropsy study conducted on 36 Thoroughbred racehorses which were subjected to euthanasia for other reasons than pelvis problems, Haussler *et al.* showed that 25% presented sacroiliac joint injuries at different stages (Haussler *et al.* 1999; Haussler 2004). Moreover, Dalin and Jeffcott observed obvious degenerative cartilage lesions on sacroiliac joints although horses included in the study did not present any signs of back pain (Dalin and Jeffcott 1986a). Therefore, prevalence of sacroiliac disease is probably high in the performance horses population and the clinical significance of these changes remains doubtful (Dalin 1984; Jeffcott *et al.* 1985; Haussler and Stover 1998; Haussler 2004).

Degenerative osseous changes of the sacroiliac joints are usually found on the left and right side at post-mortem examination (Dalin and Jeffcott 1986a; Haussler *et al.* 1999; Haussler 2004). In the same way, in clinical cases, ultrasonographic findings indicative of osteoarthritic lesions are commonly found bilaterally but the grade is often different on left vs. right side (Denoix 2016). In our daily practice, we observe in several hundreds of horses every year that ultrasonographic changes and grades of the sacroiliac joints lesions are more common and more severe in males and geldings than in females without having more clinical or athletic incidence.

Authors' declaration of interests

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Ethical animal research

Not applicable.

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Authorship

All authors contributed to the manuscript preparation.

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Review Article

Prepubic tendon rupture in the mare

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Keywords: horse; mare; prepubic tendon rupture; abdominal wall; body wall

Summary

The following article discusses the clinical appearance, diagnosis, management and prognosis of abdominal wall tearing and prepubic tendon (PPT) ruptures of mares.

Introduction

Prepubic tendon (PPT) ruptures are a condition of the heavily pregnant mare. Many features of this condition overlap those of abdominal wall (AW) ruptures or hernias, often making them difficult to distinguish in the early stages. They may be categorised together as body wall defects. The conditions can be difficult to manage and constitute a high-risk pregnancy. Historically, the conditions have been given a guarded prognosis for survival of mare and foal (Hanson and Todhunter 1986).

Anatomy

The abdominal wall is made up of the *external* and *internal abdominal oblique* muscles and their aponeuroses, the *transversus abdominis* and *rectus abdominis* muscles. Any or all of these muscles may be involved in abdominal wall tearing (Hanson and Todhunter 1986). In cases of AW rupture, the intestines (and less commonly the uterus) can lie subcutaneously.

The prepubic tendon extends ventrally from the brim of the pelvis, obstructing fetal delivery in malpresentations where the fetus has its head deviated ventrally. The PPT runs along the pectin of the pelvis from one iliopubic eminence to the other (**Fig 1**) and is comprised of the linea alba and the insertion of the *rectus abdominis* muscle, which crosses such that fibres from either side of midline insert onto the PPT (Habel and Budras 1992). It is the origin of the pectineus muscle (running from iliopubic eminence to the pelvic symphysis) and the origin of the gracilis muscles, which run from the cranial end of the PPT to the inner thigh. Complete rupture of the PPT leads to complete loss of support to the ventrolateral abdominal wall (Hanson and Todhunter 1986).

Signalment

Although traumatic abdominal wall tearing is possible in any horse, PPT rupture is a syndrome only of the heavily pregnant mare. It is more common in older, multiparous mares, but will occasionally be seen in maidens. A breed predisposition has been cited in draught horses (Hanson and Todhunter 1986), and a heritable component is suspected in the Egyptian Arab (Nahachewsky *et al.* 2013). Suggestions have been made that Standardbreds with abdominal wall tearing may also appear to be over-represented (Ross *et al.* 2008), and this appears to be true in our case population. Other commonly cited predisposing factors are the presence of twins or hydrops (Hanson and Todhunter 1986).

Clinical signs of body wall defects

Mares with abdominal wall tearing usually show signs of abdominal pain. They show a progressive ventral or ventrolateral oedema, making palpation of underlying defects in the abdominal wall difficult. Occasionally, the outline of gastrointestinal viscera can be seen directly under the skin (**Fig 2**).

Mares with PPT are often distressed and painful. They are reluctant to move or lie down. Tachycardia of 60–80 beats/min and upwards is common. They often demonstrate a more severe and rapidly progressive ventral oedema, compared with mares with abdominal wall tearing. This oedema commonly extends from the forelimbs caudad to the udder. These mares develop a characteristic stance as the pelvis tips cranially without stabilisation by the abdominal wall. The flank area is poorly defined and lordosis develops with elevation of the *tubera sacrale*, *tubera ischia* and tailhead (Hendriks *et al.* 2007). The mammary gland will be oedematous and may have an abnormally "pulled forward" conformation with the teats pointing cranially. Blood may be seen exiting the front orifice of each teat (**Fig 3**).

Both conditions can usually be diagnosed based on their clinical signs. The main differential diagnosis is that of hydrops (hydroallantois or hydramnion) in which mares will also demonstrate progressive abdominal enlargement with accompanying ventral oedema (MacPherson 2012).

Transrectal ultrasonography is of limited use; whilst the prepubic tendon is palpable per rectum in nonpregnant mares, it cannot be palpated with a foal in utero. Transrectal palpation however may alert one as to the possibility of hydrops where one will palpate a severely distended uterus, and potentially an absence of fetal ballottement (Slovis *et al.* 2013).

Transabdominal ultrasonography may allow one to differentiate AW tearing from a PPT rupture. In cases of abdominal wall tearing, it may be possible to visualise defects within the muscle wall (**Fig 4**), with accompanying haematomas or haemorrhage.

Transabdominal ultrasonography will allow one to detect underlying hydrops or (sometimes unreliably) twin pregnancies. Transabdominal ultrasonography is a key diagnostic tool in monitoring fetal viability during treatment.

Management

Decision making in these cases can be difficult, as saving both mare and fetus in advanced cases is unusual in the

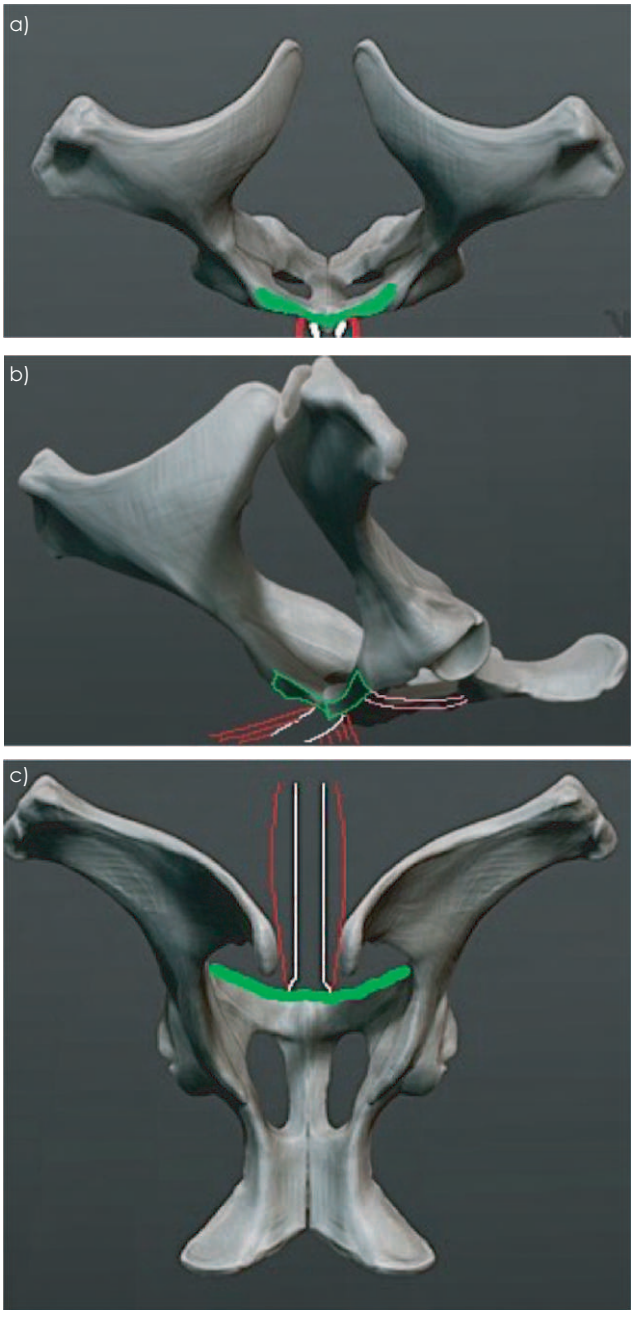

Fig 1: Schematic illustration of the prepubic tendon and its relationship with the pelvis of the mare from the a) cranial, b) craniolateral and c) dorsal perspective. Green = prepubic tendon; White = linea alba; Red = rectus abdominis muscle; Pink = pectineus muscle.

author's experience. Factors that must be considered are the gestational stage, severity of the tears and accompanying clinical signs, the level of pain experienced by the mare and the clinicians ability to control it, the fetal viability, and the relative value (economic or sentimental) of the mare and fetus.

Ideally, one would provide supportive care until parturition occurs naturally at term. This is the preferred course of action in cases where the pain experienced by the mare can be

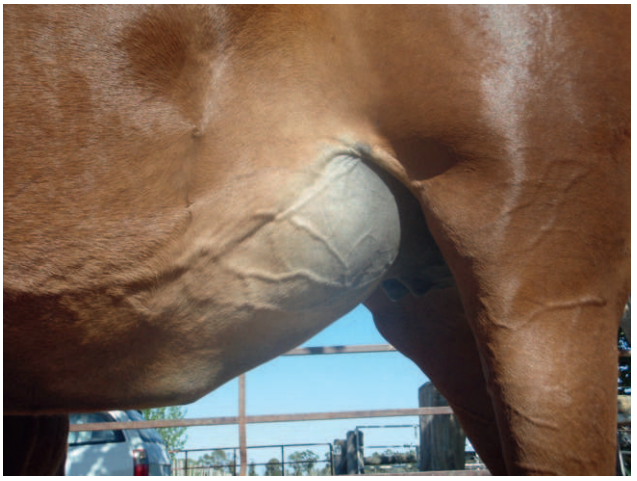

Fig 2: Abdominal wall tear in a Standardbred mare showing outline of ventral colon.

Fig 3: Blood exiting cranial orifice of teat.

controlled and the condition is progressing slowly. However, the clinician should establish prior to commencing treatment whether survival of the foal or mare is more important to the clients. In the instance in which the status of the mare is worsening and mare survival is of paramount importance, abortion (or induction of a nonviable fetus) should be performed. In cases in which foal survival is a priority, efforts should be directed to maximising gestational length until parturition occurs or is induced following confirmation of fetal readiness for birth. A successful outcome following induced parturition is heavily dependent on fetal maturity. It is well accepted that fetal maturation occurs only within approximately 10 days of parturition, when fetal adrenocortical hormones rise and trigger changes to facilitate life in an extra-uterine environment (Ousey 2008). These changes include an increase in thyroid hormone, an increase in the neutrophil: lymphocyte ratio (which impact on thermoregulation and glucose homoeostasis), an increased skeletal muscle tone, and maturation of the fetal lung and gastrointestinal system (Paccamonti 2012). Foals that fail to complete this final stage of maturation are thus born

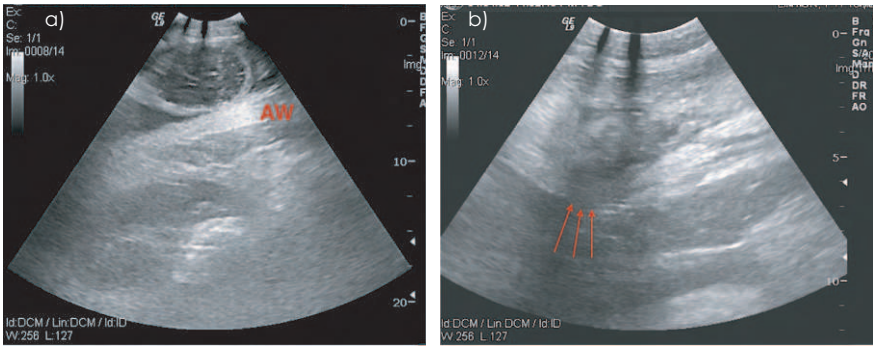

Fig 4: a) Ultrasonographic image obtained from right caudoventral abdominal wall in a case of abdominal wall tearing. Intestine is visible external to the abdominal wall (AW). b) Ultrasonographic image obtained from right caudoventral abdominal wall in a case of abdominal wall tearing. The tear is outlined in arrows.

demonstrating many or all of the features of prematurity; low body weights, hypoglycaemia (associated with low body glycogen stores), hypothermia, a poor suck reflex, inability to digest enteral feeds, pulmonary and renal dysfunction, incomplete ossification and deficient musculoskeletal development (Ousey 2008).

Should the mare suddenly deteriorate whilst attempting to maximise gestational length and foal survival, intervention will be required; a caesarean (C section) or induction of parturition. Induction is usually preferable over C section, as the mares are often systemically compromised and pronounced oedema makes incisional complications common. Whilst an elective C section is beneficial in a few cases (when fetal maturity is suspected, it may allow the mare to have a reduced role in delivery [MacPherson 2012]), it is also indicated if the condition is terminal.

There is a lack of data in the literature to help guide treatment. One retrospective study (Ross *et al.* 2008) of a group of 13 mares showed a higher foal survival rate in mares that were managed conservatively vs. those in which interventions (euthanasia, elective C sections or induced parturitions) were performed. Whilst this is valuable information, it is a retrospective study where mares were not randomly allocated; for example, euthanasia with no attempt to save the foal was performed in two of the more severely affected mares (Ross *et al.* 2008). Nonetheless, although the exact number of foals surviving was not clearly outlined in this study, it certainly seems higher than many previously documented cases. Thus, wherever possible, conservative treatment should be the initial treatment regime of choice to allow more time for fetal maturation and therefore increased chance of a viable neonate.

Finally in severe cases (requiring intensive monitoring and treatment) in which neither the mare nor fetus has significant value, euthanasia is a justifiable alternative.

Supportive care

Supportive management consists of stall rest and abdominal support to prevent progression of the tear. Abdominal support will further control the oedema and makes mares more comfortable. Support can be achieved through homemade bandages (e.g. Tensoplast[1]), homemade slings (**Fig 5**) or commercial abdominal support (**Fig 6**) such as the CM Hernia Belt[2]. Mares should be monitored for pressure necrosis developing along the spine; frequent repositioning and alterations in padding should be performed to allow redistribution of pressure and air movement around the skin.

Diet should be modified to improve mare comfort by reducing the bulk of the diet; minimise hay intake, feed a balanced high protein hard feed designed for the pregnant broodmare, and consider periodic nasogastric intubation with paraffin oil to maintain a soft faecal consistency.

Analgesia is critical in these painful mares. Nonsteroidal anti-inflammatories (NSAIDs) and opioids are often the backbone of treatment but a multimodal approach should be used, where possible to capitalise on synergistic if not additive effects of drugs without additional toxicity (provided drugs are metabolised and excreted by different routes). As well as systemically administered NSAIDs and opioids, consideration should be given to transdermal opioids, continuous rate infusions (CRIs) of lidocaine (0.05 mg/kg bwt/min), butorphonal (0.013 mg/kg bwt/h) and ketamine (0.4–0.8 mg/kg bwt/h) and potentially gabapentin. This latter drug is most commonly advocated for neuropathic pain and chronic pain states, but its use will likely be explored for other types of pain in equine patients.

Fig 5: Homemade canvas sling: design made to distribute weight evenly along the back, with adequate padding along the spine and with mesh to allow breathing of the skin. Image and design courtesy of Dr Angus McKinnon.

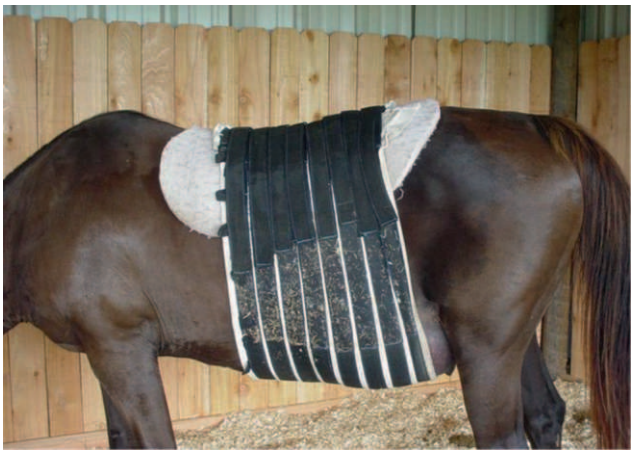

Fig 6: The CM Hernia Belt: commercial abdominal support bandage. Image courtesy of CM Equine Products[2].

Broad spectrum antimicrobials are indicated to reduce abscess formation within the haematomas (Rodgerson 2011). Progestin therapy is indicated to maintain uterine quiescence, and in the treatment of any accompanying placentitis.

Monitoring

Frequent monitoring of these mares is required, with particular noting of her pain status, and cardiovascular parameters. Mares close to foaling should have their mammary secretions monitored daily (in the evening) or twice daily, so that if deterioration of mare or foal occurs, the clinician is alerted to "fetal readiness for birth".

Maternal endocrine monitoring may be used to assess fetal maturity, well being and impending parturition. A complete description is beyond the scope of this article but is well summarised by Vaala (2011). As a very brief overview, progestagens remain fairly constant until approximately 3 weeks prior to birth, when a gradual elevation should occur. If progestagens rise prior to this, placental compromise (such as placentitis) is likely. A significantly decreased level however is indicative of fetal compromise. Similarly, total oestrogens can be measured; the normal pattern is a peak at 7–8 months of gestation followed by a gradual decline. Low oestrogen levels prior to 9 months indicate fetal stress and compromise, though the sensitivity of this in late pregnancy may be reduced as severe fetal stress can occur before levels decline (Vaala 2011).

Fetal monitoring is important to detect fetal stress, as this may prompt intervention sooner. An in depth description of transabdominal ultrasonographic fetal monitoring is described by Reef *et al.* (1995). Briefly, daily transabdominal ultrasonographic examination of the fetus should be performed, assessing;

- Fetal presentation (with transverse or posterior presentations indicating likely dystocia),
- Fetal heart rate (with either bradycardia of <60 beats/min or tachycardia of >120 indicating fetal stress)
- Fetal activity level (some degree of activity should be noted within a period of 30 min).

Fetal stress and viability can also be monitored via ECG examination. This can either be completed conventionally with the electrodes placed on the mare with one on dorsal midline, one on ventral midline and others placed on either side of the flanks. The fetal ECG should be able to be distinguished from the maternal ECG, which has larger, slower deflections (Vaala 2011). An alternative is a telemetric system such as the Televet 100,[3] in which both maternal and fetal ECGS are obtained but with the use of software that identifies the maternal R waves, then extracts them from each event to leave a "cleaned" signal representing fetal R waves. Frequent monitoring of the ECG will allow the clinician to detect bradycardia or tachycardia, indicative of fetal demise or distress respectively.

The presence of colostrum and the analysis of mammary secretions are an important indicator of fetal readiness for birth. It is proven and well accepted that when mares were induced to foal with calcium levels greater than 10 mmol/L the foal survival rate was better than those induced with a calcium lower than this (Ousey *et al.* 1984). The majority of mares with a calcium greater than 10 mmol/L also foal within 24–72 h (Card 2011). Sodium and potassium will also alter after the calcium levels rise, such that at the time of parturition mares should have a decreasing sodium and an increasing potassium, with inversion occurring around 30 mmol/L. A typical electrolyte profile of a mare due to foal imminently would be:

- Ca >10 mmol/L
- Sodium ≤30 mmol/L
- Potassium ≥35 mmol/L

As such, this would be the desired electrolyte profile in a mare in which parturition is being induced. An adapted scoring system pertaining to calcium, sodium and potassium concentrations has been devised to predict the likelihood of a positive outcome following induction (**Table 1**) (Ousey *et al.* 1984).

It is preferable to use a laboratory analysis of mammary secretion electrolytes as many stall side tests rely on the use of calcium alone. This is less accurate as elevated calcium may also be seen in cases of placentitis or twins (Paccamonti 2012). Water hardness kits are used in some clinics, and these are helpful tools but can be prone to inaccuracies as some measure calcium and magnesium; however magnesium may rise prior to calcium (Paccamonti 2012). Laboratory analysis of calcium, sodium and potassium together optimise accuracy. However, even with laboratory analysis of a full panel of electrolytes, the clinician should be aware that limitations will still exist, and a risk of inducing parturition in premature foals with lower survival rates remains.

In addition to monitoring electrolytes, it has been reported that a reduction in pH occurred in peri-parturient mares, and that twice daily determination of pH could effectively predict parturition (Korosue *et al.* 2013). This is valuable information,

TABLE 1: Scoring system for mammary secretion electrolyte concentrations (Ousey *et al.* 1984)

Calcium (mmol/L)	Sodium (mmol/L)	Potassium (mmol/L)	Points for each electrolyte
≥40	≤30	≥35	15
≥7	≤50	≥30	10
≥5	≤80	≥20	5

Total score ≥35 suggests a probable safe induction.

as a single pH measurement undertaken each evening is simple, practical and cost effective. The procedure can be performed with pH strip papers or a simple, pH meter (Ellerbrock and Canisso 2016). The majority of mares with a pH <7 have been shown to foal within 24 h (Canisso *et al.* 2013). Other clinicians have confirmed this; in addition it is possible that the pattern of pH change may reflect fetal maturation (Ellerbrock and Canisso 2016), which is an exciting prospect for the future.

In cases in which the mare deteriorates during treatment and suspected intervention is likely, clinicians should consider starting the mare on dexamethasone in a bid to hasten fetal maturity. Ousey *et al.* (2011) have shown that 100 mg of i.m. dexamethasone given daily for 3 days at 315–317 days of gestation can result in a shorter gestational length and advanced fetal maturity. In their initial studies, treated mares had a shortened gestation length, on average, by nearly 2 weeks compared with control mares. The foals appeared mature and healthy, and though smaller, they had similar bodyweights compared with control mares.

It is important to note that clinicians should take care in extrapolating this work to clinical cases for several reasons; as outlined in this article, similar regimes of glucocorticoid administration to pony mares later in pregnancy (Days 331–347) caused dystocia and fetal death (Jeffcott and Rossdale 1977). Ousey *et al.* (2011) suggest that the difference in these results are likely linked to the level of fetal cortisol at the time of treatment; perhaps glucocorticoid treatment when fetal cortisol levels are low simulate endogenous production and the ensuing tissue maturation whereas administration closer to parturition when fetal cortisol levels are higher may suppress endogenous adrenocortical activity and maturation. In addition, treatment is not without disadvantages; as well as potentially suppressing the fetal adrenal activity (via the negative feedback on the hypothalamus-pituitary-adrenal axis), dexamethasone has potential effects on prostaglandin synthesis in the mare with the potential to contribute to dystocia and/or premature placental separation (Ousey *et al.* 2011). Ousey *et al.* also make the comment that many sick mares will already have raised cortisol levels and activation of the fetal hypothalamic-pituitary-adrenal axis; in these instants glucocorticoids may disrupt the maturation process, further evaluation of the regime in the compromised mare is required. Currently the use of steroids to hasten fetal maturation in a sick mare is still in the experimental stages; however, favourable results have occurred in a small number of mares (Ousey 2008). The regime does however give the clinician a management option to attempt precocious fetal maturation in the situation in which a mare starts to deteriorate whilst carrying a likely premature foal.

Parturition

If the mare can reach full term, attendance and assistance of parturition is essential, as mares have little to no ability to contract their abdominal wall. To plan for adequate personnel to assist foaling, induction of these mares can be desirable.

Induction of parturition may be performed in cases in which one is confident of fetal readiness for extra-uterine life. It should be remembered that success of elective parturition is very much dependant on readiness for birth. Criteria for successful parturition include a gestational length of >330 days, colostrum in the udder (though this may be hard to ascertain with blood), relaxed sacrosciatic ligaments around the tailhead, a relaxed cervix and the appropriate changes in the mammary secretions (Jeffcott and Rossdale 1977). In cases in which one is not confident of this, induction should be restricted to cases in which the mare is uncontrollably painful, or terminally compromised. If induction is performed, oxytocin is generally the clinician's drug of choice. Glucocorticoids are inappropriate, as multiple doses over multiple days are needed. Their use is more appropriate in attempting to increase fetal maturation as previously outlined. Prostaglandins are discouraged, as there is a relatively long and variable time to foaling. There is also an increased risk of premature placental separation (Macpherson and Paccamonti 2011).

There are many different dosage regimes for oxytocin and in general, the method of oxytocin administration has not been shown to affect foal viability (Macpherson *et al.* 1997). A slow approach to induction with lower doses such as 2.5–5 IU is preferable as 10–20 IU can be quite painful and rapid with poor fetal positioning. Our preferred regime is a simple 5–10 IU i.v., repeated if necessary in 20–30 min (LeBlanc 2007).

Prostaglandin E_2 may be used to increase cervical dilation in mares undergoing induction, but is not mandatory.

Following successful parturition, the mare should be carefully monitored for complete expulsion of the fetal membranes. The foal should be initially classed as a neonate at high risk of developing neonatal maladjustment syndrome, and neonatal sepsis. If the foal does appear normal, consider colostrum supplementation as severe oedema may hinder normal nursing. Reduced colostrum quantities and running milk are reported in mares with pregnancies matured with corticosteroids (Ousey *et al.* 2011).

As the oedema resolves post foaling, the extent of the defect can be re-evaluated. Surgery is indicated in a small number of cases of true abdominal wall tears and these are repaired with direct suturing or insertion of a prosthetic mesh. If surgery is considered to be viable, the ideal timing will be 3–4 months post foaling (Freeman 2005). This delayed surgical repair reduces the risk of infection present when inflammation and oedema still persist. In addition, fibrosis and scarring of the edges of the defect will have greater strength for suture holding (Meek *et al.* 1977). There are many publications in the literature discussing variations in repair of acquired hernias (albeit mostly focused on incisional hernias, rather than abdominal wall defects in pregnant mares) and from these it appears that the choice between direct suture repair and mesh placement can largely be dictated by surgeon preference, as the overall success rate (in incisional hernias) is similar between the two techniques (Davis and Rakestraw 2002; Whitfield-Cargile *et al.* 2011). If using mesh, it may be placed within the abdominal cavity (Caron and Mehler 2009), inside the defect but in a retroperitoneal location (Elce *et al.* 2005), or subcutaneously, outside the hernia ring (Van Der Velden and Klein 1994). A variety of materials have been described for incisional hernias and traumatic abdominal wall hernias; polypropylene (Van Der Velden and Klein 1994), plastic (Elce *et al.* 2005), composite materials (combining polypropylene and expanded polytetrafluoroethylene [Caron and Mehler 2009]) and silk (Haupt *et al.* 2015). Again the choice is dictated by surgeon preference.

Laparoscopic repair of incisional hernias has been described (Rijkenhuizen 2005; Caron and Mehler 2009); reported advantages included a broad exposure of the hernia and definition of the hernia margins, a reduced risk of infection due to its less invasive character, the potential for surgery to be performed earlier as incision portals are further away from the defect and its surrounding oedematous tissue (Rijkenhuizen 2005) and the ability to identify and transect adhesions if present (Caron and Mehler 2009). This technique will likely require further evaluation in the cases of abdominal wall tearing, but is likely to gain increasing popularity.

Although a large number of reports describing incisional and traumatic hernia repairs exist, few reports specifically describe surgical repair of abdominal wall tearing in mares (Meek *et al.* 1977). It should be remembered that many hernias do not require surgical repair (Freeman 2005). Hernia repair is also not without risks, including chronic colic, incisional drainage, implant infection and further muscle tearing (Freeman 2005). Long-term survival rates varying from 50% (Elce *et al.* 2005) to 92% (Davis and Rakestraw 2002; Whitfield-Cargile *et al.* 2011) are reported. Potentially, it is difficult to justify the surgical repair in mares, in which many can foal successfully with abdominal wall defects. Surgical repair however, is indicated in those cases in which one is suspicious that a large hernia may be lead to complete rupture of the abdominal wall (Freeman 2005).

Rupture of the prepubic tendon in the mare is not a surgical condition, in contrast to small animals. Repair of prepubic tendon rupture (often secondary to blunt trauma) in dogs is commonly reported (Smeak 2014). Techniques include reattachment of the anatomical musculature with direct suture, re-attachment of the ligament with sutures placed through holes drilled in the pubis; with or without the use of prosthetic mesh and the use of muscle flaps from sartorius muscle (Smeak 2014) or the *rectus abdominis* (Archipow and Lanz 2011). These techniques in the dog seem to have a high success rate with a relatively low risk (15%) of recurrence (Smeak 2014). In contrast, surgical repair of the prepubic tendon has not been documented in the horse. It is likely that no repair would have sufficient strength given the considerable tension of the ventrolateral abdominal wall in the horse.

In summary, many mares with abdominal wall defects can successfully carry further pregnancies, and foal successfully, with assistance. The clinician should decide on a case by case basis whether re-breeding is appropriate. If a bona fide PPT rupture is suspected, re-breeding and carrying a foal to term is not advisable. Retirement from breeding or assisted reproductive techniques such as embryo transfer is recommended in appropriate breeds.

Prognosis

The condition can prove fatal to the mare for a number of reasons. Evisceration may occur, either prior to parturition, as a result of skin necrosis (as seen by this author), or during parturition (LeBlanc 2007). Catastrophic body wall rupture can lead to the mare's abdomen reaching the ground (A. O. McKinnon, personal communication). Rupture of a gastrointestinal viscus may occur, or incarceration of gastrointestinal viscera through a tear in the body wall may ensue. Finally, fatal haemorrhage may occur as the uterus loses the support of the body wall. One case report has also documented spinal cord trauma necessitating euthanasia (Hendriks *et al. 2007)*.

Survival rates of both mare and foal vary greatly between published reports. One older study presented four mares; in this all four foals and three mares died; the surviving mare died 6 months later (Hanson and Todhunter 1986). A larger more recent study (13 mares) demonstrated survival in 10/13 mares (Ross *et al.* 2008). The number of foals surviving is not clearly recorded but said to be good. This group found that foal survival was significantly better in the conservatively managed mares vs. those with intervention. It is also interesting that the group found foal survival was not significantly affected by gestational age, or type of body wall defect, although only three of 13 cases appear to involve the PPT. One recent case report (Schutten 2016) reports successful foaling of a conservatively managed Standardbred mare with a complete PPT rupture. Our clinical experience and that of others (Santschi and Vaala 2011) would suggest that mares with complete rupture of the PPT carry a poor prognosis. Logically, foals of a lower gestational age will have a more guarded prognosis for survival.

It would appear that room exists within the literature for a larger multi-centre case series documenting the outcome of these cases. Perhaps our increasing abilities to monitor fetal viability and fetal well being, to control the condition of these mares with more sophisticated multimodal analgesic regimes, or our increasing proficiency at managing the high risk neonate mean that survival of these foals and their dams can improve the prognosis for this condition from the previously disastrous condition it has been historically.

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Ethical animal research

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Manufacturers' addresses

[1]BSN medical Australia and New Zealand, Mount Waverley, Victoria, Australia.
[2]CM Equine Products, Norco, California, USA.
[3]Kruuse UK Ltd., Sherburn In Elmet, North Yorkshire, UK.

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Critically Appraised Topic

What is the best treatment for mares with post-partum haemorrhage?

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Summary

Determining the 'best' treatment for mares with post-partum haemorrhage is a challenge for equine practitioners. There have been many approaches described, some directly contradictory, with scant evidence supporting choices made for treatment. Information available from peer-reviewed literature may be biased as reports primarily originate from large private or university-based referral hospitals. There are no large breeding farm population-based studies or studies directly comparing treatments.

PICO question

In mares affected by post-partum haemorrhage, is intensive medical therapy more effective than conservative therapy?

Search strategy

CAB Abstracts on the OVID interface was searched from 1973 to 2017 using the following terms: (1) equine* OR horse* OR equus OR foal* OR colt* OR equid* OR mare or mares; (2) postpartum interval/OR postpartum period/OR parturition complications; (3) postpartum* OR post-partum* OR postparturition* OR post-parturition* OR postparturient* OR post-parturient*); (4) haemorrhage/OR haemorrhagic colitis/ OR haemorrhage/OR haemorhag*.mp. OR hemorhag*.mp. OR haemorrhag*.mp. OR hemorrhag*.mp.; (5) drug therapy/OR treatment/OR therapy/OR surgical operations/OR surgery/ OR immunotherapy/OR medical treatment/OR treat*.mp. OR manag*.mp. OR therap*.mp. OR surg*.mp. OR med*.mp. OR drug*.mp. OR pharma*.mp. OR immuno*.mp. OR chemo*.mp; (6) 2 OR 3; (7) 1 AND 4 AND 5 AND 6; (8) limit 7 to English language; (9) 1 AND 4 AND 6; (10) limit 9 to English language.

In total, 14 manuscripts were identified fulfilling the search criteria for 7 and 8. Four were considered not applicable for a variety of reasons (wrong species; related to surgical intervention; not pregnancy related). Three were opinion-based reviews included in conference proceedings with an additional three being opinion-based reviews in peer-reviewed veterinary journals. Two were single case reports (Mogg *et al.* 2006; Oikawa *et al.* 2009) and two were retrospective university or large private referral hospital-based studies (Dolente *et al.* 2005; Arnold *et al.* 2008). A single retrospective university-based study yielded data on an additional three mares with peripartum bleeding out of 19 cases of haemoperitoneum (Pusterla *et al.* 2005). Of the two

TABLE 1: Treatments administered to mares suffering post-partum haemorrhage as reported in peer-reviewed retrospective studies and single case reports*

Reference	Study population and sample size	Study design	Treatments	Number treated (%)	Survival (%)
Arnold *et al.* (2008)	Private referral hospital 73 mares	Retrospective (1998–2005)	Flunixin meglumine	72/73 (99)	NS
			Polyionic crystalloid i.v. fluids	69/73 (95)	59/69 (86)
			Aminocaproic acid	67/73 (92)	57/67 (85)
			Sedation	51/73 (70)	NS
			Whole blood transfusion	33/73 (45)	25/33 (76)
			Hypertonic saline	33/73 (45)	16/33 (48)
			Pentoxyfylline	32/73 (44)	NS
			Epidural	29/72 (40)	NS
			Naloxone	24/73 (33)	18/24 (75)
			Oxytocin	14/73 (19)	13/14 (93)
			Plasma transfusion	11/73 (15)	8/11 (73)
			Laparotomy	6/73 (8)	2/6 (33)
			Hb-based oxygen carrying solution	5/73 (7)	4/5 (80)
			Polymyxin B	4/73 (6)	NS
			Hetastarch	4/73 (5)	3/4 (75)
			Conjugated oestrogens	2/73 (3)	NS
			Yunan baiyao	2/73 (3)	NS
			10% formalin	1/73 (1)	NS

TABLE 1: Continued

Reference	Study population and sample size	Study design	Treatments	Number treated (%)	Survival (%)
Dolente *et al.* (2005)	University referral hospital 27/163 mares with post-partum complications	Retrospective (1992–2002)	None specified	NS	NS *87% post-partum bleed mares, personal knowledge of author
Pusterla *et al.* (2005)	University referral hospital 2/19 horses with post-partum haemoperitoneum	Retrospective (1992–2003)	Not specified by cause	16/19 (84)* *3 euthanised without treatment at owners' request ($$)	14/16 (88)* *Outcome of post-partum mares not specified
			Polyionic crystalloid i.v. fluids	14/16 (88)	NS
			NSAID	10/16 (63)	NS
			Whole blood transfusion	8/16 (50)	NS
			Conjugated oestrogen	8/16 (50)	NS
			Antimicrobials	7/16 (44)	NS
			Aminocaproic acid	5/16 (31)	NS
			Plasma transfusion	3/16 (19)	NS
			Dexamethasone	2/16 (13)	NS
			Formalin	1/16 (6)	NS
Oikawa *et al.* (2009)	Single mare University hospital	Case report	Polyionic crystalloid i.v. fluids	1/1 (100)	1/1 (100)
			Flunixin meglumine	1/1 (100)	1/1 (100)
			Tranexamic acid	1/1 (100)	1/1 (100)
			Ergometrine	1/1 (100)	1/1 (100)
			Bovine lactoferrin	1/1 (100)	1/1 (100)
Mogg *et al.* (2006)	Single mare University hospital	Case report	Water by NGT	1/1 (100)	1/1 (100)
			Antimicrobials	1/1 (100)	1/1 (100)
			Flunixin meglumine	1/1 (100)	1/1 (100)
			Abdominal drainage/lavage	1/1 (100)	1/1 (100)

NGT, nasogastric tube; NS, not specified; NSAID, nonsteroidal anti-inflammatory drug.
*The table is organised with treatment most frequently administered first, with survival associated with those treatments in a separate column.

reproduction-focused retrospective studies, one presented data from 73 mares (10 with prepartum haemorrhage, 63 with post-partum haemorrhage) presented to a single large referral private hospital (Arnold *et al.* 2008) and one was a single-referral university hospital-based study of 163 mares hospitalised with post-partum complications, 27 with post-partum haemorrhage (Dolente *et al.* 2005) (**Table 1**). There were no studies reporting on the incidence or treatment of mares with post-partum haemorrhage remaining on the home farm.

There is a paucity of information available regarding the efficacy of treatment of post-partum haemorrhage, resulting in an inability to compare conservative vs. intensive treatment. Data that are available are from large referral institutions where intensive treatment occurs commonly. Most commonly administered treatment included flunixin meglumine or other nonsteroidal anti-inflammatory drugs (NSAIDs), i.v. polyionic crystalloid fluids, aminocaproic acid or other promoters of coagulation and whole blood/plasma transfusion. Overall, survival of mares presented to such institutions is quite good, ranging from 87% to 84% where those data could be gleaned from the manuscripts, excluding case reports. This may, in the authors opinion, be related to the stability of the mares and their ability to survive the initial haemorrhage and transportation to a referral facility. There is no information available related to treatment at a farm location, the incidence of post-partum haemorrhage over the general population of broodmares or survival of affected mares related to the general population.

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Critically Appraised Topic

In the mare, does manual removal of fetal membranes negatively affect fertility?

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Background

Retained fetal membranes (RFM) are the most frequently occurring post-partum condition of the mare encountered in clinical practise (Threlfall 2011). The condition is defined as the retention, complete or partial, of the allantochorionic membrane for an extended period of time following expulsion of the foal. The vast majority of publications agree that fetal membranes (FM) should be considered pathologically retained if they have not been expelled within 3 h post-partum, at which time it is considered appropriate to implement therapeutic intervention (Brinsko 2007).

Despite the high incidence of RFM, a lack of consensus exists regarding the optimal treatment regimen. Due to the higher risk of fatal sequelae, the approach to treatment of RFM in the mare is very different to that taken when managing this condition in other domestic species. Manual removal as an intervention for the treatment of RFM remains controversial due to the perceived risks and potential negative effects on future fertility. The commonly cited immediate risks of manual removal include severe haemorrhage, pulmonary embolism, intussusception of the uterine horn and uterine prolapse (Threlfall 2011). It is reported that manual removal of FM may also have a negative impact on fertility by causing delayed uterine involution, the cervix to remain open longer post foaling (Vandeplassche *et al.* 1971), retention of microvilli that serve as foci of infection, fibrosis and permanent endometrial damage (Threlfall 2011). Methods of manual removal vary between reports and there is no well-described, universally-accepted technique for manual FM removal.

Search strategy

A population, intervention, comparison, outcome (PICO) question was constructed: In the mare, does manual removal of fetal membranes negatively affect future fertility?

The keywords (mare OR mares) AND ((retained membrane) OR (retained placenta)) AND manual were used to search CAB abstracts (1910 – present) and Scopus.

Quantity of evidence

The search yielded 14 results from CAB abstracts and no additional sources were retrieved through Scopus. Papers in a language other than English were excluded; the remaining papers were screened based on title and abstract and three experimental studies that suitably addressed the PICO question were identified. These papers comprised of two clinical trials (Sevinga *et al.* 2002; Cuervo-Arango and Newcombe 2009) and a single cohort study (Ishii *et al.* 1999).

Quality of evidence

All studies included primarily (Cuervo-Arango and Newcombe 2009) or exclusively (Ishii *et al.* 1999; Sevinga *et al.* 2002) heavy draught breed mares. The study by Ishii *et al.* (1999) lacked power (n = 10) and did not include any relevant calculations of significance. Similarly, Cuervo-Arango and Newcombe (2009) included 12 manual removals, whilst Sevinga *et al.* (2002) had the largest sample size (n = 30).

Ishii *et al.* (1999) performed manual removal of FM in 10 mares; however, the technique they used to perform this procedure was not described in the paper. These authors found that mares, which underwent manual removal of FM, tended to have an increased non-pregnant term, defined as the number of days from parturition to last mating prior to a positive pregnancy diagnosis (58.5 days), in comparison to mares that did not undergo manual removal of FM (33.8 days). The timing of manual removal of FM relative to parturition was not recorded, making it difficult to identify other factors, such as retention time, that may have contributed to decreased fertility rates. They stated that a number of mares with positive bacterial swabs were treated with an intrauterine infusion of antibiotics with or without uterine irrigation; however, it was not specified whether these mares were those that had undergone manual removal of FM.

Cuervo-Arango and Newcombe (2009) described successful prophylactic removal of FM immediately post foaling. Whilst this study did not address RFM 'per se' it does provide clinically relevant information. Attempts at removal were ceased if the mare stood prior to completion of the procedure, and these mares were allowed to expel membranes naturally. In this study, mares that retained FM or experienced dystocia were excluded from the results, reducing the relevance of these findings to a clinical scenario. However, exclusion of mares that retained FM does remove the influence of placental retention time on the measured fertility outcomes.

Sevinga *et al.* (2002), did not describe the technique used for manual removal of FM; however, the uterus of each mare was flushed with 50–100 L of water once manual removal was complete. They performed manual removal of RFM approximately 7 h post parturition to first allow for repeated oxytocin administration. Mares that retained FM and underwent manual removal received significantly (P = 0.005) more subsequent intrauterine treatments than those mares

with RFM that did not undergo manual removal. Intrauterine treatments were in the form of an antibiotic infusion post-breeding. This paper acknowledged that due to a lack of blinding, there may have been bias towards mares that underwent manual removal in selecting animals to receive these interventions and that this may have positively influenced fertility outcomes.

Sevinga *et al.* (2002) measured an array of fertility parameters (for example pregnancy rate per cycle, pregnancy losses) and concluded that there were no significant differences in the outcomes between mares with RFM that were removed manually and those with RFM that expelled the FM spontaneously or following medical intervention. Cuervo-Arango and Newcombe (2009) measured the accumulation of free intrauterine fluid, as well as pregnancy rate at first service and pregnancy rate at the end of the season. These authors' also found no significant differences between mares that had early manual removal of FM and those that passed FM naturally. They concluded that early manual removal of FM has no detrimental effects on subsequent fertility of the mare.

Clinical implications

Manual removal of FM may be performed without negatively affecting fertility of the mare; however, the evidence is insufficient to recommend manual removal in all cases.

All data that are currently available relate primarily to heavy breed horses that are known to have a higher incidence of RFM than light horse breeds. The application of results from heavy breeds directly to other breeds may not be appropriate as there is potential for varied responses to manual removal between breeds.

Equine clinicians should consider manual removal as a valid treatment option in heavy breed horses and also in high risk cases that have failed to respond to conservative therapy and repeated oxytocin administration. This approach of implementing manual intervention following oxytocin treatment is in agreement with the conclusions of Vandeplassche *et al.* (1971), despite this paper regularly being cited to describe the risks of manual removal of FM.

The advantages of manual removal of FM are likely to exceed the risks to mare health and fertility; however, mares which undergo the procedure may require closer monitoring and concurrent intrauterine treatments to facilitate rebreeding. Prolonged placental retention time is shown to have greater negative influence on pregnancy rates in Thoroughbred mares compared to heavy draught mares (Ishii *et al.* 2013), further supporting the need for timely removal of RFM in these mares.

The underlying aetiology of retention of FM may influence the effects of manual removal and thus future fertility outcomes. For example, it is possible that the response to manual removal will be different in mares with RFM due to fibrotic adhesion of the allantochorion to the endometrium compared to mares with RFM due to secondary uterine atony. Mares experiencing secondary uterine atony have decreased oxytocin receptor expression in the endometrium and allantochorion, reducing the likelihood of successful expulsion of FM with oxytocin therapy alone (Rapacz-Leonard *et al.* 2015). This increases the indication for manual removal of FM in cases of secondary uterine atony, as oxytocin therapy is less likely to be successful.

Conclusion

Manual removal of RFM has previously been discouraged based primarily on anecdotal and observational evidence. The three recent publications on the effects of manual removal of FM on mare fertility that have been discussed in this article, do not support these long-held beliefs. Further investigations, especially in light horse breeds, are warranted. Evaluation of FM removal techniques and time of removal relative to parturition would be essential if manual removal is to be considered in a routine treatment protocol for RFM in the mare. However, the manual removal of RFM should be considered in relation to substantially proven and successful techniques, such as those described by Burns *et al.* (1977) and Meijer *et al.* (2015).

Author's declaration of interests

No conflicts of interest have been declared.

Ethical animal research

Ethical review not applicable for this critically appraised topic.

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Authorship

M. Platt and A. Walker made a major contribution to study design, search execution, analysis and interpretation of results and preparation of the manuscript. A. Gunn contributed to study design, analysis and interpretation of results, editing of the manuscript. All authors gave their approval of the final manuscript.

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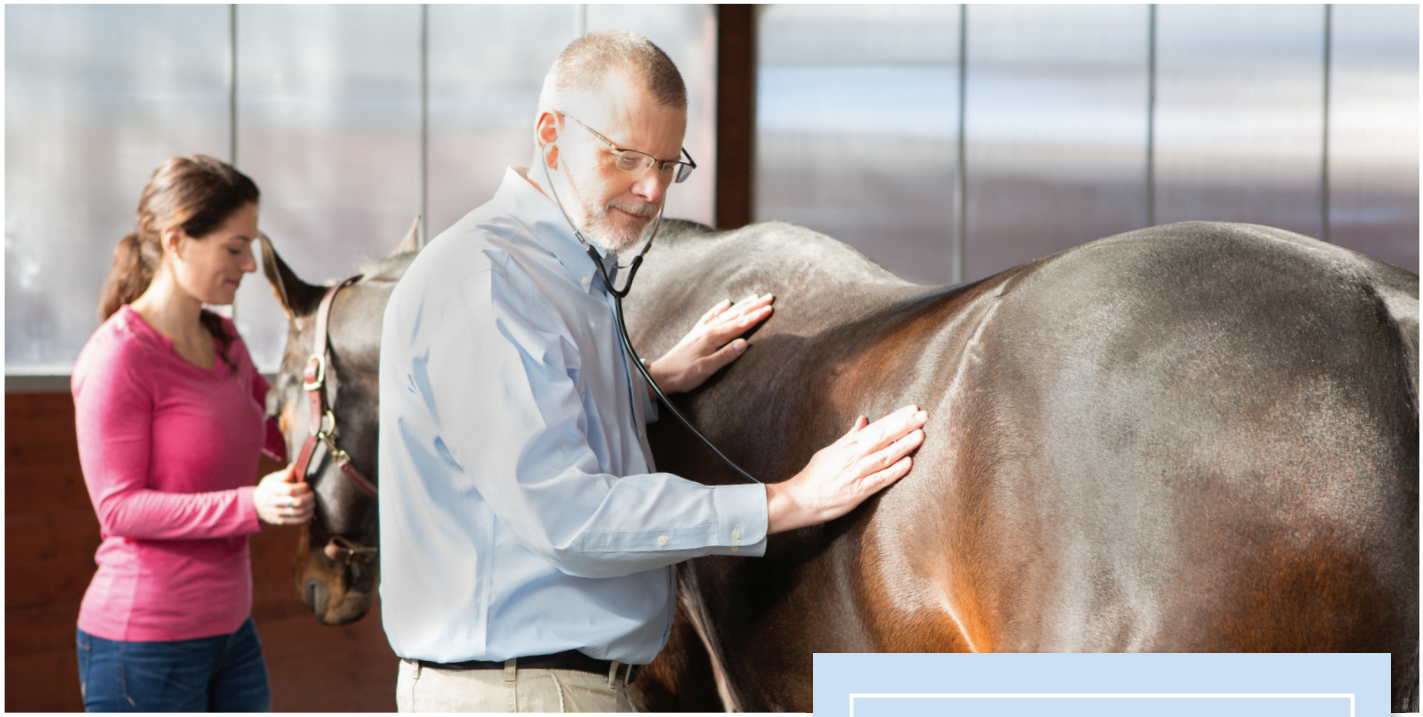

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Correspondence

Letter to the Editor: Post-operative reflux – a surgeon's perspective

Post-operative reflux - an alternate perspective

There have been two recent articles written by D.E. Freeman, including an editorial in the Equine Veterinary Journal ('50 years of colic surgery') (Freeman 2018a) and the present article ('Post-operative reflux – a surgeon's perspective' [Freeman 2018b]) which propose that there is an escalating level of post-operative reflux noted in horses following small intestinal surgery at veterinary hospitals except those associated with the aforementioned author. Coupled with this assertion is the impression that surgeons are overly pessimistic about prognosis and are far more reliant on pharmacological treatment of post-operative reflux (POR) or the associated syndrome of functional post-operative ileus (POI). In terms of pessimism, it is noteworthy that Freeman *et al.* euthanised 22% of horses with small intestinal surgery in a 2000 article under anaesthesia (Freeman *et al.* 2000) which perhaps stimulated a change in opinion, although this is not explained in the present Equine Veterinary Education article. I propose that the most ethical practice with colic surgery is to present a realistic prognosis to the owner prior to surgery, and to refine the prognosis at the time of surgery, considering additional expenses and the emotional impact of post-operative outcome. The key in my view is realism in view of all the literature that has been published vs. pessimism.

The surgeon's perspective proposed by Freeman has a number of numerical errors, although I have not been through all of the values within particularly figure 2 of the present article. The prevalence in the Blikslager 92–94 study was not 47%, but 21%, as stated in the original manuscript (Blikslager *et al.* 1994). This incorrect number was also reported by Freeman in the Equine Veterinary Journal editorial (Freeman 2018a,b). In another study by Fogle *et al.*, Freeman has picked apart the data to make a point that the prevalence of POI was 70%, but this only included 33 horses receiving carboxymethylcellulose for the first time in a clinical study, whereas the prevalence in the remaining 170 horses was 44% (Fogle *et al.* 2008). I agree that these numbers are concerning and that we should seek better methods to reduce POR. However, a similar splitting of percentages could be applied to a study by Freeman *et al.*, in which 18% of horses with a handsewn side-to-side jejunocaecal anastomosis developed colic and POR, but 70% of horses with a stapled side-to-side jejunocaecal anastomosis developed colic and POR (Freeman and Schaeffer 2010). These numbers are merged with numbers from two other studies to give a far lower rate of approximately 10% in the present Equine Veterinary Education article (Freeman 2018b [see figure 2, legend]).

Overall, the hypothesis appears to be that repeat celiotomy is the key approach to POR to address technical errors, particularly shortened mesentery and anastomotic stenosis. This brings up a couple of points. Firstly, these complications are unusual in my view, especially mesenteric shortening, which can be obviated by leaving the mesentery as long as possible in resection cases (ligating within approximately 6–8 cm of the margin of the bowel), and avoiding 'gathering' of the cut mesentery, as has been indicated by Freeman (Freeman 1997). The second point is that repeat laparotomy adds greatly to the expense in many hospitals and is a particularly rigorous approach to POR given that most horses will stop refluxing within 48-h of medical management, particularly those on lidocaine (Malone *et al.* 2006). Overall, I would suggest a different overall hypothesis: pharmacological management of POR is effective in the absence of technical surgical errors. There is evidence to support why this might be the case that the author has overlooked. Dr Freeman mentions equine studies assessing the inflammation that occurs following small intestinal manipulation, which is clearly increased within the muscle layers during the recovery period (Little *et al.* 2005). We also know that intestinal inflammation is exacerbated by the administration of flunixin meglumine and ameliorated by administration of lidocaine (Cook *et al.* 2009). There is also the analgesic effect of lidocaine, particularly when given in combination with flunixin meglumine, that should not be over-looked (Cook *et al.* 2008). I am in favour of reducing unnecessary usage of medications in post-operative colic patients but I think this has to be done carefully based on evidence which is still forthcoming in the form of multi-institutional randomised controlled trials (Ziegler *et al.* 2019). I would strongly encourage broad involvement in randomised controlled trials to gather the evidence we need to make informed choices on management of equine syndromes such as POR/POI. Ultimately, it is the entire population of post-operative colic patients that we are trying to address, rather than the relatively smaller numbers of horses that have been published in studies with differing objectives and outcomes.

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Correspondence

Letter to the Editor: Response to Dr Blikslager's letter on post-operative reflux

Thank you very much for giving me the opportunity to respond to the letter by A.T. Blikslager (Blikslager 2020) regarding my reviews in Equine Veterinary Education (Freeman 2018a) and in Equine Veterinary Journal (Freeman 2018b). I will limit my responses to small intestinal surgery, presumably the topic of interest.

Dr Blikslager is correct that 22% of horses in the study mentioned (Freeman *et al.* 2000) were euthanised intra-operatively, but then he incorrectly assumed that these cases reflect an inconsistency or redirection in my stance on pessimism. Many surgeons were involved in the study and few, if any, of these euthanised cases were mine; however, they did represent a pessimistic approach to small intestinal strangulation that has contributed to my current views. I do not subject the owner to intraoperative discussions about prognosis in small intestinal strangulations, except in catastrophes beyond dispute (see below), and believe this approach is not unethical, as implied.

I suspect that Dr Blikslager's realism could vary widely across the broad spectrum of surgeons and might include pessimism in some cases. The owner of a horse that needs colic surgery knows that the horse has a life-threatening disease and might already be distraught and pessimistic, especially with old horses and even with previous veterinary advice (Ireland *et al.* 2011). Therefore, I believe that my role is not to promote or sustain this pessimism before or during surgery, but to give the horse every chance I can to save its life. I do not engage in intraoperative discussions with owners of horses with a primary small intestinal strangulation unless for a rare but undisputed catastrophe (e.g. ruptured stomach, uncontrollable haemorrhage from a portal vein). Rarely, an owner might request intraoperative euthanasia over resection and anastomosis during preoperative discussions but that is based on their own experiences or advice from others (Ireland *et al.* 2011).

Dr Blikslager's approach to "refining the prognosis at the time of surgery" is likely to lead to an overly pessimistic assessment in my opinion. Many horses with severe ischaemic lesions can have a far more favourable outcome than expected, defying all prognostic indicators derived "in view of all the literature". "All the literature" does not apply to all hospitals and all surgeons and, more importantly, to every horse. I believe that the owner should be spared a difficult intraoperative decision that lacks satisfactory guidelines and should instead be granted the benefit of a completed surgery. For example, red discoloration of peritoneal fluid is not a grave indicator of prognosis, contrary to what is stated in "the literature" (Van den Boom *et al.* 2010). It is very common in horses with small intestinal strangulation, most of which survive.

Dr Blikslager is correct about numerical errors, but they are his, not mine. The number of horses with post-operative ileus (POI) in the manuscript I cited (Blikslager *et al.* 1994) was 21%, as he stated, but that was for both small and large intestinal lesions. I was only interested in small intestinal cases, as stated in figure 2 (Freeman 2018a). According to table 1 in Dr Blikslager *et al.*'s paper (1994), 23 of 49 horses (47%) that had a small intestinal disease developed post-operative reflux (POR/POI), so the percentage I used was correct and in line with others he has published (Morton and Blikslager 2002; Fogle *et al.* 2008). I can assure Dr Blikslager that the numbers reported in figure 2 (Freeman 2018a) have been carefully checked for accuracy.

The comment that I "picked apart the data" to find a 73% rate of POR in the paper by Fogle *et al.* (2008) implies that this information was not readily apparent. Actually, this percentage is prominently displayed in table 2 (Fogle *et al.* 2008) and to characterise this group as "only 33 horses" misses the point. These horses constituted a group over a specific time period (2003–2005) that followed the other 170 horses (1994–2002) in chronological order to provide an example of how the prevalence of POR appeared to increase over that interval (figure 2 in Freeman 2018a). This observation supports the objective of my commentary (Freeman 2018a) and contradicts the positive role that Dr Blikslager assigns to pharmacological management of complications (Blikslager 2009). I believe we need to consider the role of many factors in POR and my commentary was intended to address that.

Dr Blikslager made an error in his "splitting of percentages" in my jejunocecostomy paper (Freeman and Schaeffer 2010) that he could have avoided by reading the *erratum* for that paper (Freeman and Schaeffer 2011a). He interpreted the third row on our table 2 as evidence that 70% of the 10 horses with the stapled anastomosis had POR, whereas horses in that row actually had colic alone, POR alone, or both combined (Freeman and Schaeffer 2011a). In fact, 40% of horses in the stapled group had POR (with or without colic) as clearly stated in the first row of table 2 (Freeman and Schaeffer 2010). As Dr Blikslager correctly noted, but with the wrong numbers, when six horses with POR of 32 total (19%) in the jejunocecostomy study were merged with two other studies, the percentage of horses with POR dropped to 10%, largely because no horse in one of these studies developed POR (Freeman and Schaeffer 2011b).

Dr Blikslager's statement about repeat celiotomy provides an example of pessimism. Repeat celiotomy is always expensive but so is prolonged medical treatment of POR. Contrary to what he suggests, repeat celiotomy is not "the key approach to POR" for me, but I do see targeted prevention of POR through specific surgical techniques and a reduced emphasis on the role of POI as critical (Freeman 2018a). Repeat celiotomy plays an important role in treating POR because a physical obstruction can contribute more to this complication (Bauck *et al.* 2017a) than Dr Blikslager recognises. His criticism should be tempered with awareness that repeat celiotomy (one or two) immediately terminated POR in 81% of cases in a recent study (Bauck *et al.* 2017a), despite the additional inflammation that a second surgery would inflict on the affected intestine. This response, the favourable short-term survival rate, and median survival time

of 90 months (Bauck *et al.* 2017a) surpass responses to lidocaine (Malone *et al.* 2006) or any drug in colic-related studies. By comparison, the slower resolution of POR with lidocaine (Malone *et al.* 2006), needs to be regarded with caution in a disease that can resolve spontaneously (Nolen-Walston *et al.* 2007).

I disagree with Dr Blikslager's hypothesis that "pharmacological management of POR is effective in the absence of technical surgical errors", largely because it is impossible to rule out a technical error or a physical obstruction in any horse, simply because it is discharged after one surgery. Presumably technical errors or surgically related complications can produce a broad continuum of physical changes that cause different degrees of intestinal obstruction. Any form of physical obstruction (e.g. anastomotic stenosis) that causes POR could have a transient effect, possibly because it is sufficiently mild to allow recovery of intestinal function shortly after surgery, either through resolution of the obstruction or adaptation to it. Such "recoveries" could explain the increased risk for death after hospital discharge in horses that developed POR/POI (Fogle *et al.* 2008) but "responded to medical treatment."

Dr Blikslager's comment about the rarity of technical errors raises the concern that he dismisses the importance of such errors in outcome. I imagine that we all commit more errors than we think, especially in as complicated a surgery as resection and anastomosis, and denial is not the pathway to prevent them. Some technical errors are unexpected (Freeman and Schaeffer 2010) and some forms of physical obstruction are difficult to prevent or recognise (Bauck *et al.* 2017a). However, most of them are poorly tolerated and so we should all be circumspect about our potential role in their development.

I cannot agree with the comment that "we also know that intestinal inflammation is exacerbated by the administration of flunixin meglumine". The paper cited to support this statement examined mucosa only (Cook *et al.* 2009) and not the muscle layers that are relevant to POI. More importantly, flunixin meglumine did not increase inflammation in the muscle layers and serosa after ischaemic injury in another study that Dr Blikslager coauthored (Little *et al.* 2005). The claim that I overlooked evidence in favour of pharmacological treatment is true, largely because such evidence is weak or lacking (Freeman 2018a,b). The statement that the exacerbation of inflammation was "ameliorated by administration of lidocaine" also relates to the study on the mucosal layer only (Cook *et al.* 2009), whereas a more recent study could not consistently demonstrate an antiinflammatory effect of lidocaine across all layers in different models of jejunal inflammation (Bauck *et al.* 2017b). I fully agree and have stated that lidocaine does provide visceral analgesia (Freeman 2018b), especially with flunixin meglumine (Cook *et al.* 2008).

The study supporting Dr Blikslager's statement, "inflammation that occurs following small intestinal manipulation, which is clearly increased within the muscle layers during the recovery period" (Little *et al.* 2005) actually did not examine response to manipulation in equine small intestine, in any layer. Undoubtedly surgically relevant manipulation does induce inflammation in intestinal muscle layers in horses (Bauck *et al.* 2017b), but transferring this information from laboratory animals to POR in horses lacks support (Freeman 2018a). For example, the inflammation theory for POR embraced by Dr Blikslager would seem to predict that a repeat celiotomy, with as much manipulation and inflammation as induced at the first surgery, would exacerbate POR; the opposite seems to be true (Bauck *et al.* 2017a).

Dr Blikslager should recognise that horses with strangulated small intestine deemed viable and not resected do not seem particularly prone to POR/POI or post-operative endotoxaemia (Freeman *et al.* 2014). This is critical because these horses are the clinical correlates of the ischaemia and reperfusion models that Dr Blikslager uses to advance his inflammation hypothesis (Little *et al.* 2005; Cook *et al.* 2009). These clinical cases, with favourable survival rates, but without lidocaine and with full-dose flunixin meglumine (Freeman *et al.* 2014) do not support his views about pharmacological management of post-operative complications.

The last statement in Dr Blikslager's letter causes the most concern. It reads as if we should dismiss studies with "differing objectives and outcomes," whatever that means, and focus only on randomised controlled trials (RCTs). This would seem to relegate other studies, including mine, to outlier status and promote the types of studies he favours as more reflective of the direction to follow. Surely, the objectives and outcomes of all studies are the same for the "colic population at large" and that is to improve survival rates and reduce complications, suffering and cost. He faults my studies as having "relatively smaller numbers of horses," which is interesting considering that they have larger numbers, alone or in combination, than the RCTs he cites, twice as many for some of the objectives examined (Malone *et al.* 2006; Ziegler *et al.* 2019). I agree that RCTs play an important role in studying these issues, but biases in design and data presentation (Blikslager 2018; Ziegler *et al.* 2019) need to be resolved before they can allow "informed choices." In the meantime, if Dr Blikslager embraced the message in papers he dismisses, he might find that positive outcomes can be achieved with "differing objectives," an appropriate degree of optimism, and without expensive pharmacological management.

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