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L'impression 3D est une méthode permettant de produire un objet physique à partir d'un modèle numérique en superposant de fines couches de matériau. Dans un type d'impression 3D, un filament du matériau (l'encre) est fondu, déposé en une couche, puis refroidi rapidement. Un autre type d'imprimante 3D utilise un processus de stéréolithographie (SLA), qui crée un objet à partir d'un matériau liquide, généralement un polymère photosensible thermosolvant, en utilisant un faisceau laser UV pour solidifier la résine de polymère couche par couche. Les thermoplastiques sont couramment employés en impression 3D mais des liquides, des poudres, des métaux, des céramiques ou des cellules vivantes sont aussi utilisés. Les principaux avantages de cette méthode de fabrication sont qu'elle est précise et reproductible à haute vitesse et à faible coût.

Les imprimantes 3D sont désormais utilisées pour créer un vaste éventail de produits, notamment des jouets, des produits alimentaires, des bijoux, ainsi que des pièces d’automobiles et d’avions. Il y a environ 5 ans, d’immenses imprimantes 3D et du béton à séchage rapide ont permis de construire 10 maisons en Chine en une seule journée, pour un coût inférieur à $5000 chacune.

L'impression 3D a servi en médecine pour la première fois dans les années 1990 pour la production d’implants dentaires et de prothèses sur mesure. Les autres domaines de la médecine dans lesquels l’impression 3D joue un rôle comprennent la planification chirurgicale, l’enseignement et la formation, la recherche, et l’administration de médicaments (1).

L’examen de répliques d’organes de patients imprimées en 3D améliore considérablement la planification des chirurgies complexes en permettant l’exploration de diverses approches chirurgicales et une expérience pratique avant l’intervention (1). Le recours à ces modèles réduit la durée de la chirurgie et améliore les résultats. Les enseignants ont utilisé l’impression 3D pour créer des modèles d’organes et de structures qui aident...
a role in regenerative medicine. A sheep model has shown the feasibility of using a hand-held device (biopen) to deposit cultured cells and a bioscaffold into a cartilage defect in vivo. In the future, printed organs or portions of organs will likely be used for transplantation into humans. There is considerable research on the use of 3D printing for drug delivery (1). The technique permits printing of specific doses for an individual, creating pills that contain immediate release and sustained release layers, and producing pills that incorporate several drugs with different release profiles in a single pill.

3D printing is also finding application in veterinary medicine. In late 2018, Dr. Michelle Oblak at the Ontario Veterinary College made news around the world because of her use of a 3D printed customized part of the skull of a dog with a massive brain tumor (2). Dr. Oblak remarked on how well-prepared she and her Cornell University colleague, Dr. Galina Hayes, were when they walked into the operating room — because they had been able to study the 3D model of the dog’s head and tumor and to have the 3D printed skull replacement on hand. Earlier this year a 3D printed indirect lens adapter was described as part of an inexpensive system for fundoscopy in dogs and cats (3). The other parts of the system were a smart phone and an indirect ophthalmoscopy lens. This system is suitable for acquiring, archiving, and sharing images of the retina by veterinary ophthalmologists and general practitioners.

Other applications of 3D printing in veterinary medicine have been reported. Patient-specific drill guides have been shown to be effective in a variety of procedures including placement of pedicle screws in vertebrae and stabilization of fractures in dogs. 3D printing has also been used for making a customized implant for treatment of canine cruciate ligament by tibial tuberosity advancement, for producing a small animal immobilizer for radiotherapy, for creating rhino horns, and for producing custom ballistic vehicles for drug delivery to wildlife. Within a few years I expect that many veterinary practices will have a 3D printer in the office.

References

Carlton Gyles
(Opinions expressed in this column are those of the Editor)

les étudiants en anatomie et en physiologie. L’impression d’organes humains (organoides) à partir de cellules vivantes devrait occuper une place importante dans la recherche sur le dépistage des drogues, la toxicologie et l’oncologie. La combinaison de la technologie des cellules souches et de l’impression 3D a mené au développement d’organoides imitant la structure et la fonction des organes reproductifs et peut jouer un rôle en médecine régénérative. Un modèle de mouton a montré qu’il était même possible d’utiliser un dispositif portatif (BioPen) pour déposer des cellules en culture et une biomatrice dans une lésion cartilagineuse in vivo. À l’avenir, des organes imprimés, partiels ou complets, seront probablement utilisés pour transplantation chez l’humain. Il y a beaucoup de recherche sur le recours à l’impression 3D pour l’administration de médicaments (1). Cette technique permet d’imprimer des doses spécifiques pour un individu, en créant des comprimés formés de couches à libération immédiate et à libération prolongée ou des comprimés contenant plusieurs médicaments à caractéristiques de libération différentes.

L’impression 3D a également des applications en médecine vétérinaire. À la fin de l’année 2018, la Dʳ Michelle Oblak de l’Ontario Veterinary College a fait les manchettes dans le monde entier en remplaçant une partie du crâne d’un chien souffrant d’une énorme tumeur crânienne par une plaque réalisée sur mesure par impression 3D (2). La Dʳ Oblak a souligné à quel point elle et sa collègue de l’Université Cornell, la Dʳ Galina Hayes, étaient bien préparées lorsqu’elles sont entrées dans la salle d’opération, parce qu’elles avaient pu étudier le modèle 3D de la tête et de la tumeur du chien ainsi que l’implant de remplacement fabriqué par impression 3D. Plus tôt cette année, un adaptateur imprimé en 3D a été utilisé avec un téléphone intelligent et une lentille d’ophthalmoscopie indirecte pour créer un système peu coûteux pour l’examen du fond de l’œil chez le chien et le chat (3), qui fonctionne pour l’obtention, la sauvegarde et le partage d’images de la rétine par des ophthalmologistes vétérinaires et des médecins vétérinaires généralistes.

D’autres applications de l’impression 3D en médecine vétérinaire ont aussi été décrites. Les guides chirurgicaux sur mesure se sont révélés efficaces dans diverses interventions, notamment pour la mise en place de vis pédiculaires dans les vertèbres et la stabilisation des fractures chez le chien. L’impression 3D a également été utilisée pour la fabrication d’un implant sur mesure pour le traitement d’une rupture du ligament croisé crânial par avancement de la tubérosité tibiale, pour la fabrication d’un immobilisateur d’animal de compagnie pour la radiothérapie, pour la fabrication de cornes de rhinocéros, et pour la production de dispositifs d’administration de médicaments aux animaux de la faune. Je crois que d’ici quelques années, de nombreux établissements vétérinaires seront équipés d’une imprimante 3D.

Renvois

Carlton Gyles
(Les opinions exprimées dans cette rubrique sont celles du rédacteur en chef.)
Veterinary Medical Ethics
Déontologie vétérinaire

Ethical question of the month — July 2019

As government support of public institutions declines, universities have become increasingly dependent on funding from alternate sources such as research grants and corporate sponsorship. These sources of funding are most often directed towards specific projects or areas of study. As a result, these alternate sources of funding are not equally available to all areas of study at a university. One area where large research grants and corporate sponsorship are limited is the field of bioethics. As a result, departments of bioethics are consolidating or disappearing in many universities across North America. How can universities ensure that students have access to a wide range of educational opportunities if funding is increasingly controlled by private sponsorship?

An ethicist’s commentary on defunding of bioethics programs

Regrettably, limited funding for certain areas is nothing new in universities, even during periods of copious funding. Fields that have potential for attracting additional funding tend to receive priority. University administrators tend to see little potential value in teaching bioethics. Let us also recall that there was virtually no teaching of medical ethics, even in medical schools, until the 1960s, with the exception of Catholic institutions.

My own experience of being named University Bioethicist at Colorado State University provides an interesting case. As I have mentioned before in this column, during the 1970s, concurrent with my creating the world’s first course in veterinary medical ethics, I became aware of the paucity of regulations protecting animals used in research and teaching. There was, for example, no use of analgesia in research or in teaching. Teaching dogs received an incredible 9 surgeries in the course of 3 weeks of surgery teaching. I considered this state of affairs morally reprehensible and scientifically unacceptable. I thus went to work with 2 veterinarian colleagues with extensive research experience to provide a legislative basis for compulsory anesthesia and analgesia. It took us 10 years for our efforts to bear fruit, but it did, and as of 1985 it became federal law for virtually all animals used in research, teaching, and testing. Prior to 1985, these topics were not taught to veterinary students, medical students, or graduate students in biomedical science.

Given the success of our endeavors, we were able to convince university administrators of the value of having the University lead in such activities, and I was appointed University Bioethicist to ensure that such leadership would continue. The leadership our University demonstrated has been of inestimable value to our reputation in the public mind.

It should be noted that my colleagues and I did not sit idle waiting for the University to act, but rather took the reins in showing the great value of a solid reputation in bioethics to the well-being of our University, particularly as a public university. We do not have a department of bioethics, nor much of an administrative structure — we do what needs to be done when situations arise. In this way, we combine leadership in this area with programs and courses demonstrating its efficacy.

When it comes to training leaders in bioethics, we have found that progress is often sparked by students with specific interests. Roughly 10 times a year I receive a letter from a student saying “I want to learn to do what you do.” In one notable case in the early 1980s, I attracted a graduate student with a good deal of interest in biosafety. With the help of a number of key people who were very concerned about universities’ casual attitudes towards the dangers associated with research and work done with dangerous pathogens, the student assembled a very persuasive dossier of dangerous practices at the University which
could well have ramified in disaster. To his credit, he persisted in gathering such data despite patent skepticism by senior administrators — “what are you worried about? No one has been killed yet!” Eventually, and well ahead of most institutions, we hired a senior biosafety officer who has helped assure that we are in a leadership position.

One dean, with a long career at the Centers for Disease Control and Production (CDC), initially opined that he did not need a philosophy graduate student to teach him about biosafety, but changed his tune when he read the master’s thesis and became an ardent supporter. Similar occurrences have taken place regarding animal use, genetic engineering, and other bioethics issues. And in this way, we have grown our program.

Thus, in this era of truncated public support for higher education, I do not recommend sitting and waiting for funding for bioethics programs. I rather suggest doing something of an aggressive sales job showing administrators the value of a practical approach to bioethics. One unfortunate incident of animal abuse or mishandling of biosafety can shut down an entire program, or generate unwanted scrutiny from federal agencies, or majorly harm the university’s image with the general public. A successful bioethics program is more like preventive medicine than anything else. The presence of an independent voice for bioethics does much to assure that the University is operating honorably.

In sum, if one wishes to create or preserve an academic program, it is probably most important to demonstrate its value and efficacy. Programs no longer survive merely because they sound good.

Bernard E. Rollin, PhD

Ethical question of the month — October 2019

Six horses died during the chuckwagon races at the 2019 Calgary Stampede. Injuries and occasional deaths will never be eliminated from equine competitive events. Should a threshold for injuries and mortalities be established to distinguish between competitive events with reasonable and unreasonable risks for the safety of the horses competing? Should the fact that chuckwagon races do not represent an authentic historic component of Western Canadian cattle culture be considered in such a decision?

Les réponses au cas présenté sont les bienvenues. Veuillez limiter votre réponse à environ 50 mots et nous la faire parvenir par la poste avec vos nom et adresse à l’adresse suivante: Choix déontologiques, a/s du Dr Tim Blackwell, 6486 E. Garafraxa, Townline, Belwood, Ontario N0B 1J0; téléphone: (519) 846-3413; fax: (519) 846-8178; e-mail: tim.e.blackwell@gmail.com.

Suggested ethical questions of the month are also welcome! All ethical questions or scenarios in the ethics column are based on actual events, which are changed, including names, locations, species, etc., to protect the confidentiality of the parties involved.

Les propositions de questions déontologiques sont toujours bienvenues! Toutes les questions et situations présentées dans cette chronique s’inspirent d’événements réels dont nous modifions certains éléments, comme les noms, les endroits ou les espèces, pour protéger l’anonymat des personnes en cause.
1. With a diaphragmatic hernia, which of the following organs is most commonly herniated into the thorax?
   A. Stomach  
   B. Small Intestine  
   C. Liver  
   D. Spleen  
   E. Kidney

2. Which of the following is the typical signalment of an animal afflicted with an inflammatory nasopharyngeal polyp?
   A. Middle-aged cat  
   B. Geriatric dog  
   C. Young cat  
   D. Young dog  
   E. Geriatric cat

3. Examination of microscopic urine sediment from an adult horse with suspected hematuria reveals an increased number of red blood cells. A substantial variation in red blood cell size, shape, and hemoglobin content (dysmorphism) is also found. Which of the following is the most likely explanation for these findings?
   A. Glomerular bleeding  
   B. Tubular bleeding  
   C. Renal pelvis bleeding  
   D. Ureteral bleeding  
   E. Urethral bleeding

4. Which of the following syndromes in feedlot cattle has NOT been associated with BVD virus?
   A. Bovine Respiratory Disease (BRD)  
   B. Thrombocytopenia  
   C. Mucosal disease  
   D. Polioencephalomalacia  
   E. Diarrhea
5. Young turtles fed a diet of raw hamburger typically have signs of which of the following?
   A. Vitamin A deficiency
   B. Vitamin E deficiency
   C. Vitamin A excess
   D. Vitamin E excess
   E. Biotin deficiency

(See p. 1088 for answers./Voir les réponses à la page 1088.)

Questions and answers were derived from Review Questions and Answers for Veterinary Boards 2nd ed., a 5-volume series including Basic Sciences, Clinical Sciences, Small Animal Medicine and Surgery, and Ancillary Topics, by kind permission of the publisher, Mosby-Year Book, Inc., St. Louis, Missouri.
71st CVMA Convention and Council Update

This past summer, the CVMA brought the veterinary world to the joint CVMA-WSAVA (World Small Animal Veterinary Association) Congress in Toronto. This rare event on Canadian soil attracted an attendance of almost 2200 and provided for continuing education with national and international speakers and networking among Canadian and international veterinarians. The Convention featured 40 tracks presented by 108 Speakers.

Global Summit: The CVMA president-elect, Dr. Melanie Hicks, organized and chaired the Global Summit themed “The Gold Standard of Animal Welfare — Positive and Negative Impact on Animals and Veterinarians.” Dr. Susan Hazel, senior lecturer, Animal Behavior, Welfare & Ethics, Australia, led a session on “Global Animal Welfare: Challenges and Opportunities.” Dr. David Fraser, professor, Faculty of Land and Food Systems, University of British Columbia spoke about “What Do We Mean by One Welfare?” Dr. Heather Bacon from the University of Edinburgh spoke about “The Gold Standard of Animal Welfare — Positive and Negative Impact on Animals and Veterinarians.” Members of the audience and speakers engaged in interesting discussions.

Global Forum: Dr. Serge Chalhoub, University of Calgary, CVMA National Issues Committee member, moderated this forum on telehealth and animal welfare. The aim was to explore implications on animal welfare from telehealth and telemedicine. The CVMA developed a telemedicine position statement in 2014 and is reviewing its position given the fast-changing environment.

Emerging Leaders Program (ELP): The objective of the Emerging Leaders Program is to provide participants with training in non-technical (life skills) competencies, particularly

71e Congrès de l’ACMV et nouvelles du conseil d’administration

L’été dernier, l’ACMV a invité la communauté vétérinaire au congrès conjoint de l’ACMV et de la WSAVA (World Small Animal Veterinary Association) à Toronto. Cet événement rare en sol canadien, qui a attiré près de 2200 personnes, proposait des activités de formation continue avec des conférenciers de renommée nationale et internationale et a permis le réseautage entre médecins vétérinaires du Canada et d’ailleurs dans le monde. Le congrès comportait 40 exposés présentés par 108 conférenciers.

Sommet mondial : La Dre Melanie Hicks, présidente désignée de l’ACMV, a organisé et présidé le Sommet mondial dont le thème était «La norme d’excellence en matière de bien-être animal — Impact positif et négatif sur les animaux et les médecins vétérinaires». La Dre Susan Hazel, conférencière principale et experte australienne en comportement, bien-être animal et éthique, a dirigé un atelier intitulé «Bien-être des animaux dans le monde : Défis et occasions». Les titres des exposés du Dr David Fraser, professeur à la Faculté des systèmes terrestres et alimentaires de l’Université de la Colombie-Britannique, et de la Dre Heather Bacon, de l’Université d’Édimbourg, étaient respectivement «Qu’entendons-nous par un seul bien-être?» et «La norme d’excellence en matière de bien-être animal — Impact positif et négatif sur les animaux et les médecins vétérinaires». Les membres de l’auditoire et les conférenciers ont eu des discussions très intéressantes.

Forum mondial : Dr. Serge Chalhoub, de l’Université de Calgary et membre du comité sur les enjeux nationaux de l’ACMV, a animé le forum sur la télésanté et le bien-être des animaux qui visait à explorer les implications de la télésanté et de la télé-médecine sur le bien-être des animaux. L’ACMV a rédigé un énoncé de position sur la télémédecine en 2014 et réévalue actuellement sa position compte tenu de l’évolution rapide de ce secteur.

Many attendees of the morning workshop volunteered in the afternoon at the clinic of the Toronto branch of the Community Veterinary Outreach.

Plusieurs participants à l’atelier de l’avant-midi ont fait du bénévolat l’après-midi à la clinique torontoise de Community Veterinary Outreach.
skills relating to teamwork, communication and professionalism. The program, this year with Canadian and international participation, was chaired by Dr. Chris Bell and facilitated by Dr. Rick DeBowses.

**Outreach Program:** In partnership with the WSAVA, and the CVMA, the Community Veterinary Outreach (CVO) hosted a half-day workshop highlighting the CVO’s One Health model and approaches, along with presentations by both human and animal health partners. Participants were then invited to attend the CVO clinic for homeless and vulnerably housed pet owners at the Yonge Street Mission in Toronto, Ontario.

**Annual General Meeting (AGM):** The president of WSAVA, Dr. Shane Ryan, addressed the CVMA AGM, and leaders of the 3 levels of government (the mayor of Toronto, premier of Ontario, and Prime Minister of Canada) sent welcome letters. The CVMA president, Dr. Terri Chotowetz, looked back on a successful year with a record membership of 7400 veterinarians and 7850 affiliated veterinary technicians. Dr. Chotowetz highlighted a few of CVMA’s many accomplishments, including the delivery of the new, web-based antimicrobial prudent use guidelines (including food animals and small animals), work done on cannabis, African Swine Fever, telemedicine, the release of the 3rd edition of the Kennel Code, the development and reviews of numerous position statements, advocacy efforts and more. She thanked the more than 600 CVMA volunteers and the CVMA staff team for their dedication and work.

International veterinary leaders attending the AGM included Dr. John de Jong, president, American Veterinary Medical Association (AVMA); Dr. John Howe, president-elect, AVMA; Dr. Janet Donlin, executive vice-president and chief executive officer, AVMA; Dr. Julia Crawford, president, Australian Veterinary Association; Dr. Rens Van Dobbenburgh, president, Federation of Veterinarians of Europe (FVE); Dr. Patricia Turner, president-elect, World Veterinary Association (WVA); and Dr. Andrew Maccabe, chief executive officer, Association of American Veterinary Medical Colleges (AAVMC).

**Programme des futurs leaders (PFL):** L’objectif du Programme des futurs leaders est d’offrir aux participants une formation sur des compétences non techniques (compétences de la vie courante), en particulier en ce qui a trait au travail d’équipe, à la communication et au professionnalisme. Le programme, qui a eu cette année une participation canadienne et internationale, a été présidé par le Dr Chris Bell et animé par le Dr Rick DeBowses.

**Programme de rayonnement:** En partenariat avec la WSAVA et l’ACMV, Community Veterinary Outreach (CVO) a organisé un atelier d’une demi-journée sur son modèle et ses approches «Une santé» ainsi que des présentations par des partenaires de la santé humaine et de la santé animale. Les participants ont ensuite été invités à assister à une clinique de CVO destinée aux propriétaires d’animaux sans abris ou logés de façon vulnérable à la Yonge Street Mission à Toronto, en Ontario.

**Assemblée générale annuelle (AGA):** Le Dr Shane Ryan, président de la WSAVA, s’est adressé aux membres présents à l’AGA de l’ACMV, et les dirigeants des trois paliers de gouvernement (le maire de Toronto, le premier ministre de l’Ontario et le premier ministre du Canada) ont envoyé des lettres de bienvenue. La Dr Terri Chotowetz, présidente de l’ACMV, a fait le bilan d’une année fructueuse caractérisée par l’adhésion record de 7400 médecins vétérinaires et de 7850 techniciens vétérinaires affiliés. La Dr Chotowetz a souligné quelques-unes des nombreuses réalisations de l’ACMV, notamment la publication en ligne des nouvelles lignes directrices sur l’utilisation prudente des antimicrobiens (pour les animaux destinés à l’alimentation et les animaux de compagnie), les travaux menés sur le cannabis, la peste porcine africaine et la télémédecine, la publication de la troisième édition du Code de pratiques recommandées aux chiens, la rédaction et la révision de nombreux énoncés de position, et diverses activités de défense des intérêts. Elle a remercié les quelque 600 bénévoles de l’ACMV ainsi que le personnel de l’ACMV pour leur dévouement et leur travail.

Parmi les leaders vétérinaires internationaux présents à l’Assemblée générale figuraient le Dr John de Jong, président...
The new president and executive of the CVMA were introduced: Dr. Melanie Hicks, president; president-elect, Dr. Enid Stiles; vice-president, Dr. Louis Kwantes, executive member, Dr. Chris Bell; treasurer, Dr. Brian Evans; and Mr. Jost am Rhyn, CEO. The CVMA would like to extend sincere thanks to Dr. Terri Chotowetz, now immediate past-president, for her leadership and many years of dedication to the CVMA and the veterinary profession.

A special thank you to the 2 parting executive members, immediate past-president, Dr. Troye McPherson and the long-serving treasurer, Dr. Barry Stemshorn, for their dedication to the profession and for sharing their expertise.

The CVMA and its members honored several greatly deserving professionals during the Awards Ceremony held following the AGM:

- CVMA Small Animal Practitioner Award — Dr. Kate Lupton
- CVMA Humane Award — Dr. Dennis Will
- Merck Veterinary Award — Dr. Karin Orsel
- CVMA Practice of the Year Award — Veterinary Specialty Centre of Newfoundland and Labrador
- CVMA Life Membership — Dr. Jim Brackett
- RVL Walker Award — Ms. Kate Rundle
- CVMA President’s Award — Dr. Lloyd Keddie

The CVMA Convention is the place for Canadian veterinarians to meet.

Numerous meetings took place during and around the Convention including those with the following groups: deans; the Registered Veterinary Technologists and Technicians of Canada; presidents of veterinary species groups; the National Examining Board (NEB) and the regulatory bodies; the Canadian Council of Veterinary Registrars (CCVR); the NEB; the Provincial Forum (including provincial veterinary medical association [VMA] executive directors and communications managers); the Presidents’ Meeting (including presidents of VMAs, national veterinary species groups, and veterinary regulatory bodies); and the Students of the CVMA.

de l’American Veterinary Medical Association (AVMA); le Dr John Howe, président désigné de l’AVMA; la Dr Janet Donlin, vice-présidente-directrice et directrice générale de l’AVMA; la Dr Julia Crawford, présidente de l’Australian Veterinary Association; le Dr Rens Van Dobbenburgh, président de la Fédération vétérinaire européenne (FVE); la Dr Patricia Turner, présidente désignée de la World Veterinary Association (WVA); et le Dr Andrew Maccabe, directeur général de l’Association of American Veterinary Medical Colleges (AAVMC).

La nouvelle présidente et la nouvelle composition du comité exécutif de l’ACMV ont été présentées : Dr Melanie Hicks, présidente; Dr Enid Stiles, présidente désignée; Dr Louis Kwantes, vice-président; Dr Chris Bell, membre exécutif; Dr Brian Evans, trésorier; et M. Jost am Rhyn, président-directeur général. L’ACMV aimerait exprimer ses sincères remerciements à la Dr Terri Chotowetz, maintenant présidente sortante, pour son leadership et ses nombreuses années de dévouement à l’ACMV et à la profession vétérinaire.

Nous tenons également à remercier deux membres qui quittent le comité exécutif, c’est-à-dire le Dr Troye McPherson, président sortant, et le Dr Barry Stemshorn, trésorier de longue date, pour leur dévouement envers la profession et pour avoir partagé leur expertise.

L’ACMV et ses membres ont rendu hommage à plusieurs professionnels méritants lors de la cérémonie de remise des prix qui a suivi l’AGA.

- Prix du praticien des petits animaux de l’ACMV — Dr Kate Lupton
- Prix humanitaire de l’ACMV — Dr Dennis Will
- Prix vétérinaire Merck — Dr Karin Orsel
- Prix de la pratique de l’année de l’ACMV — Veterinary Specialty Centre of Newfoundland and Labrador
- Membre à vie de l’ACMV — Dr Jim Brackett
- Prix R.V.L. Walker — Mme Kate Rundle
- Prix du président de l’ACMV — Dr Lloyd Keddie

Le congrès de l’ACMV est le lieu de rencontre des médecins vétérinaires canadiens.

De nombreuses réunions ont eu lieu pendant et en marge du congrès, notamment celles des groupes suivants : les doyens; les technologues et techniciens vétérinaires agréés du Canada; les présidents des groupes vétérinaires par espèces; le Bureau national des examinateurs et les organismes de réglementation; le Conseil canadien des registraires vétérinaires (CCRV); le BNE; le Forum provincial (y compris les directeurs et les gestionnaires des communications des associations vétérinaires provinciales); les présidents (y compris ceux des associations vétérinaires provinciales, des groupes vétérinaires nationaux par espèces et des organismes de réglementation vétérinaire); et les étudiants de l’ACVM.
CVMA Strategic Plan 2020–2022: In late 2018, the CVMA, through a 3rd party, conducted a quantitative online survey of members, students, non-members, and a qualitative survey through telephone interviews. Based on the findings, in March 2019, the CVMA conducted a strategic planning workshop that included Council members, Committee chairs and management staff. In July, Council approved 3-year Strategic Priorities and prioritized Objectives. The priorities are as follows: 1) Provide Leadership on National and International Veterinary Issues; 2) Provide Advocacy and Leadership on Animal Welfare; 3) Engage Membership and the Veterinary Community; and 4) Promote Meaningful Careers and Personal Wellness for Veterinary Professionals. The Priorities and Objectives will guide the CVMA’s operational plans for the next 3 years.

Labor shortage: In most parts of Canada, there appears to be a shortage of veterinarians and veterinary technicians. This is underpinned by record numbers of classified ads, anecdotal information and partially by provincial data collection. The CVMA will be conducting a national labor market study with the intention of using the data for consideration by veterinary college funders, for consideration in Canada’s immigration policies, and for consideration in adapting the veterinary practice as and if needed.

In the meantime, the CVMA has reached out to the AVMA/CVM-Council on Education (CoE) accredited international veterinary colleges who will promote Canada as a marketplace for veterinary education. Council directed that the Animal Welfare Committee conduct research on brachycephalic animals and if needed.

Animal Welfare

Neutering of Dogs and Cats: Council approved the following revised position statement:

“The Canadian Veterinary Medical Association (CVMA) strongly recommends that cats and dogs not intended for breeding be neutered before sexual maturity, except when there are scientifically justifiable health or behavioral benefits that might be gained by delaying the procedure.”

Castration of Horses, Donkeys, and Mules: Council approved the following revised position statement:

“The Canadian Veterinary Medical Association (CVMA) considers castration of horses, donkeys, and mules a major veterinary surgery, which should only be performed by a veterinarian using appropriate surgical, anesthetic, and analgesic techniques.”

Brachycephalic Dogs: Council directed that the Animal Welfare Committee conduct research on brachycephalic animals with the intent to increase awareness.

Plan stratégique 2020–2022 de l’ACMV : À la fin de 2018, l’ACMV, par l’intermédiaire d’une tierce partie, a mené un sondage quantitatif en ligne auprès de membres, d’étudiants et de non-membres, ainsi qu’un sondage qualitatif par entretiens téléphoniques. À la lumière des résultats, l’ACMV a organisé en mars 2019 un atelier de planification stratégique auquel ont participé les membres du conseil d’administration, les présidents des comités et le personnel de gestion. En juillet, le conseil d’administration a approuvé les priorités stratégiques et les objectifs prioritaires triennaux. Les priorités sont les suivantes : 1) assurer un leadership sur les questions vétérinaires nationales et internationales; 2) assurer la défense des intérêts et un leadership en matière de bien-être animal; 3) mobiliser les membres et la communauté vétérinaire; et 4) promouvoir des carrières significatives et le bien-être personnel des professionnels vétérinaires. Les priorités et les objectifs guideront les plans opérationnels de l’ACMV pour les trois prochaines années.

Pénurie de main-d’œuvre : Dans la plupart des régions du Canada, il semble y avoir une pénurie de médecins vétérinaires et de techniciens en santé animale. Cette situation est étayée par un nombre record d’annonces classées, des renseignements anecdotiques et en partie par la collecte de données provinciales. L’ACMV mènera une étude nationale sur le marché du travail dans le but de fournir des données à prendre en considération au moment de prendre des décisions concernant les subventions des écoles vétérinaires, les politiques d’immigration du Canada et l’adaptation de la pratique vétérinaire au besoin.

L’ACMV a communiqué avec les écoles vétérinaires internationales agréées par l’ACMV/AVMA-CoE pour leur demander de promouvoir le Canada en tant que marché pour la pratique de la médecine vétérinaire. Au cours des deux dernières années, environ 40 % de tous les certificats de compétence délivrés par le Bureau national des examinateurs de l’ACMV l’ont été à des médecins vétérinaires formés à l’étranger. Le marché du travail vétérinaire canadien acquiert de cette façon un nombre important de médecins vétérinaires, plus élevé que le nombre de diplômés des écoles vétérinaires canadiennes.

Bien-être des animaux

Stérilisation des chiens et des chats : Le conseil a approuvé l’énoncé de position révisé suivant :

«L’Association canadienne des médecins vétérinaires (ACMV) recommande fortement que tous les chiens et chats qui ne font pas partie d’un programme d’élevage responsable soient stérilisés avant l’âge de la maturité sexuelle, sauf s’il y a des bienfaits valables pour la santé ou le comportement justifiant le report de l’intervention.»

Castration des chevaux, des ânes et des mulets : Le conseil a approuvé l’énoncé de position révisé suivant :

«L’Association canadienne des médecins vétérinaires (ACMV) considère la castration des chevaux, des ânes et des mulets comme une intervention qui devrait seulement être réalisée...»
End-of-Life Issues: Council directed that the Animal Welfare Committee conduct research around end-of-life issues and make recommendations to Council on how to proceed.

Animals in Sport and Competition: Council approved the following new position statement:

“The Canadian Veterinary Medical Association (CVMA) accepts the humane and ethical use of animals in competition and sport. The CVMA strongly supports progressive implementation of strategies to mitigate risks involved with the care and management of animals used in sport and competition, to promote sound physical, social and psychological health and well-being of the animal, and to find alternatives that end avoidable harm and suffering.”

Use of Animals in Entertainment and Recreation: Council approved the following revised position statement:

“The Canadian Veterinary Medical Association (CVMA) accepts the humane and ethical use of animals for entertainment and in the arts. The CVMA strongly supports progressive implementation of strategies to mitigate risks involved with the care and management of animals used in entertainment and the arts, to promote sound physical, social and psychological well-being of the animal, and to find alternatives that end avoidable harm and suffering.”

National Issues

Telemedicine: Advancing technology is rapidly transforming the practice of veterinary medicine. Medical consultation through telecommunication technology offers opportunities to improve the delivery of animal health care, but also presents challenges to practitioners, animal owners and other stakeholders. At the request of the Canadian veterinary regulatory bodies, the CVMA developed its 1st position statement on telemedicine in 2014. The environment changes rapidly. The CVMA has been in contact with the AVMA and other jurisdictions on this topic. At present, the Association envisions the development of a Pan Canadian Framework on Telemedicine, in conjunction with stakeholders, including regulators.

Cannabis: Since October 2018, human use of recreational cannabis is legal in Canada. This brings potentially more risk of exposure for dogs and there is evidence that reports to Poison Control have increased since that time. Later this year, edibles are scheduled to be legalized as well. Veterinarians are permitted to prescribe and dispense registered drugs with cannabinoids, including extra-label human drugs, however currently there are no veterinary drugs and only one registered human drug not suitable for animals. Currently, the Canadian Veterinary Drugs Directorate has approved clinical trials for veterinary drugs containing cannabinoids, but having one come to market is 6 to 10 years away. The only approved cannabis products for animals available at this time are veterinary health products made from hemp that in fact have no concentrated cannabinoids, including cannabidiol (CBD), make no health claims and are sold at retail outlets. The CVMA has been advocating for inclusion of veterinarians in the Act to authorize cannabis for medical purposes, and for warning labels to keep human cannabis products away from pets.

par un vétérinaire, en utilisant des techniques chirurgicales, anesthésiques et analgésiques appropriées.”

Chiens brachycéphales : Le conseil a demandé au comité sur le bien-être animal de faire des recherches sur les animaux brachycéphales dans le but d’accroître la sensibilisation.

Problèmes relatifs à la fin de vie : Le conseil a demandé au Comité sur le bien-être animal de mener des recherches sur les problèmes relatifs à la fin de vie et de faire des recommandations au conseil sur la manière de procéder.

Animaux dans les sports et les compétitions : Le conseil a approuvé le nouvel énoncé de position suivant :

«L'Association canadienne des médecins vétérinaires (ACMV) accepte l'utilisation non cruelle et éthique des animaux lors de compétitions et de sports. L'ACMV appuie vivement la mise en œuvre progressive de stratégies afin d'atténuer les risques associés aux soins et à la gestion des animaux utilisés dans les sports et les compétitions, de promouvoir la santé et le bien-être physique, social et psychologique de l’animal et de trouver des solutions de remplacement en vue de mettre fin à des torts et à des souffrances évitables.»

Utilisation des animaux dans les divertissements et le domaine des arts : Le conseil a approuvé l’énoncé de position révisé suivant :

«L'Association canadienne des médecins vétérinaires (ACMV) accepte l’utilisation non cruelle et éthique des animaux dans les divertissements et le domaine des arts. L'ACMV appuie vivement la mise en œuvre progressive de stratégies afin d’atténuer les risques associés aux soins et à la gestion des animaux dans les divertissements et le domaine des arts, de promouvoir la santé et le bien-être physique, social et psychologique de l’animal et de trouver des solutions de remplacement en vue de mettre fin à des torts et à des souffrances évitables.»

Enjeux nationaux

Télémédecine : Les technologies de pointe transforment rapidement la pratique de la médecine vétérinaire. Les consultations médicales effectuées par le biais de la technologie des télécommunications offrent des possibilités d’améliorer la prestation des soins de santé animale, mais posent également des problèmes aux praticiens, aux propriétaires d’animaux et aux autres intervenants. À la demande des organismes canadiens de réglementation vétérinaire, l’ACMV a élaboré son premier énoncé de position sur la télémédecine en 2014. Le milieu change rapidement. L’ACMV a été en contact avec l’AVMA et d’autres juridictions sur ce sujet. À l’heure actuelle, l’Association envisage d’élaborer un cadre canadien sur la télémédecine en collaboration avec les intervenants, y compris les organismes de réglementation.

Cannabis : Depuis octobre 2018, la consommation humaine de cannabis à des fins récréatives est légale au Canada. Ce changement augmente potentiellement le risque d’exposition pour les chiens; d’ailleurs, le nombre de déclarations aux centres antipoison a augmenté depuis la légalisation. Il est aussi prévu que les produits comestibles contenant du cannabis soient légalisés plus tard cette année. Les médecins vétérinaires sont autorisés à
**African Swine Fever:** The CVMA is working with the Canadian Food Inspection Agency and other stakeholders to share and promote information to prevent African Swine Fever from infecting the Canadian pig population. As well, the Association has offered the federal government the assistance of its Canadian Veterinary Reserve, made up of volunteer veterinarians who can be deployed in case of major foreign animal diseases or civil emergencies involving animals.

**Importation of Dogs:** The CVMA is concerned about the movement of dogs from other countries to Canada that could result in importation of diseases, both canine diseases and zoonoses such as leishmaniasis, *Brucella canis* infection, and rabies. For the past few years, the CVMA has tried to address this issue by organizing discussions with a number of national stakeholder organizations with similar concerns. To increase awareness, the Association created a checklist for veterinarians and the public and it continues to advocate with the federal government to address this issue.

**Service Dogs:** As a government-led stakeholder approach to setting standards was not successful, the CVMA is now working on a position statement and/or guidelines on Service Animals that represents a broadened scope. The Association has conducted an environmental scan of service animal policies in governments and veterinary member associations in the United States, the United Kingdom, Australia, and New Zealand.

**Antimicrobial Use:** Since late 2018, all antimicrobials for animals are accessible through a veterinary prescription only (including antimicrobials in feed and water). The CVMA, together with government and other stakeholders, has been assisting this important transition through the provision of resources and information.

The CVMA has developed new web-based CVMA Guidelines for Veterinary Antimicrobial Use for 6 species groups: beef; small ruminants; dairy; companion animals (canine, feline); swine; and poultry. In the next phase, the CVMA will add guidelines for equine and aquaculture.

Over the next few years, the CVMA will also develop an antimicrobial use surveillance pilot, including food animal veterinary practices. It is the intention to collect these data through electronic veterinary prescriptions, as well as dispensing data from the feed mills. The data will serve to ameliorate antimicrobial stewardship and provide data needed by the World Organisation for Animal Health (OIE).

**Veterinary Technician Program Accreditation:** Council approved the full accreditation of the Vanier College Animal Health Technology Program, Saint-Laurent (Montreal), Quebec. There are currently 19 CVMA-accredited veterinary technician programs across Canada.

**National Examining Board (NEB):** Within the first 6 months of 2019, 245 applicants registered with the NEB compared to 379 over a 12-month period in 2018. Out of these 245 applicants, 105 are from international AVMA/CVMA-CoE accredited colleges.

In the first 6 months of 2019, the NEB issued 497 Certificates of Qualification, which compares to 531 for a 12-month period in 2018. The Certificate of Qualification makes veterinarians eligible to apply for licensure in all jurisdictions in Canada. 

prescribe and to vend des médicaments homologués contenant des cannabinoides, y compris des médicaments pour humains utilisés hors homologation. Cependant, il n’existe actuellement aucun médicament vétérinaire et un seul médicament homologué pour humains qui ne convient pas aux animaux. La Direction des médicaments vétérinaires du Canada a approuvé des essais cliniques pour des médicaments vétérinaires contenant des cannabinoides, mais il s’écoulera de 6 à 10 ans avant leur commercialisation. Les seuls produits de cannabis approuvés pour les animaux disponibles à l’heure actuelle sont les produits de santé vétérinaires à base de chanvre qui, en fait, ne contiennent pas de cannabinoides concentrés, y compris le cannabidiol (CBD), n’ont aucune indication homologuée concernant la santé, et sont vendus au détail. L’ACMV préconise l’inclusion des médecins vétérinaires dans la loi sur le cannabis à des fins médicales, et l’ajout d’une mise en garde dans les monographies disant de garder les produits de cannabis pour humains hors de la portée des animaux de compagnie.

**Peste porcine africaine:** L’ACMV collabore avec l’Agence canadienne d’inspection des aliments et d’autres intervenants pour partager et diffuser l’information pertinente afin de prévenir l’infection du cheptel porcin canadien par la peste porcine africaine. De plus, l’Association a offert au gouvernement fédéral l’aide de sa Réserve vétérinaire canadienne, composée de médecins vétérinaires volontaires qui peuvent être mobilisés en cas de maladie animale étrangère grave ou d’urgence civile impliquant des animaux.

**Importation de chiens:** L’ACMV s’inquiète des mouvements de chiens entre d’autres pays et le Canada qui pourraient entraîner l’importation de maladies, qu’il s’agisse de maladies canines ou de zoonoses comme la leishmaniose, l’infection par *Brucella canis* ou la rage. Au cours des dernières années, l’ACMV a organisé des discussions avec plusieurs organisations nationales d’intervenants partageant les mêmes préoccupations. Pour accroître la sensibilisation, l’Association a créé une liste de contrôle à l’intention des médecins vétérinaires et du public et elle continue de plaider auprès du gouvernement fédéral pour régler ce problème.

**Chiens d’assistance:** L’approche adoptée par le gouvernement pour établir des normes n’ayant pas abouti, l’ACMV travaille actuellement sur la rédaction d’un énoncé de position et/ou de lignes directrices sur les animaux d’assistance ayant un champ d’application élargi. L’Association a analysé les politiques relatives aux animaux d’assistance des gouvernements et des associations vétérinaires aux États-Unis, au Royaume-Uni, en Australie et en Nouvelle-Zélande.

**Utilisation des antimicrobiens:** Depuis la fin de 2018, tous les antimicrobiens pour animaux ne sont accessibles que sur ordonnance d’un médecin vétérinaire (y compris les antimicrobiens à administrer dans les aliments et dans l’eau). L’ACMV, de concert avec le gouvernement et d’autres intervenants, a contribué à cette transition importante en fournissant des ressources et de l’information.

L’ACMV a élaboré de nouvelles directives en ligne sur l’utilisation des antimicrobiens vétérinaires pour six groupes d’espèces: les bovins de boucherie, les petits ruminants, les bovins laitiers, les animaux de compagnie (chiens et chats), les porcs, et la volaille. Lors de la prochaine phase, l’ACMV ajoutera des lignes directrices pour les chevaux et l’aquaculture.

Au cours des prochaines années, l’ACMV développera également un projet pilote de surveillance de l’utilisation des
Council on Education: For decades, the CVMA has been a member of the AVMA CoE. All 5 Canadian veterinary colleges are AVMA/CVMA-CoE accredited. So far this year, the CVMA has participated in 5 college site visits and will be visiting another 4 colleges this year. Currently, 50 veterinary colleges are accredited: 30 in the United States, 5 in Canada, 1 in France, 4 in Australia, 1 in New Zealand, 3 in Great Britain, 1 in Ireland, 1 in The Netherlands, 1 in South Korea, 2 in the West Indies, and 1 in Mexico.

Business Management: The 2018 national economic and trends reports were submitted to Council and presented during the Provincial Forum. Some of the many findings include: number of current and new clients are down from last year; revenues are climbing; expenses are under control; net income is increasing; associate veterinarian compensation is growing nationally and in most provinces. Details can be found on the CVMA website.

Tick Awareness: For the 4th year, the CVMA, in partnership with industry, delivered the national Tick Awareness Month with the objective of raising public awareness on the most pressing questions about ticks and tick control. Target groups are pet owners, veterinarians, veterinary technicians, and the media. The CVMA relied heavily on social media (Twitter, Facebook, Instagram) and promoted the campaign through The Canadian Veterinary Journal, provincial veterinary associations, industry publications, its online newsletter and media. The CVMA launched a new educational website for Canadian pet owners (www.TickTalkCanada.com).

Mental Health: While 1 in 5 Canadian veterinarians and technologists has reported thoughts of suicide, burnout, and depression, most will be cautious about talking to a co-worker, friend, or family member about it. They are even less likely to adopt self-care strategies or seek professional help. This fall, the CVMA and Merck Animal Health will partner to launch It’s time to talk about mental health awareness week. The objective of the campaign is to start having open and honest conversations about mental health in the veterinary community to help break down the stigma and create a community of support wherein veterinary team members help each other.

As part of the campaign, material such as a webinar, social media posts, mental health resources, and prevention tools to help recognize burnout will be produced and distributed to the veterinary community.

2020 CVMA Convention: Council approved the 2020 Convention Program. Some of the new features will include: A Plenary Session on Friday; antimicrobials, y compris des pratiques vétérinaires pour les animaux de consommation. La surveillance devrait s’effectuer avec les données des ordonnances vétérinaires électroniques et les données provenant des usines d’aliments pour animaux. Les résultats serviront à améliorer la gestion des antimicrobiens et fourniront les données dont a besoin l’Organisation mondiale de la santé animale (OIE).

Agreement des programmes de TSA/TV : Le conseil a approuvé l’agrément complet du programme de techniques de santé animale du Collège Vanier, situé dans l’arrondissement Saint-Laurent de la ville de Montréal, au Québec. Il existe actuellement 19 programmes de TSA/TV agréés par l’ACMV au Canada.


Au cours des six premiers mois de 2019, le BNE a délivré 497 certificats de compétence, comparativement à 531 pour une période de 12 mois en 2018. Le certificat de compétence permet aux médecins vétérinaires de présenter une demande de permis dans toutes les juridictions du Canada.


Gestion commerciale : Le rapport économique national et les tendances pour 2018 ont été soumis au conseil et présentés lors du forum provincial. Voici quelques-unes des nombreuses conclusions : le nombre de clients actuels et nouveaux est en baisse par rapport à l’année dernière ; les revenus augmentent ; les dépenses sont maîtrisées ; le revenu net augmente ; la rémunération des vétérinaires associés est en augmentation à l’échelle nationale et dans la plupart des provinces. Consultez le site de l’ACMV pour les détails.

Sensibilisation aux tiques : Pour la 4e année, l’ACMV, en partenariat avec l’industrie, a organisé le mois national de sensibilisation aux tiques dans le but de sensibiliser le public aux questions les plus pressantes concernant les tiques et la maîtrise des tiques. Les groupes cibles sont les propriétaires d’animaux, les médecins vétérinaires, les techniciens en santé animale et les médias. L’ACMV a beaucoup utilisé les médias sociaux (Twitter, Facebook, Instagram) et a fait la promotion de la campagne dans La Revue vétérinaire canadienne, auprès des associations vétérinaires provinciales, dans des publications de l’industrie, dans son infolettre en ligne et dans les médias. L’ACMV a lancé un nouveau site Web éducatif pour les propriétaires d’animaux de compagnie canadiens (www.TiqueToCanada.com).

Santé mentale : Bien qu’un médecin vétérinaire et technicien en santé animale canadien sur cinq ait signalé avoir des idées suicidaires ou souffrir d’épuisement professionnel ou de dépression, la plupart hésitent à en parler à un collègue, à un ami ou à un membre de la famille. Il est donc encore moins probable qu’ils tentent d’adopter des stratégies pour prendre soin d’eux-mêmes ou d’obtenir de l’aide professionnelle.

Cet automne, l’ACMV et Merck Santé animale s’unissent pour lancer la Semaine de sensibilisation «Il est temps de parler de santé mentale en médecine vétérinaire». L’objectif de la campagne est d’amorcer une discussion ouverte et honnête à propos de la santé mentale au sein de la collectivité vétérinaire, afin d’aider à dissiper les préjugés et de créer une communauté de soutien au sein de laquelle les membres des équipes vétérinaires s’entraident.
Dans le cadre de la campagne, du matériel (webinaire, publications pour les réseaux sociaux, ressources en santé mentale et outils de prévention pour aider à reconnaître l'épuisement professionnel) sera produit et distribué à la communauté vétérinaire.


Happy Animal Health Week! Veterinary Teams Across Canada Unite to Promote Optimal Nutrition for Optimal Health!

Bonne semaine de la vie animale! Les équipes vétérinaires du Canada s’unissent pour promouvoir une nutrition optimale pour une santé optimale!

This month, we celebrate Animal Health Week from October 6 to 12, 2019. The Canadian Veterinary Medical Association (CVMA) is highlighting the importance of nutrition through its campaign slogan, “Optimal Nutrition for Optimal Health: Talk to Your Veterinary Team about Your Animal’s Dietary Needs.”

This year’s theme is an opportunity to remind animal owners about the importance of seeking professional veterinary advice regarding what and how much they feed their animals based on species, age, and overall health. Eating a balanced diet is as important for our pets, livestock, and other animals as it is for us. Proper nutrition can help set the stage for our animals to live healthy lives.

During this Animal Health Week, the CVMA is emphasizing that:

• Optimal nutrition is central to optimal health and well-being.
• Diets must be appropriate for species, breed, age, and health status of an animal.
• Portion control is of utmost importance — obesity is a leading cause of illness and premature death in overfed animals.
• All diets, prepared commercially or at home, must be formulated with appropriate balances of essential nutrients as required by your animal.
• Speak to your veterinary team for advice on types and amounts of food your animal needs.

Ce mois-ci, nous célébrons la Semaine de la vie animale du 6 au 12 octobre 2019. L’Association canadienne des médecins vétérinaires (ACMV) souligne l’importance de la nutrition par le slogan de sa campagne, «Nutrition optimale = Santé optimale : Consultez votre équipe vétérinaire pour vous renseigner sur les besoins alimentaires de votre animal».

Le thème de cette année rappelle aux propriétaires d’animaux qu’il est important de demander conseil à un professionnel vétérinaire pour savoir quels aliments et quelle quantité donner à leur animal en fonction de son espèce, de son âge et de son état de santé général. Une alimentation équilibrée est aussi importante pour les animaux de compagnie, le bétail et les autres animaux que pour nous. Une bonne nutrition peut aider les animaux à vivre en santé.

Durant la Semaine de la vie animale, l’ACVM soulignera l’importance des points suivants :

• Une nutrition optimale est essentielle pour une santé optimale.
• La diétetique doit être appropriée pour l’espèce, la race, l’âge et l’état de santé de l’animal.
• Le contrôle des portions est crucial — l’obésité est l’une des principales causes de maladie et de mort prématurée chez les animaux qui consomment trop de nourriture.
• Tous les aliments, qu’ils soient préparés dans le commerce ou à la maison, doivent être formulés selon des apports appropriés de nutriments essentiels conformément aux besoins de l’animal.
Social media
The CVMA has promoted Animal Health Week for over 30 years. The Association invites you to share your celebrations on Facebook (facebook.com/CanadianVeterinaryMedicalAssociation), Twitter (in English @CanVetMedAssoc and in French @Assoccanmedvet), and Instagram (@cvma.acmv) using the hashtag #AnimalHealthWeek. Please also tag us in your social media posts to be featured in our social media promotions.

Our sponsors
Generous support of the 2019 Animal Health Week campaign is provided by Principal Sponsor, Royal Canin, and Program Sponsors, iFinance Canada (Petcard) and The Personal Home and Auto Insurance.

The CVMA would not be able to carry out the important educational campaign that Animal Health Week is without the generous support of our sponsors and the dedication of veterinary teams throughout the country. Thank you.

During this week-long campaign many veterinary clinics and hospitals host open houses, plan dog washes, organize pet poetry or photo contests, and clinic tours. Some veterinarians visit school children or appear on television to talk about animal health care.

Canadian Veterinary Students Join International Working Professionals at the 2019 WSAVA/CVMA Convention for the Emerging Leaders Program

From July 16–19, the 44th World Small Animal Veterinary Association (WSAVA) World Congress and concurrent 71st Canadian Veterinary Medical Association (CVMA) Convention took place in Toronto, Ontario.

One of the highlights for students attending the conference was the Emerging Leaders Program; this year’s focus was how veterinarians can make their practices both “productive and fun.” The workshop lasted 2 days and comprised lectures and interactive exercises.

Experienced equine surgeon Dr. Richard DeBowes facilitated the program. He serves as associate dean for Veterinary Development and External Relations and works as a professor at Washington State University. He works with veterinary students and working professionals to help increase both their quality of

• Les propriétaires d’animaux devraient consulter leur équipe vétérinaire pour se renseigner sur le type et la quantité d’aliments dont leur animal a besoin.

Réseaux sociaux
L’ACMV fait la promotion de la Semaine de la vie animale depuis plus de 30 ans. Elle vous invite à partager vos célébrations sur Facebook (facebook.com/CanadianVeterinaryMedicalAssociation), Twitter (@CanVetMedAssoc en anglais et @Assoccanmedvet en français), et Instagram (@cvma.acmv) à l’aide des mots-clics #AnimalHealthWeek et #SemaineDeLaVieAnimale. Veuillez également nous identifier dans vos publications sur les médias sociaux pour figurer dans nos promotions sur les médias sociaux.

Nos partenaires
La campagne de la Semaine de la vie animale 2019 est généreusement appuyée par le commanditaire principal, Royal Canin, et les commanditaires du programme, iFinance Canada (Petcard) et La Personnelle Assurance auto et habitation.

L’ACMV ne serait pas en mesure de mener l’importante campagne de sensibilisation que constitue la Semaine de la vie animale sans le soutien de ses commanditaires et le dévouement des équipes vétérinaires du pays. Merci!

Au cours de cette campagne d’une semaine, de nombreux établissements vétérinaires organisent des journées portes ouvertes, des séances de lavage de chien, des concours de poésie ou de photos, ainsi que des visites guidées. Certains médecins vétérinaires vont parler des soins de santé pour animaux dans les écoles ou à la télévision.

Canadian Veterinary Students Join International Working Professionals at the 2019 WSAVA/CVMA Convention for the Emerging Leaders Program

Des étudiants en médecine vétérinaire canadiens réunis avec des professionnels internationaux dans le cadre du Programme des futurs leaders 2019 lors du Congrès conjoint de l’ACMV/WSAVA

Du 16 au 19 juillet, le 44e Congrès mondial de la World Veterinary Veterinary Association (WSAVA) et le 71e Congrès de l’Association canadienne des médecins vétérinaires (ACMV) ont eu lieu à Toronto, en Ontario.

L’une des activités marquantes pour les étudiants participants était le Programme des futurs leaders, axé cette année sur les façons dont les médecins vétérinaires peuvent rendre leurs pratiques à la fois productives et agréables. L’atelier, qui durait deux jours, comprenait des conférences et des exercices interactifs.

Le Dr Richard DeBowes, chirurgien équin d’expérience, a animé le programme. Enseignant et vice-doyen à la Washington State University responsable du perfectionnement vétérinaire et des relations extérieures, il travaille avec des étudiants en médecine vétérinaire et des professionnels pour les aider à améliorer
life and the efficiency of their practice. He stresses the importance of professionalism, individuality and most importantly joy.

The workshop started with a mindful exercise: participants were asked to reflect on the clinics at which they were or have been employed. They were then asked to identify personal core values and examine how these lined up with workplace cultures and practices.

Participants went on to describe leadership and what it looks like to them, narrowing in on the relationship between what we think, what we feel, and what we do. This was accompanied by icebreaker activities in which participants had to step out of their comfort zones to accomplish simple tasks, utilizing personal and team leadership abilities.

The 1st day’s session ended with closing remarks acknowledging the 2 aspects of the veterinary profession, namely that a veterinary practice is a business in addition to a service. Discussion ensued on how to best manage these 2 priorities.

L’efficience de leur pratique et leur qualité de vie. Il insiste sur l’importance du professionnalisme, de l’individualité et, surtout, de la joie.

L’atelier a commencé par un exercice de réflexion: les participants ont été invités à penser aux cliniques dans lesquelles ils avaient été ou étaient employés. Ils ont ensuite déterminé leurs valeurs personnelles fondamentales et examiné comment ces valeurs s’harmonisaient avec les cultures et les pratiques en milieu de travail.

Les participants ont ensuite décrit le leadership et ce qu’il signifie pour eux, en précisant le lien qui existe entre ce que nous pensons, ce que nous ressentons et ce que nous faisons. Ce cheminement a été accompagné d’activités permettant de «briser la glace» au cours desquelles les participants ont dû sortir de leur zone de confort pour accomplir des tâches simples, en utilisant leurs habiletés personnelles et leurs capacités de leadership d’équipe.

La première journée s’est terminée par une allocution de clôture soulignant les deux aspects de la profession vétérinaire, à savoir qu’un établissement vétérinaire est une entreprise en plus d’être un service. Une discussion a suivi sur la meilleure façon de gérer ces deux priorités.

Le Dr DeBowes a encouragé les participants à imaginer à quoi ressemblerait une expérience de pratique idéale pour le client. Il leur a demandé comment seraient les cliniques si elles étaient gérées par Disney, en insistant à plusieurs reprises sur l’importance de respecter les clients, de valoriser leur temps et de les traiter comme des invités.

La deuxième journée a été consacrée à la manière d’appliquer les connaissances acquises lors de la séance précédente au
Dr. DeBowes encouraged participants to imagine what an ideal practice experience would be like for the client; he asked what clinics would look and feel like if they were run by Disney, repeatedly stressing the importance of honoring the clients and their time, and treating them as guests in veterinary establishments.

The 2nd day focused on how to apply what had been learned in the previous session through team-building exercises. Participants spoke up and stepped up to leadership roles, while simultaneously relying on one another to accomplish target goals. This reflected the main focus of the day: strong leaders bring about change and achieve the desired goals.

Dr. DeBowes also spoke about group cultures and how to improve group morale, teamwork and overall harmony. He also addressed veterinary paradigm shifts including the increasing number of female veterinary professionals, new approaches to pain management, and developments pertaining to prudent antibiotic usage. Subsequently, participants were encouraged to be active leaders in both their practices and personal lives to prepare for impending paradigm shifts that will influence the future of the profession.

Dr. DeBowes concluded by demonstrating how to conduct a good recruitment interview, as well as what traits to look for when hiring a new employee: hunger, humility, and emotional intelligence. He also encouraged students to start with “why” we are in this profession, and that “what” we do in it will follow.

Following Dr. DeBowes’ presentation on the 2nd day, the program sponsor, Virox Animal Health, brought in 2 guest speakers for a question and answer session. Founder Dr. Michelle Lem and clinic head and board member Dr. Susan Kilborn from Community Veterinary Outreach shared tips on caring for animals whose owners are homeless; they also expanded on their other areas of expertise, including mental health and wellness inside and outside of the practice; staff and client relationships; compassion; and fatigue and burnout. Their conversational approach to difficult topics created a welcoming atmosphere and participants who had been strangers a day before became both open and vulnerable with one another as they shared their stories and struggles. This one-hour session fostered a sense of unity within the group and participants left the program bolstered by a sense of the wonderful community that the veterinary profession creates for and with one another.

Over the course of the Emerging Leaders Program, Dr. DeBowes facilitated individual and group development of interpersonal and leadership skills with a constant focus on morality and the need for a daily source of joy. He will be presenting a similar Student Leadership Workshop at the University of Calgary's Faculty of Veterinary Medicine in the coming school year and has also presented at the Ontario Veterinary College as well as the Western College of Veterinary Medicine in past years. I would encourage students and working professionals to attend both of these programs to allow their leadership skills, goal setting and sense of greater purpose in the veterinary profession to flourish in this challenging, encouraging and supportive setting.

(by Emma Bush, AVC SCVMA 2019–2020 Representative)
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Achieving humane outcomes in killing livestock by free bullet II: Target selection

Dennis D. Will, Terry L. Whiting

Abstract — Killing infected or surplus-to-market livestock by free bullet is unavoidable in Foreign Animal Disease response in countries exporting large numbers of live animals. Correct targeting and placement of free bullet projectiles result in immediate death, thereby making this method acceptable for humane animal killing. Regulatory veterinarians will be responsible for animal welfare in overseeing emergency killing of livestock by free bullet. To assure humane fatal penetrating brain injury under field conditions, veterinarians as operational experts, need to fully understand the anatomy of all farmed animals and the pathophysiology of the terminal ballistics of weapon systems to make appropriate, on the ground decisions, in emergency situations.

Résumé — Atteinte de résultats humanitaires lors de l’abattage de bovins par balles de fusil II : Sélection de la cible. L’abattage par balles de fusil de bovins infectés ou en excès pour le marché est inévitable lors de la réponse à l’apparition d’une maladie exotique dans les pays exportant de grandes quantités d’animaux vivants. La mise-en-joue et le placement appropriés de balles de fusil résultent en mort immédiate, rendant ainsi cette méthode acceptable pour l’abattage humanitaire d’animaux. Les vétérinaires d’agences réglementaires seront responsables du bien-être animal en supervisant l’abattage d’urgence par balles des bovins. Afin d’assurer une blessure cérébrale pénétrante fatale dans des conditions de terrain, en tant qu’experts opérationnels, les vétérinaires doivent comprendre à fond l’anatomie de tous les animaux de la ferme et la pathophysiologie de la balistique terminale des armes afin de prendre les décisions appropriées sur le terrain lors de situations d’urgence.

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Introduction

Slaughterhouse stunning of animals using a captive bolt (CB) and field humane euthanasia by firearm utilize penetrative brain injury to induce immediate unconsciousness, respiratory arrest (apnea), and death. Scientific literature on penetrating brain injury (PBI) originates largely from human military and civilian case studies (1,2) and from experimental models (3,4). In feral pest animal control by firearm “head-shot” is the goal as it causes immediate loss of sensibility and death. Head-shooting free ranging ruminants for commercial meat or pest control is achievable. Night shooting of kangaroo by firearm “head-shot” is confirmed on the majority of harvested carcasses. High-powered rifle and expanding projectile systems were employed and long distance over 100 m shots were taken. Wind speed was identified as a primary cause for weapon system failure presumably because of a combination projectile drift and decreased visibility. Processing was halted in situations of significant wind and blowing snow (D. Will, unpublished data).

In human medicine, ballistic penetrating brain injury (PBI) has a very high case fatality rate. Civilian gunshot wound to the head is commonly self-inflicted, most often utilizes low energy .22 rimfire projectiles, and is most often fatal (6). In a series of 786 patients in the State of Maryland with gunshot wound to the head, 712 (91%) eventually died with 594 dying at the scene; no data on the type of firearm was reported (2). Current medical animal use ethics is in conflict with experiments using live animals and inducing penetrating brain injury (7); ongoing research tends to use models, other knowledge is gained by abattoir and killing for disease control studies.

Biomechanical effect of bullet to the brain

The transference of kinetic energy of projectiles during soft tissue penetration has been extensively investigated. Soft tissue injury is caused by the formation of a permanent cavity due to direct tissue crushing by the projectile and tissue is also stretched by creation of a temporary cavity due to lateral pressure causing
tissue expansion away from the moving projectile. The lateral pressure of a missile in the brain encased in an intact cranium can create a temporary cavity of only limited size as brain tissue is forced into regions of less resistance such as the frontal sinus and various foramina of the skull. The cranium has limited ability to stretch, when that limit is exceeded skull bones are torn apart along suture lines (8,9). Gunshot wound to the brain is known to involve the development of high pressures based on volume and speed of back splatter patterns (10) and pressure measurement in simulant and animal models (11–13). In a histological review of 42 cases of fatal handgun penetrating brain injury the mechanism of death was consistent with acute intracranial pressure on the brain stem from the passage of the missile through the brain (14). With very high energy projectiles, massive skull fracture and displacement of the brain (15) has been described in human forensic medicine.

The ballistic behavior of the .22 caliber rimfire system is widely documented. The .22 caliber firearms and ammunition are widely available and frequently used in human assault with firearm (6). The average .22 long rifle (LR) weapon system has sufficient kinetic energy (140 to 200 J) for solid ball projectiles to penetrate the human torso and stop under the elastic skin at the point where a larger caliber firearm would exit and perforate the torso (16). The .22 LR has ample energy to penetrate the human skull and has had military application in WWII and Vietnam primarily in covert assassination by close range PBI (17).

In small abattoir application in Saskatchewan, experienced workers have no difficulty in stunning American bison (Bison bison) cows and young bulls using .22 LR in situations in which the bison are well-restrained in a knocking box. Mature bull bison require the use of a .30 calibre center fire weapon system (.30 M1 carbine) to penetrate the thick hide and skull of this species. Penetration of the calvarium by free bullet or CB (18) is necessary for successful stunning.

Captive bolt pistol physics
Captive bolt (CB) technology (slaughterer’s guns, livestock stunners) started at the beginning of the 20th century with various tools to hold a bolt over the target area of the slaughter animal skull and then a second worker to drive the bolt into the brain with a heavy hammer (19). The modern penetrating bolt is intended to physically penetrate deeply in the calvarium to damage the reticular formation or the ascending reticular activating system, anatomically the thalamus in the anterior brainstem (20). Captive bolts are high mass, slow, 50 m/s, low energy tools to create penetrating brain injury. The penetrating end of the sliding bolt has an outside cutting edge which cuts a circular plug of skin, tissue, and skull and drives that plug some distance, 6 to 9 cm, into the brain tissue without creating secondary missiles of bone chips (21). After skull penetration, much of the remaining energy is converted into stress in the rubber compression washers or internal spring which provide automatic retraction of the bolt from the skull (22). If the bolt effectively penetrates the braincase (sheep model) the animal will be successfully stunned (23). In addition to frequent failure in male adult bison, the short bolt penetration limits effectiveness in livestock with pronounced frontal sinuses such as the Asian water buffalo (Bubalus bubalis). Free bullet stunning has been tested and specific ammunition recommended for this species (Geco .357 Magnum Hollow Point, 158 gr, 10.2 g, 796 J) (24).

Engineered to deliver 400 J or less (21), the action of the bolt pushing through brain tissue does not create a temporary cavity; however, the permanent cavity is significantly larger than with free bullet as the bolt is typically 10 to 12 mm in diameter, whereas the .22 rimfire is 5.56 mm in diameter (25). It is unlikely that livestock stunned with a CB develop sufficient intracranial pressure to sustain distant axonal injury in the midbrain or the brainstem as do livestock killed with a free bullet (26).

Using live sheep at the time of slaughter, Finnie (27) compared the extent of brain trauma between a commercial CB pistol (Schermer ME, Ettlingen, Germany, no longer in production) and two .22 rimfire projectiles. The CB had a penetration depth of 8 cm (27) and diameter of 12 mm (26). No information was provided on the kinetic energy of the CB. Based on the 1993 brand name of the .22 cartridges tested and current brand names, they may have been “superspeed” (Winchester Super Speed 22LR, Round Nose, 40 gr Lead Core, Copper Plated, 1265 ft/s) 193 J and “subsonic” (.22 Winchester Subsonic 42 Max Rimfire Ammo, Lead, Hollow Point 42 grain, 1065 ft/s) 143 J. In this study which targeted the temporal area of fresh sheep heads the hollow point bullets (low energy) were contained within the cranium while the solid point bullets (high energy) perforated the skull. The 143 J hollow point projectile typically fragmented early in the penetration of the skull accelerating bone fragments into the brain tissue. The bullet material was retained within the skull (7 sheep) or lodged in the subcutaneous tissue on the contralateral side (3 sheep). The experimental animals were not monitored for apnea post injury. On histological examination the projectiles caused distant brain injury consistent with temporary cavity and high pressure shear injury within the cranium, whereas the CB injury was largely limited to the compressed tissue of the permanent cavity (27).

The intracranial pressure effects that mediate the severe brain trauma of ballistic PBT are absent or much diminished in the application of the CB (25). Captive bolt kills by tissue damage alone while penetrating missiles can accelerate secondary bone fragments and distant injury due to the creation of intracranial overpressures.

The physics of ricochet
One example of field testing of firearm systems for emergency slaughter of cattle emphasized the need to ensure that the longitudinal axis of the projectile impacted the frontal bone at an 85° to 90° angle…. to ensure proper targeting of the brain and brainstem and minimize the risk that the projectile ricochets (28). There is no scientific evidence, nor do the principles of Newtonian physics allow for a soft medium such as hair-skin-tissue-bone of the skull to significantly deflect the line of trajectory of common small arms bullets at angles of incidence where a competent shooter would operate.

In 1969, the Federal Bureau of Investigation (FBI) published an article in their journal, the “Law Enforcement Bulletin” on how to utilize hard surfaces like concrete and brick walls to
indirectly shoot a target. That is to intentionally target a hard surface to ricochet a bullet (.38 Special, rifled 12 ga. slug) and strike a target that is not in the direct line of sight. A 22.5° angle of incidence provided the most predictable bullet bounce. Rifle projectiles travelling in the 1000 m/s range did not result in ricochet in this study as they disintegrated on impact with the hard surface (29).

There is a critical angle of incidence for any hard surface and projectile; above this angle the projectile will penetrate the surface. Slow projectiles (< 300 m/s) can ricochet where high speed projectiles will not. Projectiles lose 10% to 20% of their velocity on hard surface deflection and leave the hard surface at a lower angle than the angle of incidence (30,31). Shotgun slugs (velocity: 370 m/s) and rifle bullets (velocity: 740 m/s) can be made to ricochet from frozen or unfrozen concrete at an incident angle between 5° and 35° (shotgun), 2° to 20° (rifle), all tested ammunition showed remarkably high variations in the ricochet's angular deviation (32).

Puddles of water have been identified as a ricochet hazard in the urban law enforcement environment. Using 9-mm FMJ (7.4 g, 115 gr, 407 m/s, 617 J) the critical angle of ricochet was 6.5°. At a critical angle of 6.6° the bullet consistently submerged. At angles greater than 4.1° the projectile tumbled upon exit from the water surface. This experiment demonstrated that bullets did not skip off the water but hydroplaned on the surface a distance of up to 62 cm (33).

If ricochet is defined as any measurable deviation in trajectory, then bullets can “ricochet” by tangential wounds to the human skull, more commonly described as a grazing gunshot injury. Grazing or tangential human gunshot injury typically results in a comminuted depressed fracture of the skull at the impact site (34,35) and intracranial hemorrhage (36). A skin-skull-brain model has been developed to better understand the grazing gunshot wound in humans (7,37).

Ricochet, in ballistic terms, bears no resemblance to the billiard table concept of slow-moving objects bouncing off one another. However, in penetrating brain injury there can be ricochet within the skull where energy depleted projectiles are unable to penetrate the internal lamina of the skull and rebound to cause an extended wound tract in the brain parenchyma (6,14,38). Ricochet as a risk of injury to others, in the case of livestock killing with free bullet is minimal and similar to the risk of missing the target, and risk of over-penetration.

**Bullet placement**

Penetrating the cranial vault is the single most important factor influencing the capacity of a bullet to cause immediate or rapid physiological incapacitation and death. Any projectile penetrating the cranium with residual energy of even a few Joules will cause a hydraulic pressure spike and acute brain dysfunction stunning of the animal. In battlefield triage, any penetrating head wound in a comatose patient combined with flaccid skeletal muscle is recognized as a predictor of imminent death due to midbrain injury (39). Pithing of cattle post-CB stunning physically destroys the brain stem and results in a flaccid carcass which enhances the worker safety when hoisting cattle for bleeding (40). Pithing has been recommended whenever a bovine animal has to be euthanized without exsanguination (41).

Traditional landmarks on the external surfaces of food animals for effective humane stunning are derived from industry experience in large slaughter plants using CB pistol with a limited penetration depth and a nearly immobilized target. The system is designed to have the bolt make perpendicular contact with the front of the animal’s skull. Restraint limits the possible movement of the animal’s head. Brainstem penetration in youthful feeder cattle using this approach is readily achieved (42), but not necessary in an industrial process where the animal will be immediately exsanguinated once stunned.

Guidelines for humane killing with penetrating bolt usually use pictorial graphics that right-angle “target” the front of the skull with the limited bolt reach. The American Veterinary Medical Association (AVMA) Euthanasia and Slaughter
Guidelines currently suggest the penetrating captive bolt (PCB) be placed perpendicular to the skull at an anatomic site defined as on the intersection of 2 lines each drawn from the lateral canthus of the eyes to the base of the opposite horn. An alternate method for identifying this anatomic site is on the midline of the forehead or skull half-way between 2 lines, one drawn laterally across the poll and the other from lateral canthus to lateral canthus of each eye (43). When the PCB is held perpendicular to the skull for maximum penetration depth, the bolt is directed toward the diencephalon and midbrain. The pons and medulla oblongata are not directly targeted using this external anatomic guidance. In actual application brain stem structures are frequently crushed because slight tilting of the PCB will direct the bolt caudally toward these structures.

With the use of free bullet, minimizing the risk is over penetration and direct targeting of the pons and medulla oblongata is the objective. Visualizing the deep target from the front of the skull, the deep target is the point where the spinal canal joins the skull, the atlanto-occipital joint. Physical destruction of the midbrain is an additional safety measure in killing by free bullet as the midbrain is in most cases rendered non-functional by the extreme intra-cranial pressure secondary to temporary cavity formation. In any biological system there are exceptional cases in which calvarium penetration by free bullet will not result in immediate incapacitation.

In free-bullet systems, it is often not desirable or possible to achieve a right angle placement of a firearm trajectory with the line of penetration directed to the atlanto-occipital joint. Operators in the field who attempt to humanely kill tall horses using a firearm designed to be operated with 2 hands while standing at ground level in front of an animal, will find they are too short to achieve a right angle shot with the butt of the firearm against the shoulder. In human populations of European descent the average height of males is 178 cm and the average female is 165 cm ± 7 cm (44). A saddle or draft horse standing in an alert position will have skull positioned considerably higher than the shoulder of a person standing on the same elevation. In killing with free bullet midbrain target is available from a wide range of angles (Figure 1).

The brainstem in all food animals is located at the floor of the cranial cavity, at the level of the internal acoustic meatus and midway between the bases of the attachment of both ears. To be consistently effective in field situations the operator must target the brainstem by planning each shot to the animal’s head in 3 dimensions. This is accomplished by looking at the animal’s head and ears and visualizing the location of the brainstem within the head. The bullet entry point on the surface of the animal’s head is adjusted as required (dorsally, ventrally, or laterally).

In field situations of free-bullet killing, the options for the bullet entry point on the external surface of the animal’s head can be any point along a semi-circle that starts near one temple and extends across the frontal bone to the opposite temple. The brainstem is the center or axis of this semi-circle. The firearm can be discharged from a position directly in front of the animal, or to the left or right of the medial plane of the animal’s head, as long as the brainstem and midbrain are the primary target within the cranium. The entry point on the exterior surface of the head is not a fixed point on the frontal bone necessary in the use of CB of limited penetrating depth (Figure 2).

Modern low energy pistol (< 800 J) penetrating ballistic wounds to the calvarium

Modern controlled expansion handgun projectiles expand up to twice their original penetrating surface area and do not break up during terminal flight. This class of ammunition is commonly referred to as “Safety” bullets as they do not exit the target, or “Action” bullets as their terminal performance is an active process of bullet deformation and expansion of the cross-sectional crushing surface. Action safety projectiles do not perforate the human or similarly sized soft tissue target. In a study using ballistic gelatin, 2 commonly available 9-mm controlled expanding rounds (Hornady XTP and Speer Gold Dot) achieved full expansion at 5 cm of penetration (45). In a study using the skulls of freshly killed market pigs using FMJ and custom built expanding 9-mm projectiles propelled at equivalent kinetic energy, hollow point, Action-4 and soft-point projectiles did not exit the skull and demonstrated complete conversion of kinetic energy to tissue damage (46).

Clinical experience

One author (DW) has spent over a decade auditing humane slaughter in small provincial abattoirs in Saskatchewan and Manitoba, where stunning of large ruminants with free bullet is common. Although in theory, ballistic penetration of the brain case should result in stun/death, evidence from splitting skulls from free bullet stunning, indicates that consistent effective stunning is assured only by penetration and physical disruption of the brainstem. In split skull examination the further the cranial permanent cavity tract is from the brainstem the greater the chance that it resulted in a poor stun (DM Will, unpublished data).

The preferred skull position targets published in best practices for abattoir CB placement assume the stunner operator is above the animal and the animal isn’t trying to look at the stunner operator (47). When an individual stands in front of animals...
Deterioration of fine motor skills related to operating the load-

equipped with .22 LR flexible nature of this weapon system. In a previously reported system to wide availability, general individual operator familiarity, and emergency or disease control operation requiring free bullet kill-

operator as heavy CB stunners cannot be safely placed on the frontal bone. In our experience free bullet at 0.5 to 1 m muzzle-

Experienced abattoir workers can effectively kill all domestic cattle breeds in Canada and immature bison and bison cows with a .22 LR carbine when the brainstem is targeted. The point of projectile impact with the skull varies on the front of the head (up, down, left, right) to ensure the bullet travels through the brainstem when it travels to/through the cranial vault.

In fractious animals such as bison, free bullet is safer for the operator as heavy CB stunners cannot be safely placed on the frontal bone. In our experience free bullet at 0.5 to 1 m muzzle-head distance is more accurate than attempts with the various CB stunners.

Discussion

This paper does not address the significant risk of failure associated with human fatigue — both mental and physical. In any emergency or disease control operation requiring free bullet killing, the .22 LR weapon system will be initially considered due to wide availability, general individual operator familiarity, and flexible nature of this weapon system. In a previously reported humane killing of surplus to market piglets using the .22 LR system (48) bolt-action and lever action rifle systems failed due to operator issues such as hand cramping, hand blisters, and deterioration of fine motor skills related to operating the loading actions. Auto loading and pump action (uses major muscle groups only) weapon systems were operated for 5 to 6 h without operator injury or obvious debilitating fatigue.

The choice of weapon system to achieve humane killing depends on situation-dependent variables (Figure 3). These are overall operational time pressure (restraint) often time con-

Risk of over-

penetration, missed target, worker fatigue

Figure 3. Considerations in planning or reviewing use of free bullet weapon systems in humane killing of livestock under emergency conditions.

and the skull of the target, and the size of the animal targeted. Where the target is restrained and the muzzle of a tool can be placed on the skull, then CB is the preferred choice using the smallest effective chemical charge to avoid CB overheating concerns and operator fatigue. Small ruminants can generally be physically restrained to allow CB stunning. When the target can be approached to within 1 m muzzle-skull distance such as breeding pigs, many horses, and most dairy cows, the current system of choice would be the .410 shotgun with lead-free, shot loads. The .410 shotgun at < 1 m distance has sufficient energy to reliably kill any livestock as long as the trajectory includes penetration of the cranium. The .410 has almost no recoil and requires less muscular exertion and less fine motor control than chemically fired CB systems. In situations in which the target cannot be closely approached, more than a 1-meter muzzle-target distance, solid projectiles must be used. With solid projectiles, the rate of failure to stun/kill will increase with increasing distance due to targeting error. Experience using sub-

sonic .30 caliber systems in wildlife management where noise and over penetration are a risk, there is very little margin for error in targeting (49). The choice of system at a distance of 1 to 7 m, indoors or in corals is a rifle chambered for appropriate pistol rounds using controlled expanding bullets carrying 400 to 800 J of energy. Lead-free ammunition, both projectile and accelerant, is preferred under all situations in which animals are humanely killed.

The North America meat complex currently operates as a commercial zone disease free without vaccination for foot and mouth disease, hog cholera, and African swine fever. Periodic failure is an inevitable consequence of complex systems. Any system expected to achieve a livestock humane kill using free bullet is also complex and should be accompanied by an active risk and reliability (50) evaluation system. Weapon systems are in continuous development and new products are frequently commercialized. At the time of a North American meat com-

plex failure similar in scope to the British 2001 foot and mouth disease outbreak there may be other specific choices in free bullet weapon systems. The veterinary considerations for any specific recommendation may be informed by the analysis and experience reported in this and sister publication (Can Vet J 2019;60:524–531).

Shooting of animals with free bullet can not guarantee imme-

diate insensibility and death in all animals. All animals should be examined clinically and those showing signs of life should be euthanized before moving the carcass for disposal.

Acknowledgments

No specific funding source is associated with the production of this paper. Dr. Will gratefully acknowledges the many small abattoir and slaughterhouse personnel in Saskatchewan and Manitoba who contributed to his understanding of humane slaughter with free bullets during his career with the Canadian Food Inspection Agency. The line drawing in Figure 2 was done freehand by Willyn R. Whiting, referring to plate 17 "bovine heifer calf, sagittal section of the head", in Popesko P. Atlas of Topographical Anatomy of the Domestic Animals. 2nd ed. Philadelphia, Pennsylvania: WB Saunders, 1978:30.
References

Effect of a short pre-anesthetic fast on arterial blood gas values in isoflurane-anesthetized donkeys

Jill Maney, Erika Little, Tarisai Dzikiti

Abstract — This study compared arterial blood gas parameters in anesthetized adult donkeys after a 5-hour fast (n = 22) or no fast (n = 21). Donkeys were premedicated with xylazine, induced to anesthesia with ketamine and diazepam or midazolam, and maintained with isoflurane in oxygen while breathing spontaneously and positioned in lateral recumbency. Sampling occurred approximately 25 minutes after induction. Arterial pH, bicarbonate concentration, and base excess were higher in fasted donkeys compared to unfasted donkeys. There were no differences in partial pressure of arterial oxygen, partial pressure of arterial carbon dioxide, or arterial lactate concentrations. No advantages of a short pre-anesthetic fast were identified.


Introduction

Observation of a pre-anesthetic fast in horses is recommended in the literature and is a common clinical practice. Withholding food for 8 to 14 h (1) or 8 to 12 h (2) has been recommended in texts with minimal supporting evidence. In theory, a pre-anesthetic fast will decrease gastrointestinal volume and subsequent pressure on the diaphragm and vena cava while the patient is recumbent, thereby improving cardiopulmonary function. However, no differences were found in partial pressure of arterial oxygen (PaO₂) during general anesthesia in fasted versus non-fasted horses (3). In addition, fasting likely affects gastrointestinal function after anesthesia. A trend towards decreased incidence of post-operative colic was shown in fasted compared to unfasted horses undergoing non-abdominal procedures (4). In another study, however, unfasted horses did not have an increased rate of post-operative colic (5).

Donkeys (Equus asinus) are a less common anesthetic patient than horses and are less frequently studied. Multiple anatomic and physiologic differences exist between the species. There are no known published guidelines for pre-anesthetic fasting in donkeys, and practice is mixed. Several studies report an 8- to 12-hour pre-anesthetic fast (6–8), while others report no fast (9–11). The advantages of pre-anesthetic fasting in donkeys would likely be similar to those theorized in horses.

The purpose of this study was to compare arterial blood gas values in spontaneously breathing donkeys under general anesthesia after a short pre-anesthetic fast versus no fast. It was hypothesized that fasted donkeys would have higher PaO₂ and lower arterial partial pressure of carbon dioxide (PaCO₂) after 25 min of general anesthesia with isoflurane in oxygen.

Materials and methods

Ethical approval was obtained from the Institutional Animal Care and Use Committee of Ross University School of Veterinary Medicine, St. Kitts (18.01.01/Maney). Forty-six adult standard donkeys utilized during the spring semester 2018 student surgery laboratory course were eligible for inclusion. Donkeys were anesthetized as part of a student exercise to perform arthrocentesis of 2 joints. Student anesthetists were closely
supervised by veterinary anesthesiologists or trained veterinary technicians. Personnel were not blinded to the treatment groups.

Donkeys were determined to be healthy based upon physical examination, packed cell volume, and total protein measured within 10 d before the procedure. Assignment to the fasted or unfasted group was determined by computer-generated randomization table. Donkeys were group-housed in a dry paddock with water supplied ad libitum and fresh Guinea grass fed twice daily. Approximately 5 h before the induction of anesthesia, the fasted group was placed in a smaller fenced area with access to water but not grass. Both groups had access to grass supplied the afternoon before anesthesia until the time of separation.

Xylazine (Anased; Akorn Animal Health, Lake Forest, Illinois, USA) was administered at 2 mg/kg body weight (BW), IM for sedation to allow jugular catheter placement. A 14-gauge, 13-cm catheter (DAYCATH; MILA International, Florence, Kentucky, USA) was sterilely placed in the left jugular vein after subcutaneous injection of lidocaine. Additional xylazine was administered IV as needed to provide adequate sedation before induction of anesthesia. Donkeys were induced to anesthesia with ketamine (Ketaset; Boehringer Ingelheim Vetmedica, St. Joseph, Missouri, USA), 3 mg/kg BW, IV, and midazolam (Midazolam; West-Ward Pharmaceutical, Eatontown, New Jersey, USA), 0.05 mg/kg BW, IV, or diazepam (Diazepam; Rotexmedica GmbH, Trittau, Germany), 0.05 mg/kg BW, IV. Induction drugs were administered over 5 to 10 s and the donkey was guided into right lateral recumbency on a padded mat. Endotracheal intubation using a 14- or 16-mm internal diameter cuffed tube was performed and the donkey was attached to a Universal-F circuit with oxygen flowing at 4 to 6 L/min. The cuff was inflated to prevent a leak at 20 cm H2O breathing system pressure and isoflurane was initiated at a vaporizer setting of 2%. Positive pressure ventilation was not administered before arterial blood sampling. After approximately 20 min, oxygen flow was decreased to 2 to 3 L/min and isoflurane concentration within 5 min of collection. Donkeys with a measured PaO2 < 80 mmHg had an additional sample drawn by an anesthesiologist or technician in order to verify arterial rather than venous sampling. Donkeys were extubated after a swallow or voluntary movement, recovered by hand, and examined twice daily for at least 1 wk after anesthesia.

A prospective power analysis (G*Power Version 3.1.9.2; Universitat Kiel, Germany) determined that 21 donkeys in each group were required to detect a difference of 90 mmHg in PaO2 with an alpha of 0.05 and beta of 0.20. Statistical analysis was performed using a commercial software package (GraphPad Prism Version 7.00 for Windows; GraphPad Software, San Diego, California, USA). Normality was determined using the Shapiro–Wilk test. For normally distributed data, comparisons between groups were made using an unpaired 2-way t-test. Non-normally distributed data were analyzed using the Mann-Whitney test. The incidence of diazepam, midazolam, xylazine, propofol, ephedrine, and dobutamine administration, and PaO2 < 100 mmHg were compared between groups using a Chi-square test. Significance was set at alpha < 0.05.

### Results

Forty-three of 46 eligible donkeys were included in data analysis. One donkey was excluded due to aggressive behavior and resulting deviation from the premedication protocol, 1 due to unclear data recording, and 1 due to administration of manual positive pressure ventilation before the time of arterial blood sampling. The fasted group included 20 castrated males and 1 fallen gelding, 22 were non-castrated, the unfasted group consisted of 20 castrated males and 1 fallen gelding, and 22 were non-castrated.

#### Table 1. Measured variables [mean ± standard deviation (range)] in fasted and unfasted donkeys during isoflurane anesthesia.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Fasted (n = 22)</th>
<th>Unfasted (n = 21)</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>7.37 ± 0.03 (7.31 to 7.42)</td>
<td>7.32 ± 0.03 (7.26 to 7.37)</td>
<td>&lt; 0.0001</td>
</tr>
<tr>
<td>PaO2 (mmHg)</td>
<td>274 ± 119 (71 to 458)</td>
<td>214 ± 90 (89 to 385)</td>
<td>0.07</td>
</tr>
<tr>
<td>PaCO2 (mmHg)</td>
<td>51.4 ± 4.3 (45.4 to 59.2)</td>
<td>53.5 ± 11 (31.2 to 69.7)</td>
<td>0.42</td>
</tr>
<tr>
<td>HCO₃⁻ (mmol/L)</td>
<td>29.9 ± 3.0 (25.3 to 35.6)</td>
<td>27.4 ± 4.5 (18.2 to 33.6)</td>
<td>0.036</td>
</tr>
<tr>
<td>BE</td>
<td>5 ± 3 (~1 to 11)</td>
<td>1 ± 4 (~8 to 8)</td>
<td>0.007</td>
</tr>
<tr>
<td>Lactate (mmol/L)</td>
<td>1.72 ± 0.52 (1.02 to 3.05)</td>
<td>1.98 ± 0.59 (1.01 to 2.80)</td>
<td>0.13</td>
</tr>
<tr>
<td>Indirect SAP (mmHg)</td>
<td>89 ± 12 (70 to 110)</td>
<td>83 ± 15 (60 to 120)</td>
<td>0.14</td>
</tr>
</tbody>
</table>

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2 female donkeys weighing 122 ± 15 kg (mean ± SD). The unfasted group included 21 castrated male donkeys weighing 122 ± 15 kg. There were no differences between groups in diazepam or midazolam administration, or additional drugs administered (xylazine, propofol, ephedrine, dobutamine). The time of arterial sampling after induction was the same in the fasted (28 ± 9 min) and unfasted (26 ± 7 min) groups. The time from anesthetic induction to extubation was the same in the fasted (95 ± 21 min) and unfasted (94 ± 12 min) groups. There were no adverse events.

Two donkeys in the fasted group and one in the unfasted group had initial PaO2 < 80 mmHg. Arterial sampling was confirmed in 1 of the fasted donkeys and the initial sample was used for analysis. The other 2 samples were suspected to have been venous and the second (arterial) samples were used for analysis. The incidence of PaO2 < 100 mmHg was not different between the fasted (3/22) and unfasted groups (2/21). Blood gas parameters and systolic blood pressures are reported in Table 1.

Discussion

Donkeys undergoing a short pre-anesthetic fast had higher pH, HCO3−, and BE compared to unfasted donkeys. No difference in PaCO2, PaO2, or systolic blood pressure was found between groups.

Differences in pH, HCO3−, and BE, while statistically significant, were considered clinically insignificant. Limited conclusions may be drawn due to lack of a baseline measurement, relatively short fasting time, and minimal differences between groups. Previous studies examining the effects of fasting on equids have not recorded these parameters (12,13). Determining changes in acid-base status over time in fasted, non-anesthetized equids may provide valuable clinical information.

While the lack of difference between groups in PaCO2 and PaO2 was consistent with a previous study in horses (3), it was in contrast to our hypothesis based upon the presumed cardiopulmonary effects of fasting and data from other species. During halothane anesthesia, 48-hour fasted cattle had lower PaCO2 and higher PaO2 values compared to unfasted cattle; however, this was a significantly longer fasting time and in a species with significant anatomical and physiological differences from that in the current study (14). Larger donkeys than those used herein may have been more likely to show differences after fasting. While no statistically significant differences were found in the present study, a trend towards higher PaO2 in the fasted group was seen (P = 0.07). A larger sample size, longer fasting time, longer anesthesia time, positioning in dorsal recumbency, or additional sampling time points may have shown a difference between groups in this parameter. A 5-hour fast is standard for this population at the study institution and a longer fast would have been impractical considering an early-afternoon start time. A longer fasting time in the fasted group cannot be ruled out, as fresh grass was fed the afternoon before the day of anesthesia and it is unknown how much grass was consumed overnight. A longer anesthesia time and positioning in dorsal recumbency would likely increase ventilation-perfusion mismatching and may have revealed a difference between groups. Percutaneous arterial sampling may have induced error associated with inadvertent venous sampling, although repeated sampling was utilized to verify an arterial source. Because FiO2 was not measured, differences in this parameter between groups cannot be ruled out and would have affected PaO2 values.

There were no adverse events in either group. While there is conflicting evidence regarding fasting and post-operative colic in horses, no donkeys showed signs of colic at any time. This does not rule out gastrointestinal dysfunction and further research is indicated to examine the effects of pre-anesthetic fasting and duration of anesthesia on post-anesthetic gastrointestinal health in equids.

A short pre-anesthetic fast resulted in higher pH, HCO3−, and BE in donkeys after approximately 25 min of general anesthesia with isoflurane in oxygen. These differences were considered to be clinically insignificant. No differences were found between groups in PaO2 or PaCO2. No advantages of a short pre-anesthetic fast were identified.

References

Comparison of the sedative effects of alfaxalone and methadone with or without midazolam in dogs

Fabiana Micieli, Ludovica Chiavaccini, Monique D. Paré, Joana Braun Chagas, Giancarlo Vesce, Giacomo Gianotti

Abstract — This blinded, randomized, prospective study evaluated the sedative and physiologic effects of a combination of alfaxalone and methadone with or without midazolam in adult dogs. Sixteen dogs received methadone (0.5 mg/kg body weight) and alfaxalone (1 mg/kg body weight), either with or without midazolam (0.5 mg/kg body weight), by intramuscular injection. Quality of sedation, heart rate, respiratory rate, systolic arterial pressure, rectal temperature, arterial oxygen saturation of hemoglobin, and dose of alfaxalone required for endotracheal intubation were recorded. Sedation score increased over time in both groups; however, dogs premedicated with methadone and alfaxalone appeared significantly less sedated than dogs premedicated with midazolam at 15, 20, and 25 minutes post-injection ($P = 0.04$). Dogs receiving methadone and alfaxalone were almost 5 times more likely to show excitement than those receiving midazolam ($P = 0.03$). We concluded that adding midazolam to an intramuscular combination of methadone and alfaxalone cannot be recommended in healthy dogs.

Introduction

In fearful or aggressive animals, reliable intramuscular (IM) sedation is required to reduce stress, facilitate handling, and improve safety for both the animal and the operator (1,2). Various combinations of IM $\alpha_2$-adrenergic agonists, benzodiazepines, and opioids are commonly used for sedation in aggressive dogs (3–5). However, $\alpha_2$-adrenergic agonists, used alone or in combination with other drugs, are associated with profound cardiovascular and respiratory effects (3,6) that limit their use for premedication of older or systemically sick patients (7).

Alfaxalone is a synthetic neuroactive steroid that produces anesthesia by enhancing and modulating the inhibitory effects...
of GABA at the GABA<sub>A</sub> receptors. At lower concentrations, it modulates the amplitude of GABA-induced currents at the receptor, in a way similar to benzodiazepines, and, at higher concentrations, it actively binds to the receptor, exerting an agonist effect similar to that produced by other GABA<sub>A</sub>-agonist induction agents (8). Alfaxalone produces good quality anesthesia, with fast onset, good muscle relaxation, minimal cardiovascular effects, and mild respiratory depression when administered intravenously at clinically relevant doses in dogs (9–11), making it a clinically acceptable induction agent for unstable canine patients (12).

The IM route of injection is currently not approved in the United States and Canada (13). Nevertheless, IM injections of alfaxalone have successfully been used, off label, alone, or in combination with α2-adrenergic agonists and/or opioids to induce anesthesia in dogs (1,2,14–17). Tamura et al (15) found that IM administration of alfaxalone in healthy beagles produced reliable and dose-dependent anesthesia, without clinically significant hypotension or respiratory depression. Similar results were found in a later study from the same group comparing IM injection of alfaxalone alone or in combination with medetomidine and butorphanol (1). However, in both studies, transient muscular tremors and twitching were observed during recovery (1,15). The effects of an IM combination of morphine, alfaxalone, and midazolam followed by IV alfaxalone induction and sevoflurane maintenance on intraocular temperature and the sparing effects on the induction dose of morphine, alfaxalone, and midazolam followed by IV administration of a combination of methadone, midazolam, and alfaxalone (MMA) (methadone hydrochloride, 10 mg/mL; Mylan Institutional, Rockford, Illinois, USA), 0.5 mg/kg body weight (BW) and (Alfaxan, 10 mg/mL; Jurox, Kansas City, Missouri, USA), 1 mg/kg BW, with or without midazolam (MA) (midazolam hydrochloride, 5 mg/mL; West-Ward, Eatontown, New Jersey, USA), 0.5 mg/kg BW. The randomization was kept secret until the time of preparation of the drugs by a veterinary nurse not involved in the study. Dogs were acclimatized to handling in a small quiet room for at least 20 min before the study. All injections were delivered into the epaxial muscles by a researcher blinded to the treatment, after verifying extravascular needle placement.

Sedation was assessed at 10, 15, 20, and 25 min after administration of the drug using a composite numeric sedation scale

### Materials and methods

This was a blinded randomized prospective clinical study that was approved by the Privately Owned Animal Protocol Committee and the University of Pennsylvania Institutional Animal Care and Use Committee (protocol number: 805861).

Our major outcome of interest was the difference in sedation scores between the 2 drug combinations. A sample size of 14 animals was deemed adequate for finding a difference in sedation score of 10%, with an estimated variance between subjects of 1 and an error variance of 9.5, a study power of 0.8 and an alpha of 0.05. Sixteen client-owned adult dogs, of various breeds, undergoing elective surgical procedures under general anesthesia, were enrolled in the study. Informed owner consent was obtained for each dog prior to enrolment.

Dogs were considered clinically healthy based on preanesthetic physical examination, hematology and serum biochemistry. Exclusion criteria included owner refusal, American Society of Anesthesiologists (ASA) physical status ≥ III, intractable behavior, animals younger than 12 wk or older dogs (> 75% of breed life expectancy), pregnancy and neurologic disease.

Food, but not water, was withheld overnight. Dogs were randomly assigned using a commercially available software (Microsoft Excel for Mac; Microsoft, Redmond, Washington, USA) to receive IM premedication with methadone, midazolam, and alfaxalone (MMA) (methadone hydrochloride, 10 mg/mL; Mylan Institutional, Rockford, Illinois, USA), 0.5 mg/kg body weight (BW) and (Alfaxan, 10 mg/mL; Jurox, Kansas City, Missouri, USA), 1 mg/kg BW, with or without midazolam (MA) (midazolam hydrochloride, 5 mg/mL; West-Ward, Eatontown, New Jersey, USA), 0.5 mg/kg BW. The randomization was kept secret until the time of preparation of the drugs by a veterinary nurse not involved in the study. Dogs were acclimatized to handling in a small quiet room for at least 20 min before the study. All injections were delivered into the epaxial muscles by a researcher blinded to the treatment, after verifying extravascular needle placement.

Sedation was assessed at 10, 15, 20, and 25 min after administration of the drug using a composite numeric sedation scale

### Table 1. Criteria for evaluating sedation score in dogs. a

<table>
<thead>
<tr>
<th>Assessment</th>
<th>Score definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Posture</td>
<td>0 — standing position, walking</td>
</tr>
<tr>
<td></td>
<td>1 — in sternal or lateral position, but stands when stimulated</td>
</tr>
<tr>
<td></td>
<td>2 — remains in sternal recumbency, resists lateral recumbency</td>
</tr>
<tr>
<td></td>
<td>3 — remains in lateral recumbency but may lift head</td>
</tr>
<tr>
<td></td>
<td>4 — remains in lateral recumbency even when stimulated</td>
</tr>
<tr>
<td>Response to clipper sounds</td>
<td>0 — reacts strongly when clippers are turned on</td>
</tr>
<tr>
<td></td>
<td>1 — reacts mildly when clippers are turned on</td>
</tr>
<tr>
<td></td>
<td>2 — no response when clippers are turned on</td>
</tr>
<tr>
<td>Response to clipping</td>
<td>0 — reacts strongly to clipping</td>
</tr>
<tr>
<td></td>
<td>1 — reacts mildly to clipping</td>
</tr>
<tr>
<td></td>
<td>2 — no response to clipping</td>
</tr>
<tr>
<td>Response to restraint and catheterization</td>
<td>0 — alert, readily reacts to restraint and catheterization</td>
</tr>
<tr>
<td></td>
<td>1 — alert, but minimally responds to restraint and catheterization</td>
</tr>
<tr>
<td></td>
<td>2 — no reaction or movement in response to restraint and catheterization</td>
</tr>
</tbody>
</table>

a Modified from Santos et al (18).
Table 2. Cardiorespiratory variables, temperature, and cumulative sedation scores recorded at different time points after sedation with methadone and alfaxalone, with \(n = 8\) or without \(n = 8\) midazolam.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Treatment</th>
<th>Baseline</th>
<th>10 min</th>
<th>15 min</th>
<th>20 min</th>
<th>25 min</th>
</tr>
</thead>
<tbody>
<tr>
<td>HR (bpm)</td>
<td>MA</td>
<td>109 ± 30</td>
<td>86 ± 28</td>
<td>91 ± 28</td>
<td>87 ± 31</td>
<td>87 ± 27</td>
</tr>
<tr>
<td></td>
<td>MMA</td>
<td>116 ± 18</td>
<td>106 ± 28</td>
<td>102 ± 12</td>
<td>105 ± 19</td>
<td>106 ± 19</td>
</tr>
<tr>
<td>(f_R^b) (bpm)</td>
<td>MA</td>
<td>78 ± 44</td>
<td>63 ± 48</td>
<td>62 ± 43</td>
<td>68 ± 43</td>
<td>75 ± 44</td>
</tr>
<tr>
<td></td>
<td>MMA</td>
<td>85 ± 49</td>
<td>75 ± 48</td>
<td>87 ± 45</td>
<td>84 ± 49</td>
<td>87 ± 46</td>
</tr>
<tr>
<td>SAP (mmHg)</td>
<td>MA</td>
<td>130 (125, 160)</td>
<td>127 (107, 140)</td>
<td>120 (110, 140)</td>
<td>120 (105, 140)</td>
<td>130 (120, 130)</td>
</tr>
<tr>
<td></td>
<td>MMA</td>
<td>140 (137, 151)</td>
<td>120 (110, 137)</td>
<td>130 (110, 140)</td>
<td>125 (107, 130)</td>
<td>121 (112, 130)</td>
</tr>
<tr>
<td>(SpO_2) (%)</td>
<td>MA</td>
<td>98 (96.98)</td>
<td>96 (96, 100)</td>
<td>97 (96, 100)</td>
<td>96 (96, 98)</td>
<td>98 (96, 99)</td>
</tr>
<tr>
<td></td>
<td>MMA</td>
<td>97 (96, 98)</td>
<td>97 (96, 98)</td>
<td>95 (94, 96)</td>
<td>97 (94, 98)</td>
<td>96 (95, 99)</td>
</tr>
<tr>
<td>Temp (°C)</td>
<td>MA</td>
<td>101.6 (101.0, 102.3)</td>
<td>101.0 (100.5, 101.2)</td>
<td>101.1 (100.5, 101.3)</td>
<td>101.0 (100.2, 101.1)</td>
<td>100.8 (100.3, 101.2)</td>
</tr>
<tr>
<td></td>
<td>MMA</td>
<td>38.2 (38, 38.5)</td>
<td>38.2 (37.9, 38.4)</td>
<td>38.1 (37.8, 38.5)</td>
<td>38 (37.7, 38.7)</td>
<td>37.8 (37.5, 38.3)</td>
</tr>
<tr>
<td>Sedation score</td>
<td>MA</td>
<td>0 (0, 0)</td>
<td>5 (3, 8)</td>
<td>8 (7, 9)</td>
<td>9 (8, 9)</td>
<td>8 (6, 9)</td>
</tr>
<tr>
<td></td>
<td>MMA</td>
<td>0 (0, 0)</td>
<td>6 (2, 7)</td>
<td>6 (2, 7)</td>
<td>6 (3, 8)</td>
<td>5 (2, 7)</td>
</tr>
</tbody>
</table>

\(^a\) Indicates significantly different \((P < 0.05)\) from MA group.
\(^b\) Indicates significantly different \((P < 0.05)\) from baseline.

Data are expressed as mean ± SD or median (Q1, Q3).

MA — methadone, alfaxalone; MMA — methadone, midazolam, and alfaxalone; HR — heart rate, \(f_R\) — respiratory rate; SAP — systolic arterial pressure; \(SpO_2\) — peripheral oxygen saturation; Temp — temperature.

0–10, modified from one previously published for assessing sedation in cats (Table 1) (18). Cardiopulmonary variables were measured before premedication and sequentially at 10, 15, 20, and 25 min after injection. Heart rate (HR) was measured by thoracic auscultation and respiratory rate \((f_R)\) was obtained by direct observation of thoracic excursions. The systolic arterial pressure (SAP) was measured on the palmar common digital artery using the Doppler method, with an appropriately sized cuff placed above the carpus (width 40% of limb circumference). Artery using the Doppler method, with an appropriately sized cuff placed above the carpus (width 40% of limb circumference). Rectal temperature (\(T^R\)) was measured with a digital thermometer and arterial oxygen saturation of hemoglobin (\(SpO_2\)) using a pulse oximeter (Masimo Rad-5 Pulse Oximeter; Masimo Animal Health, Irvine, California, USA). Adverse events and signs of excitement, defined as leg withdrawal, shivering, rigidity, twitching, struggling, vocalization, wide-eyed facial expression or biting, were noted. All data were collected by a single observer (FM), blinded to the treatment, who was experienced in the clinical methods and scoring systems employed in this trial but who did not participate in the administration of drugs. The successful clipping and placing of an IV over-the-needle catheter was recorded as part of the sedation assessment (Table 1). Anesthesia was induced with IV alfaxalone administered to effect at a rate of 1 mg/kg BW per min using the same infusion syringe pump (Graseby 3400; Smith Medical, Dublin, Ohio, USA). When the dog lost palpebral reflex along with swallowing and gag reflex, the infusion was terminated, the animal was positioned in sternal recumbency, and intubation was attempted. The total amount of alfaxalone administered for achieving intubation was recorded. Then, the study was considered concluded and anesthesia was maintained following hospital protocol.

Statistical analysis

All statistical analysis was performed using commercially available software (Stata/IC 14.2 for Mac; StataCorp LP, College Station, Texas, USA). Data were analyzed for normality with the Shapiro-Wilk test and reported as mean ± standard deviation (SD) or median (Q1, Q3) if normally or not normally distributed, respectively. Differences in weight and physiological variables (HR, \(f_R\), SAP, \(SpO_2\), Temp) at baseline between dogs receiving MA and MMA were analyzed with a 2-sided Student’s \(t\)-test for unequal variances or 2-sample Mann-Whitney rank-sum test, for normally and not normally distributed data, respectively. Not normally distributed data and ordinal data were rank transformed for further statistical analysis. For each outcome measure (HR, \(f_R\), SAP, \(SpO_2\), Temp, sedation score) a mixed-effect linear model with dogs as random effect and time and treatment as fixed effects was used, with an interaction term between time and treatment as appropriate and covariance set to unstructured. The association between premedication treatment and signs of excitement was compared using maximum-likelihood Chi-squared test (lr-chi). Differences in dose of alfaxalone required for endotracheal intubation were compared using a 2-sample Mann-Whitney rank-sum test. The median difference between dogs in the 2 treatment groups and 95% confidence interval (95% CI) was calculated for weight, baseline SAP, time to induction, and differences in dose of alfaxalone using the Hodges–Lehman method. Significance was set for a \(P\)-value ≤ 0.05 throughout.

Results

Dogs weighed 7.72 ± 2.47 kg (mean ± SD) (range: 4.80 to 12.20 kg). There was no statistically significant difference in weight (median difference: 0.30 kg, 95% CI: −0.20 to 0.70 kg, \(P = 0.79\)), heart rate (HR) \([\text{difference of means: } 7 \text{ beats/min (bpm), } 95\% \text{ CI: } -3.36 \text{ to } 19.96, P = 0.58]\), respiratory rate \((f_R)\) \([\text{difference of means: } 6.25 \text{ breaths per min, } 95\% \text{ CI: } -56.3 \text{ to } 43.8, P = 0.79]\), systolic arterial pressure (SAP) \([\text{median difference: } 10 \text{ mmHg, } 95\% \text{ CI: } -20 \text{ to } 20 \text{ mmHg, } P = 0.43]\), peripheral oxygen saturation \((SpO_2)\) \([\text{difference of means: } 0.29\%, 95\% \text{ CI: } -0.76 \text{ to } 1.3\%, P = 0.56]\), and temperature \((\text{Temp})\) \([\text{difference of means: } 0.31\%, 95\% \text{ CI: } -0.30 \text{ to } 0.91\% \text{ CI: } P = 0.30]\) at baseline between groups.

Table 2 shows cardiorespiratory parameters, temperature, and sedation scores recorded at different time points after sedation with either MA or MMA. When considering all variables in the model, sedation increased over time after premedication \((P < 0.01)\). However, dogs premedicated with MMA appeared significantly less sedated than dogs premedicated...
with MA at 15 min (coef: −17.51, 95% CI: −32.52 to −2.49, \(P = 0.02\)), 20 min (coef: −17.45, 95% CI: −32.77 to −2.44, \(P = 0.02\)), and 25 min (coef: −18.66, 95% CI: −33.67 to −3.65, \(P = 0.01\)) post-injection. With both treatments, HR (\(P < 0.01\)) and SAP (\(P < 0.01\)) significantly decreased after injection. However, HR did not decrease more than 15% with respect to baseline and SAP never got below 120 mmHg. There was no statistically significant difference in HR (coef: 16.59, 95% CI: 11.10 to 21.97, \(P = 0.03\)) or SAP (coef 8.69, 95% CI: 2.77 to 14.62, \(P = 0.09\)) among dogs premedicated with MA or MMA. Overall, there was no statistically significant difference in \(f_R\) (coef: 0.38, \(P = 0.15\)), \(\text{SpO}_2\) (coef 0.14) between treatments over time. Five out of eight dogs (62.5%) premedicated with MMA showed signs of excitement and in 3 of these 5 cases, those signs did not disappear until induction of anesthesia. In the MA group, only 1 dog (12.5%) showed signs of excitement and only at 10 min post-injection. Overall, dogs premedicated with MMA were 5 times more likely to show signs of excitement than dogs premedicated with MA (lr-chi 4.56, \(P = 0.03\)).

Time between premedication and induction ranged between 25 and 53 min (median: 27 min). There was no difference in time to induction between the 2 groups (median difference: 1.5 min, 95% CI: −2 to 9 min, \(P = 0.60\)). Dogs premedicated with MA required a median of 1.56 (1.30, 2.13) mg/kg BW of alfaxalone for induction, compared with 1.61 (1.16, 2.36) mg/kg BW required by dogs premedicated with MMA. The amount of alfaxalone used for induction was not significantly different between the 2 treatments (median difference: −0.04 mg/kg BW, 95% CI: −1.25 to 0.60, \(P = 0.92\)).

**Discussion**

We rejected our hypothesis and demonstrated that the addition of midazolam, 0.5 mg/kg BW, to an IM combination of methadone, 0.5 mg/kg BW, and alfaxalone, 1 mg/kg BW, resulted in a higher likelihood of excitement and lower sedation score than the combination without midazolam, in healthy adult dogs. Moreover, adding midazolam did not decrease the total amount of alfaxalone required for endotracheal intubation. In both sedation protocols the physiological parameters were maintained in normal range.

When administered intramuscularly, alfaxalone is reported to induce dose-dependent sedation, but also to cause some undesirable behavioral and locomotor effects, such as muscle tremors, limb extension, paddling, excitement, and staggering gait during recovery (15). In a recent canine study, an IM alfaxalone dose like the one we used (1 and 2 mg/kg BW) resulted in variable degree of sedation and high prevalence of adverse effects such as ataxia, auditory hyperesthesia, visual disturbance, pacing and tremor, suggesting that this dose may not be clinically useful when used alone in healthy dogs (17). Previous studies, however, reported that the addition of opioids and sedatives to IM alfaxalone ensures good sedation/anesthesia and a better quality of recovery in dogs (11,16). Lee et al (16) showed that, despite the cardiorespiratory suppression, the IM co-administration of butorphanol (0.1 mg/kg BW), medetomidine (0.01 mg/kg BW), and alfaxalone (1.5 mg/kg BW) produces deep sedation and a reasonable quality of anesthesia in healthy beagles. This agrees with our findings, which showed that the combination of methadone and midazolam with a low-dose of alfaxalone (1 mg/kg BW) produced an adequate level of sedation for 25 min. Nonetheless, the level of sedation achieved with the addition of midazolam was significantly lower than the level of sedation achieved without midazolam from 15 to 25 min after IM injection. This could be explained by the fact that dogs that received midazolam showed more signs of excitement. Paradoxical behavior, like excitement and hyper-responsiveness to noise lasting for 5 to 20 min was reported in dogs after IM administration of midazolam at doses such as that used in this study (19). In a recent study, the prevalence of paradoxical behavior after sedation with different combinations of medetomidine and midazolam was like that reported herein (20). These signs are probably due to the “dissinhibitory” effects of benzodiazepines on suppressed behavior or could be due to an excitement phase in response to the loss of muscle tone (19). Simon et al (21) reported that the addition of methadone (0.75 mg/kg BW) did not prevent the midazolam-induced behavioral changes, as shown in the present study. The excitement observed in the midazolam group could also have been increased by alfaxalone. Cruz-Benedetti et al (14) reported that IM alfaxalone (4 mg/kg BW) caused paddling, trembling, and nystagmus in 50% of dogs; however, only 1 dog in the MA group showed signs of excitement. Furthermore, methadone should be considered as a possible concurrent cause of our observed excitement. Opioids increase the risk of dysphoria and are known for producing excitement through dopaminergic and narcotic mechanisms. Monteiro et al (22) reported anxiety and crying when methadone (0.5 mg/kg BW) was administered IM as a single agent in dogs.

In both groups, HR significantly decreased over time; this was probably the result of the increased vagal tone induced by methadone (23,24). However, HR never decreased below 15% of baseline. This is comparable to the 12.5% decrease in HR previously reported after IM administration of methadone (0.5 mg/kg BW) in dogs (24). A significant decrease in SAP was also detected in both groups, but hypotension was not observed.

The amount of alfaxalone required for endotracheal intubation did not differ between groups. Similarly, Le Chevaillier et al (20) didn’t find any difference in the dose of propofol needed for induction between dogs premedicated with only medetomidine or different combinations of medetomidine and midazolam, despite observing a higher prevalence of excitatory behavior in the latter. In this study, the concomitant administration of alfaxalone and methadone, with or without the adjunct of midazolam, provided a dose reduction of approximately 64% compared with induction doses of alfaxalone without premedication reported previously (25). The effects of methadone, midazolam, or their combination on dexmedetomidine sedation and on propofol anesthesia induction dose have recently been studied in dogs by Canfran et al (5). While reducing the amount of propofol required for intubation and prolonging sedation, the adjunct of midazolam (0.3 mg/kg BW) to the dexmedetomidine-methadone (0.05 to −0.3 mg/kg BW) combination provided no benefit on the degree of sedation (5). We did not record any head shaking, muscle tremor, paddling...
agitation, and noise hyper-sensitivity reported by others after alfaxalone induction (2,9,11).

One of the major limitations of this study was the lack of crossover design. However, the study was designed as a prospective clinical trial using client-owned dogs. We recognize that the use of a sedation scale validated for the species would have been ideal (26). However, at the time the study was conducted, no validated sedation score was published for dogs. The sedation scale proposed by Santos et al (18) for cats was adaptable to this population and suited our study design. However, this made the assessment of clinical significance of the difference challenging. Finally, the fact that the study concluded with the assessment of clinical significance of the difference in the duration of sedation and the quality of recovery for the 2 protocols.

Further studies are required to assess the duration of sedation and the quality of recovery for the 2 protocols.

In conclusion, our results suggest that the combination of methadone (0.5 mg/kg BW) and alfaxalone (1 mg/kg BW) administered IM produced moderate to deep sedation without changes in HR, fH, or SAP in healthy adult dogs. The addition of midazolam (0.5 mg/kg BW) to this combination resulted in high prevalence of behavioral changes and variability in sedation scores suggesting that it would not be useful in a similar population. Based on these data the addition of midazolam to an IM combination of methadone and alfaxalone cannot be recommended for sedation in healthy adult dogs.

References

Diagnostic utility of thoracic radiographs and abdominal ultrasound in canine immune-mediated hemolytic anemia

Michael Andres, Erik Hostnik, Eric Green, Catherine Langston, Valerie J. Parker, Chen Gilor, Adam J. Rudinsky

Abstract — The utility of thoracic radiographs and abdominal ultrasound to identify abnormalities in canine immune-mediated hemolytic anemia (IMHA) is evaluated. Dogs with regenerative anemias and a clinical diagnosis of IMHA that had thoracic radiographs or abdominal ultrasound performed as part of the evaluation were included. The utility of imaging studies was assessed based on a previously utilized scheme. Patient population and clinical signs were consistent with previous reports of IMHA. In 38 out of 50 dogs, the same clinical evaluation and assessment would have been performed without thoracic radiographs. In 32 out of 64 dogs, the same clinical evaluation and assessment would have been performed without abdominal ultrasound. The results indicate that thoracic radiographs and abdominal ultrasound are of variable utility in identifying concurrent abnormalities in canine patients with IMHA. Prospective studies should be designed to further investigate whether abnormalities identified on imaging studies are related to the IMHA or affect patient prognosis.

Résumé — Utilité diagnostique des radiographies thoraciques et d’échographie abdominale lors d’anémie hémolytique à médiation immunitaire. L’utilité de radiographies thoraciques et d’échographie abdominale pour identifier les anomalies lors d’anémie hémolytique à médiation immunitaire (IMHA) est évaluée. Des chiens avec anémie régénérative et un diagnostic clinique d’IMHA qui avaient eu des radiographies thoraciques ou une échographie abdominale effectuées comme élément de leur évaluation ont été inclus. L’utilité des examens d’imagerie fut évaluée selon un système déjà utilisé. La population des patients et les signes cliniques étaient en lien avec des rapports antérieurs d’IMHA. Chez 38 des 50 chiens, la même évaluation clinique et appréciation auraient été effectuées sans les radiographies thoraciques. Chez 32 des 64 chiens, la même évaluation clinique et appréciation auraient été effectuées sans l’échographie abdominale. Les résultats indiquent que les radiographies thoraciques et l’échographie abdominale sont d’une utilité variable à identifier des anomalies concomitantes chez des patients canins avec IMHA. Des études prospectives devraient être élaborées pour étudier plus à fond si des anomalies identifiées lors d’examen par imagerie sont reliées à l’IMHA ou affectent le pronostic du patient.

(Traduit par Dr Serge Messier)
evaluation are aimed at identifying potential underlying causes of disease and concurrently clinically significant abnormalities. This often includes comprehensive imaging of the patient including thoracic radiographs and abdominal ultrasound. The purpose of this study was to investigate the diagnostic utility of the imaging recommended in cases of canine IMHA based on the presence and significance of abnormalities identified.

Materials and methods

The Health Information Section at The Ohio State University Veterinary Medical Center searched the medical record database between January 2005 and January 2015 for dogs with regenerative anemia (based on institutional reference ranges for hematocrit and reticulocyte count). Medical records were retrospectively reviewed (MA). To be included, the following diagnostic tests had to have been performed as part of the diagnostic work-up: a complete blood (cell) count (CBC), biochemistry profile, urinalysis, and imaging (that included at least thoracic radiographs or abdominal ultrasound). Dogs were included if they had a clinical diagnosis of IMHA that was based on conventional criteria: regenerative anemia, evidence of hemolysis (hyperbilirubinemia, hemoglobinemia, bilirubinuria, or hemoglobinuria), and 2 or more of the following clinicopathologic findings: macroscopic or microscopic agglutination, positive Coombs’ test, and 2+ spherocytes on slide review (1,13–15). Inclusion into the study required meeting all inclusion criteria and a confirmed diagnosis of IMHA upon review of the file by a Board-certified internist (AR). Cases were excluded if thoracic radiographs and abdominal ultrasound were not performed, if imaging studies were not performed within the first 48 h after hospital admission, or if analyzed diagnostics were not performed at The Ohio State University Veterinary Medical Center.

Three-view thoracic radiographic and abdominal ultrasonographic studies were reviewed by a Board-certified radiologist blinded to diagnosis (EH). Radiographic reports were generated and then reviewed and used as reference for the study. Definition of normal imaging findings is outlined in Appendix A. Abnormal ultrasonographic findings were tabulated and their clinical significance regarding the diagnosis was evaluated by 4 Board-certified internists (AR, CG, CL, VP). This evaluation was performed in conjunction with case information including results of aspirates or biopsies if acquired during imaging examination. A modified version of a previously published scheme was used for evaluation (16,17). All cytologic and biopsy results used in the subjective grading scheme were reviewed by a Board-certified clinical or anatomic pathologist.

The assessment scheme consisted of 2 questions asked independently for both thoracic radiographic and abdominal ultrasonographic studies. The following example is provided in the context of thoracic radiographs.

Question 1: Did the imaging results contribute to the overall case management? [Overall Diagnostic Utility (ODU)]

Yes

No

Question 2: What was the diagnostic utility of the thoracic radiographs? [Diagnostic Utility Score (DUS)]

1. Diagnosis was obtained via thoracic radiographs (including image guided biopsy or aspirate).

| Table 1. Selected descriptive data of complete blood cell count and biochemical profile results in the 64 study dogs. |
|-----------------|-------------|-----------------|-----------------|
| Complete blood cell count | Mean/Median | Standard deviation/Range | Reference range |
| Plasma protein | 71 | 11 | 56 to 73 g/L |
| Hematocrit | 16 | 3.3 to 20.0 | 40% to 59% |
| MCV | 74 | 60 to 95 | 62 to 77 fl |
| MCHC | 33.9 | 24.1 to 42.0 | 330 to 361 g/L |
| Reticulocyte count | 151.2 | 120.3 to 432.9 | < 105 × 10⁶/L |
| Platelet count | 123 | 80 to 712 | 145 to 463 × 10⁶/L |
| Total leukocyte count | 31.1 | 4.2 to 50.7 | 4.8 to 13.9 × 10⁶/L |
| Segmented neutrophil count | 23.2 | 1.4 to 38.9 | 2.6 to 10.8 × 10⁶/L |
| Lymphocyte count | 1.2 | 0.2 to 7.8 | 1.0 to 4.6 × 10⁶/L |
| Monocyte count | 2.2 | 0.2 to 13.0 | 0.1 to 1.1 × 10⁶/L |
| Biochemistry profile | Mean | Standard deviation | Reference range |
| BUN | 7.5 | 2.14 to 61.1 | 1.78 to 7.14 mmol/L |
| Creatinine | 61.88 | 8.84 to 742.1 | 53.04 to 141.44 mmol/L |
| Phosphorus | 1.25 | 0.75 to 4.32 | 1.03 to 2.62 mmol/L |
| Calcium (total) | 2.33 | 1.99 to 2.89 | 2.33 to 2.90 mmol/L |
| Sodium | 146 | 136 to 163 | 143 to 153 mmol/L |
| Potassium | 3.65 | 2.6 to 5.7 | 4.2 to 5.4 mmol/L |
| Chloride | 111 | 5.2 | 109 to 120 mmol/L |
| Bicarbonate | 15.5 | 4.6 | 15 to 25 mmol/L |
| ALT | 67 | 6.0 to 3995.0 | 10 to 55 IU/L |
| AST | 59 | 10.0 to 2714.0 | 12 to 40 IU/L |
| ALP | 298 | 55 to 6800 | 15 to 120 IU/L |
| CK | 317 | 53 to 9279 | 50 to 400 IU/L |
| Cholesterol | 0.15 | 0.06 to 0.42 | 0.08 to 0.21 mmol/L |
| Total bilirubin | 22.74 | 1.71 to 360.1 | 1.71 to 6.84 μmol/L |
| Total protein | 58 | 10 | 51 to 71 g/L |
| Albumin | 30 | 5 | 29 to 42 g/L |
| Globulin | 29 | 7 | 22 to 29 g/L |
| Glucose | 5.88 | 4.72 to 23.42 | 4.27 to 6.99 mmol/L |

BUN — blood urea nitrogen; ALT — alanine aminotransferase; AST — aspartate aminotransferase; ALP — alkaline phosphatase; CK — creatine kinase; MCV — mean corpuscular volume; MCHC — mean corpuscular hemoglobin concentration.
2. Imaging provided information that warranted additional diagnostics for further evaluation due to increased likelihood of changing case management.
3. Thoracic radiographs provided descriptive information that did not change case management.
4. Thoracic radiographs provided confounding information that did not support or contradicted the diagnosis.
5. The thoracic radiographs were diagnostically unremarkable.

The 2 case outcomes (ODU, DUS) were used for further reporting. The purpose of the ODU was to provide a comprehensive assessment of utility after consideration of the complete medical information. The DUS was aimed at identifying specific reasons why imaging was considered either diagnostically useful or not useful during case review. Pertinent patient information from the clinical history, physical examination, and clinicopathologic results was collected from patient files.

Statistical analyses were performed using commercially available software (IBM SPSS Statistics 2012; IBM, Armonk, New York, USA). Descriptive statistics were calculated and reported for age, gender, body weight, and clinical variables. Abnormalities identified during imaging studies as well as ODU and DUS scores are reported. Continuous variables were tested for normality using the Shapiro-Wilk test. Agreement of the 4 reviewers for the subjective utility grading scheme (ODU and DUS) was assessed using Fleiss kappa.

Results

The medical record search retrieved 187 dogs that satisfied the inclusion criteria for diagnosis of IMHA. From this population, 67 were excluded because neither thoracic radiographs nor abdominal ultrasound were completed or were not completed within time limits specified in relationship to hospital admission, 43 were excluded as the diagnostics or diagnosis were performed at another hospital, and 13 dogs had insufficient data available in the medical record. Sixty-four dogs met all inclusion and exclusion criteria and were, therefore, included in the study.

Thirty-two dogs were male with 4 of the dogs intact. Thirty-two dogs were female with 1 female being intact. Median age was 7 y (range: 3 to 14 y). Median body weight was 19.8 kg (range: 3.5 to 53.6 kg). Breeds included 17 mixed breed dogs, 6 cocker spaniels, 5 shih tzu, 3 miniature schnauzers, 3 beagles, 2 each of following breeds (miniature pinscher, toy poodle, standard poodle, Maltese, Labrador retriever, golden retriever, miniature dachshund, and Pomeranian), and 1 each of the following breeds (Rottweiler, Australian shepherd, collie, keeshond, samoyed, Bouvier des Flanders, Siberian husky, Doberman pinscher, standard schnauzer, Boston terrier, English springer spaniel, Swiss mountain dog, German shepherd dog, and German shorthair pointer). Clinical complaints reported at hospital admission included nonspecific signs in 57 of 64 (89%) dogs (lethargy, depressed state, weakness), gastrointestinal signs in 40 of 64 (63%) dogs (inappetence, vomiting, melena, diarrhea, hematochezia), cardiorespiratory signs in 11 of 64 (17%) dogs (dyspnea, coughing, exercise intolerance, labored breathing, syncope), urinary signs in 13 of 64 (20%) dogs (hematuria, incontinence, polyuria and polydipsia), and neurologic signs in 5 of 64 (8%) dogs (seizure, seizure-like behavior). Pertinent summary data from the CBCs and biochemistry profiles are listed in Table 1. Regarding pertinent clinicopathologic findings; 64 (100%) dogs had spherocytosis, 48 (75%) dogs had nucleated red blood cells noted, 50 (78%) dogs had either macro, micro, or both forms of autoagglutination, and 23 (36%) were Coombs positive.

Agreement analyses among the reviewers for the ODU and DUS are presented in Appendix B. Thoracic radiographic studies were performed in 50 of the 64 dogs (78%). In these studies, 34 (68%) dogs were deemed radiographically within normal limits or diagnostically unremarkable while 16 (32%) had radiographic abnormalities (Table 2). Majority agreement was met in 48 of 50 cases (96%) with the conclusion being that in 10 cases (20%) radiographs contributed to overall case management and

<table>
<thead>
<tr>
<th>Table 2. Total number of dogs with each (A) abdominal palpation finding, (B) thoracic radiographic finding, and (C) abdominal ultrasonographic finding.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>A. Abdominal palpation findings</strong></td>
</tr>
<tr>
<td>Splenomegaly</td>
</tr>
<tr>
<td>Distended abdomen</td>
</tr>
<tr>
<td>Organomegaly (non-specific)</td>
</tr>
<tr>
<td>Abdominal mass</td>
</tr>
<tr>
<td>Hepatomegaly</td>
</tr>
<tr>
<td>Total number of dogs</td>
</tr>
<tr>
<td>4</td>
</tr>
<tr>
<td>3</td>
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<tr>
<td>3</td>
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<tr>
<td>1</td>
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<tr>
<td>1</td>
</tr>
<tr>
<td>12</td>
</tr>
<tr>
<td><strong>B. Thoracic radiograph findings</strong></td>
</tr>
<tr>
<td>Sternal lymphadenopathy</td>
</tr>
<tr>
<td>Interstitial pattern</td>
</tr>
<tr>
<td>Cardiomegaly</td>
</tr>
<tr>
<td>Alveolar pattern</td>
</tr>
<tr>
<td>Cholelithiasis</td>
</tr>
<tr>
<td>Aerophagia</td>
</tr>
<tr>
<td>Megasophagus</td>
</tr>
<tr>
<td>Aspiration pneumonia</td>
</tr>
<tr>
<td>Gastric foreign body</td>
</tr>
<tr>
<td>Hepatomegaly</td>
</tr>
<tr>
<td>Pleural effusion</td>
</tr>
<tr>
<td>5</td>
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<tr>
<td>4</td>
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<tr>
<td>3</td>
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<td>1</td>
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<tr>
<td>1</td>
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<tr>
<td>1</td>
</tr>
<tr>
<td>23</td>
</tr>
<tr>
<td><strong>C. Abdominal ultrasound findings</strong></td>
</tr>
<tr>
<td>Peritoneal effusion</td>
</tr>
<tr>
<td>Liver: Diffuse echogenicity change (hyperechoic)</td>
</tr>
<tr>
<td>Liver nodules</td>
</tr>
<tr>
<td>Splenic nodules</td>
</tr>
<tr>
<td>Edematous gallbladder wall</td>
</tr>
<tr>
<td>Nonspecific chronic renal changes</td>
</tr>
<tr>
<td>Hepatomegaly</td>
</tr>
<tr>
<td>Urinary bladder sediment</td>
</tr>
<tr>
<td>Renal cortical cysts</td>
</tr>
<tr>
<td>Gallbladder sludge</td>
</tr>
<tr>
<td>Lymphadenopathy</td>
</tr>
<tr>
<td>Splenomegaly</td>
</tr>
<tr>
<td>Adrenomegaly (1 – unilateral, 2 – bilateral)</td>
</tr>
<tr>
<td>Cystolith</td>
</tr>
<tr>
<td>Bilateral pyelectasia</td>
</tr>
<tr>
<td>Cholecystolith</td>
</tr>
<tr>
<td>Abdominal mass</td>
</tr>
<tr>
<td>Pancreatitis</td>
</tr>
<tr>
<td>Cholecystitis</td>
</tr>
<tr>
<td>Gastrointestinal wall thickening</td>
</tr>
<tr>
<td>Emphysematous cystitis</td>
</tr>
<tr>
<td>Pneumoperitoneum</td>
</tr>
<tr>
<td>Benign prostate hyperplasia</td>
</tr>
<tr>
<td>Spleen: Diffuse echogenicity change (hypochogenicity)</td>
</tr>
<tr>
<td>Cystitis</td>
</tr>
<tr>
<td>Mottled liver</td>
</tr>
<tr>
<td>Splenic vein thrombus</td>
</tr>
<tr>
<td>Total number of dogs</td>
</tr>
<tr>
<td>11</td>
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<tr>
<td>10</td>
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<td>7</td>
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<td>2</td>
</tr>
<tr>
<td>2</td>
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<tr>
<td>3</td>
</tr>
<tr>
<td>104</td>
</tr>
</tbody>
</table>
in 38 (76%) they did not contribute to overall case management. Specific findings in the 2 cases of disagreement included mediastinal fat or sternal lymphadenopathy, cholecytoliths, and hepatomegaly in 1 dog, and mild sternal lymphadenopathy and cholecytoliths in the second dog.

On question 2, pertaining to thoracic radiographs, majority agreement was reached in 47 of 50 cases (94%). Split disagreement between the final 3 cases was between an assigned score of 2 or a score of 3. These included 1 dog with mild left atrial enlargement without evidence of heart failure and multiple small metallic gastric foreign bodies, a second dog with mild sternal lymphadenopathy and cholecytoliths, and a third dog with generalized cardiomegaly and mild pleural effusion. In total, 0 dogs received a score of 1, 8 received a score of 2, 5 received a score of 3, 0 received a score of 4, and 34 received a score of 5.

Abdominal ultrasonographic studies were completed in 63 of the 64 dogs (98%). In these studies, 16 (25%) were deemed ultrasonographically within normal limits or diagnostically unremarkable, while 47 (75%) had ultrasonographic abnormalities. Ultrasonographic abnormalities are summarized in Table 2. In 23 cases (37%), there was majority agreement that the imaging study contributed to overall case management. In 32 cases (51%), there was majority agreement that the imaging study did not contribute to overall case management. Specific findings in the 8 cases of split disagreement included 3 with hepatic nodules, 2 with hepatomegaly, 2 with mild peritoneal effusion, and 1 each with gall bladder wall edema, hypoechoic liver, splenic nodule, renal cyst, and 1 each with urine sedimentation, gall bladder sludge, decreased renal corticomedullary distinction, gall bladder sludge, cystic calculi, and cholecytitis.

On question 2, pertaining to abdominal ultrasound, majority agreement was reached in 54 of 63 cases (86%). Split disagreement between the final 9 cases was between being assigned a score of 2 or a score of 3. These included the following findings: 5 with hepatic nodules, 2 each with splenomegaly, hepatomegaly, hyperechoic liver, gall bladder wall edema, splenic nodule, renal cyst, and 1 each with urine sedimentation, gall bladder sludge, decreased renal corticomedullary distinction, mild peritoneal effusion, hypoechoic spleen, mild pylectasia, mottled liver, decreased renal corticomedullary distinction, gall bladder sludge, and cholelithiasis. In total, 0 dogs received a score of 1, 14 received a score of 2, 23 received a score of 3, 0 received a score of 4, and 17 received a score of 5.

**Discussion**

The diagnostic utility of both thoracic radiographs and abdominal ultrasound to identify abnormalities was variable in canine IMHA. In total, 68% of thoracic radiographic studies and 25% of abdominal ultrasonographic studies did not reveal any abnormalities. When the findings were interpreted in conjunction with clinical case information, 76% of thoracic radiographic studies would not have changed the clinician's diagnostic and treatment plans in case management and diagnosis, while 50% of abdominal ultrasonographic studies were not useful in case management and diagnosis.

Historical clinical signs, laboratory abnormalities, and imaging findings were largely consistent with those previously reported in canine IMHA (1,12). Prior to this publication, there have been limited descriptions of thoracic and abdominal imaging in patients with canine IMHA. Many imaging findings in this study were consistent with specific disease processes and/or incidental findings, and overlapped significantly with findings reported in both normal dogs as well as dogs affected by other diseases (18–20). Subjectively, there was 1 ultrasonographic imaging finding that seemed to occur more frequently than the authors would have expected: gallbladder wall edema (17%, 11/64 dogs). The cause, relationship, and significance of this finding are unknown and cannot be addressed with this study design. Immune-mediated hemolytic anemia is an inflammatory disease and there is a potential link between gallbladder wall edema and inflammatory reactions (21,22). Further studies are required to investigate this hypothesis and determine the repeatability of this finding.

Importantly, to definitively identify whether an abnormality discovered on imaging studies is the cause of or related to IMHA will require larger, prospective clinical trials specifically designed to overcome the limitations herein. These studies may be able to provide more concrete direction in terms of the true utility of imaging studies, as well as when to proceed with imaging and when not to in the best interest of the patient and client. However, it is important to note that in individual cases, diagnostic imaging was vital to case management and until further information is published, the specifics of each individual case should be considered when recommending any diagnostic test. Furthermore, there can be inherent value in an imaging study without significant abnormalities. Therefore, while this study is able to successfully challenge the dogma that imaging studies are an imperative portion of every canine IMHA evaluation, it is unable to determine the value of imaging in individual cases.

This study is limited by its retrospective nature, which could result in either case selection bias and/or information bias. In the hospital in which the study was performed, the current standard of care for canine IMHA is that all cases receive complete diagnostic work-ups inclusive of thoracic and abdominal imaging. As such, it is standard recommendation to perform these tests unless contraindicated financially or medically. Therefore, selection bias for medical reasons should be minimized in this study as the decision to perform imaging is based to a lesser extent on clinician preference and more on financial restraints.

Furthermore, this retrospective study describes a single clinical disease process with restrictive inclusion criteria to standardize the imaging results as much as possible, the numbers in this study are low. The reason for including only diagnostic tests that were performed and evaluated at the Ohio State University Veterinary Medical Center was to ensure validity of the imaging results. However, the restrictive inclusion criteria and resulting small number of cases in this series may have excluded some cases of IMHA, including animals which were not initially regenerative and would eventually meet IMHA criteria later in hospitalization. Additional diagnostic tests (e.g., aspirate cytology of imaging abnormalities) were performed on a case-by-case basis and were not controlled. This may have resulted in missing some pertinent findings in cases with abnormalities that were not examined further or cases with normal imaging and underlying diseases. Lastly, not all animals presented to the hospital with IMHA were included due to lack of imaging studies performed. The exact reason why imaging was not performed could not be
determined in most cases. However, the most likely reason was financial, as complete imaging is considered standard-of-care in the institution in which the study was performed.

This study relied on previously used, semi-objective outcome measures; ODU and DUS. There is inherent subjectivity to these scoring categories that can be affected by individual bias. However, the current study attempted to minimize this by using multiple reviewers (4 total) who had independent access to each medical record and evaluated each medical record. The results of the Fleiss kappa indicate that for thoracic radiographs there was consistent and reliable scoring of each case using this system amongst the 4 reviewers. Consistent scoring was not as strong for abdominal ultrasound and was potentially caused by the higher incidence of nonspecific findings on ultrasound evaluations. Therefore, confidence can be placed in the repeatability of the diagnostic utility scoring assignment for thoracic radiographs, while there was a large clinician bias towards ultrasound utility in this study.

Canine IMHA is an expensive and challenging disease to treat. Each individual case work-up will be different, being affected by a myriad of clinical variables, including attending clinician, owner financial constraints, and availability of diagnostic tests. Significant resources are dedicated to the diagnostic tests used to determine the primary or secondary nature of an IMHA case, including thoracic radiographs and abdominal ultrasound. If it is possible to identify treatable secondary causes of IMHA or significant complications of illness and/or concurrent disease, this may lead to multiple benefits to the patient including a faster recovery, enhanced quality of life, and long-term cost savings. Alternatively, if these diagnostic tests fail to provide additional information, the resources and stress to the patient may have opposite deleterious effects. This conundrum underscores the need for follow-up studies on this subject to better identify which patients will benefit from further imaging investigation.

In conclusion, this study demonstrates that the overall utility of these imaging modalities to identify abnormalities is not high. However, the findings are not consistent amongst all cases and therefore cannot be used to advise the clinician to either consistently recommend or not recommend these 2 diagnostic tests in every IMHA patient. Until further information is determined from additional studies, the choice to perform these diagnostic tests should be based on the individual patient, client, and clinician variables and expected case-by-case diagnostic utility.

**Appendix A. Definitions of normal imaging findings for canine abdominal ultrasound.**

<table>
<thead>
<tr>
<th>Organ system</th>
<th>Normal description</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peritoneal space</td>
<td>The peritoneal space was evaluated for increased fluid or gas volume, as well as any identifiable masses or change in echogenicity.</td>
<td>(23)</td>
</tr>
<tr>
<td>Lymph nodes</td>
<td>Lymph centers examined included, but were not limited to the jejunal, hepatic, splenic, colic, mesenteric, gastroduodenal, medial iliacs, and sublumbar lymph nodes. The lymph nodes were relatively isoechoic to surrounding normal soft tissues with regular margins. Normal lymph nodes had a short axis diameter to long axis diameter of &lt;0.4 cm.</td>
<td>(24,25)</td>
</tr>
<tr>
<td>Pancreas</td>
<td>Pancreatic tissue margins were indistinct, and the echogenicity was isoechoic to slightly hypoechoic to that of surrounding mesenteric fat with thickness &lt;1 cm.</td>
<td>(26)</td>
</tr>
<tr>
<td>Adrenal glands</td>
<td>Adrenal glands were hypoechoic to the surrounding fat. Identification of a corticomedullary rim was considered insignificant if appropriately sized. On longitudinal view, the normal glands appeared bilobed to ovoid with a maximum width less than 0.81 cm for the right adrenal gland and 0.74 cm for the left adrenal gland.</td>
<td>(27,28)</td>
</tr>
<tr>
<td>Liver</td>
<td>Hepatic parenchyma was uniformly hyperechoic/isoechoic to right renal cortex and hypoechoic to spleen with more course echotexture. The causal margin of the hepatic parenchyma was cranial to the stomach with a sharp angle.</td>
<td>(29)</td>
</tr>
<tr>
<td>Gallbladder and biliary tract</td>
<td>Gallbladder wall was a thin echogenic line between anechoic bile (in the normal patient) and the hepatic parenchyma. The gallbladder tapered into the cystic duct. The common bile duct was &lt;0.3 cm. Dependent echogenic luminal material in the gallbladder was interpreted as sludge and considered insignificant.</td>
<td>(30)</td>
</tr>
<tr>
<td>Spleen</td>
<td>Normal splenic architecture was homogeneous with fine echotexture that was hyperechoic the left renal cortex and liver.</td>
<td>(31)</td>
</tr>
<tr>
<td>Gastrointestinal tract</td>
<td>The GI tract was evaluated for wall thickness, appearance of wall layers, luminal contents and diameter, and motility. Wall thickness was measured from the inner luminal interface to the outer serosal surface, and considered normal if within published reference ranges (stomach: 2 to 5 mm, duodenum: 3 to 6 mm depending on body weight, jejunum: 2 to 5 mm depending on body weight, ileum: 2 to 4 mm, and colon: 2 to 3 mm). Wall layers were considered normal if all layers were clearly visible, had normal relationship with each other, and were of normal echogenicity.</td>
<td>(32,33)</td>
</tr>
<tr>
<td>Urinary tract</td>
<td>The kidneys had a distinction between the cortex and medulla with a normal shape. Size was fairly subjective and if felt abnormal then a renal length to aorta ratio was calculated; abnormal was considered &lt;5.5 or &gt;9.1. The ureters were indistinct with acute tapering at the renal hilus. No luminal hypoechogenicity within the ureter. The renal pelves were &lt;2 mm on transverse image. The bladder was evaluated for content, wall layer appearance, and wall thickness according to published reference ranges depending upon bladder distention (minimally distended ~2.3 mm, moderately distended ~1.4 mm) and body weight.</td>
<td>(34–36)</td>
</tr>
<tr>
<td>Genitals</td>
<td>If present, ovaries/uterus or the testes were identified. The ovaries were hyperechoic to region peri-renal fat with homogeneous appearance with similar echogenicity to the renal cortex. Uterine horns and body did not have luminal fluid. The testes were located within the scrotum with symmetry and a distinct hyperechoic mediastinum that dissects through homogeneous parenchyma.</td>
<td>(37,38)</td>
</tr>
</tbody>
</table>
Appendix B. Agreement statistics among the 4 internists who reviewed the individual cases.

<table>
<thead>
<tr>
<th>Assessment</th>
<th>Majority agreement</th>
<th>Disagreement</th>
<th>Findings in cases of disagreement</th>
<th>Fleiss Kappa</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Thoracic radiographs</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ODU</td>
<td>48 out of 50</td>
<td>2 out of 50</td>
<td>Mediastinal fat or sternal lymphadenopathy, cholecystoliths, hepatomegaly ((n = 1)); mild sternal lymphadenopathy, cholecystoliths ((n = 1)).</td>
<td>(\kappa = 0.72)</td>
</tr>
<tr>
<td></td>
<td>Useful</td>
<td>Not Useful</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>10 out of 48</td>
<td>38 out of 48</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DUS</td>
<td>47 out of 50</td>
<td>3 out of 50</td>
<td>Mild left atrial enlargement, metallic gastric foreign bodies ((n = 1)); mild sternal lymphadenopathy, cholecystoliths ((n = 1)); generalized cardiomegaly, mild pleural effusion ((n = 1)).</td>
<td>(\kappa = 0.67)</td>
</tr>
<tr>
<td>Category 1</td>
<td>Category 2</td>
<td>Category 3</td>
<td>Category 4</td>
<td>Category 5</td>
</tr>
<tr>
<td>0 out of 48</td>
<td>8 out of 48</td>
<td>5 out of 48</td>
<td>0 out of 48</td>
<td>34 out of 48</td>
</tr>
<tr>
<td>Abdominal ultrasound</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ODU</td>
<td>55 out of 63</td>
<td>8 out of 63</td>
<td>Gall bladder wall edema ((n = 1)), hypoechoic liver ((n = 1)), splenomegaly ((n = 1)), cholecystitis ((n = 1)), hepatic nodules ((n = 3)), mottled liver ((n = 1)), heptomegaly ((n = 2)), mild peritoneal effusion ((n = 2)), decreased corticomedullary distinction ((n = 1)), gall bladder sludge ((n = 1)), cystic calculi ((n = 1)), cholecystolith ((n = 1)).</td>
<td>(\kappa = 0.25)</td>
</tr>
<tr>
<td></td>
<td>Useful</td>
<td>Not Useful</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>23 out of 63</td>
<td>33 out of 63</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DUS</td>
<td>54 out of 63</td>
<td>9 out of 63</td>
<td>Splenomegaly ((n = 2)), hepatomegaly ((n = 2)), urine sedimentation ((n = 1)), gall bladder sludge ((n = 1)), hepatic nodules ((n = 5)), decreased corticomedullary distinction ((n = 1)), mild peritoneal effusion ((n = 1)), hyperechoic liver ((n = 2)), hypoechoic spleen ((n = 1)), gall bladder wall edema ((n = 2)), mild pyelectasia ((n = 1)), splenic nodule ((n = 2)), mottled liver ((n = 1)), thrombus in splenic vein ((n = 1)), cholecystitis ((n = 1)), enlarged right lobe of the pancreas ((n = 1)), renal cyst ((n = 2)), cystitis ((n = 1)), cholelithiasis ((n = 1)).</td>
<td>(\kappa = 0.31)</td>
</tr>
<tr>
<td>Category 1</td>
<td>Category 2</td>
<td>Category 3</td>
<td>Category 4</td>
<td>Category 5</td>
</tr>
<tr>
<td>0 out of 63</td>
<td>14 out of 63</td>
<td>23 out of 63</td>
<td>0 out of 63</td>
<td>17 out of 63</td>
</tr>
</tbody>
</table>
References


Article

Potential for BioXmark liquid fiducial marker to improve identification of superficial component of canine oral tumors for computer-based radiation therapy planning

Benoit Clerc-Renaud, Mary-Keara Boss, Lynn R. Griffin, Susan M. LaRue, Del Leary

Abstract — The objective of this study was to evaluate a novel liquid fiducial marker, BioXmark, to improve identification of the superficial component of oral tumors in dogs with computed tomography imaging. Liquid fiducial marker was injected in 6 patients at the visible and palpable extent of each tumor. Gross tumor volumes with and without BioXmark were compared in terms of volume and conformity using a Paddick conformity index, Dice similarity coefficient, and gross tumor volumes mismatch analysis. All patients showed an increase in gross tumor volumes defined by BioXmark compared with the conventionally identified post-contrast gross tumor volumes contours. Volumetric conformity and gross tumor volumes mismatch analysis of the superficial component of gross tumor volumes resulted in a median conformity index of 0.61 and median Dice similarity coefficient of 0.76. The superficial gross tumor volumes showed a median increase of 47% when BioXmark was used. This study demonstrated a potential utility to combining liquid fiducial markers to post-contrast computed tomography images for improved oral tumor localization and gross tumor volumes contouring for radiation therapy planning.

Résumé — Potentiel du marqueur de repère liquide BioXmark à améliorer l’identification d’éléments superficiels de tumeurs orales canines pour la planification de radiothérapie assistée par ordinateur. L’objectif de la présente étude était d’évaluer un nouveau marqueur de repère liquide, BioXmark, à améliorer l’identification des éléments superficiels des tumeurs orales canines par tomodensitométrie. Le marqueur de repère liquide fut injecté à six patients à la limite visible et palpable de chaque tumeur. Les volumes bruts des tumeurs avec et sans BioXmark furent comparés en termes de volume et de conformité en utilisant l’index de conformité de Paddick, le coefficient de similarité de Dice, et une analyse de disparité des volumes bruts des tumeurs. Tous les patients montrèrent une augmentation des volumes bruts des tumeurs déterminés par BioXmark comparativement aux volumes bruts des tumeurs déterminés par la méthode conventionnelle d’identification des contours post-contrastes. La conformité volumétrique et l’analyse de disparité des volumes bruts des tumeurs du composant superficiel des volumes bruts des tumeurs a résulté en un index de conformité médian de 0,61 et un coefficient de similarité de Dice médian de 0,76. Les volumes bruts superficiels des tumeurs montraient une augmentation médiane de 47 % lorsque le BioXmark était utilisé. La présente étude a démontré une utilité potentielle à combiner des marqueurs de repère liquides aux images de tomodensitométrie post-contraste pour améliorer la localisation de tumeurs orales et la détermination des volumes bruts des tumeurs pour la planification de la radiothérapie.

(Traduit par Dr Serge Messier)

Introduction

Oral tumors are common in dogs and represent 6% to 7% of canine cancers (1–3). Local therapy options commonly include radiation therapy, surgery, or a combination of these modalities. Radiation therapy has proved to be successful in the treatment of many oral tumors in veterinary medicine (4–10). Accurate oral tumor delineation on computed tomography (CT) for computer-based radiation planning remains challenging, despite the presence of an easily, visually identifiable and palpable oral mass on physical examination. As the oral mucosa is naturally contrast enhancing, this decreases the distinction between normal tissue and tumors on CT images. Additionally, tumors may also be heterogeneously or non-contrast enhancing, further confounding the line between normal and abnormal tissues. To produce an optimal and effective radiation therapy plan, accurate target delineation is of paramount importance.

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Use of this article is limited to a single copy for personal study. Anyone interested in obtaining reprints should contact the CVMA office (hbroughton@cvma-acmv.org) for additional copies or permission to use this material elsewhere.
This retrospective study was performed to evaluate the use of liquid fiducial markers for future patients in order to improve identification of canine oral tumors on CT images for gross tumor volumes (GTV) contours for computer-based radiation therapy planning in patients that had received peritumoral liquid fiducial injections.

Traditional fiducial markers have been an integral part of radiation therapy in human medicine but have limited use in veterinary medicine. They are considered standard of care in prostate radiotherapy (11) and are commonly used for breast (12), bladder (13), and internal organs such as the pancreas (14). Fiducial markers are generally small radio-opaque objects, often small diameter spheres or wires, externally placed or internally implanted in patients which allow for spatial localization of the tumor for radiation therapy. The advent of liquid fiducial markers has led to an increased recognition of their utility in image-guided radiation therapy (IGRT), most notably in the treatment of bladder tumors (15–18). More recently, liquid fiducial markers have been evaluated for tumor localization and assessment of inter- and intra-fractional movement of targets within the thoracic cavity (19–22). The use of liquid fiducial markers has allowed for more accurate tumor delineation for radiation planning (15,18), increased inter-observer agreement on tumor contours for radiation therapy (17), and improved target verification during therapy (15).

BioXmark (Nanovi, Lyngby, Denmark) is a relatively new liquid fiducial marker. Unlike other liquid fiducials, BioXmark uses passive ethanol efflux into the surrounding tissues to become highly viscous, further stabilizing the product at the injection site. BioXmark has been assessed against traditional markers and another commercially available liquid fiducial marker in a pre-clinical thoracic phantom model (23) in addition to tumor target positioning in a porcine model (24,25). Recently, its use for radiotherapy for prostate tumors in a phantom model was shown to be favorable compared to solid gold fiducial markers (26). BioXmark has also been used successfully in clinical patients with lung tumors undergoing radiation therapy (20–22). The objective for this retrospective study was to determine the feasibility and utility of using BioXmark to identify the superficial aspect of oral tumors in dogs in combination with CT imaging. This is the first report of the use of a liquid fiducial marker in veterinary medicine.

Materials and methods

Liquid fiducial

BioXmark is an injectable, biodegradable liquid fiducial marker composed of sucrose acetate isobutyrate (SAIB), iodinated SAIB, and ethanol available in 1 mL ampules. The ampules were kept refrigerated before use. Luer lock syringes with variable micro-adjustments ranging from 10 to 50 μL (3Dose Luer lock syringe; Vlow medical, Eindhoven, Netherlands) were used for injection into a pre-clinical tissue model and clinical patients. Eighteen-gauge needles were used to load the liquid fiducial while 22 Ga needles were used for injections. Sterile isopropyl wipes (Webcol wipes; Covidien, Mansfield, Massachusetts, USA) were used as needed to remove excess liquid fiducial from the needle tip before or between injections.

Evaluation of optimal injection volume and inter-injection distances using a tissue model

Commercially available beef steaks were used as a tissue model for pre-clinical evaluation. A linear array of different injection volumes (10, 25, and 50 μL) and inter-injection distances (3, 5, 10 mm) were obtained using a premeasured paper template for injections. Subsequently, an array of circles ranging from 1, 2, 3, and 4 cm in diameter and different inter-injection distances (5, 10, 15, and 20 mm) were obtained. Identification of the liquid fiducials was obtained with a kilo voltage cone beam CT (kV CBCT) from the onboard imaging (OBI) of a linear accelerator (Trilogy; Varian Medical Systems, Palo Alto, California, USA). The CBCT acquisition parameters were those designated under a “high-quality head” setting as follows: 80 kVp, 25 mA, 512 × 512 pixel matrix, 2-mm slice thickness, and a full fan bowtie filter. Images were subsequently imported into a treatment planning software (Eclipse version 13; Varian Medical Systems, Palo Alto, California, USA). Visual acuity and contrast-to-noise ratios were used to confirm identification of the fiducial markers and evaluate differences between injection volumes and inter-injection distances. A contrast-to-noise (CNR) ratio is useful in imaging analyses to qualify how easily a feature can be visualized through contrast. This is not the same as signal-to-noise (SNR), in which coherent signal may be high, but visualization of features can still be difficult. The Rose criterion states that if the CNR of a hotspot becomes smaller than 3 to 5, it becomes very difficult to discern an adjacent object within an image (27). In our study, a CNR value > 2 would objectively deem an object visible using a CNR formula equal to:

\[ |\bar{x}_m - \bar{x}_b| \div \sqrt{\sigma^2_m + \sigma^2_b} \]

where: \( \bar{x}_m \) and \( \bar{x}_b \) represent the mean of the signal intensity in Hounsfield units for the marker and background as noted in a previous study (23), \( \sigma^2_m \) and \( \sigma^2_b \) represent the standard deviation of the signal intensity values for the marker and background regions.

Patient population and inclusion criteria

Client-owned dogs with naturally occurring oral tumors that were presented to the oncology service at our institution between July and September 2016 were considered for this proof of concept study. Patients were given liquid fiducial markers when clinical resources were available to assist in tumor identification in addition to standard of care CT imaging with pre- and post-contrast images. Criterion for this study was that each patient had a physically identifiable, accessible, and macroscopic oral tumor at the time of CT imaging. Clients provided written consent for treatment at the time of admission and all reported procedures in this retrospective study were part of that treatment.

Computed tomography imaging and liquid fiducial injections

Patients were placed under general anesthesia and imaged using a multi-slice CT scanner (Gemini TF BIG BORE; Philips, Cleveland, Ohio, USA). Computed tomography acquisition parameters were 120 kVp, variable mAs, 512 × 512 pixel matrix, and the smallest appropriate field of view. Per our
institution’s protocol for head and neck CT scans, a helical scan of the region of interest was reconstructed in a pre-contrast 1-mm transverse detail algorithm and 2-mm transverse standard algorithm pre- and post-contrast images on all patients. Non-invasive immobilization devices for head and neck tumors were used for radiation therapy planning positioning for each patient before imaging, as previously described (28). These immobilization devices were nearly transparent in terms of contrast compared to the fiducial markers used. After acquisition of pre- and post-contrast scans, the patient was removed from the immobilization devices. The extent of the tumor was determined using visual and physical cues. Injections of the liquid fiducial were administered around the periphery of the tumor with the aid of a graduated wire according to the recommended contiguous inter-injection distances defined during the preclinical tissue model experiments and at a depth beyond 4 mm to ensure visualization of the marker in imaging. Any fluid that was pushed to the surface of the injection was removed. After injection, the patient was repositioned in the same immobilization setup and re-scanned to obtain a post-fiducial injection CT image set. A final additional image registration was also performed within the treatment planning system to align the post-fiducial injection CT with the pre-fiducial injection CT.

Tumor contouring
The CT scans for each patient were used for radiation therapy planning. Post-contrast and post-fiducial image sets were imported into the treatment planning software. The post-contrast gross tumor volumes were defined with the group consensus of 2 radiation oncology residents, 1 medical physicist, a Board-certified veterinary radiation oncologist, and a dual Board-certified radiation oncologist and radiologist. Each patient’s history, physical examination findings, and photographs of the lesions were available for the group during the GTV contouring process; however, the fiducial marker placements were not known to the group during the assessment of the post-contrast GTV (GTV₀). The image sets which included the liquid fiducial markers were contoured separately by the lead author to identify the fiducial-guided GTV (GTV₉). The GTV₉ was defined by using the fiducial markers as limits for

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**Figure 1.** Schematic representation of the different gross tumor volumes analyzed in this study. A – Total post-contrast GTV (GTV₀). B – Superficial component of GTV₀ (GTV₉). C – The fiducial GTV (GTV₉). D – The mismatch GTV (GTV₉) in blue separated from GTV₀ in red. E – The combined GTV using post-contrast and liquid fiducial markers in green (GTV₀,F). Green lines represent injection sites for liquid fiducial marker.

**Figure 2.** Dorsal view of linear fiducial array with increasing injection volumes and distances between BioXmark injections. All injection volumes are visible.
the cranial, caudal, and lateral margins, with a limited depth of 4 mm from the body surface. The 4-mm depth followed the surface using the treatment planning system contouring tools and thus was automatically done. The 4-mm depth was empirically chosen as the deepest point at which the tumor could be determined from surface palpitation. Beyond this point, the potential boundary of the underlying tumor could not be confirmed. The limitation of depth to 4 mm was established with the consideration that only the superficial component of the tumor could be palpated to this depth to guide the liquid fiducial injections.

To assess how the conventionally determined GTV would change when liquid fiducial markers were used, we examined changes in volume to the entire tumor (GTV<sub>O</sub>). Note that GTV<sub>O</sub> is the gross tumor volume that was determined as the typical standard of care through expert interpretation of CT images and without any additional fiducial markers. Recalling that our fiducial-guided tumor volume, GTV<sub>F</sub>, only gives information around the surface of the tumor, we also recorded changes to the superficial GTV structure sets. Tumors with large total volumes likely minimized the relatively small change in volume noted by the fiducial markers at the superficial level. Ultimately, this assessment of the superficial GTV contours magnified the impact of the fiducial marker and was for evaluation purposes only. Total gross tumor volumes would be used clinically for treatment purposes.

### Table 1. Means, standard deviations, and contrast-to-noise ratios for different injection volumes.

<table>
<thead>
<tr>
<th>Volume (µL)</th>
<th>(\bar{x}_m) (HU)</th>
<th>(\bar{x}_b) (HU)</th>
<th>(\sigma_m)</th>
<th>(\sigma_b)</th>
<th>CNR</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>423</td>
<td>41</td>
<td>103</td>
<td>19</td>
<td>4.15</td>
</tr>
<tr>
<td>25</td>
<td>485</td>
<td>13</td>
<td>116</td>
<td>23</td>
<td>3.97</td>
</tr>
<tr>
<td>50</td>
<td>605</td>
<td>17</td>
<td>133</td>
<td>20</td>
<td>4.38</td>
</tr>
</tbody>
</table>

\(\bar{x}_m\) — mean of the signal intensity for the marker; \(\bar{x}_b\) — mean of the signal intensity for the background; \(\sigma_m\) — standard deviation of the signal intensity values for the marker; HU — Hounsfield units; \(\sigma_b\) — standard deviation of the signal intensity values for the background; CNR — contrast-to-noise ratio.

Figure 3. Sagittal view of linear array with increasing injection volumes and distances between BioXmark injections. A 10-µL volume provides adequate visibility along the injection tract for all inter-injection distances; larger volumes result in excessive marker pooling.

Figure 4. Dorsal view of circular array with BioXmark injections. To best delineate a circular shape, it was determined that a minimum of 3 injections per quadrant was needed. Based on these injections in the tissue model, tumors \(\leq 3 \text{ cm}\) are best delineated with 5 mm between injections compared to 10 mm spacing for tumors \(\geq 3 \text{ cm}\) in diameter.
Table 2. Patient demographics.

<table>
<thead>
<tr>
<th>Patient</th>
<th>Tumor location</th>
<th>Tumor size (cm)</th>
<th>Histopathologic diagnosis</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Rostral mandible</td>
<td>2.2 × 1.1 × 0.9</td>
<td>Fibrous hyperplasia</td>
</tr>
<tr>
<td>2</td>
<td>Rostral mandible</td>
<td>6.3 × 3.8 × 3.3</td>
<td>Acanthomatous ameloblastoma</td>
</tr>
<tr>
<td>3</td>
<td>Caudal mandible</td>
<td>2.8 × 2.5 × 2.2</td>
<td>Osteosarcoma versu ossifying fibroma</td>
</tr>
<tr>
<td>4</td>
<td>Rostral maxilla</td>
<td>8.0 × 4.5 × 3.0</td>
<td>Osteosarcoma</td>
</tr>
<tr>
<td>5</td>
<td>Rostral maxilla</td>
<td>3.5 × 3.4 × 2.0</td>
<td>Fibroblastic osteosarcoma</td>
</tr>
<tr>
<td>6</td>
<td>Rostral mandible</td>
<td>2.6 × 1.7 × 1.6</td>
<td>Myxosarcoma</td>
</tr>
</tbody>
</table>

Volumetric conformity and mismatch fraction analysis

The conformity between the different tumor contours was assessed using the Paddick conformity index as previously described (29) to compare 2 volumes for both total (GTV_O) and superficial (GTV_S) tumor volumes. The conformity index is defined as:

Conformity index = \( TV_{PI} \times TV \)

where: conventionally PIV and TV are the respective volumes of the planning irradiated volume (PIV) that reached the prescription dose and the actual contoured targeted tumor volume (TV), and the TV_{PI} is the overlap volume between PIV and TV. This equation was used to compare the gross tumor volumes that included the fiducial markers to the standard of care post contrast GTV (GTV_O). As such, the conformity index equation for total gross tumor volumes was:

Conformity index = (overlap between GTV_O AND GTV_O+F)/TV

Similarly, the conformity index equation for superficial gross tumor volumes is:

Conformity index = (overlap between GTV_S AND GTV_S+F)/TV

A conformity index of 1 indicated perfect conformity between 2 volumes. Values < 1 indicated discrepancies between volumes with smaller values representing bigger differences.

In addition to conformity index values, Dice similarity coefficients (DSC) (30) were also calculated as another metric to compare 2 volumes. The equation was defined as:

DSC = 2TV_{PI}/(TV + TV)

Evaluation of injection volume and inter-injection distances using a tissue model

Analysis of CBCT images of the tissue model array showed that all liquid fiducial volumes and inter-injection distances were visible (Figure 2). The CNR values associated with injection volumes of 10, 25, and 50 µL were 4.15, 3.97, and 4.38, respectively (Table 1). The optimal injection volume was 10 µL based on appropriate deposition of the liquid fiducial marker for identification and the least amount of pooling at the injection site (Figure 3). The CNR values showed little difference between the trial volumes and did not influence the optimal volume decision. An injection volume of 10 µL did not result in any cross-contamination of the fiducial marker between injection sites for the trial inter-injection distances used. To determine the optimal injection spacing a simple assertion that there should ideally be at least 3 points over a 90° angle for a spherical shape:

\[ 3d \leq \frac{2\pi r}{4} \]

where: \( d \) is the spacing and \( r \) is the radius for the sample sphere. This would allow for reasonable curvature to demarcate tumor shapes more realistically. Using this logic in the tissue model with a circular array confirmed that an inter-injection distance of 5 mm for tumors < 3 cm and 10 mm for tumors ≥ 3 cm would be recommended (Figure 4).

Patient population

Six dogs were included in the study (Table 2). The median age among the patients was 8 y. There were 2 spayed females, 1 intact male, and 3 castrated males. The breeds represented included 2 golden retrievers, 1 Labrador retriever, 1 German shepherd, 1 standard schnauzer, and 1 mixed breed. The median weight was 34.6 kg.

Tumor contouring, volumetric conformity, and GTV mismatch analysis

Great variability existed among patient gross tumor volumes in this study (Table 3). The GTV_O values ranged from 0.64 to 59.13 mL (median: 18.41 mL) while GTV_S values ranged from 0.51 to 18.22 mL (median: 4.04 mL). The addition of GTV_S increased all tumor volumes to a new range of 1.87 to 63.94 mL (median: 20.71 mL) for GTV_O+F and 1.75 to 21.11 mL (median: 6.45 mL) for GTV_S+F.
**Figure 5.** Patient #1 with rostral mandibular tumor. A — Tumor on physical examination. B–F — Transverse post-fiducial consecutive CT slices identifying fiducial markers (green), total post-contrast gross tumor volume (GTV$_{O}$, red), and mismatch GTV (GTV$_{M}$, blue) containing additional volume not identified by GTV$_{O}$.

**Table 3.** Patient gross tumor volumes.

<table>
<thead>
<tr>
<th>Patient</th>
<th>Total gross tumor volumes (mL)</th>
<th>Superficial gross tumor volumes (mL)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>GTV$_{O}$</td>
<td>GTV$_{O+F}$</td>
</tr>
<tr>
<td>1</td>
<td>0.64</td>
<td>1.87</td>
</tr>
<tr>
<td>2</td>
<td>47.26</td>
<td>49.61</td>
</tr>
<tr>
<td>3</td>
<td>24.90</td>
<td>27.76</td>
</tr>
<tr>
<td>4</td>
<td>59.13</td>
<td>63.94</td>
</tr>
<tr>
<td>5</td>
<td>11.91</td>
<td>13.66</td>
</tr>
<tr>
<td>6</td>
<td>3.54</td>
<td>5.11</td>
</tr>
</tbody>
</table>

GTV — gross tumor volume; GTV$_{O}$ — total post-contrast GTV; GTV$_{O+F}$ — post-contrast and fiducial GTV; GTV$_{S}$ — superficial component of GTV$_{O}$; GTV$_{S+F}$ — superficial component of GTV and fiducial GTV.

**Table 4.** Patient volumetric analysis of gross tumor volumes with the Paddick conformity index and Dice similarity coefficient (DSC).

<table>
<thead>
<tr>
<th>Patient</th>
<th>Conformity index</th>
<th>Dice similarity coefficient</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total gross tumor volumes</td>
<td>Superficial gross tumor volumes</td>
</tr>
<tr>
<td>1</td>
<td>0.34</td>
<td>0.29</td>
</tr>
<tr>
<td>2</td>
<td>0.95</td>
<td>0.86</td>
</tr>
<tr>
<td>3</td>
<td>0.90</td>
<td>0.61</td>
</tr>
<tr>
<td>4</td>
<td>0.92</td>
<td>0.62</td>
</tr>
<tr>
<td>5</td>
<td>0.87</td>
<td>0.65</td>
</tr>
<tr>
<td>6</td>
<td>0.69</td>
<td>0.61</td>
</tr>
</tbody>
</table>

**Table 5.** Patient gross tumor volume mismatch and percentages.

<table>
<thead>
<tr>
<th>Patient</th>
<th>Mismatch volume</th>
<th>Mismatch percent</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>GTV$_{M}$ (mL)</td>
<td>GTV$<em>{M}$/GTV$</em>{O}$ (%)</td>
</tr>
<tr>
<td>1</td>
<td>1.15</td>
<td>179.69</td>
</tr>
<tr>
<td>2</td>
<td>1.57</td>
<td>3.32</td>
</tr>
<tr>
<td>3</td>
<td>2.50</td>
<td>10.04</td>
</tr>
<tr>
<td>4</td>
<td>3.75</td>
<td>6.34</td>
</tr>
<tr>
<td>5</td>
<td>1.38</td>
<td>11.59</td>
</tr>
<tr>
<td>6</td>
<td>1.25</td>
<td>35.31</td>
</tr>
</tbody>
</table>

GTV — gross tumor volume; GTV$_{M}$ — mismatch GTV; GTV$_{O}$ — total post-contrast GTV; GTV$_{S}$ — superficial component of GTV$_{O}$.
Conformity between GTV contours varied substantially amongst patients (Table 4). Conformity index values for total gross tumor volumes ranged from 0.34 to 0.95 (median: 0.87). In comparison, conformity index values for superficial gross tumor volumes ranged from 0.29 to 0.86 (median: 0.61). Dice similarity coefficients for total gross tumor volumes ranged from 0.51 to 0.98 (median: 0.95) and ranged from 0.45 to 0.93 (median: 0.76) for superficial gross tumor volumes.

Gross tumor volumes mismatch analysis assessed mismatch volumes (GTVM) as well as percentage changes relative to total or superficial standard of care gross tumor volumes (Table 5). The GTVM values ranged from 1.15 to 3.75 mL (median: 1.48 mL). Percentage increases for GTV O ranged from 3.32% to 179.69% (median: 10.82%) with the addition of GTV M. Similarly, percentage increases for GTV S ranged from 8.62% to 225.49% (median: 46.56%) with the addition of GTV M.

All patient GTV O and GTV S contours increased with BioXmark use (Table 3). As an example, a selected case from this study (patient #1, Table 2) is presented to demonstrate the difference between contours with and without liquid fiducial markers (Figure 5). The tumor (Figure 5A) was identified and palpated before CT imaging; then, the tumor volume was contoured on transverse CT images after fiducial injection which showcased the difference between GTV O and GTV M (Figures 5 B–F). Three-dimensional reconstructions of this case and another selected case (patients #1 and #6, Table 2) are presented to further demonstrate the importance of GTV M in the contouring process (Figure 6).

Discussion

This study demonstrated the feasibility of using BioXmark to improve the identification of the palpable and superficial extent of oral tumors in dogs in combination with CT imaging. The liquid fiducial markers were easily identified on both CBCT and multi-slice CT scanner images with good CNR values. The optimal injection volume for intraoral tumors in dogs was determined to be 10 μL according to a preclinical tissue model. This allowed good identification of the liquid fiducial markers with the least amount of pooling between injection sites. The preclinical tissue model analysis also validated the recommended inter-injection distances of 5 mm for tumors < 3 cm and 10 mm for tumors ≥ 3 cm. These guidelines provide a clinical protocol to optimize accurate tumor delineation while minimizing the number of injections needed, amount of liquid fiducial required, and procedure time (~5 to 10 min with current guidelines). However, smaller or larger intra-injection distances may be considered clinically to best outline irregular tumor shapes. These preclinical tissue model results dictated the guidelines which were subsequently used in clinical patients.

Our results demonstrated the clinical role of liquid fiducial markers in combination with CT imaging for aiding in the identification of oral tumors in dogs in the contouring process for radiation therapy planning. Use of the liquid fiducial markers allowed identification of a well-defined marker on CT images. Given that the injections were placed around visually and palpably abnormal tissue in each patient’s oral cavity, this increased clinician confidence in creating an accurate GTV contour for planning purposes. All conformity index and DSC values were less than 1, indicating a discrepancy between tumor contours with and without liquid fiducial marker use. Given image registration and the addition of GTV F to GTV O structures, this indicated that potential abnormal tissue identified and palpated on physical examination was not recognized by post-contrast CT images alone. It is important to note that
the converse is also true, meaning that portions of abnormally appearing tissue on CT images may not have been visualized or palpated abnormally on physical examination. As such, portions of GTV₀ and GTV₃ contours did not always overlap with GTVₐ. This occurred in 2 of the 6 patients in which GTVₐ were larger than GTV₃. The GTV mismatch analysis resulted in a corresponding median increase of 11% for the total gross tumor volumes and a median increase of 47% for the superficial volumes when using BioXmark. Liquid fiducials, therefore, can be used in conjunction with post-contrast CT images to aid in tumor delineation, most notably in the oral mucosa where CT contrast can sometimes have limited uptake making tumor delineation difficult.

The numerous benefits of liquid fiducial markers have increased their applicability in clinical practice (15–20, 22,32,33). Several advantages over traditional fiducial markers include biodegradability, easy and non-invasive administration, long-term tissue stability of several months, and decreased artifacts on advanced imaging, among others (20,21,23). Although most commonly used for radiation planning, liquid fiducials were used initially for surgical planning (34). The potential of these markers to localize hard to visualize tumors through CT contrast on advanced imaging for radiation planning and treatment delivery could increase treatment accuracy. Pre-clinical studies have evaluated the use of BioXmark for the treatment of pancreatic tumors (35,36) and delineation of esophageal tumors for radiotherapy (37). The use of liquid fiducials made a significant difference in bladder tumor contours and appropriate positioning during therapy in humans (17). Other possible uses may include intraoperative injection of resected tumor beds or post-operative tumor scars for adjuvant radiotherapy planning and delivery. Outside of this study, we have employed BioXmark at our institution in clinical practice. For example, the surgical scar of a feline patient was injected with BioXmark during planning CT image acquisition. The liquid fiducial markers were used both for planning and daily position matching with CBCT throughout this patient’s treatment protocol. New products such as PalpMark (Novani, Lyngby, Denmark) are available and are being evaluated for similar uses. There were limitations to this study. First, liquid fiducial markers could only be used to assess the superficial extent of tumors, so information from post-contrast CT images was essential. The use of magnetic resonance imaging (MRI) should also be considered as another modality to aid tumor delineation. Fusion of MRI and CT images may be the most helpful for contouring and radiation therapy planning. Both superficial and total gross tumor volumes should be assessed in future studies as publications regarding MRI and contouring of oral tumors are scarce in veterinary medicine. Secondly, all the injections and fiducial contours were done by one individual. Although this allowed for consistency of fiducial placement in our study, the results of injection accuracy, precision, and gross tumor volume contours may differ among individuals. This interindividual variation should be evaluated using similar CT images with fiducial marker injections and different radiation oncologists. The high HU of the injected fiducial markers can lead to challenges in dosimetry. However, we did not observe any artifacts generated by the highly attenuating material. Migration of the markers over time was not assessed.

In conclusion, this is the first study evaluating BioXmark in clinical patients in veterinary medicine. BioXmark provides a novel and useful tool for enhanced localization of oral tumors in dogs when combined with CT imaging for radiation therapy planning. Future studies should be performed to further investigate the role of this product and other liquid fiducial markers in both veterinary radiation and surgical oncology.

Acknowledgments
The authors thank Dr. Beatrice Jeneti for aiding in tumor contouring. The authors also thank Dr. Morten Albrechtsen, Mr. Torsten Jepsen, and the Nanovi company for providing BioXmark for this study.

References


Medical and behavioral evaluation of 8 cats presenting with fabric ingestion: An exploratory pilot study

Isabelle Demontigny-Bédard, Marie-Claude Bélanger, Pierre Hélie, Diane Frank

Abstract — The aims of this pilot study were to: i) conduct a thorough behavioral and medical evaluation of cats presenting for chronic fabric ingestion; and ii) implement specific treatments for conditions identified and evaluate the outcome of treatment on fabric ingestion. Eight cats which ingested fabric at least weekly were recruited. Cat owners recorded daily baseline frequency of pica and gastrointestinal signs for 1 month prior to the behavioral and medical investigation and again during a follow-up period. Diagnoses were made and response to treatment was monitored and modified as needed. Abnormalities included mild hypercholesterolemia \((n = 7)\), gastric or intestinal eosinophilic infiltrates \((n = 6)\), suspected delayed gastric emptying \((n = 4)\), suspected gastric reflux \((n = 1)\), and *Giardia* spp. \((n = 1)\). Four of the eight cats responded partially to treatments. Treatment of fabric ingestion in cats remains a challenge and further investigation is needed.

Résumé — Évaluation médicale et comportementale de huit chats ingérant des tissus: une étude pilote. Les objectifs de cette étude pilote étaient: i) d’entreprendre une évaluation médicale et comportementale chez des chats présentant un comportement chronique d’ingestion de tissus; et ii) de mettre en place des traitements spécifiques pour les conditions identifiées et d’évaluer les résultats sur le comportement d’ingestion de tissus. Huit chats qui ingéraient hebdomadairement du tissu furent recrutés. Les propriétaires compilèrent la fréquence quotidienne de pica et les autres signes digestifs pendant un mois avant le début de l’étude puis de nouveau lors du suivi. À la suite du diagnostic posé, la réponse aux traitements de chaque chat fut suivie et les traitements étaient modifiés au besoin. Les changements observés incluaient une légère hypercholestérolémie \((n = 7)\), une infiltration gastrique ou intestinale éosinophilique \((n = 6)\), une suspicion de retard de vidange gastrique \((n = 4)\), une suspicion de reflux gastrique \((n = 1)\) et la présence de *Giardia* spp. \((n = 1)\). La moitié des chats ont répondu partiellement aux traitements instaurés. Le traitement d’ingestion de tissus demeure un défi et de la recherche future s’avère nécessaire.

(Traduit par les auteurs)

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Introduction

Pica in cats is defined as ingestion of non-nutritive substances such as fabric, plastic, rubber, paper, cardboard, soil, string, and plants (1). Most behavioral studies on pica published to date do not discriminate between actual ingestion and chewing or sucking on an item (1,2). Several behavioral hypotheses have been formulated regarding the potential causes or contributing factors such as boredom, lack of social contact, redirected hunting behavior, genetic predisposition, early weaning, fasting, craving for fiber, or compulsive disorder (3,4). In a recently published study on pica in cats, the behavior did not seem to be the consequence of a suboptimal environment or early weaning (5). Cats with pica vomited more often and were fed *ad libitum* less commonly than were healthy cats (5). Another study also reported an abnormally intense appetite in affected cats (2).

Medical causes in which pica in cats has been documented include pyruvate kinase deficiencies, immune-mediated hemolytic anemia, and feline infectious peritonitis (6–9). In these studies, limited or no information is available on the type of items ingested or characterization of the pica behavior (6–9). Interestingly, in rats (a species without emetic reflex), pica is documented following administration of cisplatin, an emetogenic chemotherapeutic drug, and other emetogenic drugs (10,11). This suggests that pica in rats is comparable to vomiting in other species (11). In dogs, pica can occur with gastric dysmotility, small intestinal disease, and hookworm infection (12–14).
To date, there have been no specific studies evaluating possible underlying or contributing medical conditions in cats exhibiting pica. Anecdotally, fabric ingestion is considered a potential sign of a gastrointestinal disorder. Therefore, the aims of this pilot study were to i) conduct a thorough behavioral and medical evaluation of affected cats including complete gastrointestinal evaluation; and ii) implement specific treatments for medical conditions identified and evaluate the outcome of these treatments on fabric ingestion.

Materials and methods

In this study, the term pica refers to the actual ingestion of inedible items with a focus on fabric ingestion. Ten cats were recruited at the Veterinary Teaching Hospital (VTH) between March 2013 and April 2015. An advertisement was sent to veterinarians in private practice and was published both on the website and in the electronic newsletter of the Faculty of Veterinary Medicine, University of Montreal. Cats were eligible for the study if they ingested fabric at least once a week and received no medication for pica. Cats were not eligible if they were diagnosed with a concurrent medical disorder that would increase their anesthetic risk. Owners were asked to provide the individual cat’s preferred fabric for up to 1 h daily for 1 mo at a time to measure frequency of pica. Owners supervised their pet and fabric was removed as soon as the cat started chewing the material. Cats were excluded if the only fabric they ingested consisted of shoelaces or threads since these items were considered too dangerous to offer even under supervision. Owners did not modify how they were managing access to fabric in their home. They were asked to log naturally occurring pica episodes (which item and circumstances) as well as the test results with the preferred fabric. For the latter, owners recorded the date and time, presence or absence of pica, offered item, length of the time the item was provided (up to a maximum of 1 h), time of last meal, and whether the item was chewed without ingestion. Owners recorded baseline frequency of pica during 1 mo before the behavioral and medical investigation and again during the follow-up period. Owners also included concurrent gastrointestinal signs such as vomiting or diarrhea and any other abnormal medical or behavioral sign in their monthly logbooks. Response to treatment was defined as 50% or more reduction in frequency of pica during monthly follow-up testing compared to baseline. All owners gave informed consent for enrollment of their cats in the study. This study was conducted in accordance with the ethical principles of the animal care and use committee of the University of Montreal.

Behavior was evaluated using a standardized general questionnaire (questionnaire from the behavioral medicine service of the VTH) and a more specific questionnaire on pica. Both questionnaires included closed-ended and open-ended questions as well as a section in each questionnaire for additional comments from owners. Questionnaires are available upon request to the corresponding author. Information about fabric ingestion included the preferred item, age of onset of the pica behavior, frequency, duration of an episode, changes in frequency and duration since onset, time of the day when pica occurred and circumstances in which it occurred. Owners were also asked how serious they considered the fabric ingestion behavior to be, what had been tried so far to manage the problem, and if the cat had health issues and/or required medical attention because of fabric eating.

A complete medical history was obtained for each cat. Pica was considered a potential sign of a gastrointestinal disorder so specific questions related to presence of potential additional gastrointestinal signs such as vomiting, diarrhea, constipation, flatulence, borborygmus, eructation, increased salivation, or repetitive swallowing were asked. A physical examination by a Board-certified internist (MCB) and a neurological examination by a Board-certified neurologist were conducted. Cats were then hospitalized. Complete blood (cell) count (CBC), serum chemistry panel, total thyroxine, fasted ammonia and urinalysis were obtained for each individual. Cats were also screened for feline immunodeficiency virus and feline leukemia virus by an enzyme-linked immunosorbent assay (ELISA). Feline specific pancreatic lipase immunoreactivity, cobalamin, and folate were measured. Fecal examination using a zinc-sulfate centrifugation technique was also done. A Board-certified radiologist conducted abdominal ultrasonography. Then, the cats were hospitalized and offered a meal of their regular diet available until 8 pm before being fasted again overnight.

The cats were anesthetized the following morning. A Board-certified internist (MCB) performed the oral examination and standard upper gastrointestinal endoscopy. A minimum of 2 mucosal samples were taken from each of the following 5 gastric locations: greater curvature and fundus, lesser curvature, pyloric antrum, pylorus, and cardia when possible. Full-thickness biopsies of the distal duodenum, jejunum, and ileum were subsequently obtained by laparotomy. Tissue samples were fixed by immersion in 10% neutral-buffered formalin, routinely processed, embedded, sectioned, and stained with hematoxylin, eosin, phloxine, and saffron. Sections were evaluated by a Board-certified pathologist (PH) based on the guidelines published by the World Small Animal Veterinary Association Gastrointestinal Standardization Group (15).

Based on clinical presentation, physical examination, neurological examination, laboratory results, and gastrointestinal evaluation, tentative diagnoses were made and specific treatments prescribed. Response to treatment was monitored and treatments were modified as needed. Cats were followed for a minimum period of 6 mo during which the owners were asked to offer the preferred fabric on a daily basis for 1 mo and record the current frequency of pica and gastrointestinal signs. Most cats (based on tentative diagnosis) received sequential treatments and owners were requested to submit these monthly logbooks once treatments had been implemented for at least 2 to 4 wk.

Hence, logbooks were requested at least once during the follow-up period and, in some cases, 2 to 3 times, depending on each treatment set in a given cat.

Results

Of the 10 cats recruited, 8 cats were enrolled in the study. One cat was excluded because of chronic kidney disease and hypercalcemia and the other had a partially obstructive ureterolith with azotemia. Three owners were referred to the behavioral medicine service by their local veterinarians. One owner found
Table 1. Age of onset of pica, prior attempted management/treatment strategies, and behavioral findings in cats with pica.

<table>
<thead>
<tr>
<th>Cat</th>
<th>Breed</th>
<th>Age of cat at onset of pica</th>
<th>Prior attempted management/treatment strategies</th>
<th>Aggression towards people (P) or cats (C)</th>
<th>Thunderstorm fear or phobia/other fears</th>
<th>Other behavioral problems</th>
<th>Environmental enrichment/outdoor access</th>
<th>Items chewed (C) ingested (S)</th>
<th>Owner comments and feeding frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>DSH</td>
<td>Present at adoption: 5 mo</td>
<td>None</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Cat tree, hiding places, food distributors. No outdoor access.</td>
<td>Fabric (I) Laces and threads (I) Wood (C) Plastic (C) Paper (C)</td>
<td>Pica has increased in frequency over time. Two meals daily.</td>
</tr>
<tr>
<td>2</td>
<td>Birman</td>
<td>Sucking: 3 mo Pica: 2 y</td>
<td>Sucralfate, famotidine, fluoxetine prior to study.</td>
<td>C: To other cat in home No</td>
<td>Masturbates on other cat in home</td>
<td>Cat tree, hiding places. No outdoor access.</td>
<td>Fabric (I) Laces and threads (I)</td>
<td>Additional medical care as a result of pica. <em>Ad libitum</em> feeding.</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>DLH</td>
<td>6 to 8 mo</td>
<td>None</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Cat tree, hiding places, food distributors. Outdoor access.</td>
<td>Fabric (I) Laces and threads (I) Wood (C) Plastic (C) Rubber (C) (I)</td>
<td>Will eat any food available (increased appetite). Two meals daily.</td>
</tr>
<tr>
<td>5</td>
<td>Siamese</td>
<td>6 mo</td>
<td>Hide preferred fabrics and items.</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Hiding places, food distributors, cat training. No outdoor access.</td>
<td>Fabric (I) Plastic (C) (I) Laces and threads (I)</td>
<td>Very sociable cat, vocal, likes to cuddle. <em>Ad libitum</em> feeding.</td>
</tr>
<tr>
<td>6</td>
<td>DSH</td>
<td>12 mo</td>
<td>Fluoxetine prior to study, more interactive play time, preventing access to items.</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Cat tree, hiding places, food distributors, cat training. Outdoor access.</td>
<td>Fabric (I) Laces and threads (I) Paper (C) (I) Rubber (C) (I)</td>
<td>Great cat, sociable, very vocal. Licks “Body Shop” soap. Three meals daily.</td>
</tr>
<tr>
<td>7</td>
<td>DSH</td>
<td>At time of foster home adoption: 8 mo</td>
<td>Preventing access to fabric.</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Cat tree, hiding places, food distributors, cat training. No outdoor access.</td>
<td>Fabric (I) Laces and threads (I) Plastic (C) (I) Paper (C) Rubber (C) Destroyed dog toys (I)</td>
<td>“Hyperactive cat.” Three meals daily.</td>
</tr>
<tr>
<td>8</td>
<td>DLH</td>
<td>6 mo</td>
<td>Zylkene Z/D diet</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Hiding places. No outdoor access.</td>
<td>Fabric (I) Plastic (C) (I) Rubber (C)</td>
<td>Cat relinquished to shelter because of fabric ingestion. Cat will be euthanized if pica is not resolved. Two meals daily.</td>
</tr>
</tbody>
</table>

DSH — Domestic shorthair; DLH — Domestic longhair.
Owners reported touching the cat. No other behavioral changes were noted in any eating fabric. Six cat owners were able to interrupt the behavior witnessed. Six cats were described as being self-absorbed while unchanged over time, 2 felt the problem had worsened (more frequent), and 1 said the frequency had decreased over time. Duration of fabric eating events was difficult to establish as most owners interrupted the behavior or had no idea (events not witnessed). Six cats were described as being self-absorbed while eating fabric. Six cat owners were able to interrupt the behavior either by calling or talking to the cat, yelling, making noise, or touching the cat. No other behavioral changes were noted in any cat concurrent with, or after the onset of pica. Owners reported information about the study on the VTH’s website. Two cats belonged to veterinary students and 2 cats were currently from different shelters (1 in a temporary foster home) but unavailable for adoption because of the fabric ingestion behavior. One cat was to be euthanized if the fabric ingestion was not resolved.

**Behavioral findings**

Results from the general questionnaire are summarized in Table 1. The preferred fabric ingested varied among cats and included polar fleece, carpet, wool, cotton, socks, and clothes. Fabric ingestion was never associated with a meal, a particular event, time of day, the presence of a person or a particular location. Seven owners answered that fabric ingestion occurred during presence or absence of the owner and one said it occurred during her absence. Four owners felt the problem had remained unchanged over time, 2 felt the problem had worsened (more frequent), and 1 said the frequency had decreased over time.

<table>
<thead>
<tr>
<th>Cat</th>
<th>Breed</th>
<th>Gender</th>
<th>Current age (mo)</th>
<th>Other GI signs aside from pica</th>
<th>Other signs</th>
<th>ALT&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Cholesterol&lt;sup&gt;b&lt;/sup&gt;</th>
<th>Triglycerides&lt;sup&gt;c&lt;/sup&gt;</th>
<th>Histopathology and other findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>DSH</td>
<td>NM</td>
<td>18</td>
<td>Vomiting 1/x/month, Licking floor, Abdominal discomfort</td>
<td>Licks self, more than normal as per owner</td>
<td>39</td>
<td>C: 5.21</td>
<td>T: 0.89</td>
<td>Mild multifocal LPE, GER suspected: gastroesophageal junction erythematous (approx. 1/3 of the pseudosquinted surface) and possible fibrin associated.</td>
</tr>
<tr>
<td>2</td>
<td>Birman</td>
<td>NM</td>
<td>79</td>
<td>Vomiting hairballs 3/x/month</td>
<td>None</td>
<td>58</td>
<td>C: 5.69</td>
<td>T: 0.46</td>
<td>Moderate EE, mild diffuse gastric fibrosis, intestinal fibrosis. Trichobezoar in esophagus (0.5 cm x 0.2 cm) and in jejunum.</td>
</tr>
<tr>
<td>3</td>
<td>DLH</td>
<td>NM</td>
<td>41</td>
<td>Vomiting 1/x/month, Intermittent decreased appetite, Occasional diarrhea</td>
<td>Licks blanket and floor</td>
<td>93</td>
<td>C: 7.71</td>
<td>T: 0.58</td>
<td>DGE suspected, mild intestinal fibrosis. Trichobezoar in pyloric antrum without mechanical obstruction.</td>
</tr>
<tr>
<td>4</td>
<td>DSH</td>
<td>NM</td>
<td>43</td>
<td>Vomiting 3/x/month concomitant apathy</td>
<td>Licks the sofa</td>
<td>41</td>
<td>C: 4.11</td>
<td>T: 0.89</td>
<td>EE, EG, DGE suspected, mild intestinal fibrosis. Mix of fabric, food and hair intertwined in the stomach.</td>
</tr>
<tr>
<td>5</td>
<td>Siamese</td>
<td>NM</td>
<td>41</td>
<td>Vomiting 1/x/month</td>
<td>Sucks body parts Licks plastic</td>
<td>108</td>
<td>C: 5.03</td>
<td>T: 0.36</td>
<td>Mild multifocal EE, DGE suspected. Trichobezoar in pyloric antrum and pylorus causing partial mechanical obstruction.</td>
</tr>
<tr>
<td>6</td>
<td>DSH</td>
<td>NM</td>
<td>54</td>
<td>None</td>
<td>Licks soap daily</td>
<td>83</td>
<td>C: 4.4</td>
<td>T: 0.68</td>
<td>Moderate to severe EE, mild EG&lt;sup&gt;d&lt;/sup&gt;, fabric in ileum, possible pancreatitis.</td>
</tr>
<tr>
<td>7</td>
<td>DSH</td>
<td>SF</td>
<td>11</td>
<td>Vomiting 8/x/month</td>
<td>None</td>
<td>46</td>
<td>C: 4.35</td>
<td>T: missing</td>
<td>DGE&lt;sup&gt;e&lt;/sup&gt;, mild focal EE.</td>
</tr>
<tr>
<td>8</td>
<td>DLH</td>
<td>SF</td>
<td>23</td>
<td>None</td>
<td>None</td>
<td>47</td>
<td>C: 1.87</td>
<td>T: missing</td>
<td>Moderate EE, intestinal fibrosis, Giardiasis.</td>
</tr>
</tbody>
</table>

<sup>a</sup> ALT: Alanine aminotransferase values of cats with pica [reference interval (RI): 16.00 to 63.00 U/L].

<sup>b</sup> RI for cholesterol: 1.81 to 3.88 mmol/L. Median cholesterol level: 2.65 mmol/L. RI for triglycerides: 0.57 to 1.14 mmol/L. Values outside the reference range are in bold.

<sup>c</sup> Mean cholesterol level: 3.12 mmol/L. Median cholesterol level: 2.65 mmol/L. RI for triglycerides: 0.57 to 1.14 mmol/L. Values outside the reference range are in bold.

<sup>d</sup> DSH — Domestic shorthair; DLH — Domestic longhair; NM — neutered male; SF — spayed female; LPE — lymphoplasmacytic enteritis; EE — Eosinophilic enteritis; EG — Eosinophilic gastritis; DGE — Delayed gastric emptying; GER — Gastroesophageal reflux.

**Figure 1.** Trichobezoar removed during endoscopy in 1 cat.
Table 3. Frequency of pica, tentative diagnoses, and treatment of cats with pica.

<table>
<thead>
<tr>
<th>Cat</th>
<th>Pica monthly frequency baseline</th>
<th>Pica monthly frequency end of study</th>
<th>Tentative diagnoses</th>
<th>Treatments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>11</td>
<td>2</td>
<td>Mild hypercholesterolemia</td>
<td>Fenbendazole, metronidazole, hypoallergenic diet, prednisolone, famotidine, cisapride</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Mild multifocal LPE</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>GER suspected</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>6</td>
<td>3</td>
<td>Mild hypercholesterolemia</td>
<td>Fenbendazole, hypoallergenic diet, prednisolone, omeprazole</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Moderate EE</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Trichobezoar</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>17</td>
<td>2</td>
<td>Mild hypercholesterolemia</td>
<td>Metronidazole, hypoallergenic diet, small frequent meals, omeprazole, metoclopramide, cisapride</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>DGE suspected</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Fibrosis</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Trichobezoar</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>30</td>
<td>28</td>
<td>Mild hypercholesterolemia</td>
<td>Fenbendazole, hypoallergenic diet, prednisolone, small frequent meals, omeprazole, cisapride</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>EE</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>EG</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>DGE suspected</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>7</td>
<td>5</td>
<td>Mild hypercholesterolemia</td>
<td>Fenbendazole, metronidazole, hypoallergenic diet, prednisolone, small frequent meals, omeprazole</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Mild multifocal EE</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>DGE suspected</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Trichobezoar</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>24</td>
<td>18</td>
<td>Mild hypercholesterolemia</td>
<td>Fenbendazole, metronidazole, hypoallergenic diet, prednisolone, small frequent meals, omeprazole</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Moderate to severe EE</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Mild EG</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Possible pancreatitis</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>22</td>
<td>19</td>
<td>Mild hypercholesterolemia</td>
<td>Fenbendazole, hypoallergenic diet, prednisolone, small frequent meals, omeprazole, metoclopramide, cisapride</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>DGE</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Mild focal EE</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>5</td>
<td>1</td>
<td>Giardiasis</td>
<td>Fenbendazole</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Moderate EE</td>
<td></td>
</tr>
</tbody>
</table>

LPE — lymphoplasmacytic enteritis; GER — Gastroesophageal reflux; EE — Eosinophilic enteritis; DGE — Delayed gastric emptying; EG — Eosinophilic gastritis.

Medical findings

Physical examination was within normal limits except for cat 1 (mesenteric lymphadenomegaly), cat 8 (mild bilateral conjunctivitis), and cat 2 (left-sided parasternal grade II/VI systolic heart murmur). A cardiac evaluation of cat 2 was therefore conducted and revealed a mitral valve dysplasia with mild regurgitation. No treatment was prescribed but a follow-up was recommended. Neurological examination was within normal limits except for cat 4 (vestibular ataxia present since adoption as a kitten) and cat 5 (genetic pendular nystagmus).

Other than a stress leukogram in 3 cats, the CBCs were within normal limits. Total thyroxine was within normal limits in all cats. Fasted ammonia was within normal limits except for cat 3 [98.00 μmol/L, reference interval (RI): 0 to 95.00 μmol/L]. Fasting and post-prandial bile acid concentrations were unremarkable.

Serum chemistry panels were considered unremarkable except in 3 cats [elevated alanine aminotransferase (ALT) but below a 2-fold increase of the upper normal limit] (Table 2). When rechecked at least 3 mo later, the values were either within normal limits or marginally elevated. Cholesterol levels were marginally elevated in 7 of the 8 cats (Table 2).

Cat 6 had a mildly increased serum specific pancreatic lipase (3.9 μg/L, RI: 0 to 3.5 μg/L) which may suggest pancreatitis. The pancreas was unremarkable upon abdominal ultrasound. The serum specific pancreatic lipase was re-evaluated 1 mo later and was within normal limits. All other cats had a serum specific pancreatic lipase within normal limits. Folate was elevated in 5 cats. No cats showed hypocobalaminemia.

All cats were negative for feline immunodeficiency virus and feline leukemia virus. Urinalysis was unremarkable in all cats. Fecal examination was unremarkable in all except 1 cat (positive for *Giardia* spp).

Except for presence of dental tartar in some cats, oral examination was within normal limits in all animals. All cats had abnormalities of the gastrointestinal tract (Table 2). Three cats had large trichobezoars that were removed during endoscopy or laparotomy (Figure 1). Cat 6 had a foreign body (fabric in the ileum) that was removed by enterotomy. Cat 7 had a mild abdominal modified transudate surrounding the liver.

Frequency of pica during 1-month baseline and 1-month follow-up are shown in Table 3. Tentative diagnoses and treatments are also shown in Table 3. None of the cats had complete resolution of pica.

Discussion

This study represents a preliminary and exploratory collection of data on cats which eat fabric.
Pica in the behavioral literature is listed as a possible manifestation of obsessive-compulsive or compulsive disorders in cats (3,4). As a result, these patients are generally referred to behavioral medicine services rather than internal medicine or neurology services. To the authors’ knowledge, there are no publications on medical investigation of cats which eat fabric, even though this behavior was reported in the literature as early as 1967 (16). The commonly accepted definition of compulsive disorders states that the behavior appears in a situation of stress or conflict and then emanates from that situation (3). The current literature also reports that onset of compulsive disorders in cats is usually around social maturity (17), although the age of social maturity is not defined in any publication. Obsessive-compulsive or compulsive disorders are considered a subset of anxiety disorders (17). In the present exploratory study, fabric ingestion was not associated with an event, person, or location. The cat’s age at onset of fabric ingestion ranged from 5 to 12 mo in 7 cats and appeared later in only 1 cat at 24 mo of age. These 2 observations raise the question as to whether pica truly represents a compulsive disorder. According to the behavioral questionnaires, except for cat 2 (inter-cat aggression), none of the other cats showed signs of anxiety/fear or other behavioral problems in the home environment. Cat 2 had been treated with a psychotropic medication (fluoxetine) before the study with only partial improvement noted (according to the owner). Cat 6 had also previously received fluoxetine to treat the pica, without improvement.

Six cats enrolled in this study were domestic short- or long-haired and only 2 were purebred, a Birman and a Siamese. In a recent retrospective study (5) most of the cats that were presented with pica were also domestic short- or longhair cats ($n = 55$) rather than purebred cats ($n = 28$). These results indicate that pica is not restricted to oriental breeds. Only 3 of the 8 cats ingesting fabrics were also sucking on fabrics. These 2 behaviors may not be linked as it was previously thought and, as now suggested by some authors, they might reflect different motivations (18).

Delayed gastric emptying was suspected in 4 cats based on the presence of food material in the stomach after more than 12 h of fasting. A definitive diagnosis was not obtained as scintigraphy was not available at the VTH at the time of this study. The most common sign of delayed gastric emptying is chronic vomiting of food more than 8 h after a meal (14,19–21). Other signs include anorexia, eructation, pica, polydipsia, and weight loss (20). Abdominal discomfort may also be present (14). A motility disorder may also result in gastric formation of trichobezoars in some cats (20). There are, however, no published data on prevalence of trichobezoars or delayed gastric emptying in cats. Further investigation is thus warranted.

Gastric reflux was suspected in 1 cat because of an erythematous region at the gastro-esophageal junction. As is often the case, a definitive diagnosis was not obtained because it would have required continuous measurement of the distal esophageal sphincter pressure and intraluminal esophageal pH (22–26). Potential causes of gastroesophageal reflux include chronic vomiting, gastric motility disorders, a hiatal hernia, and decreased pressure of the distal esophageal sphincter following anesthesia (23,24,26). Clinical signs of gastric reflux can include salivation, licking lips, odynophagia, extending of the neck during swallowing, anorexia, vomiting, regurgitation, halitosis, severe vocalization following a meal, and hesitation to move or lie down (22–28). Episodes of gastric reflux are more frequent on an empty stomach (25). In a recent study (5), cats without pica were fed meals more frequently or ad libitum compared to cats with pica. Perhaps, as is reported in infants with symptomatic gastroesophageal reflux, fasting may exacerbate the incidence of gastric reflux in cats as well (29). The possibility of gastric reflux in cats either going unnoticed or not easily diagnosed, motivated the decision to try omeprazole as a treatment option in this study. Many cats showed improvement of the pica behavior after omeprazole was added to the treatment protocol. A future trial of omeprazole at various doses in a larger sample of fabric eating cats may be warranted.

Gastroesophageal reflux disease, esophagitis, gastritis, inflammatory bowel disease, and side effects from medication can all cause upper abdominal pain or discomfort also referred to as dyspepsia in humans (30). Dyspepsia is described as organic if an underlying disorder is confirmed, and as functional if no underlying condition is identified. The mechanism of functional dyspepsia remains obscure, but gastric inflammation or hyperacidity, motor disorder, or visceral hypersensitivity all have been hypothesized (30). To date, there is no information about the existence of functional dyspepsia in cats. Functional gastroesophageal reflux is common in infants and manifests as episodes of regurgitation or vomiting. During the last few decades, the role of intestinal microflora in health and disease has gained interest and there are strong indications that diet can influence the relative number of microbial species in the gastrointestinal flora. One study (31) showed that probiotic supplementation (Lactobacillus reuteri) significantly accelerated gastric emptying and significantly decreased regurgitation in infants. Further research on motility disorders, gastric reflux, and treatments in cats is necessary.

Interestingly, all cats had abnormalities of the gastrointestinal tract, although it is not possible to ascertain that these changes were associated with fabric ingestion. No cat had clinical signs or laboratory findings suggestive of disease in another system. It was surprising that 6 cats from this study had gastric or enteric eosinophilic infiltrates, because lymphoplasmacytic gastrointestinal infiltration is more prevalent in cats (32–35). Cats with eosinophilic inflammation of the gastrointestinal tract seem to be more refractory to conventional treatments (34). In a case series of human patients diagnosed with eosinophilic gastroenteritis (considered a rare disease) all had mucosal disease and were presented with dyspepsia (36). Another study found that duodenal eosinophilia may characterize a subset of human adults with functional dyspepsia (37). If cats which eat fabric suffer from dyspepsia, confirming this possibility and offering treatment options will improve the welfare of these cats. Future studies are warranted.

Mild hypercholesterolemia was found in 7 cats. The median and mean cholesterol values of the cats with pica were higher than the upper limit of the reference range but less than 10 mmol/L, so these may be not clinically significant. As
triglyceride levels were within normal limits or lower, no further investigations were conducted. However, waxing-and-waning vomiting, diarrhea, and abdominal discomfort or pain are common clinical signs of hyperlipidemia (38). Primary hypercholesterolemia is rare in cats (39). Low-density and high-density lipoproteins are primarily involved in cholesterol metabolism (38). Further investigation in the production and clearance of these lipoproteins could be warranted in cats with fabric ingestion.

There were limitations in this pilot study. The sample size was small and there was no matched control group with GI signs without pica. The choice of not having a control group was based on the invasive medical procedures (i.e., laparotomy and full-thickness biopsies). The owners of cats that participated in the study were fully aware of the risks associated with general anesthesia and surgery. They were hoping to obtain answers on the underlying causes and potential treatments for their cats. And in 1 case, the cat if not successfully treated, would be euthanized. All the researchers made it a priority to monitor the cat’s well-being during the entire study. Special attention was given to post-operative pain management and none of the cats had any complications associated with the procedures. Initially, the plan was to evaluate 20 cats. But as time progressed, and response to treatment seemed variable for the first 8 cats, the decision was made to discontinue the planned complete medical investigation on additional cats.

In conclusion, fabric ingestion in cats, a specific form of pica, remains a diagnostic challenge. Complete resolution and, in some cases, even improvement with current proposed treatment plans seems difficult to achieve. These preliminary observations are meant as a starting point for future studies to determine more precisely what is happening medically and behaviorally in this sub-group of cats which eat fabric.

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References

1. C) This is due to the liver’s close association with the diaphragm. The stomach, small intestine, and spleen are also found with fair regularity in a diaphragmatic hernia, but less commonly than the liver. Kidneys are fairly firmly attached to the retroperitoneal space and are only rarely displaced into the thorax with a diaphragmatic hernia.

Ceci est dû à la proximité du foie et du diaphragme. L’estomac, le petit intestin et la rate peuvent aussi faire hernie régulièrement lors de hernie diaphragmatique, mais moins communément que le foie. Les reins sont rattachés assez fermement à l’espace rétropéritonéal et sont seulement rarement déplacés dans le thorax lors de hernie diaphragmatique.

2. C) Young cats are most commonly afflicted with this disease, which arises from the tympanic bulla.

C) Les jeunes chats sont plus communément affligés par cette maladie qui provient de la bulle tympanique.

3. A) Microscopic examination of urine sediment is helpful in distinguishing glomerular from nonglomerular hemorrhage. The hallmark of glomerular bleeding is red blood cell dysmorphosis.

A) L’examen microscopique de sédiment d’urine est utile pour distinguer une hémorragie glomérulaire d’une hémorragie non glomérulaire. Le signe cardinal du saignement glomérulaire est la dysmorphie des globules rouges.

4. D) Polio is believed to be caused by a thiamine deficiency and has not been associated with BVD virus. All other syndromes have been associated with either acute or persistent infection with BVD virus.

D) On croit que la polio est causée par une carence en thiamine et n’est pas associée au virus de la diarrhée virale bovine. Tous les autres syndromes ont été associés à une infection soit aiguë, soit persistante avec le virus de la diarrhée virale bovine.

5. A) Because raw hamburger is low in vitamin A, a vitamin A deficiency is possible.

A) Comme le bœuf haché cru a une faible teneur en vitamine A, une carence en vitamine A est possible.
Common bile duct obstruction palliated with common bile duct re-implantation (choledochoduodenostomy) in a cat

Galina Hayes, Sacha Devereux, John P. Loftus, Mason Jager, Gerald Duhamel, Tracy Stokol

Abstract — A cat was presented with complete biliary obstruction at the level of the distal common bile duct (CBD), with loss of normal architecture. The area was excised and submitted for histopathology. Concurrent cholecystitis and gall bladder necrosis necessitated cholecystectomy. The proximal CBD was preserved and re-implanted adjacent to the original duodenal papilla. The cat recovered and remained asymptomatic for 6 months. At clinical relapse a carcinoma of suspected biliary origin was confirmed, and the cat was euthanized. In situations in which the CBD lumen cannot be re-established, the pathology is limited to the distal CBD, and the gall bladder is not available for cholecystoenterostomy, CBD re-implantation may be an option to salvage and retain a functional biliary tree.

Résumé — Remédiation d’une obstruction du canal cholédoque par réimplantation du canal cholédoque (cholédochoduodenostomie) chez un chat. Un chat fut présenté avec une obstruction biliaire complète au niveau du canal cholédoque distal (CBD), avec perte de l’architecture normale. La région a été excisée et soumise pour examen histopathologique. Une cholécystite concomitante et une nécrose de la vésicule biliaire ont nécessité une cholécystectomie. Le CBD proximal fut préservé et réimplanté de manière adjacente à la papille duodénale originale. Le chat a récupéré et est demeuré asymptomatique pendant 6 mois. Lors d’une rechute clinique une suspicion de carcinome d’origine biliaire fut confirmée, et le chat euthanasié. Dans des situations où la lumière du CBD ne peut être ré-établie, que la pathologie est limitée au CBD distal, et que la vésicule biliaire n’est pas disponible pour une cholecystoenterostomie, la réimplantation du CBD peut être une option pour sauvegarder et maintenir un système biliaire fonctionnel.

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Extrahepatic biliary obstruction in cats results in icterus, anorexia, lethargy, weight loss and vomiting (1). It can result from any pathologic process that obstructs the flow of bile from the liver to the duodenum. Various surgical interventions to temporarily or permanently resolve biliary obstructions or divert the flow of bile have been described, including choledochotomy (2), placement of a temporary cholecystostomy tube (3), choledochal stenting (4), and cholecystoenterostomy (5). These techniques rely on being able to access and re-establish the lumen of the CBD or having a viable gall bladder available for permanent biliary diversion. In the unusual clinical setting in which neither of these components is present, CBD resection and re-implantation may be the only remaining option. To our knowledge, this is the first detailed report of CBD re-implantation in the cat in this setting.

Case description

A 9-year-old spayed female domestic shorthair cat weighing 3.8 kg was referred because of an 8-day history of anorexia and lethargy. Referral blood analysis identified increased liver enzyme activities [alanine transaminase (ALT) = 836 U/L; reference interval (RI): 10 to 20 U/L, alkaline phosphatase (ALP) = 94 U/L; RI: 10 to 90 U/L], and elevated total bilirubin concentration (162.5 μmol/L; RI: 1.7 to 10.3 μmol/L). Supportive care consisting of intravenous fluid therapy (Normosol R; Hospira, Lake Forest, Illinois, USA), metronidazole (Unichem, Hasbrouck Heights, New Jersey, USA), 50 mg, PO, q12h, and ursodiol (Par, Chestnut Ridge, New York, USA), 30 mg, PO, q24h, was initiated; however, clinical signs failed to improve and laboratory parameters continued to deteriorate. Five days after initiating medical therapy the total bilirubin had increased to 181.3 μmol/L, with further increases in ALT (660 U/L) and ALP (165 U/L) prompting referral.
Physical examination at presentation identified icteric mucous membranes, sclera, and skin together with cranial abdominal pain. Hematologic and biochemical testing revealed a stress leukogram, increased liver enzyme activities [ALP = 215 U/L, RI: 13 to 83 U/L; ALT = 739 U/L, RI: 35 to 176 U/L] gamma-glutamyl transferase (GGT) = 13 U/L, RI:0 to 2 U/L] and hyperbilirubinemia (213.8 μmol/L, RI: 0 to 3.4 μmol/L). Thoracic radiographs were unremarkable. Abdominal ultrasonographic examination revealed a moderately enlarged gallbladder (6 mL, RI: 0.8 to 4.5 mL) with a markedly thickened wall (3.5 mm, RI: 0.6 to 1.2 mm) characterized by heteroechoic, polypoid, undulating mural margin and a moderate amount of intraluminal sediment. A scant amount of pericholecystic free fluid was observed. The cystic duct was moderately enlarged (6.6 mm, normal value < 5 mm). The CBD was dilated proximally (5 mm, normal value: < 4 mm). The lumen of the common bile duct could not be detected over the distal 1 to 2 cm adjacent to the duodenal papilla, and non-shadowing material obliterating the lumen (Figure 1). The duodenal papilla was normal on ultrasound.

Surgical exploration was recommended in the face of worsening icterus unresponsive to medical management and suspected cholecystitis and/or CBD obstruction. The following morning the cat was placed under general anesthesia. The cat was premedicated with remifentanil (Ultiva; Mylan, Canonsburg, Pennsylvania, USA), constant rate infusion (CRI) at 0.1 μg/kg body weight (BW) per min, and induced 15 min later with alfaxalone (Alfaxa; Vedo, St. Joseph, Missouri, USA), 0.5 mg/kg BW, IV. A 4-mm internal diameter cuffed endotracheal tube was used for intubation, and anesthesia was maintained with isoflurane vaporized in oxygen and delivered using a pediatric semi-closed circle system. The cat was ventilated with a tidal volume of 12 mL/kg BW at a respiratory rate of 8 to 12 breaths/min. Peak inspiratory pressures did not exceed 12 cm H₂O. A balanced electrolyte solution (Normosol R; Hospira) was infused at 3 mL/kg BW per hour. Electrocardiography, pulse oximetry, esophageal temperature, expiratory partial pressure of carbon dioxide, and direct arterial blood pressure were monitored and recorded at 5-minute intervals. An episode of hypotension (mean arterial pressure = 52 mmHg) occurring before initiation of surgery was managed with atropine (Pfizer, New York, New York, USA), 0.04 mg/kg BW, IV, and ephedrine (Akorn, Bridgewater, New Jersey, USA) and then 0.035 and 0.018 weasel wires (Infiniti Medical, Redwood City, California, USA). Fluoroscopy was not used. Cannulation of the distal common bile duct could not be achieved, with termination of catheter passage at the mass-like structure previously noted. Neoplastic disease was suspected. The distal 2 cm of extra-mural CBD was resected with an ~0.5 cm margin of grossly normal although dilated CBD achieved proximally, and the resected tissue was submitted for histopathologic examination. The CBD was ligated using 4/0 polydioxanone (PDS, Ethicon, Bridgewater, New Jersey, USA) at the point of confluence with the external surface of the duodenum to eliminate the risk of intestinal content reflux. Due to the removal of the gall bladder, a cholecystoenterostomy was performed rather than the more traditional cholecystoenterostomy. A technique similar to that described by Gregory et al (6) for intra-vesicular ureteroneocystostomy was used. A 6-mm diameter skin punch (Integra, Plainsboro, New Jersey, USA) was used to create a circular defect in the duodenal wall, placed to minimize tension on the remaining length of CBD, and adjacent to the duodenal papilla. A stay suture was placed in the resected proximal end of the CBD and this end was drawn through the duodenal wall in a “drop-in” technique. The end was trimmed to an oblique angle and the biliary mucosa sutured to the duodenal mucosa using 4 simple interrupted sutures of 6/0 PDS (Ethicon). The duodenotomy was closed routinely following duodenal biopsy. Wedge biopsies collected for culture and the gallbladder was submitted for histopathologic examination.

Further examination revealed that the CBD abruptly truncated and was replaced by palpably thickened and abnormal tissue (mass-like) over the distal 2 cm to the level of the external surface of the duodenum. The duct was dilated to approximately 0.5 cm proximal to this area. A duodenotomy was performed at the level of the duodenal papilla and stay sutures [4/0 polydioxanone (PDS, Ethicon, Bridgewater, New Jersey, USA)] were placed in the duodenal wall to retract the duodenotomy site. The duodenal papilla was identified. Catheterization and flushing were attempted, both retrograde through the duodenal papilla and normograde down the cystic duct initially using 5Fr and then 3Fr catheters (Cardinal Health, Dublin, Ohio, USA) and then 0.035 and 0.018 weasel wires (Infiniti Medical, Redwood City, California, USA). Fluoroscopy was not used. Cannulation of the distal common bile duct could not be achieved, with termination of catheter passage at the mass-like structure previously noted. Neoplastic disease was suspected. A cholecystoenterostomy was performed rather than the more traditional cholecystoenterostomy. A technique similar to that described by Gregory et al (6) for intra-vesicular ureteroneocystostomy was used. A 6-mm diameter skin punch (Integra, Plainsboro, New Jersey, USA) was used to create a circular defect in the duodenal wall, placed to minimize tension on the remaining length of CBD, and adjacent to the duodenal papilla. A stay suture was placed in the resected proximal end of the CBD and this end was drawn through the duodenal wall in a “drop-in” technique. The end was trimmed to an oblique angle and the biliary mucosa sutured to the duodenal mucosa using 4 simple interrupted sutures of 6/0 PDS (Ethicon). The duodenotomy was closed routinely following duodenal biopsy. Wedge biopsies
were taken from the left lateral, left medial, and right lateral liver lobes and submitted for histopathologic examination. The remainder of the abdominal exploration was unremarkable. An intra-abdominal Jackson-Pratt drain was placed (Infiniti Medical) to facilitate early detection of bile leakage. The abdomen was lavaged with warm sterile saline and closed routinely.

After surgery the cat was maintained on intravenous Normosol-R (Hospira) at 16 mL/h, fentanyl (Hospira), 2 to 3 µg/kg BW per hour, B-vitamins, N-acetylcysteine (Hospira), 50 mg/kg BW, IV, q12h, metronidazole (Hospira), 10 mg/kg BW, IV, q12h, enrofloxacin (Bayer, Pittsburgh, Pennsylvania, USA), 5 mg/kg BW, IV, q12h, potentiated amoxicillin sulbactam (Pfizer), 22 mg/kg BW, IV, q8h, and ondansetron (Accord, Durham, North Carolina, USA), 0.3 mg/kg BW, IV, q8h. After 2 d appetite continued to be reduced prompting placement of a naso-esophageal tube allowing enteral nutritional support with a CRI of a liquid feed (Clinicare, Zoetis, Parsippany, New Jersey, USA) initiated at one-third of resting energy requirement.

Intra-operative aerobic and anaerobic culture results were negative in the face of broad-spectrum antibiotic therapy. A boarded veterinary pathologist read histopathology samples. The liver biopsies showed chronic supplicative lymphoplasmacytic destructive cholangitis with mild microvesicular lipidosis. The gall bladder changes were consistent with chronic lymphoplasmacytic neutrophilic proliferative cholecystitis with mucosal hyperplasia, edema, erosions, and necrosis. The duodenal biopsy showed chronic diffuse lymphoplasmacytic enteritis. Histopathology of the tissue obstructing the common bile duct demonstrated complete obstruction of the bile duct lumen and loss of normal architecture with abundant dense fibrous connective tissue and spindle cells (Figure 2). There was no evidence of neoplasia.

Three days after surgery abdominal ultrasound showed resolution of the previously noted dilation of the CBD (CBD diameter = 3 mm), with no evidence of peritonitis. Serial biochemistry profiles showed a steady decrease in serum total bilirubin concentrations from 213.8 µmol/L before surgery to 138.5 µmol/L and 27.4 µmol/L 2 d and 2 mo after surgery, respectively (RI: 0 to 176 U/L). ALT = 95 U/L (RI: 5 to 50 U/L), AP = 87 U/L (RI: 13 to 83 U/L), and GGT = 10 U/L (0 to 2 U/L), but were static or improved relative to the 3-day post-operative values (ALT = 966 U/L, ALP = 360 U/L, GGT = 13 U/L).

The cat remained stable and in clinical remission on the management described until 6 mo after surgery, at which time she was presented for acute onset vomiting, dehydration, and lethargy. The cat was not clinically icteric at that time. Blood gas analysis identified changes consistent with a
chronic severe hypochloremic metabolic alkalosis with respiratory compensation \( [pH = 7.53 (RI: 7,31 to 7.46), pCO_2 = 68.8 \text{ mmol/L (RI: 27 to 50 mmol/L)}, HCO_3 = 55.8 \text{ mmol/L (RI: 17 to 28 mmol/L)}, base excess (BE) = 33.1 \text{ mmol/L (RI: -4 to 4 mmol/L)}, corrected Cl = 73 \text{ mmol/L (RI: 110 to 119 mmol/L)}] \). Abdominal ultrasound identified a 3 cm × 5 cm extramural duodenal mass at the level of the duodenal papilla suspected to be causing gastric outflow obstruction. A fine-needle aspirate was performed and cytologic examination of modified Wright's stained smears identified neoplastic epithelial cells in a pink background (presumptive mucin production) with low numbers of macrophages and neutrophils (Figure 3). The cytologic diagnosis was carcinoma. Based on the location of the mass, a biliary carcinoma was the main differential diagnosis for tumor type. Due to poor prognosis, the patient was euthanized; postmortem examination was not performed.

Discussion

In this report, we describe the successful palliation of a cat with an obstruction of the distal common bile duct and acute cholecystitis with a cholecystectomy and end-to-side choledochoenterostomy at the level of the duodenum adjacent to the major duodenal papilla. A previous study focused on cholecystoenterostomy as an approach to management of irretrievable CBD obstruction, with a single cat in that study reported to have received choledochoduodenostomy (5). Cholecystoenterostomy was not possible in this case due to the severity of the concurrent gall bladder disease, limiting our ability to include the gall bladder in a biliary diversion procedure. To our knowledge, a detailed report of choledochoenterostomy in the cat has not been made. As such, there is limited information on indications, technique, and outcome in the veterinary literature. A study of human patients in whom permanent biliary diversion was performed for management of CBD obstruction secondary to neoplasia randomized patients to receiving either cholecystoenterostomy or choledochoenterostomy, and concluded that choledochoenterostomy was superior as it was less likely to result in biliary bypass failure (7). A similar non-randomized study compared outcomes in human patients who required permanent biliary diversion for the palliation of pancreatic cancer and concluded that cholecystoenterostomy and choledochoenterostomy were equivalent in effectiveness in achieving bypass and prolonging survival time (8). In recent years CBD obstruction in human patients caused by a benign or neoplastic process and having access to the CBD lumen have been treated by endoscopic placement of self-expanding metal biliary stents (9,10), which have also translated successfully into the veterinary arena (4). Unfortunately, luminal access across the CBD obstruction could not be achieved in this case. The key indications for choledochoenterostomy animals at this time would appear to be an unsalvageable CBD and unavailable gall bladder.

The major technical challenge of choledochoenterostomy in small animals is the relatively small diameter and short length of the CBD. In this case, obstruction was sufficiently chronic that the CBD had dilated to a 5-mm diameter, making re-implantation relatively straightforward. In the absence of similar dilation, use of an operating microscope might be required. A relatively similar surgical situation is the re-implantation of the feline ureter; in both situations, a small diameter tube is being re-implanted into a larger organ, with the major risks being dehiscence or stricture at the anastomosis site. For this reason we elected to use the Gregory et al (6) technique to perform the procedure, with the minor addition of the use of a skin punch to create the enteric defect and placement of a stay suture to draw the end of the CBD through the duodenal wall. Care was taken to minimize trauma to the distal end of the CBD in view of the relative sparsity of tissue and the likely deleterious consequences of excessive tension on the implantation site. Sutures were placed at the luminal rather than serosal surface to achieve mucosal apposition.

The final diagnosis in this case was carcinoma of suspected biliary origin, based on the location, lack of mural duodenal involvement, and presumptive mucin production by the tumor. Neoplasia was not detected in the original surgical biopsies submitted for histopathologic examination, despite re-examination after the cytologic diagnosis. We do not know whether the tumor was part of the original disease on presentation that was missed on biopsy, or whether it developed subsequently. The severity of the fibrous tissue deposition around the CBD described in the original histopathological report led us to question whether the CBD injury was a stricture that had formed secondary to mechanical injury from a large cholelith that had subsequently passed, or whether the patient was exhibiting a form of sclerosing cholangitis, an immune-mediated disease causing chronic inflammation and fibrosis of the biliary tract. The latter has been reported to occasionally result in stricture and complete obstruction of the extra-hepatic ducts in human patients (11,12). In human patients sclerosing cholangitis is known to predispose to the development of cholangiocarcinoma (13). Cholangiocarcinomas are also reported to occur in human patients as a late-onset complication of choledochoenterostomies due to chronic irritation from reflux of food particles and digestive material into the common bile duct at the anastomosis with the small intestine (14). It is unclear whether this was the case with our patient; however, given the association of the carcinoma with the surgical site it is possible that this could be a consequence of persistent inflammation and irritation as has been reported in the human literature.

Similar to another report, the extrahepatic bile duct obstruction (EHBDO) in this cat was not the sole component of the clinicopathological picture, with histopathologic evidence of cholecystitis, cholangiohepatitis, and inflammatory bowel disease. In a study of 22 cats with EHBDO managed with a surgical biliary diversion procedure, obstruction was secondary to an inflammatory lesion in 60% of the cats, with concurrent hepatitis, cholecystitis, pancreatitis, and enteritis. The remaining 40% of cats were diagnosed with neoplasia, most of which were carcinomas of the biliary tract, intestine, or pancreas (5).

Anatomic variation may have a substantial impact on clinical outcome following EHBDO surgery in the cat. The major pancreatic duct usually joins the CBD before it enters the duodenum, but they sometimes share an opening (15). The duct(s) cross the serosal surface of the duodenum at the mesenteric wall, approximately 3 cm distal to the pylorus, travel through the muscularis, and empty obliquely into the duodenum at the level
of the major duodenal papilla (16). The feline accessory pancreatic duct empties 2 cm distal to the major one and occurs in only 20% of cats (16). From a surgical perspective, disease that results in loss of the CBD to the level of the duodenal papilla and requires biliary diversion may result in the loss of drainage of the exocrine pancreas necessitating chronic pancreatic enzyme supplementation in 80% of cats. In this cat it is not known whether the pancreatic duct(s) remained patent; however, stool quality returned to normal in the post-operative period and pancreatic enzyme supplementation was not required.

This case report suggests that a choledochoenterostomy may be a viable option for a biliary diversion surgery in cats in which the distal CBD is irreversibly obstructed, and the gall bladder is not available for a reconstructive procedure.

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References

Case Report  Rapport de cas

Sacrococcygeal luxation and complete tail amputation following a tail pull injury in a horse

Lea P. Riddell, Seiji Yoshimura, Angela V. MacKay, David G. Wilson

Abstract — A 17-year-old Quarter horse mare was presented because of traumatic luxation of the fifth sacral and first coccygeal vertebrae resulting in loss of sensation, motor function, and perfusion of the tail. The case was complicated by an associated tail head hematoma. Due to the severity of the injury, tail amputation was performed at the level of the luxation. Tail amputations in horses at the sacrococcygeal junction following a suspected tail pull injury are infrequently reported in the literature.

Résumé — Luxation sacrococcygienn e et amputation complète de la queue à la suite d’une blessure par traction de la queue chez un cheval. Une jument Quarter horse âgée de 17 ans fut présentée pour cause de luxation traumatique de la cinquième vertèbre sacrée et de la première vertèbre coccygienn e résultant en une perte de sensation, de fonction motrice et de perfusion de la queue. Le cas était compliqué par l’association d’un hématome de la tête de la queue. Compte tenu de la sévérité de la blessure, l’amputation de la queue fut effectuée au site de la luxation. Les amputations de la queue chez les chevaux à la jonction sacrococcygienn e à la suite d’une blessure suspectée causée par traction de la queue ne sont rapportées que peu fréquemment dans la littérature.

Sacrococcygeal luxations in horses are not commonly reported in the literature. When reported, this injury is most often due to direct trauma or falling onto or backing up into a firm surface (1). Horses with sacral trauma, coccygeal luxation, and coccygeal fractures are reported to exhibit clinical signs that are similar to those of feline patients with tail pull injuries (2). Horses with sacrococcygeal injuries exhibit clinical signs that may include gait abnormalities and hind limb lameness, abnormal defecation and micturition, pain on palpation of the injury (3), and lack of tail mobility and sensation (4). Diagnosis of injuries to the sacrococcygeal region relies upon a comprehensive history and physical examination that is often accompanied by imaging such as radiography. The definitive diagnosis will guide treatment for sacrococcygeal injuries in horses. There are successful reports of surgical stabilization for coccygeal luxations and fractures (3), but tail amputation is advised in certain circumstances.

This report describes a complete traumatic sacrococcygeal luxation in a horse and successful management with tail amputation.

Case description

A 17-year-old Quarter horse mare was presented to the Western College of Veterinary Medicine, Veterinary Medical Center (VMC) equine ambulatory service because of an acute tail injury. The owner observed a large amount of detached tail hair wrapped around a fence post, an open wound at the most distal aspect of the mare’s tail and a large amount of swelling at the tail head. The horse was up-to-date on vaccinations and had no prior history of injuries or systemic illness.

On presentation, the horse was bright, alert, and responsive. The mare was tachycardic (60 beats/min) and tachypneic (32 breaths/min) with a normal rectal temperature. There was a firm swelling, approximately 25 cm in diameter, around the tail head, and extending ventrally to the dorsal aspect of the anus. A large portion of tail hair was absent, revealing an open wound at the most distal aspect of the tail and the caudal aspect of the 14th coccygeal vertebra. The most distal coccygeal vertebra appeared to have been traumatically amputated and was attached to the tail hair and skin that had been found wrapped around a fence post. The tail was cold on palpation and there was no hemorrhage from the wound, even following debridement. The tail had no deep pain sensation; approximately 10 cm cranial to the tail head on the midline skin sensation was present. The tail was limp during examination and appeared to lack motor function. The perineum had absent skin sensation.

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and there was no anal tone. A rectal examination confirmed significant firm swelling around the anus that extended dorsally and peristaltic waves could be felt within the rectum along with firm fecal material. When the mare attempted to defecate, there was a significant amount of straining resulting in the passage of a small amount of fecal material. Micturition was observed and was within normal limits and urinary bladder tone was determined to be normal on rectal palpation. No lameness or neurologic deficits were associated with the hind limbs.

Radiographs of the sacral coccygeal region revealed marked sacrococcygeal luxation with significant caudal displacement of the first coccygeal vertebra. Subluxation was also present between the first and second coccygeal vertebrae. In addition, there were vertebral facet avulsion fractures affecting the dorsocranial and caudal vertebral body of the first coccygeal vertebra.

The mare was administered detomidine hydrochloride (Dormosedan; Zoetis, Kirkland, Quebec), 0.01 mg/kg body weight (BW), IV, and butorphanol tartrate (Torbugesic; Zoetis), 0.01 mg/kg BW, IV, to achieve standing sedation. Phenylbutazone (Phenylbutazone 20%; Rafter 8 Products, Calgary, Alberta), 4 mg/kg BW, IV, and butorphanol tartrate (Torbugesic; Zoetis), 0.02 mg/kg BW, IM, were administered for analgesia. The distal tail wound was aseptically prepared, debrided, and surgically repaired at the initial evaluation to reduce the risk of ascending infection. Local analgesia was not required due to absence of deep pain. The subcutaneous tissue was closed using 2-0 poliglecaprone 25 (Monocryl; Ethicon/Johnson and Johnson, Markham, Ontario) in a simple continuous pattern followed by a simple interrupted pattern in the skin using 0 polydioxanone (PDS; Ethicon/Johnson and Johnson). The mare was administered phenylbutazone (Buzone Conc.; Vétoquinol, Lavaltrie, Quebec), 2 mg/kg BW, PO, q12h for 5 d following initial presentation and benzylpenicillin procaine (Depocillin; Merck, Kirkland, Quebec), 22 000 IU/kg BW, IM, q12h for 7 d. The mare was transitioned to a soaked hay cube diet to soften feces and the owner was instructed to run water from a garden hose (cold hose) over the tail head twice daily.

Forty-eight hours after initial presentation ventral anal tone had returned but the tail continued to be cold on palpation and lacked sensory and motor function. The mare was able to defecate and urinate normally. Ultrasound evaluation of the tail head swelling showed multiple, hypoechoic fluid pockets, the fluid within the pockets appeared stagnant. These signs were consistent with a hematoma, without active hemorrhage. Repeat radiographs showed foci of gas within the swelling around the tail head that were not previously visible (Figure 1). The radiographic and ultrasonographic results suggested the presence of a hematoma with possible abscessation.

Five days after initial presentation the swelling ruptured between the tail head and anus. Malodourous blood clots and serosanguinous fluid were expressed from the ruptured site. The tail continued to be cold to the touch and upon creation of a small incision, distal to the tail head, there was no blood flow. The mare was referred to the Large Animal Surgery Service at the VMC for further surgical management.

On presentation to the VMC, the mare was bright, alert, and responsive and vital parameters were within normal limits. The margins of the ruptured hematoma extended 25 cm cranially on the dorsal aspect of the sacral vertebrae and 10 cm cranially, beneath the tail, on the ventral aspect of the sacral vertebrae. The sacrococcygeal luxation was palpable on digital
exploration of the wound. Devitalized tissue within the hematoma was debrided and the area was flushed thoroughly with saline. Due to the continued lack of tail motion, sensation, and perfusion, the tail was amputated 8 d after initial presentation. Surgery was performed under standing sedation. The mare was placed in stocks and sedated with detomidine hydrochloride (Dormosedan; Zoetis), 0.01 mg/kg BW, IV, and butorphanol tartrate (Torbugesic; Zoetis), 0.01 mg/kg BW, IV. The surgical site was aseptically prepared and local anesthesia was not required due to complete lack of sensation at the planned incision site. An incision was made on the dorsal aspect of the tail head between the last sacral vertebra and first coccygeal vertebra using a #22 scalpel blade and made continuous with the ventrally located hematoma rupture site. The entire tail was removed distal to the last sacral vertebra. Following amputation, the surgical wound was thoroughly lavaged with saline and left to heal by second intention (Figure 2). The mare was discharged from the hospital 24 h after amputation and was treated with sulfamethoxazole and trimethoprim tablets (Apo-Sulfatrim — DS; Apotex, Toronto, Ontario), 15 mg/kg BW, PO, q12h for 7 d. The wound was cold hosed twice daily for a total of 2 wk.

Two weeks after amputation the mare was no longer receiving medications and the wound bed was entirely covered in granulation tissue (Figure 3). Recheck evaluation at 5 wk after amputation revealed further granulation tissue development and successful epithelialization at the most cranial aspect of the amputation site. By 6 mo there was no longer an open defect, and the amputation site was completely covered with epithelialized tissue with long hairs beginning to grow from the most caudal aspect of the amputation site. One year after amputation the mare had made a full recovery and continued to have normal function of her hind limbs, normal anal tone, and a completely healed amputation site (Figure 4). The mare reportedly had no difficulty rising or laying down. At no time was any muscle atrophy around the sacral vertebrae noted. Follow-up communication with the owner indicated that the mare resumed normal behavior and adapted well to the loss of...
the tail. A fly sheet is applied as necessary and the horse has resumed a regular riding routine.

Discussion

This report describes an etiology for sacrococcygeal injury: traction or tail pull injury, which is commonly diagnosed in feline patients (2). Clinical signs were similar to those described in cats but can vary depending on severity and exact location of the injury. In this case the mare maintained normal micturition, normal defecation, and had no gait abnormalities or neurologic deficits of the hind limbs suggesting that spinal cord segments S1-4 were intact. Injury to these spinal cord segments results in abnormal micturition, defecation, hind limb ataxia, and potential gait abnormalities (3,4). It has been reported that the hind limb gait abnormalities may be mild and only identified under specific circumstances, such as after limb flexion (3). The mare lacked sensation to the perineum and initially had absence of anal tone, suggesting there had been peripheral nerve damage to the caudal rectal nerve (4). The straining during defecation described in this case was most likely due to pain associated with the tail head swelling rather than an abnormality relating to defecation. The lack of sensation and motor function to the tail noted in this case are likely related to peripheral damage to the coccygeal nerve (4), but it is possible that the trauma caused the muscle attachments of the tail to rupture (1). This was difficult to determine due to the severe distortion of soft tissue within the tail head hematoma, but when the ruptured hematoma was debrided, torn muscle fibers were seen. The presence of the hematoma also suggests that tension-induced trauma ruptured the blood vessels supplying the tail. Depending on the severity of nerve damage, some consideration may be required for future reproductive use of affected mares. In this case there were no plans to use the mare for breeding purposes. Following sacrococcygeal injury there can be changes to the mare’s perineal conformation (5) and a Caslicks procedure may be indicated. In addition, in severe cases with urinary bladder paresis the mare can experience urine pooling in the cranial vagina and potentially the uterus (6) that can lead to significant reproductive issues.

Overall, the mare’s clinical signs and devitalized tail were attributed to peripheral nerve damage and potential rupture of the musculature and vasculature of the tail but not direct damage to the spinal cord. When tail and anus paralysis are present without a history of trauma, polyneuritis equi should be considered as a differential diagnosis (7). Although an uncommon disease, it affects the cauda equina producing similar clinical abnormalities to tail pull injuries (7).

With feline patients, in addition to a full history and physical examination, it is recommended to acquire radiographs (2). Knowledge of normal sacrococcygeal anatomy is important when assessing these radiographs. The horse has 5 sacral vertebrae and approximately 20 coccygeal vertebrae (8). In adults, the sacral vertebrae are fused, and in some cases, there may be fusion between the fifth sacral and first coccygeal vertebrae (9). Due to the large musculature and anatomic location of the sacrococcygeal region in the horse it may be difficult to acquire diagnostic images. In cases in which radiographs are ineffective in identifying a lesion and clinical signs are unhelpful, nuclear scintigraphy and ultrasonography could be considered to further assess the sacrococcygeal region and pelvis (5). In the current case, a definitive diagnosis was made with radiographs, and ultrasonography was used to evaluate the tail head swelling.

There are both conservative and surgical management options available for sacrococcygeal injuries. Treatment is dependent on the specific injury and may be further guided by prognosis. It has been reported in cats that when there is a lack of deep pain there is a significantly reduced prognosis for return of tail function (2). As described frequently in the literature for feline patients, treatment becomes more aggressive when there is urinary dysfunction and fecal retention (2). It is possible for appropriate micturition and defecation functions to return but intensive care is required and may include fecal emptying and repeated bladder voiding with urinary catheterization. Management of these issues can be difficult in cats and becomes even more challenging in a horse. In this case, the mare maintained urinary and fecal functions, but there was a lack of deep pain around the tail base and an absence of blood supply resulting in a devitalized tail. These 2 clinical signs are considered indications for amputation (2,10). Amputation of the devitalized portion of the horse’s tail has previously been performed (11) but did not require the entire tail to be removed.

Complete amputation of the tail is not without potential complications. An important concern is the lack of insect control for the patient. The tail is an important defense mechanism for normal insect control. Without it, horses may require blanketing during fly season with possible additional insect control measures such as providing smudges, pharmaceutical insect repellents, or an indoor space where insects are reduced. This management consideration requires thorough discussion with the owner before performing a complete tail amputation to ensure insect management requirements can be met. In this case, the owners were dedicated to the mare’s quality of life and committed to providing the necessary insect control measures. Ascending infection following tail amputation is another potential complication to consider (4). Infection risk was reduced in this case by using aseptic technique during surgical procedures and administering appropriate antimicrobial therapy.

While complete tail amputation can lead to complications, there are also consequences to leaving a devitalized tail in place. A limp tail in contact with the perineum can result in skin scalding from urine and fecal matter that requires frequent attention from the owner and results in discomfort for the horse. The weight of the tail can also continue to cause pain for the horse due to continued traction at the injury site. The risks and benefits of each option should be considered carefully on a case-by-case basis. Partial or complete tail amputation may be warranted in cases in which tail necrosis has occurred, potentially due to application of a tight tail bandage or crush injury when conservative management has been unsuccessful. In the described case, the lack of blood supply and deep pain to the tail, and ruptured hematoma at the tail head significantly reduced the prognosis of the patient regaining tail function; and therefore, complete tail amputation was recommended.
The sacrococcygeal luxation reported in this case due to a suspected tail pull incident has a number of similarities to cat tail pull injuries with regard to clinical signs, diagnosis, and treatment. Due to the limited amount of literature available on sacrococcygeal luxations in horses, the large amount of data obtained from similar cases in cats may provide information that can be used to guide diagnosis and treatment in horses.

Acknowledgment
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References

Book Review
Compte rendu de livre

Animal Handling and Physical Restraint

I was interested in reviewing this book as I don’t have any restraint reference materials in my library, and am always concerned with new staff members injuring themselves inadvertently while handling patients.

The first 3 chapters were a great review of the benefits involved in good animal handling and restraint. These chapters covered the history of different species and why each species needs to be handled in a certain way, depending on their natural behavior in the wild (prey versus predator among other factors), and their typical husbandry needs. Did you know that confining dogs within crates is meant to mimic their actual dens in the wild? I had never really thought of the why behind how veterinary staff handle animals and found these chapters to be a thoroughly interesting read. Some great tables, which summarize the key points involved in animal handling are provided.

After the introduction, the author goes into specific restraint needs for the more common animal species including dogs, cats, small mammals, birds, reptiles, horses, cattle, small ruminants, swine, and poultry. There are also specific chapters dedicated to rope tying and containment for larger animals.

Each species chapter reviews the behavior of the species and how to be safe when handling that species, going from the basics of handling for routine care to handling for common medical procedures. Special equipment needed for handling and how to transport a particular species safely and effectively is discussed. I thought each chapter was laid out very well and the figures used for restraint demonstrations were well done.

This book is probably too lengthy to be used in the way I was hoping, for veterinary assistants or kennel staff to read in order to understand the basics of restraint. I did, however, learn some valuable tips for myself that I can share with staff members, through the in-depth analysis and detail provided for each species evaluation. This book would appeal to veterinary students and veterinary technicians mainly, but as noted, would be too wordy for training purposes for general staff.

Reviewed by Samantha Fuller, DVM, BSc, Hart Family Veterinary Clinic, Prince George, British Columbia.
Alveolar echinococcosis in an Ontario dog resembling an hepatic abscess

Christopher Pinard, Benoît Cuq, Thomas Gibson, Brigitte Brisson, Brandon Plattner, Brandon Lillie, Dorothee Bienzle, Emily Brouwer, Bruno Gottstein, Andrew Peregrine

Abstract — A boxer dog was evaluated because of lethargy, vomiting, and abdominal pain. Ultrasonography revealed multiple cystic structures in the abdomen. Exploratory laparotomy revealed 3 well-encapsulated hepatic masses and abdominal effusion with suppurative inflammation. Collectively, these findings suggested the hepatic masses were most likely abscesses. However, histologic examination of the hepatic masses revealed multi-cystic structures, consistent with alveolar echinococcosis. The diagnosis was confirmed by DNA sequencing. The dog was treated with daily albendazole, but within a few weeks exhibited adverse side effects. After 6 months, the dog’s condition deteriorated, and it was euthanized.


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Echinococcus multilocularis is a zoonotic tapeworm that is expanding its historical range in North America (1). Adult tapeworms are found in the small intestine of wild canids, and the intermediate larval stage is found in the abdomen of rodents; the resultant disease is termed alveolar echinococcosis (AE). Dogs may also develop patent intestinal infections by ingestion of infected rodents and are the primary zoonotic concern. However, despite a wide geographic distribution of the parasite, infections in dogs have historically not been described in North America. Surprisingly, since 2012, cases of AE in dogs have been reported in southern Ontario. This report describes the fourth case and the problems encountered with medical management of the disease.

Case description

A 4-year-old male castrated boxer dog, weighing 28 kg, was first presented in June 2015 to the Ontario Veterinary College Health Sciences Centre (OVC-HSC) for lethargy, vomiting, and abdominal pain of 1-month duration. One week before presentation, the dog developed a distinct bulge over the left flank. Physical examination revealed all vital parameters were within normal limits. However, the dog was 5% to 7% dehydrated and a tense abdomen was detected upon palpation. Quick assessment tests (packed cell volume, total solids, blood urea nitrogen) and blood gas analysis were performed and were within normal limits. Fluid obtained by abdominocentesis was highly cellular and contained mainly degenerate neutrophils, as well as eosinophils and macrophages, with a total solids concentration of 42 g/L [reference interval (RI): 0 to 30 g/L].

Based on the fluid characteristics, a septic abdomen was the suspected diagnosis. Complete blood (cell) count (CBC) and biochemical profile revealed leukopenia (4.4 × 10^9/L; RI: 4.9 to 15.4 × 10^9/L), neutropenia (1.72 × 10^9/L; RI: 2.9 to 10.6 × 10^9/L), hyperphosphatemia (1.87 mmol/L; RI: 0.90 to 1.85 mmol/L), hyponatremia (138 mmol/L; RI: 140 to 154 mmol/L), and increased amylase activity (1138 U/L; RI: 299 to 947 U/L). Abdominal ultrasound examination was performed and revealed 2 large fluid-filled masses immediately caudal to the liver, a moderate volume of echogenic peritoneal effusion, and mild hepatic lymphadenomegaly.
An emergency exploratory laparotomy revealed 3 well-encapsulated hepatic masses. The largest mass was approximately 25 cm in diameter and adhered to the right lateral and right medial hepatic lobes and gallbladder. The 2 smaller masses were located along the margins of the left medial and left lateral hepatic lobes (Figure 1A). The smaller masses were removed using a thoracoabdominal stapler device (TA30 Premium; Medtronic, Brampton, Ontario) and submitted for histologic examination. Because the largest mass was considered non-resectable, the contents were emptied using continuous suction; thereafter, omentalization was performed. Aerobic and anaerobic bacterial culture on fluid collected from the abdomen yielded no growth.

After surgery, the dog was prescribed ampicillin (Ampicillin for Injection USP; Fresenius Kabi Animal Health, Richmond Hill, Ontario), 22 mg/kg body weight (BW), IV, q8h, enrofloxacin (Baytril Injectable Solution; Bayer Animal Health, Mississauga, Ontario), 11 mg/kg BW, IV, q24h, metoclopramide (Metoclopramide hydrochloride injection USP; Omega, Montreal, Quebec), 2 mg/kg BW per day, IV, continuous rate infusion, famotidine (Famotidine Injection; Omega, Montreal, Quebec), 0.5 mg/kg BW, IV, q12h, tramadol (Tramadol HCl; Chiron Compounding Pharmacy, Guelph, Ontario), 3 mg/kg BW, PO, q8h, and maropitant citrate (Cerenia Injection; Zoetis Canada, Kirkland, Quebec), 1 mg/kg BW, IV, q24h, and was monitored in the intensive care unit for 4 d. The dog was discharged with tramadol (3 mg/kg BW, PO, q8h for 4 d, then 3 mg/kg BW, PO, q12h for 3 d) and amoxicillin/clavulanic acid (Clavamox Tablets; Zoetis Canada), 13.75 mg/kg BW, PO, q12h for 3 d. Approximately 16 d after surgery, the sutures were removed and the dog was observed to be doing well clinically.

Histologic examination of the 2 smaller hepatic masses revealed multi-cystic structures containing eosinophilic, periodic acid-Schiff (PAS)-positive membranes, and calcareous corpuscles (Figure 1B), consistent with a diagnosis of hepatic AE. Therapy with praziquantel (Droncit Cestocide Tablets; Bayer Animal Health, Mississauga, Ontario), 5 mg/kg BW, PO, was administered immediately, and a second dose was prescribed at the time of discharge to be given by the owners at home 2 wk later. Hepatic tissues were submitted to the Institut für Parasitologie, University of Bern, Switzerland, for polymerase chain reaction (PCR) analysis. DNA sequence data for PCR-generated fragments of the mitochondrial 12S rRNA gene (2) and restriction fragment length polymorphism analysis of the 12S rRNA gene and NADH dehydrogenase 1 gene (3) confirmed the presence of the metacestode stage of *E. multilocularis* and the final diagnosis of hepatic AE.

Once the PCR results confirmed the presence of *E. multilocularis*, albendazole (Valbazen; Zoetis Canada) therapy was initiated at 10 mg/kg BW, PO, q24h for life. Following the patient’s discharge, monthly CBCs and biochemical profiles with physical examinations were performed by the referring veterinarian to monitor for potential side effects associated with albendazole therapy (4). After 4 wk of this treatment protocol the dog exhibited decreased appetite, nausea, and vomiting. As a result, an intermittent albendazole therapeutic protocol was...
initiated (10 mg/kg BW, PO, q24h for 4 wk, 4 wk off, repeated for life) which the dog tolerated well.

Three months after the initial presentation the dog returned to the OVC-HSC for a re-check examination and abdominal ultrasound. A large irregular fluid-filled structure was present in the cranial abdomen measuring approximately 15 cm × 14 cm, surrounded by a hyperechoic wall measuring up to 3 cm in thickness. The dog was maintained on the intermittent albendazole treatment regimen described, and continued on famotidine (10 mg/kg BW, PO, q24h for 4 wk, 4 wk off, repeated for life) which the dog tolerated well.

At post-mortem examination, the right medial liver lobe was markedly enlarged, with 50% to 60% of the hepatic tissue replaced by multifocal, coalescing, firm white raised nodules and a large fluid-filled cyst (Figures 2A, B). On the abdominal surface of the diaphragm, adjacent to the diaphragmatic surface of the right medial liver lobe, multiple well-demarcated firm nodules (ranging in size from 0.5 to 5 mm) were present (Figure 2A).

Histologic examination of the hepatic parenchyma revealed cystic structures lined by eosinophilic laminated hyaline membranes with an intact germinal epithelial layer. There was abundant fibrin and eosinophilic necrotic debris, abundant granular basophilic material, as well as calcareous corpuscles. Examination of the diaphragm revealed multifocal and coalescing raised nodules identical to those described in the liver. The histologic diagnosis was multilocular metacestode cysts with metastasis to the diaphragm, consistent with AE.

**Discussion**

Alveolar echinococcosis is an emerging, important zoonotic disease in parts of central Europe caused by the metacestode stage of the parasite *E. multilocularis*. Historically, the red fox (*Vulpes vulpes*) has served as the definitive host in this region. However, in North America other species such as coyotes (*Canis latrans*) are also capable of harboring adult parasites. Rodent species (mice, voles) typically act as the intermediate hosts (5).

This sylvatic life cycle follows a distinct pattern in which the definitive host harbors the adult parasite in the distal small intestine, and sheds eggs in feces that are immediately infective in the environment. It should be noted that *Echinococcus* spp. eggs are morphologically indistinguishable from *Taenia*-type eggs. After ingestion of eggs, the parasite migrates to the liver where it develops into a multicystic larval stage which contains a germinal layer from which protoscolices may develop (5,6). The larval stage exhibits exogenous budding; the parasite buds smaller portions of its cystic-like structure that invade neighboring tissue and spread to distant organs, behaving very similar to a tumor (5). When an infected intermediate host is consumed by the definitive host, an adult tapeworm develops in the small intestine.

Historically, it was generally accepted that the endemic areas in Canada and the USA for *E. multilocularis* included Alaska, the Northern Tundra region of Canada, the north central region of the USA (North Dakota, South Dakota, Iowa, Minnesota, Montana, Wyoming, Nebraska, Illinois, Wisconsin, Indiana, Ohio, Missouri, Michigan) and 3 Canadian Prairie provinces.
(Alberta, Saskatchewan, Manitoba) (7). However, in recent years, the geographical range has expanded into parts of British Columbia and Ontario, Canada (1,8,9). In part, this is thought to be due to large numbers of foxes and coyotes establishing in urban areas (10).

Since the 1980s, AE has been described in domestic dogs in Belgium, France, Germany, and Switzerland (6,11). This manifestation is thought to be associated with either ingestion of large numbers of infective eggs, or auto infection in association with adult *E. multilocularis* within the small intestine (12) and has only been described in areas with high levels of infection in wild canids. There are no cases of AE in North American dogs described in peer-reviewed literature prior to 2009. However, since 2009, at least 14 dogs have been diagnosed with AE in Canada; 1 in British Columbia (8), 3 in Alberta, 3 in Saskatchewan, 1 in Manitoba (1), and 6 in Ontario (9,13; Peregrine, personal communication, 2018). The dog described here is the fourth Ontario case, but had spent time in Alberta, where it had contact with coyotes. In addition, approximately 10 mo before the AE diagnosis the dog was attacked by a coyote in the Guelph area, Ontario.

Dogs with AE typically present with abdominal distention, lethargy, anorexia, and/or vomiting (12,14). Other, less common clinical signs include diarrhea, weight loss, polypnea, fever, and polyphagia. Based on cases seen in Switzerland, the median age at diagnosis is 3.1 y (1.1 to 10.7 y), with no significant breed predilection (14).

In cases of suspected AE, ultrasonography often reveals a space occupying lesion in the cranial abdomen. Large heterogeneous poorly delineated hepatic masses are observed with a thick hyperechoic outer surface, an irregular inner surface, and a central cavity filled with echogenic fluid. Free abdominal fluid (generally attributed to rupture of the cystic structure) is present in approximately 35% of cases and has been identified as a poor prognostic sign (14). On gross examination, multiple nodular firm pale-tan masses are present that typically resemble neoplasia. However, occasionally, as with the case described here, the gross appearance is that of abscesses. The liver is the most common organ affected; however, extension(s) into neighboring organs is possible (14). Dissemination to the lung, the most common organ affected; however, extension(s) into surrounding tissue (13,14). Examination of masses by histology and confirmatory diagnosis via PCR specific for *E. multilocularis* is the gold standard for diagnosing AE (3,14,16).

The dog described here was treated with praziquantel as soon as a presumptive diagnosis of hepatic AE was made; work in Switzerland has indicated that some dogs with hepatic AE also have intestinal infections (17). Therapy was initiated at this stage to eliminate adult tapeworms that may have resided in the small intestine and posed a zoonotic threat to those in contact with the dog. However, praziquantel is considered to have no impact on the larval stage, and it does not eliminate the infectivity of parasite eggs in intestinal contents. Once a confirmatory diagnosis was attained via PCR, treatment was initiated with albendazole at 10 mg/kg BW, PO, daily for life (18). However, at this dosage, albendazole can cause bone marrow toxicity leading to aplastic anemia in some dogs (4). Therefore, dogs receiving albendazole should be monitored with a CBC weekly for 1 mo, and then every 3 to 4 mo thereafter. This treatment regimen is recommended whether or not surgical excision is pursued. As in humans, surgical excision is only recommended if complete resection can be achieved (14). In the case herein, AE was not diagnosed until after surgery was performed as the masses were thought most likely to be abscesses. Dogs with any type of intervention (albendazole therapy, surgical, or both) have been shown to live significantly longer than those that have no intervention (14). Unfortunately, the dog described here was unable to tolerate daily treatment with albendazole. As a result, a more tolerable albendazole treatment regimen (10 mg/kg BW, daily, for 4 wk, stop for 4 wk, repeated for life) was initiated. However, while no adverse side effects were observed, the dog survived for only 6 mo. Since the post-mortem examination indicated significant replacement of hepatic parenchyma by parasite tissue, the intermittent treatment protocol did not prevent parasite growth. This is a poignant reminder that long-term management of cases of canine AE should include daily treatment with albendazole for life at 10 mg/kg BW. In general, because of the late stage at which AE is usually diagnosed, the prognosis and long-term survival potential of patients with AE are poor and should be emphasized in discussions with owners. However, some dogs can survive for extensive periods if maintained on daily albendazole treatment (14).

Alveolar echinococcosis in dogs is not directly transmissible to humans. However, as mentioned, some dogs with hepatic AE also have adult *E. multilocularis* residing in the small intestine; eggs shed by adult tapeworms in the feces are immediately infective for people. In humans, the larval stage of *E. multilocularis* is associated with a high case fatality rate unless it can be completely excised by surgery and/or controlled via treatment with a benzimidazole (19). Of particular concern is that the clinical incubation period is 5 to 15 y and disease may only manifest itself once infection is well progressed (19). Although the dog described here showed no evidence of a patent intestinal infection via a standard fecal flotation method at the time the presumptive diagnosis was made, all family members of the dog were tested for antibody to *E. multilocularis* (20); none tested positive.

As indicated, since 2012, 6 cases of AE have been diagnosed in domestic dogs residing in Ontario; 5 resided at the western end of Lake Ontario. This is a concern since 5 of the 6 dogs had not left the province, suggesting significant environmental contamination in the areas in which each dog resided. As such, it is noteworthy that since 2015, cases of AE have been diagnosed in 3 lemurs and 1 chipmunk in the same geographical area (21,22). As a result of these data and others, *E. multilocularis* was made reportable in all animal species in Ontario in January 2018 (23). In May 2018, *E. multilocularis* infection in humans was designated a disease of public health significance in Ontario (24).

Currently, monthly administration of praziquantel at 5 mg/kg BW is recommended in endemic regions to prevent patent intestinal infections and shedding of infective eggs in the feces of dogs that hunt (14). As such, this treatment protocol may...
also be effective at reducing the risk of canine AE associated with autoinfection. Encouraging pet owners to continue with safe handling practices with their pets, including appropriate hygiene and routine diagnostic/deworming protocols will help control the infection and prevent transmission.

Lastly, this case emphasizes the importance of carrying out histology on dogs with hepatic masses; grossly, the lesions of hepatic AE are typically very similar to those of hepatic neoplasia or abscesses. This is of concern, as the number of AE cases in Canada may therefore be underreported. Histologic examination of hepatic biopsies should therefore be performed in all cases that look suspicious for hepatic neoplasia or abscess. Such a recommendation is particularly important in Canadian provinces in which AE has been diagnosed in dogs.

Acknowledgments

We thank Dr. Barbara Deter for referring this case to the OVC-HSC and Dr. Grant Maxie, Animal Health Laboratory, University of Guelph, for assistance with submission of samples to Switzerland for diagnostic testing.

References

23. R.R.O. 1990, Reg. 557: COMMUNICABLE DISEASES — GENERAL under Health Protection and Promotion Act, R.S.O. 1990, c. H.7, Section 6.1, Paragraphs (2) and (3).
Surgical fenestration combined with omentalization for the treatment of renal cysts in 2 dogs

Jiyoung Park*, Changhwan Moon*, Mokhyeon Lee, Hae-Beom Lee, Seong Mok Jeong

Abstract — Two cases of surgical fenestration combined with omentalization for canine renal cysts using laparotomy and laparoscopy are described. After surgery, the cystic lesions gradually diminished in size, and a complete regression was confirmed in Case 2 by ultrasonography. The dogs maintained good condition without clinical signs of renal compromise for 14 months (Case 1) and 24 months (Case 2). Omentalization is a simple and effective procedure for canine renal cysts that conserves the remaining parenchyma and can be performed by a laparoscopic approach.

Résumé — Fenestration chirurgicale combinée à une omentalisation pour le traitement de kystes rénaux chez deux chiens. Deux cas de fenestration chirurgicale combinée à une omentalisation pour traiter des kystes rénaux canins utilisant la laparotomie et la laparoscopie sont décrits. Après la chirurgie, les lésions kystiques ont graduellement diminué en grosseur, et une régression complète fut confirmée par échographie dans le Cas 2. Les chiens ont maintenu une bonne condition sans signe clinique de complication rénale pendant 14 mois (Cas 1) et 24 mois (Cas 2). L’omentalisation est une procédure simple et efficace pour les kystes rénaux canins qui conserve le parenchyme restant et peut être réalisée par une approche laparoscopique.

Renal cysts (RCs) are fluid-filled, epithelial-lined, benign cystic structures within the renal cortex or medulla (1,2). Renal cysts are common in humans, and a retrospective study of simple RCs in healthy individuals reported that there was an overall prevalence of 10.7% and that 35.3% of these occurred in humans who were 70 years and older (3–5). Although the etiology remains unknown, tubular obstruction and ischemia in obstructed areas have been suggested (3). Renal cysts may originate from diverticulae of the distal convoluted renal tubules or collecting tubules (6). Metabolically active epithelial cells may cause an accumulation of fluid (7). Simple RCs are solitary cysts that induce no renal compromise; they are common in humans and dogs but not in cats (8,9) and are classified as Bosniak category 1 with the following characteristics in humans: thin smooth-walled lesions without features of malignancy, such as calcification, septation, or contrast enhancement observed by computed tomography (CT) (4,6,10).

Renal cysts in dogs and cats can be congenital, such as polycystic kidney disease (PKD) in Persian cats or bull terrier dogs, with an autosomal dominant trait; RCs can also be acquired, developing secondary to chronic nephropathies (9,11). Most RCs are benign and clinically silent, are found incidentally in healthy dogs, and generally require no treatment (8,11). Clinical signs, such as anorexia, depression, abdominal pain, or vomiting, are usually nonspecific and are caused by renal failure (11). Renal failure develops from cystic compression of the renal parenchymal vasculature (11). Renal ischemia can activate the renin-angiotensin-aldosterone system, resulting in hypertension (2,11,12). Although rare, cystic compression can result in distortion of the renal pelvis, hematuria, or obstructive uropathy, and cystic rupture into the abdomen or pelvicalyceal system is also possible in humans (12,13). A palpable mass is occasionally identified, and mechanical mass effects may result from the presence of large space-occupying cysts (3,4). In humans, pain is the most frequent complaint and indication for treatment. The pain is caused by distension of the innervated renal capsule, stimulating nociceptive fibers, and can present as behavioral changes in dogs (11).

Ultrasonographically, RCs are round or oval anechoic lesions with thin hyperechoic walls accompanying distal acoustic enhancement (6,8). Computed tomography indicates that RCs...
have radiodensities similar to water \([-10 \text{ to } 20 \text{ Hounsfield units (HU)}]\), which is slightly lower in density than the adjacent renal cortex (6,13). Although there is no consensus on optimal timing for intervention, treatment indications include RCs with clinical signs and associated hypertension, infection, or urinary tract obstruction, RCs that are larger than 4 cm in diameter (in human medicine) (1,3), and RCs with a risk of malignancy (14). Treatment options include percutaneous aspiration, sclerotherapy to injure the cystic wall cells, cysto-retroperitoneal shunting, percutaneous fulguration and marsupialization, and surgical fenestration (deroofing and wide excision of the cystic wall) (3,4,6,12–14). Treatment goals include symptom relief and prevention of recurrence (12). This report describes 2 canine RCs treated by surgical fenestration and omentalization by laparotomy and laparoscopy.

Case descriptions

Case 1
An 11-year-old, 4.2 kg, intact female Yorkshire terrier dog was referred for multiple masses on the bilateral mammary chains, except the left first gland, which was suspected to be adenocarcinoma according to cytology. Preoperative thoracic radiography showed no specific findings. Ultrasonography and CT scanning, however, revealed diffuse hypoechoic nodules in the liver and a 36 × 40 × 46 mm anechoic hypodense cyst on the cranial pole of the right kidney without contrast enhancement (HU = 6.5), which was separated from the renal pelvis (Figures 1A, B). The patient had no clinical signs associated with these lesions, and laboratory examination results [complete blood (cell) count (CBC), chemistry, electrolytes, and urinalysis] were within the normal ranges except for a mild increase in total bilirubin [25.7 \mu\text{mol/L}, reference range (RR): 0 to 15.4 \mu\text{mol/L}]; blood urea nitrogen (BUN) was 5.7 mmol/L (RR: 2.5 to 5.7 mmol/L), creatinine was 79.6 \mu\text{mol/L} (RR: 44.2 to 159.1 \mu\text{mol/L}), urine specific gravity (USG) was 1.040. There was no proteinuria. Blood pressure (BP) was 120 mmHg.

At the time of the total mastectomy, an ovariohysterectomy and liver biopsy were also performed by a laparotomy. The laparotomy facilitated open fenestration combined with omentalization of the RC (Figure 2). When the RC was explored, a pale-colored intracapsular cyst was protruding from the right kidney, and transparent cyst fluid was aspirated and analyzed as a modified transudate, which was not urine (Table 1). The inner surface of the cavity was smooth when the cyst was opened. The thin wall of the cyst was sufficiently excised, with < 5 mm of marginal tissue adjacent to renal parenchyma remaining. Then, the omentum was fixed loosely with 2 horizontal mattress sutures (3-0 polyglyconate; Maxon, Covidien, Watford, UK).

The patient recovered uneventfully and was routinely managed for mastectomy [BP: 120 mmHg, BUN: 3.9 mmol/L, creatinine: 53.0 \mu\text{mol/L} on postoperative day (POD) 3]. A histopathological evaluation was not performed on the RC, but a diagnosis of mammary gland adenoma and hepatic lipogranuloma was made. Postoperative ultrasonography (Figures 3A, B) on POD 28 revealed that the omentum had maintained its position, and a 19.4 × 13.2 mm anechoic cyst was present at the omentalized site. The cyst had decreased to 16 × 14 mm on POD 56 and further decreased to 7 × 7 mm on POD 213. A follow-up by telephone was conducted by the referring veterinarian 14 mo after surgery, and the patient was reported to be in good condition without any complications or clinical signs.

Case 2
A 14.5-year-old, 10.9 kg castrated male cocker spaniel dog was presented for surgical treatment of RC. The RC was first identified during a regular health screening 15 mo before the surgery. Ultrasonography revealed an anechoic cortical cyst (19.4 × 14.7 mm) separated by a hyperechoic septum at the caudal region of the right kidney. Although the owner complained that the dog had mild abdominal distension, there were no specific clinical signs or alterations in any of the blood examinations and urinalysis. With a tentative diagnosis of asymptomatic RC requiring no intervention, ultrasonographic monitoring was carried out because the patient had suffered from several concurrent diseases. These included mild mitral valve insufficiency (cardiac murmur grade 3), hind limb weakness.
associated with T12–13 intervertebral disc disease (IVDD), and lumbosacral stenosis, severe pruritus, and lichenification associated with bilateral externa otitis and hypothyroidism, bilateral keratitis/cataract, and left ocular lens luxation/glaucoma.

Eventually, the lesion developed into a large, anechoic cyst, growing up to 36 mm in diameter over the next 14 mo (Figure 1C); the cyst measured 22.6 × 18.2 mm, 28.9 × 22.5 mm, 30.8 × 28.4 mm, and 36.2 × 30 mm upon examination at 2, 9, 10, and 14 mo, respectively. The RC had expanded to the mid-kidney and was in the peripelvic area but was unrelated to the pelvis. Two new small cysts (6.4 × 3.9 mm and 1 × 1 mm) were then identified in the contralateral kidney. Urinalysis showed no proteinuria but microhematuria (＞5 cells per high-power field) and granular casts (＞2 per low-power field) were observed. The patient still showed no clinical signs, and all values of the laboratory data (CBC, chemistry, and electrolytes) were within the reference range except for mild leukocytosis (22 000 cells/μL, RR: 6000 to 17 000 cells/μL); BUN: 5 mmol/L, creatinine: 44.2 μmol/L, USG: 1.035. The BP was 140 mmHg. Nonetheless, it was decided to undertake surgery.

Two weeks later, a laparoscopic fenestration with omentalization was performed in dorsal recumbency through three 5-mm ports (Figure 4). A primary port was located using the Hasson technique, 2 cm caudal to the umbilicus. The right upper quadrant was explored with a 5 mm, 30° laparoscope (1188 HD camera; Stryker, Portage, Michigan, USA) under 11 mmHg of intra-abdominal pressure. A second port was placed 5 cm cranial to the primary, and a third port was placed in the right paramedial region, caudal to the kidney using finger indentation under laparoscopic visualization. The duodenum was retracted caudo-medially to visualize the RC on the mid-part of the right kidney. Protruding laterally from the kidney, the intracapsular RC was pale and tan-colored with less capsular vascularity than the surrounding unaffected renal parenchyma. A 22-G spinal needle was used to aspirate cystic fluid percutaneously, and the collapsed cyst was grasped and freed from the peritoneum by blunt dissection. The cyst wall was opened with a laparoscopic scissor, the area was suctioned completely with several yellow fragile debris, and the cytology revealed that the cystic fluid was not urine but exudate (Table 1).

The patient recovered well and showed good activity and appetite after surgery. However, high C-reactive protein (CRP, RR: 0 to 190.5 mmol/L) and leukocytosis (neutrophilia with a regenerative left shift) were present: 1504.8 mmol/L and 41 000 cells/μL on POD 1, and 1352.4 mmol/L and 59 000 cells/μL on POD 2, respectively. These values subsided with cefotaxime (Cefotaxime natrium inj.; Kukje pharm, Sungnam, Korea), 3.2 mg/kg body weight (BW), loading IV followed by 5 mg/kg BW per hour constant rate infusion (CRI), and enrofloxacin (Baytril; Bayer Korea, Seoul, Korea), 5 mg/kg BW, SC, q24h during the entire hospitalization period (4 d); the patient was discharged on POD 4. Postoperative histopathology of the resected cystic wall revealed numerous sites of...
hyalinization, which were interpreted as laser artifacts or hyalinized collagen, likely caused by compression of the cyst wall by the cyst fluid, and rarely small aggregates of desquamated epithelial cells were observed.

The omentum remained at the intended location (Figures 3C, 3D), and the lesion was $18 \times 14$ mm on POD 15 with hyperechogenicity, $21 \times 17$ mm on POD 45, $5 \times 4$ mm on POD 79, and it had disappeared after the next follow-up on POD 136. The 1-year examination showed no abnormality [BP: 140 mmHg, BUN: 4.5 mmol/L, creatinine: 44.2 μmol/L, symmetric dimethylarginine: 90 μg/L (RR: 0 to 140 μg/L), USG: 1.035], with no proteinuria and no urinary casts, and the patient was in good condition 24 mo after surgery without any clinical signs or renal compromise.

Discussion

While there is an abundance of information regarding RCs in humans, information regarding the incidence, treatment, or prognosis of RCs, except for PKD, is scarce in dogs. In this report, both RCs were intracapsular, extending from the parenchyma and distorting the renal contour. At the time of diagnosis, the patients had no clinical signs, such as abdominal pain or hypertension. Nonetheless, surgery was elected despite the age of the patients and their concurrent diseases.

Percutaneous aspiration or sclerotherapy under ultrasonography, fluoroscopy, or CT guidance are alternative, simple, and noninvasive techniques (2–4,8,10,11), but in the present cases, these techniques were not considered because of their recurrence rates and their requirement for general anesthesia. The success rate of percutaneous management is variable according to cyst size, sclerosing agent, single or multiple sessions, definition of success, or duration of follow-up (10). Previous studies involving sclerotherapy with 95% ethanol in 6 dogs and 4 cats reported a 100% success rate upon reexamination at 20 d (1 dog) (2), 3 to 4 wk (4 dogs and 4 cats) (11), and 6 mo (1 dog) (8) after the procedure. However, a human study that investigated 51 laparoscopic RC surgeries reported that 15 patients (29.4%) had a previous history of cyst aspiration, and 6 of these also had sclerotherapy (11.8%) (14). With high recurrence rates (up to 95% for aspiration alone and 0% to 78% for sclerotherapy) (10,13), some researchers in human medicine have recommended that sclerotherapy be used only as an initial therapy in cases of a single, small, symptomatic cyst (10) or for patients with significant comorbidity; this procedure provides a diagnostic sample.
for fluid analysis and allows for monitoring for pain relief (4). Sclerotherapy can result in local pain or loss of renal function because of inadvertent leakage of the sclerosing agent outside of the cyst or into the pelvicalyceal system (12). Open fenestration may be invasive, but in Case 1, it was performed as an additional procedure during a preplanned laparotomy. The lesion was not malignant, but was not a normal structure. The laparotomy provided an opportunity to operate on the cyst greater than 4 cm, which is a criterion for intervention in human medicine. The procedure was performed in a timely manner, was straightforward, and did not result in any complications.

Human studies on simple RCs have reported that 74% of RCs remained unchanged in size, but the average size increase and rate of cystic enlargement for RCs that became enlarged were 1.4 to 2.8 mm and 3.2% to 5% per year, respectively (13,15). Renal cysts have also been shown to double their size over 10 y (6). In this report, the cyst in Case 2 became enlarged rapidly, and lesions developed in the contralateral kidney. The original lesion increased in size by 17 mm (89.5%) over 14 mo, which is a relatively steep growth rate compared to that in human studies. The lesion was accompanied by alterations in urinalysis; therefore, a surgical intervention with a minimally invasive approach was conducted. The growth rate in Case 1 was not evaluated because the lesion was treated immediately after diagnosis. Further investigation regarding the stability or growth rate of canine RCs is required to determine whether any similarities are shared with RCs found in human medicine.

Surgical deroofing can be performed for large recurrent RCs and has a high success rate (95% to 100%) in human patients (10). Evaluation of the communication between the cyst and the pelvicalyceal collection system should be performed before surgery, because a retroperitoneal urinoma or urinary ascites can potentially develop after decortication (4). Contrast medium studies with intravenous urography, retrograde ureteropyelography, direct instillation into the cyst after aspiration, contrast-enhanced CT, or fluoroscopic renal cystogram can be used (4,10,14). This was not performed in Case 2, but fortunately, the cystic fluid was not urine, and there was no communication.

**Figure 4.** Laparoscopic fenestration and omentalization of a canine renal cyst (RC) (Case 2). Intra-abdominal image of the RC (arrow) in the right kidney (A) and percutaneous aspiration using a spinal needle (B). The collapsed cyst (arrow) was circumferentially separated from the peritoneal lining with perinephric fat (arrowheads), and then the cyst wall was opened (C). The turbid orange-colored fluid was completely drained (D). Cyst wall tissue was removed using an ultrasonic scalpel (E), and the kidney returned to its normal bean-like shape (F). The omentum was packed into the cystic pocket (G) and sutured to the trimmed edge (H). Omentalized kidney (I).
with the renal pelvis. Not all investigators emphasize this procedure (8,11,14), but this could be a key to differentiating simple RC from communicating RC, calyceal diverticulum (human), or cystic neoplasm (10,13,16). Methylene blue can also be injected via the ureteric catheter for final inspection at the end of the procedure (14). Regarding decortication, an incomplete handling or insufficient excision of the cystic wall increases the recurrence rate; therefore, a surgical excision as wide as possible should be attempted. Additionally, omentum or perinephric fat can be interposed to prevent recurrence (4,14,17). Due to the physiological drainage of omentum, it has been used in the treatment of cystic diseases in various organs in veterinary medicine (18). The abundant meshwork of omental vasculature and lymphatics can absorb fluid and promote resolution of infection, and the omentum reduces dead space, provides increased blood flow, promotes angiogenesis and lymphatic drainage, adheres to the site of inflammation sealing off the diseased area, and enhances local immune function and wound healing (19).

Accordingly, in dogs and cats, omentalization has been performed for the treatment of cysts, pseudocysts and abscesses in the prostate, pancreas, liver, uterine stumps, and subumbilical lymph nodes for chronic effusion in synovial cavities and for the treatment of chylothorax (18–21). Omentalization is a simple but effective treatment for lesions with concerns of high recurrence or in nonresectable lesions, while preserving not only the remaining normal parenchyma but also the adjacent vital structures (19,21). In Case 1, omentalization was performed after RC deroofing because the hilar side of the cystic wall was not removed so as to avoid damage to the renal parenchyma. The cyst did not regress immediately after surgery, but it decreased in size gradually, providing evidence that the omentum provides continuous physiological drainage of the RC. Case 1 did not develop any related clinical signs of renal compromise over the 14-month follow-up period, and based on that result, the rapidly progressing RC in Case 2 was treated with the same procedure (surgical fenestration and omentalization) by a minimally invasive approach.

The laparoscopic approach did not result in any intraoperative or postoperative complications. Compared to other parenchymal organs, kidneys are covered by a capsule of thick connective tissue and are therefore relatively firm. In Case 2, moreover, the cortical lesion was a clearly compartmentalized, solitary intracapsular cyst that was not associated with the renal pelvis. Additionally, the RC had no gross inflammation, adhesions to adjacent tissues, or cystic rupture, and there were no vital structures immediately adjacent to lesion at risk of injury, as in the case of prostatic or pancreatic cysts. These findings facilitated laparoscopic omentalization; as a result, the RC was not difficult to manipulate. There was minimal hemorrhage during suture-biting adjacent to the renal parenchyma that did not require intervention for hemostasis. Laparoscopic ligating clips could facilitate the ease and speed of the procedure. Because the cyst occupied the midzone of the right kidney and we needed to maneuver the lateral or dorsal convex side of the kidney away from the renal hilus, a right-side up position could have been more convenient. However, the procedure was achieved by means of medially rotated retraction of the dorsal edge of the cystic wall and tilting the surgical table after the cyst was released from the peritoneum, and there was no need for conversion. Although the excision of the cyst wall was not as extensive as in Case 1, the cystic lesion disappeared completely.

In human medicine, complications associated with RC include infection, hemorrhage, or rupture of the cyst, which occur in 2% to 4% of patients (6). The incidence of cyst infection in human PKD patients has been reported to be 8.4% (22), with E. coli being the most commonly found pathogen. Cystic fluid culture was not performed in either of the cases, and histopathology was inadvertently excluded in Case 1. It was difficult to evaluate the postoperative morbidity of fenestration and omentalization in Case 1 because these procedures were performed in conjunction with routine procedures, although the patient recovered favorably. Although Case 2 had an excellent postoperative condition (alertness, appetite, activity, and urination), the patient experienced an acute increase in CRP and leukocytes with left shift for the next 2 d. It could contribute to his comorbidities or surgical stress, but the possibility of cystic infection could also not be ruled out. During percutaneous aspiration, the cystic content escaped due to internal pressure (a Veress needle could have been useful). Although a direct smear of the exudate showed no bacteria or inflammatory cells, it cannot be definitively diagnosed as sterile because bacterial culture was not conducted. However, the lesion did not have a markedly thickened or calcified wall, which is often identified in infected RCs (6), and the patient successfully recovered without developing peritonitis. Hyperechogenicity in the cystic lesion observed on POD 15 did not result in an intervention because the omentalization had been performed, and the lesion resolved spontaneously.

Although the artifacts in Case 2 prevented histopathological interpretation including evidence of malignancy, CT examination is warranted if any change is noted in the shape of the RC wall and clinical signs during preoperative surveillance or conservative management (15) to determine whether there is progression associated with malignancy. Clinical signs are more common with neoplastic lesions than simple cysts (6). In a study of 61 human RC patients, there were 2 cases of neoplasms that originated from the cystic wall. These cases were identified in each patient 5 and 6 y after the initial diagnosis of a simple RC, which had either a small solid component or an irregularity of the wall (15). A risk of malignancy has been correlated with findings of calcification, septation, lobulation, wall thickening or irregularity, nodularity, and contrast enhancement by CT (6).

Since it was first described in 1992, laparoscopic intervention has become a standard for the treatment of symptomatic and simple RCs in human medicine (10,12,14). Laparoscopic intervention has a high success rate, a lower level of invasiveness than open surgery, and a low complication rate (13). Various approaches, including conventional transperitoneal, retroperitoneal, single site surgery, and natural orifice pathways, have been used (10,12,14). In a study by Erdem (12), laparoscopic decortication (n = 17) achieved a symptomatic success rate of 94.2% and a radiographic success rate of 100% during a follow-up period of 12.5 mo. Three patients experienced minor complications (subcutaneous CO₂ leakage and self-regressed

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paralytic ileus). In another study of 51 laparoscopically treated patients, complications included gonadal vessel injury (n = 1), mild ileus (n = 2), low grade fever (n = 3), and perinephric hematoma (n = 1) (14). Those patients were 100% symptom-free, without urinary tract obstruction for 6 to 12 mo after surgery, but recurrence was observed through ultrasonography in 3 patients. In addition, Okeke et al (4) reported no postoperative complications in 7 patients, except for 1 episode of refractory hemorrhage, and a 100% success rate was observed 17.7 mo after surgery. In Case 2, transperitoneal laparoscopic fenestration followed by omentization was performed because of the rapid accumulation of cystic fluid and changes in urinalysis. Based on previously reported results, a favorable prognosis is expected.

This report describes incidentally detected RCs in 2 dogs, and surgical fenestration and omentization resulted in regression of the RCs. Omentization was effective, and a laparoscopic approach was feasible in our systemically compromised patient. Further studies are warranted using a larger number of cases and long-term follow-up.

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Multiple imaging modalities for the diagnosis of tracheal collapse in a calf: A case report

Hanna Vermedal, Luis G. Arroyo, Christina McKenzie, John D. Baird

Abstract — A 4-month-old Holstein Friesian calf was presented to the Ontario Veterinary College with progressive respiratory distress. The calf was diagnosed with tracheal collapse following perinatal rib fractures. Tracheal collapse has been infrequently reported in calves and is a possible sequela after delivery by forced extraction. Clinical signs can appear from days to months after birth, making the connection between clinical signs and dystocia more challenging. Multiple imaging modalities were used to diagnose and determine the severity of the tracheal collapse, and to establish the most likely cause and prognosis.

Résumé — Modalités multiples d’imagerie pour le diagnostic de collapse trachéal chez un veau : rapport de cas. Un veau de race Holstein Friesian âgé de 4 mois fut présenté au Ontario Veterinary College pour détresse respiratoire progressive. Un diagnostic de collapse trachéal à la suite de fractures de côtes périnatales fut posé. Le collapse de la trachée n’a été rapporté que très peu fréquemment chez les veaux et serait une séquelle possible d’une mise-bas par extraction forcée. Les signes cliniques peuvent apparaître des jours jusqu’à des mois après la naissance, rendant l’association entre les signes cliniques et la dystocie encore plus difficile. Des modalités multiples d’imagerie furent utilisées pour diagnostiquer et déterminer la sévérité du collapse trachéal, et afin d’établir la cause la plus probable et le pronostic.

(Traduit par Dr. Serge Messier)

Tracheal collapse occurs in several species, but is a particularly common disorder in small dog breeds (1). Tracheal collapse has been less frequently reported in calves. A congenital etiology has been proposed (2), but most reported cases are presented with a history of thoracic trauma from dystocia and forced extraction during delivery (3–7). Forced extraction causes dorsoventral compression of the trachea, and injury to the tracheal rings. In cases of rib fractures, the injury to the tracheal rings could be exacerbated further by bony callus formation during healing of the fractures (6). Most of the calves reported with tracheal collapse were born in breech position and were assisted mechanically during parturition (3–5). Clinical signs of tracheal collapse in calves can appear from days to months after birth, and reported signs include dyspnea at rest, coughing, wheezing, cyanosis, inspiratory stridor, and reduced tolerance for exercise (3,5,6). Affected calves are often treated medically for suspected pneumonia, with poor to no response to treatment (2–5). The calf in the current case displayed characteristic clinical signs of tracheal collapse with a typical history of dystocia and poor response to medical therapy. As in previous reports, the diagnosis was made late in the course of disease. The aim of this report is to present multiple diagnostic imaging modalities used to determine the cause, severity, and prognosis associated with a severe tracheal deformity in a 4-month-old Holstein Friesian calf.

Case description

A 4-month-old female Holstein Friesian calf weighing 106 kg was presented to the Ontario Veterinary College with progressive respiratory distress of several days’ duration. The calf had a history of dystocia and had been delivered by forced extraction. The calf delivery was scored as moderate according to the farm scale of calving difficulty score chart. No abnormal respiration or growth retardation was noticed during the first months of life.

On presentation, the calf was lethargic and dyspneic at rest with a respiratory rate of 92 breaths/min and an inspiratory stridor that worsened when stimulated. The calf was mildly tachycardic with a heart rate of 116 beats/min. Rumen motility was decreased and the rectal temperature was 38.7°C. On auscultation over the trachea a wheezing inspiratory sound was heard.
with increasing intensity close to the thoracic inlet. Auscultation of the lung fields revealed increased broncho-vesicular sounds that decreased in intensity caudally. No crackles or wheezes were heard. Thoracic ultrasound revealed mild diffuse pleural roughening in the form of “comet-tail” artifacts of both the right and left lung fields. A complete blood (cell) count (CBC) revealed a slightly elevated red blood cell (RBC) concentration \( [8.5 \times 10^{12}/L; \text{reference interval (RI): } 4.9 \text{ to } 7.5 \times 10^{12}/L] \), and a serum biochemistry profile revealed mild hypoproteinemia \( (55 \text{ g/L; RI: } 66 \text{ to } 86 \text{ g/L}) \) with mild hypoglobulinemia \( (22 \text{ g/L; RI: } 30 \text{ to } 53 \text{ g/L}) \). The calf was administered intranasal oxygen with a flow rate of 10 L/min and was started on ceftiofur sodium (Excenel; Zoetis, Kirkland, Quebec), 2.2 mg/kg body weight (BW), IV, q24h.

Endoscopic examination of the trachea revealed a severe, dorsoventrally collapsed trachea commencing at the level of the thoracic inlet extending caudal to approximately 10 cm cranial to the tracheal bifurcation (Figure 1A).

Lateral thoracic radiographs confirmed a dorsoventrally collapsed trachea commencing at the level of the fifth cervical vertebra extending beyond the thoracic inlet to the second pair of ribs, with the most severe tracheal narrowing at the level of the thoracic inlet (Figure 1B).

After the diagnosis of tracheal collapse, surgical treatment options were discussed with the owners; however, they elected to euthanize the calf 10 d after presentation.

A computed tomography (CT) study performed post-mortem revealed severe narrowing of the trachea from the level of the fifth cervical vertebral body extending caudally to the thoracic inlet (Figure 2). The collapse of the trachea continued caudally and resolved at the level of the second and third pairs of ribs. The first and second ribs showed bilateral callus formation indicative of bone healing following previous rib fractures (Figure 3).

Post-mortem examination revealed subcutaneous edema along the length of the ventral neck, as well as severe edema of the thymus. The collapsed trachea extended for about 15 cm from the level of the thoracic inlet. The luminal diameter of the most severely collapsed segment was 7 mm, compared with 18 mm in the mid-cervical trachea (Figure 4). The first and second pairs of ribs bilaterally, and the third right rib, had prominent bony callus formation from healing rib fractures. There was marked subcutaneous emphysema along the thoracic walls, and mild pulmonary edema.

**Discussion**

The present case reflects the most commonly reported etiology for tracheal collapse in calves, namely cranial thoracic trauma or fracture of the first pair of ribs during birth (3–7). Rib fractures are common in neonatal calves and foals, with a prevalence of 20.1% for costochondral dislocation or rib fractures in foals less than 3 d old (8), and 23% for rib fractures in perinatally dying calves (9). When forced extraction is considered, the prevalence of rib fractures in calves has been reported to be up to 40% (10).

Tracheal collapse is common in small dogs, and although the etiology is unknown, the consensus is that tracheal collapse in dogs is caused by congenital weakening of the cartilage rings, with exacerbation of clinical signs due to obesity, airway irritants, or cardiac disease (11). The case presented in this report had a history of dystocia, having been delivered by forced extraction. Forced extraction causes dorsoventral compression and injury to the tracheal rings, which could be exacerbated by bony callus formation during fracture healing, or by the negative inspiratory
pressure continuously weakening the affected tracheal segment (6). Most of the calves reported with tracheal collapse were born in the breech position and assisted mechanically during parturition (3–5).

Reported clinical signs of tracheal collapse in calves include depression, dyspnea at rest, open mouth breathing, coughing, cyanosis, inspiratory stridor, and severely reduced tolerance for exercise (3,5,6), as observed in this case. Palpable callus formation or deformation of the ribs has also been reported (3,4). Commonly, affected calves are treated medically for suspected pneumonia or laryngitis, with no response to treatment (2–5). Clinical signs of tracheal collapse can appear within a few days (4) to several weeks after birth (3). The onset of clinical signs in this case reportedly appeared several weeks after birth, which hindered the association between clinical signs and dystocia during the initial assessment.

A diagnosis of tracheal collapse can be confirmed with diagnostic imaging modalities such as radiography, endoscopy, and CT (3,5,6). Tracheoscopy provides an intra-luminal view of the extent and severity of the collapsed segment (1) and correlates well with radiographic findings, as seen in this case. Rib fractures or healed rib fractures can be diagnosed with lateral radiographs (3,5), but overexposure, underexposure, or motion artifacts can preclude adequate interpretation of lateral radiographs (8). Lateral thoracic radiographs will reveal a dorsoventrally collapsed trachea as observed in this case. A latero-lateral collapsed trachea may not be seen on lateral thoracic radiographs (12); however, this type of collapse has not been reported in calves. Computed tomography (CT) allows differentiation between a dorsoventral and latero-lateral tracheal collapse, assessment of rib fractures and effect on the thoracic inlet diameter (12). Additionally, CT offers more benefits in cases suitable for surgical treatment, as three-dimensional reconstructions enable better evaluation of the severity of the rib fractures, collapsed trachea, and pre-surgical planning (5). Radiographs have been shown to underestimate the diameter of the affected collapsed segment compared to CT (1). Ultrasonographic examination of the lung fields is useful to differentiate tracheal collapse from pneumonia (13), and even the use of a linear probe would give an indication of a possible presence of pneumonia. A recent study using thoracic ultrasonography to determine lung consolidation associated with pneumonia in calves reported a sensitivity of 85% and 94% for chronic clinical and acute subclinical cases, respectively, with specificities of 98% and 100%, respectively (14). The same study also documented the presence of rib fractures in 6% of the calves (14), which is lower than previously reported, indicating that rib fractures can easily be missed on thoracic ultrasonographic evaluation.

A classification system has been published for tracheal collapse in dogs, which grades the severity of tracheal collapse from I to IV, whereby a grade I is normal, a grade II is 50% reduction of the tracheal lumen, grade III is 75% reduction, and grade IV is obliteration of the tracheal lumen by flattened tracheal rings (15). No classification system has been published for large animals.

In dogs, medical treatment is often successful in mildly affected individuals, by breaking the cycle of inflammation that triggers coughing and further inflammation (1,11). As the etiology of tracheal collapse in calves is different than that in dogs, medical treatment is unlikely to improve the long-term outcome in calves. Tracheostomy to relieve the respiratory distress is also not effective to treat these calves, due to the location of the stenosis. Intranasal oxygen administration has been shown to increase arterial partial pressure of oxygen and arterial oxygen saturation in neonatal calves with respiratory distress syndrome (16), and could temporarily increase arterial oxygen in calves with hypoxia from tracheal collapse.

The most common surgical treatments of tracheal collapse in dogs are extra-luminal rings and intra-luminal stents (11). A surgical treatment for tracheal collapse in calves with an extra-luminal ring prosthesis has been reported (3), with varying degrees of success. The ring prosthesis temporarily restored the intra-luminal diameter of the trachea at the time of placement; however, continued tracheal growth caused varying degrees of tracheal narrowing and stenosis by mucosal infolding of the trachea after surgery (3). Therefore, it has been recommended that the ring-shaped prosthesis be removed 2 to 3 mo after surgery, based on radiographic findings or re-collapse. An alternative recommendation is to place a spiral prosthesis to accommodate tracheal growth without stenosis formation (3). Surgical resection to increase the thoracic inlet diameter has also been reported in calves (3). Costectomy of the first and second ribs with associated callus formation in affected calves did not improve the diameter of the collapsed trachea (3). More recently, partial rib resection of the first and second ribs for the treatment of tracheal collapse in 3 calves with rib fractures sustained during difficult deliveries was reported (5). Two out of the three calves recovered well after surgery, whereas 1 had recurrence of

![Figure 3. Computed tomography images showing (A) callus formation (white arrows) of the first pair of ribs and (B) severe narrowing of the trachea starting at the level of the fifth cervical vertebrae extending caudal to the second thoracic vertebrae (between white arrows).](image)

![Figure 4. A – Segmental tracheal collapse at the level of the thoracic inlet. B – Intraluminal diameter of collapsed segment and a normal tracheal ring at the level of mid-cervical tracheal segment.](image)
wheezing and subsequently was slaughtered. Partial rib resection led to improvement of stridor in 2 cases, indicating that not all cases of tracheal collapse and stenosis may require placement of tracheal prosthesis (5). The optimal surgical intervention to treat tracheal collapse in calves may vary according to age, degree of severity of the collapse, and degree of severity of callus formation after rib fractures, which can be assessed by CT examinations.

Tracheal collapse should be considered as a differential diagnosis in calves presenting with worsening dyspnea and failure to respond to medical treatment, particularly those calves with a history of dystocia and forced delivery. In cases with palpable thoracic wall abnormalities, the suspicion of traumatic tracheal collapse should be considered. The historical and clinical presentation of the calf presented in this report are characteristic of tracheal collapse cases. Dorso-ventral compression of the cranial thorax can occur during assisted delivery and may become a risk factor in the development of tracheal collapse (3). The overall incidence of tracheal collapse in calves is unknown but likely to be low. However, this condition may be underestimated as the final diagnosis may require specialized diagnostic equipment.

References


Book Review

Compte rendu de livre

Canine Infectious Diseases: Self-Assessment Color Review


The CRC Press “Self-Assessment Color Review” series is notorious for offering case-based reviews of veterinary medicine. This particular book focuses on canine infectious diseases which are commonly found in veterinary practice. Case classifications include bacterial, viral, fungal, and parasitic infections as well as issues surrounding vaccinations. Although laid out in a random fashion, there is a list of cases sorted by classification if the reader were to search for a particular disease to review.

The case-based approach allows the details of each case to be provided step-by-step, similar to how they may appear in real practice. This allows an opportunity for both veterinarians and veterinary students to test existing knowledge and ponder the case. The color illustrations are an excellent addition, helping to identify classic and unique features of a condition, and also to create a more pleasurable learning experience. Each case is concise allowing the text to be picked up for short periods of study. Answers are found at the back of the text, and although in-depth, a link to an online resource for further study might be helpful. However, as these study guides are intended to be somewhat brief, additional online material might be outside their scope and likely would increase costs. Even though there are more and more online opportunities to review cases, this text and the CRC Press review series, still offer a solid and useful approach to study.

Reviewed by Janeen Junaid, DVM, MVSc, VCA Bay Cities Animal Hospital, Burlington, Ontario.
Multiple excisions of an equine sarcoid and the repercussions
Heather Melinyshyn

Abstract — A 13-year-old Morgan crossbred mare was presented in May 2018 with a 10-cm mass on the medial aspect of the left hind fetlock. In September and November 2018 and June 2019 the mass was incompletely excised and continued to grow. A diagnosis of spindle cell tumor, consistent with equine sarcoid, was made based on histopathology from the last excision.

A 13-year-old, 500-kg Morgan crossbred mare was presented to Prescott Animal Hospital in Prescott, Ontario in May 2018 with a 10-cm mass on the medial aspect of the left hind fetlock. The horse had recently been purchased from a riding school to be used as a trail horse. The new owner was aware of the mass when she purchased the horse but was unaware if it had been treated. The owner felt the lesion did not appear to cause any discomfort, but occasionally bled if the right hind foot came into contact with the mass. The horse was kept in a small fenced-in area with another horse, with free choice hay and water. A run-in shelter was available. Differential diagnoses included exuberant granulation tissue, granuloma (fungal or foreign body), and staphylococcal pyogranuloma.

Upon initial examination in May 2018, the horse was adequately sedated with injectable detomidine hydrochloride (Dormosedan; Zoetis, New Jersey, USA), 0.01 mg/kg body weight (BW), IV, and injectable butorphanol tartrate (Torbugesic; Zoetis), 0.01 mg/kg BW, IV. Lidocaine, as hydrochloride monohydrate (Lurocaine 20 mg/mL; Vétoquinol, Lavaltrie, Quebec), 20 mL, SQ, was injected as a regional nerve block. The mass and surrounding area were scrubbed aggressively and surgically prepared. The mass was excised, but due to the proximity of joints, other structures, and high skin tension, good margins were not obtained. The skin and subcutaneous tissues were not closed, but a bandage was applied. The owner declined laboratory submission of a sample for histopathology. She was instructed to keep the wound clean and apply clean bandages. No other skin lesions were noted, and the horse appeared to be healthy otherwise.

In June 2018, the mare was re-examined as the mass had grown. The veterinarian recommended monitoring the mass and continuing to clean the area and apply sugar topically to reduce swelling. An injection of ceftiofur crystalline free acid (Excede, 200 mg/mL; Zoetis), 6.6 mg/kg BW, IM, was administered to rule out infection as a cause. The owner was instructed to monitor the area and phenylbutazone powder (Buzone Conc. 225 g; Vétoquinol), 4 mg/kg BW, PO, was dispensed to aid in pain relief and inflammation.

On a follow-up examination in September 2018 the mass had grown 10 cm on the medial aspect of the fetlock, and an additional 5-cm mass was located on the dorsal aspect of the pastern, just above the coronary band. The masses appeared lobulated and there were additional 1-cm nodules on the surface of the skin surrounding the larger mass on the distal limb. A similar surgical approach was conducted as per the excision completed in May, using detomidine/butorphanol and lidocaine. In addition, a tourniquet was applied to the proximal cannon bone. Both masses were excised using a size 20 scalpel blade. Pressure bandages were applied to limit bleeding. The mare was given phenylbutazone (Buzone Conc. 225 g; Vétoquinol), 4 mg/kg BW, PO, q12h, for 3 d and trimethoprim (80 mg/mL)-sulfadiazine (400 mg/mL) (Summit Veterinary Pharmacy, Aurora, Ontario), 20 mg/kg BW, PO, q12h, for 7 d. Three days later, the veterinarian returned to apply cryotherapy to the mass margins and the smaller masses in the area (Figure 1). The owner was instructed to keep the area as clean as possible and perform frequent bandage changes. Once the areas were dry with minimal discharge, the owner agreed to apply a wound powder.
The mass was excised for the third time in November 2018 as a result of an increase in size and anatomic location. The mass appeared necrotic with serosanguinous discharge. It measured 10 cm $\times$ 7 cm at this time, with a mushroom cap-like appearance extending from the medial aspect of the fetlock. A similar excision was performed as done previously. Phenylbutazone (Phenylbute injection 20%; Phoenix, St. Joseph, Missouri, USA), 4 mg/kg BW, IV, was given before conducting the procedure. The mare was given phenylbutazone and trimethoprim-sulfadiazine, PO as previously described. Once again, the owner declined to submit a biopsy. The mass was debulked and cryotherapy was performed. The owner elected to use a topical herbal paste (Xxterra; Larson Laboratories, Fort Collins, Colorado, USA) in a thin layer to the area once daily for 4 d, no treatment for 7 d, and then repeat the 4-day treatment course once more if the mass had not sloughed. The owner noted significant reduction in the size of the mass with improved healing after the use of Xxterra (Figure 1).

In June 2019, the veterinarian was called out to the farm to remove the mass again. The mass was now 3 times the size it was in June 2018 (Figure 2). It measured 25 cm wide and had a mushroom shape, with the base being approximately 10 cm wide. A lengthy discussion with the owner determined this would be the last attempt at a surgical debulking procedure in the field. Once again, the mare was sedated with detomidine/butorphanol and a tourniquet was placed proximally to the mass on the cannon bone. The horse was sedated adequately, and the mass was excised in pieces. The entire mass could not be excised due to excessive blood loss from the procedure. Pressure bandages were applied immediately. N-Butyl alcohol (Clotol 200 mg/mL; Pfizer, London, Ontario), 50 mL, IV, was given to promote clotting. This caused the mare to become atactic for approximately 3 min, but she recovered uneventfully under supervision. Ceftiofur crystalline free acid (Excede 200 mg/mL; Zoetis), 6.4 mg/kg BW, IM, was administered and the horse was monitored closely as she recovered from sedation.

Forty-five minutes post-procedure the mare showed signs of colic. On examination she was quiet, alert, and responsive, had a temperature of 37.0°C, a pulse of 40 beats/min, and a respiratory rate of 20 breaths/min. Gastrointestinal sounds were decreased to absent in all quadrants. An IV catheter was placed and flunixin meglumine (Flunazine; Vétoquinol) was injected at a dose of 1 mg/kg BW, IV. In addition, 1 L of hypertonic saline (Hypersaline 7.2%; DMVet, Coaticook, Quebec) was given IV, followed by 5 L of Lactated Ringer’s solution (Baxter, Mississauga, Ontario), IV, administered as a bolus. The horse was walked, passed gas, and became interested in a wet mash. Over the next 20 min gut sounds improved. The horse was given a second 1 L hypertonic saline solution (Hypersaline 7.2%; DMVet), IV, and she began to drink and consumed approximately 12 L of water.

A fixed sample of tissue was sent to the Animal Health Laboratory at the University of Guelph for histopathology. The tissue was identified as an atypical population of spindle cells arranged in a disorganized fashion and supported by fibrillar connective tissue stroma, consistent with equine sarcoid. The cells appeared to exhibit oval nuclei with scant cytoplasm, 2-fold anisokaryosis, and 11 mitotic figures were observed per 10 high power fields. The surface of the mass showed severe ulceration.
and inflammation with neutrophil exudates and occasional colonies of bacteria. It was apparent on histopathology that the surface epidermis was still remaining, extending into the spindle cell tissue, with spindle cells making direct contact with the epidermis. No distinct margins of normal tissue were evident.

**Discussion**

Although equine sarcoid is one of the most common cutaneous neoplasms in horses, the risk factors that predispose horses to sarcoids have only partially been identified (1,2). Horses of all ages can be affected (3), but horses are typically presented between 2 and 9 y of age with no significant gender predilection (1). There appears to be a genetic link with the incidence of sarcoids with Quarter horses being 2 times more likely to develop sarcoids than Thoroughbreds, and Thoroughbreds being twice as likely to develop sarcoids as standardbreds (4,5).

The equine sarcoid is a benign fibroblastic tumor that can have 6 different clinical manifestations (2–4). The mildest and most superficial form is the occult (flat) sarcoid. It is identified as a thickened epidermis and a change in color or density of the hair coat (4). These sarcoids occur mainly on thinly haired regions of the body (3). There is a nodular sarcoid form that is solid and can vary widely in size and number (3,4). They are firm masses that are often large and still maintained within the dermis and epidermis (3). Verrucose sarcoids have a wart-like appearance and can vary widely in size and extensiveness (2,4). They are characterized by crusting and outgrowths of keratin (3). Inflammatory responses may be present if a secondary infection is involved (3). Fibroblastic sarcoids are fleshy and exophytic in appearance (2,4). This type of sarcoid often appears exudative with pedunculated lesions or immobile with a broad base (4). Fibroblastic sarcoids can be highly vascular and ulcerated (3). Another type of sarcoid that is very common can appear mixed, incorporating more than 1 type of sarcoid (2–4). This may appear spontaneously but can also be associated with certain wound types (4). Finally, the malignant form of equine sarcoid is a rare but invasive tumor (3). It can arise spontaneously or develop from a milder sarcoid type that has been exposed to repeated trauma (4). Histopathology is required to confirm the diagnosis of equine sarcoid (5).

Although not explored in this case, there is evidence that equine sarcoids can be caused by bovine papilloma virus 1 and 2 (2–5). It is possible that transmission between horses may occur (4). Flies can act as vectors of either viral particles or the viral-infected fibroblasts between horses, or from site-to-site on the same horse (3,4). Indirect transmission can also occur via fomites, tack, and grooming equipment (4).

It was speculated that the sarcoid in this horse developed from a former wound that failed to heal adequately as this is the most common cause of distal limb equine sarcoid (3,4). Distal limb lesions on horses are difficult to heal, but sarcoid transformation of wounds is a serious complication and has a great impact on wound healing (4). The transformation of a wound into a sarcoid is not frequently recognized as early sarcoid tissue resembles granulation tissue (2,4). Any type of wound is susceptible to sarcoid transformation and the time to sarcoid development varies (4). Injury, transmission from other sites, contact with affected horses or fomites, and failure to completely remove existing sarcoids during surgical excision can predispose a horse to the development of sarcoids (4).

Clinical management of equine sarcoi is a challenge, especially those on the distal limb (4). No treatment is ideal, but it is paramount that all sarcoid cells be removed as residual cells replicate aggressively (2,4). Current treatment options include surgical excision, cryosurgery, laser surgery, immunomodulatory therapy, topical or intralesional administration of cytotoxic/antimitotic/caustic chemicals, photodynamic therapy, radiation therapy, and antiviral drugs (2–4). Surgical excision alone is usually unsuccessful (3,4), as was shown with this mare. The best results have been shown with a wide and deep excision, followed by electrocauterity (2). As discussed with the owner, the anatomic limitations of the surgery, along with the inability to obtain good margins due to location of the mass, led to frequent recurrence of the tumor (4). In addition, seeding of the sarcoid cells often occurs during surgical excision (4). In this case, attempts were made to educate the owner on the repercussions of attempted surgical excision, the lack of diagnosis from a laboratory, and the importance of cryotherapy and topical therapy, but the owner insisted on her preferred method of treatment.

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Serving homeless populations through a One Health approach

Michelle Lem

The Canadian Observatory on Homelessness defines “homeless” as “the situation of an individual, family or community without stable, safe, permanent, appropriate housing, or the immediate prospect, means and ability of acquiring it” (1). Homelessness includes people who are unsheltered (i.e., living in public spaces or spaces not intended for human living), are emergency sheltered, provisionally accommodated (e.g., short-term or interim housing, institutional care), and those at risk of homelessness (1). In Canada, almost a quarter of a million people experience homelessness in a year. Youth make up 20% of Canada’s homeless population with 40 000 youth experiencing homelessness every year (2). Almost 30% of homeless youth identify as LGBQT2S, 58% have been involved with child protection and 63% have experienced physical, sexual, or other forms of abuse (3). Over 50 000 people experience hidden homelessness in any given year and almost 1 in 10 Canadians have experienced hidden homelessness at some point in their lives (4).

It is estimated that approximately 20% of those experiencing homelessness in Canada are pet owners (5). Pet ownership by this population has been shown to have both benefits and barriers. Pet ownership by those experiencing homelessness has been shown to positively influence the pet owners’ sense of self (6), promote responsibility and pride, and create routine and structure that many did not have prior to becoming a pet owner (5). Pet ownership has also been associated with lower prevalence of depression among street-involved youth (7) and acted as a strong motivator to decrease their use of alcohol and/or drugs and avoid arrest (5). These human-animal relationships are often described as “my best friend,” “my only family,” companion or child-like, and are often the only source of unconditional love without judgment (5).

Among the systemic barriers for homeless pet owners are inaccessibility to emergency sheltering, counselling, addictions treatment, and/or healthcare and other support services with their pet (5). Other barriers include increased difficulty in obtaining pet-friendly housing, and an inability to take advantage of employment and/or education opportunities as there is no safe place to leave their animal companion while at work or school (5). Adding to pet-related barriers are negative social stigmas and social triaging experienced by those who are living rough, often with mental health issues and/or substance use challenges. These negative experiences contribute to a sense of distrust of healthcare providers among this population.

In serving homeless pet owning populations, it is therefore necessary to first understand the experiences of those we are serving and to be able to understand their lived experiences through the social determinants of health framework (8). What is critical is to see how systemic (e.g., employment, housing, employment, healthcare, social exclusion) and structural factors (e.g., social ideology, political and economic factors, globalization) impact the daily lives of individuals and families living homeless along with their animal companions and their access to care and support. As animals are sentinels of human health and welfare, we can see how the social determinants of animal health are closely tied to the social determinants of human health (9).

In understanding these shared social determinants of health — the micro to macro social, political, and economic influences on human and animal health, we are practicing One Health.

Another critical aspect of serving homeless pet owning populations is in a personal reflection of values and beliefs. Values shape our relationships with clients, community partners, and ourselves. These values must be examined through an ongoing process of critical self-reflection. As veterinarians we hold privileged positions of having animal health knowledge and power. As human beings, we also hold personal biases and beliefs based on our social and physical environment and experiences. It is crucial to examine how our own biases and beliefs may impact the care we provide, but also how we are affected by decisions of others with whom we may not agree. This is perhaps not uncommon in the daily experiences of veterinarians but can be amplified when serving pet owners who are living homeless, experiencing multiple challenges and are strongly and negatively impacted by structural inequalities.

As veterinarians serving vulnerable populations, adopting ethical values that are consistent with the profession of social work is necessary in order to practice from a One Health framework.
For example, many of the values that Community Veterinary Outreach adopts are based on the Canadian Association of Social Workers Code of Ethics (10) and include respecting the inherent value and worth of each person and animal; offering support, compassion, and affirmation, not judgment; valuing diversity and striving to create an environment that is inclusive of and accessible for all; believing that clients are experts in their own lives, with existing resiliencies and inherent strengths, and that clients have a right to self-determination, autonomy and agency. In a One Health model clients are considered health partners. In terms of health practices, values include practicing evidence-based medicine and believing that all people and animals are entitled to a high standard of care, regardless of socioeconomic status. Therefore, practicing from a One Health approach involves considering the values, goals, and perspectives of multiple stakeholders in the One Health model, including ourselves, those we serve, and our community partners.

Community One Health practices will be discussed next. It should be emphasized, however, that these core practices of ongoing critical self-reflection, goals and values determination, and understanding of the lived experiences of those we serve, the multiple barriers that contribute to those experiences (including the social determinants of health) are critical first steps to serving marginalized populations. Creating strong collaborative partnerships in community health is an obligatory One Health practice to remove interdisciplinary barriers in both delivering and accessing health services by homeless populations. By offering human health services and health education alongside preventative veterinary care, Community Veterinary Outreach provides innovative access to both veterinary and human health care for at-risk populations. Community Veterinary Outreach partners with health providers from public health agencies, mental health agencies, social service agencies, community health centers, and academic institutions. Health professionals include nurses and nurse practitioners, dental hygienists, social workers, psychologists, and pharmacists as well as students from health care programs.

In working collaboratively in a One Health model of care, all team members regardless of professional background or training, are committed to supporting the health and welfare of both the people and their animals. Practically, this common goal means that veterinarians are as concerned with human health issues that may arise during interactions with pet owners, as they are with animal health issues. This kind of active listening for human health concerns is often a skill that is learned through consistent practice. In addition to active listening skills, we employ communication practices based on the spirit, principles, and processes of motivational interviewing (11), as well as health messaging amplification. Finally, in a One Health model of care, veterinarians learn how to confidently and effectively communicate with clients about human activities that impact animal health including exercise, and tobacco and cannabis use. It is important to note that in doing so, veterinarians are not expected to extend advice beyond their scope of practice but rather to facilitate connections to appropriate human health providers. In this way veterinarians act as community connectors for clients.

The client-veterinary relationship is unique, in that through a mutual caring for an animal, a strong and trusting relationship develops. Additionally, through presentation of animal health concerns, veterinarians often learn of personal and environmental challenges that clients are dealing with such as a new move, loss of a loved one, illness, or work challenges. For homeless clients, these concerns also include structural inequalities and intersected experiences of abuse, victimization, trauma, extreme poverty, and discrimination. Practicing from a One Health perspective, therefore, also means that with any presenting animal health issue, we gather knowledge from the human and environmental sectors as well as the animal sector. In so doing, veterinarians create a more holistic picture of the client, animal, and the context in which they are living with and experiencing the presenting issue. A One Health approach to veterinary practice seeks to adequately and accurately see clients as whole persons. To provide this kind of care is to go beyond an understanding of medical issues, to also understand how their experiences, relationships, and environment affect the lives of both humans and their animal companions.

References
As best any participants could remember, the informal group originated about 25 years ago. Those present at that time felt positive about 2 factors that precipitated its formation: They all shared a common interest and, none of them could remember what it was. This did not occur as a result of the members' declining memory. It resulted from the addition of other members with different practice-related backgrounds over the years. At present, it consists of practice owners, associates, business managers, and technicians. This, in turn, affects the range of topics they discuss.

The way the group maintains contact also has changed. Originally, they informally met during their free time at large veterinary meetings. Later when advances in communication technology permitted this, they began keeping in touch electronically. More recently, they added informal on-line “meetings” to their repertoire to address issues that came up in a more timely manner. One such meeting resulted after associate veterinarian, Dr. Vigneri vented to practice-owner Dr. Mereza about clients who spent so much time checking their phones for messages during their animals’ appointments, she doubted they heard much, if anything, she said to them. When an informal survey revealed that this and other forms of disrupted communication also had interfered with the work of other group members, they set up an informal electronic meeting to address this topic.

First, the group tackles Dr. Vigneri’s concern: the problems related to clients whose attachment to their cellphones seemed to exceed their attachment to their animals’ wellbeing. She notes that this probably is a companion animal client issue. However, several members of the group who work with food animal clients question this assumption. Based on the latter’s experience, the clients’ age and not the animals’ species determine the presence or absence of this annoying behavior. However — and yet another benefit of this highly eclectic group — several other members pointed out that, although the majority of clients overly attached to their phones are younger, they also encounter those in their 70s and even older who behave in a similarly troublesome manner. Regardless of the clients’ age, though, all agree that these client behaviors are annoying time- and energy-vampires.

“Either they ask me about something I’ve already mentioned, or they contact me later for that same information,” comments one obviously frustrated practitioner. “In the worst-case scenario, they do neither because nothing I told them registered at all. Instead, they wrongly assume that they know everything they need to know!”

All the participants express concerns about the negative consequences of this lack of client engagement. Whether practitioners, technicians, specialists, or business managers, they all agree that the disruptive client response could compromise the welfare of any animals involved. Those who had experienced these situations also observed that clients whose animals did experience any negative consequence were more likely to blame the veterinarian or staff member for it instead of their own disengagement.

The discussion then turns to practitioners who give in to distraction when on the phone with other veterinarians: Is this acceptable or problematic communication behavior? That question elicits a consensus “It depends” response. For example, if practitioner Dr. Brown and specialist Dr. Doe agree on a specific time for the former to call the latter to discuss a referral case, then the onus is on both veterinarians to give each other their undivided attention at that time. On the other hand, if they make no such arrangement and Dr. Brown or Dr. Doe calls the other in hopes that the other might be available, then no such caveat applies. However, they all agree that when the possibility of disruptions exists, those could undermine the quality of the communication that occurs at any time. Several participants also note the tendency to over-estimate one’s own inability to engage successfully with a caller despite any distractions while simultaneously recognizing the negative effects these have on others’ ability to do so.

“I consider myself an experienced multitasker, but I know I’m not giving any caller my full attention if someone in the...
room asks me a question at the same time or my phone alerts me that I have a new message. That doesn’t happen if I’m alone in my office with the door closed and I can give the caller my full attention,” admits a hesitant young practitioner. “But if the caller gets distracted by something going on at their end, I immediately can tell by the change in their voice and comments when this occurs. In that case, I’ll start to check my emails and texts or focus on other chores too. Sometimes we’re able to get back on track. Sometimes not. Either way, it’s not what I’d call efficient or quality communication.”

Regardless how reluctant the practitioner feels about revealing this information, the groups’ ready agreement makes it clear that most had experienced this same problem. And even the busiest and most phone-attached multitaskers among them agree that such forms of communication are often time-consuming and not that productive.

Less often acknowledged but even more problematic, these distracted calls may trigger a negative ripple effect. Dr. Mereza takes an unscheduled, disrupted call that may communicate incomplete information to him or the caller. The call also causes him to delay seeing a scheduled client or accomplishing other tasks in a timely manner. In addition to leaving Dr. Mereza with doubts regarding the quality of the information he shared with the unscheduled caller he devoted an hour to first thing that morning, this disruption creates others that result in a 2-hour backlog by the end of the day. These delays also interfere with clients and others affected by the delay to fulfill their own obligations in a timely manner. This upset his clients and staff; it also upset his family when he misses yet another school event.

This group discussion segues naturally into one regarding the handling of calls related to true emergencies when they occur. All agree that these should be addressed immediately. However, their discussion also helps them realize that, were they not spending so much time engaged in preventable disruptive forms of communication, they could handle such calls more quickly and effectively.

Business managers attuned to the needs of waiting room staff who often had first phone contact with clients also mentioned the benefits of established practitioner phone hours. These enable staff members to schedule non-emergency calls for clients who call at other times. The ability to tell such callers, “Dr. Smith isn’t available now, but she will be during her phone hour. Would you like me to schedule an appointment for you to talk to her then?” confers multiple benefits. It enables the caller to do something immediately, i.e., make an appointment with the practitioner, without disrupting the practitioner’s schedule. It communicates that the practice does care about addressing the needs of the caller. It facilitates quality communication because practitioners can access any caller-related information before the call if necessary. Practitioners also can give scheduled callers their undivided attention during their calls.

The group then turns its attention to preventive approaches for other forms of disruptive phone communication. This generates a lively debate that yields multiple excellent situation-specific recommendations. However, the solution that strikes all of them as the most practical and effective involves addressing the root cause of many of the problems instead of addressing each kind individually.

“After watching this problem increase and the negative fallout it could create throughout our practice, I had attractive signs made for the exam and treatment rooms that identified these as phone-free zones to ensure the animals’ welfare and quality care,” explains the practice owner who suggested this approach. “We also announced the new practice in our newsletter and via social media. Because we all agree that distracting phone interactions are detrimental to animal comfort and quality care, none of the staff feels embarrassed about reminding those who ignore the message.”

Naturally someone in the group asks what happens or should happen if a client continues to disregard the request. That subject also triggers another animated debate. Ultimately, they agree that politely asking these clients to reschedule their appointments for a time when they are not so busy is the best approach. However, some did argue that doing so without alienating the client could require a fair amount of confidence and tact in some cases. But then most admit that those skills apply to multiple aspects of quality client and staff communication. This made them worth developing if necessary. Eventually they all agree that ensuring the animal’s welfare and quality care remained the focus of these discussions made it easier for them to persevere and more difficult for clients to take the policy personally. Apprising potential employees of the policy in the employee’s handbook addresses similar problems related to staff members.

Fortunately for practitioners and the companion animals and livestock in their care, most people involved in this process will moderate their phone usage for the animals’ benefit.
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