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– Melissa King, King Equine Vet Services, McDonough, GA
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As 2016 draws to a close, I am frequently asked “How was it?” Simple answer: It was great! For me, the challenge was work-life integration. Somewhat like a juggler, I was able to keep the balls in the air of family, practice, AAEP and community with the support and commitment of my “families”—children; Equine Veterinary Care practice staff, partner and clients; and AAEP staff, officers, board and volunteers. Thank you all!

As your president, I straddled the line between “what is” and “what might be.” These two scenarios are not often black and white but usually shades of gray—some positive possibilities and other negative realities. Always the primary consideration is relating the issue back to the AAEP mission and our 2020 Strategic Plan. How does the matter affect the health and welfare of the horse? How does it affect our members’ health and wellness—member value, education, fiscal matters, promotion and advocacy of our profession, and individual wellness both emotional and physical, are front and center in all decisions.

Communication is a priority for AAEP. Monthly conference calls among officers and board members help steer a steady course. Electronic communications inform you of emerging issues, news, opportunities and actions in the works. Mailed media brings you the latest peer-reviewed science and more updates; and, of course, CE meetings are the pinnacle of communication.

But what about member communication? We heard you loud and clear. The 2015 CE Needs Analysis was reviewed carefully and changes were made to future CE to implement your wishes. The AAEP-AVMA Economic Survey provided much information which will guide our industry in the future. Each CE meeting evaluation provides direct and immediate feedback on subjects, speakers and locations, all invaluable in future planning. Listserv discussions and questions to leadership or the AAEP office with concerns provide touch points for emerging issues. In this age of instant gratification, sometimes the most difficult part of the equation is allowing time for a thoughtful and well-informed response. Patience is not a strong suit for most of us!

As I look back on 2016, many of the highlights involved communication or collaboration. Spring saw the formation of the Infectious Disease Committee, tasked with overseeing the Equine Disease Communication Center website and serving as a resource for subject matter experts on infectious disease such as advising on a biosecurity project in collaboration with USEF and AQHA. Spring also witnessed the formation of a Public Auction Task Force to provide guidance in public auction policy as it relates to veterinary procedures; continued work on the Performance Horse Task Force white paper and collaborative education directed at our members and their clients in both sport horse and Western horse arenas; further development of the EIPH Research Project that evolved from the EIPH experts meeting in November 2015; continuing efforts on the AVMA-AAEP Economic Survey development; vigilant oversight of the dentistry politics at the state and federal levels; and approval of the AAEP’s Practice Life Podcast series featuring “soft subjects” such as practice dynamics and new graduate support systems.

Thoroughbred racing’s Triple Crown series inevitably stimulates a renewed focus on medication and safety issues, and this year was no exception with H.R. 3084 (Barr/Tonko bill) receiving increased discussion. A group of AAEP delegates took our Racing Committee’s comments to Washington, D.C., during the American Horse Council meeting in June and met with Congressman Barr. This led to continued dialogue and, in November, a meeting with Travis Tygart, CEO of the proposed regulatory agent USADA, in our quest to understand and position AAEP as an influential entity in this fluid process of racing politics. Two days before that meeting, the AAEP’s longstanding commitment to the health of the racehorse was recognized when I had the pleasure of accepting on behalf of the association the 2016 Joe Palmer Award for meritorious service to racing from the National Turf Writers and Broadcasters Association.

A renewed commitment to promoting the charitable arm of AAEP Foundation emerged from the concurrent summer board meeting and Foundation Advisory Council strategic planning session with creation of the My Mentor scholarship program as our first endowed scholarship. An officers’ retreat in August completed the selection of the many volunteer positions on committees and listservs utilizing the recommendations of the Leadership Development Committee based on information gleaned from completed Volunteer Interest Forms on the AAEP website.

Attendance at the British Equine Veterinary Association meeting, Irish Champions weekend and the Mexican continued on page IV
The Caribbean is calling sport horse practitioners
Register for AAEP’s Resort Symposium in Grand Cayman by January 6

If sport horses are a part of your practice, you won’t want to miss the AAEP’s 19th Annual Resort Symposium, being held Jan. 30–Feb. 1, 2017, at the Westin Grand Cayman Seven Mile Beach Resort & Spa.

The tropical meeting offers 15 CE credits with an exclusive focus on sport horse medicine. Is a presented performance problem neurologic, musculoskeletal or both? How can I use advanced imaging techniques to diagnose lameness conditions in problematic anatomic regions of the fetlock and proximal cannon bone? What frequency, duration and intensity of exercise is ideal for the equine athlete returning from injury? These are just a few of the questions that will be answered at the meeting.

Following half-day educational sessions, enjoy some midwinter fun in the sun on U.S. News and World Report Travel’s No. 1 beach in the world for 2015-2016.

Or join your colleagues for optional group excursions that include horseback riding on the beach, a Cayman cultural safari tour and a catamaran sail and snorkel.

To take advantage of this unique education-vacation opportunity, you must register by Jan. 6. For additional information or to register for the meeting and optional excursions, visit www.aaep.org/info/resort-symposium.

Thanks to IDEXX and Merial for their sponsorship of the 19th Annual Resort Symposium.

AAEP podcast offers advice on managing work-family balance

If you are a practitioner with children or planning to start a family in the future, you’ll want to download and listen to the November episode of AAEP Practice Life, a recently launched podcast about life as an equine veterinarian.

In the current episode, entitled “Balancing Family Life with Equine Practice,” Drs. Amanda House, Ernie Martinez and Gina Tranquilo Shade share their strategies for maintaining equilibrium between the challenges of children and career. The guests discuss the biggest surprises of parenthood, managing pregnancy and practice, work-life balance issues and advice to young veterinarians who want to start a family.

Search “AAEP Practice Life” on iTunes to download the current episode or subscribe to future episodes. Listen in your truck between calls, in the clinic between appointments or at home in your spare time.

From the President’s Desk, continued from page III

Equine Veterinary Association meeting were wonderful opportunities to network with our international members and explore their challenges which, for the most part, mirror those we face in North America: staying abreast of emerging science and technology in equine practice; workplace challenges, including student debt and employment; and overall health, with Europe placing a premium on safety and wellness. Meanwhile, attendance at an international equine summit in China offered a fascinating glimpse of emerging veterinary care in that region.

This president’s letter serves as my last opportunity to thank you, the membership, for the great honor AAEP has bestowed upon me. Rest assured AAEP staff and Executive Director David Foley work the same hours we do (weekends/holidays etc.) to keep the AAEP afloat and full steam ahead. Your officers, board of directors and multitude of volunteers at every level are engaged and passionate about fulfilling the AAEP’s mission. There is no room for complacency. The President’s job might be summed up best by the late Shimon Peres: “You must be ahead of time, because if you want to represent the status quo, what do you need leaders for?”
Nominate a distinguished researcher for the 2018 AAEP Milne Lecture

Deadline to nominate is January 30

Nominations from the AAEP membership are being accepted for the 2018 Frank J. Milne State-of-the-Art Lecture.

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

The award recipient will be determined by a subcommittee of the AAEP Educational Programs Committee in February 2017 and will then be presented to the board of directors for approval. The selected individual will deliver their lecture and receive their award at the AAEP’s 2018 Annual Convention in San Francisco, Calif.

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

A Milne Lecture nomination form may be requested from Carey Ross, scientific publications coordinator, at cross@aaep.org, and must be returned to her by Jan. 30, 2017.

Dr. Thomas J. Divers delivers the 2015 Milne Lecture “The Equine Liver in Health and Disease.”

Share your colic research at the 12th International Equine Colic Research Symposium

Deadline to submit an abstract is February 8

The 12th International Equine Colic Research Symposium will be hosted by the AAEP Foundation in Lexington, Ky., on July 18-20, 2017. The symposium immediately follows the AAEP’s Focus on Colic and Focus on Dentistry meetings, July 16-18, 2017.

The deadline to submit an abstract for the symposium is Feb. 8, 2017, at 5:00 p.m. EST. The meeting format and guidelines for abstracts are available at http://foundation.aaep.org/colic-research-symposium-i-70.html.

Punch your 2017 convention ticket by submitting your research

With the AAEP’s 62nd Annual Convention in the books, it’s time to prepare for 2017 by submitting papers to be considered for presentation during the 63rd Annual Convention in San Antonio, Texas, Nov. 17-21. The primary author of selected papers will receive complimentary registration and a stipend to support travel to the meeting.

Eligible for consideration are scientific papers, “how-to” papers, review papers, abstracts ≤ 250 words and The Business of Practice papers. In a change from prior years, all paper presentations will be limited to 15 minutes with an additional 5 minutes for Q&A.

All papers must be submitted by 3:00 p.m. ET on March 15, 2017, at http://aaep2016.abstractcentral.com. 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 Instructions for Authors available on the site.
Ethics: Ethical considerations for the regulatory veterinarian

By Nancy Diehl, VMD, and Deborah Lamparter, VMD

Highlights:
Remaining objective and unbiased is crucial when regulating colleagues.

Building mutually beneficial relationships with practitioners is possible and achieves the best results.

People skills are essential to fulfilling regulatory duties.

Like those in many other professional groups, veterinarians have careers or opportunities in which they are regulating the work of other veterinarians. Industry-specific organizations such as state racing commissions have veterinarians whose duties include overseeing the work of private practitioners at the racetrack and perhaps recommending or advising on regulatory actions the commission may take against those practitioners. Professional organizations such as the AAEP have authority over membership privileges granted in their bylaws. State licensing boards include veterinarians and have strong regulatory functions over licensed veterinarians. For a regulatory veterinarian, enforcing rules and licensing requirements against one’s professional colleagues can be fraught with emotional and professional conflicts.

Though some will argue against self-regulation by professional groups, veterinarians, compared to non-professionals, should be ideally situated to regulate colleagues. We know the intricacies of medical practice, understand that undesirable outcomes can occur without negligence and know how varied practice environments can influence how our work gets done. We have an ability to see a more nuanced view of a situation than a non-professional. In addition, presumably because we are educated professionals, we have a manifest responsibility to put emotions and biases aside and behave objectively.

Threats to objectivity
However, there are hazards for veterinarians placed in these regulatory positions that can put objectivity in peril. We can be too close or too familiar with a situation. We may say, “but we know everyone does it” or “well, that’s not ideal, but that’s the way it is in real life.” Also, as we see the realities of practice over the years, we may lower the bar as to what we expect is normal, usual or acceptable behavior. We can be too close to the people we are regulating. It is natural to become friends or at least friendly with our colleagues who we work with or see every day. We may cultivate those relationships, and we appreciate when they act as partners in helping us in our regulatory missions. But these relationships can easily lead to a reluctance to pursue actions against our colleagues who are acting outside the bounds.

A reluctance to support regulatory or legal action against a fellow veterinarian because of friendship, loyalty to the profession or empathy is certainly not limited to regulatory veterinarians. It’s a question all private practitioners face at some point. Unfortunately, the job often requires regulatory veterinarians, with limited time resources and often with limited authority, to determine the best level of scrutiny they can or should apply to practitioners. Regulatory veterinarians must assure practitioners’ compliance with the rules, and avoiding or ignoring a practitioner’s suspect activity can be consequential not only to the objectives of the regulating body but also to the welfare of the horse.

Establishing effective relations
However, rather than approach this duty with a heavy hand, a good working relationship between regulatory veterinarians and practitioners can achieve better results for the welfare of horses. Within the confines of the rules and policies they must follow, regulatory veterinarians should be equitable in their dealings with all practitioners and a resource for current information such as recommendations from testing laboratories or prospective rule changes. Most regulatory veterinarians will say their goal is not to catch people but to help them comply with the rules.

On the other side of the equation, the practitioner may be able to share with the regulatory veterinarian information on particular stables or horses at risk, for example in continued on page VII
Ethics, continued from page VI

competition or in contagious disease control. Regulatory veterinarians recognize the conundrum practitioners face in handling certain situations that fall between the need for client confidentiality and the duty to maintain the integrity of the system and provide for the welfare of the horse. Regulatory veterinarians therefore must hold information in confidence and maintain the trust of the practitioner that he or she will use good judgment in confidentially using that information. Behaviors and actions by regulatory veterinarians and practitioners that are mutually beneficial and, ultimately, for the welfare of the horse (or horse population) can be a constant source of soul searching for the correct ethical justification.

Balancing relationships and the regulatory framework
How can regulatory veterinarians have successful relationships with practitioners that are mutually beneficial but still conform to the organization’s regulatory mission?

• Attempt to maintain collegial relationships while avoiding close friendships.
• Avoid gifts. This may be codified by a management directive from the regulatory body.
• Follow the rules. Be clear, unwavering and equitable in enforcing the rules among all members or licensees. Within those confines, if the regulatory veterinarian has the need and authority to interpret a rule or choose options within a rule, he or she should clarify and explain parameters for making those choices.
• Explicitly enumerate and explain the rules. Approach rules enforcement as an educational venture. Rather than a heavy-handed approach, make each moment a teachable one that helps practitioners clearly understand the history, reasoning and means of complying with the rules.
• Use good judgment with any confidential information provided by practitioners so that you are known for being trustworthy.

Veterinarians taking on regulatory duties must have tremendous people skills along with medical skills. Experience in practice settings is certainly good preparation. Some of the duties are, by nature, more adversarial than collegial, something veterinarians probably have precious little training or experience in. Following the rules while building good relationships with practitioners can benefit and protect the regulatory body as well as the welfare of the horses involved.

Dr. Diehl is a regulatory veterinarian for the Pennsylvania Harness Racing Commission, Dr. Lamparter is chief state veterinarian for the New Jersey Racing Commission. Each is a member of the AAEP’s Professional Conduct and Ethics Committee.
Drs. Fassinger and Lee reward the horse, join mentors and colleagues with Legacy gift

Veterinary medicine and AAEP membership have provided a rewarding and fulfilling career for Dr. Jane Fassinger, owner of All Creatures Mobile Vet Service, and Dr. John Lee, Jr., founder of Unionville Equine Associates.

The couple, who got engaged at an AAEP meeting in Lexington, Ky., in 1998, relocated from Pennsylvania to Magdalena, N.M., in 2015 following Dr. Lee’s retirement from practice. Dr. Fassinger reopened her mixed animal practice in the rural village of 926 residents, and her husband now serves as her assistant when not busy with his new roles as firefighter and ambulance driver-in-training.

When making estate plans, the couple pledged a portion of their estate to the AAEP Foundation, becoming members of the Legacy Society. The couple recently discussed their Legacy gift, which they described as a way to give back to an animal and industry they love as well as follow the lead of mentors and colleagues who have been helpful in their careers such as Drs. Bill Moyer, Michelle LeBlanc, Ann Dwyer and others.

How did you become involved with the AAEP?

John: My first all-equine job was with two vets named Jerry Bilinski and Ted Sprinkle. They shipped me off to Boston for the 1975 AAEP meeting. I just got into it and loved it! When I moved to Pennsylvania and my practice grew, I encouraged everyone to join the AAEP. It's just been a great group. Of all the groups I’ve belonged to, AAEP has been the most enthusiastic, positive, grow and lead the industry bunch.

Jane: I was a student chapter member and have been a member ever since. One of the biggest things, like John said, is the AAEP is kind of the cohesive link between members of a profession who are extremely independent. And it does keep us together.

How would you describe the AAEP Foundation to someone who isn’t familiar with the it?

John: The Foundation is the only charitable organization that I’m aware of that is directed totally by trained professionals that also love what they do. Everyone’s background in this is the same, which in this case because we’re species-specific, I think is critical. This foundation is totally horse oriented and run by horse professionals; the distribution of funds is by horse professionals. With all the arguing about the Clinton Foundation and the Trump Foundation, there can be no arguing about the AAEP Foundation in the sense that 100% of every dollar donated goes to help the horse.

Jane: Most of us in this profession feel very blessed and we love what we do and it’s been good to us. The Foundation represents an awesome opportunity to give back.

Could you talk about the considerations or thought process that went into your estate gift to the Foundation and, perhaps, the importance of estate planning in general for equine practitioners?

Jane: We’ve probably all heard the saying “there’s nothing so good for the inside of a man as the outside of a horse.” We believe this, we live it and this is our way of putting our money where our mouth is to ensure that future generations have the same opportunities that we have had to live this dream.

John: Equine veterinarians are used to working long hours every day, they’re used to being involved in the profession and planning to be involved at some level their whole lives. I think it’s important for veterinarians to take a break in their busy schedule at whatever level they may be and do estate planning.

We both had already included donations to our veterinary colleges in our wills so it was just natural to include AAEP. I think that’s critical because AAEP is your educational partner for the rest of your life. Vet school is just four years; AAEP is forever.

Interested in joining the Legacy Society?
Contact Jodie Bingham, Foundation development coordinator at (859) 233-0147 or jbingham@aaep.org.
Practices welcome newcomers, earn rewards in Time to Ride Challenge

A pair of veterinary practices introduced a combined 630 newcomers to horses at beginner-friendly events during the summer as part of the 2016 Time to Ride Challenge.

The third annual challenge, which is designed to bring new enthusiasts into the horse industry, saw a record 1,004 events held across the United States between June 1 and Sept. 30. A total of 28,175 newcomers with little to no horse experience enjoyed a hands-on introduction to horses and riding during these events.

Lodi Veterinary Care in Lodi, Wisc., and Alpine Animal Hospital in Carbondale, Colo., were awarded $500 and $250, respectively, for being among the top hosts in their divisions.

“We have previously hosted events as a clinic in conjunction with local barns,” said Mara Krisko, an equine veterinary technician at Lodi Veterinary Care who led the practice’s Time to Ride efforts. “From those events, we know that improving relationships with the horse industry through opportunities that are not usually geared for newcomers is an important part of expanding the horse industry in the future.”

“It’s a fun activity where staff and doctors get to provide a service to the kids and interact with the community,” said Dr. Chuck Maker, an AAEP member with Alpine Animal Hospital. “Kids and parents love it, and that makes us feel good too. We are hoping that the exposure increases young riders’ likelihood to become grown up riders someday.”

Time to Ride is an initiative of the American Horse Council’s marketing alliance, of which the AAEP is among 12 members, to address the long-term growth of the horse industry by connecting parents with family-friendly horse activities in their area. For more information, visit www.timetoride.com.

Touch Point: ‘Getting to Know the Sport’ videos help you learn your client’s business

If your client is a competitor or a professional horseperson who makes his or her living in the horse industry, your expertise about the sport or breed in which they’re involved is important to their satisfaction with your services.

According to the AAEP’s market research, owners who are satisfied with their veterinarians are substantially more likely than those who aren’t satisfied to say that their veterinarian “understands my business.”

Of the 19 attributes tested in our research with owners and trainers, “my veterinarian understands my business” was among those with the largest difference in ratings between the satisfied and the dissatisfied.

Gaining the necessary expertise about your client’s business can be as easy as attending a horse show or researching a discipline on the Internet. It just requires the willingness to learn more about the things most important to your clients.

Get started by watching the Touch program’s video series, “Getting to Know the Sport,” featuring the newest videos on the discipline of Standardbred racing. The series provides an introduction to several disciplines within equine sport and offers advice from an experienced veterinarian and trainer in each discipline. All Touch resources are available exclusively to AAEP members at touch.aaep.org.
Cargill Feed & Nutrition, an Educational Partner of the AAEP since 2001, is committed to translating nutrition research into feed solutions to improve the health of horses. With industry-leading research partners such as Texas A&M University, the Nutrena® and Progressive Nutrition® brands of feeds and supplements have a rich history of creating innovative nutrition solutions.

When it comes to nutrition that supports the health of your clients’ horses, Cargill’s team of Equine Nutrition Experts has your back. With a host of nutrition solutions within our brand portfolios, we are here to provide education and support.

Visit www.ToplineBalance.com and check out our unique, educational assessment tool. We’d be happy to help get you and your staff trained on how to use it and help your clients. Give us a call at (800) 367-4894 or visit our website www.NutrenaWorld.com.

**Opportunity Knocks!**

**Chicago-area ambulatory practice seeks associate**

Premier Equine Veterinary Service, LLC in Lemont, Ill., is looking for an enthusiastic and compassionate associate veterinarian to join our equine ambulatory practice. Applicant must have good client communication, be service oriented and have strong technical skills. We serve primarily sport horses, Saddlebreds, hunter-jumpers and occasional Western disciplines. An interest in lameness and sport horse medicine is a must!

We provide preventative care, dentistry, advanced diagnostics, advanced therapies and 24-hour emergency service. The practice is equipped with digital ultrasound, digital radiography, endoscopy, PowerFloat dental equipment, shockwave, etc. A practice vehicle is provided. Experience is preferred, but all applicants are welcome. Salary and benefits are based on experience and are negotiable. Contact Dr. Alison Powers at (888) 860-0244 or apowersdvm@gmail.com.

**The AAEP welcomes new members and congratulates recent graduates**

**New Members:**
- Rachel Busato, DVM, Port Perry, ON, Canada
- Nathan Chase Canada, DVM, Bryan, TX
- Emily Comstock, DVM, Barre, VT
- Nicola Cribb, DVM, MA, DACVS, Guelph, ON, Canada
- Randy de Gref, DVM, Oldenzaal, Netherlands
- Rachel Fraser, DVM, New Berlin, NY
- Sophie Gattuso, DVM, St-Hippolyte, QC, Canada
- Josephine Hale, DVM, Alphington, VIC, Australia
- Vickie A. Heidlage, DVM, Claremore, OK
- Wesley Louis Lee, DVM DACVS-LA, Benton, LA
- Aslaug Mandel, DVM CVA CCRT, Snowmass Village, CO
- Adolfo Francisco Martinez, MVZ, Jackson, MI
- Patrick McGrath, MVB, Co. Kildare, Ireland
- Tanya Mestayer, DVM, Lafayette, LA
- Monica Cardoso Mira, DVM, Evora, Portugal
- Mindy Osborne, DVM, Oak Hill, WV
- Perry P. Parks, DVM, Asheboro, NC
- Sam Sina Parsaye, DVM, Laporte, CO
- Rodrigo Ferreira Riba De Ave, DVM, Lisboa, Lisbon District, Portugal
- Joel Robbins, DVM, Scottsbluff, NE

**Recent Graduates:**
- Kathy K. Seino, DVM, Pullman, WA
- Laura E. Tucker, DVM, St. Paul, MN
- Linda Van Veen, DVM, Oldenzaal, Netherlands
- Robert Wishner, DVM, El Centro, CA
- Chin Yong, DVM, Elmont, NY
- Weston Brown, DVM, Harmony, MN
- Beth Byles, DVM, Ringoes, NJ
- Teresa Ann Duthie, DVM, Ocala, FL
- Jennifer Earnest, DVM, Newman Lake, WA
- Tyler Elliott, DVM, Wellington, NV
- Laura Fitzharris, DVM, Bristol, United Kingdom
- Alexandria Fritz, DVM, Beverly Hills, FL
- Sarah Renee Furtney, DVM, Ocala, FL
- Christine Machin, DVM, Simpsonville, KS
- Megan Marchitello, DVM, Leesburg, VA
- Meghan Brady McCarthy, DVM, Wellington, FL
- Anna Sims, DVM, Great Falls, MT
- Carin Elizabeth Stevens, DVM, Fort Hood, TX
- Hobie Wilson, DVM, Athens, AL
Members in the News

USAHA honors industry veterinarian

The United States Animal Health Association presented Dr. Angela Pelzel-McCluskey with the USAHA Federal Partnership Award on Oct. 16 in Greensboro, N.C. The award honors a federal employee for collaboration with state and industry stakeholders in animal agriculture.

Dr. Pelzel-McCluskey, an equine epidemiologist for USDA-APHIS Veterinary Services and 2001 graduate of Texas A&M University, was honored for her work and collaboration with states and industry in dealing with equine health issues.

PRCA awards Texas practitioner

The Professional Rodeo Cowboys Association honored Dr. Marty Tanner as its 2016 Zoetis PRCA Veterinarian of the Year at the annual PRCA Awards Banquet Nov. 30 in Las Vegas, Nev. The award recognizes the dedication of veterinarians across North America to the health and welfare of rodeo livestock.

Dr. Tanner specializes in lameness treatment and surgery, with an emphasis on the rodeo and barrel racing performance horse, at Elgin Veterinary Hospital in Elgin, Texas. A 1986 graduate of Mississippi State University, Dr. Tanner travels throughout North America assisting his clientele. Several world champions attribute their success, in part, to Dr. Tanner.

Longtime Maryland racing veterinarian honored

Honor Roll member Dr. David Zipf, chief veterinarian for the Maryland Racing Commission, received the 2016 Joe Kelly Maryland Million Unsung Hero Award from the Maryland Million on Oct. 22. The award, named for the late dean of Maryland turf writers, recognizes honesty, hard work and humility.

After receiving his veterinary degree from The Ohio State University in 1965, Dr. Zipf joined the Maryland Racing Commission as a staff veterinarian. He has been a regular at Maryland racetracks for 51 years.

AAEP mourns the passing of two longtime members

Retired AAEP Honor Roll member and respected steeplechase horseman Dr. John K. Griggs died Oct. 19 at his farm in Lexington, Ky. He was 84.

Dr. Griggs received his veterinary degree from Auburn University. According to the National Steeplechase Association, he served in the Air Force before settling in Lexington in 1958. He joined the AAEP in 1961.

Dr. Griggs’ involvement in steeplechase racing spanned several decades. He trained the winners of 103 races from 496 starts between 1979 and 2013 and remained active as an owner through 2015. He is best known as the owner and trainer of Warm Spell, North America’s champion steeplechase horse in 1994.

Dr. Scott Weems, founder of Sisters Equine in Sisters, Ore., died Oct. 14 at the age of 59.

A 1981 graduate of Texas A&M University, Dr. Weems opened Weems & Stephens Equine Hospital in Aubrey, Texas, in 1984. While attending a veterinary meeting in Oregon, he discovered the city of Sisters and moved his family there in 2006. He began offering ambulatory service throughout Central Oregon the following year. The ambulatory practice grew into Sisters Equine, a clinic that opened in 2013.

An AAEP member since 1984, Dr. Weems served on the Reproduction Committee from 1989–1991.
AAEP Meetings and Continuing Education

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Highlights of recent clinically relevant papers

Dobutamine, fluids and anaesthesia
This study by Claire Loughran and colleagues in Australia investigated whether providing concurrent fluid support improved cardiovascular status in horses given dobutamine under anaesthesia.

Six horses were anaesthetised on two separate occasions at least 3 weeks apart and received either intravenous infusion of dobutamine alone or dobutamine infusion with a 20 mL/kg bwt bolus of Hartmann’s solution. The treatments were targeted to achieve a mean arterial blood pressure of 80 mmHg within 30 min of the start of the infusion. There was no significant increase in cardiac index between the treatments. During treatment with dobutamine, there was a significant increase in arterial oxygen content and haemoglobin concentration, to values that were significantly higher than those measured during the combined dobutamine and fluids treatment, during which there was no significant change in these factors. There was also a significant increase in oxygen delivery index during dobutamine treatment. However, there was no significant difference in femoral blood flow measurements (a proxy measurement of peripheral perfusion) when dobutamine only was administered. During the combined treatment, femoral blood flow in the upper and lower (dependent) limbs increased significantly over time.

This study shows that in isoflurane-anaesthetised horses, dobutamine administration alone causes an increase in cardiac index and oxygen delivery index, but a combination of dobutamine and crystalloid fluid bolus achieves significant improvements in femoral blood flow, providing evidence that this approach improves peripheral perfusion.

Effects of adhesion barriers
In this meta-analytical review Amelia Munsterman and colleagues in the USA aimed to determine the efficacy of adhesion barriers on adhesion formation in horses.

A search using PubMed/MEDLINE and Google Scholar was performed, followed by secondary searches of veterinary trade journals, bibliographies of relevant articles, manufacturer websites, and technical reference guides. Randomised experimental trials in healthy horses that included both a treatment and control group were considered. Euthanasia or laparoscopy was the endpoint required to identify adhesion formation. A meta-analysis was performed using a random effects model, with the effect size calculated as an odds ratio (OR) with 95% confidence intervals (CI). Statistical significance was set at P<0.05.

Of the 354 peer reviewed publications that met the search criteria, nine relevant studies were identified and investigated the use of sodium carboxymethylcellulose (CMC) solutions, sodium hyaluronate/carboxymethylcellulose (HA/CMC) membranes, hyaluronate (HA), and fucoidan solutions. The odds of adhesions in horses treated with an adhesion barrier were significantly lower than untreated controls (OR = 0.102; 95% CI [0.041, 0.254]; P<0.001). When analysed as subsets for each type of barrier, horses treated with HA/CMC membranes and CMC solutions had significant OR for fewer adhesions (OR = 0.061; 95% CI [0.013, 0.292]; OR = 0.119; 95% CI [0.034, 0.415], respectively; P<0.001).

This meta-analysis demonstrated adhesion barriers provide a positive effect on the odds of adhesion formation. The limitations of this study included the small sample size and a bias towards publication of studies with only positive findings.

Bronchopneumonia in foals
In this study Steeve Gigueré and colleagues in the USA investigated whether measurement of serum amyloid A (SAA) assay concentrations can accurately differentiate pneumonic from healthy foals.

Serum samples were collected from 54 pneumonic foals (aged 3 weeks to 5 months) at hospital admission. Foals were categorised as having pneumonia caused by R. equi or by other micro-organisms based on culture of a tracheobronchial aspirate; 44 healthy controls were used for comparison. In addition, serum samples were obtained at 2-week intervals from 47 foals born at a farm endemic for R. equi. SAA concentrations were measured by a point-of-care assay. Diagnostic performance of SAA was assessed by use of receiver operating characteristic curves.

Concentrations of SAA in foals with bronchopneumonia were significantly higher than those of healthy foals, but 15/54 pneumonic foals (28%) had SAA concentrations <5 µg/mL. There was no correlation between SAA concentrations and radiographic score in foals with R. equi pneumonia. The ability of SAA to predict development of R. equi pneumonia at the endemic farm was limited (sensitivity 64%; specificity 77%).

Overall, SAA concentrations are significantly higher in pneumonic than in healthy foals. However, performance of SAA in detecting pneumonic foals is limited by the high proportion of false-positive and false-negative results.

Laminitis risk factors
This prospective cohort study by Nicola Menzies-Gow and colleagues in the UK set out to evaluate risk factors influencing the development of pasture-associated laminitis in ponies, prior to disease occurrence.

The study included 446 non-laminitic ponies aged 10–20 years, with an approximately equal number of mares and geldings. Breeds included Welsh, Shetland, cob and crossbreeds. At the start of the study, weight, body condition score and crest measurements were recorded and an overnight dexamethasone suppression test (DST) was performed. Venous concentrations of the following mediators were measured: plasma adiponectin, leptin, serum insulin, several insulin-like growth factors, C-reactive protein, p-selectin, E-selectin and plasma triglycerides. Owners were contacted on an annual basis for 3 years to determine whether pasture-associated laminitis had been diagnosed by their veterinary surgeon in the last 12 months.

On initial examination, 73% were overweight or obese and 0.5% were underweight (0.5%). After 1 year, 4% had developed pasture-associated laminitis. After 2 years, this had increased to 6.7% and after 3 years to 9.9%. After 3 years, the factors which had emerged from statistical analysis as significant risk factors for laminitis were low plasma
adiponectin, high basal insulin and high insulin post-dexamethasone. No statistically significant associations were found with the other mediators or with plasma triglyceride levels. None of the morphometric measures proved to be associated with laminitis.

The finding that low plasma adiponectin is present in ponies prior to the onset of signs of laminitis indicates that this may be a risk factor for laminitis as opposed to simply a sign of the disease. Hyperinsulinaemia and insulin dysregulation are already known to be risk factors for the disease. An exaggerated response to exogenous dexamethasone in the DST was associated with an increased risk of laminitis in this study. The main limitation of the study was that horses were only subjected to clinical examination and blood tests on one occasion at the study onset, and biomarkers and body condition may have changed considerably in the subsequent 3 years.

**Equine gastric glandular disease risk factors**

The aim of this study by J. Mönki and colleagues in Finland and South Africa was to determine the risk factors for equine gastric glandular disease (EGGD). This case-control study included 83 horses with endoscopic evidence of EGGD and 34 controls which were either healthy horses or horses with equine squamous gastric disease (EGGD) without EGGD.

The data were analysed by multivariable logistic regression modelling. An additional analysis compared horses with glandular lesions (n = 43) against healthy horses (n = 22).

On first analysis, Warmblood breed (OR = 13.9, 95% CI: 2.2–90.9, P = 0.005) and an increasing number of caretakers (OR = 7.3, 95% CI: 0.98–55.6, P = 0.053) were associated with an increased risk of EGGD. On analysis of the subset of data, Warmblood breed (OR = 28.6, 95% CI: 2.96–250.0, P = 0.004) and increasing number of riders (OR = 12.99, 95% CI: 0.94–166.7, P = 0.056) were risk factors. The presence of sand in the colon appeared to have a protective effect against EGGD (OR = 0.195, 95% CI: 0.04–10.0, P = 0.051 for sand vs. no sand present).

These findings suggest that Warmbloods are predisposed to EGGD and multiple handlers/riders might increase the risk of EGGD. Identification of risk factors allows speculation on potential pathophysiological mechanisms of EGGD.

**Effects of resveratrol on lameness**

This study by Ashlee Watts and colleagues in the USA determined the effect of resveratrol administration in performance horses with lameness in the distal tarsal joints. This randomised, blinded, placebo-controlled clinical trial used 45 client-owned horses with lameness localised to the distal tarsal joints. All horses received injections of triamcinolone acetonide in the centrodistal and tarsometatarsal joints of both hindlimbs. A placebo or a supplement containing resveratrol was fed twice daily by owners for 4 months. Primary outcomes were horse performance as determined by rider opinion (better, worse, or the same) and change in lameness severity from the enrolment examination.

Complete data were obtained for 21 horses that received resveratrol and 20 that received the placebo. Percentage of riders who reported that the horse’s performance was better, compared with worse or the same, was significantly higher for the resveratrol group than for the placebo group after 2 (20/21 [95%] vs. 14/20 [70%]) and 4 (18/21 [86%] vs. 10/20 [50%]) months. The change in A1:A2 ratio between the enrolment and 4-month recheck examinations was significantly better for horses in the resveratrol vs. placebo group. However, subjective lameness scores and degree of asymmetry of pelvis movement did not differ between groups.

In performance horses with lameness localised to the distal tarsal joints, injection of triamcinolone in the centrodistal and tarsometatarsal joints of both hindlimbs followed by oral supplementation with resveratrol for 4 months resulted in reduced lameness, compared with triamcinolone injection and supplementation with a placebo.

**Equine atypical myopathy**

R. Karliková and colleagues in the Czech Republic have recently published the results of their metabolic study of equine atypical myopathy (AM). In order to study metabolic changes, serum and urine samples from nine horses with atypical myopathy and 12 control samples from clinically healthy horses were collected and then analysed using high-performance liquid chromatography coupled with tandem mass spectrometry; serum metabolic profiles as the disease progressed were also studied. Metabolic data were evaluated using unsupervised and supervised multivariate analyses.

Significant differences were demonstrated in the concentrations of various glycine conjugates and acylcarnitines (C2-C26). Furthermore, the concentrations of purine and pyrimidine metabolites, vitamins and their degradation products (riboflavin, trigonelline, pyridoxate, pantothenate), and selected organic and amino acids (aspartate, leucine, 2-oxoglutarate, etc.) were altered in horses with AM. These results represent a global view of altered metabolism in horses with AM.

S. Wright

**References**


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EQUINE VETERINARY EDUCATION / AE / DECEMBER 2016
**Editorial**

**A life less solitary**

The impact of stable design upon equine welfare has once again come under recent scrutiny in the UK, with calls for more welfare friendly housing to be investigated and introduced where possible. Confining a horse to a stable restricts interaction with conspecifics and limits the ability to move and forage. For a social, free ranging species this can be challenging. From a veterinary perspective, a suboptimal environment and the associated adrenal response can be detrimental to horse health and manifest as damaging stereotypic or even dangerous behaviour. This has safety implications for horses and handlers, including veterinarians.

Despite a growing body of evidence which reports that keeping horses in groups best meets their physical and behavioural needs, many horses still continue to be housed individually. The key reason for this continued isolation appears to be concern regarding equine group dynamics and the resultant risk of injury. Horses kept at livery yards are often turned out in unstable groups with individuals being continuously removed and replaced. This can contribute to elevated levels of aggression within the group. In discussion with horse owners, some feel that their horses do not mind, or even enjoy being stabled. This is largely based on the anthropomorphic belief of what the horse finds comfortable and not on the horse’s physiological and behavioural needs. Veterinary schools across the UK spend time teaching their students husbandry and management systems for farmed animals that ensure optimal welfare, yet traditional housing of horses is still regarded as acceptable when research findings state otherwise.

**Emerging housing solutions**

Inventive, welfare friendly housing systems are now emerging with recommendations for use based on scientific evidence and improved knowledge of equine social structure and behaviour. The ultimate aim is to provide practical housing that is welfare friendly for all horses and facilitates movement and trickle feeding, with no increased risk of injury to horse or handler.

Although this concept is a challenging one, there is now a movement towards improved stable design, in particular in Northern Europe, where specific legislation exists related to minimum stable dimensions and turnout time. Guidelines in the UK are not this specific, but do state that horses should be given the space appropriate to their physiological and ethological needs in accordance with established experience and scientific knowledge. Established experience has largely continued to house horses individually; however, scientific knowledge is now growing and results of numerous studies agree that it is time for a change.

Concerns regarding injury in group housed horses are being addressed. Work by Jørgensen et al. (2009) reported that 80% of all aggressive interactions recorded in group housed horses were threats, not involving physical contact as would be the case in free ranging horses. Very few injuries were found and most were superficial. Current findings highlight that the important preventative factors to consider when group housing horses are early social experience, management of feeding and space allowance and this is where future research must focus.

Horses housed in groups from an early age display less aggressive behaviour to both known and unknown conspecifics, as is the case in a range of species. Group housing therefore provides the opportunity for horses to develop their social skills and improve the chances of successful group living as adults. Group housed horses have also been shown to be more adaptable to training (Rivera et al. 2002) and show decreased objectionable behaviour and a reduced adrenal response when compared to individually housed horses (Yarnell et al. 2015). Recommendations on group composition and introduction of horses to group living is available (Hartmann et al. 2011); however, this is largely in scientific format and inaccessible to everyday horse owners, resulting in a lack of guidelines for the general public and professionals alike.

Movable walls placed in the centre of existing barn style housing are becoming increasingly popular. This provides low-ranking horses with an area to eat and rest peacefully without the risk of becoming trapped or cornered by high-ranking individuals. Larger combination barns suitable for three or more horses with an outdoor area offer improved social contact and space. Electronic feeding stations that respond to an individual chip that the horse wears allow peaceful feeding and provision of ad libitum forage which is individually accessible to all horses can help to reduce aggression (Fig 1). If group housing is not possible then terraced individual paddocks with stables attached provide some physical contact and improved space with a reduced risk of injury (Fig 2).

![Fig 1: Provision of ad libitum forage which is individually accessible to all horses can help to reduce aggression. Photograph with kind permission of Agroscope, Swiss National Stud Farm.](image-url)
Developments in outdoor housing of horses includes tracked systems and active stables designed to encourage movement. The design of mini home ranges using the natural grazing behaviour of horses are also growing in popularity, as in the equicentral system. This system involves a linked paddock design with a communal yard where shade and water are provided. Horses will graze and then voluntarily return, rest, drink and congregate in a central area. In addition to the equine welfare benefits, this system reduces pressure on paddocks and offers sustainable land management. The system can be modified or smaller elements used for smaller areas of land.

If group or extended outdoor housing is not possible then social contact can still be facilitated in individually housed horses. Minor modifications to existing housing can be made. Leaving the upper half of stables open or replacing solid walls with appropriately spaced bars is currently being used successfully at the Swiss National Stud. Even placing a window between stables allows for some physical and visual contact and companionship (Fig 3).

### Conclusion

Each horse is an individual and therefore there may not be a single optimal way to house them. In the UK there is a push for better welfare in farmed animals, yet many people are still happy to keep horses in a way that does not reflect their needs as a species.

More work is needed to objectively assess realistic and practical housing design that offers improved equine welfare but also minimises risk of injury to horses and their owners, trainers and veterinarians. In addition to this there is an apparent need for guidance on successfully introducing horses to group living. These factors combined will provide the evidence needed for optimal housing and improved health and welfare for our horses.

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### References


**Fig 2**: Terraced individual paddocks with stables attached provide some physical contact and improved space with a reduced risk of injury. Photograph with kind permission of Agroscope, Swiss National Stud Farm.

**Fig 3**: Stables at Nottingham Trent University have an internal window allowing physical and visual contact and companionship.
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**Case Report**

**Soft tissue sarcomas in the pharyngeal region of a 5-year-old Quarter Horse mare**

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**Keywords:** horse; soft tissue sarcoma; tumour; neoplasia

**Summary**
This case report describes the identification of multiple soft tissue sarcomas in the pharyngeal region of a 5-year-old Quarter Horse mare. Diagnostic work-up included physical examination, radiography, ultrasonography, endoscopic examination of upper airways and guttural pouch, and post mortem examination with histopathology. Humane euthanasia was indicated due to the chronicity of the condition, prognosis and financial constraints.

**Case details**

**History**
A 5-year-old Quarter Horse mare presented to the Littleton Equine Medical Center (LEqMC) for evaluation of 3 soft tissue swellings on the lateral aspect of the right neck, caudal to the vertical ramus of the mandible, ventral to the right ear and caudolateral to the right eye. The swellings had been noted acutely 2 months prior to presentation at LEqMC and attributed to trauma. The attending veterinarian at that time aspirated dark red thick material from the swelling and advised the owners to monitor. Heart rate and body temperature had been documented to be within normal limits, but increasing inspiratory stridor and respiratory distress were noted. The mare was then evaluated in the field several weeks later by a veterinarian from LEqMC. Local drainage was attempted, which yielded 1500 ml thick black fluid aspirate and was successful at reducing the size of the swellings for several hours. The fluid was submitted for culture and cytology (Fig 1). Culture did not yield bacterial growth. Cytology revealed few epithelial cells. Due to the progression of clinical signs of increased respiratory effort, the mare was referred into the clinic for further diagnostics and treatment including endoscopy and radiographs.

**Clinical findings**

On initial examination, the mare was bright, alert and responsive. Her heart rate (40 beats/min), respiratory rate (16 breaths/min) and rectal temperature (36.7°C) were within normal limits. Increased respiratory effort was observed on inspiration. An approximately 6 x 8 cm fluctuant soft tissue enlargement was present over the ventrolateral aspect of the right neck caudal to the vertical ramus of the mandible. The area was not warm or sensitive to palpation. A second 4 x 4 cm soft tissue enlargement was present dorsolateral to the right eye. The right eye appeared exophthalmic (Fig 1). A third 6 x 6 cm soft tissue enlargement was present ventral to the right ear. Passive and active extension, flexion and rotation of the neck did not appear to cause the horse discomfort. A venous blood sample was submitted for a complete blood count, which revealed all values within normal limits (packed cell volume 39%, total protein 58 g/l, white blood cell count 7.6 x 10^9/l, fibrinogen 0–100 mg/dl).

**Radiographic and ultrasonographic examination**
Radiographs of the head revealed a fourth large focal soft tissue mass with radiopacity similar to that of fat axial to the mandible cranio medial to the largest of the fluctuant swellings that were palpable externally caudal to the vertical ramus of the mandible. A fluid-air line was appreciated on radiographs within the interstitium outside the guttural pouch where the soft tissue was palpable externally, suggestive of a haematoma (Fig 3). Ultrasonography of the 3 areas of external swelling revealed fluctuant homogenous soft tissue just deep to the skin. Approximately 25 ml of thick black fluid was aspirated from one of the swellings with ultrasound guidance, but did not change the dimensions of the external swelling. The ovoid soft tissue mass visible on radiographs was not detectable on ultrasonography.

**Endoscopic examination**
Endoscopy of the upper airways and guttural pouches was performed. Endoscopy of the pharynx revealed pharyngeal stenosis caused by collapse of the lateral and dorsal walls of the pharynx, presumably from external compression. Endoscopy of the larynx appeared within normal limits. Endoscopy of the left guttural pouch revealed a small approximately 2 x 2 cm light tan ovoid polyp on the lateral wall of the lateral pouch. Endoscopy of the right guttural pouch was attempted but was not possible due to pressure from within the pouch attributed to extramural compression. Blood was observed from the entrance to the right guttural pouch upon attempted entry.

**Treatment**
Ventral drainage of the external fluctuant soft tissue mass caudal to the vertical ramus of the right mandible was established with a 3 cm ventral incision made with a No. 15 scalpel blade. A biopsy of the tissue surrounding the soft tissue swelling was taken at that time, but was not submitted due to the clinical progression of the case. Dark red thick blood clots were removed from the external swelling, which reduced the dimensions of the swelling. No active haemorrhage was present at that time. Drainage was maintained with a Jackson Pratt drain for several hours, which yielded a small amount of serosanguineous fluid. The drain was removed and there continued to be serosanguineous fluid draining from the incision site. The horse was
administered trimethoprim sulfadiazine antimicrobials (30 mg/kg, per os, q. 12 h) and maintained in the hospital overnight. The horse’s condition continued to deteriorate; she became listless, refused food and continued to demonstrate increased respiratory effort. Humane euthanasia was elected by the owners due to the chronicity of the condition, prognosis and financial constraints (Fig 4).

Post mortem examination
A limited post mortem examination was performed, including dissection of the masses and gross evaluation for metastases. Six discrete soft tissue masses were identified and removed. On gross examination of the thorax and intestinal tract, no evidence of metastases was found. Five of the masses were within the pharyngeal region of the neck and one mass was found extending into the retrobulbar space axial and caudal to the right eye. Macroscopically, the masses were yellowish-white and firm. None of these masses were the same as the 3 fluctuant masses palpable externally. Samples of the masses were submitted for histopathology. Histologically, the masses had low cellular atypia and a low mitotic rate, consistent with slow progression. The masses were consistent with a soft tissue sarcoma (STS), a locally aggressive neoplasm with capacity for metastasis.

Discussion

Clinical findings
The 3 fluctuant soft tissue swellings that were palpable externally were haematomas with apparently mixed arterial and venous blood. The deeper soft tissue masses identified on post mortem examination were locally invasive and found to
be eroding the carotid and linguofacial branch of the external jugular vein. The haematomas that were detectable externally were attributed to haemorrhage from these blood vessels. The right eye was exophthalmic on clinical examination, which was attributed to the retrobulbar mass extending into the retrobulbar space found on post mortem examination. The soft tissue swelling caudolateral to the right eye was also a haematoma.

The fluid-gas line detectable on radiographs was attributed to blood in the largest of the haematomas within the interstitium external to the guttural pouch. The haematomas were examined with ultrasonography, but the STSs were not appreciated on ultrasound or fully defined with radiography. The largest of the sarcomas was detected with radiography as discussed above. Post mortem examination confirmed that the STSs were too deep to be well defined with ultrasound.

Entry to the right guttural pouch was obviated upon endoscopy. *Post mortem* examination revealed extramural compression of the guttural pouch by 2 masses, one axial caudal and the second lateral caudal to the lateral compartment of the right guttural pouch. Although no pharyngeal displacement of the guttural pouch was noted on endoscopy, introduction of the guide wire was only possible for 1.5 cm caudal of the *plica salpingopharyngeus*. The increased respiratory effort and lack of appetite noted clinically was attributed to pharyngeal stenosis and difficulty eating due to extramural compression by the masses.

Computed tomography to characterise further the extent and involvement of the masses as well as surgical removal were offered to the clients and were declined in this case due to financial constraints. In this horse, the sarcomas were not palpable externally and were too deep internally to be well defined by ultrasound or radiographs. The location of the masses was not verified until post mortem examination was performed. Upon post mortem examination, a surgical corridor that would have allowed for safe excision of the masses was not appreciated. Given the extent of the local infiltration of the carotid artery and linguofacial branch of the external jugular vein by the masses upon post mortem examination, it was considered unlikely that complete resection with wide margins would have been possible. Had the owners wished to pursue further diagnostics or if the authors are faced with a similar clinical case in the future, computed tomography would be considered the modality of choice to assist with preoperative planning to remove a lesion diagnosed as an STS on histopathology. A magnetic resonance imaging may also be useful to highlight and distinguish soft tissue structures involved in the masses. Thoracic radiographs as well as aspirates of regional lymph nodes could have been performed to look for evidence of metastasis and may have been useful in prognosticating for the owner.

**Soft tissue sarcomas in the horse**

Soft tissue sarcomas include neoplasms such as fibrosarcoma, synovial cell sarcoma, rhabdomyosarcoma, haemangiosarcoma and leiomyosarcoma. STSs are a diverse group of neoplasms of mesenchymal origin that typically present as focal soft to firm masses in dermal or subcutaneous tissues (Hughes 2007). Soft tissue sarcomas have several important features in common in terms of biological behaviour that is important for prognosis. They tend to have poorly defined margins, be locally infiltrative, and commonly recur after surgical excision.

Equine STSs occur commonly near the head, including nose and paranasal sinuses (Story et al. 2005; Veraa et al. 2009), and have been appreciated more commonly in younger horses (Jansson and Nyberg 2004; Hughes 2007). Synovial cell sarcomas are uncommon in veterinary species, and have been more commonly reported in dogs than horses (Fox et al. 2002). Fibrosarcomas are extremely rare in horses, but have been reported in connective tissues in the head and trunk, joints, tendon sheaths, and bursae (Story et al. 2005) as well as one case at the site of equine influenza vaccination (Kannegieter et al. 2010). Leiomyosarcomas have been reported in horses, originating from rectal, small intestinal and gastric tissue (Clem 1986; Mair 1990; Boy 1992).

Types of STSs can be difficult to differentiate in all species. STSs as a group of tumours present the greatest diagnostic challenge as the histological patterns often overlap and frequently a diagnosis cannot be obtained by histopathological examination alone (Hughes 2007). The development of immunohistochemical techniques have aided in the diagnosis of STSs (MacEwen et al. 2000; Morris et al. 2002; Scott and Miller 2003). Previous reports have utilised combinations of immunohistochemistry and electron microscopy to determine STS type (Findley et al. 2014) in order to provide owners with an accurate prognosis and treatment plan. Difficulty in differentiation of tumours in equids exists due to histopathological overlap, and may result in confusion in diagnosis of sarcoids, fibroma, fibrosarcoma, neurofibroma, neurofibrosarcoma or schwannoma (Scott and Miller 2003).

Immunohistochemical staining and examination of ultrastructural cell morphology via electron microscopy have been used to distinguish types of soft tissue sarcomas (Findley et al. 2014). One case report documents the use of immunohistochemistry in the diagnosis of equine fibrosarcoma (Story et al. 2005). Another report documents 2 cases where immunohistochemistry in combination with electron microscopy aided in diagnosis of soft tissue sarcomas associated with the fetlock joint (Findley et al. 2014). Immunohistochemical staining was performed using the following antibodies: pancytokeratin, vimentin, desmin, alpha smooth muscle actin, factor VIII, major histocompatibility complex II and S-100. Cases positive for vimentin and actin and negative for S-100 and desmin expression were consistent with previous reports of fibrosarcomas (Ramaekers et al. 1988; Story et al. 2005), while pancytokeratin has been previously detected in synovial sarcomas (Fisher 1990).

Poorly differentiated sarcoma is a rare neoplasm in the horse, but has been reported in the sinonasal cavity (Dixon and Head 1999), thoracic cavity (Sweeney and Gillette 1989), and as an extradural mass in the thoracic and lumbar spine (Van Biervliet et al. 2004). Euthanasia was performed in all cases given the poor prognosis (Sweeney and Gillette 1989; Dixon and Head 1999; Van Biervliet et al. 2004) due to the malignant nature of this type of tumour and difficulty or impossibility of achieving wide margins in surgical resection.

On the basis of our clinical, radiographic and cytological findings, our differential diagnoses included several types of STSs. A definitive diagnosis would be based upon histological examination in combination with immunohistochemical analysis (Sanders et al. 1996; Pawel et al. 1997; Dixon and...
Head 1999; Van Biervliet et al. 2004; Penel et al. 2008), and may have been useful to provide the owners with the most accurate prognosis if further treatment had been elected. If there had not been financial constraints in this case, computed tomography would have been considered the modality of choice to characterise further the extent and involvement of the masses prior to attempts at surgical removal. Magnetic resonance imaging may also be useful to highlight and distinguish soft tissue structures. In the horse, adjunctive treatment modalities such as local radiotherapy, cryotherapy and intralesional chemotherapy (cisplatin, 5-fluorouracil) have been shown to be effective in the treatment of sarcomas. These adjunctive therapies may also be useful in other types of STS in conjunction with surgical removal or in cases where wide surgical excision may not be possible such as the head or distal limbs (Scott and Miller 2003).

Authors’ declaration of interests
No conflicts of interest have been declared.

Ethical animal research
Littleton Equine Medical Center is a private practice. Permission was obtained from the owner of the horse described in this case study for publication of the case for educational purposes.

Authorship
The horse described in this case study was treated in the field by L. Toll and referred to the clinic for further evaluation and treatment. The case was managed in the clinic by D. Devine and L. Pezzanite. The patient was subsequently subjected to euthanasia by D. Devine and L. Pezzanite, and samples of the mass were submitted for histopathology. Contributions for preparation of the manuscript for publication were made by L. Pezzanite, D. Devine and L. Toll. All authors gave their approval for the final version.

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References
Clinical Commentary

Decision-making without a diagnosis

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Keywords: horse; communications; oncology; diagnosis; cytology; euthanasia

There have been a number of articles relating to single case reports of rare neoplastic tumours in horses (Van Hessewijkstra et al. 2015). The accompanying article contributes to this growing body of literature describing a horse with soft tissue sarcomas in the head and neck (Pezzanite et al. 2016). Along with these articles, many short reviews of the subject matter have been published outlining a particular aspect of the clinical case to contribute to the readers’ knowledge such as the differential diagnosis, prognosis and treatment and reviews of accumulated knowledge on that particular neoplasia (Sullins 2015). Many single case reports and the accompanying article on a horse with soft tissue sarcomas also highlight a situation that occurs far too frequently in veterinary medicine when discussions and decisions have to be made without all the information required. Often this is not explicitly discussed in the article which is focused on the clinical signs and diagnosis of the neoplasia. As regards the horse with multiple soft tissue masses in the head and neck, the clinicians were not able to obtain a definitive diagnosis prior to a clinical progression of the disease process combined with likely financial constraints resulting in the horse being subjected to euthanasia (Pezzanite et al. 2016). The case report therefore serves to underline 3 interrelated issues in veterinary medicine which are particularly evident when dealing with horses with potential neoplasia; the potential dearth of evidence-based information, the reliability and role of diagnosis in decision-making and importance of communication in veterinary medicine today. The ability to draw on evidence-based information and ability to make a confident diagnosis have an enormous effect on communication with, and decision-making by, the owner. The relative lack of these 2 components concerning horses with neoplasia can create challenges.

Certainly, the many case reports serve to underline the lack of information available concerning the less common neoplastic diseases in horses. Evidence-based practice has been defined as that combining clinical judgement with scientific evidence (Vandeweerde et al. 2012). The scientific evidence has blinded, randomised controlled trials and cohort studies as possessing good evidence for a certain diagnosis or treatment with systematic reviews and meta-analyses serving to combine the information from a number of different studies. However, given the difficulty of achieving these studies in veterinary medicine, case studies and retrospective or observational studies also play an important role. When confronted with a horse with suspect equine neoplasia a search of the available literature does not yield any systematic reviews or randomised controlled trials but there are many large and excellent studies on the more common tumours of the head (sinuses in particular) and urogenital system (Dixon and Head 1999; Head and Dixon 1999; Van den Top et al. 2008, 2010, 2015; Dixon et al. 2011, 2012). Some papers have proposed adoption of standard diagnostic and treatment protocols as well as grading scales for equine tumours similar to human and small animal medicine but many patients are still treated without consideration of tumour grade (Van den Top et al. 2008, 2010). It is difficult to assess if the demand for standardised protocols proposed in one paper have been adopted by others (Van den Top et al. 2010). Case reports of less common tumours, such as soft tissue sarcomas of the head and neck, can help inform clinicians of possible diagnoses but apart from sinus and urogenital tumours it is difficult to find large studies or standardised approaches (Pezzanite et al. 2016). There have been some attempts to improve the ability of a clinician to look for strong evidence with the introduction of the identified articles in journals such as Equine Veterinary Journal and the grouping of equine neoplasia cases reports by Equine Veterinary Education into a 2-part virtual issue dedicated to oncology which is an available resource for many equine practitioners. However, other veterinary bodies certainly show that greater efforts could be made to aid in establishing strong scientific evidence. The Veterinary Cancer Society (VCS), mainly composed of small animal veterinarians, is a strong force for improving communication within the veterinary oncology community and combining forces to acquire information on large numbers of cases. The VCS has several subgroups established with the goal of improving collaboration and recruitment of cases to clinical trials (the Veterinary Cooperative Oncology Group) and standardising the grading and pathological diagnosis of cancer (Oncology-Pathology Working Group). This also serves as a guide for what can be achieved within the equine veterinary community. It is the author’s experience that there are many equine clinicians open to forming such a group but it has yet to be spearheaded. Promoting collaboration between private clinics and universities to gather information on large numbers of cases with equine neoplasia can result in improved studies with information which clinicians can use to guide their diagnostic efforts and communications with the owner. While the VCS serves as a resource and guide for veterinarians wanting to conduct studies another small animal group has tried to improve the standard of veterinary evidence by creating common outcome measurements. A group of small animal surgeons successfully started a movement and have developed and published standard outcome measures for canine orthopaedic studies (the Canine Orthopedic Outcome Measure Program) (Cook 2014). These types of guidelines will help promote consistency amongst future clinical trials and retrospectives leading to robust systematic reviews (Cook 2014). Currently, strong retrospective and large
case series are common in equine neoplasia with many small case reports. The goal should be to form a more global initiative to combine clinical cases and research efforts and thus provide more evidence for clinicians such as those treating the horse with soft tissue sarcomas in the accompanying report (Pezzanite et al. 2016).

The initiative of the VCS to form standardised pathology for oncology is also an important consideration. Many equine tumours are diagnosed through cytology or biopsy. The inability to obtain a diagnosis can be frustrating and problematic. The experience of many clinicians, including the author, is that cytology and even superficial biopsies of head and neck tumours can be nondiagnostic (Dixon and Head 1999). Inflammation or granulation tissue often surrounds masses and associated bleeding and haematomata formation does not appear to be uncommon. This was demonstrated in the horse with the soft tissue sarcomas with significant haematomata adjacent to the masses (Pezzanite et al. 2016). This lack of information poses potential difficulties in communication with clients and decisions on potential treatments. The potential outcome associated with different potential neoplastic diseases in the horse complicates the problem as many relatively benign tumours may be treated with surgical excision, whereas in others the investment of emotion and finances of the owner into surgery and potential adjunctive therapy may not be warranted. Consider, for example, tumours of the head and sinuses. There exist several large studies of the common neoplastic conditions and the prognosis may vary significantly between surgical excision of a cementoma compared with an osteosarcoma (Dixon and Head 1999). The inability to obtain a definitive diagnosis without surgical excision is well recognised and the possibilities must be discussed with the owner. The diagnosis of soft tissue sarcoma was unable to be confirmed in the horse in the accompanying case report following cytological examination of the fluid (Pezzanite et al. 2016). This was likely due to a lack of available cells in the sample as the fluid was mainly haemorrhagic. Even when an appropriate sample is obtained there are several issues surrounding the diagnosis of neoplasia from cytology. The clinician must be able to interpret the results appropriately. There have been studies on the sensitivity and specificity of cytological examinations in veterinary medicine with false negatives reported to be more common than false positives and range of sensitivity varying by sample location from 33–66% (Cohen et al. 2003). The quality of the sample obviously has a large effect on the ability of the pathologist to give a diagnosis. Most veterinarians rely heavily on the written interpretation provided by the pathologist at the end of the report rather than the actual cellular information. This has led to several interesting studies on the consistency of the words used in relation to a diagnosis of neoplasia and the need for communication between treating veterinarians and pathologists (Christopher and Hotz 2004; Christopher et al. 2009). Veterinary pathologists are certainly aware that the diagnosis of neoplasia contributes significantly to the decisions regarding euthanasia and treatment by the owners. The understanding of the meaning behind qualitative words used such as ‘consistent with’, ‘probable’ or ‘possible’ vary between pathologists and between veterinarians and therefore has an important effect on communication with clients. A study has shown that the wording used in the cytology report combined with the experience of the veterinarian significantly impacted the choice of treatment for that animal (Christopher et al. 2010). There was considerable overlap in values that veterinarians assigned to words such as ‘possible’ and ‘probable’ or ‘consistent with’ in one study in which veterinarians were asked to assign a range of percentages to each word in the clinical report (Christopher et al. 2010). It is therefore understandable that veterinarians would prefer to have numerical values for probabilistic information, whereas the pathologist who deals with variation in sample quality prefers qualitative modifiers knowing that the results have a significant effect on the outcome for the animal (Christopher et al. 2009). Certainly, the overall combined effect of the studies on cytological diagnosis is of a rapid and useful test that should be used within the clinical context of each animal and combined with other modalities of diagnosis if possible. The possibility of a standardisation of terminology should be considered but is unlikely to completely resolve the differences in interpretation of wording by individuals. In the case of the horse with the soft tissue sarcomas, it is apparent that the cytology was not useful as it neither ruled in or out the possibility of neoplasia (Pezzanite et al. 2016).

Without the ability to draw on evidence-based medicine or accurate diagnoses, the ability to discuss with the owner the options for further diagnostics, treatments and potential prognoses becomes a significant challenge. Communication in veterinary medicine has been receiving increasing attention in recent years with most curriculums integrating communication training in some form or another (Mossop et al. 2015). Communication skills come naturally to some people but are a skill that can be taught and improved upon with practice like any other veterinary skill set. Despite these improvements, surveys of recent veterinarians still show discomfort and decreased communication skills when discussing euthanasia and difficult decision-making with clients (Nogueira Borden et al. 2010; Dickinson et al. 2014; Meehan and Menniti 2014). Having scientific data on which to base the conversation helps guide owners in their decision-making. One study shows that owners have an easier time making decisions when presented with numeric data in the form of numbers and graphs as opposed to qualitative word descriptions (Man-Son-Hing et al. 2002). Similar to the demonstrated desire of veterinarians to have numeric data from the pathologist is the owners desire to have numeric data from their veterinarian. The confusing interpretations of the meaning behind qualitative words can make finding the correct decision more difficult. In the accompanying article the veterinarians had neither numeric data to say that the likelihood of these masses being neoplastic was ‘x’ nor the evidence to say what type of tumour and associated prognosis would be expected (Pezzanite et al. 2016). As with many similar situations in equine veterinary medicine, the discussion was likely based on the clinical signs and associated immediate quality of life vs. the potential cost of further investigations weighed against an unknown chance of long-term success. It is undoubtedly easier to discuss a known diagnosis with known treatment options with associated expectations of success. While the expectations of equine clients in particular has not been studied, most studies in other species such as cows and small animals indicate the expectations are similar across species and disciplines (Cipolla and Zeconi 2015). In many situations, communications are performed over the telephone; however, in more complicated situations where the information to be discussed is less well defined, it can be useful to make an appointment for the owners to come into the clinic and
discuss the situation in a quiet room. This is not always possible but certainly facilitates the communication between veterinarian and client. Veterinarians must be open and honest with the lack of information and empathise with the difficulty of decision-making in the face of unknown variables. Frank discussion of financial limitations and the reality that these play in decision-making can place clients more at ease. Open acknowledgement of financial realities can help owners accept this as a reasonable factor in the decision to euthanise. Additionally, the discussion of the clinical signs and options for diagnostic and surgical interventions can be discussed with the associated improved likelihood of having a definitive diagnosis after further investment. It should be clear that the prognosis will commonly only be established after significant diagnostic and surgical interventions. If financial limitations are not the main concern then the decision to proceed and potentially continue with post operative adjunctive therapies in the case of a malignant tumour diagnosis can be easier to make. Importantly, the veterinarian should be able to dedicate a period of uninterrupted time to discuss the difficult decisions with the owner and acknowledge the limitations of the existing scientific knowledge.

The case report on soft tissue sarcomas in the neck and head of a horse therefore serves not only to add to the literature on potential diagnoses for masses in this region but also to highlight the problems facing equine practitioners in applying evidence-based medicine and communication with clients in the face of the lack of information. The contribution of case reports is not undervalued but they also underline the need to advance the scientific literature in a certain area. Cancer in horses has been receiving increased attention with increasing numbers of geriatric horses and thus it may be time to consider following in the footsteps of other veterinary groups in forming a common interest subgroup or establishing guidelines for clinical studies to standardise outcome measures.

**Author’s declaration of interests**

No conflicts of interest have been declared.

**References**


Surgical repair of a mandibular degloving injury in a 5-month-old colt

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Keywords: horse; mandible; degloving injury; avulsion; laceration

Case history

A 5-month-old male Welsh Pony/Cob mix, weighing 155 kg, was referred to the Veterinary Teaching Hospital at North Carolina State University for evaluation of a head laceration that occurred approximately 3 h prior to presentation. The colt had been seen playing with a chain on the pasture gate when he caught his left cheek on an attached hook. Before the owner was able to remove the hook, the horse had unsuccessfully tried to free himself, furthering the tissue damage in the process. The primary veterinarian sedated the colt with a combination of butorphanol tartrate (Torbugesic® 0.01 mg/kg bwt i.v.) and xylazine (Rompun® 0.3 mg/kg bwt i.v.) and diagnosed an avulsion of the lower lip, exposing the underlying mandible. Additionally, a full thickness laceration was present where the hook had been caught in the cheek. Following recommendation of the veterinarian, the owner decided to bring the colt to the hospital for further evaluation and treatment.

Presentation

Upon presentation, the horse was quiet and alert with a heart rate of 60 beats/min, respiratory rate of 32 breaths/min and temperature of 38.7°C. The penetrating laceration in the left cheek was approximately 6 x 2 cm in size and communicating with the oral cavity over its entire length. The lower left lip was swollen and the colt was unable to close his mouth on that side (Fig 1). The remainder of the physical examination and complete blood count were within normal limits. Following sedation with a combination of butorphanol tartrate (0.01 mg/kg bwt i.v.) and detomidine hydrochloride (Dormosedan®, 0.01 mg/kg bwt i.v.), examination of the oral cavity revealed avulsion of not only the lip but also the left cheek, exposing parts of the labial surface, interalveolar margin and body of the mandible. Bone could be seen from the first deciduous left incisor (701) to the deciduous third premolar (707). Part of the nonerupted third incisor (703), prior to the injury covered by gingiva, was also visible. The avulsed lip was warm to the touch, suggesting an intact blood supply to the tissues. Furthermore, a structure emerging from the mental foramen, presumably the neurovascular bundle consisting of mental artery, vein and nerve, was connected to the avulsed lip (Fig 2). Neither visual inspection and palpation nor radiographs identified any damage to the osseous structures or teeth. The mouth was rinsed with water, the skin around the penetrating laceration clipped and the...
wound cleaned with a diluted povidone-iodine solution. Subsequently, a bandage was placed to cover the wound and support the avulsed lower lip. Gentamicin sulfate (Gentafuse® 6.6 mg/kg bwt i.v. s.i.d.), potassium penicillin (Pfi zerpen® 22,000 iu/kg bwt i.v. q.i.d.), metronidazole (Metronidazole® 15 mg/kg bwt per os t.i.d.) and flunixin meglumine (Banamine® 1.1 mg/kg bwt i.v. b.i.d.) were administered. Because of an unknown vaccination history, the horse also received an intramuscular tetanus toxoid injection.

Treatment
Financial constraints prohibited surgical correction of the injury at this point and the owner decided to continue with conservative treatment, understanding that cosmetic and functional outcome may be undesirable. During the next 36 h, the oral cavity was rinsed every 6 h and administration of systemic antibiotics and flunixin meglumine continued. While the horse was able to eat and drink, food material kept accumulating between the cheek and degloved mandible as well as in the penetrating laceration. Two days after admission, financial support was made available and the owner agreed to surgical repair of the injury.

Surgery
On the same day, the colt was anaesthetised, placed in right lateral recumbency and a nasotracheal tube placed. The skin over the left mandible and maxilla was clipped, the penetrating wound cleaned and the area prepared for surgery. The oral cavity was rinsed with a diluted povidone-iodine solution before the exposed left mandible, buccal and submucosa and penetrating wound were debrided with different sized Spratt bone curettes. Using a battery-powered drill with a 2.0 mm drill bit, 7 holes were created parallel and 0.5–1 cm ventral to the free edge of the interalveolar margin (diastema). Radiographs had shown the absence of a canine tooth (304), allowing the drill holes to be spread out evenly between the third incisor (703) and second premolar (706, Fig 3a). A 16 gauge needle was passed through the cheek at the level of, about 1.5 cm ventral to, the most caudal drill hole. A No. 2 monofilament nylon suture (Ethilon)™ was fed through the needle and drill hole. The suture was then directed over the free margin of the diastema and out through another 16 gauge needle positioned 1.5 cm dorsal to the first one. This process was repeated over each drill hole (Fig 3b). Additional mattress sutures were placed through the cheek and around the second premolar (707) as well as through the lower lip and around the second incisor (702). Once all interrupted mattress sutures had been preplaced, they were tied over soft rubber tubing on the skin surface. Tightening of these sutures resulted in reduction of the lip and cheek avulsion and closure of the dead space between the mandible and avulsed soft tissues. The gingiva was closed with No. 2.0 polyglactin 910 (Vicryl)™ in a simple continuous pattern. Reduction of the avulsion injury also led to sufficient apposition of the edges of the penetrating wound and no separate closure of this laceration was pursued. The colt recovered from general anaesthesia without any complications.

Fig 1: Appearance of the horse before surgery. The penetrating wound as well as the inability of the horse to close the lips can be appreciated.

Fig 2: Part of the degloved left mandible prior to surgical repair. The thickened and inflamed neurovascular bundle, presumably consisting of the mental artery, vein and nerve, can be seen entering the mental foramen (white arrow).

Fig 3: a) The holes, created with a 2 mm drill bit, can be seen 0.5–1 cm ventral to the free edge of the diastema. b) All transmandibular mattress sutures were placed before any of the No. 2 monofilament nylon sutures were tightened and tied.
Post surgical treatment
Following the operation, the horse was able to close the lips, prehend food and drink without water coming from the penetrating wound. Intravenous medications were discontinued within 24 h after surgery and substituted by intramuscular ceftiofur (Excede® 6.6 mg/kg bwt i.m.) and oral flunixin meglumine at the previously administered dose.

The horse was discharged 48 h after surgery with instructions to continue the initiated antibiotic treatment until recheck examination and administer oral flunixin meglumine for 3 more days. The colt was turned out to pasture and resumed his normal diet.

Outcome
Follow-up examination 11 days after surgery showed that the gingival suture had failed (Fig 4) but the superficial wound was healing appropriately by second intention. The full thickness mattress sutures were in place, preserving the correct anatomical alignment of the soft tissues with the mandible. The penetrating laceration had filled in with granulation tissue (Fig 5). On Day 27 after surgery, the mattress sutures were removed. The penetrating laceration as well as the gingival wound had fully healed and facial symmetry was re-established. Six months after the injury, only a dark scar was present at the previous injury site (Fig 6).

Discussion
Lacerations are common equine emergencies with the distal limbs being affected most frequently (Dolente et al. 2008; Stashak and Schumacher 2008). Degloving injuries below the carpus or tarsus are especially challenging as they expose bone by avulsion of the overlying skin, subcutaneous tissues and periosteum (Hanson 2008). Complications including sequestrum formation, development of exuberant granulation tissue and extensive periosteal new bone growth are not uncommon.

The abundant blood supply to the head is often quoted as a reason for the apparently excellent healing potential of head lacerations (Barber 2005; Barber and Stashak 2008). Additionally, the high visibility of these injuries generally leads to early recognition and treatment, while the great distance from the ground helps to prevent severe contamination (Barber and Stashak 2008). Degloving injuries on the head most commonly occur over the dorsal facial bones but avulsion of the lower lip with exposure of the rostral mandible has been described as a sequela to horses falling and hitting the ground with their lip and chin (Barber and Stashak 2008; Tirosh-Levy et al. 2013). Shear forces upon contact with the ground lead to separation of the tissue layers which are typically contaminated with gravel or dirt. In the case presented here, the soft tissues were

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pulled from their bony attachment by a hook in the horse’s cheek, leading to a degloving injury that extended far into the oral cavity. Closure of the dead space and reconstruction of the correct anatomical alignment of lip and cheek were considered crucial for an uncomplicated healing process and a functional outcome. The initially applied head bandage allowed the horse to prehend food and maintain closed lips during mastication but could not prevent food packing in the left buccal vestibule or leakage of water from the penetrating laceration. Additionally, the colt had to be restrained every 6 h for lavage of the oral cavity and sedated once daily for a bandage change. After exploration of the injury under general anaesthesia, it was decided that transmandibular mattress sutures (Spiro 1995), placed through the interalveolar margin and cheek, would provide a strong holding layer and accomplish the previously established goals of a surgical repair (reduction of dead space, anatomical alignment). While a lower lip avulsion in a horse has been treated successfully using a suture technique that relied on subgingival fascial tissue as the holding layer (Tirosh-Levy et al. 2013), we believe that a stronger repair is warranted in more extensive avulsion injuries. In this case, the injury extended as far caudal as the third premolar, following the interalveolar margin along its entire length. Therefore, the suture was exposed to food and in permanent contact with the tongue, likely increasing the risk of dehiscence when compared with wounds in the labial vestibule. If a repair with suture material fails, stainless steel surgical wire, with its excellent tensile strength and inertness, should be considered for a second attempt.

Many surgical procedures on the horse’s head are routinely performed in standing animals, including most fracture and laceration repairs. However, the extent of the injury in this case made access to the most caudal aspect of the degloving injury difficult and manipulation was not well tolerated by the colt. In order to ensure the best possible repair, it was decided to perform the procedure under general anaesthesia. However, placement of transected mandibular mattress sutures should be possible in appropriately sedated horses following local anaesthesia of the surgical site.

After surgery, the horse required minimal treatment and was able to return to pasture within 48 h after surgery.

Conclusion

To our knowledge, this is the first case report of an extensive mandibular degloving injury repaired by directly suturing the avulsed lip and cheek to the exposed bone. Placement of the transmandibular mattress sutures was straightforward and provided a strong repair that required minimal post surgical management and resulted in an excellent functional and cosmetic outcome.

Authors’ declaration of interests

No conflicts of interest have been declared.

Ethical animal research

Client consent for publication of this case was obtained prior to surgery.

Source of funding

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Authorship

T. Prange and J. Partlow treated the colt during his stay in the hospital and performed the surgery. J. Parks was the veterinarian who completed the initial examination while all 3 authors performed follow-up examinations on the horse. T. Prange wrote the first draft of the publication which was subsequently improved and approved by J. Partlow and J. Parks.

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4Pfizer, New York, USA.
5Heritage Pharmaceuticals, Eatontown, New Jersey, USA.
6Merck, Milliboro, Delaware, USA.
7Ethicon Inc., Somerville, New Jersey, USA.

References


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Clinical Commentary

Mandibular degloving injuries in horses: Considerations and treatment

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Prange et al. (2016) describe a case of a mandibular degloving injury of a 5-month-old colt that responded well functionally and cosmetically to surgical repair with transmandibular horizontal mattress sutures. As Prange et al. (2016) observed, despite the fact that head injuries are common in horses, mandibular degloving injuries are rarely reported (Hague and Hannas 1998; Barber and Stashak 2008). Only two cases of mandibular degloving injuries in horses have been reported. The first case was that of a 6-month-old Arabian filly that stumbled on the pavement, degloving the bottom lip from the rostral mandible (Tirosh-Levy et al. 2013). The second case is reported by Prange et al. (2016) and occurred in a 5-month-old Welsh-Pony Cob cross when a hook on a chain that the colt was playing with lodged in its cheek and degloved the associated soft tissue structures from the underlying rostral portion of the left mandible (2015).

Mandibular degloving injuries are not uncommon in human medicine and tend to be the traumatic result of extreme sports such as skiing or bicycling. They also tend to occur in adolescents and youths presumably because of the risk-taking nature of these age groups (Dula et al. 1984; McLaughlin 2000; Revuelta and Sandor 2005; Rahpeyma and Khajestehmadi 2013). Although only two mandibular degloving injuries in horses have now been reported, both cases occurred in horses less than a year old suggesting that these types of injuries may also be more common in young horses, perhaps a reflection of their occasional fractious nature and curiosity (Tirosh-Levy et al. 2013; Prange et al. 2016).

Despite the fact that the mouth is riddled with commensal bacteria and foreign food particles, it has long been observed that healing in the oral cavity is superior to that on other areas of the body with minimal scar formation. Gingival healing tends to be scarless, whereas healing of the buccal surface usually forms a scar, albeit less so than on the skin (Szpaderska et al. 2003; Larjava et al. 2011). Everyday mastication creates abrasions and cuts in the gingiva that must heal quickly and efficiently. It has been theorised that this superior type of healing is mandatory for survival as an oral cavity prone to developing scar tissue would be detrimental to consuming food (Larjava et al. 2011).

The author is unaware of any studies evaluating wound healing of the oral cavities of horses but several studies performed in human and animal models can help us understand what healing processes are likely to take place in the oral cavity of horses (Szpaderska et al. 2003; Schrementi et al. 2008; Chen et al. 2010; Larjava et al. 2011).

Healing of wounds within the oral cavity has revealed many properties that appear to be similar to fetal wound healing (Bullard et al. 2003; Ferguson and O’Kane 2004). Both wound healing of the mouth and the fetus have minimal inflammation and minimal fibrotic response. A study by Gilm et al. (2015) examined the concentrations of inflammatory cells in the oral mucosa to that of the skin in human patients. Fluorescent immunohistochemistry of the oral mucosa revealed significantly decreased levels of inflammatory cells such as neutrophils and macrophages when compared with the skin, similar to that of fetal wound healing. It is believed that decreased levels of these inflammatory cells contribute to enhanced wound healing because this results in decreased concentrations of inflammatory cytokines, allowing for a reduced fibrotic reaction and minimal collagen production. In addition, both fetal and oral wound healing take place in a moist environment, which is believed to enhance epithelial turnover (Bullard et al. 2003; Ferguson and O’Kane 2004; Larjava et al. 2011).

There are several other factors that likely enhance wound healing in the oral cavity. Saliva contains elevated levels of a protein called epidermal growth factor (EGF), a growth factor that enhances wound healing. It is believed that elevated levels of EGF in the saliva promote rapid wound healing in the mouth. Veterinarians are aware that animals, including horses, will lick their wounds, it is believed that this behaviour helps debride the wound as well as increase the concentration of EGF at the wound site to promote healing (Hart and Powell 1990). In addition, oral mucosa has an increased blood supply and it has been theorised that this abundant blood supply provides fast delivery of growth factors to the wound (Gilm et al. 2015). Most cells within the salivary glands also produce IgA antibodies which neutralise any bacterial infiltration into wounds to help prevent infection (Chandra et al. 2004).

As far as the author is aware, no research has been done to evaluate the effects of suture type on tissue reaction and wound healing in the oral cavity of horses but many studies have been done in the field of human dentistry with both animal models and human patients (Javed et al. 2012). Although one should not extrapolate too much from these studies to horses considering interspecies differences, many interesting observations were made that should be considered when choosing a suture type for equine oral surgery.

When deciding which suture material to use in the oral cavity, several factors must be taken into consideration including tensile strength, absorbability and filament structure. Monofilament suture is preferred over multi-filament because bacteria do not strongly adhere to the suture and therefore are not easily transported into the surgical site. Nonabsorbable sutures should be chosen for areas of high motion or tension and for cases of anticipated prolonged...
healing, although removal of the sutures is necessary when healing is complete. If an absorbable suture is desired, one with a longer absorption time such as polydioxanone (PDS) should be used as degradation of sutures can be accelerated in the mouth due to the action of enzymes found in the saliva. Biological materials such as catgut should be avoided as they are multi-filamentous and Wick bacteria into the surgical site, enzymes found in the saliva quickly degrade them and they can cause a strong inflammatory reaction because of the presence of foreign animal antigens. Overall, nylon has proven to be the least reactive suture to use in the oral cavity in man (Javed et al. 2012). The degloving injury in the case presented by Prange et al. (2016) was repaired using transmandibular mattress sutures with No. 2 monofilament nylon (Ethilon) followed by closure of the gingiva with No. 2 polygalactin 910 (Vicryl) in a simple continuous pattern. The gingival repair was noted to have failed at recheck on Day 11 but by Day 28 the remainder of the original wound had granulated in and had excellent reduction permitting removal of the transmandibular sutures. It is possible that the choice of No. 2 polygalactin 910 (Vicryl), an absorbable braided multi-filament, may have promoted inflammation of the site due to bacterial infiltration or suture reaction. A case report of human patients that had subepithelial connective tissue grafts to cover exposed tooth roots using polygalactin 910 had abscess formation at the surgical sites as an occasional complication. The abscess formation was theorised to be due to either suture reaction or infection of the surgical site by conduction of bacteria along the suture. In order to decrease the possibility of abscess formation in this procedure, the authors had recommended using a monofilament instead of a multi-filament suture (Vastardis and Yukna 2003). It is possible that the gingival repair of the colt presented by Prange et al. (2016) dehisced secondary to suture reaction and/or abscess formation. Perhaps an absorbable monofilament such as PDS or a nonabsorbable monofilament such as nylon in addition to support with stainless steel surgical wire, as Prange et al. (2016) proposed, would have had a more favourable outcome. Also, placing a temporary drain at the ventral portion of the soft tissue of the chin rather than relying on drainage through the original wound may have promoted better healing as complete closure of a contaminated wound often leads to profuse exudate which may cause dehiscence (Barber and Stashak 2008). It is unclear whether the periosteum was intact in the case that Prange et al. (2016) described. It is very important in the case of a mandibular degloving injury that this be determined as the periosteum acts as a barrier between oral bacteria and the bone and it supplies the cortex with blood and a disrupted periosteum is more likely to form a sequestrum. If in this case the periosteum was indeed avulsed from the bone, the correct treatment is to place viable soft tissue immediately adjacent to the exposed bone (Reid Hanson 2004), just as Prange et al. (2016) performed. In addition, suturing the soft tissue back into its normal orientation most likely contributed to the excellent functional and cosmetic result. If the tissue had not been replaced, a significant blemish and functional consequences likely would have resulted. When presented with a trauma case, a thorough examination is important as injuries to adjacent structures may not be readily apparent. In this case, the type of trauma was known and resulted from a hook avulsing the soft tissue off the mandible. However, if it were unknown how the horse sustained the injury, injuries due to blunt trauma such as fractures of the maxilla, mandible, orbit and teeth should be considered. However, one should be cautious placing an oral specimen in the mouth if fractures of the mandible are suspected. In addition, even if it appears that no cranial nerves are directly involved in the injury, a complete cranial nerve examination should be performed to determine if any nerves are involved secondary to soft tissue swelling. The case presented by Prange et al. (2016) had involvement of the mental neurovascular bundle but no mention is made as to whether the horse had compromised function of the mental nerve. Injury to the mental nerve results in loss of sensation or paraesthesia to the lower lip and rostral chin on the affected side. A total loss of sensation is likely of no detriment to the horse but paraesthesia of the affected area may cause a burning or prickling sensation that could lead to self-mutilation (McDonnell 2008). Also, disruption of the mental artery and vein would likely have little impact due to the abundance of collateral blood supply (Budras et al. 2009). Lacerations of the mouth and in particular degloving injuries are dramatic and can seem daunting to repair. However, a surgical attempt is warranted for the welfare of the horse and these injuries heal favourably provided an adequate repair is performed. Failure to repair these injuries would result in production of profuse granularity tissue formation, possibly leading to an end result which is both cosmetically and functionally unsatisfactory.

Author’s declaration of interests
No conflicts of interest have been declared.

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None.

References

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Case Report

Severe polyuria and polydipsia as major clinical signs in a horse with unilateral renal adenocarcinoma

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Keywords: horse; renal adenocarcinoma; polyuria; polydipsia; unilateral nephrectomy

Summary
A 14-year-old Swiss Warmblood gelding was presented with chronic severe polyuria, polydipsia and weight loss. At the time of admission, water intake was 240 l/day. On rectal examination, a large mass was identified in the left dorsal abdominal quadrant, which was shown to originate from the left kidney by transabdominal ultrasonographic examination. Unilateral nephrectomy via flank incision was performed under general anaesthesia. Histopathological examination of the tumour revealed a papillary renal adenocarcinoma. Successful outcome and survival was documented 13 months after surgery. Severe polyuria and polydipsia should be considered as major clinical signs for renal carcinoma in horses, which can be successfully treated with unilateral nephrectomy if no signs of metastatic spread are evident.

Introduction
Primary renal tumours are rare in horses (Haschek et al. 1981; Brown and Holt 1985). A retrospective study reviewing 3633 equine necropsies at Cornell University between 1953 and 1976 revealed a prevalence for primary renal neoplasms of 0.11%, and for renal carcinoma of 0.055% (Haschek et al. 1981). Due to the aggressive nature of renal cell carcinomas, the disease is often far advanced, metastatic spread has already occurred and treatment options are limited at the time of initial presentation (Rhind et al. 1999). Reported clinical signs are variable and include weight loss, pyrexia, anaemia, haematuria, and colic (Berggren 1980; Haschek et al. 1981; Van Amstel et al. 1984; Brown and Holt 1985; Owen et al. 1986; West et al. 1987).

This case report describes the diagnostic work-up, surgical treatment and successful outcome of a horse with unilateral renal adenocarcinoma initially presented with severe polyuria (PU) and polydipsia (PD).

Case details

History
A 14-year-old Swiss Warmblood gelding was presented to the Equine Department of the Vetsuisse Faculty, University of Zurich, Switzerland, with a 2–3 year history of progressive severe PD and PU. Chronic weight loss despite normal appetite was first recognised one year prior to admission. Water consumption measured by the owners was approximately 240 l/day. The gelding had been fed with grass hay ad libitum and approximately 10 kg concentrated feed/day.

Complete blood count and biochemistry profile performed by the referring veterinarian had revealed minor abnormalities such as mild thrombocytopenia (73 × 10⁹/l), reference range [rr] 90–300 × 10⁹/l) and a slight increase in lactate dehydrogenase activity (489 U/l; rr 400 U/l). However, urinalysis had shown hyposthenuria (urine specific gravity 1.004) and an elevated protein/creatinine ratio of 1.55 (rr<1.0). A modified water deprivation test had been conducted over 2 days and water intake was restricted to 40 l/day. Urinalysis one and 2 days after water restriction revealed urine specific gravity of 1.012 and 1.008, respectively. Water intake was then restricted to 70 l/day for 18 days until referral. Up to this date the horse had participated successfully in showjumping competitions.

Clinical findings
On initial physical examination, the gelding was bright and alert, but in poor body condition (530 kg, body condition score 3/9). Heart rate (40 beats/min) and respiratory rate (10 breaths/min) were within normal limits and the rectal temperature was 37.4°C. The mucous membranes were pink with a capillary refill time <2 s. Gastrointestinal borborygmi were present in all quadrants. Rectal examination revealed a large mass in the left dorsal abdominal quadrant, while the left kidney could not be identified. Normal micturition was observed. The gelding’s water intake at the time of admission was not restricted and voluntary water intake represented 60 l over 24 h.

Complete blood count revealed a packed cell volume of 41% (rr 30–42%), total leukocyte count of 7.1 × 10⁹/l (rr 4.2–8.2 × 10⁹/l) and platelet count of 150 × 10⁹/l (rr 119–250 × 10⁹/l). Erythrocyte indices and leucocyte differentiation were unremarkable. Plasma biochemical analyses revealed no abnormalities other than mild hyperbilirubinaemia (35.5 μmol/l; rr 17.4–35.2 μmol/l), hyperglycaemia (6.5 mmol/l; rr 4.5–5.9 mmol/l) and hypochloraemia (96 mmol/l; rr 102–147 mmol/l) as well as slightly increased glutamate dehydrogenase (4.7 U/l; rr 0.5–2.2 U/l) and sorbitol dehydrogenase (12.3 U/l; rr 0.1–7.6 U/l) activities. Urea (21 mmol/l; rr 3.5–7.0 mmol/l) and creatinine (59 μmol/l; rr 82–147 μmol/l) concentrations were slightly decreased. Plasma protein, albumin and total calcium concentrations were within normal limits with 62 g/l (rr 60–70 g/l), 29 g/l (rr 25–34 g/l) and 3.05 mmol/l (rr 2.9–3.3 mmol/l), respectively. A free catch urine sample was submitted for urinalysis that revealed a specific gravity of 1.003 and a pH of 7.0. Urine sediment analysis identified no abnormalities.

Transabdominal ultrasonographic examination revealed a 40 × 15 cm large heterogeneous space-occupying lesion in the area of the left kidney (Fig 1). The right kidney was normal in shape and size with mildly decreased corticomedullary distinction and inhomogeneous echogenicity of the cortex.
Other organs within the abdominal cavity did not show any abnormalities.

A presumptive diagnosis of renal neoplasia was made. Radiographic examination of the thorax revealed a generalised broncho-interstitial lung pattern. There were no radiological signs of metastatic spreading such as neoplastic infiltration of the lungs, visible as multiple nodular soft tissue opacities.

Surgery

Since there was no evidence of metastatic spread, unilateral nephrectomy via flank incision was performed. During the procedure, further examination of the abdominal cavity also did not reveal any evidence of metastasis. Premedication included cefquinome (Cobactan, 2 mg/kg bwt) and phenylbutazone (Phenylarthrite6, 4 mg/kg bwt). General anaesthesia was induced with medetomidine (Dorbene3, 7 μg/kg bwt), diazepam (Valium4, 0.02 mg/kg bwt) and ketamine (Narketan5, 2.2 mg/kg bwt) and maintained with isoflurane in oxygen-enriched air, medetomidine constant rate infusion (Dorbene, 3.5 μg/kg bwt/h), and dobutamine constant rate infusion (Dobutrex6, 20 mg/kg bwt/h).

Surgery was performed in right lateral recumbency. The approach involved a dorsal flank incision, rib resection and blunt retroperitoneal dissection to expose the kidney as previously described (Woodie2012). The hilus of the kidney was exposed by blunt tissue transection between the capsule of the kidney and the mesenteric root, which resulted in severe bleeding that originated from vessels that reached the hilus from the side of the mass. The hilus was then crushed with an emasculator (single crush castrator)7, ligated dorsally with braided lactomer 2 USP suture and transected ventral to the emasculator. As soon as the hilus was crushed, the bleeding stopped. Blood loss was compensated by infusing 17 l of lactated Ringer’s solution and 8 l of whole blood. The mass was then removed from the abdominal cavity. Primary closure of the incision was performed in 3 layers in a routine fashion.

Gross appearance and histopathology

The mass measured approximately 30 × 40 × 15 cm (Fig 2). It was well demarcated and expanded between the renal capsule and pelvis by compressing the adjacent renal parenchyma and pelvis. The cut surface was friable, grained, and yellow and red mottled.

Histologically, the mass was multilobulated, partially encapsulated, but infiltratively growing. The neoplastic cells formed papillary projections composed of one or up to 3 layers of well-differentiated cuboidal epithelial cells lying on a moderate amount of fibrovascular and hyalineous stroma (Fig 3). The neoplastic cells had scant amount of strongly eosinophilic and distinctive cytoplasm and apically located oval to pleomorphic nuclei with finely stippled chromatin and 1–3 small nucleoli. Anisocytosis and anisokaryosis were mild, the mitotic rate was low. Multifocally, neoplastic cells invaded the fibrous capsule of the tumour and lymphatic vessels.

The adjacent renal parenchyma displayed a severe loss of glomeruli, tubules and collecting ducts, which were replaced by a severe interstitial fibrosis together with a marked lymphoplasmacytic inflammation and severely dilated lymph vessels. Remaining tubules and ducts had moderately dilated lumina and their epithelial cells showed signs of regeneration. The intima and media of arterial vessels were hypertrophic (Fig 4).

With immunohistochemistry, all neoplastic cells were strongly positive for pancytokeratins (M082101)8, which confirmed the tentative diagnosis of a papillary adenocarcinoma (Fig 3, inset).

Post operative care and outcome

The horse recovered uneventfully from general anaesthesia and was maintained on i.v. maintenance fluids for 24 h after surgery. The gelding received cefquinome (1.0 mg/kg bwt i.v. or i.m. b.i.d., for 8 days, Cobactan3) and flunixin meglumine (1.1 mg/kg bwt i.v. s.i.d., for 7 days, Fluinixinmin9). On the second day after surgery, the gelding developed diarrhoea. However,
there were no clinical signs of endotoxaemia, and rectal temperature and white blood cell counts stayed within normal limits. Based on the risk of shedding of Salmonella, the gelding was moved to the isolation facility. The diarrhoea resolved the following day without any additional therapy. Faecal bacterial culture was consistent with normal faecal flora. Water intake and urine specific gravity were measured at different time points before and after surgery (Fig 5) and improved to 41.5 l/day and 1.030, respectively, on Days 10 and 12 post surgery.

The horse was discharged from the hospital 14 days after surgery without any further medication. Telephone follow-up with the owner 4 weeks, 5 months and 13 months after discharge confirmed that the horse was bright and alert, had a good appetite, and had gained a reasonable amount of weight. Additionally, the horse resumed normal exercise and returned to previous use as an athletic horse (showjumping) at the same level of performance. No further episodes of PU/PD had been observed by the owner. Water intake and urine specific gravity were measured again 13 months post operatively and remained stable at 40 l/day and 1.029.

Discussion

Primary renal neoplasia is rare in horses. Renal cell carcinoma (RCC), also known as renal adenocarcinoma, hypernephroma and Grawitz's tumour, is the most commonly reported primary renal neoplasia (Brown and Holt 1985). It occurs most frequently unilaterally, although both kidneys can be affected (West et al. 1987). Horses of all ages are affected and in contrast to man, where 3 times as many males as females are affected, no sex or breed predisposition has been observed in horses (Ramirez and Seahorn 1996; Knowles et al. 2008; Wise et al. 2009). Known as the 'masquerades of human medicine' (Palapattu et al. 2002), in <15% of affected human patients, a mass is palpable or obvious clinical signs such as haematuria and flank pain are present. However, 10–40% of all human patients with RCC develop paraneoplastic syndrome including weight loss, anorexia, and metabolic or biochemical abnormalities such as hypercalcaemia or nonmetastatic hepatic disorders (Palapattu et al. 2002). In a retrospective study it was reported that many horses with renal carcinomas also show nonspecific clinical signs at presentation (Wise et al. 2009). A veterinary literature search revealed 18 cases of equine renal carcinoma that were described in detail. Of these, 83% were presented with weight loss, 50% with haematuria, and 39% with mild colic (Knowles et al. 2008). In addition, pyrexia and anaemia were also commonly found on admission. The horse presented here showed progressive PU/PD that had started several years prior to referral and chronic weight loss that had been observed for one year. To our knowledge, PU/PD associated with unilateral RCC is rarely reported. The first case was a 10-year-old pony gelding that was presented because of back pain, colic and anaemia with a daily water intake of 45–68 l (Brown and Holt 1985). In the second case, a historical complaint of PU/PD was suspected to be secondary to psychogenic water consumption and not associated with the diagnosis of RCC (Ramirez and Seahorn 1996).

Different diagnoses for PU/PD in horses include psychogenic PD, acute or chronic renal failure, pituitary pars intermedia dysfunction, endotoxaemia, overzealous i.v.-fluid administration, central or nephrogenic diabetes insipidus, and diabetes mellitus (McKenzie 2007). Based on the history, clinical signs, physical examination and laboratory results, iatrogenic causes, pituitary pars intermedia dysfunction, acute or chronic renal failure, endotoxaemia, and diabetes mellitus were excluded as possible causes for PU/PD in the presented case. To distinguish further between psychogenic PD, central diabetes insipidus, and nephrogenic diabetes insipidus, a modified water deprivation test, possibly followed by an antidiuretic hormone (ADH) challenge test, needs to be performed (Schott 2010). Restriction of water intake to 40 ml/kg bwt/day for 3–4 days with frequent assessment of

Fig 3: Histologic section of the left kidney: The neoplasm forms branching papillary projections consisting of a single or up to 3 layers of epithelial cells supported by a fine hyaline fibrovascular stroma (haematoxylin and eosin, bar = 50 µm). Inset: Immunohistochemistry depicts neoplastic cells with strong cytoplasmic staining for cytokeratin and negatively stained stroma (haematoxylin counterstain).

Fig 4: Photomicrograph showing adjacent renal parenchyma with loss of glomeruli (G), tubules (T) and collecting ducts (D), severe interstitial fibrosis (asterisk) and multifocal lymphoplasmacytic inflammation (arrow). The remaining tubules and ducts show moderate luminal dilation. Lymphatic vessels (L) are severely dilated; arterial vessels (V) show prominent medial hypertrophy (haematoxylin and eosin, bar = 100 µm).
hydration status and urine specific gravity should allow re-establishment of medullary hypertonicity and production of urine with a specific gravity exceeding 1.025 by the end of the testing period (Brown 1997; Knottenbelt 2003). In the present case, the gelding showed a mild increase of urine specific gravity during the modified water deprivation test. However urine specific gravity did not exceed 1.025. Since the modified water deprivation test was only performed over 2 days, psychogenic PD could not be ruled out as a cause of severe PU/PD in this case, but seemed less likely.

Another possible cause of PU/PD in our case is central or nephrogenic diabetes insipidus. Measurement of endogenous ADH concentration or assessment of the response to exogenous ADH administration is necessary to distinguish between these 2 conditions (McKenzie 2007; Kohn and Hansen 2010). Central diabetes insipidus, which is characterised by a decreased number or degeneration of neurosecretory neurons in the supraoptic nuclei of the hypothalamus leading to ADH deficiency, can not be induced by trauma, intracranial neoplasia, and inflammatory diseases. It is also described as an idiopathic syndrome (Filar et al. 1971; Breukink et al. 1983; McKenzie 2007; Schott 2010). Primary nephrogenic diabetes insipidus, characterised by a failure of the renal tubules to respond to ADH, is a rare cause of PU in the horse (Schott et al. 1993; McKenzie 2007). However, most commonly diabetes insipidus occurs secondary to renal failure and a variety of endocrine, metabolic, infectious, or mechanical (post obstruction) disorders. In other species, hypokalaemia, hypercalcaemia in association with neoplasia or administration of certain drugs (e.g. gentamicin), are reported to cause nephrogenic diabetes insipidus (Fenner 2001; Cohen and Post 2002). Nephrogenic diabetes insipidus has also been described as part of the paraneoplastic syndrome in a human patient and in a dog with metastatic intestinal leiomyosarcoma (Feibusch et al. 1980; Cohen and Post 1999).

In these case reports, various paraneoplastic mechanisms leading to nephrogenic diabetes insipidus have been described such as antibody formation to the vasopressin receptor, excessive production of neuropsychin or synthesis of an analogue of vasopressin inhibiting the renal action of vasopressin (Chan et al. 1968; Datta and Chaudhury 1968; Breslow and Walter 1972; Kamoi et al. 1977; Dousa et al. 1979; Cohen and Post 1999, 2002).

A possible explanation for the severe PU/PD observed in the present case is secondary nephrogenic diabetes insipidus due to interference with the production and the function of aquaporin-2, a vasopressin-regulated water-channel protein increasing the permeability of the collecting ducts, either directly by the neoplasia or through molecules secreted by the tumour as already suggested in the previously mentioned canine case report (Cohen and Post 1999). Complete resolution of PU/PD after tumour resection was also reported in this dog. However, the clinical signs reoccurred later on after metastatic spread of the primary tumour throughout the abdomen (Cohen and Post 1999). In the present case, psychogenic PD cannot be completely excluded as the cause of severe PU/PD. Continuation of the modified water deprivation for another 1–2 days may have led to an increase of urine specific gravity above 1.025, which would have confirmed psychogenic PD. Given that not all aspects of a complete diagnostic work up were carried out in the presented case the ultimate cause of severe PU/PD remains unknown.

Renal cell carcinomas originate from the proximal or distal renal tubules, generally in the renal cortex, and grow from one pole of the kidney by expansion (Ramirez and Seahorn 1994). Metastatic spread of RCC is common in a variety of species. However, in veterinary medicine an accurate prognosis is difficult to give due to an insufficient number of cases in a lot of species. In a review on RCC in horses, 19/27 horses with RCC...
were diagnosed with metastatic spread to other organs, with both lungs and liver being the most commonly affected sites (Wise et al. 2009). When a presumptive diagnosis of renal neoplasia has been reached, screening for metastases is therefore warranted.

In recent years, attempted treatment of renal carcinoma has been described several times. In a retrospective study, exploratory surgery for diagnostic and therapeutic purposes was reported in 6/27 horses with renal cell carcinoma (Wise et al. 2009). In 4 of these 6 horses, the tumour was considered to be too invasive for excision, and 3 of those horses were subjected to euthanasia during anaesthesia. One mare recovered from anaesthesia after the tumour was deemed inoperable and was discharged to the owner’s care. This mare was alive and in-foal one year after discharge. One horse had to be subjected to euthanasia due to severe haemorrhage during tumour resection (Wise et al. 2009). Successful standing unilateral nephrectomy was performed in one affected horse. However, the horse returned within 7 months after discharge due to severe metastatic disease and was subsequently subjected to euthanasia (Hilton et al. 2008). Only the aforementioned horse survived to discharge in this retrospective study of 27 horses (Wise et al. 2009). Twenty-two horses were subjected to euthanasia because of the deleterious systemic effects of the neoplasms and poor prognosis for survival and 4 horses died as a direct result of the primary neoplasm.

In the case presented here, unilateral nephrectomy via flank incision under general anaesthesia was elected due to the massive size of the tumour. Although severe haemorrhage occurred during tumour resection, nephrectomy was successfully completed. The PU/PD had completely resolved during tumour resection (Wise et al. 2009). Successful standing unilateral nephrectomy was performed in one affected horse.

The authors would like to acknowledge Dr Thomas Wagner for the referral of this case.

Acknowledgement
The authors would like to acknowledge Dr Thomas Wagner for the referral of this case.

Manufacturers’ addresses
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Case Report

Pulmonary artery compression in a Thoroughbred colt due to a mediastinal abscess

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Keywords: horse; pulmonary artery compression; echocardiography

Summary

In the case presented, a young horse was referred for further evaluation based on a presumptive diagnosis of pulmonic valve endocarditis, bronchopneumonia and a cranial mediastinal abscess based on thoracic ultrasound, echocardiography and clinical signs. However, further echocardiographic evaluation revealed that the abscess was compressing the right ventricular outflow track causing outflow obstruction, a murmur associated with right ventricular outflow tract obstruction (acquired pulmonic stenosis) and right ventricular hypertrophy. Vegetative endocarditis was not present. Medical management was unsuccessful, but surgical drainage and long-term antimicrobial therapy were effective and the horse returned to a successful racing career.

Case history

A 3-year-old Thoroughbred colt (and several stable mates) spiked intermittent fevers in excess of 39.2°C over a 2-week period. Thoracic ultrasound revealed a cranial mediastinal abscess and pleural roughening cranioventrally in the left thorax. The colt was treated with potassium penicillin (22,000 IU/kg bwt i.v. q.i.d.), gentamicin (6.6 mg/kg bwt i.v. s.i.d.) and enrofloxacin (7.5 mg/kg bwt i.v. s.i.d.) for 7 days and resumed race training. However, the fever recurred and a cardiac murmur that had not previously been detected was noted. Thoracic ultrasound, including echocardiography was performed. Based on this examination, the sonographer diagnosed bronchopneumonia, a cranial mediastinal abscess and suspected pulmonic valve endocarditis. The colt was referred to MidAtlantic Equine Medical Center for further evaluation.

Clinical findings

At presentation, the colt’s rectal temperature and respiratory findings were within normal limits and mucous membranes were pink and moist with a prompt capillary refill time. The heart rate was 52 beats/min and cardiac auscultation revealed a grade V/VI ejection quality (crescendo-decrescendo or diamond shaped, holosystolic) murmur with the point of maximum intensity (PMI) over the pulmonic valve area. A similar but lower intensity murmur (grade II/VI) was noted on the right thorax at the third intercostal space. Systemic venous congestion was not present. At rest the lung fields ausculted within normal limits bilaterally; however, during re-breathing, mild wheezes were heard over the left mid-thorax. The horse recovered within 5–6 breaths with a moderate amount of coughing elicited after the re-breathing bag was removed. An ultrasound examination of the right and left thorax demonstrated a 20 × 20 cm cranial mediastinal mass (presumed to be an abscess). The abscess was homogenously hypoechoic with an echogenic centre and capsule (Fig 1). Additionally, pleural roughening was noted bilaterally in the cranioventral aspects of the lung fields, but no pleural effusion was present. Abnormal clinical pathology findings included leucocytosis (14.9 × 10⁹/l; normal 5.5–12.5 × 10⁹/l), hyperfibrinogenaemia (8.0 g/l; normal 2.0–4.0 g/l) and hyperproteinaemia (88 g/l; normal 57–80 g/l). Three blood samples were submitted for culture and sensitivity, but there was no growth.

An echocardiogram was performed, which revealed right ventricular hypertrophy and enlargement as well as mild thickening of the aortic and pulmonic valves, consistent with valvulitis. The right ventricular wall thickness was similar to the left ventricular wall thickness and the chamber was subjectively dilated with a thick moderator band (Fig 2a). No valvular vegetations were evident. Left heart size and systolic function was within normal limits (Table 1). A large, cranial mediastinal mass, presumed to be an abscess based on the history, was visibly compressing the right ventricular outflow tract. The mass was visible from the right and left side of the
thorax, but easiest to visualise from the right. The right ventricular outflow velocity was measured with continuous wave Doppler and was significantly increased to 4.0 m/s (Fig 3a). Using the modified Bernoulli equation (pressure gradient = $4 \times$ velocity$^2$), the systolic pressure gradient between the right ventricle and the pulmonary artery was calculated to be 64 mmHg. This elevated gradient was presumed to be secondary to compression of the right ventricular outflow tract rather than congenital pulmonic stenosis or pulmonic valvular endocarditis leading to acquired pulmonic stenosis. Clinically insignificant aortic regurgitation was also noted with no aortic valvular abnormalities other than mild thickening. Medical management was continued, but he was switched to oral antimicrobials: metronidazole (15 mg/kg bwt t.i.d.), rifampin (5 mg/kg bwt b.i.d.) and oral chloramphenicol (50 mg/kg bwt q.i.d.) since he had not responded to potassium penicillin, gentamicin and enrofloxacin. In addition to antibiotic therapy, a nonsteroidal anti-inflammatory agent (flunixin meglumine at 1.1 mg/kg bwt i.v. s.i.d.) and i.v. fluids (60 ml/kg bwt/day after 20 l bolus) were administered because of evidence of mild dehydration. Intravenous fluids were discontinued after 5 days.

The cranial mediastinal mass was monitored by thoracic ultrasound weekly until discharge 18 days later. At the time of discharge the mass had decreased in size to 12 × 15 cm and clinical laboratory abnormalities had resolved. One month later, the horse was returned for re-evaluation. A grade V/VI, ejection-quality (crescendo-decrescendo or diamond-shaped, holosystolic) murmur with a PMI over the pulmonic valve area persisted. No other abnormalities were noted on physical examination. A repeat echocardiogram revealed the mediastinal mass remained large (20 × 20 cm), hypoechoic and continued to compress the right ventricular outflow tract. Right ventricular enlargement and hypertrophy were unchanged. A thoracic ultrasound was not performed at this time. Because of the inadequate response to medical management, surgical intervention was recommended. The following day, the colt was placed under general anaesthesia for surgical debridement of the abscess. He was placed in left lateral recumbency and his forelimbs were pulled forward to

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| AO pfv = aortic peak flow velocity; AO = aortic diameter during diastole; IVSd = intraventricular septal diameter during diastole; LA = left atrial diameter obtained from the left parasternal long axis view; LVFWd = left ventricular free wall during diastole; LVIDd = left ventricular internal diameter during diastole; LVIDs = left ventricular internal diameter during systole; PA pfv = pulmonary artery peak flow velocity; PA = pulmonary artery diameter during diastole; SF = left ventricular shortening fraction. * Data obtained from 26 normal Thoroughbred horses (Long et al. 1992). † Data obtained from 29 normal Thoroughbred horses (Patteson et al. 1995). ‡ Data obtained from 40 normal Thoroughbred horses (Blissitt and Bonagura 1995).
gain access to the cranial mediastinum. A skin incision was made behind the triceps muscle and, under ultrasound guidance, a 32 French Argyle thoracic catheter was advanced into the abscess. Three litres of sanguinous fluid drained spontaneously. Chloramphenicol therapy was continued, but rifampin and metronidazole were discontinued. The abscess was lavaged with 25 l of sterile saline and yellow, granular tissue and black necrotic tissue was removed with suction. A sample was submitted for aerobic and anaerobic culture and sensitivity, but there was no growth. The size of the abscess was reduced on ultrasound to 4 × 5 cm. The skin incision was left open to facilitate drainage and the catheter was removed. Immediately following surgery (after recovery from anaesthesia) the systolic murmur associated with compression of the right ventricular outflow tract disappeared; however, over the next several days the murmur returned and the abscess size gradually increased. Therefore, 2 weeks following the first surgery, the colt underwent a second surgery under general anaesthesia and was prepared as described previously. The abscess was evaluated by ultrasound at the point of the previous surgical site and a 32 French Argyle catheter was inserted into the abscess through a 2 cm skin incision. Approximately 1–2 l of sanguinous fluid drained spontaneously and a sample was submitted for culture and sensitivity with no growth detected. The abscess was lavaged and then suctioned repeatedly to remove fibrin and blood clots. The catheter was sutured in place for future lavages, 2 g of ampicillin was infused into the abscess, and left in situ by plugging the catheter with a 3 ml syringe plunger. The abscess was lavaged daily for 7 additional days and the catheter was then removed. The abscess was monitored by ultrasound weekly and had decreased in size (7 × 4 cm) 2 weeks later.

Oral chloramphenicol was continued until the horse was switched to oral doxycycline (5 g [10 mg/kg bwt] twice daily) therapy for one month and discharged from the hospital. One month after discharge (6 weeks following surgery), the colt was returned for re-evaluation. A cardiology re-examination was performed and revealed a grade II/VI ejection quality murmur (crescendo-decrescendo or diamond-shaped, holosystolic) with a PMI at the pulmonic valve area. The right ventricle remained mildly enlarged, although it had decreased in size compared to the previous echocardiogram (Fig 2a and b). Left ventricular systolic function remained normal (Table 1). Valve thickness was normal; however, the cranial mediastinal abscess was still present, although significantly smaller in size (7.3 × 4 cm). The flow velocity measured in the right ventricular outflow tract with continuous wave Doppler remained mildly elevated with a calculated gradient of 27 mmHg between the right ventricle and the pulmonary artery (Table 1). The impact of these findings on athletic performance was unknown at the time, although the horse was placed back into training.

The horse returned for routine re-examination one year after discharge. No murmur was noted on physical examination. On echocardiogram the mediastinal mass was still visible, but it had further decreased in size (2.5 × 3 cm). Cardiac size and function were normal, as was and the flow velocity measured in the right ventricular outflow tract (Fig 3b). The trace aortic insufficiency was unchanged compared to previous examinations. A re-evaluation was recommended, but the horse was not returned to the clinic after this examination. The horse went on to race successfully in Grade I stakes races 2 years after the time of admission, without any additional cardiopulmonary complications (telephone communication).

Discussion

Congenital pulmonic stenosis has been described in numerous reports in the equine literature as a single defect or part of complex congenital heart disease (Prickett et al. 1973; Vitums et al. 1973; Critchley 1976; Borst 1978; Reynolds and Nicholl 1978; Keith 1981; Vitums and Bayly 1982; McClure et al. 1983; Hinchcliff and Adams 1991). However, although the cardiac murmur noted in this colt was characteristic of pulmonic stenosis, the fact that it was not present from birth makes congenital disease highly unlikely in this case. Cranial mediastinal masses may be mediastinal lymphosarcoma (Garber et al. 1994; De Clerq et al. 2004; Sugiyama et al. 2008) or cranial mediastinal abscess (Byars et al. 1991; Griffin 2002). In one of these reports, a systolic cardiac murmur was noted on Day 8 of hospitalisation and later resolved (Griffin 2002). The cause of the murmur was not identified, but it is possible a similar process occurred as is described in the case presented here. To the authors’ knowledge, this is the first case of acquired pulmonic stenosis documented by echocardiography in the horse, and followed to resolution.

Acquired pulmonic stenosis with a similar pathophysiology has been reported in human patients most commonly due to neoplasia (Ozer et al. 2009; Badheka et al. 2012), but has also been recognised secondary to mediastinal abnormalities (Tardif et al. 1994; Satpathy et al. 2007; Bulaczi et al. 2011). From these human case reports, it is unclear how long
right ventricular remodelling (return to normal size) requires in man. However, in a group of human patients with right ventricular hypertrophy secondary to chronic thromboembolic pulmonary hypertension, the capability of the right ventricle to regain normal morphology was assessed following pulmonary endarterectomy procedures. The right ventricular wall thickness decreased consistently over the 2 year span of the study, although the decrease was only significant during the first 12 months following surgery (D’Armini et al. 2007). Given this remodelling pattern in man, it is not surprising that right ventricular thickness did not return to normal for 12 months following resolution of the obstruction in this colt.

Cranial mediastinal abscesses have been described previously as a potential sequela to pleuropneumonia in the horse (Byars et al. 1991; Griffin 2002). Bacterial seeding of the mediastinal lymph nodes may lead to abscessation (Beadle 1999; Griffin 2002) or the accumulation of pleural fluid may wall off and become encapsulated as an abscess (Reef 1998). In the present case, the former route appears more likely given the absence of pleural effusion. Because repeated cultures of the mass presented here were negative, it would be most accurate to describe the lesion as a cranial thoracic or mediastinal mass since a definitive diagnosis was not obtained. However, it was most consistent with an abscess.

Byars et al. (1991) reported that most horses with cranial mediastinal abscesses were successfully treated with conservative therapy (medical management). However, conservative therapy was not effective in this colt and surgical drainage was pursued. The same approach has also been successfully implemented in a standing horse (Griffin 2002). In the earlier case as well as the colt presented here, an indwelling catheter was necessary for complete resolution (Byars et al. 1991). Cranial mediastinal abscessation should be considered a possible sequela in all cases of equine pneumonia, and if present appropriate medical therapy should be initiated. If the lesion does not resolve with medical management, placement of a catheter within the abscess for drainage and lavage appears to be an effective treatment.

Authors’ declaration of interests

No conflicts of interest have been declared.

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Case Report

Diagnosis of lumbosacral intervertebral disc disease and protrusion in a horse using ultrasonographic evaluation and computed tomography

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Keywords: horse; ataxia; intervertebral disc; incontinence; lumbosacral disease; ultrasonography; computed tomography

Summary
This case report describes the clinical presentation, diagnostic imaging modalities, treatment and post mortem evaluation of lumbosacral intervertebral disc protrusion in a mature Quarter Horse gelding 10 days after initial signs were noted. Grade 3 hindlimb ataxia, conscious proprioceptive deficits, urinary and faecal incontinence were present, which did not improve with anti-inflammatories, antimicrobial therapy, corticosteroids, antioxidant therapy, cold-laser therapy or electroacupuncture. Imaging modalities utilised ante mortem were computed radiography, transcutaneous and transrectal ultrasonography. Transectal ultrasonography yielded findings highly suggestive of lumbosacral intervertebral disc protrusion and due to the lack of improvement and a poor prognosis, the horse was humanely subjected to euthanasia. Post mortem computed tomography, necropsy and histopathological evaluation confirmed lumbosacral intervertebral disc disease and protrusion into the spinal canal with subsequent impingement of the spinal nerve roots. Lumbosacral intervertebral disc protrusion as a clinical disease in the horse has not been previously described and should be included as a differential diagnosis in cases with acute hindlimb ataxia, proprioceptive deficits, and urinary and faecal incontinence.

Introduction
The causes of hindlimb ataxia and lumbosacral pain are often ambiguous, difficult to diagnose and of uncertain aetiology, which can arise from spontaneous musculoskeletal disease, neurological dysfunction, or traumatic injuries. The lumbosacral joint is the most mobile intervertebral joint between the cranial thoracic vertebrae and pelvis in the horse (Townsend and Leach 1984; Denoix et al. 2005). This mobility makes the lumbosacral joint more susceptible to injury than other intervertebral joints (Werpy 2007). Inherent differences exist between the intervertebral discs of man, horses and other domestic species that make equine discs less prone to pathological disease and protrusion (Yovich et al. 1985; Kranenburg et al. 2013). Fundamentally, the nucleus pulposus and annulus fibrosus originate from the notochord and sclerotome respectively in all of these species (Risbud and Shapiro 2011; Sivakamasundari and Lufkin 2012). However, disc morphology, orientation and surrounding anatomy in the horse prevents the classical type I and II disc disease and protrusion.

Intervertebral disc protrusions in the horse have been reported in the cervical spine (Foss et al. 1983; Nixon et al. 1984; Stadler et al. 1988; Furr et al. 1991; Speltz et al. 2006) and one case report exists of thoracic intervertebral disc disease in a donkey (Drouard et al. 2003). Equine cervical intervertebral disc disease has been diagnosed with myelography and post mortem examination (Rooney 1978; Foss et al. 1983; Nixon et al. 1984; Stadler et al. 1988). Radiographic evaluation has been used supportively to identify intervertebral disc space collapse, but lacks the sensitivity to evaluate soft tissue structures. While the use of ultrasound to evaluate lumbosacral disease has been reported, to date no report exists utilising transrectal ultrasonographic evaluation to help diagnose lumbosacral intervertebral disc disease and protrusion in the horse. The diagnosis of the case at hand was further confirmed by computed tomography and post mortem evaluation. This report serves to describe a rather novel clinical presentation, diagnostic modalities and pathologies associated with lumbosacral intervertebral disc disease in a Quarter Horse gelding.

Case history
A 13-year-old, 450 kg Quarter Horse gelding presented with a 10-day history of intermittent urine dribbling, frequent urination and competition in a rodeo 6 days prior to presentation. Treatment by the regular veterinarian included a routine sheath cleaning and herbal supplementation with lemon oil added to his drinking water. The horse presented acutely for obstipation at the external anal sphincter, continuous urine dribbling, bilateral hindlimb ataxia and a fever of 40.6°C.

Clinical findings
Neurological examination revealed bilateral hindlimb ataxia (grade 3), absent tail tone, absent sphincter tone and bilateral hindlimb conscious proprioceptive deficits with the left more severely affected than the right. Assessment of the cranial nerves and mentation yielded no abnormalities. An abdominal palpation per rectum was performed and the rectum was evacuated. A large, turgid and painful bladder was palpated and a urinary catheter was passed to facilitate voiding of the bladder.

The horse was isolated due to his previous travel history and fever. Polymerase chain reaction was conducted on nasal swabs and whole blood for equine herpesviruses 1 and...
4, and influenza. Results were negative. Complete blood count and serum blood chemistry revealed hyperfibrinogenaemia, leucocytosis with a neutrophilia, hypocalcaemia, hypomagnesaemia and hyperbilirubinaemia. No other abnormalities were noted.

**Treatment**

Initial therapy consisted of maintenance fluids (Plasmalyte) at a rate of approximately 50 ml/kg bwt/day, flunixin meglumine (1.1 mg/kg bwt, i.v. q. 12 h), trimethoprim sulfadimethoxazole (20 mg/kg bwt, per os, q. 12 h), vitamin E (20,000 u, per os, q. 24 h), aspirin (20 mg/kg bwt, per os, q. 24 h), dimethyl sulfoxide (1.0 g/kg bwt, i.v. as a 10% solution, q. 24 h). The horse ate well and underwent rectal evacuation every 6 h in addition to manual bladder expression if deemed full at the time of evacuation. A 9 mm indwelling stallion urinary catheter was passed into the bladder to facilitate passive voiding and prevent retrograde air flow into the bladder. Electroacupuncture and cold-laser therapy of the back and lumbosacral area were instituted 48 h after presentation and performed daily without clinical improvement. A one time dose of dexamethasone (0.1 mg/kg bwt, i.v.) followed by prednisolone sodium succinate (1.0 mg/kg bwt, per os q. 24) were administered to evaluate for any improvement of clinical or neurological signs; no change was detected.

**Diagnosis**

Lateral radiographic views of the lumbar vertebrae and lumbar dorsal spinous processes of the thoracolumbar region (T17–L3) were acquired using a conventional computed radiography system [CR-Siemens 24 V, 50/60 Hz, 150 W]¹. Ultrasonographic evaluation of the pelvis and lumbar spine was performed transrectally and transcutaneously. Transrectal images were obtained using a linear array intraoperative ultrasound probe at 10 MHz and transcutaneous images were obtained utilising a macroconvex transducer at 4 MHz (LOGIQ 9 Ultrasound)². Computed tomography was conducted post mortem and images of the lumbosacral spine and pelvis were obtained using standard algorithm 3 mm slices and sharp algorithm 2 mm slices (TF Big Bore PET/CT)². Kilovoltage peak was set at 140, mAs at 600, mA at 275, with a pitch of 0.688, field of view at 550 and matrices 1024 x 1024 pixels. Images were reconstructed in dorsal and sagittal planes.

The caudal lumbar spine could not be sufficiently evaluated radiographically. The spinous processes were assessed for positioning, narrowing of the space between processes, impingement, and any evidence of fractures and/or osseous remodelling. Mild narrowing between the T17 and T18 spinous processes was noted with sclerosis along the caudal margins. There was no evidence of abnormalities associated with the articular facets or vertebral bodies. Ultrasonography revealed marked disruption of the normal echogenicity of the lumbosacral disc and a central area of hypoechogenicity (Fig 1). Additionally, the caudal vertebral endplate of L6 was markedly irregular with multifocal areas of mineralisation within the lumbosacral disc. Mild osseous proliferation affected the L6–S1 intertransverse joints and there was mild asymmetry of the width of the sacroiliac joints and mild osteophytosis present. No fractures within the pelvis were identified. The changes seen associated with the L6–S1 intervertebral disc were considered the most significant finding. The marked degenerative changes of the lumbosacral intervertebral disc coupled with associated degenerative changes of the L6 vertebral endplate in conjunction with the clinical signs led to a presumptive diagnosis of intervertebral disc protrusion or extrusion into the spinal canal. Post mortem computed tomography images confirmed compression of the ventral aspect of the spinal nerve roots at L6–S1 characterised by flattening of the ventral margin of the nerve roots and loss of normal signal of epidural fat (Fig 2).

**Macroscopic post mortem findings**

Severe intervertebral disc protrusion at L6–S1 (cauda equina) into the vertebral canal focally and markedly compressing the overlying nerve roots was present. Marked haemorrhage was also noted to extend from L4 to S3 (Fig 3).

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**Microscopic post mortem findings**

Histopathological evaluation revealed focally extensive, chronic and severe Wallerian degeneration of the spinal cord at L5–S1. Multifocal to coalescing lymphohistiocytic and necrosuppurative inflammation was noted in the ventrolateral spinal nerve roots and dorsal nerve root ganglia with severe gliosis (Fig 4). Inflammation extended through the meninges to the surrounding adipose tissue where there was necrotising perineural steatitis at the cauda equina. Special stains for infectious agents including acid-fast bacilli, protozoa, fungus and Gram stainable bacteria only revealed the presence of scattered Gram-negative bacilli in inflamed and noninflamed tissue, which were interpreted as secondary post mortem contaminants. Occasional small meningeal veins were occluded by degenerate disc material (cartilaginous emboli; Fig 5).

**Discussion**

Intervertebral disc disease is rarely reported in the horse and is not classically thought of as a clinical degenerative joint disease. Although degenerative change in the lumbosacral intervertebral disc has been documented in clinically normal horses, a correlation between these changes and a predisposition to disc protrusion has not been established (Townsend et al. 1986; Denoix 1999a,b; Folkel 2012). Similarly, degenerative change of the lumbosacral disc has been described in clinically normal, asymptomatic human individuals as well (Boden et al. 1990). Degenerative changes in the lumbosacral intervertebral disc are theorised to be due to increased dorsoventral motion and increased disc thickness relative to the intervertebral discs in the caudal thoracic and lumbar spine (Townsend and Leach 1984; Denoix 1999a,b). In man, intervertebral disc disease and herniation are associated with the loss of diffusional capability of the endplate blood vessels that supply the nucleus pulposus, which leads to degeneration and change in cellular composition and morphology (Roberts et al. 2006). Disc herniation in other domestic species is associated with a multigenic predisposition and other multifactorial agents in certain breeds (Harris and Dhupa 2008; Jeffery et al. 2013).

The lack of clinical disc disease in the horse is attributed to the absence or poorly developed nucleus pulposus, and relatively thin width of the intervertebral discs. Equine intervertebral discs have a central fibrocartilaginous area that becomes more fibrous peripherally and is relatively thin, making horses less susceptible to disc prolapse (Jeffcott and Dalin 1980; Nixon et al. 1984). Additionally, the sacrocaudalis dorsalis and multifidus muscles are thought to further stabilise and support the lumbosacral area undergoing dorsoventral motion (Stubbs et al. 2006).

Kinematic evaluation of the lumbosacral space reveals a large range of dorso-ventral mobility of the joint ranging 9° ± 32° from L5–S1 and is attributed to a greater thickness and smaller height of the lumbosacral intervertebral discs (Denoix 1999a, 1999b). The smaller height and increased thickness of the disc brings the centre of rotation closer to the disc and results in greater tensile and compressive strain (Nagy et al. 2010). Additionally, wide divergence of dorsal

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**Fig 2:** Transverse image at the level of the lumbosacral intervertebral disc space (a) and sagittal reconstruction of the lumbosacral spine (b). The white line on the sagittal image denotes the level of the transverse image. There is compression of the ventral aspect of the spinal nerve roots at L6–S1 characterised by flattening of the ventral margin (red arrows) of the nerve roots and loss of normal signal of epidural fat. As this was a post mortem, noncontrast enhanced examination, the soft tissue detail is limited.

**Fig 3:** Photomicrograph of L6 showing haemorrhage and focal lymphoplasmacytic inflammation of the ventral spinal nerve roots with severe congestion and multifocal haemorrhage (magnification x40).
spinal processes, absence of a supraspinous ligament, and a poorly developed interspinous ligament make the lumbosacral joint more susceptible to injury compared to other intervertebral spaces (Jeffcott and Dalin 1980; Werpy 2007; Nagy et al. 2010). Lumbosacral instability may have predisposed this horse to injury and disc protrusion; however, there was no evidence or prior history of trauma, decreased athletic performance, or back or lumbosacral pain. No osseous lumbosacral stenosis was noted at post mortem examination that would have predisposed the horse to compression of the cauda equina, or instability of L6–S1.

Acute spinal cord injury results from concussion and compression of the spinal cord or associated spinal nerve roots attributed to explosive type I herniation or the insidious nature of a type II intervertebral disc protrusion. Primary and secondary injury result in ischaemic and haemorrhagic necrosis of the spinal cord due to the effects of trauma, local ischaemia, vasoactive substances, free radicals and cellular enzymes (Nout-Lomas 2010; Jeffery et al. 2013). Neurological dysfunction is typically categorised into central or peripheral nervous system disease. Increased cerebrospinal fluid creatine kinase can be elevated in central nervous system disease attributable to compression of the spinal cord but may be elevated in cases of trauma and inflammatory disease (Furr and Tyler 1990; Furr et al. 1991). Cerebrospinal fluid analysis was not performed in this horse but is warranted in cases suspected of having central nervous system pathology. Equine protozoal myelitis (EPM) was tentatively ruled out based on the geographic location of the horse and the acute onset of clinical symptoms following strenuous exercise. Moreover, causative protozoa of EPM were not identified in affected sections stained with Giemsa and periodic acid-Schiff staining. Sarcocystis neurona is known to affect the central nervous system without involvement of the intervertebral discs and therefore disc disease and subsequent protrusion is unlikely to occur in EPM.

Somatic innervation of the bladder originates from the sacral cord (S1–S2) by way of the pelvic nerve and branches of the pudendal nerve, which also innervate the perineum and external anal sphincter (Bayly 2010). Sympathetic supply provided via the hypogastric nerve arrives from the L1–L4 segment and synapse on the caudal mesenteric ganglion (Bayly 2010). Injury to the cauda equina at the level of L6–S1 explains the absence of anal sphincter tone, absent tail tone and presence of a neurogenic bladder. The inability to urinate or defecate coupled with the bilateral hindlimb ataxia indicate a central lesion, and rules out peripheral neuropathy.

The lumbosacral joint is best evaluated through transrectal ultrasound (Denoix et al. 2005) and normal variation and degenerative changes in asymptomatic horses have been documented (Nagy et al. 2010). The lumbosacral intervertebral disc is imaged as an echogenic mass with 2 distinct portions, the ventral portion and central portion. The ventral border of the disc, fibre orientation, conformation and disc echogenicity are assessed in both portions (Denoix 1999a,b). A diffuse loss in echogenicity, fibre degeneration, disc fissure and focal hypoechoic spots are suggestive of fibre rupture, disc cavitation or healing tissue. Hyperechoic spots can be indicative of previous lumbosacral trauma or change secondary to intervertebral disc mineralisation (Denoix 1999a,b).

Ultrasonographic diagnosis of lumbosacral intervertebral disc disease requires careful evaluation and knowledge of normal age-related changes in horses in addition to changes in echogenicity, shape, positioning of the intervertebral disc and correlation of clinical signs. Moreover, horses diagnosed with lumbosacral or sacroiliac pain may warrant further investigation and follow-up utilising nuclear scintigraphy to correlate degenerative changes with inflammatory changes or remodelling associated with the lumbosacral area.

Neuropaenatomical localisation and ultrasonography were essential tools in presumptively diagnosing intervertebral disc protrusion. The incidence of lumbosacral intervertebral disc disease clinically affecting horses is not known and warrants further investigation in horses. Although lumbosacral intervertebral disc protrusion has not been documented in the horse, the inclusion of moderate to severe lumbosacral intervertebral disc protrusion should be considered as a differential diagnosis in cases of hindlimb ataxia, urinary and faecal incontinence.
Authors’ declaration of interests
No conflicts of interest have been declared.

Ethical animal research
Direct consent by the owner was obtained for all treatment, and ante and post mortem diagnosis and imaging. Additionally, the owner and family authorised using the case findings for compilation into a report for submission to a journal.

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Authorship
C. Krueger’s contribution was triage and care of the case and drafting of the manuscript. J. Gold’s contribution involved case management and manuscript drafting process. M. Barrett’s contribution was the diagnostic imaging modalities and interpretation of findings. T. Aboellail was responsible for histopathological examination and interpretation. All authors were directly involved in the writing and revision process.

Manufacturers’ addresses
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Case Report

Laparoscopic-assisted tube cystotomy for urethral rupture in a foal

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Keywords: horse; urethral tear; tube cystotomy; laparoscopy; urine diversion

Introduction

Urethral rupture is not commonly seen in horses (Schott II and Woodie 2012). Urethral laceration is observed in horses mainly in the penile or extra-pelvic urethra as a result of the superficial location and susceptibility to trauma (Schott II and Woodie 2012). Bladder rupture is widely reported in the literature (Dunkel et al. 2005; May et al. 2008; Rijkenhuizen et al. 2008) but pelvic urethral rupture has only recently been described for the first time in a foal (Castagnetti et al. 2010). The case reported here describes the management of urethral injury in a colt using perineal urethroplasty and laparoscopic-assisted tube cystotomy which permitted complete urine diversion and allowed the urethral tear to heal completely.

Case history and clinical findings

A 10-day-old Tennessee Walking Horse colt weighing 60 kg was presented to the Hebrew University School of Veterinary Medicine Teaching Hospital with tenesmus and swelling around the anus. The foal had a normal delivery and was healthy until the day of referral. The owners gave the foal water. The foal was seen nursing from his dam and surrounding the anus was related to the hard faeces with the presence of sand; however, the reason for the weak flow of urine containing blood clots was unclear.

Antimicrobial therapy was initiated with penicillin G sodium (20,000 u/kg bwt i.v. q. 6 h) and gentamicin sulfate (6.6 mg/kg bwt i.v. q. 24 h). Initial fluid therapy included 3 l lactated Ringer’s solution administered as a bolus, followed by 2.5% dextrose at 300 ml/h. The foal also received fluoxin megilumine (0.5 mg/kg bwt i.v. q. 12 h), ranitidine (6.6 mg/kg bwt per os q. 8 h) and psyllium (Pactopsyllium 75%) (0.5 g/kg bwt per os q. 12 h) given by nasogastric tube. The inguinal hernia was manually reduced every 2 h.

During the first day of hospitalisation, the foal appeared weak and did not nurse properly. He was still urinating in a weak flow but was no longer straining to defaecate.

The following day, skin sloughing and necrotic tissue appeared on his right perineal region, creating a large wound between the anus and semimembranosus muscle. The wound (10 cm long, 4 cm wide and 3 cm deep) was suspected to communicate with the urethra due to urine leakage from the wound. Upon digital palpation, a urethral tear was suspected and retrograde positive-contrast cystography performed. An 18F Foley catheter was aseptically placed in the urethra in retrograde fashion and 100 ml lohexol (Ominpaque) injected thorough the catheter. Lateral abdominal radiograph demonstrated a dorsal urethral tear in the pelvic cavity, midway between the bladder and ischial arch.

Treatment

A subischial urethroty was performed in lateral recumbency as previously described (Schumacher et al. 1995; Schott II and Woodie 2012). The foal was premedicated with butorphanol tartrate (Morphosan) 0.04 mg/kg bwt i.v. Anaesthesia was induced with ketamine hydrochloride (Clorketan) 1.5 mg/kg bwt i.v. and midazolam (Midolam) 0.2 mg/kg bwt i.v. and maintained with isoflurane (Isoflurane USP) in 100% oxygen. A 3 cm long urethroty was performed in close proximity to the medial edge of the wound. A sterile 24F Foley catheter was inserted through the new opening and secured in place with a purse-string suture. This procedure was necessary since a Foley catheter of the desirable length which could reach the bladder from the urethral orifice was not available. In addition, following the urethroty procedure, a surgical debridement was performed around the original wound in the perineal region (Fig 1).

In the following days, the foal’s strength improved, the wound was lavaged and cleaned twice a day with sterile saline and reduced in size producing healthy looking.
Foley catheter removed. The area around the wound was aseptically prepared with chlorhexidine and ethanol 70%, the wound itself was cleaned with povidone iodine and saline solution. In order to prevent contamination of the surgical site, the anus was sutured in a purse-string fashion using No. 0 USP nylon suture material. Approach to the pelvic urethra was achieved by means of the Gokel's pararectal approach (Abuja et al. 2010), through the perineal wound. After the urethral tear was exposed, the lesion was sutured full thickness with No. 3-0 USP Glycomer 631 (Biosyn) placed in a simple continuous fashion. The subcutaneous tissue was sutured in the same fashion. The perineal wound was debrided and left to heal by second intention. An endoscopic evaluation through the urethrotomy ensured that the urethral tear was completely sutured. A sterile, nonflexible, 16F feeding tube was inserted through the urethral orifice to penetrate the mucosal plug and obtain a patent urethra. Evaluation with the endoscope directed distally through the urethrotomy ensured that the urethral plug was removed and no mucosal damage was observed. To ensure urinary diversion from the urethral tear, a sterile 24F Foley catheter7 was inserted again through the urethrotomy opening and secured in place with a purse-string and Chinese-finger-trap sutures using No. 0 USP nylon suture material. The foal was subsequently placed in dorsal recumbency to prepare the left inguinal area for surgical repair of the inguinal hernia and castration of the left testis in the same fashion. The remaining as proximally as possible using No. 0 USP polydioxanone monofilament (PDS) in a simple continuous fashion. Castration and hernia repair proceeded without complications and the foal recovered well from surgery.

Several hours after surgery, the foal was alert and attentive, nursing from his dam and passing urine through the catheter. After surgery, the foal received flunixin meglumine (0.5 mg/kg bwt i.v. q. 12 h), ceftiofur sodium (4 mg/kg bwt i.v. q. 24 h) and omeprazole (4 mg/kg bwt per os q. 24 h). In addition, balloon dilatation of the penile urethra was performed every 2–3 days post surgery to ensure the urethral cavity would remain open and prevent recurrence of mucosal plugs. For each dilatation procedure the foal was sedated with butorphanol tartrate 0.01 mg/kg bwt i.v. (Morphasol)3 and xylazine hydrochloride (Thiazone 100 injection) 0.5 mg/kg bwt i.v., a sterile 18F Foley catheter inserted 20 cm deep to the urethral orifice and the balloon inflated with saline solution 3 times, 10 s each time. At the end of the procedure, the catheter was removed. Ten days after the surgery, the Foley catheter was removed from the urethrotomy opening. On the following day, urine was leaking from the pararectal incision, in addition to normal urination through the penis. Therefore, endoscopic evaluation of the surgical site was performed through the urethrotomy, revealing dehiscence of the sutures in the urethra. Evaluation of the bladder revealed a great improvement of the cystitis with marked decrease in mucosal discolouration and oedema. The inguinal incision had healed without complications. Retrograde positive-contrast cystography was repeated and demonstrated leakage from the perineal wound and a diverticulum dorsal to and along the length of the pelvic urethra. Therefore, endoscopic evaluation of the surgical site was performed through the urethrotomy, revealing dehiscence of the sutures in the urethra. Evaluation of the bladder revealed a great improvement of the cystitis with marked decrease in mucosal discolouration and oedema. The inguinal incision had healed without complications. Retrograde positive-contrast cystography was repeated and demonstrated leakage from the perineal wound and a diverticulum dorsal to and along the length of the pelvic urethra. Therefore, endoscopic evaluation of the surgical site was performed through the urethrotomy, revealing dehiscence of the sutures in the urethra. Evaluation of the bladder revealed a great improvement of the cystitis with marked decrease in mucosal discolouration and oedema. The inguinal incision had healed without complications. 

Blood work before surgery, including packed cell volume (PCV) and total solids (TS), revealed mild anaemia (PCV/TS 25%/59 g/l). The same anaesthetic protocol was used as previously, the foal was placed in sternal recumbency and the Foley catheter removed. The area around the wound was 

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**Fig 1:** This photograph shows the foal after temporary subischial urethrotomy and placement of a Foley catheter. Note the amount of skin sloughing and necrotic tissue due to urine leakage from a pelvic urethral tear.

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granulation tissue. Unfortunately, some urine continued to leak from the tear through the perineal wound. Three days after urethrotomy, an endoscopy was performed through the urethrotomy opening to examine the urethra and characterise the tear. The same anaesthetic protocol, as previously mentioned, was used. The tear was located in the dorsal pelvic urethra, 3 cm cranial to the perineal wound, was 3 cm long and involved about 25% of the urethral circumference. Additionally, examination of the bladder revealed severe cystitis with discoloured, irritated and oedematous mucosa. Further investigation of the urethra revealed a mucosal plug distally to the urethrotomy site, 20 cm from the urethral orifice, completely occluding the urethral cavity. The plug could not be removed or penetrated using a Foley catheter through the urethral orifice or the urethrotomy opening. Since cystitis was diagnosed, the foal was commenced on ceftiofur sodium (4 mg/kg bwt i.v. q. 24 h).

Due to the endoscopic findings, surgery was recommended to the owner to repair the urethral tear. Furthermore, during hospitalisation the inguinal hernia did not resolve spontaneously and the hernia sac seemed to enlarge despite repeated manual reduction, thus it was decided to reduce the hernia surgically as described elsewhere (Schumacher 2012). The contents of the hernia, including small intestine leaking from the pararectal incision, in addition to normal urination through the penis. Therefore, endoscopic evaluation of the surgical site was performed through the urethrotomy, revealing dehiscence of the sutures in the urethra. Evaluation of the bladder revealed a great improvement of the cystitis with marked decrease in mucosal discolouration and oedema. The inguinal incision had healed without complications. Retrograde positive-contrast cystography was repeated and demonstrated leakage from the perineal wound and a diverticulum dorsal to and along the length of the pelvic urethra. Therefore, endoscopic evaluation of the surgical site was performed through the urethrotomy, revealing dehiscence of the sutures in the urethra. Evaluation of the bladder revealed a great improvement of the cystitis with marked decrease in mucosal discolouration and oedema. The inguinal incision had healed without complications. Retrograde positive-contrast cystography was repeated and demonstrated leakage from the perineal wound and a diverticulum dorsal to and along the length of the pelvic urethra. Therefore, endoscopic evaluation of the surgical site was performed through the urethrotomy, revealing dehiscence of the sutures in the urethra. Evaluation of the bladder revealed a great improvement of the cystitis with marked decrease in mucosal discolouration and oedema. The inguinal incision had healed without complications. 

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similar manner by means of the Gokel’s pararectal approach through the previous incision. The urethral tear was sutured with No. 3-0 USP Glycomer 631 (Biosyn) placed in a simple continuous fashion. The diverticulum appeared as mucosal tissue and was removed using sharp dissection. The space remaining was eliminated using No. 3-0 USP polydioxanone monofilament (PDS) placed in a circumferential 4 bite fashion. A sterile 24F Foley catheter was inserted through the urethrotomy opening and secured in place (Fig 3). During surgery, the foal lost a considerable amount of blood due to continuous oozing from the tissue. Blood work showed PCV and total solids decreased from 24%/62 g/l to 15%/55 g/l and the foal received 1 l of whole blood collected from its dam. The colt recovered well from surgery, receiving the same treatment as after the first surgery and 8 days after surgery the Foley catheter was removed. Once more, after catheter removal, urine started leaking from the surgery site. Endoscopic evaluation was performed through the urethrotomy, revealing dehiscence of the sutures. The colt was submitted to a third operation for urethral tear repair and laparoscopic-assisted tube cystotomy. The same anaesthetic protocol as previous surgeries was used. Blood work before the surgery, including PCV and total solids, revealed mild anaemia (PCV/TS 21%/58 g/l).

The foal was positioned in dorsal recumbency for laparoscopy surgery and the ventral abdomen and pelvis areas were clipped and prepared aseptically. Following draping, insufflation (Stryker 40 l Insufflator) with CO₂ (15 cm/H₂O) was performed through the ventral midline just caudal to the umbilicus, using a teat cannula. Next, at the same location, the laparoscopic portal (laparoscope 10 mm diameter, 37 cm length, 0° angle) was positioned. The second portal site was located 7 cm to the left of the ventral midline, 3 cm caudally to the first portal. The third and last portal was located just 3 cm caudally to the second portal (Fig 4). The trocars for the instrumental portals were inserted under vision. The surgery table was tilted into Trendelenburg position (∼15 head down) to improve observation of the bladder. Through the second and third portals, a Babcock forceps (10 mm diameter, 45 cm length) and Allis forceps (10 mm diameter, 45 cm length) were inserted to grasp the bladder and pull it toward the body wall. The most caudal portal was extended and a small portion of the bladder exteriorised through this portal. Two stay sutures were placed in the bladder wall and

![Fig 2: Retrograde positive-contrast cystography of the foal. Note the urethral tear with leakage at the perineal wound (horizontal arrow) and the diverticulum dorsal to the urethra which was recognised and demolished in the second attempt to repair the tear (vertical arrow).](image1)

![Fig 3: The foal after a second attempt to close the urethral tear via a pararectal approach.](image2)

![Fig 4: The foal’s abdomen showing the location of the laparoscopic portals chosen for laparoscopic-assisted tube cystotomy.](image3)
Foley catheter inserted in the bladder through the stab bladder at the centre of the purse-string suture and an 18F Foley catheter inserted in the bladder through the stab incision. The balloon of the Foley catheter was inflated with 10 ml of sterile saline solution to secure it within the urinary bladder and the purse-string suture tightened. In order to secure the bladder to the body wall and achieve cystoscopy, another purse-string suture was placed between the ventral abdominal muscles and bladder using No. 0 USP polydioxanone. The abdominal cavity was deflated and the portal sites closed in 2 layers: the rectus abdominis muscle with an inverted cruciate pattern using No. 0 USP polydioxanone and the subcutaneous tissue with buried continuous sutures using No. 2-0 USP polydioxanone. The foal was then positioned in sternal recumbency for the third attempt at urethral tear repair, using the same approach and technique as in previous surgeries. The urethral tear was sutured with No. 3-0 USP polydioxanone placed in a simple continuous fashion after debridement of the tear. The subcutaneous tissue was sutured with No. 2-0 USP polydioxanone placed in a simple continuous fashion and the skin sutured using No. 2-0 USP nylon placed in near-far-near fashion. The foal recovered well from the surgery and appeared alert and attentive, nursing from his dam and passing urine through the tube cystotomy catheter (Fig 5).

Fig 5: The foal after insertion of tube cystotomy with laparoscopic assistance.

Post operative medications included flunixin meglumine (0.5 mg/kg bwt i.v. q. 12 h), penicillin G sodium (20000 u/kg bwt i.v. q. 6 h), gentamicin sulfate (6.6 mg/kg bwt i.v. q. 24 h) and omeprazole (4 mg/kg bwt per os q. 24 h). In addition, balloon dilatation of the penile urethra was performed every 2–3 days to ensure the urethral cavity would remain patent. The surgical incision and perineal urethropathy were lavaged and cleaned routinely with sterile saline. For the first few days after surgery, urine leakage through the perineal incision was noted. However, endoscopic evaluation through the penis, a week after the operation, showed that the sutures in the urethral wall were intact and leakage had stopped. No remnants of the urethral plug were seen during the endoscopy. Ten days after surgery, the skin sutures were removed and 3 weeks after surgery the Foley catheter, serving as the tube cystotomy, was removed under sedation. At that stage, the perineal urethropathy site had completely healed by second intention. Later that day, an ultrasonographic evaluation of the abdomen revealed a small and empty bladder with no evidence of free fluid in the abdomen. On the same day, the foal was observed urinating through its penis without tenesmus or leakage from the urethral repair site. The next day, retrograde positive-contrast cystography was performed using a similar technique as performed upon initial evaluation under general anaesthesia and no leakage was observed from the urethra or the bladder.

The foal was discharged from the hospital 90 days following admission in good body condition, was alert and responsive, the perineal wound had almost completely healed and he was urinating normally through the penis without evidence of urine leakage from the surgical incisions. Communication with the owners 4 months after discharge from the hospital, confirmed that the foal was in good health, urinating normally with good flow and without straining and had not shown any signs of abdominal discomfort.

Discussion

This case report describes the successful treatment of urethral tear in a foal using direct repair, combined with laparoscopic-assisted tube cystotomy. Complete healing was possible only after effective urine diversion from the tear which was achieved by tube cystotomy.

Diagnosis of urethral rupture can be challenging and occasionally the only suggestive clinical sign is marked soft tissue swelling in the surrounding tissue (Schott II and Woodie 2012). The diagnosis of urethral tear in the present case was made only 24 h following presentation, given the fact that there was no urine retention in the peritoneal cavity, blood work revealed no azotaemia and no related clinical signs were noted. Urine leakage from distal urethral sites is more likely to fistulate to the outside and the patient may have fewer systemic signs attributable to azotaemia (Boothe 2000). In the current study, a urethral tear was suspected only when the perineal wound appeared which developed overnight. Contrast radiographs allowed the diagnosis of urethral rupture and endoscopic evaluation of the urethra was helpful in determining the exact location, size and severity of the injury. Nevertheless, observing the foal urinating blood clots, although it was only once, should have raised suspicion of urinary tract damage. Thus, to expedite the diagnosis, one needs to evaluate the urinary tract thoroughly in every foal with a history or suspicion of pelvic trauma.

A urethral tear may be treated in a conservative manner by using an indwelling urinary catheter and treating the patient for fluid, electrolyte and acid-base disturbances (Boothe 2000; Schott II and Woodie 2012). Surgical management is indicated for more severe urethral injuries and in those cases, gentle tissue handling, preservation of blood supply and accurate apposition of tissues are necessary (Boothe 2000; Schott II and Woodie 2012). Urine contact with the periurethral tissues causes delayed wound healing and periurethral fibrosis (Anderson et al. 2006). Urinary diversion is thought to favourably influence urethral healing by minimising urine contact with injured subepithelial tissue. This kind of diversion can be established by various techniques including perineal urethropathy/urethroscopy, indwelling transurethral catheterisation and tube cystotomy (Cooley et al. 1999; Boothe 2000; Anderson et al. 2006). Catheterisation is a useful way to achieve urinary diversion and it may also guide the re-epithelialisation of urethral mucosa.
(Cooley et al. 1999). One can claim that catheterisation should not be included as one of the techniques to achieve urinary diversion since an indwelling catheter is placed in the same route as the urine normally takes. However, catheterisation may allow minimal urine contact with the injured urethra to be achieved and therefore promote healing. Nevertheless, catheters may also have deleterious effects on urethral healing by causing inflammation at the site of injury, as a foreign body response to the catheter and increasing the possibility of ascending infection (Lees and Osborne 1979; Barsanti et al. 1985). In the current case, catheterisation with a Foley catheter did not succeed in averting urine from the tear since urine managed to partially bypass the catheter from the bladder.

Tube cystotomy is a long recognised and well documented technique for urinary diversion in small animal and small ruminants (Ewoldt et al. 2006; Beck et al. 2007) and only recently a laparoscopic technique for percutaneous tube cystotomy in dogs was described (Zhang et al. 2010). To the author’s knowledge, tube cystotomy has not previously been described in foals. In the present case, laparoscopic-assisted tube cystotomy was performed without complications. Compared with performing traditional laparocystotomy, laparoscopic cystotomy allows observation of the urinary bladder in situ. The procedure is less invasive with less complications and allows for a quicker recovery. Laparoscopy has been used successfully for similar procedures in horses including bladder urolith removal and repair of a ruptured bladder (Rocken et al. 2006; Rijkenhuizen et al. 2008). In this case, the use of laparoscopic-assisted tube cystotomy resulted in a complete urinary diversion that facilitated healing of the urethral tear and perineal wound without the disturbance of urine in the periurethral tissues.

A recent report described a combination of urethral and bladder rupture in a foal which were both repaired by suturing the tears. The urethral repair dehisced and the tear healed well by second intention (Castagnetti et al. 2010). In the present case, we insisted on primary repair of the urethral tear, since second intention wound healing of urethral rupture may lead to stricture formation, which increases patient morbidity (Layton et al. 1987; Schott II and Woodie 2012). In the article by Castagnetti et al. (2010), as well as in our 2 initial attempts at direct suturing of the urethral defect, the repair failed due to incomplete urinary diversion by a urethral Foley catheter. Surgical incisions in the perineal urethra heal well by secondary intention despite continuous passage of urine through the incision (Schumacher et al. 1995). However, when the urethral defect is deep in the pelvic region as in our case, urine damages the surrounding periurethral tissues causing delayed healing of the tear and its surroundings (Anderson et al. 2006). We believe that complete periurethral incision is helpful and may even be essential for effective healing of urethral repair when dealing with tears located deep in the pelvic region.

The mucosal plug appearing in the distal urethra of the foal initially did not obstruct the entire urethral lumen, given the fact that the foal was seen urinating through the urethral orifice on presentation and was not straining at any stage. The reason for development of the urethral plug is not clear: minor trauma that resulted in stricture or anatomic defect are possible causes. Urethral obstruction can be caused by a urethral urolith or plugs (mainly in cats) or other reasons such as tumours, inflammation or strictures (Michels et al. 2001; Marks et al. 2003; Bennett et al. 2005; Hostutler et al. 2005). In horses there are no previous reports on urethral mucosal plugs, as seen in this case.

Balloon dilation has previously been reported as a safe and effective treatment for urethral strictures in man and dogs (MacDiarmid et al. 2000; Bennett et al. 2005). Additionally, this technique has been applied in veterinary patients to resolve strictures and stenosis of tissues including the oesophagus, nasopharynx and nasomaxillary opening in dogs, cats and horses (Leib et al. 2001; Tillotson et al. 2003; Berent et al. 2006; Bell et al. 2009). In the present case, we used balloon dilatation to ensure the urethral cavity would remain patent and prevent recurrence of mucosal plugs. We observed no complications using this technique and managed to perform the procedure while the foal was awake, sedated and showing no marked discomfort or resistance.

It appears that effective urine diversion is more essential for the healing of the tear than primary urethral repair. The combination of the 2 techniques, however, may speed healing time and reduce complications such as the development of strictures.

This case demonstrates the effective use of laparoscopic-assisted tube cystotomy in order to achieve effective urinary diversion in a case of urethral tear in a foal.

Authors’ declaration of interests
No conflicts of interest have been declared.

Manufacturers’ addresses
1 Copolak Ltd, Patach tikva, Israel.
2 GE Healthcare Ireland, Cork, Ireland.
3 AniMedica GmbH, Senden-Bosensell, Germany.
4 Vetoquinol, Paris, France.
5 Rafa Laboratories Ltd, Jerusalem, Israel.
6 Piromal Healthcare Limited, Andhra Pradesh, India.
7 Well Lead Medical Co., Ltd, Panyu, Guangzhou, China
8 Suzhou Industrial Park Texnet Import & Export Co., Ltd. Suzhou, Jiangsu, P. R. China.
9 Nature Vet Pty Ltd, Glenorie, New South Wales, Australia.
10 Stryker, Kalamazoo, Michigan, USA.

References


Original Article

Ultrasonographic and morphological sequelae to repeated testicular biopsies in stallions in relation to the lateral branching of the testicular artery


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Keywords: horse; stallion; testicular biopsy; testicular artery; ultrasonography; sequelae

Summary
The objectives of this study were to investigate the sequelae to repeated testicular biopsies in stallions and to determine if arterial injuries can be prevented. This study was part of a larger project focused on the antispermatogenic effects of an oral contraceptive compound, RTI-4587-073(l), which was given to 3 mature Miniature horse stallions, while another 3 received a placebo treatment. Testicular biopsies were taken once before treatment and 3 times after treatment. They were obtained from alternating testes, 2 procedures per testis, 2 samples each time, using a 18 gauge split-needle core biopsy instrument (penetration depth: 22 mm). Colour Doppler ultrasonography was performed prior to the procedure to detect and thus avoid lateral branches of the testicular artery. Testicular parenchyma was evaluated ultrasonographically just before, and 2–6 h, 3 days and weekly after the biopsies were obtained. Changes in testicular volumes and semen parameters were monitored. All stallions were then castrated and the testes were evaluated for any gross pathology. There was no major scrotal swelling or gross haemorrhage after the procedures. Only mild, focal lesions were found in the testicular parenchyma 3 and 7 days after taking the biopsies. Three lateral branches of the testicular arteries were punctured, but there was no evidence of significant bleeding or other complications associated with these injuries. We conclude that repeated testicular biopsies may be taken from stallions without causing major complications, regardless of a presence or absence of the lateral branches of the testicular artery. Furthermore, we conclude that using colour Doppler ultrasonography to detect the lateral branches of the testicular arteries is unreliable; however, puncturing these vessels during a biopsy procedure does not necessarily result in significant haemorrhage.

Introduction
Testicular biopsy is rarely performed in veterinary medicine due to the invasive nature of this procedure and its potential for serious complications. Numerous studies performed in various species of animals and in men have focused on the safety of the testicular biopsy (Bielanski 1960; Lopate et al. 1989; DeLlVento et al. 1992; Altay et al. 2000; Faber and Roser 2000; Heath et al. 2002; Carluccio et al. 2003; Pearson et al. 2011). These studies have evaluated various techniques including surgical incisional and split-needle core biopsy. Haemorrhage, testicular sclerosis and atrophy were reported after incisional testicular biopsies in stallions (Galina 1971; Varner 1991). Currently, a split-needle core biopsy technique is most commonly used in order to avoid these devastating consequences. Unfortunately, the amount of tissue sampled may not be sufficient for a detailed quantitative evaluation of spermatogenesis (Blanchard 2011). In order to overcome this problem, making a skin incision before firing a biopsy instrument can help to avoid collecting skin cells and subdermal connective tissue. Furthermore, taking 2 samples during each procedure increases the number of cross-sections of seminiferous tubules obtained (Morey et al. 1999).

Since stallion testes are highly vascularised, the main potential complication of testicular biopsy is haemorrhage. Smith proposed that, in stallions, testicular biopsies be taken from the cranial-lateral quadrant of the testis in order to avoid injuring the lateral branches of the testicular artery, which may run over the central area of the lateral surface of the testis (Smith 1974). However, our recent observations have shown (Fig 1) that, in some stallion testes, the lateral branches of the testicular artery also run over the cranial aspect of the lateral surface of the testis (Pozor and Hamnik 2016). Taking a biopsy from this area can thus puncture this vessel, possibly causing haemorrhage. Unfortunately, our efforts to detect the lateral branches of the testicular artery and to determine its exact position using B-mode ultrasonography were not always successful (Pozor and Kolonko 2000). While colour Doppler ultrasonography (CDU) should be more effective for visualising these vessels, there have been to date no published reports confirming this speculation.

Repeated biopsies are occasionally taken from testes in order to obtain sperm for intracytoplasmic sperm injection, to evaluate testes contralateral to the testes with testicular tumour, or to detect histological changes due to progressive hypospermatogenesis (Amer et al. 1999; Nieschlag et al. 2010). While repeating these invasive procedures increases risk of haemorrhage, the occurrence of this complication is minimised by taking tissue samples from avascular areas (Hunt and Foote 1997).
To the best of our knowledge, the consequences of taking testicular biopsy from stallion testes with the lateral branches of the testicular artery have not been examined yet. Therefore, the first objective of this study was to investigate sequelae in stallions to repeated testicular biopsy, especially those lesions relating to the presence of the lateral branches of the testicular artery. Another objective of this work was to test our ability to prevent biopsy-related arterial injuries by using CDU.

Materials and methods

The study included 6 mature Miniature horse stallions, aged 7–12 years. All stallions were housed in individual paddocks (14 x 11 m) and fed with grain and hay. The project was approved by the Institutional Animal Care and Use Committee of the University of Florida.

This study is part of a larger project focusing on the acute and chronic effects of a contraceptive compound – RTI-4587-073(l) – on testicular histology and endocrine function in stallions (Pozor et al. 2014). In this project, 3 stallions from the treated group received a single oral dose of RTI-4587-073(l) (12.5 mg/kg bwt, per os) to suppress spermatogenesis, while 3 stallions from the control group received only a placebo treatment. Testicular biopsies were taken from each stallion, from alternating testes, during 4 separate sessions, every other week: once during the baseline period (the left testes of all stallions) and 3 times during the post treatment period (right, left and right testes). Two samples of testicular parenchyma (2 needle passes) were taken from testis each time. CDU was used to detect the lateral branches of the testicular artery in order to identify the safest area from which to obtain the biopsy. In order to monitor complications after the testicular biopsy procedures, the stallions’ testes were evaluated using B-mode ultrasonography: just before the procedure; 2–6 h after the procedure; 3 days after the procedure; and weekly throughout the rest of the experiment. Testicular dimensions were determined, using ultrasonography, 2 weeks before performing the first procedure (baseline), 1 week after the second procedure (at one procedure/testis), and 1 week after the fourth procedure (at 2 procedures/testis). Three weeks prior to the first biopsy procedure, semen was collected daily for 5 consecutive days in order to remove the extragonadal sperm reserve. Thereafter, 2 ejaculates/week were collected and evaluated from each stallion except for the 1 week when the compound was administered to the treated stallions. Two weeks after the last testicular biopsy, all stallions were castrated, and their testes were grossly evaluated.

Detection of the lateral branches of the testicular artery

Colour Doppler ultrasonography was used to determine the presence of and to localise the lateral branches of each testicular artery, shortly before taking biopsies. For this examination, each stallion was placed in the procedure area, held on a lead rope attached to a halter. A portable ultrasound machine, equipped with a 5–10 MHz linear transducer, and a 5–8 MHz curved-array transducer (Titan) was used for ultrasonography (Fig 2a). CDU was used to detect the lateral branches of the testicular artery, as follows. The transducer was placed on the medial side of each testis (in a vertical plane), with the ultrasound beam directed...
laterally (Pozor and Kolonko 2000; Pozor 2007). After activating colour Doppler modality the operator positioned a sampling box on the lateral surface of the testis to allow visualisation of any major arterial vessels in this area. The pulse repetition frequency (PRF) was set to a low level, consistent with low blood-flow velocities. The transducer was moved slowly from the cranial pole all the way to the caudal pole of the testis in order to visualise the entire lateral surface of each testis and in an attempt to detect all blood vessels. The presence and location of each arterial vessel was noted in order to select the safest area for taking biopsies. CDU did not directly guide biopsy procedures.

**Testicular biopsies**

Testicular biopsies were taken from one testis at a time (with 2 biopsies taken per testis during a single procedure). Sampled testes were alternated; each testis had biopsies taken twice, with 4 weeks’ rest between both procedures. The procedures were based on a previously described protocol (Faber and Roser 2000), with minor modifications. Briefly, each stallion was brought individually to the procedure area. Its testis (left or right, alternating as described above) was evaluated using CDU for the presence of the lateral branches of the testicular artery (Fig 2a). If one or 2 of these vessels were found on the lateral surface of the sampled testis, the operator attempted to take the biopsy from an artery-free area. If no evidence of the lateral arterial branches was found, biopsies were taken first from the cranial-lateral quadrant of the testis and then from the caudal-lateral quadrant. The second biopsy was taken from an area that was separated from the previous biopsy site by approximately 15 mm. Each stallion was sedated immediately after ultrasound examination (20–40 μg/kg bwt of detomidine hydrochloride i.v.; 0.05 mg/kg bwt of butorphanol tartrate i.v.). The scrotum was prepared aseptically with surgical scrub, alternating between chlorhexidine and alcohol (Fig 2b). A small amount of local anaesthetic (1–2 ml of 2% lidocaine hydrochloride solution) was administered subcutaneously (Fig 2c) in the area from which arterial vessels were previously determined to be absent. A small stab incision was made into the scrotal skin with a No. 10 scalpel blade in the previously anaesthetised area of the scrotum (Fig 2d). Holding down the testis, the

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**Fig 2**: Testicular biopsy of the stallion, using the 18 gauge split-needle core biopsy technique: (a) colour Doppler ultrasound evaluation of the testis in order to detect the presence of the lateral branches of the testicular artery; (b) surgically scrubbing the scrotum; (c) injecting local anaesthetic; (d) making a stab incision through the skin; (e) spring-loaded split-needle biopsy gun; (f) taking the biopsy sample.
operator took a sample of testicular tissue using the 18 gauge x 16 cm spring-loaded split-needle disposable biopsy instrument (Bard Monopty disposable biopsy instrument®; Fig 2e). The penetration depth was 22 mm, and the length of the sample notch was 17 mm. The needle was fired into the testicular parenchyma twice, through the same incision, at 2 different angles (Fig 2f). Haemostasis was obtained by applying firm compression with sterile gauze to the incision and to the biopsy site for approximately 5 min. No additional treatment was administered after the procedure. Stallions were monitored for any symptoms of scrotal swelling, discomfort, or changes in body temperature over the following 48 h.

**Testicular evaluations using ultrasonography**

For the ultrasonographic evaluation, each stallion was brought individually to custom-made stocks, held using a halter and a rope. Stallions’ scrota were evaluated using a portable ultrasound machine, as previously described. To evaluate the testicular parenchyma, the transducer was placed on the lateral surface of each testis with the ultrasound beam directed medially. The transducer was moved from the cranial to the caudal pole of the testis, scanning through the entire testis with special attention paid to those areas from which the biopsies were taken. Testicular dimensions were determined, and testicular volumes were calculated as described previously (Pozor et al. 2014).

**Semen collections and evaluations**

Semen was collected and evaluated as previously described (Pozor et al. 2014).

**Castrations and gross examinations of testes**

All stallions were castrated 2 weeks after the last biopsy, using standard methods. In order to prevent testicular damage, local anaesthetic (lidocaine 2%) was injected only to the spermatic cord, and the parietal vaginal tunic was kept intact. All testes were carefully examined after castration. The mobility of the testes within the vaginal cavity was determined first. The vaginal parietal tunic was gently removed; all lateral branches of the testicular artery were localised, and the biopsy sites were visually inspected. Then,

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<th>TABLE 1: Arterial branches of the testicular artery and lesions detected by B-mode ultrasonography in stallion testes 3 and 7 days after taking biopsies</th>
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* This artery was not detected by CDU.
the testes were dissected in order to identify any lesions within the testicular parenchyma, especially in all areas from which the biopsies were taken.

Results

Detection of the lateral branches of the testicular artery
Lateral branches of the testicular artery were detected by CDU in 2 testes of 2 different stallions, one before the first procedure and the other before the second procedure. One was localised in the cranial-lateral quadrant of the testis, while the other ran over the caudal-lateral quadrant. The location of these vessels detected during CDU examination was confirmed during gross examination after castration. None of these vessels were punctured during the biopsy procedure.

Testicular biopsies
We performed 24 biopsy procedures (6 stallions with 4 procedures each). Since each procedure involved 2 needle passes, we performed 48 biopsies in total. All stallions recovered well, and we observed no major scrotal swelling, changes in body temperature, or gross haemorrhage.

Testicular evaluations using ultrasonography
All testes had normal, uniformly echogenic testicular parenchyma prior to biopsy and treatment. Five stallions had symmetrical testes and one (control) stallion had slightly asymmetrical testes (left testis volume 37 cm³; right testis volume 24 cm³).

There were no detectable changes in the echogenicity of the testicular parenchyma at the biopsy sites, in any of the testes, either during the first 2–6 h after the procedure, or 2 weeks after. The results of the ultrasound examinations performed 3 and 7 days after the procedures are summarised in Table 1. During 24 ultrasound examinations performed 3 days after biopsy, 2 examinations per testis, testicular or peritesticular lesions were detected on 11 occasions. Lesions were discovered in 5 out of 12 testes after each of the 2 procedures; one testis had a lesion discovered after the first procedure, but not after the second (Table 1). During ultrasound examinations performed 7 days after

![Fig 3: Representative ultrasonographic images of the lesions detected 3 days after performing testicular biopsy (lesions—arrows): (a) small hypoechoic, spindle-shaped lesion; (b) large hypoechoic lesion; (c) hyperechoic area at the biopsy site; (d) hypoechoic, longitudinal thin (vermiform) lesion at the biopsy site’s needle track; (e) 2 hypoechoic, longitudinal (vermiform) lesions resulting from firing the biopsy instrument twice; (f) subcutaneous haemorrhage (*—testis).]
biopsy, testicular lesions were detected in only 2 testes after the first procedure and in 2 other testes after the second procedure. Arterial puncture was associated with a hypoechoic lesion on one occasion (Testis 5), while punctures of 2 other vessels were not associated with any detectable lesion (Testes 6 and 8). The rate of lesion occurrence was similar among the control and treated stallions.

Figures 3 and 4 show representative examples of these changes. The most frequently seen lesion was a small hypoechoic, focal area in the testicular parenchyma (Figs 3a and 4a–c). The largest lesion, found in one testis, 3 days after the second biopsy, was 8 × 14 mm in size (Fig 3b). In one case, there was a hypoechoic area along the track of the biopsy needle (Fig 3c). Several cases showed one or 2 thin, hypoechoic lines consistent with the biopsy tracks (Figs 3d,e and 4d). One case had evidence of subcutaneous accumulation of a moderate amount of nonuniformly echogenic fluid, probably blood, directly below the skin incision and biopsy site (Fig 3f). All of these lesions resolved spontaneously within 2 weeks of each procedure.

As previously reported, there was no significant change in testicular volume in treated or control stallions (Pozor et al. 2014). Three testes from 2 control stallions (Testes 4–6) had similar or slightly higher volumes following all biopsy procedures than during the baseline period, while the other 3 testes (Testes 1–3) from the control stallions were slightly smaller than before (Supplementary Item 1). We did not observe significant changes in testicular symmetry in control stallions.

Semen evaluations
The changes in the semen parameters were previously reported (Pozor et al. 2014). There were no changes in the analysed semen parameters in the 3 stallions from the control group (Pozor et al. 2014).

Gross evaluations
The biopsy sites were detected on all testes as pinpoint-sized and healing indentations (Fig 5). Various mild lesions were associated with the biopsies in 5 out of the 12 testes. Thin adhesions were found at the biopsy sites between the parietal and visceral vaginal tunics surrounding 2 testes, but both were easily movable (Fig 5a). One of the other 4 testes had a small blood clot at the biopsy site attached to the visceral vaginal tunic (Fig 5e). Five lateral branches of the testicular artery were present on the lateral surfaces of 4 testes; 3 testes had one branch each, while one testis had 2 lateral branches. Of these 5 vessels, 2 were intact (and previously detected by CDU), while the other 3 had been punctured during the biopsy procedures (and not detected by CDU); however, there was no evidence of bleeding in these areas (Fig 5d–f). No significant lesions in the testicular parenchyma were detected during dissection and visual inspection (Fig 6). The only evidence of the biopsy procedure in the testicular parenchyma was small, ‘vermiform’ and pale tissue that filled in the elongated tunnel left after the removal of the sample core from the testicular parenchyma (Fig 6c,d). These structures were consistent with the granulated tissue that filled in all biopsy sites after the procedures. However, these areas were not examined in histological detail.

Discussion
Repeated testicular biopsies in stallions, performed in our study, caused only minimal side effects, even when arterial injury had occurred during the procedure. We learned that the lateral branches of the testicular artery in stallions are difficult to detect using CDU. Although 5 lateral arterial branches were present on the lateral surfaces of 4 testes, only 2 of these were detected ultrasonographically.
Subsequently, the 3 arterial branches not detected were punctured during testicular biopsy, despite which we found no evidence of major bleeding; we detected a small intratesticular lesion ultrasonographically in only one testis, and there was no gross pathology directly associated with such puncture. The consequences of testicular biopsies in our research stallions included minor to moderate, subcutaneous or intraparenchymal bleeding, along with the formation of granulated scar tissue at the sites of tissue removal. The intraparenchymal bleeding was minor and transient, completely resolving within 2 weeks of the testicular biopsy procedures. Furthermore, minor adhesions between the vaginal tunics of 2 testes did not affect the mobility of the testes within the vaginal cavities. Testicular volume or semen parameters did not significantly change in the 3 control stallions after repeated biopsy procedures. One treated stallion had a dramatic bilateral change in testicular volume, which was attributed to the antispermatogenic compound (Pozor et al. 2014); however, the effect of the biopsy procedures on these testes cannot be excluded.

All of the findings of our study suggest that testicular biopsy is a relatively safe procedure that rarely causes serious consequences in stallions, even when repeated after 4 weeks, regardless of the presence of the lateral branches of the testicular artery. However, we performed our study on Miniature horse stallions, whose testes and testicular vessels are smaller than those of light-type or draught horses. Larger vessels, when injured, may more seriously hemorrhage than we observed in our animals. Perhaps, however, such larger arteries may also be more easily visualised using B-mode or colour Doppler ultrasonography. In our previous studies in stallions, we were able to visualise and measure testicular arteries in stallion testes as small as 1.2 mm in diameter, using the CDU modality (M. Pozor, unpublished data). Several investigators have suggested that testicular biopsies in stallions be taken from the cranial-lateral quadrant of the testis, since the lateral arterial branches run over the central segment (Collin 1973; Smith 1974). However, our recent study showed that these vessels often also run over the cranial-lateral area of stallion testes (Pozor and Harnik 2016).

Fig 5: Representative photographs of gross lesions resulting from testicular biopsy (solid arrows—biopsy sites; dotted arrows—adhesions; *—lateral branches of the testicular artery): (a) thin adhesions present between the parietal and visceral vaginal tunics; (b) the lateral branch of the testicular artery present, no lesions; (c) no lesions present; (d) the lateral branch of the testicular artery present and punctured during biopsy, with only a very small site of puncture and no significant lesions present; (e) 2 lateral branches of the testicular artery present, one punctured during biopsy with only a very small puncture site, a small blood clot at the second biopsy site; (f) the lateral branch of the testicular artery present (central location) and punctured during biopsy, with only a very small puncture site and no significant lesions present.
Therefore, taking a biopsy from the cranial-lateral region does not assure the operator that major arterial vessels will not be punctured.

A relatively thin, 18 gauge biopsy instrument was used in our study. All biopsy samples had enough testicular tissue to determine the antispermatogenic effects of the contraceptive compound, in keeping with the purpose of our previously published work (Pozor et al. 2014). However, the numbers of cross-sections of seminiferous tubules were insufficient to perform a detailed, quantitative evaluation of spermatogenesis. Most other investigators that have used this biopsy technique in stallions have chosen larger-gauge instruments, most frequently of 14 gauge size (Faber and Roser 2000; Pearson et al. 2011). While the samples taken with 14 gauge instruments were larger and provided more testicular tissue for evaluation, the resulting lesions were more extensive than when using 18 gauge biopsy guns. Thirty-one per cent of testses sampled with 14 gauge biopsy instruments developed scrotal swelling, and 23% of such procedures resulted in transient haematoma formation (Pearson et al. 2011). None of our research animals developed scrotal swelling or formed testicular haematomas after biopsy (2 sessions, 2 biopsies taken each time) using the smaller gauge instrument. It has been demonstrated that testicular biopsy samples taken from stallions using 18 gauge, split-needle biopsy instruments have sufficient size and quality to evaluate spermatogenesis (Carluccio et al. 2003). Furthermore, instruments of 18 gauge size have been used successfully in human andrology.

Based on the results of our study we conclude that taking testicular biopsies from stallions using 18 gauge split-needle core biopsy instruments causes only mild, transient lesions in testicular parenchyma, even with repeated biopsy procedure, regardless of a presence or absence of the lateral branches of the testicular artery. Detection of the lateral branches of the testicular arteries using CDU is unreliable, and choosing the cranial-lateral quadrant of the stallion testis does not guarantee that the large arterial vessel will not be injured during biopsy. However, puncturing these vessels during a biopsy procedure does not have to result in significant haemorrhage, if adequate 5 min haemostasis is applied.

**Authors’ declaration of interests**

No conflicts of interest have been declared.

**Ethical animal research**

The project was approved by the Institutional Animal Care and Use Committee of the University of Florida (IACUC Study #200903566).

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**Antimicrobial stewardship policy**

Antimicrobials were not used in this study.

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Authorship

M. Pozor was responsible for the study design, getting funds, study execution, data analysis, manuscript preparation and submission. G. Zambrano helped in all procedures, data entry and analysis and manuscript revisions. E. Runcan helped in performing biopsies and manuscript revisions. A. Kelleman helped in performing biopsies, data analysis and manuscript revisions. M. Macpherson helped in data analysis and manuscript revisions.

Manufacturers’ addresses

1SonoSite Inc, Bothell, Washington, USA.
2CR Bard Inc., Tempe, Arizona, USA.

References


BRIEF SUMMARY

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Antiprotozoal Myeloencephalitis (EPM) in Horses

For Oral Use Only

BRIEF SUMMARY

For use as an antiarthritic agent. For the treatment of Equine Protozoal Myeloencephalitis (EPM) in horses. For the treatment of EPM in horses used for breeding purposes, during pregnancy, or in lactating mares, has not been evaluated. The safety of MARQUIS (ponazuril) with concomitant therapies in horses has not been evaluated. The safety of MARQUIS (ponazuril) with concomitant therapies in horses used for breeding purposes, during pregnancy, or in lactating mares, has not been evaluated.

ADVERSE REACTIONS

In the field study, eight animals were noted to have unusual daily observations. Two horses exhibited blisters on the nose and mouth, three animals showed skin reactions followed by necropsy upon termination of treatment. There were several instances of feeding. One half of each group was treated for 28 days and the other half for 56 days. For customer care or to obtain product information, including a Material Safety Data Sheet, call 1-888-637-4251 Option 2, then press 1. ©MARQUIS is a registered trademark of Merial.

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Review Article

Cataracts: Clinical presentations, diagnosis and management

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Keywords: horse; eye; cataract; intraocular lens; lens

Summary

Cataracts can be developmental or acquired lesions and cause minimal or significant visual impairment. The ability to identify cataracts and determine the likely effect on the visual potential of the horse is an important part of an equine ocular examination. Cataract surgery is the only treatment for those cataracts that cause significant visual impairment. Understanding appropriate patient selection and potential post operative complications is important so that owners can be appropriately advised of their options.

Cataracts are any opacity of the lens. They can minimally impair vision or cause blindness depending upon the location and extent of the lesion. Significant visual loss can cause some horses to be dangerous, prevent them from being used for their intended purpose and diminish their economic value (Colitz and McMullen 2011). Cataracts are present in 5-7% of horses with otherwise normal eyes (Matthews 2000). Cataracts are the most common congenital abnormality in foals (Priester 1972; Roberts 1992). In adult horses, cataracts are a common sequela to equine recurrent uveitis (ERU) (McLaughlin et al. 1972; Roberts 1992). Therefore an understanding of the clinical presentations, diagnosis and management of cataracts is an important facet of equine ophthalmology.

An appreciation of the anatomy and physiology of the lens helps in understanding how and why cataracts form. The lens is an asymmetrically biconvex, clear structure located behind the iris and held in place by zonules, small fibres that extend from the lens equator to the ciliary body. The lens fine focuses the image projected onto the retina (Beebe 2003). The lens is anatomically composed of an external lens capsule surrounding the peripheral cortex and central nucleus (Beebe 2003). A single layer of lens epithelial cells lines the anterior lens capsule which is the basement membrane of the lens epithelial cells. At the equator these epithelial cells divide and differentiate into lens fibre cells. Lens fibres are continually formed throughout life. The fibre cells elongate and lose their organelles and nucleus during their transformation to mature lens fibres (Rafferty and Rafferty 1981). These transforming cells form the peripheral lens cortex. Where the ends of the fibres meet they form the anterior and posterior lens sutures (Beebe 2003). The posterior suture is tri-radiate or Y-shaped (Matthews 2004). The anterior suture can be Y-shaped or slightly irregular. The suture lines can often be seen during examination of the lens. The lens fibres are pushed centrally as new fibres are added. These mature lens fibres form the outer portion of the nucleus. The central nucleus forms within the embryo. The primary fibre cells are buried in the centre of the lens, form the embryological nucleus and represent the oldest portion of the lens (Colitz and McMullen 2011). The secondary lens fibres produced up until the time of birth form the fetal nucleus which surrounds the embryological nucleus (Beebe 2003; Colitz and McMullen 2011).

The lens is transparent because of the regular structure of the lens fibres, absence of membrane bound organelles and small and uniform extracellular space between the fibre cells (Beebe 2003). Furthermore, the lens has no blood vessels. Instead, the lens receives nutrition primarily from the aqueous humour (Matthews 2004). The lens proteins are primarily soluble crystallins (Beebe 2003) and the high concentration of crystallins causes the cells to be transparent and reduces light scattering (Delaye and Tardieu 1983; Veretout et al. 1989). Any imbalance in lens metabolism, DNA damage or protein damage can cause the cells to lose transparency, swell or rupture (Paterson and Delamere 1992). Light is then reflected and refracted creating the opacity known as a cataract (Paterson and Delamere 1992). Once a cataract forms, the damage cannot be reversed.

Clinical presentations

Cataracts in foals are most commonly congenital or developmental lesions with an incidence of 33.6-35.3% in foals with ocular abnormalities (Priester 1972; Roberts 1992). Cataracts of the embryonic or fetal nucleus do not progress and will get smaller over time as that region of the nucleus is compressed with the addition of adult nuclear fibres (Matthews 2004; Colitz and McMullen 2011). If vision is not significantly impaired, no therapy is warranted. A complete ocular examination should be performed as congenital cataracts can occur in conjunction with other lesions such as microphthalmia, anterior segment dysgenesis, persistent pupillary membranes, aniridia, persistent hyaloid artery, persistent hyperplastic vitreous, posterior lenticulons and lens coloboma (Erikson 1955; Matthews and Barnett 2004; Colitz and McMullen 2011). If present, these other ocular lesions may also compromise vision or could increase the potential for complications if cataract surgery is performed.

Congenital cataracts can be a hereditary condition in some breeds of horses. In Quarter Horses and Belgians the inherited cataracts are associated with aniridia, a complete absence of the iris (Erikson 1955; Joyce 1983). In breeds with a silver dapple coat colour due to a mutation at the PMEL 17 locus, such as the Rocky Mountain horse (Ramsey et al. 1999), Comtois (Segard et al. 2013), ponies (Komaromy et al. 2011) and Icelandic horse (Andersson et al. 2011), the inherited cataracts are part of the multiple congenital ocular anomalies syndrome (Ramsey et al. 1999; Andersson et al. 2011).
The other ocular anomalies can include iridal hypoplasia, uveal or retinal dysplasia, iridal hypoplasia, megalocornea and retinal detachment [Fig 1] (Ramsey et al. 1999; Andersson et al. 2011; Komaromy et al. 2011; Segard et al. 2013). Inherited nuclear cataracts have been reported sporadically in Arabians and Thoroughbreds (Matthews 2004). In Morgan horses bilateral, nonprogressive, nuclear or perinuclear opacities can be inherited in an autosomal dominant mode (Beech et al. 1984; Beech and Irby 1985). However, in Morgan horses a similar, noninherited nuclear cataract has also been described (Beech and Irby 1985).

In adult horses, newly-formed cataracts are most often acquired or secondary and caused by equine recurrent uveitis (ERU) (Abrams and Brooks 1992; Matthews 2004; Colitz and McMullen 2011). Between 8 and 25% of horses in the United States are affected by ERU and almost all of these horses will develop some degree of cataract (Abrams and Brooks 1992). Therefore, in an adult horse with cataracts, one must look very closely for evidence of previous or ongoing inflammation such as aqueous flare, posterior synechia, corpora nigra atrophy or fibropupillary membranes. Other causes of cataracts include trauma, whiplash injury, retinal detachment and neoplasia (McLaughlin et al. 1992; Matthews 2000). Horses greater than 18 years of age may develop senile cataracts (Matthews 2004). With increasing age, the concentration of insoluble crystallins within the lens increases and causes an increase in light scatter and a loss of transparency (Matthews 2004). Brunescence, a yellowing of the lens, may also occur with advancing age. Nuclear sclerosis, a normal ageing change, should not be confused with a cataract. The progressive compression of the nucleus by the continual addition of the new peripheral lens fibres alters the refractive index of the nucleus. Light is bent differently causing the appearance of a greyish sphere in the central lens. However, with distant direct illumination the nucleus is optically clear with no obstruction of the tapetal fundus and normal visualisation of the fundus with indirect ophthalmoscopy (Matthews 2004).

A horse with cataracts may present with significant visual impairment or be considered by the owner to have completely normal vision. If cataracts are the primary cause for the visual impairment, the cataracts are typically very extensive and significantly impair visualisation of the fundus during the ocular examination. The owners may have noted the white opacity within the eye. More often cataracts are noted during new foal examinations, prepurchase or routine annual physical examinations. The significance for vision and likelihood of progression must then be assessed.

**Diagnosis**

Vision must first be assessed using maze and menace testing. The dazzle reflex and pupillary light reflexes (PLRs) are then assessed. A cataract alone should not prevent a normal dazzle reflex or PLR no matter how dense or large the opacity. The absence of either suggests the presence of additional ocular lesions. The intraocular pressures should then be measured. To critically evaluate the lens, the pupil must be dilated. Tropicamide 1% opthalmic solution is most commonly used as only 20–30 min are required to achieve maximal mydriasis (Colitz and McMullen 2011).

A darkened area is preferable when performing the examination to facilitate visualisation of cataracts, especially focal lesions. Using a Finnoff transilluminator or bright penlight, direct the beam of light at a 45° angle into the eye and directly observe the lens (Gilger and Stoppini 2011). With this direct illumination or transillumination any opacity will appear white. The examiner should then retroilluminate the lens by directing the light source to obtain a bright tapetal reflex (Gilger and Stoppini 2011). Some cataracts are more easily detected with retroillumination because the opacity blocks the returning light causing a black area in the tapetal reflection (Severin 1995). Magnification from a head loupe, direct ophthalmoscope or slit-lamp can aid in the visualisation of smaller lesions. On distant direct ophthalmoscopy an “onion ring” appearance might be noticed in the cortex of older horses (Matthews 2004). This concentric cortical lamination is of no clinical significance, is not a cataract and is not a precursor to a cataract (Matthews 2004).

If a cataract is noted, the size and location within the lens should be determined. Drawings or photographs are particularly useful to document the cataract. The location can be described as capsular, subcapsular, cortical, perinuclear or nuclear as well as anterior, posterior, axial or equatorial (Figs 2 and 3). Focal cataracts along the visual

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**Fig 1:** The right eye of a Rocky Mountain Horse with multiple congenital ocular anomalies syndrome. Note the iridal hypoplasia and failure to dilate after application of tropicamid as well as the immature cataract.

**Fig 2:** A posterior cortical, axial and paraxial, incipient cataract in the left eye of this horse. The cataract was not causing any visual disturbances and therefore surgical removal was not considered.
axis, particularly the posterior axis, might be more likely to impair vision than cataracts in the lens periphery because they could have a greater effect on the image being projected onto the retina (Lambert and Drack 1996).

Cataracts can also be classified by the amount of lens involvement:
- **Incipient** – less than 15% of the lens affected. The horse is visual (Fig 4).
- **Immature** – 16–99% of the lens affected. Vision may be impaired (Fig 5).
- **Mature** – 100% of the lens affected. The tapetal reflection is not visible. The horse is blind (Fig 6).
- **Hypermature** – the lens is beginning to resorb. Wrinkles may be seen along the anterior lens capsule. As cortical lens fibres undergo liquefaction, lens proteins diffuse through the lens capsule and incite an immune-mediated uveitis (Brooks et al. 2014). Lens subluxation or luxation can also occur as the zonules are stretched and broken by the shrinking lens capsule.

The majority of equine cataracts are nonprogressive, except for those due to uncontrolled ERU (Matthews 2004) or cataracts acquired as adults. Therefore one should attempt to ascertain the underlying cause. In a young animal the cataract is likely developmental or inherited unless signs of uveitis or trauma are detected. Senile cataracts in the mature horse are typically condensations along the posterior sutures with focal cortical cataracts (Matthews 2004). Senile cataracts are typically bilateral but not necessarily symmetrical (Matthews 2004). Eyes with cataracts due to uveitis often have other ocular findings such as posterior synechia, corpora nigra atrophy, vitreal syneresis or retinal detachment.

### Management

The only treatment for cataracts is surgical removal of the lens. Phacoemulsification, the use of an ultrasonic handpiece to break apart and aspirate the lens fibres, is the surgical procedure of choice (Whitley et al. 1983; Dziezyc et al. 1991; McLaughlin et al. 1992; Brooks 2005; McMullen and Utter 2010). However, surgery is reserved for those horses with significant visual impairment. If the cataract is not causing visual impairment, no treatment is required unless the cataract has induced uveitis that should be controlled with topical or systemic anti-inflammatory medications. If the cataract is due to ERU, controlling the underlying disease process may slow or halt the progression of the cataract. Topical atropine 1% ophthalmic solution has been recommended in the literature to dilate the pupil to increase the visual potential in horses with focal axial or nuclear cataracts (Beech et al. 1984; Latimer and Wyman 1985; McLaughlin et al. 1992). Owners should be forewarned that photophobia may result and the effects of cycloplegia on equine vision are not well described. In the author’s personal experience, administration of topical atropine has not improved functional vision for these patients.

Performing cataract surgery in horses raises philosophical and ethical concerns (Colitz and McMullen 2011). Even with placement of an intraocular lens (IOL), vision in a horse that has had phacoemulsification can never be considered normal (Colitz and McMullen 2011; Brooks et al. 2014), raising questions of liability during prepurchase examinations and if a rider were to be injured by such a horse (Colitz and McMullen 2011). Without placement of an IOL, the horse will be markedly hyperopic (far-sighted) after surgery (Farral and Handscombe 1990; Millichamp and Dziezyc 2000). In some studies hyperopic horses were felt to have normal vision by their owners (Farral and Handscombe 1990; Whitley et al. 1990; Dziezyc et al. 1991; Millichamp and Dziezyc 2000; Fife et al. 2006). However, in other studies, owners have noted differences in vision, particularly at night (Whitley et al. 1983; Farral and Handscombe 1990); Dziezyc et al. 1991).

Case selection is critical. First the owner must understand the commitment of time and money the surgery will require. In addition, the owner must have reasonable expectations for the possible surgical outcomes. The reported success rate for vision is 88% in the first month post operatively (Brooks et al. 2014). However, the success rate decreases dramatically over time and at 6–12 months post operatively only 34% of horses retained vision in the study by Brooks et al. (2014). At more than 2 years post operatively only 26% remained visual (Brooks et al. 2014). Perhaps the visual outcome was better than 26% as horses that were lost to follow-up were considered failures but might still have retained vision.

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**Fig 3:** A nuclear cataract. The cataract had likely been present since birth and is unlikely to progress. The lesion did not appear to cause any visual compromise in this horse.

**Fig 4:** An incipient, posterior cortical cataract discovered as an incidental finding during the ophthalmic examination. No signs of equine recurrent uveitis were noted and the cataract did not appear to cause any visual difficulties for the horse.
Fig 5: A late immature cataract involving most of the anterior and posterior cortex. The denser white area is an area of anterior capsular fibrosis. This cataract caused significant visual impairment. As no other ocular abnormalities were noted, phacoemulsification was performed to improve the horse’s visual potential.

Fig 6: A mature cataract in a 4-month-old foal. This cataract had been present since birth and caused the foal to be blind. Because of the blindness, phacoemulsification was performed to provide vision for the foal.

study by Edelmann et al. (2014), 58% of horses remained visual after one year. However, many horses in the study were lost to follow-up. If the horses lost to follow-up were considered blind, then the percentage of horses that retained vision after 12 months falls to 33%, a rate similar to the Brooks et al. (2014) study. Complications following surgery can also result in loss of the globe (Fife et al. 2006; Brooks et al. 2014; Edelmann et al. 2014).

The foal or horse must be halter-broken and possess a temperament that will allow frequent application of post operative medications (Gelatt et al. 1974; Whitley et al. 1983, 1990; Dziezyc et al. 1991). The individual must be free of systemic disease. Foals in particular should be thoroughly screened for thoracic disease, especially Rhodococcus equi infections, prior to surgery (Whitley et al. 1983, 1990; Dziezyc et al. 1991; Brooks 2005, 2008; McMullen and Utter 2010). A physical examination, thoracic auscultation, thoracic radiographs and/or thoracic ultrasonography, complete blood count, serum biochemistry and fibrinogen level should be performed (Colitz and McMullen 2011). The remainder of the globe must be normal. If the horse has experienced previous bouts of ERU, the uveitis must be controlled. Miosis, anterior or posterior synchia, ocular hypotony, lens capsule rupture, lens instability, extensive capsular fibrosis and vitreal herniation into the anterior chamber would preclude surgery (Colitz and McMullen 2011; Brooks et al. 2014). An electroretinogram (ERG) is recommended to ensure the retina is functional and rule out conditions such as congenital stationary night blindness (Witzel et al. 1977a,b; Nunnery et al. 2005; Sandmeyer et al. 2007). An ocular ultrasound should be performed to ensure the retina is not detached and the posterior lens capsule is intact. Foals should have surgery performed before 6 months of age to ensure the parts of the brain receiving images from the affected eye are stimulated properly and develop their full visual potential (Crewther et al. 1983; Brooks 2005). In human infants, failure to perform surgery during development of the brain can result in deprivation amblyopia, a reduction in vision because the retina did not receive a clear image during key periods of development and therefore higher visual centres failed to develop (Crewther et al. 1983; Birch and Stager 1988; Whitley 2005). Whether deprivation amblyopia occurs in horses is not definitively known but earlier surgical intervention should maximise the chance for normal retinal and higher visual centre development.

Preoperatively, systemic broad-spectrum antibiotics and flunixin meglumine are administered. Topical antibiotics, corticosteroids (dexamethasone or prednisolone acetate ophthalmic solutions) and a mydriatic agent (atropine or tropicamide ophthalmic solutions) are applied to the affected eye. Surgery is performed under general anaesthesia. Use of an operating microscope is imperative. A phacoemulsification unit with instrumentation modified for horses greatly facilitates performing surgery, particularly in adult horses, due to the large size of the equine eye (Fig 7) (Townsend et al. 2011; Brooks et al. 2014; Edelmann et al. 2014). Systemic neuromuscular blockade or retrobulbar nerve blocks are needed to facilitate positioning of the globe and prevent anterior movement of the vitreous and posterior lens capsule due to contraction of the extra-ocular muscles (Townsend et al. 2011; Brooks et al. 2014; Edelmann et al. 2014). The surgical site is prepared with a 1:50 povidone iodine solution. The surgical site is draped for surgery. A scleral tunnel or clear corneal incision is made (Millichamp and Dziezyc 1996; Townsend et al. 2011; Brooks et al. 2014; Edelmann et al. 2014). As the anterior chamber is entered, care must be taken not to damage the iris due to the shallow anterior chamber at the iris base (Brooks et al. 2014). After reforming the anterior chamber with a viscoelastic agent, a continuous circular capsulorrhexis is performed to create a 10 mm opening in the anterior lens capsule. Phacoemulsification is then performed using ultrasound to break up the lens fibres while at the same time aspirating the fragments and irrigating fluid into the eye to maintain the anterior chamber and prevent collapse of the globe (Fig 8). The posterior capsule is very thin and mobile in horses and can easily be torn during phacoemulsification if one is not exceedingly cautious (Brooks 2005; Whitley 2005; Brooks et al.
After removal of the lens material, a foldable acrylic IOL can be placed if desired (Fig 9). Placement of an IOL improves post operative refractive error and diminishes post operative capsular opacification (McMullen and Utter 2010; Townsend et al. 2011). Whether placement of an IOL causes an increase in post operative complications is currently heavily debated but a recent retrospective study did not find any poorer outcomes for horses with IOLs (Edelmann et al. 2014). Three dioptric strengths are currently available for equine lenses: +14, +18 and +21 (Colitz and McMullen 2011). The +14 is recommended for foals and ponies (Colitz and McMullen 2011; Townsend et al. 2013). For adult horses both the +14 and the +18 dioptr lens have been recommended (McMullen et al. 2008; McMullen and Utter 2010; Townsend et al. 2011). The incision is then closed with 7-0 to 9-0 absorbable suture such as polyglactin 910 in a simple interrupted or continuous pattern. More detailed descriptions of the surgical procedure can be found in several references (Brooks 2005; Colitz and McMullen 2011; Townsend et al. 2011; Harrington et al. 2013; Brooks et al. 2014) (Supplementary Item 1-7).

Potential intraocular complications include iris or corpora nigra prolapse through the incision, corpora nigra haemorrhage, miosis, capsular tears, loss of lens material into the vitreous through posterior capsular tears, vitreous protrusion through a posterior capsular tear and retinal swelling (Colitz and McMullen 2011; Brooks et al. 2014; Edelmann et al. 2014). Per Edelmann et al. (2014), the presence of intraocular complications did not affect the overall success rate for the surgery but eyes with vitreal prolapse or hyphema became blind.

Post operatively, the topical steroids, topical antibiotics and depending on surgeon preference, a topical nonsteroidal anti-inflammatory solution, are continued for 2–3 months depending on corneal wound healing, degree of inflammation and surgeon preference (Colitz and McMullen 2011; Townsend et al. 2011; Harrington et al. 2013; Brooks et al. 2014; Edelmann et al. 2014). If corneal ulceration develops, the topical corticosteroids must be discontinued. Placement of a subpalpebral lavage system greatly facilitates application of topical medications. The systemic antibiotics are continued for 3–7 days post operatively to decrease the risk of endophthalmitis. Flunixin meglumine and gastric protectants are continued for 2–4 weeks after surgery depending on the degree of inflammation.

Post operative complications can occur days to years following surgery. Potential complications include fibrin within the anterior chamber, hyphema, decreased menace response, vitreal prolapse, loss of concurrently implanted cyclosporine implants, corneal oedema, post operative ocular hypertension, corneal ulceration, uveitis, retinal detachment, endophthalmitis, fibropapillary membrane formation, endothelial degeneration causing diffuse corneal oedema, posterior capsular opacification, retinal degeneration, phthisis bulbi, anterior or posterior synechia, iris bombé, wound leakage, retained lens material and glaucoma (Fife et al. 2006; Colitz and McMullen 2011;

Recent articles have examined the impact of multiple factors on the success rate (percentage of horses with vision) for phacoemulsification in horses. While previously foals were thought to have higher success rates than adult horses, age was not a factor in success rate (Edelmann et al. 2014). This was likely due to the modification of instruments to fit the larger equine eye that have become available within the last 10 years. Placement of an IOL was also not related to the long-term retention of vision (Edelmann et al. 2014). Horses with chronic preoperative uveitis were less likely to remain visual post operatively (Edelmann et al. 2014). Placement of a cyclosporine implant, either previously or at the time of surgery, in patients with uveitis did not improve the visual outcome (Edelmann et al. 2014). Causes of vision loss included retinal detachment, endophthalmitis, glaucoma, chronic uveitis, extensive posterior synechia, globe rupture and phthisis bulbi (Brooks et al. 2014; Edelmann et al. 2014).

In summary, a careful ophthalmic examination is necessary to detect cataracts and determine their likely cause and effect on vision. In adult horses the majority of cataracts occur secondary to ERU. In foals most cataracts are developmental lesions. For those individuals with significant visual impairment, if the patient meets very stringent selection criteria, the potential for visual improvement makes cataract surgery a worthwhile procedure.

**Author’s declaration of interests**

No conflicts of interest have been declared.

**Ethical animal research**

Ethical review not applicable for review article.

**Source of funding**

None.

**References**


Supporting information

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

Supplementary Item 1: The corneal incision, entry into the globe, and introduction of viscoelastic material into the anterior chamber are demonstrated.

Supplementary Item 2: Creation of the continuous circular capsulorhexis with the high frequency diathermy probe is demonstrated.

Supplementary Item 3: The initial phacoemulsification of the lens is demonstrated.

Supplementary Item 4: The final phacoemulsification of the lens is demonstrated.

Supplementary Item 5: Irrigation and aspiration of the remaining cortical material is shown.

Supplementary Item 6: Placement of the foldable intraocular lens is shown.

Supplementary Item 7: Final positioning of the intraocular lens and closure of the incision are shown.

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