Uterine perforation secondary to metritis and placenta percreta in a postpartum bitch

Management of a severe peripartum hemorrhage following cesarean section in a dog

In-hospital medical management of feline urethral obstruction: A review of recent clinical research

Gastrointestinal nematode prevalence and fecal egg counts in beef cattle from western Canada

Prevalence of methicillin-resistant *Staphylococcus pseudintermedius* on hand-contact and animal-contact surfaces in companion animal community hospitals

Anesthetic and analgesic effects of an opioid-free, injectable protocol in cats undergoing ovariohysterectomy: A prospective, blinded, randomized clinical trial

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Letters to the Editor Courrier des lecteurs

Dental radiography — A comment

Dear Editor,

Regarding the Veterinary Dentistry column published in the February 2020 issue of The Canadian Veterinary Journal (Can Vet J 2020;61:197–200), on dental radiography and malpractice, the issue of lack of training for registered veterinary technicians has not been addressed.

I strongly agree dental radiography is essential and part of the best practice philosophy, but my expectations are that our technicians should be capable of performing these procedures. My dentist does not spend his time radiographing my oral cavity and I don’t believe veterinarians should be leading the charge to perform these on our patients.

There are courses offered by specialists that help, but the basic training seems to be missing in the technician curriculum. I don’t believe it’s in the patient’s best interest to be under anesthesia for 45 minutes or more to obtain DIAGNOSTIC radiographs.

DVM and RVT colleagues please help.

Submitted by Paul Francis, DVM, Komoka-Kilworth Animal Clini, Komoka, Ontario.

Dental radiography — A response

Thank you for your thoughtful comments regarding the column titled, “Performing dental procedures in dogs and cats without dental radiographs: malpractice?” It was my intention when writing this piece to spark a conversation and bring attention to the very fact that dental radiography is necessary to perform routine dental treatments despite the lack of training in the current veterinary curricula. As you pointed out, this is true for the veterinary technicians as well, and it has naturally been the role of the veterinarian to instruct the technicians on how to perform diagnostic dental radiographs. Your concern that this is taking 45 minutes of anesthesia time only strengthens the point that this needs to be adequately taught prior to veterinarians and technicians working on clinical patients in practice.

Regarding radiographs in human dentistry, it is routine for a dentist to perform panoramic dental survey radiographs in addition to bite-wing site-specific dental radiographs at the initial visit followed by repeat radiographs (semi-annually or annually) for active surveillance of identified dental pathology. The need for radiographic imaging is balanced with the risks of X-ray exposure to a greater degree in human dentistry, as exposure is measured over lifetime. Dental radiographs are recommended by the Ontario Dental Association before and after oral surgery, restorative dentistry, orthodontic tooth movement, and endodontic procedures. If your dentist is not taking radiographs at your regular dental visits, this likely indicates that there is no pathology that requires radiographic imaging to evaluate. A human dentist colleague of mine recently said that performing dental procedures without diagnostic radiographs is like driving with a blindfold. I do not believe that veterinarians are leading the charge, however, if that were the case, then I think we should.

Kind regards,

Graham Thatcher, DVM, DAVDC, University of Wisconsin-Madison, School of Veterinary Medicine, Madison, Wisconsin, USA and Alta Vista Animal Hospital, Ottawa, Ontario, Canada.

Constructive and professional comments made in the spirit of intellectual debate are welcomed by the Editor. Writers are expected to be respectful of others and to ensure that letters are considerate and courteous. The Editor reserves the right to remove comments deemed to be inflammatory or disrespectful.
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VIDO-InterVac: A story of impressive vision
VIDO-InterVac : l'histoire d'une vision novatrice

In late March of this year, television, radio and newspapers all reported on funding of approximately $28 million at the Vaccine and Infectious Disease Organization — International Vaccine Centre (VIDO-InterVac) in Saskatoon. This funding was aimed primarily at development of a vaccine against coronavirus disease 2019 (COVID-19) (1), which could make VIDO-InterVac a household name in Canada and across the globe.

The exceptional facilities and research programs at VIDO-InterVac allow it to undertake projects that cannot be done at any other place in Canada and at only a few other places in the world. These facilities include 285 000 square feet of space approved for the study of Risk Group 2 and Risk Group 3 infectious diseases, containment level 3 large animal capacity, and a 160-acre research farm for large animal studies up to containment level 2.

VIDO-InterVac holds a special place in the veterinary community. It started in 1975 as the Veterinary Infectious Disease Organization (VIDO) — the brainchild of Dr. Chris Bigland, a faculty member at the Western College of Veterinary Medicine in Saskatoon. With funding from the Devonian Group of Charitable Foundations, the University of Saskatchewan and the provinces of Saskatchewan and Alberta (2) Dr. Bigland established VIDO and became its first director. In its early years VIDO emphasized research on calf diarrhea and soon developed a calf scour vaccine. Subsequently, Stephen Acres, Lorne Babiuk and Andrew Potter became directors, each leading the organization for about 10 years. In 2019, Dr. Volker Gerds took over as the new director.

Under Stephen Acres’ leadership, VIDO built its massive research station for large-scale animal trials and developed several vaccines for animals. The next director, Lorne Babiuk, was a distinguished virologist who had a bigger vision for VIDO and initiated a major expansion recognized by renaming as the Vaccine and Infectious Disease Organization — International Vaccine Centre (VIDO-InterVac). Babiuk sought to capitalize on the similarities between humans and animals in viral

À la fin du mois de mars un peu plus tôt cette année, des reportages à la télévision, à la radio et dans les journaux ont fait état d’un financement d’environ 28 millions de dollars accordé au centre VIDO-InterVac (Vaccine and Infectious Disease Organization — International Vaccine Centre, ou Organisme de recherche sur les vaccins et les maladies infectieuses – Centre international de recherche sur les vaccins), à Saskatoon. Ce financement visait principalement le développement d’un vaccin contre la COVID-19 (1), qui pourrait faire du centre VIDO-InterVac un nom connu au Canada et partout dans le monde.

Les installations et les programmes de recherche exceptionnels du centre VIDO-InterVac lui permettent d’entreprendre des projets qui ne peuvent se faire nulle part ailleurs au Canada, et seulement à quelques autres endroits dans le monde. Ces installations comprennent 285 000 pieds carrés d’espace approuvé pour l’étude des maladies infectieuses des groupes de risque 2 et 3, une capacité de confinement des grands animaux de niveau 3, et une ferme de recherche de 160 acres pour les études sur les grands animaux jusqu’au niveau de confinement 2.

Le centre VIDO-InterVac occupe une place particulière dans la communauté vétérinaire. Il a été mis sur pied en 1975 sous le nom de VIDO (pour Veterinary Infectious Disease Organization) d’après l’idée originale du Dr Chris Bigland, membre du corps professoral du Western College of Veterinary Medicine à Saskatoon. Grâce à du financement du Devonian Group of Charitable Foundations, de l’Université de la Saskatchewan et des provinces de la Saskatchewan et de l’Alberta (2), le Dr Bigland a créé le VIDO et en est devenu le premier directeur. Dans ses premières années d’existence, l’organisme a mis l’accent sur la recherche sur la diarrhée des veaux et a rapidement mis au point un vaccin contre cette maladie. Par la suite, Stephen Acres, Lorne Babiuk et Andrew Potter ont successivement dirigé l’organisme pendant environ 10 ans chacun. En 2019, le Dr Volker Gerds a pris la relève en tant que nouveau directeur.

Sous la direction de Stephen Acres, le VIDO a construit sa gigantesque station de recherche pour les essais à grande...
infections and the body’s response to them. Indeed, Babiuk’s work on an animal rotavirus vaccine had earlier formed the basis of a successful rotavirus vaccine for children. Babiuk was successful in selling his ideas about transforming VIDO into a world class facility for research and development of vaccines against a wide range of human and animal pathogens, especially those that require isolation facilities. He obtained funding of approximately $150 million from the Canada Foundation for Innovation, the Government of Saskatchewan, and the University of Saskatchewan, which enabled VIDO to build the International Vaccine Centre, an advanced biosafety level 3 facility for animals. Under his leadership, VIDO-InterVac grew into an internationally recognized research powerhouse.

Andrew Potter, an internationally recognized bacteriologist, built on the Babiuk legacy and expanded the research and vaccine development programs at VIDO-InterVac. Among many of his achievements, he contributed to the development of the first genetically engineered animal vaccine. The most recent director, Dr. Gerds, has exceptional expertise in vaccines for neonatal animals and humans, mucosal immunology, and vaccine delivery and formulation. He is a good fit for continuation of the strong record of leadership at VIDO-InterVac.

Over the years, VIDO-InterVac has developed several vaccines for cattle, poultry and swine, several of which have been in collaboration with industry and university partners. Recently, VIDO-InterVac announced a collaboration with The International Vaccine Institute of South Korea to investigate SARS-CoV-2, the virus causing the COVID-19 pandemic, and to develop vaccines and potential treatments. VIDO–InterVac is busy creating models of the coronavirus disease in ferrets and hamsters in order to use these animals to test a COVID-19 vaccine, which it is developing (3). The plan is to immunize ferrets and hamsters then challenge them with the virus and monitor development of lesions and shedding of the virus. VIDO-InterVac is also planning a large vaccine manufacturing facility to bolster Canada’s limited capacity in this field.

The story of VIDO-InterVac is a story of inspired Canadian leadership and bold vision. The amalgamation of animal and human vaccine research and development at VIDO-InterVac is a good example of One Health in practice and illustrates the value of pooling ideas and facilities to find solutions for diseases of animals and humans.

References

Carlton Gyles

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

édifice sur les animaux et développé plusieurs vaccins pour les animaux. Le directeur suivant, Lorne Babiuk, était un éminent virologue qui avait une vision plus large et qui a entrepris une expansion majeure reconnue par un changement de nom : VIDO est devenu VIDO-InterVac. Babiuk a cherché à tirer parti des similitudes entre les humains et les animaux dans les infections virales et la réponse du corps à celles-ci. En effet, les travaux de Babiuk sur un vaccin antirotavirus pour animaux avaient précédemment constitué la base du développement réussi d’un vaccin antirotavirus pour les enfants. Babiuk a piloté la transformation du VIDO en un centre de classe mondiale pour la recherche et le développement de vaccins contre un large éventail d’agents pathogènes des animaux et des humains, en particulier ceux qui nécessitent des installations d’isolement. Il a obtenu un financement d’environ 150 millions de dollars de la Fondation canadienne pour l’innovation, du gouvernement de la Saskatchewan et de l’Université de la Saskatchewan, ce qui a permis la construction du centre international de recherche sur les vaccins, une installation de pointe de sécurité biologique de niveau 3 pour les animaux. Sous sa direction, VIDO-InterVac est devenu un centre de recherche de renommée internationale.

Andrew Potter, un bactériologue connu mondialement, s’est appuyé sur l’héritage de Babiuk et a élargi les programmes de recherche et de développement de vaccins du centre VIDO-InterVac. Une de ses nombreuses réalisations est sa contribution au développement du premier vaccin génétiquement modifié pour animaux. Le directeur actuel, le D’ Gerds, possède une expertise exceptionnelle en vaccins pour les animaux et les humains nouveau-nés, en immunologie muqueuse et en administration et formulation de vaccins. Il saura maintenir et renforcer la position de leader du centre VIDO-InterVac.

Au fil des ans, le centre VIDO-InterVac a développé plusieurs vaccins pour les bovins, la volaille et les porcs, dont plusieurs en collaboration avec des partenaires de l’industrie et du milieu universitaire. Récemment, VIDO-InterVac a annoncé une collaboration avec l’Institut international de recherche sur les vaccins de Corée du Sud pour étudier le SARS-CoV-2, le virus à l’origine de la pandémie de COVID-19, et pour développer des vaccins et des traitements potentiels. Les chercheurs du centre VIDO-InterVac sont en train de créer des modèles de la maladie chez les furets et les hamsters afin d’utiliser ces animaux pour tester un vaccin contre la COVID-19 qu’ils s’efforcent à développer (3). Leur plan est d’immuniser les furets et les hamsters, puis de leur faire subir une provocation par le virus et de surveiller le développement de lésions et l’excrétion du virus. Le centre VIDO-InterVac prévoit également la création d’une grande usine de fabrication de vaccins afin de renforcer la capacité limitée du Canada dans ce domaine.

L’histoire du centre VIDO-InterVac en est une de leadership canadien inspiré et de vision novatrice. La fusion de la recherche
et du développement de vaccins pour animaux et humains au centre VIDO-InterVac est un bon exemple de l’approche « Une santé » dans la pratique et illustre la valeur de la mise en commun des idées et des installations pour trouver des solutions aux maladies des animaux et des humains.

Références
2. VIDO-InterVac History. Disponible au : https://www.vido.org/about/history (dernière consultation le 31 mars 2020).

Carlton Gyles
(les opinions exprimées dans cet article sont celles du rédacteur en chef.)

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References:
An ethicist’s commentary on aggressive dog

It does not appear to be the case that there is any certainty that a person presenting himself or herself as an expert on animal behavior can guarantee their work as mitigating canine aggression. Some people are more successful than others, and some “experts” are better with some dogs than others. It seems that mitigating dangerous canine behavior is as much an art as a science. My suspicions in this area are confirmed by practical experience.

If the animal behaviorist recommends euthanasia for the animal that suggests lack of competence. Were I the veterinarian, I would network with my peers to find someone more experienced with aggression, perhaps a good trainer with a solid track record. I would also spend some time with the owner asking how often the dog displays aggression in the household.

Once I knew more about the animal’s behavior, I might consider rehoming the animal. I had a dog that had been rented out to construction sites as a guard dog. He had never bonded with his owner, who had received the dog as compensation for manual labor. I had the dog for seven years, and he never showed aggression to me or my wife, and in fact bonded with a turkey, sharing food and housing! While there must be incorrigibly aggressive dogs, I have never met one that had not been chronically ill-treated.

Some of my friends run the Best Friends animal sanctuary in Utah. They are very pleased to tell you of all the dogs trained to fight that they have received that have been rehabilitated. I have trained, as mentioned above, numerous dogs, including junkyard dogs, guard dogs, alleged “attack dogs,” watch dogs, service dogs, and believe I have encountered only one that did not respond well to kindness. In my experience humans are far more incorrigible than dogs. I have retrained horses that could not find homes because they were alleged to be “killer horses.” Almost all had been subject to abuse and responded well to good treatment. The moral: Beware of “animal behavior” experts.

Bernard E. Rollin, PhD
Ethical question of the month – June 2020

A farmer, who is not one of your regular clients and who lives relatively distant from your clinic, started calling you to talk about difficulties on his farm. He appears to have both animal health and financial problems. You encourage him to call the veterinarians at his local clinic so that they can work out his animal health problems. He continues to call, often at odd hours, leaving rambling and often incoherent messages to the point that you are concerned for his wellbeing. You contact the local ministry of agriculture about mental health resources for farmers. They assure you that resources are available but that the farmer must initiate the process. You believe that this would be a difficult topic to introduce to the farmer. If this was an animal welfare situation, you would be obliged to report it, but with human welfare, you are limited by legal requirements of confidentiality. What is my best ethical action here?

Question de déontologie du mois – Juin 2020

Un agriculteur, qui n’est pas l’un de vos clients réguliers et qui vit relativement loin de votre clinique, a commencé à vous appeler pour parler des difficultés de sa ferme. Il semble confronté à la fois à des problèmes de santé animale et à des problèmes financiers. Vous l’encouragez à appeler les médecins vétérinaires de sa clinique locale afin qu’ils puissent l’aider à résoudre ses problèmes de santé animale. Il continue de vous appeler, souvent à des heures indues, et vous laisse des messages décousus et parfois incohérents, ce qui vous amène à vous inquiéter de sa santé à lui. Vous contactez le ministère de l’Agriculture de votre province pour vous renseigner sur les ressources en santé mentale offerte aux agriculteurs. On vous assure qu’il y a des ressources disponibles, mais que l’agriculteur doit entreprendre lui-même le processus de demande d’aide. Vous estimez que c’est un sujet délicat et difficile à aborder avec l’agriculteur. S’il s’agissait d’une situation de bien-être animal, vous auriez l’obligation de la signaler, mais en ce qui concerne le bien-être humain, vous êtes limité par des exigences légales en matière de confidentialité. Quelle est la façon la plus éthique d’agir dans une telle situation?

Responses to the case presented are welcome. Please limit your reply to approximately 50 words and forward along with your name and address to: Ethical Choices, c/o Dr. Tim Blackwell, 6486 E. Garafraxa, Townline, Belwood, Ontario N0B 1J0; telephone: 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.
Quiz Corner
Test éclair

1. Which of the following factors is thought to be an important contributing factor to the development of squamous cell carcinoma (SCC) in horses?
   A. Skin pigmentation, solar radiation, and age
   B. Bovine papilloma virus, skin pigmentation, and age
   C. Gray coloration, age, and the tail
   D. Bovine papilloma virus, wounds, and distal limbs

2. Which of the following dog breeds has a predilection for histiocytic ulcerative colitis?
   A. Shar-Pei
   B. Basenji
   C. Boxer
   D. Soft-coated Wheaten terrier

3. The most important component of therapy in idiopathic feline hepatic lipidosis is which of the following?
   A. Ursodeoxycholic acid
   B. Prednisone
   C. Antibiotics
   D. Feeding

4. Which of the following statements is NOT true regarding vestibular disease in dogs?
   A. Clinical signs rarely resolve.
   B. Older dogs are typically affected.
   C. Signs include head tilt, circling, falling, and nystagmus.
   D. The cause is unknown.
   E. Treatment is supportive.

5. Ovsynch synchronization for breeding is widely adopted in the dairy industry for which of the following reasons?
   A. It intensifies the signs of estrus.
   B. It lengthens the duration of estrus.
   C. It removes the need for estrus detection.
   D. It enhances the probability of conception.
   E. It requires 4 interactions with the animal.

(See p. 650 for answers./Voir les réponses à la page 650.)

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, Large Animal Medicine and Surgery, and Ancillary Topics, by kind permission of the publisher, Mosby-Year Book, Inc., St. Louis, Missouri.


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From the Council Table

Owing to the COVID-19 pandemic, the in-person 2020 CVMA Committee Weekend, scheduled for March, was switched to individual videoconferences for Executive, Council, National Issues, Animal Welfare, Professional Development, Animal Health Technologist/Veterinary Technician Program Accreditation committees and the National Examining Board. Traditionally, the Weekend allows the CVMA to undertake strategic planning, policy development and decisions. For most committee members, it’s the one opportunity per year to meet in person and to interact with Council and the other committees.

Updates on COVID-19 can be found on the CVMA website under (www.canadianveterinarians.net/coronavirus-covid-19).

Some of Council’s decisions

Free-roaming Owned, Abandoned, and Feral Cats: Council approved the following revised position statement:

“The Canadian Veterinary Medical Association (CVMA) supports evidence-based, effective and humane initiatives to reduce the population size and the impacts of free-roaming owned, abandoned and feral cats in order to promote animal health and welfare, public health, and ecological and environmental health.”

CVMA Compounding Guidelines: The CVMA will conduct a review of veterinary compounding, including CVMA’s existing Guidelines, and Decision Cascade and will examine the implications to veterinary medicine of the recent federal policy and regulatory changes.

Veterinary Technician Program Accreditation: Council approved accreditation of the following programs: Georgian College, Orillia (Ontario); Seneca College, King City (Ontario); Red River College, Winnipeg (Manitoba).

Council chose to honor the following 2020 Awards recipients:

Small Animal Practitioner Award: Dr. Suann Hosie
Merck Veterinary Award: Dr. Egan Brockhoff
Humane Award: Dr. Bettina Bobsien
Practice of the Year Award: Delaney Veterinary Services Ltd.
Industry Award: Dr. Daniel Venne
Life Membership: Dr. Eugene David Janzen
RVL Walker Award: Ms. Audrey Roy
President’s Award: Dr. Jack Wilson

Some updates

Membership: As of December 31, 2019, the CVMA had an overall membership of close to 7600 (highest membership ever). Furthermore, the CVMA is proud to have an affiliation with almost 8800 veterinary technicians who are Registered Veterinary Technologists and Technicians of Canada (RVTTC) members.

Partnerships: The CVMA has over 600 active volunteers and a staff team of 20 (equivalent to approx. 17 full-time positions). The CVMA is fortunate to have established several partnerships

Nouvelles du Conseil d’administration

En raison de la pandémie de COVID-19, le weekend de rencontres en personne de l’ACMV prévu en mars dernier a été remplacé par des vidéoconférences individuelles pour le Comité exécutif, le Conseil d’administration, le Comité sur les enjeux nationaux, le Comité sur le bien-être animal, le Comité de perfectionnement professionnel, le Comité d’agrément des programmes de TSA/TV et le Bureau national des examinateurs. Traditionnellement, ces réunions permettent à l’ACMV d’entreprendre la planification stratégique, de discuter de l’élaboration de politiques et de prendre des décisions. Pour la plupart des membres des comités, il s’agit aussi de la seule occasion de l’année de se rencontrer en personne et d’interagir avec le Conseil et les autres comités.


Voici quelques-unes des décisions prises par le Conseil

Chats en liberté appartenant à des propriétaires, abandonnés ou féraux : Le Conseil a approuvé l’énoncé de position révisé suivant :

« L’Association canadienne des médecins vétérinaires (ACMV) appuie les initiatives factuelles, efficaces et non cruelles pour réduire la taille des populations et les impacts des chats en liberté appartenant à des propriétaires, abandonnés ou féraux afin de promouvoir la santé et le bien-être des animaux, la santé publique ainsi que la santé écologique et environnementale. »

Lignes directrices de l’ACMV sur les préparations magistrales : L’ACMV se penchera à nouveau sur les préparations magistrales vétérinaires, notamment en révisant ses lignes directrices existantes et la cascade décisionnelle, et examinera les répercussions sur la médecine vétérinaire des récentes modifications apportées à la politique fédérale et à la réglementation.

Agrement des programmes de formation des techniciens en santé animale et techniciens vétérinaires : Le Conseil a approuvé l’agrément des programmes des établissements d’enseignement suivants : Georgian College, Orillia (Ontario); Seneca College Seneca, King City (Ontario); Red River College, Winnipeg (Manitoba).

Le Conseil a choisi d’honorer les personnes ci-dessous en leur décernant les prix de l’ACMV de 2020 suivants :

Prix du praticien des petits animaux : D’E Suann Hosie
Prix vétérinaire Merck : D’Egan Brockhoff
Prix humanitaire : D’E Bettina Bobsien
Prix de la pratique de l’année : Delaney Veterinary Services Ltd.
Prix de l’industrie : D’ Daniel Venne
Membre à vie : D’ Eugene David Janzen
Prix R.V.L. Walker : M’Audrey Roy
Prix de la présidente de l’ACMV : D’ Jack Wilson
that allow development and delivery of valuable services. Here are a few examples:

- **National Veterinary Oversight System (NVOS)** for antimicrobial use (AMU): this CVMA-led project will proceed through to March 31, 2023. The project includes activities such as surveillance, stewardship and communications/knowledge transfer focusing on veterinary prescriptions and feed-mill dispensing (beef, swine, and poultry), as well as enhancement to the CVMA veterinary AMU guidelines for beef, swine, poultry, dairy, equine, aquaculture, small ruminants, and companion animals. The NVOS will employ data and knowledge to support informed decision-making and enhance antimicrobial stewardship for companion and large animals. A funding contribution from Agri-Food Canada (Canadian Food Inspection Agency [CFIA]) allows the CVMA to support this project with the appropriate financial and human resources.

- **The Canadian Veterinary Reserve (CVR)**, a program of the CVMA, has now been in place for 13 years. It provides veterinary surge capacity in cases of emergencies involving animals, be it a foreign animal disease (FAD) or a civil emergency. In the event of civil emergencies or non-reportable diseases, the CVR is ready to respond to provincial authorities such as the Chief Veterinary Officers and/or the Emergency Management Officers, whereas with FADs, the CVR responds to calls from the CFIA. The CVR consists of 300 mostly private practice veterinarians from across Canada. Since its inception in 2006, this program has received funding contributions from the CFIA.

- **Mental Health Awareness Campaign**: In partnership with Merck Animal Health, the CVMA is embarking on the 2nd year of its now annual Mental Health Awareness Week. The 2020 campaign will run from September 6 to 12, featuring another webinar held on World Suicide Prevention Day, September 10, 2020. The CVMA aims to host one mental health webinar each quarter. In addition to the recorded webinars, the CVMA provides various valuable documents as resources.

- **Annual Tick-Awareness Campaign**: For the 5th year, the CVMA is partnering with Merck Animal Health in declaring March as National Tick Awareness Month. As in previous years, the CVMA produced communication material and support tools to help veterinary teams highlight the unique seasonality of ticks, to provide pet owners with updates regarding the expansion of ticks across Canada, and to increase awareness of the One Health approach to tick control and Lyme disease prevention.

The following are some of the CVMA’s activities in the field of One Health and Climate Change:

- CVMA Summit on Climate Change, One Health and Veterinary Medicine (details to come)
- National Issues Forum on Veterinary Medicine and Natural Disasters (details to come)
- Annual CVMA Tick Awareness Campaign
- National One Health Tick-Borne Illness Veterinary and Public Awareness Campaign (at submission stage with Public Health Agency of Canada)
- Dog importation and associated public health risks

**Voici quelques mises à jour intéressantes**

**Membres** : Au 31 décembre 2019, l’ACMV comptait près de 7600 membres (le plus grand nombre de membres jamais enregistré). De plus, l’ACMV est fière d’avoir une affiliation avec près de 8800 techniciens en santé animale qui sont membres de l’association TTVAC (Technologues et techniciens vétérinaires agréés du Canada).

**Partenariats** : L’ACMV compte plus de 600 bénévoles actifs et une équipe de 20 employés (ce qui équivaut à environ 17 postes à temps plein). L’ACMV a la chance d’avoir établi plusieurs partenariats qui permettent le développement et la prestation de services utiles, dont voici quelques exemples.

- **Système national de surveillance vétérinaire (SNSV) de l’utilisation des anticrobiens** : Ce projet dirigé par l’ACMV se poursuit jusqu’au 31 mars 2023. Il comprend des activités de surveillance, d’antibiogouvernance, de communication et de transfert des connaissances axées sur la prescription vétérinaire et la distribution d’aliments médicamenteux pour les bovins, les porcs et la volaille, ainsi que l’amélioration des lignes directrices de l’ACMV sur l’utilisation des antimicrobiens vétérinaires en aquaculture et chez les bovins de boucherie, les porcs, la volaille, les bovins laitiers, les chevaux, les petits ruminants et les animaux de compagnie. Le SNSV utilisera des données et des connaissances pour soutenir une prise de décision éclairée et améliorer la gestion des antimicrobiens pour les animaux de compagnie et les grands animaux. Une contribution financière d’Agroalimentaire Canada (Agence canadienne d’inspection des aliments [ACIA]) permet à l’ACMV de soutenir ce projet avec les ressources financières et humaines appropriées.

- **Réserve vétérinaire canadienne (RVC)** : Ce programme de l’ACMV, en place depuis 13 ans, sert à fournir des renforts vétérinaires en cas d’urgence impliquant des animaux, qu’il s’agisse d’une élosion de maladie animale exotique ou d’une urgence civile. Dans les cas d’urgences civiles ou de maladies dont la déclaration n’est pas obligatoire, la RVC est prête à répondre aux autorités provinciales, comme le médecin vétérinaire en chef ou les agents de gestion des urgences, tandis que dans les cas de maladies animales exotiques, la RVC répond aux demandes de l’ACIA. La RVC regroupe 300 médecins vétérinaires de partout au Canada qui œuvrent principalement en pratique privée. Depuis sa création en 2006, le programme a reçu des contributions financières de l’ACIA.

- **Campagne de sensibilisation à la santé mentale** : En partenariat avec Merck Santé animale, l’ACMV entame la deuxième année de sa désormais annuelle Semaine de sensibilisation à la santé mentale. La campagne de 2020, qui se déroulera du 6 au 12 septembre, proposera un autre webinar lors de la Journée mondiale de prévention du suicide, le 10 septembre 2020. L’ACMV a l’intention d’organiser un webinar sur la santé mentale chaque trimestre. En plus des webinaires, l’ACMV fournit divers documents utiles pouvant servir de ressources.

- **Campagne annuelle de sensibilisation aux tiques** : Pour la 5e année, l’ACMV s’associe à Merck Santé animale pour faire de mars le Mois national de sensibilisation aux tiques. Comme les années précédentes, l’ACMV a produit du matériel de communication et des outils pour aider les équipes vétérinaires à mettre en évidence la saisonnalité unique des tiques, à fournir
aux propriétaires d’animaux de compagnie des mises à jour concernant l’expansion de la présence des tiques au Canada et à accroître la sensibilisation à l’approche « Une santé » pour la lutte contre les tiques et la prévention de la maladie de Lyme.

Voici quelques-unes des activités de l’ACMV en lien avec l’approche « Une santé » et les changements climatiques :

• Sommet de l’ACMV sur les changements climatiques, l’approche « Une santé » et la médecine vétérinaire (détails à venir)

• Forum sur les enjeux nationaux qui portera sur la médecine vétérinaire et les catastrophes naturelles (détails à venir)

• Campagne annuelle de sensibilisation aux tiques

• Campagne nationale « Une santé » de sensibilisation des médecins vétérinaires et du public aux maladies propagées par les tiques (au stade de la soumission à l’Agence de la santé publique du Canada)

• Importation de chiens et risques de santé publique associés

• Utilisation et résistance des antimicrobiens : Système national de surveillance vétérinaire (SSNV) de l’utilisation des antimicrobiens

• Énoncé de position sur les diètes à base de viande crue pour les animaux de compagnie

• Activités du Groupe consultatif sur l’environnement de l’ACMV

Peste porcine africaine (PPA) : L’ACMV a offert à l’ACIA l’aide de la RVC en cas d’éclosion de PPA. L’ACMV participe à un groupe de travail sur les communications concernant la PPA dirigé par l’ACIA et à un groupe de travail formé de représentants du gouvernement fédéral, des gouvernements des provinces et des territoires et de l’industrie; ces deux groupes étudient ensemble les questions liées au dépeuplement. De plus, l’ACMV travaille avec l’ACIA pour donner accès à un webinar sur la PPA et, avec un groupe d’intervenants plus large, pour organiser un exercice national d’éclosion de la maladie. L’ACMV collabore également avec la Coalition canadienne pour la santé des animaux dans le cadre du Projet de gestion des urgences sanitaires animales pour la promotion et la prestation d’une formation sur la détection et l’intervention en cas de maladie animale exotique ou de fièvre aphteuse pour les médecins vétérinaires en pratique privée.

Étude sur la main-d’œuvre : L’ACMV a organisé deux ateliers pour discuter de certaines constatations préliminaires de l’étude sur la main-d’œuvre avec des médecins vétérinaires en pratique des animaux de compagnie et avec des médecins vétérinaires en pratique des grands animaux. Ces ateliers ont également aidé à élaborer une enquête plus vaste qui a été déployée dans la deuxième moitié du mois de février. Le rapport est attendu sous peu.

(by Jost am Rhyn, CEO, CVMA)
Retirements from The Canadian Veterinary Journal

Bruce Grahn

The Canadian Veterinary Journal (The CVJ) and the CVMA Editorial Committee wish to pay tribute to Dr. Bruce Grahn, one of its leaders and major contributors, who has decided to concentrate on other activities in his retirement. Bruce is well known for his column on Diagnostic Ophthalmology, which has appeared regularly in The CVJ since 1991. That is an amazing run of almost 30 years! Furthermore, Bruce ensured that this column would continue after his retirement by leaving the column in the hands of distinguished colleagues at the Western College of Veterinary Medicine. Readership surveys consistently heap praise on this column, and we are grateful to Bruce and his colleagues for their special role in educating veterinary practitioners. Bruce’s scholarly work is well known through his authorship of 2 books, over 150 articles, numerous book chapters, and his presentation of lectures all over the world. His newest book, Histologic Basis of Ocular Diseases in Animals, published in 2019, is an impressive publication that is likely to become a classic in ophthalmology. Despite the demands of clinical work, teaching DVM students, being an associate dean, mentoring residents, Bruce has always found time to support the profession beyond the walls of academe. He has served as associate editor of The CVJ and member of the CVMA Editorial Committee for well over 10 years. In this latter role, his ideas and his willingness to offer candid assessments have proven valuable to both The CVJ and the Canadian Journal of Veterinary Research. We thank Bruce for his imprint on veterinary ophthalmology and his outstanding record of service to the profession. We wish him well in the current phase of his career.

Départs à la retraite de La Revue vétérinaire canadienne

Bruce Grahn

La Revue vétérinaire canadienne (La RVC) et le Comité de rédaction de l’ACMV souhaitent rendre hommage au Dr Bruce Grahn, l’un des dirigeants et principaux contributeurs de La RVC, qui a décidé de se concentrer sur d’autres activités durant sa retraite. Bruce est bien connu pour sa chronique sur l’ophtalmologie diagnostique, qui paraît régulièrement dans La RVC depuis 1991, c’est-à-dire depuis presque 30 ans! D’ailleurs, Bruce a veillé à ce que cette chronique se poursuive après son départ en la laissant entre les mains d’éménants collègues du Western College of Veterinary Medicine. Les sondages auprès des lecteurs font toujours l’éloge de cette chronique, et nous sommes reconnaissants à Bruce et à ses collègues d’avoir assumé ce rôle important dans l’éducation des médecins vétérinaires. Le travail de Bruce est bien connu étant donné qu’il a rédigé 2 livres, plus de 150 articles et de nombreux chapitres de manuels, en plus de donner des conférences partout dans le monde. Son plus récent ouvrage, intitulé Histologic Basis of Ocular Diseases in Animals, publié en 2019, est un Manuel impressionnant qui devrait devenir un classique en ophtalmologie. Malgré les exigences du travail clinique, de l’enseignement aux étudiants en médecine vétérinaire, du poste de vice-doyen et de la supervision des résidents, Bruce a toujours trouvé le temps de soutenir la profession au-delà du milieu universitaire. Il a été rédacteur en chef adjoint à La RVC et membre du Comité de rédaction de l’ACMV pendant plus de 10 ans. Dans ce dernier rôle, ses idées et sa volonté d’offrir des évaluations franches se sont révélées précieuses pour La RVC et la Revue canadienne de recherche vétérinaire. Nous remercions Bruce pour l’empreinte qu’il laisse sur l’ophtalmologie vétérinaire et son impressionnante feuille de route en matière de soutien de la profession. Nous lui souhaitons la meilleure des chances dans ses futurs projets.

Dr./D’ Bruce Grahn
Dr./D’ Greg Harasen
Dr./D’ Richard Kennedy
Greg Harasen

After long and distinguished service as author, columnist and assistant editor of The CVJ, Dr. Greg Harasen has decided to step down from his role as assistant editor of The CVJ. Greg began writing articles for The CVJ in 1984 and started a regular column on orthopedic surgery in 2002. For the next 11 years he continued writing his popular column on orthopedic surgery, in which he presented sound science in a well-organized manner geared to the general practitioner. He was a practitioner who was very knowledgeable and wrote with clarity and effectiveness. He was an innovative thinker who had strong views on paths to postgraduate specialization in veterinary medicine. He advocated for independent study that would lead to certificates and diplomas, allowing practitioners to acquire recognition for expertise in a specialty without having to take time off for a residency. As an assistant editor, Greg exercised excellent judgment and was very effective in contributing to the assessment and improvement of manuscripts in orthopedic surgery. Greg had an amazing facility with words and a marvelous sense of humor that will serve him well in the various roles he continues to play.

Richard Kennedy

Dr. Richard Kennedy served as an assistant editor of The CVJ over the past 9 years. During this time Richard handled most of the manuscripts dealing with beef cattle. He was diligent and thorough and always had valuable comments to assist authors to improve their articles. Richard is leaving to serve in another capacity. About 3 years ago he joined the Canadian Rangers (part of the Canadian Armed Forces Reserve with the task of responding to local major emergencies such as wildfires, floods and earthquakes). The patrol he joined was not very active or effective and he pushed for it to become more prepared should their services be needed. In response, he was elected Patrol Commander as of January 1 and he is now busily engaged in expanding the patrol and enhancing its preparedness. We are very grateful to Richard for his exceptional service as an assistant editor of The CVJ.
The Practice Owners Economic Survey and Your Provincial Suggested Fee Guide Connection

The economics of practicing veterinary medicine in Canada can be divided in 2 eras — the era prior to, and after, the establishment of Provincial Suggested Fee Guides.

The era prior to the establishment of Provincial Suggested Fee Guides consisted of sourcing procedure rates from neighbouring practices, being unable to compensate staff appropriately, and shuffling accounts around to meet expenses, with little profitability to boot.

Once Provincial Suggested Fee Guides were made available to all practice owners, revenues increased almost immediately. With increased profitability, practice owners were compensated for their worth and able to appropriately pay hardworking staff. Practices upgraded to modern medical equipment — enhancing patient care and meeting owner expectations. Ultrasound machines, digital radiology, lasers and even CT scans were integrated into Canadian veterinary practices. Veterinary medicine was on the move! Halting the production and distribution of Provincial Suggested Fee Guides would be taking a step backwards. Fee guides are produced annually based on data submitted by YOU in the Practice Owners Economic Survey. Without your valuable data, a statistically sound and defensible document would not be possible.

Another key puzzle piece is the CVMA’s Business Management Program and its sponsors (Merck Animal Health, Scotiabank, Petsecure, and IDEXX) who contribute financially to assure that we, as practitioners, have an annual fee guide. One of the CVMA’s 3 strategic priorities is helping veterinarians achieve “a successful career and a balanced life.” Although achieving this state of balance may be considered a luxury by many practitioners, it is more easily attainable in profitable practices. When you receive your next survey, consider the fact that without your survey results, and without the support of the CVMA, and these generous sponsors, you and all Canadian veterinary practice owners would not have a fee guide.

L’économie de la pratique de la médecine vétérinaire au Canada peut être divisée en deux ères, c’est-à-dire avant et après l’élaboration des guides provinciaux des tarifs suggérés.

Avant la publication des guides provinciaux, l’économie vétérinaire était caractérisée par les recherches visant à découvrir les tarifs des pratiques environnantes, l’incapacité à rémunérer adéquatement le personnel et les transferts de fonds d’un compte à l’autre pour faire face aux dépenses, avec en prime très peu de rentabilité.

Lorsque les guides provinciaux des tarifs suggérés ont été mis à la disposition de tous les propriétaires d’établissements vétérinaires, les revenus ont augmenté presque immédiatement. Avec une rentabilité accrue, les propriétaires de pratiques ont été rémunérés à leur juste valeur et ont été en mesure de payer convenablement leur personnel. Les pratiques ont pu se doter d’équipement médical moderne, et ainsi améliorer les soins aux patients et répondre aux attentes des propriétaires. L’échographie, la radiologie numérique, l’utilisation du laser et même la tomodensitométrie ont été intégrées aux pratiques vétérinaires canadiennes. La médecine vétérinaire a le vent dans les voiles! Arrêter la production et la distribution des guides provinciaux des tarifs suggérés serait comme revenir en arrière. Or, ces guides sont mis à jour annuellement en fonction des données que VOUS fournissez dans le cadre de l’enquête économique auprès des propriétaires d’établissements vétérinaires. Sans ces précieuses données, il serait impossible d’offrir un document statistiquement solide et pertinent.

C’est aussi grâce au programme de gestion commerciale de l’ACMV et à ses commanditaires (Merck Santé animale, Banque Scotia, Petsecure et IDEXX) que nous, les praticiens, pouvons avoir accès à ce guide annuel des tarifs suggérés. L’une des trois priorités stratégiques de l’ACMV est d’aider les médecins vétérinaires à réussir une carrière prospère et à mener une vie équilibrée. Bien que l’atteinte de cet état d’équilibre puisse être considérée comme un luxe par de nombreux praticiens, il est plus facile d’y arriver quand la pratique est rentable. Ainsi, lorsque vous recevez notre prochain sondage, rappelez-vous que sans les résultats de l’enquête économique et sans le soutien de l’ACMV et de ses généreux commanditaires, il ne serait pas possible d’offrir de si précieuses guides tarifaires aux propriétaires d’établissements vétérinaires canadiens.

Sur une note positive, la médecine vétérinaire a progressé, et l’a fait de plusieurs façons au cours des 20 dernières années. Avec votre aide et le soutien continu de nos partenaires, nous pouvons tous contribuer à assurer un brillant avenir à la profession vétérinaire canadienne au cours des 20 prochaines années!

Visitez la section du programme de gestion commerciale du site Web de l’ACMV (www.veterinairesaucanada.net/practice-economics/business-management) pour consulter les guides provinciaux des tarifs suggérés et d’autres rapports économiques vétérinaires. Cette section propose également des articles sur la gestion d’une pratique vétérinaire et une tâche d’outils pour la carrière et les affaires qui offre aux médecins vétérinaires un accès
On a positive note, veterinary medicine has advanced and progressed in many ways over the past 20 years and with your help, and the continued support of our sponsors, we can all do our bit to ensure a bright future for the Canadian veterinary profession over the next 20 years!

Visit the CVMA's Business Management Program section of the CVMA website (www.canadianveterinarians.net/practice-economics/business-management) to access Provincial Suggested Fee Guides and other veterinary economic reports. This section also includes Veterinary Practice Management articles and a Career and Business Toolkit providing veterinarians easy access to pertinent online resources and information on personal financial management, veterinary business management, and client management.

(by Frank Richardson, DVM, MBA)

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CVMA Annual Source Guide — Have you confirmed your preferred mailing address?

The CVMA Source Guide is your national professional Association’s reference guide. Within these pages, you will find a complete member benefits and privileges listing that you are entitled to, our national issues and animal welfare position statements, and awards and honors information recognizing our colleagues’ achievements.

On February 28, all members received an e-mail from the CVMA informing them that preparations had begun for the 2020 Source Guide. Within this e-mail, we included the preferred mailing address currently on your profile and that will be published. If you would prefer a different address, please update your preferred mailing address by logging into your profile at (cvma.member365.com). Please note, updating your preferred mailing address means this will become the mailing address all communications from CVMA will be sent to.

If you need assistance, please e-mail (admin@cvma-acmv.org) or call us at 1-800-567-2862.

Guide annuel des ressources de l'ACMV – Avez-vous confirmé votre adresse postale?

Le Guide des ressources de l'ACMV est le guide de référence de votre association professionnelle nationale. Dans ce guide, vous trouverez des listes complètes des avantages et privilèges auxquels les membres ont droit, des énoncés de position sur le bien-être animal et les enjeux nationaux, et des récompenses et distinctions honorifiques reconnaissant les réalisations de vos collègues.

Le 28 février, tous les membres ont reçu un courriel de l'ACMV les informant que la préparation du Guide des ressources de 2020 avait commencé. Dans ce courriel, nous avons indiqué l'adresse postale associée à votre profil qui apparaîtra dans le guide. Si vous préférez qu'une adresse différente soit publiée, accédez à votre profil au cvma.member365.com et modifiez votre adresse. Veuillez noter que la mise à jour de votre adresse postale signifie que toutes les communications de l'ACMV seront dorénavant envoyées à cette adresse.

Si vous avez besoin d'aide, envoyez-nous un courriel à admin@cvma-acmv.org ou appelez-nous au 1-800-567-2862.
Case Report  Rapport de cas

Uterine perforation secondary to metritis and placenta percreta in a postpartum bitch

Lacey M. Rosenberg, Jacqueline Marinoff, Esther E. Crouch, Dominick M. Valenzano, Jeanine Peters-Kennedy, Soon Hon Cheong, Mariana Diel de Amorim

Abstract — A 3-year-old intact female Labradoodle bitch was referred due to fever and lethargy 4 days postpartum. The dog was reported to have had prolonged labor that required assistance and fetal membranes were retained. Physical examination and diagnostics led to a suspicion of metritis and uterine perforation. Ovariohysterectomy was performed. Gross and histopathology findings revealed multifocal uterine perforation, necrosuppurative metritis, and placenta percreta. Post-operative antibiotic therapy and supportive care resulted in an uneventful clinical recovery. This is the first reported case of placenta percreta in a bitch. It is presumed that this pathology was paramount in the patient's development of metritis and subsequent uterine rupture.

Key clinical message:
Placenta percreta may lead to more severe clinical consequences of metritis, including uterine rupture.

Résumé — Perforation utérine secondaire à une métrite et un placenta percreta chez une chienne en période post-partum. Une femelle Labradoodle intacte âgée de 3 ans fut référée pour cause de fièvre et léthargie 4 jours post-partum. Il fut rapporté que la chienne avait eu un travail long qui demanda de l’assistance et qu’il y avait eu rétention des membranes fœtales. L’examen physique et le diagnostic mena à un doute de métrite et de perforation utérine. Une ovario-hystérectomie fut réalisée. Les trouvailles de pathologie macroscopique et d’histopathologie révèlèrent des perforations utérines multifocales, une métrite nécro-suppurative et un placenta percreta. Une antibiothérapie post-opératoire et des soins de support ont résulté en une guérison clinique sans conséquence. Ceci représente le premier cas rapporté de placenta percreta chez une chienne. Il est présumé que chez cette chienne cette pathologie était vitale dans le développement de la métrite et de la rupture utérine subséquente.

Message clinique clé :
Un placenta percreta peut mener à des conséquences cliniques plus sévères de métrite, incluant la rupture utérine.

(Traduit par Dr Serge Messier)

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Case description

A 3-year-old 16.6 kg intact female Labradoodle bitch was presented to the Cornell University Hospital for Animals (CUHA) with the chief complaint of fever and lethargy 4 d postpartum. The bitch had been subjected to breeding management and she was bred via vaginal artificial insemination with fresh semen approximately 9 wk before she was taken to the clinic. The bitch whelped naturally, but her breeder reported a long, protracted labor in which at least 1 neonate required manual extraction. Seven puppies were delivered and all were alive at the time of birth, but 1 of the pups was mutilated by the bitch shortly after delivery and died due to its injuries. The whelping process was not closely observed, and it was unclear if all fetal membranes were delivered. After whelping and before presentation at CUHA, the kennel manager noted lethargy, anorexia, and a serosanguinous vaginal discharge, which increased in volume on the day of presentation.

Upon arrival at CUHA, the bitch was dull but responsive, dehydrated, and in poor body condition (BCS of 2/9). She had foul-smelling brownish discharge staining her hind legs, perineum, and tail. Moderate generalized cachexia was noted, and the patient was painful on abdominal palpation. Mammary glands were subjectively milk-depleted but were expressible. The 6 living puppies were briefly evaluated and found to be in good health and body condition. The puppies were sent home and fostered to different lactating dams within the kennel.
Point-of-care blood analysis showed a packed cell volume (PCV) of 28% [reference interval (RI): 41% to 58%], total solids: 62 g/L (RI: 55 to 72 g/L), blood urea nitrogen (BUN): 10.7 to 14.3 mmol/L (RI: 3.2 to 9.3 mmol/L), and a lactate of 1.3 mmol/L (RI: < 2.0 mmol/L). Venous blood gas analysis showed a mixed acid/base disturbance characterized by a respiratory alkalosis and metabolic acidosis. A focused assessment with sonography for trauma (FAST) ultrasound examination revealed a uterus filled with heterogeneous fluid and multiple pockets of gas without free abdominal fluid. Three-view abdominal radiographs were consistent with moderate, diffuse, uterine enlargement with centrally located intrauterine gas (Figure 1).

The patient was admitted to the intensive care unit for supportive care overnight. Intravenous crystalloid fluid therapy (Plasma-Lyte; Baxter Healthcare, Deerfield, Illinois, USA) was initiated [2 × 20 mL boluses, then 120 mL/kg body weight (BW) per day with 20 mEq/L KCl added], and the dog was placed on broad-spectrum antibiotics [ampicillin/sulbactam (AuroMedics, East Windsor, New Jersey, USA), 30 mg/kg BW, IV, q8h, enrofloxacin (Baytril; Bayer Animal Health, Shawnee, Kansas, USA), 10 mg/kg BW, IV q24h], maropitant (Cerenia; Zoetis, Kalamazo, MI), 1 mg/kg BW, IV, q24h, pantoprozole (Protonix IV; Pfizer, Philadelphia, Pennsylvania, USA), 1 mg/kg BW, IV, q24h, and fentanyl (Hospira, Lake Forest, Illinois, USA), 2 μg/kg BW per hour CRI for pain. Serum chemistry analysis the following morning revealed hypernatremia (139 mmol/L/L, RI 143 to 150 mmol/L), hypokalemia (3.6 mmol/L/L, RI 4.1 to 5.4), hypochloremia (100 mmol/L/L, RI: 106 to 114 mmol/L), azotemia (BUN 12.8 mmol/L/L, RI 3.2 to 9.3 mmol/L), creatinine 123.8 μmol/L/L, RI 53.0 to 123.8 μmol/L/L, hyperproteinemia/hyperalbuminemia (total protein 53 g/L, RI 55 to 72 g/L; albumin 23 g/L, RI 32 to 41 g/L), and mild elevations in alkaline phosphatase (ALP) (230 U/L, RI 7 to 115 U/L) and total bilirubin (6.8 μmol/L, RI 0.0 to 3.4 μmol/L). A complete blood cell count (CBC) showed leukocytosis [white blood cells (WBC) 24.3 × 10^9/μL, RI 5.7 to 14.2 × 10^9/μL] and neutrophilia characterized by a left shift (segmented neutrophils 17.5 × 10^9/μL, RI 2.7 to 9.4 × 10^9/μL; band neutrophils 3.9 × 10^9/μL, RI: 0.0 to 0.1 × 10^9/μL), and moderate toxic changes were noted in the neutrophils. A normocytic, normochromic, nonregenerative anemia was also noted (PCV 31%), as well as thrombocytopenia (46 × 10^9/μL, RI: 186 to 545 × 10^9/μL).

The following morning, FAST ultrasound showed a mild amount of free fluid in the abdomen, adjacent to the uterus. Cytology of the fluid led to a concern for septic peritonitis, and the patient was immediately prepared for surgery. The patient was premedicated with fentanyl (Hospira), 5 μg/kg BW and midazolam (Alvogen, Pine Brook, New Jersey, USA), 0.2 mg/kg BW, IV. General anesthesia was induced with propofol (Rapanofal; Ivaoes Animal Health, Miami, Florida, USA), 3 mg/kg BW, IV and maintained with 1.25% to 2.5% sevoflurane (Patterson Veterinary, Greeley, Colorado, USA) in oxygen and a fentanyl CRI at 0.1 to 0.2 μg/kg BW per minute. While under general anesthesia the dog received intravenous crystalloid fluid (Plasma-Lyte; Baxter Healthcare) therapy at 5 to 10 mL/kg BW per hour along with dobutamine (Hospira), 0 to 3 μg/kg BW per minute and norepinephrine (Claris, Ahmedabad, India), 0 to 0.4 μg/kg BW per minute as needed. She was treated with ampicillin/sulbactam (AuroMedics), 22 mg/kg BW, IV, 30 min before surgery and every 90 min thereafter until the procedure was completed. The patient was placed in dorsal recumbency, aseptically prepared, and a standard ventral midline celiotomy was performed. Mild effusion was present within the peritoneal cavity and the uterus was distended with fluid. On the ventral surface of the right uterine horn, 3 approximately 5-mm areas of rupture were noted that were exuding purulent material. Cultures were obtained and the entire uterus and ovaries were removed en bloc and submitted for gross and histologic evaluation. A nasogastric tube was placed prior to the patient's recovery from anesthesia.

Culture of the free peritoneal fluid resulted in growth of Staphylococcus pseudintermedius and Enterococcus faecalis, while culture of the uterine tissue resulted in growth of Staphylococcus pseudintermedius and Fusobacterium necrophorum. Sensitivity profiles for the cultured bacterial isolates were used in antimicrobial selection during the post-operative period.

The patient recovered uneventfully from anesthesia and was maintained on plasmalyte (Baxter Healthcare), 90 mL/kg BW per day, ampicillin/sulbactam (AuroMedics), 22 mg/kg BW, IV, q8h, enrofloxacin (Bayer), 10 mg/kg BW, IV, q24h, fentanyl (Hospira), 2 μg/kg BW per hour, and pregabalin (Pharmacy Compound; Cornell University Hospital for Animals, Ithaca, NY), 40 mg PO, q12h. In the immediate post-operative period, PCV was measured to be 18%. Blood-typing was performed and consistent with a type of DEA 1.1+. Half of a unit of the same type of packed red blood cells was transfused uneventfully, and post-transfusion PCV was 24%. The patient ate well when food was offered, so the nasogastric tube was only used to aspirate gastric fluid. Minimal fluid was aspirated, so the tube was removed 1 d after surgery.

On gross evaluation of the reproductive tract, each uterine horn was dilated, up to 15 × 7 × 4 cm, and dark red linear serosal discoloration corresponded to zonary placenta tion sites (Figure 2A). The serosal aspect of the right most cranial...
placentation site was punctated by 6 multifocal to coalescing, raised, irregular, pale tan 0.3 to 0.8 cm foci. Occasionally, these were crateriform and ulcerated. Similar lesions were seen on the serosal surface at the 2 most caudal placental attachment sites on the left uterine horn (Figure 2B). Approximately 500 mL of thick dark red fluid expanded the lumen with multifocal, large, slightly adhered clotted material. The uterine wall was 1 cm in width and extremely friable. The zonary sites were carpeted in fibrinosuppurative exudate and the most severely affected areas communicated with the serosal lesions. The most cranial right zonary site possessed a 3 × 3 × 3 cm closely adhered, dark red, fibrinous mat of membranous material that resembled retained fetal membranes (Figure 2C).

Microscopic examination was performed on sections of the uterus and both ovaries. Uterine sections were selected in an effort to sample areas of gross rupture, mural hemorrhage, and placentation sites, and included both uterine horns and the uterine body. Samples were fixed in 10% neutral buffered formalin, processed routinely, and embedded in paraffin wax. Embedded samples were sectioned at 5 μm and stained with hematoxylin and eosin (H&E) (Figure 3A). Multifocally throughout the uterus, corresponding to the grossly noted areas of uterine rupture and mural hemorrhage, the myometrium was infiltrated by large numbers of pleomorphic and frequently multinucleated cells, consistent with trophoblast syncytia. These cells had moderate amounts of eosinophilic cytoplasm and up to 20 round to oval nuclei with coarsely stippled to vesicular chromatin and a single prominent central nucleolus. In most affected areas, the trophoblast cells infiltrated through the entire thickness of the myometrium and extended into the serosa (Figure 3B). Additionally, there was fibrinoid necrosis of multiple vessel walls with frequent vascular thrombosis and localized infarction associated with extensive necrosuppurative metritis and numerous colonies of coccobacilli embedded in the necrotic debris within the wall and lumen. The serosa was similarly inflamed with reactive mesothelium and coated in a variably thick layer of fibrin and debris, consistent with septic peritonitis. The ovaries were unremarkable, with numerous regressing corpora lutea bilaterally, appropriate for the bitch’s post-parturient stage. Unilaterally, there was a focal area of necrosuppurative mesovaritis, also consistent with septic peritonitis. Morphologic diagnoses were placenta percreta; severe, multifocal, acute necrosuppurative metritis with focal rupture, fibrin thrombi, infarction, and intralesional coccobacilli; and moderate to severe, locally extensive, acute neutrophilic mesovaritis with vasculitis.

The patient was discharged 48 h after surgery with a 2-week course of enrofloxacin (Baytril; Bayer Animal Health), 10.2 mg/kg BW, PO, q24h, and amoxicillin/clavulanate (Putney, Portland, Maine, USA), 15 mg/kg BW, PO, q12h, and 3 d of...
pregabalin 2.4 mg/kg BW, PO, q24h. After discharge, the patent reportedly continued to have an uneventful post-operative recovery. The surviving puppies continued to thrive, being nursed by surrogate lactating bitches, and were eventually weaned and adopted by new families at 8 wk of age.

Discussion

Metritis is an acute uterine infection that typically occurs within 1 week of parturition (1). Bacteria invade the uterus during parturition, when the cervix is dilated, and proliferate to cause infection (2). Predisposing factors include retained fetal membranes, large litter size, prolonged parturition, assisted fetal delivery, and secondary uterine inertia (1,2). Several of these factors were components of this patient’s history, including prolonged labor, manual fetal extraction, and retained fetal membranes. The clinical presentation of this patient was typical for this disease, including fever, lethargy, and voluminous, malodorous, purulent discharge.

The patient also had a poor body condition score at the time of presentation. While the client reported that the patient was quite thin at the end of gestation, presumably due to a subpar plane of nutrition, we suspect that this likely worsened after she became ill. In cattle, there is an increased incidence of post-partum disease in animals that have poor body condition scores, likely associated with increased pro-inflammatory cytokines (3). There is potential that our patient’s cachexia may have predisposed her to the development and/or severity of metritis that she developed.

The fluid-filled uterus was accompanied by free gas, which is suggestive of the presence of fermentative bacteria. This was confirmed by the microbial culture results. All 3 bacterial species found in this case are of genera that have been previously isolated from the canine reproductive tract (4,5). In fact, a recent analysis of the microbiome of the healthy canine reproductive tract revealed *Staphylococcus* spp. and *Fusobacterium* spp. as being among the predominant genera in the uterus and vagina, respectively (6). It can be hypothesized that these bacteria were already present within the patient’s uterus, or invaded via the cervix during prolonged labor, and the poor uterine conditions allowed for overgrowth, proliferation, and overwhelming infection.

Abnormally invasive placentation (AIP) is typically seen in humans, and appears to affect 0.17% to 0.34% of deliveries (7). It is subclassified into 3 grades, depending on the depth of trophoblast invasion into the uterus: placenta acreta (decidual layer), increta (myometrium), and percreta (serosa and adjacent organs) (8). In humans, placenta percreta has been associated with the highest rate of maternal morbidity compared with the less severe forms of AIP, and was more likely to require hysterectomy at the time of cesarean-section delivery or in the postpartum period (7). In this case, the trophoblast cells were found to be invading through all layers of the uterus to the serosa, consistent with a diagnosis of placenta percreta.

To the authors’ knowledge, this is the first report of a case of placenta percreta in a bitch. The occurrence of this pathology is curious in this species, due to the clear difference in placentation between humans and canines. The human has a hemochorial
placenta, in which there are no maternal layers contributing to placentation and the chorion is bathed directly with maternal blood (9). The canine placenta, on the other hand, is endothe-
llochorial, characterized by the maternal endothelial basement layer in direct contact with the chorion (9). Based on this understanding, it is not surprising that abnormally invasive pla-
centation is a recognized pathology of humans, due to the fact that this species has the most invasive form of placentation (10).

The canine placenta, however, has an additional layer of tissue (maternal endothelium) through which the trophoblastic cells must traverse in order to invade the tissues of the uterus (9).

The pathogenesis of AIP in humans is not well-understood. It is thought to involve both increased trophoblast invasion and an absence of normal uterine decidua, as well as dehiscence of a scar within the uterine wall (11). Abnormally invasive placentation is most frequently seen in human females with a prior history of cesarean section delivery, with the abnormal placental invasion occurring at the surgical site (12). Other reported risk factors in humans include placenta previa, maternal age and multiparity, prior uterine surgery, prior uterine curettage, uterine irradiation, endometrial ablation, Asherman syndrome, uterine leiomyo-
matas, uterine anomalies, hypertensive disorders of pregnancy, and smoking (12). Several of these risk factors do not apply to this case, as the bitch was primiparous and relatively young, with an average litter size for her breed. It is still unclear why AIP developed in this particular patient. It is likely that this uterine pathology contributed to her severity of illness and the necessity for surgical resolution. We hypothesize that the abnormal trophoblastic invasion caused myometrial fragility, predisposing the uterus to rupture. The abnormal invasion may have also impaired myometrial function, resulting in the prolonged and inefficient labor, as was reported in this case. Secondary bacterial infection likely occurred due to the protracted labor as well. These factors combined, potentially exacerbated by the patient’s poor body condition, likely led to the development of severe metritis and subsequent uterine rupture.

Placenta percreta is a well-known pathologic condition of human pregnancy (7,8,11,12), but has never previously been reported in the bitch. It is the authors’ experience that the domestic dog does not always deliver every placenta during natural parturition, but these retained fetal membranes are typically expelled over time as lochia and are rarely associated with the development of metritis. It is suspected that the retained fetal membranes in this case were secondary to the abnormally invasive placentation that was diagnosed based on histopathology. Based on these findings, we would encourage practitioners to always consider histopathologic examination in cases of uterine perforation secondary to metritis.

Acknowledgment

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Management of a severe peripartum hemorrhage following cesarean section in a dog

Graeme M. Doodnaught, Elizabeth O’Toole, Daniel S.J. Pang

**Abstract** — This report describes the intensive blood pressure management and transfusion of a peripartum intrauterine hemorrhage following a cesarean section in a dog. The impact of pregnancy-associated physiologic changes and anesthesia on hemodynamic parameters along with potential alternate management techniques are discussed.

**Résumé** — Gestion d’une hémorragie péri-partum sévère à la suite d’une césarienne chez une chienne. Ce rapport décrit la gestion intensive de la pression sanguine et des transfusions lors d’une hémorragie intra-utérine péri-partum à la suite d’une césarienne chez une chienne. L’impact des changements physiologiques associés à la gestation et à l’anesthésie sur les paramètres hémodynamiques ainsi que des techniques de gestion alternatives sont discutés.

(Traduit par D’ Serge Messier)


Peripartum hemorrhage (PPH) is a possible complication following cesarean section in dogs and cats (1). Oxygen delivery in the body is dependent on cardiac output ($Q$), hemoglobin concentration, and the saturation of hemoglobin with oxygen (2). Hemorrhage causes a reduction in hemoglobin concentration and $Q$. The measurement of $Q$ is rarely performed in practice, instead arterial blood pressure and heart rate are used as surrogates. Classical physiological responses to hemorrhage are tachycardia and vasoconstriction; however, general anesthesia with volatile agents blunts these responses and intraoperative intravenous fluid therapy (IVFT) can further decrease hemoglobin concentration. Additionally, normal physiological changes in the pregnant bitch (relative anemia, increased heart rate, and a poor reflex response to hypovolemia) further confound the interpretation of hemorrhage during anesthesia (3). The decision to transfuse a patient in response to hemorrhage is based on evaluating these physiological responses alongside quantified blood loss, the presence of acute anemia (hematocrit < 25%), and evidence of tissue hypoxia (e.g., blood hyperlactatemia) (4). The management of a severe case of PPH has not been described in the small animal veterinary literature. This case report describes the anesthetic and critical care support of a dog with PPH that demonstrated evidence of hemorrhagic shock post-procedure; urgent transfusion therapy was required to stabilize the dog. This case has altered the authors’ institutional practice and resulted in a change in management technique for cesarean sections.

**Case description**

A 4-year-old, 35-kg, Bouvier des Flandres dog was presented to the Centre Hospitalier Universitaire Vétérinaire (CHUV) for dystocia (time of presentation 16:30 h). This was the dog’s third pregnancy, and it had been in labor approximately 18 h before admission. It had vaginally delivered 4 puppies overnight but had progressed no further in parturition. On presentation the dog was anxious but alert, demonstrating a sinus tachycardia [140 beats/min (bpm)] and was panting. Hematocrit and total protein were 37% [reference range (RR): 40% to 56%] and 62 g/L (RR: 53 to 67 g/L). Plasma urea was elevated (23.6 mmol/L; RR: 3.26 to 9.44 mmol/L), which in conjunction with a high normal plasma creatinine concentration (137 μmol/L; RR: 57 to 137 μmol/L) was presumed to be pre-renal in origin, secondary to dehydration (Table 1). Electrolyte abnormalities included elevated serum potassium (5.15 mmol/L; RR: 3.83 to 5.06 mmol/L), decreased sodium (126.6 mmol/L; RR: 142.8 to 150.2 mmol/L), and decreased chloride (94.3 mmol/L; RR: 109.0 to 118.6 mmol/L). Abdominal ultrasound revealed that 3 of the remaining 6 fetuses were in distress (heart rate < 150 bpm). As a result, the decision was made to deliver the remaining puppies by cesarean section. Informed consent was obtained from the owners and the dog was prepared for anesthesia and surgery. The dog was...
immediately started on IVFT with lactated Ringer’s solution (Lactated Ringer’s Solution USP; Baxter, Mississauga, Ontario), 10 mL/kg body weight (BW) per hour and given ampicillin (Ampicillin Sodium Injection USP 1 g; TEVA, Toronto, Ontario), 22 mg/kg BW, IV, through a cannula placed in a cephalic vein. The owners declined a recommendation that a concurrent ovariohysterectomy (OVH) be performed as they wished to breed the dog in the future.

The abdomen was clipped and cleaned, and the lumbosacral space was clipped and aseptically prepared to facilitate epidural injection following induction of general anaesthesia. No pre-medication was administered. Following 5 min of pre-oxygenation (4 L/min by face mask) general anesthesia was induced, at 17:15 h, with propofol to effect (Propoflo 28 10 mg/mL; Zoetis, Kirkland, Quebec), 5 mg/kg BW, IV. After direct orotracheal intubation (12 mm ID), the patient was connected to a small animal anesthesia machine with a coaxial circle breathing system. General anesthesia was maintained with isoflurane (Isoflurane; Fresenius Kabi, Richmond Hill, Ontario) carried in oxygen. The patient was monitored with a multiparametric anesthesia monitor [(LifeWindow LW9x; Digicare Animal Health, Boynton Beach, Florida, USA); ECG, pulse oximetry, sidestream capnography (PETCO2), invasive blood pressure, and pulse pressure variation]. The dorsal pedal artery was cannulated for invasive blood pressure monitoring as non-invasive measurements (oscillometric technique) were providing erratic values following induction. Fluid therapy was continued with lactated Ringer’s solution at 10 mL/kg BW per hour. The dog ventilated spontaneously during the procedure and exhibited hypocapnia throughout (PETCO2 < 26 mmHg). An epidural injection was performed with morphine (Morphine Sulfate 10 mg/mL, Preservative free; Sandoz, Boucherville, Quebec), 0.1 mg/kg BW, and lidocaine (Lurocaine 2%; Vétoquinol, Lavaltrie, Quebec), 3 mg/kg BW with a total volume of 0.14 mL/kg BW as soon as the dog was intubated (less than 60 s following induction). The epidural injection provided a MAC-sparing effect, with the expired isoflurane maintained between 0.2% and 0.5% during the surgery.

The dog was transferred from the preparation area to the operating theater 15 min after induction of anesthesia. The mean arterial blood pressure (MAP) was 62 mmHg (via arterial cannula measurement) and heart rate was 120 bpm upon arrival in theater. With concerns for hypovolemia, the authors instituted a brief period (approximately 1 min) of controlled (manual) ventilation to a peak pressure of 10 cmH2O which yielded a pulse pressure variation (PPV) in excess of 20% [RR: 0 to 15% (5); estimated from the arterial blood pressure waveform]. These factors considered in unison were consistent with the presence of hypovolemia. A bolus of lactated Ringer’s solution, 15 mL/kg BW, was administered over the next 25 min. This bolus finished at the time of delivery of the last puppy and IVFT was continued at 10 mL/kg BW per hour. Sixteen and 46 min after the start of surgery and anesthesia, respectively, the last puppy was delivered (actual time 18:01 h). Five puppies were delivered alive, and 1 was delivered dead. There was no improvement in PPV or reduction in heart rate following the fluid bolus. As the surgical team began to close the uterus there was a sudden decrease (over less than 5 min) in MAP to 50 mmHg, accompanied by a reduction in P\textsubscript{\text{ET}}CO\textsubscript{2} from 24 to 19 mmHg (no concurrent change in respiratory rate). A continuous rate infusion (CRI) of norepinephrine (Norepinephrine Bitartrate Injection USP 1 mg/mL; Sandoz) was started and titrated (0.2 to 0.4 µg/kg BW per minute) to effect (target MAP 65 to 70 mmHg). At this time the dog had received 30 mL/kg BW of isotonic crystalloid fluids (over 45 min since IVFT was instituted) and the expired concentration of isoflurane was 0.2% to 0.3%. For the next 10 min the MAP improved to target levels; however, the heart rate remained elevated at 120 bpm. Another decrease in MAP to 50 mmHg was seen 15 min after beginning the norepinephrine CRI. This hypotension correlated with the closure of the uterus and the surgical team did not report evidence of hemorrhage within the surgical field. At this point hypotonic saline, 2 mL/kg BW, was administered over 10 min, which was associated with a transient (5 min) increase in MAP to 70 mmHg. When the MAP decreased further to 59 mmHg, a CRI of dopamine (DO Pam HCL 1600 µg/mL; Baxter) was started at 8 µg/kg BW per minute (norepinephrine was at 0.4 µg/kg BW per minute at this time). A good response was observed (MAP 70 to 76 mmHg) for the next 10 min. As skin closure was completed the heart rate increased further to 152 bpm and MAP decreased to 61 mmHg, so volatile anesthesia was discontinued (actual time 18:45 h). Arterial blood was sampled for blood gas analysis (Table 1) and coagulation function testing as soon as the drapes were removed at the end of the surgery. Arterial blood gas analysis revealed a metabolic acidosis with respiratory compensation (pH = 7.38, HCO\textsubscript{3} = 12.7 mmol/L, P\textsubscript{\text{ET}}CO\textsubscript{2} = 21.8 mmHg with a simultaneous P\textsubscript{\text{ET}}CO\textsubscript{2} = 19 mmHg; hematocrit = 25%, total protein = 48 g/L, lactate = 1.6 mmol/L). The in-house prothrombin and activated partial thromboplastin times (SCA 2000; IDEXX, Westbrook, Maine, USA) of citrated whole blood were normal at 12 s (RR: 12 to 17 s) and 102 s (RR: 71 to 102 s), respectively.

Five minutes after discontinuing volatile anesthesia, the patient was transferred to ICU. The cessation of isoflurane provided a marginal increase in MAP to 70 mmHg. During transfer a dark hemorrhagic discharge was noted from the vagina, the presumed origin being the uterus. Heart rate had decreased from approximately 150 to 135 bpm, but MAP had decreased further, to 50 mmHg. Considering the poor response to vasopressors and the hyperkalemia and hyponatremia at presentation, there was a suspicion of hypoadrenocorticism. A 3-mg dose of dexamethasone (Dexamethasone 5, 5 mg/mL; Vétoquinol) was administered IV. Ten minutes later (at 19:00 h), norepinephrine and dopamine CRI’s were increased to 0.6 and 10 µg/kg BW per minute, respectively. A brief (5 min) improvement in MAP (80 mmHg) was seen, then over the following 15 min the MAP gradually decreased to below 70 mmHg again despite increasing norepinephrine to 0.8 µg/kg BW per min. The dog was extubated during this period (19:08 h). However, due to ongoing significant bleeding visible from the vagina, the poor response to crystalloid boluses and vasopressor support the decision was made to transfuse type-specific packed red blood cells (pRBCs) (250 mL, 7.1 mL/kg BW) to the dog over a 1-hour period. A cross match was not performed due to the
Table 1. Preoperative hematology/biochemistry, arterial blood gas at the end of anesthesia during a severe intra-uterine hemorrhage, and hematocrit at discharge in a Bouvier des Flandres bitch undergoing cesarean section. Abnormal values are in bold, with reference ranges in parenthesis.

<table>
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<tr>
<th>Analyte</th>
<th>Pre-operative</th>
<th>Post-operative/Pre-transfusion</th>
<th>Discharge (24-hour post)</th>
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<td>Sample</td>
<td>Venous</td>
<td>Arterial</td>
<td>Venous (Post-transfusion)</td>
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<tr>
<td>Hematocrit (%)</td>
<td>37*</td>
<td>25</td>
<td>30</td>
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<td>(40 to 56)</td>
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<tr>
<td>Total protein (g/L)</td>
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<td>(52 to 67)</td>
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<td>pH</td>
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<td>P&lt;sub&gt;O2&lt;/sub&gt; (mmHg)</td>
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<td>(142.8 to 150.2)</td>
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<tr>
<td>K&lt;sup&gt;+&lt;/sup&gt; (mmol/L)</td>
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<td>iCa&lt;sup&gt;2+&lt;/sup&gt; (mmol/L)</td>
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</tr>
<tr>
<td>(1 to 1.42)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total calcium (mmol/L)</td>
<td>2.14</td>
<td>ND</td>
<td>ND</td>
</tr>
<tr>
<td>(2.33 to 2.69)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HCO&lt;sub&gt;3&lt;/sub&gt; (mmol/L)</td>
<td>12.7</td>
<td>12.7</td>
<td>20.7</td>
</tr>
<tr>
<td>(21 to 25)</td>
<td>(20 to 24)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cl&lt;sup&gt;-&lt;/sup&gt; (mmol/L)</td>
<td>94.3</td>
<td>106</td>
<td>106</td>
</tr>
<tr>
<td>(109 to 118.6)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Glucose (mmol/L)</td>
<td>7.5</td>
<td>7.0</td>
<td>ND</td>
</tr>
<tr>
<td>(4.5–8)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lactate (mmol/L)</td>
<td>1.39</td>
<td>1.6</td>
<td>1.07</td>
</tr>
<tr>
<td>(0 to 2)</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Hemoglobin (g/L)</td>
<td>129</td>
<td>88</td>
<td>ND</td>
</tr>
<tr>
<td>(139 to 198)</td>
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<td>White blood cells (10&lt;sup&gt;9&lt;/sup&gt;/L)</td>
<td>16.76</td>
<td>ND</td>
<td>ND</td>
</tr>
<tr>
<td>(5.1 to 14.2)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Segmented neutrophils (10&lt;sup&gt;9&lt;/sup&gt;/L)</td>
<td>14.08</td>
<td>ND</td>
<td>ND</td>
</tr>
<tr>
<td>(2.7 to 9.8)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Band neutrophils (10&lt;sup&gt;9&lt;/sup&gt;/L)</td>
<td>0.17</td>
<td>ND</td>
<td>ND</td>
</tr>
<tr>
<td>(0 to 0.3)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lymphocytes (10&lt;sup&gt;9&lt;/sup&gt;/L)</td>
<td>1.17</td>
<td>ND</td>
<td>ND</td>
</tr>
<tr>
<td>(0.7 to 3.5)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Monocytes (10&lt;sup&gt;9&lt;/sup&gt;/L)</td>
<td>1.34</td>
<td>ND</td>
<td>ND</td>
</tr>
<tr>
<td>(0.1 to 0.9)</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Platelets (10&lt;sup&gt;9&lt;/sup&gt;/L)</td>
<td>449</td>
<td>ND</td>
<td>ND</td>
</tr>
<tr>
<td>(153 to 400)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Urea (mmol/L)</td>
<td>23.65</td>
<td>ND</td>
<td>ND</td>
</tr>
<tr>
<td>(3.26 to 9.44)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Creatinine (µmol/L)</td>
<td>137</td>
<td>ND</td>
<td>89</td>
</tr>
<tr>
<td>(57 to 137)</td>
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<td></td>
<td></td>
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<tr>
<td>ALT (U/L)</td>
<td>20</td>
<td>ND</td>
<td>ND</td>
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<tr>
<td>(20 to 80)</td>
<td></td>
<td></td>
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<tr>
<td>ALP (U/L)</td>
<td>105</td>
<td>ND</td>
<td>ND</td>
</tr>
<tr>
<td>(10 to 113)</td>
<td></td>
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</tbody>
</table>

* Hematocrit reported from pre-operative hematology/biochemistry. Post-operative hematocrits determined by centrifugation of microhematocrit tubes.

iCa<sup>2+</sup> — ionized calcium; ALT — alanine aminotransferase; ALP — alkaline phosphatase; ND — not determined.
The other 2 dogs requiring transfusions did not require additional medical intervention to maintain arterial blood pressure and the trigger for transfusion was an acute decrease in hematocrit below 20% after surgery (14 and 16 h). Therefore, the overall incidence of PPH requiring medical management or transfusion for dogs presenting for dystocia was 6.7% (3 of 45) at the CHUV over the last 2 y. The incidence of PPH requiring treatment in dogs which were not spayed at the time of cesarean section was 23% (3/13).

Discussion

This report describes the successful medical management of a severe peripartum (intrauterine) hemorrhage in a Bouvier des Flandres bitch undergoing cesarean section without ovariohysterectomy. The exact cause and risk factors associated with the intrauterine hemorrhage are unknown; leaving the uterus in situ may have increased the risk. Potential factors leading to the observed hypotension beyond the hemorrhage include the use of neuraxial blockade, and/or possible concurrent disease. The detection of PPH is not always immediate and may not coincide with surgery. Following the case reported here, a change in the management of cesarian sections was introduced at the authors' institution, resulting in post-operative blood transfusions in 2 further cases. The management of PPH in the veterinary and human literature will be discussed to provide the reader with practical techniques for managing this complication in practice.

There is only 1 report in the literature pertaining to the treatment of PPH in dogs (6). The report describes the use of medroxyprogesterone acetate (2 mg/kg BW, SC) in 10 dogs with persistent PPH. Though no controls were included, the author described satisfactory cessation of hemorrhage within 24 h. Unfortunately, to date, no standardized approach to the management of PPH has been investigated or described (1).

The incidence of PPH has not been reported in dogs. The reported incidence from the authors’ institution over the last 2 y was 6.7% for all dogs presenting with dystocia. However, all dogs with PPH (n = 3) underwent cesarean section without OVH. All dogs spayed at the time of cesarean surgery or delivering vaginally were unaffected. This may suggest a relationship between PPH and cesarean section without concurrent OVH; however, an appropriately powered prospective study with defined transfusion triggers is required to investigate this association. This retrospective analysis should be interpreted cautiously as the 2 cases of transfusion were precipitated following a change in practice (overnight hospitalization and serial hematocrit measurements) instituted after the case reported here and the small sample size (3 cases) precludes firm conclusions being drawn. Nonetheless, there are commonalities between the authors’ experiences and risk factors reported in the human literature (described below). Together, this supports the necessity for further investigation.

Peripartum hemorrhage is better described in cattle and horses. In large animals the hemorrhage is generally secondary to trauma associated with calving or foaling, with lacerations occurring in the uterus, cervix, or vagina (7). The most common cause of hemorrhage is rupture of the uterine artery within the broad ligament causing a hemATOMA or potential hemoabdomen.
In horses, PPH accounts for 40% of all periparturient deaths in mares (8). The literature in large animals describes conservative (packing body cavities, fluid therapy) and more aggressive (blood transfusion, surgical interventions) techniques for management (7,8). Unfortunately, fundamental differences in etiology and presentation limit direct comparisons among species.

In human medicine, PPH occurs more frequently in high-resource countries (partly due to the increasing proportion of cesarean sections being performed) and is a major cause of postnatal morbidity and mortality (9). The likelihood of major hemorrhage is greater in patients following cesarean section compared to vaginal delivery. A recent review evaluated techniques for the management of PPH in humans (10). The literature supports the correction of antenatal anemias (hemoglobin < 90 g/L, assessed at the beginning of the third trimester) as it will minimize the impact of PPH (11). Antenatal anemia is the only modifiable risk factor in women. Nonmodifiable risk factors for PPH include increasing maternal age, obesity, abnormal placentation, multiple pregnancies, and previous cesarean sections (10). Parturient management of hemorrhage, beyond definitive surgical hemostasis, consists of uterotoner treatments. These can be physical (uterine massage) or pharmaceutical, which include oxytocin, and/or additional uterotoner agents (misoprostol, ergometrine, and carboprost) (10). A recent meta-analysis showed that the prophylactic use of the antifibrinolytic agent TXA before the first incision in combination with oxytocin following delivery reduced the incidence of PPH (12).

Hyperfibrinolysis has been documented in trauma, shock, and invasive surgeries in humans and it increases the risk of hemorrhage. Tranexamic acid (and ω-aminocaproic acid) inhibits fibrinolysis by blocking the lysine binding site of plasminogen, thus preventing the formation of plasmin which breaks down fibrin (13). Another factor considered to prevent PPH is early consideration of hysterectomy in patients at risk (10). Based on the risk factors in humans, the patient in the current report was at increased risk due to the cesarean section versus vaginal delivery, being multiparous, not receiving uterotoner agents nor TXA prophylactically, and not having an OVH performed. An investigation into risk factors, as well as prospective studies evaluating the prevalence and prevention of PPH in veterinary species are needed.

The treatment of hypotension in this case required multiple factors to be considered simultaneously. The initial evaluation of the patient before anesthesia suggested presence of mild dehydration, likely due to the dog not eating or drinking normally during the prolonged parturition. One immediate factor which may have been responsible for the hypotension was the use of a lumbosacral epidural anesthetic. Local anaesthetics administered epidurally, alone or combined with an opioid, can cause hypotension by blockade of sympathetic response (14–16). However, epidurals with local anaesthetics limited to the abdominal region cause less hypotension compared to high thoracic epidurals, which also affect sympathetic innervation to the heart leading to decreased heart rate and contractility (16). Interestingly, in the event of PPH in humans, neuraxial analgesia is often recommended (using a rapid acting local anesthetic such as lidocaine) (17). The benefit of local anesthetic boluses through an epidural catheter is the ability to avoid general anesthesia. However, when blood loss is severe (> 1000 mL, approximately > 15 mL/kg BW) neuraxial techniques are to be implemented with caution. The approach to blood loss in the presence of neuraxial analgesia emphasizes preparedness; placement of appropriate cannulas (ideally, 2 large-bore), use of IVFT, vasopressors/inotropes, and considering early implementation of direct arterial blood pressure monitoring (17). In the reported case, despite the administration of several isotonic crystalloid fluid boluses, there was no improvement in the MAP. Given this lack of response, there was the suspicion that this patient was non-fluid responsive, and as a result the authors proceeded to vasopressor and inotropic therapies early on in the anesthetic procedure.

The use of norepinephrine, dopamine, and dobutamine in this case is based on drug availability and preparedness at the authors’ institution. Norepinephrine provides some positive inotropic effect as well as a significant increase in systemic vascular resistance. Dopamine and dobutamine are used for their marked inotropic effect (compared to norepinephrine) (18). As dopamine has a greater chronotropic effect compared to dobutamine, the change to dobutamine was an attempt to remove dopamine as a contributor to the observed tachyarrhythmia in the post-operative period. There are no consensus statements or guidelines regarding the optimal vasopressor or inotrope in hemorrhagic shock in small animals (18). In humans, ephedrine and phenylephrine are commonly used for hypotension secondary to neuraxial techniques during cesarean sections. Of the two, phenylephrine may be a better option as it has been shown to reduce the likelihood of fetal acidosis in elective cesareans (19).

A similar benefit of phenylephrine was seen when compared to norepinephrine (20). Dexamethasone was administered in an effort to correct an undiagnosed hypoadrenocorticism or the downregulation of the adrenergic receptors secondary to the presence of sepsis/systemic inflammatory response or prolonged shock. Retrospectively, the presence of a stress leukogram (Table 1), combined with the elevated baseline cortisol measurement ruled out hypoadrenocorticism.

It is possible that the early implementation of vasopressor and inotropic therapies masked the physiological signs of the uterine hemorrhage, complicating the detection of ongoing hemorrhage. Usually, a reduction in heart rate would be expected following correction of hypovolemia and hypotension. In this case, the minimal change in heart rate may have reflected an ongoing physiological response to hemorrhage. Perhaps greater volumes of crystalloid, hypertonic saline, and/or colloid fluids may have mitigated the prolonged pressure support in this case and the need for transfusion, especially considering blood lactate was within reference range, suggesting that oxygen delivery was sufficient to avoid significant generalised hypoxia and anaerobic metabolism. A greater effort to quantify the blood loss (e.g., weighing absorbent pads) may have provide earlier evidence of an acute hemorrhage and supported the decision to transfuse, though the exact volume remaining in the uterus would have remained unknown.

This report describes the successful management of a case of peripartum hemorrhage in a dog. The severity of this case
resulted in an institutional change in management (24 h hospitalization and serial hematocrit measurements) for dogs undergoing cesarean section without ovariohysterectomy as uterine hemorrhage is not always immediately apparent. Prospective studies investigating the incidence, predisposing factors, prevention, and treatment of peripartum hemorrhage and other complications associated with dystocias and cesarean sections are required.

References

In-hospital medical management of feline urethral obstruction: A review of recent clinical research

Kevin L. Cosford, Siu To Koo

Abstract — Evidence-based medical practice requires that clinical research be conducted to help guide veterinary recommendations. Unfortunately, clinical research on the treatment of feline urethral obstruction (UO) is limited. Over the past decade, a body of clinically relevant scientific literature related to the in-hospital management of feline UO has been published. This review of the literature from December 2007 to February 2019 encompasses management options, stabilization, anesthetic considerations, unblocking procedures, urinary bladder lavage, intravesical treatments, post-obstructive diuresis, urinary catheter management, catheter-associated bacterial complications, and oral medications. Studies are briefly summarized with respect to their main findings and limitations. Common recurring limitations observed include small sample sizes leading to insufficient power and potential type II errors, lack of standardized treatment protocols, and assessment of multiple inter-related confounding variables. The authors' intent is for this article to inform practitioners and inspire future clinical research initiatives which address these limitations, possibly with large-scale multicenter studies, standardized treatment protocols, and multivariate regression modeling.

Résumé — Gestion médicale en hôpital d’obstruction urétrale féline : Revue descriptive de la recherche clinique. La pratique médicale factuelle nécessite que de la recherche clinique soit menée afin d’aider à guider les recommandations vétérinaires. Malheureusement, la recherche clinique sur le traitement de l’obstruction urétrale féline (UO) est limitée. Au cours de la dernière décennie, un ensemble de publications cliniques scientifiquement pertinentes à la gestion en hôpital d’UO féline a été publié. Cette recension de la littérature de décembre 2007 à février 2019 incluait les options de gestion, la stabilisation, les considérations anesthésiques, les procédures de déblocage, le lavage de la vessie urinaire, les traitements intravésical, la diurèse post-traitement, la gestion des cathéters urinaires, les complications bactériennes associées aux cathéters et les médications orales. Les études sont résumées brièvement en lien avec leurs trouvailles principales et leurs limitations. Les limitations récurrentes observées fréquemment incluaient les petites tailles d’échantillonnage entrainant une puissance insuffisante et des erreurs de type II potentielles, un manque de standardisation des protocoles de traitement et l’évaluation de multiples variables confondues interreliées. L’intention des auteurs est que le présent article informe les praticiens et inspire de futures initiatives de recherche clinique qui vise ces limitations, possiblement avec des études multicentres de grande envergure, des protocoles de traitement standardisés et de la modélisation de régression multivariée.

(Traduit par Dr Serge Messier)
Introduction

Feline urethral obstruction (UO) remains a commonly encountered emergency for small animal practitioners. Underlying causes and approximate historical incidence rates include idiopathic obstructions (54%), urethral plugs (20%), urolithiasis (20%), and other mechanical obstructions such as strictures and neoplasia (collectively, < 5% of cases) (1,2). Survival to discharge rates are high (91% to 94%) (3–5). Reported UO recurrence rates range from 11% to 58% at various time points after initial presentation (4–8). However, the long-term survival rate varies depending upon multiple factors such as client considerations, recurrence, and complications. Gerber et al (4) reported a 91% survival to discharge rate but 51% had recurrent signs, 36% experienced re-obstruction, and 21% were eventually euthanized, which suggested a guarded long-term prognosis.

Over the past decade, numerous interesting clinical research projects have been conducted on the in-hospital treatment of feline UO classified as idiopathic or secondary to urethral plugs. A review of the literature between December 2007 and February 2019 using Pub Med, Google Scholar, Web of Science and Scopus as search engines with the term “feline urethral obstruction” was conducted. This article is neither a tutorial of feline UO management nor an exhaustive systematic review. The authors’ objective is to outline the main findings and limitations of clinical research over the past decade, relating specifically to medical management decisions performed or initiated in-hospital.

Management options

In hospital versus outpatient management

Seitz et al (9) explored whether an outpatient intervention involving one-time catheterization and no IV fluid therapy was a viable alternative to the standard protocol employing an indwelling urinary catheter, IV fluids, and other supportive treatments. In this nonrandomized, non-blinded, prospective-cohort study, conducted at a private emergency service, client-owned male cats with naturally occurring urethral obstruction (NAUO cats) (n = 107; 91 finished the study) were enrolled in the inpatient group (n = 46) if clients accepted standard treatment or the outpatient group (n = 45) only when traditional care was declined. Groups were matched by signalment, metabolic compromise, urinalysis, and supportive treatments. Nineteen cats experienced a recurrent urethral obstruction (rUO): 11% (5/46) in the inpatient group and 31% (14/45) for outpatients. The risk of rUO within 30 d was significantly greater [odd’s ratio (OR), 3.7; 95% confidence interval (CI), 1.2 to 11.4] in the outpatient group than for inpatients. The results of this clinically relevant research endeavor support traditional inpatient therapy over outpatient management with respect to decreasing the risk of rUO within 30 d.

The main limitation is that the study is observational with owner-determined treatment groups rather than random assignment to the intervention. The clinician-client relationship can be influenced by a multitude of factors, leading to 1 group designation over another. This introduces possible selection bias as a result of the decision-making process. Although random assignment represents appropriate study design, it would not be considered ethical to intentionally treat a group of patients in a novel manner (1-time catheterization protocol) without offering standard-of-care therapy (traditional management) to every client. The sample size of this study was considered appropriate to test the primary hypothesis (1-time catheterization relative to traditional management), but speculated to be too small and underpowered with respect to evaluating the potential relationship of secondary factors to rUO.

Nontraditional management without passing a urinary catheter

Cooper et al (10) described a controversial nontraditional protocol offered to clients declining standard-of-care treatment at an academic emergency service. This protocol treats UO from a functional perspective and may facilitate passage of the obstructive material by utilizing a combination of sedatives and analgesia, intermittent decompressive cystocentesis, a low stress quiet room, and subcutaneous fluids as needed. A traditional unblocking procedure is not performed. Exclusion criteria were abnormal clinical findings (i.e., bradycardia, hypothermia, or unresponsive mentation), severe metabolic acidosis and hyperkalemia, and radiographic evidence of cystic or urethral calculi.

In this nonrandomized, non-blinded prospective observational study of NAUO cats (n = 15), spontaneous urination within 72 h, resulting in hospital discharge, was observed in 11 of the 15 cats without the need for urethral catheterization. The 4 cats that failed the intervention developed complications including uroabdomen (3 cats) or hemoabdomen (1 cat). Overall, cystocentesis was performed 3 times (range: 1 to 10 times) in each cat, but 7 times (range: 4 to 11 times) in those cats failing treatment. Repeated cystocentesis over a short period of time may have predisposed patients to uroabdomen. In addition to the small sample size limiting generalizations to a larger population of NAUO cats, this observational study lacks direct comparison of the patient cohort treated with nontraditional management to a group treated with standard-of-care therapy.

Based on these 2 studies investigating controversial alternative management options, clinicians should continue to initially offer standard-of-care treatment for all cases. If traditional management is declined, clinicians should consider a novel protocol as an alternative to euthanasia if appropriate.

Stabilization

Fluid management

Choice of fluid

Fluid therapy is routinely used in the treatment of feline UO for volume support, and addressing potassium and acid-base derangements (11,12). Traditionally, potassium-deficient 0.9% physiologic saline solution was believed to be the best option for treating hyperkalemia compared with potassium-containing replacement fluids (e.g., LRS, Normosol-R), as the latter were presumed to be contraindicated. However, due to the acidifying properties of physiological saline solution (PSS), concerns arose regarding its ability to resolve and potentially exacerbate metabolic acidosis (11).
Two studies compared alkalinizing balanced electrolyte solutions (BES) (LRS and Normosol R) to PSS (13,14). In a randomized, non-blinded study of 10 cats with experimentally induced UO at an academic institution, the PSS treated group \( (n = 5) \) had significantly lower blood pH, bicarbonate, and base excess values at multiple time points over the 48-hour post-unblocking period compared to the LRS treated group \( (n = 5) \) (13). Groups were matched by body weight, rectal temperature, heart rate, respiratory rate, and hematologic, biochemical, and venous blood gas-electrolyte parameters, but not blood glucose concentration. Fluid type did not influence normalization of serum potassium or the rate at which it rapidly with the use of Normosol-R compared to saline at multiple time points over a 12-hour post-unblocking period. Groups were matched by breed, age, body weight, hydration status, and venous blood gas-electrolyte and biochemical parameters, but not blood glucose concentration. Fluid type did not influence normalization of serum potassium or the rate at which it occurred in either of these 2 studies. Compared with physiologic saline solution, balanced electrolyte solutions more rapidly resolved metabolic acidosis. Neither exacerbated hyperkalemia nor affected its resolution.

Although the experimental model used by Cunha et al (13) induced anticipated blood-gas and cardiovascular complications to allow for consistent sampling times, the naturally occurring disease state was not studied. A small sample size of normal cats in an experimental model at an academic institution limits generalizability to the larger NAUO cat population. In contrast, Drobotz and Cole (14) studied NAUO cats, but the clinical setting does not allow for strict standardization of therapy and introduces multiple confounding factors. To exemplify this limitation, 1 of the measured outcomes was serum potassium, but some of the cats received fluid therapy alone while others also received insulin and dextrose, all of which impact this electrolyte. Fortunately, repeat analysis, excluding patients receiving insulin and dextrose, did not change the results of this study.

Practitioners will have to make decisions regarding fluid therapy on a case by case basis. Both balanced electrolyte solutions and physiologic saline solution are appropriate for hyperkalemia management and initial stabilization.

**Fluid overload**

Fluid therapy is a prescription requiring ongoing reassessment due to the risk of volume or fluid overload (FO) (15). In a nonrandomized, non-blinded, retrospective case-control study of NAUO cats presented to an academic emergency service, a FO-group \( (n = 11) \) and a control-group \( (n = 51) \) selected from the same time period were evaluated for risk factors. FO was defined as the development of respiratory distress from either pulmonary edema or pleural effusion while receiving intravenous crystalloid fluids during UO treatment (16). Groups were matched by age, body weight, previous lower urinary tract disease (LUTD) episodes, and biochemical parameters, but not heart rate and serum sodium concentration.

Significant risk factors for FO were identified, including the administration of a fluid bolus at presentation (OR: 5.1; 95% CI: 1.3 to 20), and the development of a heart murmur (OR: 4.5; 95% CI: 1.1 to 18) or gallop sound (OR: 75; 95% CI: 8.1 to 694) during treatment. The development of fluid overload in this study was associated with increased cost (2.9x) and longer duration of hospitalization (4.1 versus 1.8 d) but had no effect on mortality rate. Lack of standardized diagnostic and treatment protocols, small sample size, and case misclassification, due to challenges retrospectively identifying FO cases, limit the generalizability of this study to the larger feline UO population. Thoracic radiographs and cardiac ultrasound ideally would have been performed before and after FO treatment to distinguish between FO of iatrogenic and cardiac origin.

This study emphasizes the importance of monitoring and reassessment of fluid therapy, especially in the presence of a gallop rhythm or heart murmur, and after administering a crystalloid bolus.

**Decompressive cystocentesis**

Decompressive cystocentesis is indicated in some situations, particularly difficult or delayed unblocking procedures. Routinely performing decompressive cystocentesis before the unblocking procedure is considered part of standard of care in some practice settings, though there is not currently supportive evidence. The main potential benefits include immediate emptying of the urinary bladder to relieve pain and to facilitate retrohydropulsion of the obstructive material, and passage of a urinary catheter by decreasing intraluminal pressure. An uncontaminated sample can also be collected by cystocentesis for urinalysis and culture. Major concerns revolve around the potential for iatrogenic trauma to further compromise the urinary bladder wall resulting in rupture and uroabdomen (11,17).

A nonrandomized, non-blinded, retrospective observational study evaluated the effect of routine decompressive cystocentesis in NAUO cats \( (n = 47) \) presenting to an academic emergency service (17). Evidence of abdominal effusion was present on survey abdominal radiographs in 19/34 (56%, 95% CI: 39% to 72%) cats undergoing radiography. However, none of the cats were definitively diagnosed with a urinary bladder rupture after decompressive cystocentesis. It is speculated that a transient, clinically insignificant abdominal effusion may have been present in some cats. The authors compared survival to discharge, duration of catheterization, and length of hospitalization to previously reported studies and detected no differences. The main limitation of this study is the lack of a true control group, in which decompressive cystocentesis was not performed prior to the unblocking procedure.

To address this issue, an important ongoing randomized, non-blinded multicenter prospective clinical trial known as the DECYST TRIAL is attempting to evaluate the effect of a decompressive cystocentesis before urinary catheterization (decompressive cystocentesis group) versus no intervention before urinary catheterization (UC group) (18). Interim analysis was published as an abstract in 2017. NAUO cats \( (n = 69) \), presenting to 2 academic emergency services, were randomly assigned to the decompressive cystocentesis group \( (n = 35) \) and UC group \( (n = 34) \). No complications related to decompressive cystocentesis, including uro- or hemo-abdomen, were observed.
There were no significant between-group differences with respect to ease of catheterization scores, time to place urinary catheter, duration of catheterization and hospitalization, incidence of rUO, and concentrations of serum potassium, BUN, and creatinine. Although these interim results negate an interventional effect, it is still possible with further case recruitment that the finalized study will have the power to detect between-group differences.

Until the results of this study are published, clinicians will continue to use their judgment on the role of decompressive cystocentesis in UO management.

**Anesthetic considerations**

**Protocols**

Numerous anesthetic protocols have been used or suggested in feline UO (19,20). In the authors' opinion, there is a striking paucity of clinical research comparing 2 anesthetic protocols for feline UO in a head-to-head manner. A single randomized, non-blinded study was identified in which ketamine [10 mg/kg body weight (BW)] with diazepam (0.5 mg/kg BW) was prospectively compared to propofol (5 mg/kg BW) using a model of experimentally induced UO in normal cats (n = 10) at an academic institution (21). Groups were matched by most venous blood gas-electrolyte and biochemical parameters, except total plasma protein and albumin. During recovery, time to standing was significantly shorter in the propofol group (16 min; range: 10 to 20 min) versus the ketamine-diazepam group (75 min; range: 45 to 90 min), but the quality of recovery appeared to be similar. Laboratory changes such as acid-base disturbances, azotemia, and electrolyte abnormalities stabilized in a similar manner between groups. Generalizability is limited because of the small sample size, and the use of an experimental UO model versus studying the naturally acquired disease state.

**Coccygeal epidural**

A 12-month nonrandomized, non-blinded, observational study of NAUO cats (n ≥ 15) treated with coccygeal epidurals at a private emergency service has been reported as a brief clinical communication (22). A coccygeal epidural provides local analgesia to the perineum, tail, penis, urethra, colon, and anus. This report focused on describing the technical aspects of performing a coccygeal epidural including observations with respect to the possible efficacy of the block. Potential benefits proposed included minimal additional anesthetic and analgesic requirements in most cases, during both the unblocking procedure itself and the post-unblocking period. Performing the coccygeal epidural was also reported to be relatively simple requiring only 1 attempt in most cases. The biggest limitations of this observational study are the lack of both objective study outcomes (i.e., no data) and a placebo-group. In future research, possible objective study outcomes might include time to pass a urinary catheter during unblocking, ease of catheterization scores, and post-procedure pain scoring.

Further investigation is warranted with respect to anesthetic protocols and coccygeal epidurals for the clinical management of feline UO.

**Unblocking procedure and urinary bladder lavage**

**Intraurethral atracurium besylate**

The male feline urethra is narrow and consists of striated muscle distal to the prostate, which is the location of most obstructions (23). Nicotinic acetylcholine receptors on the postsynaptic motor endplate of the neuromuscular junction are competitively inhibited by atracurium besylate, resulting in relaxation of the striated urethral musculature (24).

A novel nonrandomized, non-blinded, placebo-controlled, prospective clinical trial investigated the potential for intraurethral atracurium besylate to facilitate the unblocking procedure in NAUO cats (n = 45) presenting to an academic emergency service (24). Both atracurium besylate (n = 25) and physiologic saline solution (n = 20) groups were matched for age and weight. The time required for the removal of the UO was significantly shorter in the atracurium besylate group (21.1 ± 16.2 s) versus the physiologic saline solution group (235.2 ± 132.4 s). The proportion of studied cats in which the urethral plug was removed at the first attempt was significantly higher in the atracurium besylate group (64%, 16/25) than in the physiologic saline solution group (15%, 3/20). No side effects were reported. Cats were segregated into either group in an alternating fashion as they were enrolled, but not truly randomized. The lack of clinician blinding with regard to the intervention may affect an individual's perception of and approach to the unblocking procedure, impacting the study endpoint (time required to pass the urinary catheter).

To the authors' knowledge, intraurethral atracurium besylate is not commonly used in small animal practice as a treatment option for feline UO. Further investigation is needed to understand the efficacy and safety of this novel approach.

**Urinary bladder lavage**

Traditionally, urinary bladder lavage has been recommended following relief of the obstruction and catheter placement (20). Despite the widespread practice of urinary bladder lavage, it was only recently evaluated in a randomized, non-blinded, placebo-controlled, prospective clinical study of NAUO cats (n = 137) presenting to an academic emergency service (25). After the unblocking procedure and catheter placement, urinary bladder lavage was performed using physiologic saline solution until the retrieved fluid was clear with volumes ranging from 50 to 500 mL. Both Flush- and No Flush-groups were matched by the following relevant factors: age, body weight, neuter status, previous blocking history, and presence of crystalluria. It was found that the practice of urinary bladder lavage had no impact on in-hospital UO recurrence rates (Flush, 13% vs. No Flush, 19% [13/68]). Duration of urinary catheterization (Flush, 37 h; range: 3 to 172 h vs. No Flush, 36 h; range: 1 to 117 h), or duration of hospitalization (Flush, 3 d; range: 0.5 to 12 d vs. No Flush, 3 d; range: 1 to 9 d). Study limitations potentially affecting these outcomes include the lack of standardization for other aspects of medical treatment, the decision not to assess azotemia as an independent risk factor, and the non-blinded study design. Finally, a lower than expected
The recurrence rate may also suggest that the study was underpowered to detect between-group differences.

Small animal practitioners will need to continue to use their judgment on a case-by-case basis, as further research is needed to determine if there is truly no benefit to urinary bladder lavage during the management of feline UO.

Intravesical treatments

Glycosaminoglycans

Healthy urothelium is covered with a layer of glycosaminoglycans and glycoproteins (26). Significantly decreased urine glycosaminoglycan:creatinine ratios have been observed in cats with idiopathic cystitis compared with normal cats, suggesting a defect in the glycosaminoglycan layer of the uroepithelium (26,27). A number of clinical research studies have failed to demonstrate a beneficial effect of intravesical pentosan polysulfate sodium treatment (n = 18) over placebo (n = 17) for any of the study endpoints, including rUO rates and clinical scores based on demeanor, appetite, and abdominal pain (29). The main limitations of this study include a small sample size and missing data points, as samples were not collected at all time points, leading to the suspicion of insufficient statistical power and a Type II error.

Alkalized lidocaine

A preliminary clinical study of once daily intravesical alkalized lidocaine treatment over 5 d for interstitial cystitis in humans reported amelioration of clinical symptoms in the treatment group versus placebo (30). This novel treatment has been recommended in human guidelines for the treatment of bladder pain syndrome or interstitial cystitis. Lidocaine’s mechanism of action may be the control of neuropathic pain and inflammation. The alkalization of sodium bicarbonate converts lidocaine, a weak base, from its water-soluble ionized form to a lipid-soluble non-ionized form that can penetrate the urinary bladder wall (8,30).

In veterinary medicine, a randomized, non-blinded, placebo-controlled, prospective clinical trial was conducted to investigate the potential effect of intravesical alkalized lidocaine treatment in NAUO cats (n = 26) (Table 1) (8). The primary study endpoint was the determination of overall re-obstruction rates, for which no between-group differences were observed [treatment group 58% (7/12) and control group 57% (8/14)]. The secondary study endpoint consisted of amelioration scores defined as improvements, relative to baseline, in client assessments of clinical sign severity at 2 wk, 1 mo, and 2 mo after the study.

### Table 1. Intravesical treatments.

<table>
<thead>
<tr>
<th>Reference</th>
<th>Study type</th>
<th>Population, groups (Gs), and matched factors (MFs)</th>
<th>Treatment protocol</th>
<th>Main findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>(28)</td>
<td>Prospective placebo-controlled PILOT clinical trial — Randomized — Blinded</td>
<td>• Population: 16 NAUO cats, academic ER. • Gs: GAG (2.5 ml GAG + 1 ml PSS), n = 9 and PSS (3.5 ml), n = 7. • Mf: pain scores, [creatinine] and [K⁺], but NOT USG, and urine protein. Previous UO episodes approached significance.</td>
<td>Intravesical GAG or PSS administered by UC at 0, 12, and 24 h with a 1 h retention time. Follow-up period 7 d.</td>
<td>• 7-day rUO rates in the GAG group 0/9 (0%) and control group 3/7 (42.9%) approached statistical significance.</td>
</tr>
<tr>
<td>(29)</td>
<td>Prospective placebo-controlled clinical trial — Randomized — Double-blinded</td>
<td>• Population: 35 NAUO cats, academic ER. • Gs: PPS (30 mg in 10 ml PSS), n = 18 and PSS (10 ml), n = 17. • Mf: symptomatology, PE findings, and laboratory parameters i.e., [BUN], [creatinine], and [K⁺].</td>
<td>Intravesical PPS or PSS administered by UC at 0, 24, and 48 h with a 30-min retention time. Follow-up period 5 d.</td>
<td>• 5-day rUO rates in the PPS group 3/18 (16.7%) and the control 3/17 (17.6%) were similar.</td>
</tr>
<tr>
<td>(8)</td>
<td>Prospective clinical trial — Randomized — Non-blinded</td>
<td>• Population: 26 NAUO cats, academic ER. • Gs: AL, n = 12 (2 mg/kg BW lidocaine + NaHCO₃, n = 4; and 4 mg/kg BW lidocaine + NaHCO₃, n = 8); Control, n = 14 (Isovolumetric PSS + NaHCO₃, n = 8; and no intravesical control if temperament not permitting, n = 6). • Mf: age, breed, [BUN], [creatinine], [K⁺], and previous LUTD episodes, but NOT body weight.</td>
<td>Intravesical AL or control administered by UC every 24 h for a maximum of 3 d with a 1 h retention time. Client follow-up at 2 wk, 1 mo, and 2 mo.</td>
<td>• Overall rUO rates in the AL group 7/12 (58%) and the control group 8/14 (57%) were similar.</td>
</tr>
</tbody>
</table>

NAUO cats — client-owned male cats with naturally acquired urethral obstruction; UO — urethral obstruction; ER — emergency room; GAG; glycosaminoglycans; PSS; 0.9% physiological saline; UC — urinary catheter; PPS — pentosan polysulfate sodium; rUO — urea nitrogen concentration; [creatinine] — serum creatinine concentration; [K⁺] — serum potassium concentration; LUTD — lower urinary tract disease; AL — alkalized lidocaine; AS — amelioration scores (improvement in clinical signs provided as a score); SD — significant difference.
discharge. No between-group differences were found for most individual clinical signs and composite scores with one exception. Straining to urinate was associated with an increased amelioration score (improvement in straining to urinate) at 2 wk in the treatment group compared to the control group. Overall, follow-up data from only 11 cats, including 5 in the treatment group and 6 in the control group, were available for analysis of the secondary study endpoint. Limitations of this study include: a small sample size, lack of blinding of clients to the intervention, use of different lidocaine dosages in the treatment group, failure of some cats in the control group to receive intravesical placebo due to temperament, recall bias, and low case numbers for which follow-up was available for the secondary study endpoint.

There has not been widespread adoption of intravesical glycosaminoglycans or alkalized lidocaine in clinical practice as their role in the treatment of feline UO remains uncertain.

**Post-obstructive diuresis**

The use of an indwelling urinary catheter for the measurement of urine output allows for individualized patient fluid therapy. Post-obstructive diuresis is defined as urine production of greater than 2 mL/kg BW/h (31,32). A nonrandomized, non-blinded, retrospective study of NAUO cats (n = 32), presenting to an academic emergency service, reported an overall post-obstructive diuresis rate of 46% (13/28), which appeared to increase throughout the 84-hour measurement period (31). However, neither fluid rate nor total volume received by this study population was controlled. It was consequently impossible to discriminate between diuresis due to fluid therapy and true post-obstructive diuresis.

Another nonrandomized, non-blinded, retrospective study of NAUO cats (n = 57) presenting to an academic emergency service observed that the frequency of post-obstructive diuresis changed from 87.7% (50/57) to 36.8% (21/57) if fluid therapy was taken into consideration as a factor (32). In other words, fluid therapy may significantly affect the observed incidence of post-obstructive diuresis (32). The influence of fluid therapy on post-obstructive diuresis was determined by: i) correlating fluid rate at time “x” with urine output at time “x + 1,” and ii) defining post-obstructive diuresis in relation to fluid therapy (post-obstructive diuresis<sub>Fr</sub>) as urine output greater than the administered amount of IV fluids on at least 2 subsequent time points. There was a significant correlation between IVFT at time “x” and urine output at time “x + 1” at most time points. The authors of the article proposed that adjusting fluid therapy based upon urine output may exacerbate post-obstructive diuresis and go beyond actual requirements in some patients (32).

It was also observed in both studies that patients with acidemia were more likely to have post-obstructive diuresis. Francis et al (31) observed that acidemia (pH < 7.35) was associated with a 5-fold increase in post-obstructive diuresis over the entire study period, while Frohlich et al (32) observed that venous pH (< 7.27) and bicarbonate levels (< 15 mmol/L) were inversely correlated with urine output during the first 4 h, but not beyond that time point (32). The findings of Frohlich et al (32) call into question the role of these 2 blood gas parameters in the pathophysiology of post-obstructive diuresis, suggesting an association but not necessarily causation.

Given that true post-obstructive diuresis and iatrogenic (fluid driven) post-obstructive diuresis cannot be readily differentiated, small animal practitioners will need to utilize clinical judgement and close patient monitoring to guide decision-making on a case-by-case basis. In future clinical research endeavors, it would be prudent to develop a rigorous definition of post-obstructive diuresis that corrects for fluid therapy, which will further elucidate the role of fluid therapy relative to other factors.

**Management of indwelling urinary catheter**

**Size of indwelling urinary catheter**

Theoretically, a larger diameter indwelling urinary catheter has 2 potential benefits by preventing the following: obstruction of the lumen from kinking, debris, or clots; and urine leakage around the catheter (6,11). Alternatively, it is possible that the larger diameter catheter results in more irritation and inflammation. In 2013, two studies reported on the relationship between the size of an indwelling urinary catheter and rUO, the latter served as a primary outcome measure.

A nonrandomized, non-blinded, retrospective study (6) of NAUO cats (n = 192, 163 with complete data at 24 h), presenting to a private emergency service, identified a significantly lower rate of rUO at 24 h post-indwelling urinary catheter removal with the use of a 3.5-French (6.67%, 7/105) versus 5-French (18.97%, 11/58) catheter. Groups were matched by age, rectal temperature, body weight, and proportion of cats with azotemia or hyperkalemia at presentation. An association between catheter size and rUO was identified at 24 h but not 30 d post-indwelling urinary catheter removal. The major limitation of this study is the potential for confounding effects due to the assessment of multiple parameters over different time periods in a clinical setting without standardized treatment protocols (6,11,33).

A nonrandomized, non-blinded, prospective case series (7) of NAUO cats (n = 83, 68 with complete data) presenting to 3 private emergency services did not document an association between catheter size (3.5- versus 5.0-French) and rUO rate. Recurrent UO- (n = 10) and no recurrent UO- (n = 58) groups were matched by body weight, azotemia, venous blood gas-electrolyte parameters, urine pH, USG, crystalluria, radiographic findings, duration of hospitalization, IVFT, and critical illness category, but NOT age and breed. Mixed-breed and older cats [median, 8.2 y (range: 2.1 to 14)] were more likely to be associated with the rUO group, while purebred and younger cats [median, 4 y (range: 0.5 to 15)] were overrepresented in the no rUO-group. Case enrolment was prospective to facilitate short-term follow-up when determining the incidence of rUO, thereby minimizing recall bias. The main limitations of this observational study include the lack of random case assignment to controlled treatment groups, a small sample size with a low rate of rUO (15%), and a large number of study variables with potential confounding relationships to one another.
Decision to remove indwelling urinary catheter

Duration of indwelling urinary catheter placement

The pathophysiologic basis for recommending a longer duration of catheterization includes time for resolution of post-obstructive diuresis, detrusor atony, lower urinary tract inflammation (urethritis and cystitis), and urinary characteristics such as abnormal urine color, debris, clots, and crystals. It may also allow time for antispasmodic medications to take effect (7,9,11). When evaluating the duration of indwelling urinary catheterization (IUC) and its relationship to rUO rates, these indications for urinary catheter placement and maintenance likely also serve as confounders.

Duration of IUC and rUO rates have been evaluated as primary outcome measures in 2 retrospective studies and a secondary outcome in 1 prospective clinical trial. Hetrick et al (6) reported no association between rUO and duration of IUC. In contrast, Eisenberg et al (7) reported that longer duration of IUC was associated with a lower probability of short-term rUO. In this study (7), rUO was associated with a shorter duration of IUC (24.5 h, range: 1 to 54 h); and no rUO was associated with a longer duration of IUC (26.5 h, range: 12 to 92 h). A 2018 nonrandomized, non-blinded, prospective cohort study (9) of NAUO cats (n = 107, 91 with complete data), presenting to a private emergency service, found no relationship between duration of IUC and rUO rates.

Abnormal urine color

Seitz et al (9) identified an association between rUO and abnormal urine color at the time of catheter removal. Improvement in the color and clarity of the urine may serve as a better indicator to support indwelling urinary catheter removal, rather than focusing on a preset minimum urinary catheterization time such as 24 to 48 h (11). It should be noted that gross urine color characteristics were subjectively determined in this study with no standardized descriptive scale or pictorial reference, which should be considered in future research (9).

The biggest limitation of these studies investigating indwelling urinary catheter management is the inability to assess the effect of 1 factor in the dynamic, ever-changing clinical setting. There are numerous highly inter-related measured outcomes which vary over time, by a myriad of patient, clinician, hospital, and client factors. Multivariate regression analysis might be employed to elucidate the role of inter-related, confounding factors. However, given the observational nature of these studies, there was no attempt to standardize treatment protocols to minimize some of these variable influences. As a result, the data set generated by these observational studies can preclude multivariate regression model-building (7). Finally, the analysis of multiple parameters may result in statistical significance due to chance alone rather than underlying clinical significance.

Until more conclusive evidence exists to guide indwelling urinary catheter management, clinicians are encouraged to develop patient-specific treatment plans, while taking many factors into consideration.

Catheter-associated bacterial complications

Historically, the incidence of bacteriuria has been observed to increase after 3 d of both open and closed IUC, supporting a direct relationship between duration of catheterization and incidence of bacteriuria (34,35). Two prospective studies of NAUO cats presenting to academic emergency services addressed: the method of urine collection; the number of colony-forming units (CFUs) used as cut-off points; the timing of sample collection; and the use of strict urinary catheter management. These studies did not document positive urine cultures in any of the cases at presentation (0/18 and 0/34) (36,37). After IUC, positive urine cultures occurred within 24 h in 13% (4/31) of cases in 1 study and 16.7% (3/18) in the other. In the second study, 48-hour cultures were positive in 33% (6/18) of cases (36,37). Organisms identified included Escherichia coli, Staphylococcus, Streptococcus, and Pasteurella. A small sample size and strict urinary catheter management protocol may limit the ability to generalize these findings to the larger population of NAUO cats. However, these study findings emphasize the low incidence of primary bacterial cystitis in cases of feline UO and the risk of bacterial colonization or infection after urinary catheterization.

The recently published 2019 ISCAID guidelines for the diagnosis and management of bacterial urinary tract infections in dogs and cats are an invaluable clinical resource (38). Catheter-associated asymptomatic bacteriuria (CA-ASB) is thought to represent a transient colonization of the lower urinary tract versus a true catheter-associated urinary tract infection (CAUTI) (38). Bacterial colonization is not predictive of cystitis and is likely to self-limiting once the urinary catheter is removed (38). Current recommendations do not support antimicrobial treatment of asymptomatic bacteriuria (38).

It is very challenging for clinicians to differentiate between clinical signs related to the primary LUTD and CAUTI. The presence of lower urinary tract signs along with fever, bacteremia of unknown focus, sudden changes in character of the urine (gross appearance and odor), concurrent illness, and patient risk factors must all be considered before initiating antimicrobial therapy (38). A urine culture collected by cystocentesis should be submitted to guide therapy if CAUTI is suspected (38). Cultures of the catheter tip are not recommended (38).

To the authors’ knowledge, widely adopted good practice guidelines for the placement and maintenance of urinary catheters specifically in cats undergoing UO treatment, unfortunately, do not exist. A survey of UK veterinarians highlights the need for the development of such guidelines to minimize catheter-associated bacterial complications (39). Responding veterinarians self-reported on the standards of care used during their most recent placement of a urinary catheter: 73% used antibiotic therapy while the urinary catheter was in situ; 66% used open urine drainage (not a closed collection system); 59% did not use aseptic hand preparation of the prepuce and perineum; and 40% did not use aseptic skin preparation of the prepuce and perineum; and 40% did not use aseptic hand preparation and gloving (39).

Oral medications

Prazosin

Despite widespread acceptance of urethral spasm as a concept in veterinary medicine, this phenomenon has never been
definitively proven to occur. The only study attempting to document urethral spasm involves 6 NAUO cats at an academic institution (40). Urethral pressures were high in only 1 cat, and normal to low in the remaining 5 animals. General anesthetic was used in this study, which may have decreased urethral tone.

It is challenging to advocate for a pathophysiological basis, known as grade IV evidence, upon which α1-adrenergic antagonists might work (11,33). Most obstructions occur within the distal not the proximal portion of the male feline urethra (11,33). However, the proximal 28% to 37% of the male feline urethra consists of smooth muscle under the influence of α1-adrenergic activity, while the distal portion consists of striated skeletal muscle that is not under the same neurogenic control (11,23,33). Obstruction in the proximal urethra may occur secondary to irritation, inflammation, and urethral spasm post-catheterization (11). Proximal urethral spasms might contribute to rUO that is separate from the initial inciting cause, which could justify the use of α1-adrenergic antagonists (33).

Even though α1-adrenergic antagonist use remains controversial, these medications are routinely used in small animal clinical practice (11,33). Prazosin, a selective α1-adrenergic antagonist, has supplanted phenoxycbenzamine, a non-selective α1- and α2-adrenergic antagonist as the medication of choice for feline UO due to its presumably shorter time to onset of action, and targeted activity (6,11). Prazosin is believed both to inhibit α1-adrenergic receptors in smooth muscle, and to reduce the activity of central sympathetic neurons without the sedative effects associated with acepromazine (11,41).

Conflicting study results have been reported for prazosin use in the routine management of feline UO. A nonrandomized, non-blinded retrospective study of NAUO cats (n = 192, complete data for 186 cases at 24 h and 151 cases at 30 d), presenting to a private emergency service, identified significantly lower rates of rUO with prazosin compared to phenoxycbenzamine at 24 h [7.1% (10/140) versus 21.7% (10/46)] and at 30 d [18.2% (20/110) versus 39.0% (61/41)] post-indwelling urinary catheter removal (6). Groups were matched by age, rectal temperature, body weight, and proportion of cats with azotemia or hyperkalemia at presentation. A subsequent randomized, double-blinded, placebo-controlled prospective clinical trial of NAUO cats (n = 47) presenting to an academic emergency service did not identify differences between prazosin- (n = 27) and placebo- (n = 20) groups with respect to the rUO rates prior to discharge [7% (2/26) versus 5% (1/19)], and at 1 mo [15% (4/26) versus 17% (3/18)] and 6 mo [37% (7/19) versus 31% (4/13)] post-discharge (42). Groups were matched by age, body weight, body condition score, vaccination status, environment, diet, number of litter trays, number of other cats in household, previous episodes of UO, and venous blood gas-electrolyte parameters, but not previous episodes of LUTD.

Proposed explanations for these contradictory results involve the prazosin dosage administered, and differences between the animals randomized to the prazosin- and placebo-groups. The dosing of prazosin ranged from 0.5 to 1 mg/cat by mouth every 12 h in the retrospective study (6). In comparison, the prospective study consistently used 0.25 mg/cat by mouth every 12 h for 30 d (42). Reineke et al (42) proposed that it is possible the higher dosages in the retrospective study account for the significant differences observed between the prazosin and phenoxycbenzamine groups, but not the prazosin- and placebo-groups in their prospective study. A second possible explanation for the discordant findings of these 2 studies is that the potential beneficial treatment effect of prazosin was masked as the groups were not matched by episodes of previous LUTD [prazosin-group had higher rates 44% (12/27) versus placebo-group 10% (2/20)] (42). Consequently, Reineke et al (42) speculate that the cats in the prazosin-group were more likely to have episodes of LUTD and, therefore, increased risk of rUO, rendering detection of a treatment effect more difficult.

Reineke et al (42) reported on additional outcomes. Prazosin was associated with significantly shorter duration of IUC and hospitalization. Although prazosin treatment may result in shorter times from urinary catheter removal to voluntary urination and thereby decreased hospitalization times, a multitude of other patient factors could act as confounders. An explanation for how prazosin might shorten the duration of IUC remains elusive, possibly suggesting statistical but not clinical significance. The severity of LUTD was also reported by owners at 1, 2, 3, and 4 wk after hospital discharge. No significant between-group differences were identified. Adverse side effects reported include lethargy, anorexia, ptyalism, diarrhea, and malodorous stool.

The main limitations associated with these studies relate to the type of study. It is highly suspected that the retrospective study assessed many related variables over different time periods, thereby confounding measured outcomes and limiting potential interpretation (6,11,33). The prospective study had a small sample size and low incidence of rUO, raising the suspicion of a type II error (42). For example, Reineke et al (42) reported that rUO rates of 15% (4/26) in the prazosin-group and 17% (3/18) in the placebo-group were associated with a power of only 0.04 to detect between-group differences. Post study power analysis revealed that in order to attain a power of 0.8 and alpha < 0.05, 1149 cats and 766 cats were required for enrolment in the prazosin- and placebo-groups, respectively. If α1-adrenergic antagonists have a modest treatment effect, it will require larger sample sizes to demonstrate the effect.

The controversy over the use of α1-adrenergic antagonists in the scientific literature will likely continue to be a topic of debate and research. Until resolved, prazosin remains part of standard therapy for most practitioners.

NSAIDs
Non-steroidal anti-inflammatory drugs (NSAIDs) are commonly used in the treatment of feline LUTD. A retrospective study by Hetrick et al (6) did not report a beneficial effect of meloxicam in the treatment of feline UO. Substantial challenges exist with the assessment of pain in retrospective studies, necessitating the need for prospective, placebo-controlled clinical trials.

The use of oral meloxicam was recently evaluated in a 2016 randomized, double-blinded, placebo-controlled, prospective clinical trial of NAUO cats (n = 37) presenting to an academic emergency service (43). Meloxicam- (n = 18) and placebo- (n = 19) groups were matched by age, body weight, and parameters associated with hematology, biochemistry, venous blood
gas-electrolyte analysis, and urinalysis. Groups were not matched at presentation by episodes of previous LUTD, macroscopic hematuria and ionized calcium. A 0.1 mg/kg BW dose of an oral meloxicam suspension was administered 24 h following presentation, after circulatory volume and hydration deficits were corrected. Oral meloxicam was continued for another 4 d at 0.05 mg/kg BW every 24 h. Pain assessments were performed daily throughout hospitalization, and at a 10- to 14-day recheck following discharge. During the first 5 d post-discharge, clients evaluated clinical parameters including demeanor, food intake and painful behavior using a questionnaire with a visual analogue scale. The rUO rates were 22% (4/18) in the meloxicam group and 26% (5/19) with placebo. No significant between-group differences were observed for any of the outcomes assessed. The main limitations of this study are the small sample size, and increased number of cats with previous LUTD episodes and macroscopic hematuria in the meloxicam group at presentation, making the detection of between-group differences more challenging and potentially leading to a type II error.

Until further evaluation of NSAIDs is conducted, feline clinicians must be mindful of Canadian meloxicam label restrictions in cats to short-term use (5 d), and warnings of acute kidney injury and death with repeated higher dosing schedules. Patients should have volume and hydration deficits corrected prior to administration of an NSAID, if prescribed.

Conclusion

There were important limitations with many of these studies. Enrolment was often based on the clinical presentation of a UO. A definitive etiology was not always established as retrograde cystourethrograms were not performed in most cases to rule out strictures or urolithiasis. Most of the populations evaluated were from academic institutions and a few at private emergency practices, which could restrict the generalization of any findings to a larger population of NAUO cats. Randomization and blinding were not performed in many of these studies. Overall, groups were matched by relevant factors in many of these studies with some notable exceptions such as the higher number of previous LUTD episodes in the prazosin-group (43) over controls. Recurrent urethral obstruction rates, a measured outcome, were lower than expected in some studies, which may have decreased statistical power and made the detection of between-group differences challenging. Various forms of bias may have arisen from incomplete medical records, retrospective group assignment (misclassification bias), inadequate follow-up (follow-up bias), and clinician-client decision making (case-selection bias).

Finally, the most commonly encountered limitations include insufficient statistical power and potential type II errors due to small sample sizes, lack of standardized treatment protocols, and multiple inter-related confounding variables. There is the potential for significant limitations to be encountered with clinical research as a result of the many dynamic influences involved in the management of feline UO. In a clinical setting, controlling for many of these variables is often not possible. Observational studies, retrospective or prospective, do not attempt to standardize treatment protocols, and may not generate a data set that allows for multivariate analysis to assess for confounders with multiple inter-related variables. Multi-center research collaborations that attempt, as much as possible, to standardize treatment protocols might maximize both sample size and statistical power, while increasing the generalizability of the results to the wider population of NAUO cats.

References

Article

Gastrointestinal nematode prevalence and fecal egg counts in beef cattle from western Canada

Felicity K. Wills, Cheryl L. Waldner, John R. Campbell, Colleen Pollock, Fabienne D. Uehlinger

Abstract – Fecal samples were collected from cows (n = 1458), calves (n = 1188), and replacement heifers (n = 921) between 2012 and 2014 from 199 herds and generalized estimating equations were used to predict mean fecal egg counts and prevalence of egg-positive samples. Replacement heifers had the highest prevalence of Trichostrongylid-type eggs at 83% [95% confidence interval (CI): 78% to 87%], and cows had the lowest at 75% (95% CI: 70% to 81%). Nematodirus spp. was most frequently present in calves [predicted prevalence: 34% (95% CI: 28% to 40%)]. Mean fecal egg counts were highest in calves with 5.9 (95% CI: 3.9 to 7.8) Trichostrongylid-type eggs per gram (EPG) of feces and 1.0 (95% CI: 0.7 to 1.4) Nematodirus spp. EPG. Although mean egg counts were low to moderate, the high prevalence highlights the need to further investigate the epidemiology of gastrointestinal nematodes in western Canada. This is particularly relevant considering management changes, increasing herd sizes, climate change, and threatening anthelmintic resistance.

Introduction

Gastrointestinal nematodes (GIN) are a threat to sustainable livestock production worldwide through productivity loss and treatment costs (1,2). While parasitic gastroenteritis (PGE), characterized by diarrhea, anorexia, and weight loss primarily affects young cattle during their first grazing season, overt clinical disease is now rarely seen in North America. This is largely because GIN control programs in cattle have relied on intensive “blanket” anthelmintic treatments aimed at preventing the accumulation of parasite burdens (3). This practice, however, has led to increasing anthelmintic resistance (AR) which has been reported from around the world, including Canada (4–6).

There is limited information on the epidemiology of GIN in beef cow-calf production systems in western Canada. Beef cow-calf herds represent an economically important sector of the Canadian agrarian economy and their demographics and management have changed in recent years (7–9). For these reasons, a better understanding of the epidemiology of GIN in beef cow-calf herds in this region is needed to develop strategic control programs which optimize production while limiting the risk of increasing development of AR. The objective of this study was to describe the prevalence and intensity of GIN infection in different animal classes of beef cow-calf herds in western Canada between 2012 and 2014.
Table 1. Descriptive summary of fresh environmental fecal samples (n = 3567) collected for determination of the gastrointestinal nematode prevalence and egg count intensity from beef cows, calves, and heifers from western Canada between 2012 and 2014, by year and season of collection.

<table>
<thead>
<tr>
<th></th>
<th>Cows</th>
<th>Calves</th>
<th>Heifers</th>
<th>Overall total</th>
</tr>
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<tr>
<td></td>
<td>#Samples</td>
<td>#Herds</td>
<td>#Samples</td>
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<tr>
<td>2012</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Summer</td>
<td>580</td>
<td>33</td>
<td>511</td>
<td>31</td>
</tr>
<tr>
<td>Fall</td>
<td>117</td>
<td>4</td>
<td>117</td>
<td>6</td>
</tr>
<tr>
<td>2013</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Summer</td>
<td>426</td>
<td>21</td>
<td>171</td>
<td>10</td>
</tr>
<tr>
<td>Fall</td>
<td>83</td>
<td>5</td>
<td>161</td>
<td>9</td>
</tr>
<tr>
<td>2014</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Summer</td>
<td>131</td>
<td>7</td>
<td>91</td>
<td>6</td>
</tr>
<tr>
<td>Fall</td>
<td>121</td>
<td>10</td>
<td>137</td>
<td>10</td>
</tr>
<tr>
<td>Overall total</td>
<td>1458</td>
<td>80</td>
<td>1188</td>
<td>72</td>
</tr>
</tbody>
</table>

Materials and methods
Study population and sampling
During 2012, 2013, and 2014, fresh environmental fecal samples were collected from cows, calves, and replacement heifers from cow-calf herds in western Canada (Alberta, Saskatchewan, and Manitoba). Fresh fecal samples were collected from individual animals after observed defecation. The sample population consisted of a convenience sample of beef producers visited by a Merck Animal Health (Canada) representative or by the farm's regular herd veterinarian. There was no repeat sampling of the same properties or cattle over successive seasons or years. Date of collection, the date of last treatment with an anthelmintic, anthelmintic product name, and the animal class of the animal sampled (cow, calf or replacement heifer) were recorded where possible at time of collection. Fecal samples were individually sealed in plastic bags and shipped to the laboratory (BioCheck Veterinary Diagnostics and Technologies, Lethbridge, Alberta) with freezer packs within 24 h of collection.

Laboratory analysis
Individual fecal samples were processed using a modified Wisconsin technique according to the laboratory’s protocol (BioCheck Veterinary Diagnostics and Technologies). In brief, 3 g of feces were mixed with 15 mL of a saturated sugar solution (specific gravity 1.27) to create a fecal slurry. This slurry was strained through a course sieve and placed into a test tube, which was centrifuged at 180 × g for 7 min. The test tube was then placed on a flat surface and filled to a slight convex meniscus with the saturated sugar solution and a cover slip was placed on top. The samples were then left to stand for at least 30 min. The cover slip was removed and placed on a microscope slide for examination at 40X magnification. This method has a reported sensitivity of detection of between 0.3 and 5 eggs per gram (EPG) (10). Gastrointestinal nematode eggs were identified microscopically based on morphology as Trichostrongylid-type, Nematodirus spp. or Trichuris spp. and reported as eggs per 3 g of feces (EP3G). Eggs per gram of feces was calculated by dividing the egg counts by the original weight of the sample. For prevalence, a sample was considered positive when at least 1 Trichostrongylid-type, Nematodirus spp. or Trichuris spp. egg was identified in a sample.

Data analyses
The data were imported into a statistical software package (StataSE version 14; Stata, College Station, Texas, USA) for analysis. Based on the collection date, samples were categorized into either the summer (June, July, August) or fall (September, October, November) collection period. Because few samples were collected in spring (March, April, May) and winter (December, January, February), they were omitted from the analyses. Samples were further classified by animal class (cows, calves, and replacement heifers). Submissions that were known to have been treated with macrocyclic lactones within 45 d or with benzimidazoles within 15 d before sample collection were also excluded from further analyses (11).

Fecal samples were described for each year, season and animal class [frequency, 95% confidence interval (CI), median inter-quartile range (IQR)].

The overall prevalence (95% CI) of Trichostrongylid-type eggs was estimated using generalized estimating equations (GEE) to allow for clustering within herds. The initial null or intercept only GEE model used a binomial distribution and log link function with an exchangeable within-group correlation structure and robust standard error (to deal with overdispersion within the data). The overall mean Trichostrongylid-type EPG was also determined using a null GEE model with a negative binomial family and log link with an exchangeable within-group correlation structure and robust standard error. The prevalence (95% CI) of Nematodirus spp. positive samples and mean EPG for Nematodirus spp. were estimated in the same way as described for Trichostrongylid-type.

The effects of year, season, and animal class on the Trichostrongylid-type prevalence and EPG shedding intensity in cows, calves, and heifers were assessed with fixed effects introduced in the above GEE models. Each independent variable (year, season, and animal class) was forced into the final model and plausible interaction terms (year by season, year by animal class, season by animal class) were evaluated. The final GEE model for each outcome was produced by manual stepwise backwards elimination of non-significant interaction terms. Interaction terms were retained in the GEE if found to be statistically significant based on a Wald’s test at a P-value of ≤ 0.05. The effect of retained predictor variables...
on the predicted prevalence and EPG of Trichostrongylid-type positive samples were assessed using post-hoc pairwise comparison with a level of significance set at $P \leq 0.05$. Similar analyses were completed to estimate differences in *Nematodirus* spp. prevalence and mean EPG among years, seasons, and animal class.

**Results**

**Sample population and number of samples collected**

From 2012 to 2014, 3567 fecal samples suitable for analyses were collected from 199 herds. Table 1 shows the number of cows, calves, and replacement heifers sampled by year and season of sample collection. The number of samples collected from each herd ranged from 5 to 57 (median: 20, IQR: 6).

Null-model (unadjusted) prevalence and fecal egg shedding intensity of Trichostrongylid-type eggs and *Nematodirus* spp.

*Trichuris* spp. was only identified in 7 fecal samples from 4 herds. No *Trichuris* spp. were found in heifers in any of the years and *Trichuris* spp. was also not identified in any of the sampled cattle in 2013. Therefore, subsequent analyses were restricted to Trichostrongylid-type eggs and *Nematodirus* spp. only.

The predicted overall prevalence and mean EPG of Trichostrongylid-type positive samples from the null models were 78% (95% CI: 75% to 82%; Table 2) and 5.1 EPG (95% CI: 4.1 to 6.2; Table 3), respectively. For *Nematodirus* spp., the null-model derived predicted prevalence was 16% (95% CI: 13 to 20; Table 4) while the predicted mean EPG of *Nematodirus* spp. eggs was 0.5 (95% CI: 0.3 to 0.7; Table 5).

---

### Table 2. Results from the GEE models for predicted prevalence (95% confidence interval (CI)) of Trichostrongylid-type egg positive samples, accounting for clustering by herd, in 3567 beef cows, calves, and replacement heifers from 199 herds from western Canada sampled between 2012 and 2014, overall (null model) and by year and season of collection (final model).

<table>
<thead>
<tr>
<th></th>
<th>Cows</th>
<th>Calves</th>
<th>Replacement heifers</th>
<th>All</th>
</tr>
</thead>
<tbody>
<tr>
<td>2012</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Summer</td>
<td>87 (79 to 94)</td>
<td>87 (81 to 94)</td>
<td>88 (82 to 94)</td>
<td>86 (82 to 90)</td>
</tr>
<tr>
<td>Fall</td>
<td>64 (44 to 84)</td>
<td>94 (89 to 97)</td>
<td>89 (87 to 91)</td>
<td>87 (83 to 91)</td>
</tr>
<tr>
<td>2013</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Summer</td>
<td>72 (63 to 82)</td>
<td>59 (36 to 83)</td>
<td>74 (63 to 84)</td>
<td>70 (63 to 77)</td>
</tr>
<tr>
<td>Fall</td>
<td>63 (38 to 89)</td>
<td>74 (59 to 89)</td>
<td>82 (61 to 100)</td>
<td>70 (63 to 78)</td>
</tr>
<tr>
<td>2014</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Summer</td>
<td>80 (62 to 99)</td>
<td>81 (68 to 95)</td>
<td>91 (80 to 100)</td>
<td>77 (70 to 84)</td>
</tr>
<tr>
<td>Fall</td>
<td>49 (33 to 65)</td>
<td>83 (75 to 91)</td>
<td>70 (30 to 100)</td>
<td>83 (73 to 93)</td>
</tr>
<tr>
<td>All</td>
<td>75 (70 to 81)</td>
<td>79 (73 to 86)</td>
<td>83 (78 to 87)</td>
<td>78 (75 to 82)</td>
</tr>
<tr>
<td>Summer</td>
<td>81 (75 to 86)</td>
<td>78 (70 to 86)</td>
<td>82 (77 to 88)</td>
<td>80 (76 to 84)</td>
</tr>
<tr>
<td>Fall</td>
<td>59 (46 to 72)</td>
<td>84 (77 to 90)</td>
<td>84 (73 to 94)</td>
<td>74 (67 to 80)</td>
</tr>
</tbody>
</table>

---

### Table 3. Results from the GEE models for predicted mean eggs per gram (EPG) of feces (95% confidence interval (CI)), accounting for clustering by herd, for Trichostrongylid-type eggs in 3567 beef cows, calves, and replacement heifers from 199 herds from western Canada sampled between 2012 and 2014, overall (null model) and by year and season of collection (final model).

<table>
<thead>
<tr>
<th></th>
<th>Cows</th>
<th>Calves</th>
<th>Replacement heifers</th>
<th>All</th>
</tr>
</thead>
<tbody>
<tr>
<td>2012</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Summer</td>
<td>6.9 (3.6 to 10.2)</td>
<td>7.5 (3.9 to 11.2)</td>
<td>4.4 (2.6 to 6.2)</td>
<td>6.1 (4.6 to 7.6)</td>
</tr>
<tr>
<td>Fall</td>
<td>2.6 (1.1 to 4.0)</td>
<td>6.7 (3.1 to 10.3)</td>
<td>8.0 (2.6 to 13.4)</td>
<td>5.3 (2.9 to 7.8)</td>
</tr>
<tr>
<td>2013</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Summer</td>
<td>3.2 (2.2 to 4.3)</td>
<td>1.7 (0.7 to 2.7)</td>
<td>3.8 (2.3 to 5.4)</td>
<td>2.9 (2.4 to 3.5)</td>
</tr>
<tr>
<td>Fall</td>
<td>1.9 (0.7 to 3.0)</td>
<td>2.5 (1.4 to 3.7)</td>
<td>4.4 (4.0 to 9.4)</td>
<td>3.2 (2.4 to 4.0)</td>
</tr>
<tr>
<td>2014</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Summer</td>
<td>4.7 (2.0 to 7.5)</td>
<td>12.0 (0 to 25.7)</td>
<td>2.6 (0.5 to 4.7)</td>
<td>5.1 (2.5 to 7.6)</td>
</tr>
<tr>
<td>Fall</td>
<td>0.6 (0.3 to 0.9)</td>
<td>8.7 (1.4 to 16.0)</td>
<td>0.4 (0.2 to 0.6)</td>
<td>7.0 (1.6 to 12.4)</td>
</tr>
<tr>
<td>All</td>
<td>4.5 (3.1 to 5.9)</td>
<td>5.9 (3.9 to 7.8)</td>
<td>4.1 (3.0 to 5.3)</td>
<td>4.4 (0.6 to 8.3)</td>
</tr>
<tr>
<td>Summer</td>
<td>5.2 (3.6 to 6.9)</td>
<td>5.9 (3.5 to 8.4)</td>
<td>4.0 (2.8 to 5.1)</td>
<td>5.1 (4.1 to 6.2)</td>
</tr>
<tr>
<td>Fall</td>
<td>1.7 (0.9 to 2.6)</td>
<td>5.6 (3.3 to 8.0)</td>
<td>4.7 (1.3 to 8.1)</td>
<td>5.3 (4.1 to 6.5)</td>
</tr>
</tbody>
</table>

---

*a,b* Statistically significantly different; highest $P < 0.001$.

*c,d* Statistically significantly different; $P < 0.01$.

*e,f* Statistically significantly different; highest $P < 0.02$. 
Table 4. Results of the GEE models for predicted prevalence [95% confidence interval (CI)] of Nematodirus spp. positive samples, accounting for clustering by herd, in 3567 beef cows, calves, and replacement heifers from 199 herds from western Canada sampled between 2012 and 2014, overall (null model) and by year and season of collection (final model).

<table>
<thead>
<tr>
<th>Year</th>
<th>Season</th>
<th>Cows</th>
<th>Calves</th>
<th>Replacement heifers</th>
<th>All</th>
</tr>
</thead>
<tbody>
<tr>
<td>2012</td>
<td>Summer</td>
<td>22</td>
<td>18</td>
<td></td>
<td>26</td>
</tr>
<tr>
<td></td>
<td>Fall</td>
<td>20</td>
<td>14</td>
<td></td>
<td>26</td>
</tr>
<tr>
<td>2013</td>
<td>Summer</td>
<td>8</td>
<td>5</td>
<td></td>
<td>11</td>
</tr>
<tr>
<td></td>
<td>Fall</td>
<td>5</td>
<td>2</td>
<td></td>
<td>8</td>
</tr>
<tr>
<td>2014</td>
<td>Summer</td>
<td>12</td>
<td>6</td>
<td></td>
<td>18</td>
</tr>
<tr>
<td></td>
<td>Fall</td>
<td>10</td>
<td>9</td>
<td></td>
<td>19</td>
</tr>
</tbody>
</table>

Table 5. Final GEE model for predicted mean eggs per gram (EPG) of feces [95% confidence interval (CI)], accounting for clustering by herd, for Nematodirus spp. eggs in 3567 beef cows, calves, and replacement heifers from 199 herds from western Canada sampled between 2012 and 2014, overall (null model) and by season and year of collection (final model).

<table>
<thead>
<tr>
<th>Year</th>
<th>Season</th>
<th>Cows</th>
<th>Calves</th>
<th>Replacement heifers</th>
<th>All</th>
</tr>
</thead>
<tbody>
<tr>
<td>2012</td>
<td>Summer</td>
<td>0.9</td>
<td>0.6</td>
<td>0.7</td>
<td>1.2</td>
</tr>
<tr>
<td></td>
<td>Fall</td>
<td>0.5</td>
<td>0.3</td>
<td>0.7</td>
<td>0.7</td>
</tr>
<tr>
<td>2013</td>
<td>Summer</td>
<td>0.1</td>
<td>0.3</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Fall</td>
<td>0.03</td>
<td>0.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2014</td>
<td>Summer</td>
<td>0.3</td>
<td>0.1</td>
<td>0.6</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Fall</td>
<td>0.2</td>
<td>0.04</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Final generalized estimating equation for the predicted prevalence of Trichostrongyld-type eggs in fecal samples

The final GEE model for the predicted prevalence of Trichostrongyld-type egg positive samples included year (P < 0.001), season (P = 0.013) and a significant interaction between season and animal class (P = 0.005) (Table 6).

The predicted prevalence of Trichostrongyld-type egg positive samples differed significantly between years, with a significantly higher predicted prevalence (86%; 95% CI: 82% to 90%) in 2012 than in 2013 (70%; 95% CI: 63% to 77%; P < 0.01) and in 2014 (77%; 95% CI: 70% to 84%; P = 0.02) (Table 2). There was a significant interaction between season and animal class: the predicted prevalence in cows fell significantly (P = 0.001) between summer to fall from 81% to 59% (Table 2). The predicted prevalence in cows in the fall was also significantly lower than the prevalence in both calves and heifers in the fall (P = 0.000 and P = 0.006, respectively). The predicted prevalence did not differ significantly between animal classes in the summer or in calves and replacement heifers between summer and fall (Table 2).

Final GEE for the predicted mean Trichostrongyld-type eggs per gram of feces

The final GEE model for the predicted mean EPG of Trichostrongyld-type eggs included year (P = 0.02), season (P < 0.01), and animal class (P = 0.24) as fixed effects, and significant interactions between season and animal class (P < 0.01) and year and animal class (P < 0.01) (Table 7).

The predicted Trichostrongyld-type EPG was significantly higher in 2012 compared to that in 2013 (P < 0.001). Cows sampled in the fall had the lowest predicted mean.
Table 6. Final binomial GEE model with an exchangeable correlation structure, a logit link function, and robust standard errors, for the predicted prevalence of Trichostrongylid-type and Nematodirus spp. eggs in fresh environmental fecal samples collected from 3567 cows, calves, and heifers from 199 herds from western Canada sampled between 2012 and 2014.

<table>
<thead>
<tr>
<th>Animal class</th>
<th>Trichostrongylid-type</th>
<th>Nematodirus spp.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Odds ratio</td>
<td>P-value</td>
</tr>
<tr>
<td>Year</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2012</td>
<td>Ref</td>
<td></td>
</tr>
<tr>
<td>2013</td>
<td>0.36</td>
<td>0.00</td>
</tr>
<tr>
<td>2014</td>
<td>0.53</td>
<td>0.02</td>
</tr>
<tr>
<td>Season</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Summer</td>
<td>Ref</td>
<td></td>
</tr>
<tr>
<td>Fall</td>
<td>0.33</td>
<td>0.00</td>
</tr>
<tr>
<td>Animal class</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cows</td>
<td>Ref</td>
<td></td>
</tr>
<tr>
<td>Calves</td>
<td>0.84</td>
<td>0.58</td>
</tr>
<tr>
<td>Replacement heifers</td>
<td>1.12</td>
<td>0.68</td>
</tr>
<tr>
<td>Year by Animal class</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fall by Cows</td>
<td>Ref</td>
<td></td>
</tr>
<tr>
<td>Fall by Calves</td>
<td>4.52</td>
<td>0.00</td>
</tr>
<tr>
<td>Fall by Replacement heifers</td>
<td>3.34</td>
<td>0.03</td>
</tr>
</tbody>
</table>

Table 7. Final negative binomial GEE model with an exchangeable correlation structure, a log link function, and robust standard errors, for the predicted mean eggs per gram of Trichostrongylid-type and Nematodirus spp. eggs in fresh environmental fecal samples collected from 3567 cows, calves, and heifers from 199 herds from western Canada sampled between 2012 and 2014.

<table>
<thead>
<tr>
<th>Animal class</th>
<th>Trichostrongylid-type</th>
<th>Nematodirus spp.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Risk ratio</td>
<td>P-value</td>
</tr>
<tr>
<td>Year</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2012</td>
<td>Ref</td>
<td></td>
</tr>
<tr>
<td>2013</td>
<td>0.47</td>
<td>0.01</td>
</tr>
<tr>
<td>2014</td>
<td>0.68</td>
<td>0.32</td>
</tr>
<tr>
<td>Season</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Summer</td>
<td>Ref</td>
<td></td>
</tr>
<tr>
<td>Fall</td>
<td>0.40</td>
<td>0.02</td>
</tr>
<tr>
<td>Animal class</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cows</td>
<td>Ref</td>
<td></td>
</tr>
<tr>
<td>Calves</td>
<td>1.10</td>
<td>0.78</td>
</tr>
<tr>
<td>Replacement heifers</td>
<td>0.65</td>
<td>0.19</td>
</tr>
<tr>
<td>Season by Animal class</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fall by Cows</td>
<td>Ref</td>
<td></td>
</tr>
<tr>
<td>Fall by Calves</td>
<td>2.90</td>
<td>0.01</td>
</tr>
<tr>
<td>Fall by Replacement heifers</td>
<td>3.64</td>
<td>0.01</td>
</tr>
<tr>
<td>Year by Animal class</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2012 by Cows</td>
<td>Ref</td>
<td></td>
</tr>
<tr>
<td>2013 by Calves</td>
<td>0.58</td>
<td>0.15</td>
</tr>
<tr>
<td>2013 by Replacement heifers</td>
<td>1.62</td>
<td>0.21</td>
</tr>
<tr>
<td>2014 by Calves</td>
<td>2.90</td>
<td>0.06</td>
</tr>
<tr>
<td>2014 by Replacement heifers</td>
<td>0.91</td>
<td>0.88</td>
</tr>
</tbody>
</table>

CI — confidence interval.

Trichostrongylid-type egg count at 1.7 (95% CI: 0.9 to 2.6) (Table 3) and cows’ predicted mean EPG in the fall was significantly lower than their mean EPG in summer (P < 0.001) (Table 3). It was also significantly lower than the predicted mean EPG of calves (P < 0.001) and heifers (P = 0.021) in the fall and summer (P < 0.01 and P = 0.003, respectively) (Table 3). There was no statistically significant difference in the predicted mean EPG between seasons in calves or replacement heifers.

In both cows and calves, the predicted mean EPG differed between years. In calves, it was significantly higher in 2012 and 2014 compared to 2013 (both P < 0.001); in cows, it was significantly higher in 2012 compared to 2013 and 2014 (P = 0.01 and 0.04, respectively). Statistically significant differences are not denoted in Table 3.

Final GEE for the predicted prevalence of Nematodirus spp.

The final GEE model for the predicted prevalence of Nematodirus spp. included year (P < 0.001), season (P = 0.008), and animal class (P < 0.001) (Table 6).
The predicted prevalence was significantly higher in 2012 (22%; 95% CI: 18% to 26%) than in 2013 (8%; 95% CI: 5% to 11%; P < 0.001) or 2014 (12%; 95% CI: 6% to 18%; P = 0.02) (Table 4). There were also significantly more (P < 0.01) Nematodirus spp. positive samples in the fall (22%; 95% CI: 16% to 28%) than in the summer (13%; 95% CI: 11% to 16%). Calves had the highest predicted prevalence of Nematodirus spp. at 34% (95% CI: 28% to 40%), which was significantly higher than the predicted prevalence for cows (5%; 95% CI: 2% to 9%; P < 0.01) and replacement heifers (6%; 95% CI: 2% to 9%; P < 0.01).

Final GEE for the predicted mean Nematodirus spp. eggs per gram of feces

The final GEE model for the predicted mean EPG of Nematodirus spp. included year (P < 0.001), animal class (P < 0.001) and season (P < 0.001) and a significant interaction term between animal class and year (P = 0.02) (Table 7). The predicted mean Nematodirus spp. EPG was significantly higher in 2012 compared to that in 2013 (P < 0.001) and 2014 (P = 0.03) (Table 5). It was also significantly higher in 2014 than in 2013 (P = 0.01). Calves had the highest predicted mean Nematodirus spp. EPG at 1.0 (95% CI: 0.7 to 1.4) which was significantly higher than the predicted mean EPG for cows and heifers (both P-values < 0.01). Overall, the predicted mean Nematodirus spp. EPG was also significantly higher in the fall than in the summer (P < 0.01).

In both cows and calves, the predicted mean EPG differed between years. In calves, it was significantly higher in 2012 compared to 2013 (P < 0.01) and 2014 (P = 0.03); in cows, it was also significantly higher in 2012 compared to 2013 (P < 0.01) and 2014 (P = 0.01). Statistically significant differences are not denoted in Table 5.

Discussion

There are few studies that report the prevalence or fecal egg count (FEC) intensity of GIN in beef cattle in western Canada. Beef cow-calf production in western Canada encompasses over 70% of all cow-calf beef production in Canada (12).

Trichostrongylid-type egg prevalence was high with 78% of all samples being positive. The prevalence of Nematodirus spp. and Trichuris spp. was lower, with Trichuris spp. being an infrequent finding. This pattern in the prevalence of the morphologically identifiable types of GIN is similar to that described by Jelinski et al (9), who sampled 14 beef cow-calf herds over summer 2014, and is consistent with literature from other parts of the world (11,13).

The prevalence of Trichostrongylid-type egg positive samples found in this study is higher than the prevalence of 63% reported by Polley and Bicks (14) in intensively run cows and their calves in Saskatchewan. The prevalence of 79% in calves reported in this study is also higher than that reported by Colwell et al (15), who sampled weaned beef calves in 2008, 2009, and 2010 in Alberta and found a maximum prevalence of 48%. However, fecal samples from that study had previously been frozen and it is possible that this may have resulted in a reduced egg recovery rate and, therefore, lower prevalence estimation. The prevalence found in calf samples was, however, similar to that in an extensive study of GIN prevalence in weaned beef calves from 291 herds from 24 States in the United States, which found an overall prevalence of 86% (13). The high prevalence of GIN and the moderate egg count intensities seen in cows and replacement heifers were expected based on the GIN epidemiology and recent studies on beef cow-calf herds in Canada (9,16,17).

The prevalence and intensity of GIN based on the GEE were influenced by season and animal class and varied seasonally and annually during the study period. Overall, the prevalence of Trichostrongylid-type eggs in calves and heifers was fairly constant from summer to the fall, but was numerically higher in the fall compared to summer. This is consistent with the known epidemiology of common cattle GIN in temperate cattle producing regions (18–20). Typically, naïve animals start the grazing season in temperate climates with low egg counts and lower prevalence. The GIN prevalence and burden then tend to rise during the grazing season because of pasture contamination and environmental conditions more suitable to L3 survival on pasture. Cows may act as a source of GIN for calves through pasture contamination in the early grazing season. A rise in eggs around calving time, possible emergence of hypobiotic stages, and ingestion of overwintered larvae during the early grazing period likely contributed to pasture contamination in the spring and higher prevalence and EPG in cows compared to fall. Later in the grazing season, GIN prevalence and egg count intensity begin to decrease due to reduced larval development on pasture, effective immunity in adult cattle, and possibly the start of GIN hypobiosis, all of which will reduce the transmission and fecal egg shedding (18–20).

The FEC, while low to moderate in all animal groups, was overall highest in calves and was significantly lower in cows compared to calves and heifers. This is not unexpected as these younger and more naïve animals have yet to develop immunity against GIN (21). In contrast, mature cows would have developed acquired immunity through repeated exposure to GIN and this is probably at least in part reflected by a significant drop in the prevalence and Trichostrongylid-type EPG between summer and fall in that animal class. The Trichostrongylid-type EPG in calves and heifers was less variable. Timing of sampling varied between herds, and sampled herds varied from summer to fall and from year to year with no specific information available in terms of management (e.g., grazing management, stocking density, grazing patterns, type of water source), environmental conditions, or geographic locations (e.g., temperature, precipitation, humidity). These are factors known to affect GIN epidemiology and, therefore, the prevalence and shedding intensity (18,19,22). Also, geographical and temporal diversity in beef cattle GIN infection risk has been demonstrated from Alberta, Canada (23). It is likely that similar differences existed between the herds and years sampled in this study. Annual variations in precipitation and humidity also influence GIN larvae survivability on pasture and the risk of transmission and are likely other possible reasons for some of the yearly differences in prevalence and FEC intensity identified in this study (15).

It is interesting to note that the prevalence of Nematodirus spp. was relatively high, particularly in calves. A similar trend
has been seen in the US. Stromberg et al (13) found a prevalence of 18% in samples from 1772 weaned calves 6 to 8 mo of age. *Nematodirus* spp. is a parasite of low pathogenicity unless found in high numbers in young cattle that have not developed immunity (24). There also appears to be an increase in *Nematodirus* spp. found in cattle in the US (25). Reasons for this increase might include the development of anthelmintic resistance in the parasite or the timing of the application of anthelmintic drugs in current management protocols which may favor transmission of *Nematodirus* spp. eggs last well unhatched on pasture in the cooler months and only hatch in the warmer weather of the following summer; therefore, the time of peak transmission may be missed by treatment with anthelmintic drugs applied routinely in the spring (25). Monitoring of this parasite may become important to prevent the occurrence of clinical disease in naïve young stock.

There are potentially serious implications for Canadian beef production with changes in GIN prevalence, burden, and the development of anthelmintic resistance. This study provides a baseline for the current prevalence of GIN infection in some western Canadian beef cow-calf herds and complements similar investigations by Jelinski et al (9,17). Unfortunately, specific epidemiological information known to affect GIN burdens in grazing cattle was not collected in this study. Useful information would have included: exact geographical location of samples to account for environmental conditions (humidity, temperature, and precipitation); access to pasture/pasture types, including duration of pasture access prior to sampling; and stocking density/pasture management. The management of beef cow-calf herds in western Canada has changed considerably since Polley and Bickis conducted their study in 1986 (14). Changes in the western Canadian beef cow-calf industry include increasing herd sizes, increasing intensiveness of production systems, later spring calving, and the implementation of low-cost overwintering feeding systems (i.e., swath and bale grazing) (9,12).

Along with the changes in beef cow-cattle management in western Canada, suspected development of anthelmintic resistance and changes in climate also need to be considered for their impact on GIN burdens in beef cattle (2,26,27). The generally high prevalence of GIN infection seen in this study highlights the need for more detailed examination of the epidemiology of GIN on western Canadian beef cow-calf herds, taking into account the factors mentioned. In addition, evaluation of anthelmintic efficacy and a more in-depth understanding of producers’ attitudes and management approaches to GIN is needed to better understand how GIN in beef cattle are best managed sustainably in the future.

Samples collected in this study represent convenience samples from beef producers who were motivated to sample these particular herds/animals and who had contact/input from Merck Canada sales representatives. Additionally, different herds with presumably different management styles were sampled in different years. For these reasons, care should be taken when extrapolating the results to a wider population. Furthermore, only limited inferences can be drawn for some results categories because of low sampling numbers in some seasons and animal classes (e.g., heifer samples in the fall of 2014). However, the aim of the study was to describe trends in GIN prevalence and egg count intensities in cow-calf herds in western Canada more broadly, which was achieved with this study.

Limitations in this study and in most studies of GIN in cattle that must be considered include the difficulties in accurately diagnosing “burden,” particularly quantifying the intensity of the burden. Fecal egg counts are routinely used for diagnosis; however, they have been shown to be poorly correlated with actual burden in cattle, especially in adult cattle with acquired immunity (28,29). Furthermore, while FEC similarly low to those identified in this study have been associated with reduced production (particularly weight gain) in some studies, it is undetermined what amount of shedding intensity results in production and economic impacts and no conclusions can presently be drawn about the clinical or economic importance of the GIN prevalence and egg shedding intensity identified in this study (30,31). Despite this, FEC are widely accepted as an appropriate way of monitoring GIN infection, particularly until a more effective alternative can be validated (32,33).

In conclusion, this study provides a much-needed summary of gastrointestinal nematode infection in beef cattle from cow-calf herds in western Canada. The findings support the increased susceptibility of calves compared to cows. The high prevalence of positive FECs, when compared to historical data and when considering recent changes in cattle management, climate, and emerging anthelmintic resistance, highlight the need for further investigations. These should include obtaining a better understanding of producers’ knowledge and current management practices for GIN in their cattle, and further closing the knowledge gap on GIN prevalence, infection intensity, and species of GIN in western Canadian beef cattle, while also accounting for different management and geographic conditions. This information is necessary in order for more strategic control methods to be developed that maintain efficient production, while limiting the development of anthelmintic resistance.

Acknowledgment

We thank Merck Animal Health Canada for the databases used for this analysis.

References

12. Canada S. Alberta has the most beef cattle in Canada and the second largest farm area. Reproduced and distributed on an ‘as is’ basis with the permission of Statistics Canada 2017.
Prevalence of methicillin-resistant *Staphylococcus pseudintermedius* on hand-contact and animal-contact surfaces in companion animal community hospitals

Andrea V. Perkins, Debra C. Sellon, John M. Gay, Eric T. Lofgren, Dale A. Moore, Lisa P. Jones, Margaret A. Davis

**Abstract** — Methicillin-resistant *Staphylococcus pseudintermedius* (MRSP) is an important companion animal pathogen, but few published studies have evaluated its epidemiology in primary care settings. This study determined MRSP prevalence on hand- and animal-contact surfaces in 11 small animal primary care hospitals in Washington and Idaho, USA. Overall, MRSP was isolated from at least 1 sample from 7 of 11 hospitals (64%) and from 36 of 374 total samples (10%) with no difference in prevalence between hand- and animal-contact surfaces (*P* = 0.51). Strain typing by pulsed-field gel electrophoresis indicated high within-hospital similarity of MRSP strains, but minimal similarity between strains from different hospitals. Indistinguishable MRSP strains were present on hand- and animal-contact surfaces within individual hospitals. A questionnaire was administered to a representative from each hospital. Respondents reported that animal-contact surfaces were cleaned and disinfected more frequently than hand-contact surfaces (*P* < 0.001). Improving hand hygiene and disinfection of hand-contact surfaces may decrease exposure of veterinary patients to MSRP.

**Résumé** — Prévalence de *Staphylococcus pseudintermedius* résistant à la méthicilline sur des surfaces en contact avec les mains et des surfaces en contact avec les animaux dans des hôpitaux de première ligne pour animaux de compagnie. *Staphylococcus pseudintermedius* résistant à la méthicilline (MRSP) est un agent pathogène important chez les animaux de compagnie, mais peu d’études publiées ont évalué son épidémiologie dans les sites de soins de première ligne. Dans la présente étude on détermina la prévalence de MRSP sur les surfaces de contact avec les mains et les surfaces de contact avec les animaux dans 11 hôpitaux de première ligne pour animaux de compagnie dans les états de Washington et de l’Idaho, USA. De manière globale, le MRSP fut isolé à partir d’au moins un échantillon dans 7 des 11 hôpitaux (64 %) et de 36 des 374 échantillons (10 %) sans noter de différence dans la prévalence entre les contacts main-surface ou animal-surface (*P* = 0.51). Le typage des souches par électrophorèse en champs pulsés indiqua une similarité intra-hôpital élevée des souches de MRSP, mais une similarité minimale entre les souches provenant d’hôpitaux différents. Des souches indistinguitables de MRSP étaient présentes sur les surfaces de contact avec les mains et les animaux dans un même hôpital. Un questionnaire fut soumis à un représentant de chaque hôpital. Les répondants rapportèrent que les surfaces de contact avec l’animal étaient nettoyées et désinfectées plus fréquemment que les surfaces de contact avec les mains (*P* < 0.001). Une amélioration de l’hygiène des mains et de la désinfection des surfaces en contacts avec les mains pourraient diminuer l’exposition de patients vétérinaires au MSRP.


**Introduction**

Methicillin-resistant *Staphylococcus pseudintermedius* (MRSP) is a rapidly emerging pathogen of concern in companion animals. *Staphylococcus pseudintermedius* colonizes the canine mouth, pharynx, nares, perineal area, and rectum and is the most frequently isolated organism from surgical site infections following canine tibial plateau leveling osteotomy procedures and from dogs presenting with pyoderma (1–6). Methicillin-resistant *S. pseudintermedius* is not necessarily more pathogenic than methicillin-susceptible *S. pseudintermedius*.
(MSSP), but limited antimicrobial therapy options can prolong or prevent successful treatment of MRSP infections compared to MSSP. Methicillin-resistant S. pseudintermedius is characterized by the staphylococcal cassette chromosome mec (SCCmec), which includes the mecA gene (7). This gene confers resistance to virtually all β-lactam antimicrobials including cephalosporins by coding for an altered penicillin binding protein 2a (PBP-2a) (8). Co-resistance to other important classes of antimicrobials is increasingly common (4).

Prevalence of MRSP in healthy companion animal populations has been reported to range from 0% to 4%, whereas prevalence of MRSP in dogs presented to a dermatology referral service can be as high as 40.5% (6,9). Common carriage and infection sites include external body locations that may come into contact with surfaces in the hospital environment. Staphylococci are transmitted via direct or indirect contact and can persist on surfaces for extended periods of time (10). Close human-animal relationships include behavioral interactions such as play, petting, and sharing furniture (11). In veterinary settings human-dog interactions often involve hands for such activities as performing examinations and procedures, petting, or giving treats. Hands are therefore likely to be important vehicles for indirect transmission between patients. Video surveillance in small animal hospitals found that overall hand hygiene compliance is 14% (12). This, in conjunction with the transmission route, suggests that humans, animals, and the environment play instrumental roles in movement and persistence of MRSP in veterinary hospitals.

The epidemiology of methicillin-resistant staphylococci in companion animals has primarily been reported from teaching or referral hospitals rather than community small animal primary care veterinary practices (13,14). The few studies in primary care practices have limited numbers and data on MRSP epidemiology (15,16). Small animal primary care practices may have less support than teaching or referral hospitals for infection control resources such as dedicated infection control teams, availability of continuing education, or monitoring and surveillance protocols and practices.

As a commensal organism of many healthy dogs, it is likely that MRSP is shed into any environment in which multiple dogs are present on a daily basis. In these environments, it is expected that the hands of individuals would be periodically contaminated with MRSP and might transfer the bacteria to inanimate hand-contact surfaces. In the absence of rigorous infection control practices, this contamination would contribute to the persistence of MRSP in the health care environment and increase patient exposure to this potential pathogen. We hypothesized that hand-contact surfaces in small animal primary care veterinary hospitals would be contaminated with MRSP at the same frequency as animal-contact surfaces and that the strains isolated from surfaces would be identical within an individual hospital.

### Materials and methods

#### Hospitals

The study population consisted of 11 veterinary hospitals, 10 in Washington State and 1 in western Idaho. Hospitals were eligible for inclusion if they principally provided primary veterinary medical and surgical care to small companion animal patients. Mixed animal practices were included only if most of the patients seen were small companion animals and if the small and large animal hospitals were physically separated. Teaching, specialty, and referral hospitals were excluded. Hospitals were recruited May 2015 through January 2016 via a series of e-mails that invited participation in an observational, cross-sectional study to examine regional prevalence and epidemiology of MRSP. The recruited hospitals were purposively selected to ensure a geographically dispersed sample population. The mean distance between each hospital pair was 330.2 km (median: 342 km, range: 6 to 630 km) (Table S1, available from the authors). Summary results of environmental sampling, including the bacterial species and type of surface from which organisms were isolated, were provided to all hospitals as soon as they were available and each hospital received detailed results specific to their hospital. The Institutional Review Board of Washington State University determined that this project satisfied the criteria for exempt research.

#### Sample collection

Hospital visits for sample collection occurred between July 2016 and January 2017 during their regular business hours. An average of 34 samples (range: 33 to 35 samples) was collected from environmental surfaces within each hospital, half from predominantly hand-contact surfaces and half from predominantly animal-contact surfaces. Specific surface types that were sampled are identified in Table 1. Samples were collected using Swiffer electrostatic cloths (Procter & Gamble, Cincinnati, Ohio, USA); a new cloth and examination glove were used for each

### Table 1. Types of hand- and animal-contact surfaces sampled within participating hospitals.

<table>
<thead>
<tr>
<th>Hand-contact surfaces</th>
<th>Animal-contact surfaces</th>
</tr>
</thead>
<tbody>
<tr>
<td>Door handles&lt;sup&gt;a&lt;/sup&gt;</td>
<td>Clinic floor&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Light switches&lt;sup&gt;a&lt;/sup&gt;</td>
<td>Clipper blades&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Computer keyboards/mice&lt;sup&gt;a&lt;/sup&gt;</td>
<td>Examination tables (examination room, treatments area, clean and dirty surgery, radiology)&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Kennel/cage door handles</td>
<td>Inside surfaces of kennels/cages&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Clipper handles&lt;sup&gt;a&lt;/sup&gt;</td>
<td>Muzzles/Elizabethan collars&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Faucet handles&lt;sup&gt;a&lt;/sup&gt;</td>
<td>Stethoscope diaphragm</td>
</tr>
<tr>
<td>Otoscope handles&lt;sup&gt;a&lt;/sup&gt;</td>
<td>Endotracheal tubes&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Drawer/cabinet handles&lt;sup&gt;a&lt;/sup&gt;</td>
<td>Nail clippers</td>
</tr>
<tr>
<td>Supply containers</td>
<td>Warming pads&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Phones/printers/fax machines&lt;sup&gt;a&lt;/sup&gt;</td>
<td>Food/water bowls&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>IV pumps (buttons/pole)&lt;sup&gt;a&lt;/sup&gt;</td>
<td>Leashes</td>
</tr>
<tr>
<td>Overhead light handles</td>
<td>Carts/gurneys&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Medical charts</td>
<td>Oxygen monitors&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Ultrasound machine (buttons/knobs)</td>
<td></td>
</tr>
</tbody>
</table>

<sup>a</sup> Surfaces about which respondents were questioned concerning the frequency of cleaning and disinfection.
coagulase-positive staphylococci were requested from WADDL. Only results for methicillin-resistant isolates were tested for inducible clindamycin resistance using a D-test (18). Minimum inhibitory concentration antimicrobial susceptibility testing of antimicrobials (Table 2) was completed using broth dilution (16). Antimicrobial susceptibility testing of environmental methicillin-resistant Staphylococcus pseudintermedius (MRSP) isolates — n (%) is shown here for the proportions of isolates that were resistant, susceptible, or intermediate to 16 antimicrobials from 8 classes using CLSI breakpoints (18).

**Table 2. Antimicrobial susceptibilities of environmental methicillin-resistant Staphylococcus pseudintermedius (MRSP) isolates.**

<table>
<thead>
<tr>
<th>Antimicrobial class</th>
<th>Resistant isolates — n (%)</th>
<th>Susceptible isolates — n (%)</th>
<th>Intermediate isolates — n (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amoxicillin/Clavulanic acid</td>
<td>β-lactam</td>
<td>36 (100.0)</td>
<td>0 (0.0)</td>
</tr>
<tr>
<td>Ampicillin</td>
<td>β-lactam</td>
<td>36 (100.0)</td>
<td>0 (0.0)</td>
</tr>
<tr>
<td>Cefazolin</td>
<td>β-lactam</td>
<td>36 (100.0)</td>
<td>0 (0.0)</td>
</tr>
<tr>
<td>Cefpodoxime</td>
<td>β-lactam</td>
<td>36 (100.0)</td>
<td>0 (0.0)</td>
</tr>
<tr>
<td>Cephalothin</td>
<td>β-lactam</td>
<td>36 (100.0)</td>
<td>0 (0.0)</td>
</tr>
<tr>
<td>Oxacillin + 2% NaCl</td>
<td>β-lactam</td>
<td>36 (100.0)</td>
<td>0 (0.0)</td>
</tr>
<tr>
<td>Penicillin</td>
<td>β-lactam</td>
<td>36 (100.0)</td>
<td>0 (0.0)</td>
</tr>
<tr>
<td>Enrofloxacin</td>
<td>Quinolone</td>
<td>19 (52.8)</td>
<td>13 (36.1)</td>
</tr>
<tr>
<td>Marbofloxacin</td>
<td>Quinolone</td>
<td>19 (52.8)</td>
<td>17 (47.2)</td>
</tr>
<tr>
<td>Doxycycline</td>
<td>Tetracycline</td>
<td>14 (38.9)</td>
<td>22 (61.1)</td>
</tr>
<tr>
<td>Tetracycline</td>
<td>Tetracycline</td>
<td>14 (38.9)</td>
<td>19 (52.8)</td>
</tr>
<tr>
<td>Chloramphenicol</td>
<td>Phenicol</td>
<td>1 (2.8)</td>
<td>29 (80.6)</td>
</tr>
<tr>
<td>Clindamycin</td>
<td>Lincosamide</td>
<td>19 (52.8)</td>
<td>17 (42.7)</td>
</tr>
<tr>
<td>Gentamicin</td>
<td>Aminoglycoside</td>
<td>21 (58.3)</td>
<td>10 (27.8)</td>
</tr>
<tr>
<td>Rifampin</td>
<td>Ansamycin</td>
<td>0 (0.0)</td>
<td>36 (100.0)</td>
</tr>
<tr>
<td>Trimethoprim/ Sulfamethoxazole</td>
<td>Folate pathway inhibitor</td>
<td>20 (55.6)</td>
<td>16 (44.4)</td>
</tr>
</tbody>
</table>

Minimum inhibitory concentration antimicrobial susceptibility testing using broth dilution was performed on all MRSP isolates (n = 36). Sample (17). The dry electrostatic cloth was wiped across the desired surface, immediately placed into a sterile sampling bag with a flat wire closure (Fisherbrand; Thermo Fisher Scientific, Waltham, Massachusetts, USA), and placed into a chilled cooler with freezer packs for transport to the laboratory. The surface areas sampled were not uniform in size across surface types because the available areas varied widely (e.g., light switch versus floor); however, despite hospital diversity, similar surfaces were sampled using a consistent technique across hospitals. For example, although makes and models of computer keyboards varied between hospitals, the method of wiping lightly across the entire top of the keyboard was constant.

**Culture and isolation**

Bacterial culture and isolation were carried out at the Washington State University Paul G. Allen Center for Global Animal Health. Tryptic soy broth (TSB) (CRITERION; Hardy Diagnostics, Santa Maria, California, USA) with 2.5% NaCl (90 mL) was added to each sample bag, massaged thoroughly to evenly submerge the cloth, then incubated overnight at 35°C. The next day samples were streaked on mannitol salt agar (MSA) plates (CRITERION; Hardy Diagnostics) and incubated for 24 to 48 h at 37°C. Staphylococcus species identified according to the Clinical Laboratory Standards Institute (CLSI) protocol and isolates were tested for inducible clindamycin resistance using a D-test (18). For each sampling event, an unused electrostatic cloth was also placed in TSB with 2.5% NaCl (90 mL) and incubated overnight at 37°C, streaked on MSA supplemented with 2 μg/mL of oxacillin, and incubated for 24 to 48 h at 37°C. If yellow colonies appeared they were streaked on CBA and beta-hemolytic colonies were submitted to WADDL for bacterial identification using MALDI-TOF and MIC.

**meca detection**

Methicillin resistance was confirmed through polymerase chain reaction (PCR) detection of the meca gene in all coagulase-positive methicillin-resistant *Staphylococcus* species identified through MALDI-TOF and MIC. DNA was extracted using the boiled cell lysate method and PCR amplification was performed using a Bio-Rad T100 Thermal Cycler (Bio-Rad Laboratories, Hercules, California, USA). The reaction mixture contained forward primer 5’ATACCTTAGTTCTTTAGCGAT-3’ and reverse primer 5’-GATAGCAGTTATATTTCTA-3’ (Eurofins Scientific, Louisville, Kentucky, USA) and the reaction conditions were 95°C for 3 min, 96°C for 30 s (30 cycles), 49°C for 45 s, and the unweighted pair group method with arithmetic mean (UPGMA) algorithm with an optimization of 0%, and a tolerance no greater than 2.5% in Bionumerics (Applied Maths).
ARTICLE

Table 3. Isolation of methicillin-resistant Staphylococcus pseudintermedius (MRSP).

<table>
<thead>
<tr>
<th>Hospital</th>
<th>Hand-contact surfaces</th>
<th>Animal-contact surfaces</th>
<th>All surfaces</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Number</td>
<td>MRSP positive</td>
<td>Number</td>
</tr>
<tr>
<td>A</td>
<td>17</td>
<td>4 (23.5%)</td>
<td>17</td>
</tr>
<tr>
<td>B</td>
<td>18</td>
<td>4 (22.2%)</td>
<td>17</td>
</tr>
<tr>
<td>C</td>
<td>17</td>
<td>0 (0.0%)</td>
<td>17</td>
</tr>
<tr>
<td>D</td>
<td>18</td>
<td>0 (0.0%)</td>
<td>17</td>
</tr>
<tr>
<td>E</td>
<td>17</td>
<td>0 (0.0%)</td>
<td>17</td>
</tr>
<tr>
<td>F</td>
<td>17</td>
<td>1 (5.9%)</td>
<td>17</td>
</tr>
<tr>
<td>G</td>
<td>17</td>
<td>5 (29.4%)</td>
<td>16</td>
</tr>
<tr>
<td>H</td>
<td>17</td>
<td>1 (5.9%)</td>
<td>16</td>
</tr>
<tr>
<td>I</td>
<td>17</td>
<td>0 (0.0%)</td>
<td>17</td>
</tr>
<tr>
<td>J</td>
<td>17</td>
<td>4 (23.5%)</td>
<td>16</td>
</tr>
<tr>
<td>K</td>
<td>18</td>
<td>2 (11.1%)</td>
<td>17</td>
</tr>
</tbody>
</table>

Prevalence of methicillin-resistant Staphylococcus pseudintermedius isolated from environmental surfaces of participating hospitals.

Questionnaire
A questionnaire was developed for veterinary personnel to assess perceptions about infection control behavior in veterinary hospitals (survey provided in S2, available from the authors). It was beta-tested by veterinarians at the Washington State University College of Veterinary Medicine and a co-author (DM) provided survey expertise (20,21). One author (AP) carried out an in-person interview with 1 hospital representative immediately following environmental sample collection during each hospital visit. The interviewee was the employee identified by the owner, lead veterinarian, or manager at each hospital as the best suited to answer questions about basic hospital infection control practices. Most questions were structured with balanced interval-level scale responses and a few were multiple choice or unstructured open-ended questions (S2, S3, available from the authors) (22).

Statistical methods
To detect a 10% difference in the prevalence of MRSP on hand- and animal-contact surfaces with an α = 0.05 (2-sided) and a power of 80%, a total of 306 samples and 10 hospitals were required (23–25). The Fisher’s exact test was used to examine potential associations using R and a significance cut-off of P = 0.05 was used (26). Ordinal variables were dichotomized. The effect of missing data was determined by carrying out a sensitivity analysis. For example, Fisher’s exact tests were carried out using both possible dichotomous response options for missing values.

Results
Environmental cultures
Forty-two hospitals received invitations and 11 agreed to participate. Samples were collected from 374 surfaces in 11 hospitals; 190 samples were obtained from hand-contact surfaces and 184 from animal-contact surfaces (Table 3). Methicillin-resistant S. pseudintermedius was isolated from at least 1 sample from 7 of 11 hospitals (64%) and from 36 of 374 total samples (10%). Within-hospital prevalence varied from 0% to 39% with a median of 3%. A small number of other coagulase positive methicillin-resistant staphylococci were recovered: Staphylococcus aureus (MRSA) was isolated from 2% (8/374) of total surfaces sampled and from at least 1 surface in 4 of 11 hospitals (36%) and Staphylococcus schleiferi subspecies coagulans was isolated from 0.8% (3/374) of total surfaces sampled and from 2 of 11 hospitals (detailed sampling results are provided in Table S4, available from the authors). Of the 36 samples from which MRSP was isolated 58.3% were hand-contact surfaces and 41.7% were animal-contact surfaces; this difference was not statistically significant (P = 0.38).

Antimicrobial resistance
All MRSP isolates (n = 36) were tested against a panel of 16 antimicrobial drugs representing 8 antimicrobial classes (Table 2). Isolates were resistant to all 7 of the β-lactams that were tested. Co-resistance to at least 1 other antimicrobial was identified in 86% (31/36) of isolates, and 72% (26/36) were multi-drug resistant (MDR, resistant to ≥ 3 classes). Five isolates (14%) were resistant to only β-lactam antimicrobials, 8 isolates (22%) were resistant to 2 or 3 antimicrobial classes, and 23 isolates (64%) were resistant to between 4 and 8 antimicrobial classes. Rifampin was the single ansamycin on the panel and was the only antibiotic to which all isolates were susceptible. Three isolates (8%) from 2 separate facilities (Hospitals A and B) were susceptible to only rifampin. All MRSP isolates were negative for inducible clindamycin resistance, but 3 of the MRSA isolates were positive. Methicillin resistance was confirmed through PCR detection of the mecA gene in all MALDI-TOF identified coagulase positive Staphylococcus isolates in this study (n = 47) that exhibited a methicillin-resistant phenotype (MIC).

Questionnaire responses
When asked about frequency of disinfection of hand- and animal-contact surfaces, 25% of responses indicated daily disinfection of hand-contact surfaces compared to 90% of responses that indicated daily disinfection of animal-contact surfaces (P < 0.001). Cleaning and disinfection of these surfaces was otherwise reported to occur on a weekly basis (or less often). In response to the question “How many veterinarians, technicians/assistants, and non-technical staff are scheduled to work on a regular business day?” it was reported that hospitals were staffed with a mean of 15 people per day (median: 14.5, range: 7 to 28). Hospitals staffed with 15 or more people per day (n = 5 hospitals) were associated with significantly higher...
environmental MRSP prevalence ($P < 0.001$). When asked about the general frequency of hand antisepsis after touching common animal-contact surfaces compared to after touching common hand-contact surfaces, 64\% of respondents reported that employees always or often (compared to sometimes or rarely) practiced hand antisepsis after touching animal-contact surfaces while 9\% reported that employees always or often practiced hand antisepsis after touching hand-contact surfaces ($P = 0.02$). In response to the question “What type of disinfectant is primarily used in your clinic: bleach, accelerated hydrogen peroxide, quaternary ammonium, unknown, or other?” the primary disinfectant was identified as a quaternary ammonium product in 5/11 hospitals, a chlorhexidine solution in 4/11 hospitals, and an accelerated hydrogen peroxide product in 2/11 hospitals. Most respondents (6/11) simply reported the product brand name and were not aware of the active ingredient in the product. The researcher (AP) confirmed the active ingredient during the questionnaire process. Few hospitals were able to report annual caseload so those data were omitted from analysis; however, 9/11 hospital representatives reported...
greater than 20 patient visits on a regular business day. 1 hospital reported between 16 and 20, and 1 hospital reported between 6 and 10. Number of patient visits on a regular business day was not associated with hospital staffing numbers ($P = 0.45$). Ten hospitals reported that they had designated isolation rooms and this was confirmed by observation. Among those 10, 4 were not prepared for immediate use because they were being used for storage or for housing staff owned animals. Resident cats were observed to roam freely indoors, including in operating theaters, in 4/11 hospitals. Significant outcomes were all robust enough to withstand vulnerabilities of the sensitivity analysis.

Genotyping

Analysis of PFGE profiles resulted in 9 clusters of indistinguishable isolates. One cluster of two indistinguishable isolates came from within hospital A, 3 clusters of 2 came from within hospital B, 1 cluster of 3 and 2 clusters of 4 came from within hospital G, and 2 clusters of 2 came from within hospital J. Every cluster of indistinguishable MRSP isolates included at least 1 that was recovered from a hand-contact surface. Indistinguishable isolates were within, but not between hospitals, but the 2 hospitals nearest to one another (approximately 6 km) (Table S1, available from the authors) had isolates with PFGE profiles that differed by a single visible band (hospitals G and K) (Figure 1). One isolate from Hospital A was unavailable for PFGE.

Discussion

Our finding of MRSP contamination of an average of 10% of surfaces in 64% of small animal primary care hospitals suggests that environmental prevalence in these settings is much higher than previously thought, and that companion animal patients have multiple opportunities for exposure to MRSP in these settings. This is a critical finding for addressing the problem of MRSP because most research and interventions hitherto have focused on referral hospitals such as teaching hospitals, in which patients are referred from primary care settings such as those sampled in this study. A 2010 study of companion animal hospital environments in southern Ontario found that the hospital-level prevalence of MRSP and MRSA were 7% and 9%, respectively, which is lower than the hospital-level prevalence observed in our study (MRSP 64%, MRSA 36%) (16). Additionally, the Ontario study found a higher hospital-level prevalence of MRSA than MRSP, while our study found the opposite. The high hospital-level prevalence in this study compared to the 2010 study in Ontario could be due to geographical variation or to our smaller sample size; however, with our smaller sample size detection should have been less likely. It is also possible that our results simply reflect increased prevalence and distribution of methicillin-resistant staphyloccoci, a trend that has been observed over the last decade (4). In addition to the unexpectedly high environmental prevalence, we found that, while hand-contact surfaces (surfaces unlikely to have contamination introduced directly by animals) have the same high prevalence as animal-contact surfaces, hospitals reported consistently that hand-contact surfaces were cleaned infrequently if at all. These findings are novel and indicate potentially fruitful directions for research and interventions to mitigate the problem of MRSP in veterinary settings.

Hands of healthcare workers are the main way pathogens are transmitted between patients within hospitals (27,28). American Animal Hospital Association infection control guidelines include practicing hand hygiene before and after touching patients and surfaces in the patient's environment as well as cleaning and disinfecting intensively used patient contact surfaces between each patient such as examination tables and scales (29). In the current study, veterinary hospital representatives consistently reported that hand hygiene occurred more often after touching common animal-contact surfaces compared to hand-contact surfaces and that animal-contact surfaces were cleaned and disinfected more frequently than hand-contact surfaces. These 2 findings suggest perceived differences in risk associated with the different types of surfaces because animal contact surfaces may be considered "dirtier." They also suggest that the importance of cleaning and disinfection of hand-contact surfaces may be under-emphasized in training and continuing education for veterinary professionals.

Chlorhexidine, quaternary ammonium, and accelerated hydrogen peroxide were identified as primary hospital disinfectants. Compared with other disinfectants, accelerated hydrogen peroxide is fast acting, very safe, and highly effective against a broad spectrum of microorganisms (29). Chlorhexidine (a biguanide) and quaternary ammonium disinfectants generally have a more limited spectrum of activity and longer required contact times, respectively. They are not always effective against some organisms of veterinary concern such as Pseudomonas, bacterial spores, or non-enveloped viruses such as canine parvovirus (29–32). Despite the availability of a safer and broader-spectrum disinfectant such as accelerated hydrogen peroxide, most hospitals were using less effective agents such as chlorhexidine and quaternary ammonium compounds. The high number of hospitals reporting chlorhexidine as a primary disinfectant was of particular concern. Although chlorhexidine has antiseptic benefits such as residual activity and being non-irritating to the skin and mucous membranes, it is not typically recommended as an environmental disinfectant because it is only effective in a narrow pH range, becomes inactive in the presence of certain cleaning products, and can be an environmental toxin if improperly disposed of (29,30). The American Animal Hospital Association recommends that veterinary employees be familiar with disinfectant product labels as a crucial part of hospital biosafety (29). The frequently reported use of less effective alternative disinfectants, particularly chlorhexidine solutions, may be attributed to low cost, convenience, or availability. Alternatively, it may indicate unfamiliarity with disinfectants and industry standards. In either case there is a need for training and education, including knowledge of the spectrum of activity, appropriate dilutions, contact time, removing debris, applying soap or detergent, and allowing surfaces to dry before applying the disinfectant.

The observed resistance to β-lactam antimicrobials was consistent with the presence of the SCCmec and mecA gene, but the high level of co-resistances and the MDR profile of most of the MRSP isolates recovered suggest that MRSP can acquire...
resistance to many drugs used as alternatives to β-lactams, for example fluoroquinolones and aminoglycosides, which are important for human and veterinary medicine. The detection of MRSP isolates in veterinary hospital environments that are susceptible to only rifampin increases concerns about the diminishing number of safe and effective therapeutic options and increases the importance of prevention measures.

There were several important limitations to this study. Although participating hospitals were geographically dispersed across Washington and Idaho to be representative of regional hospitals, they may not be nationally or globally representative. Because this study relied on voluntary participation, the potential bias of self-selection must be considered. Hospitals with recently identified cases of MRSP may have been more likely to participate out of a desire for more knowledge, which could result in an overestimation of true prevalence. Conversely, such hospitals may be less willing to participate if concerned that identification of contaminated surfaces could damage the hospital’s reputation or would force them to implement potentially costly control measures, a scenario that could lead to underestimates of true prevalence. The finding of high hospital-level prevalence suggests that the latter did not affect the results. As field studies rely on volunteers it would be difficult to prevent this self-selection. Due to the cross-sectional study design, study investigators could not monitor hand hygiene compliance so we had to rely on reports by a single hospital representative. It is possible that hand hygiene practices varied between staff members in each hospital; however, responses regarding hand hygiene frequency were consistent across hospitals. It is likely that hand hygiene frequency was exaggerated due to self-reporting. Although most veterinary personnel agree that hand hygiene is important, video surveillance in small animal hospitals has demonstrated that actual hand hygiene compliance is very low (12,33). The discordance between self-reported versus directly monitored frequency of hand hygiene in these settings warrants further investigation. Animal healthcare providers and their patients may benefit from hand hygiene campaigns tailored towards veterinary care similar to those that are prominent in human medicine (34). The cross-sectional study design has an important role in epidemiological investigations, but has limited power to detect temporal relationships, which could be addressed with a longitudinal study. These data do, however, provide a snapshot of the high variability among hospitals and, given the cross-sectional design, suggests a high prevalence of surface contamination with MRSP. Finally, although we found equivalent prevalence of contamination on hand- and animal-contact surfaces, and identical PFGE strain types from different sites within hospitals, it is important to point out that environmental contamination does not necessarily mean that transmission and new acquisition by patients are occurring. The main objective of this study was to determine frequency of MRSP on hand- versus animal-contact surfaces as a preliminary step to inform future larger sample-sized and longitudinal studies.

The prevalence of MRSP on environmental surfaces in small animal primary care hospitals has not been thoroughly explored. For many companion animals, primary care hospitals may be the only type of veterinary facility visited. Sick or injured animals may visit a primary care hospital once or several times before being referred to a specialist, particularly in cases of non-healing or recurrent infections. Although MRSP is rarely pathogenic in humans, humans may act as transient carriers and/or transmission vectors to companion animals, particularly dogs, which are more frequently infected with MRSP (10,35). Our findings suggest that MRSP is frequently present in regional small animal primary care hospitals. Many of the isolates expressed co-resistance to multiple non-β-lactam antimicrobials important for both humans and animals. Although the reservoir of MRSP is known to be small companion animals, particularly dogs, contamination was not restricted to animal-contact surfaces within the sample population. The equivocality in frequency of MRSP recovery between hand- and animal-contact surfaces suggests there is opportunity for improvement of infection control protocols in these settings, especially in areas such as hand hygiene and cleaning and disinfection.

References
Anesthetic and analgesic effects of an opioid-free, injectable protocol in cats undergoing ovariohysterectomy: A prospective, blinded, randomized clinical trial

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Abstract — This study evaluated the effects of ketamine-dexmedetomidine-midazolam as part of an opioid-free, multimodal protocol in cats undergoing ovariohysterectomy. In a prospective, blinded, randomized clinical trial, cats received either 1 of 2 doses of ketamine [5 mg/kg body weight (BW), n = 10, K5 or 7 mg/kg BW, n = 13, K7] with midazolam (0.25 mg/kg BW) and dexametomidine (40 μg/kg BW) intramuscularly, intraperitoneal bupivacaine (2 mg/kg BW) and subcutaneous meloxicam (0.2 mg/kg BW) after surgery. Buprenorphine (0.02 mg/kg BW, intravenously) was administered if pain scores exceeded intervention scores with 2 pain scoring systems. Similar prevalence of rescue analgesia was observed (K5 = 6/10; K7 = 7/13) with significantly lower requirements in kittens (2/8) than adults (11/15). Tachypnea (K5 = 7/10 and K7 = 9/13) and desaturation (K5 = 3/10 and K7 = 4/13) were the 2 most common complications. Age influenced the prevalence of rescue analgesia. Most adult cats required opioids for postoperative pain relief.

Résumé — Effets anesthésiants et analgésiques d’un protocole injectable sans opioïde chez des chats soumis à une ovario-hystérectomie : essai clinique prospectif, randomisé, à l’aveugle. Lors de la présente étude nous avons évalué les effets de la combinaison kétamine-dexmedetomidine-midazolam comme élément d’un protocole multimodal sans opioïde chez des chats soumis à une ovario-hystérectomie. Dans un essai clinique prospectif, randomisé, à l’aveugle, des chats reçurent une des deux doses de kétamine [5 mg/kg poids corporel (BW), n = 10, K5 ou 7 mg/kg BW, n = 13, K7] avec du midazolam (0,25 mg/kg BW) et du dexmedetomidine (40 μg/kg BW) par voie intramusculaire, de la bupivacone par voie intrapéritonéale (2 mg/kg BW) et du meloxicam sous-cutané (0,2 mg/kg BW) après la chirurgie. De la buprenorphine (0,02 mg/kg BW, par voie intraveineuse) fut administrée si les pointages de douleur excédaient les pointages d’intervention avec deux systèmes de pointage de la douleur. Une prévalence similaire d’analgésie de secours fut observée (K5 = 6/10; K7 = 7/13) avec des demandes significativement moindres chez les chatons (2/8) que chez les adultes (11/15). De la tachypnée (K5 = 7/10 et K7 = 9/13) et de la désaturation (K5 = 3/10 et K7 = 4/13) étaient les deux complications les plus fréquentes. L’âge influençait la prévalence de l’analgésie de secours. La plupart des chats adultes ont requis des opioïdes pour soulager la douleur post-opératoire.

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Introduction

The international veterinary community does not always have access to drugs for basic standard of care including anesthetics and analgesics (1). Surgical and anesthetic procedures are often performed with injectable anesthetics with limited or no perioperative analgesia (2). Drugs such as opioids and volatile anesthetics are not readily available in many countries, although opioids are one of the cornerstones of acute pain management (3). Unfortunately, frequent drug shortage is now also a reality in North America. This problem potentially leads to unnecessary animal suffering and is a welfare issue. Colloquially, there has been an increase in continuing education and “blogs”...
regarding alternatives to opioid analgesia in veterinary patients (4,5). However, studies on “opioid-free anesthesia” and alternatives to volatile anesthesia are rare in veterinary medicine (6,7).

The objective of this study was to compare the anesthetic and analgesic effects of an opioid-free, low-volume, injectable anesthetic protocol using a combination of 1 of 2 doses of ketamine [5 mg/kg body weight (BW) or 7 mg/kg BW] with dexmedetomidine and midazolam in a multimodal analgesic protocol. The authors hypothesized that both doses of ketamine would provide an appropriate depth of anesthesia, effective analgesia (i.e., low prevalence of rescue analgesia), and minimal anesthetic complications in cats undergoing ovariohysterectomy.

**Materials and methods**

The study protocol was approved by the animal care committee of the Faculty of Veterinary Medicine (FMV), Université de Montréal (18-RECH-1978). The study was performed between November 2018 and January 2019 and is reported according to the Consolidated Standards of Reporting Trials (CONSORT guidelines; http://www.consort-statement.org).

**Animals**

Thirty female cats previously from shelter facilities were enrolled in a prospective, blinded, randomized clinical trial after obtaining the adoptive owners’ written consent (Figure 1). Inclusion criteria included any healthy cat of any breed and older than 4 mo of age. Cats were deemed healthy based on medical history, physical examination, hematocrit, and serum total protein. Pregnant and lactating cats were also eligible for inclusion since they represent the normal population undergoing ovariohysterectomy in sterilization programs. Exclusion criteria included body weight less than 1 kg, cardiac arrhythmias, body condition score > 7 or < 3 on a scale from 1 to 9, anemia (hematocrit < 25%), hypoproteinemia (total protein < 59 g/L), shy or fearful individuals not allowing adequate pain assessment, baseline pain scores consistent with presence of pain, evidence of previous ovariohysterectomy (i.e., visualization of scar and/or tattoo), and clinical signs of systemic disease. The cats were admitted to the FMV at least 12 h before general anesthesia and were housed individually in adjacent cages in a cat ward. Each cat had access to water and food bowls and a litter box. Environmental enrichment included a hanging toy, blankets, and a box in which the cat could hide or use as an elevated surface. Food, but not water was withheld for 8 to 12 h before general anesthesia.

**Experimental design and treatment groups**

Thirty subjects were randomized into 1 block with allocation ratio of 1:1. Randomization was performed by a researcher (ME) not involved with pain assessment using a randomization plan generator (www.randomization.com). Upon arrival, each cat was sequentially assigned a number (1 to 30) and according to this number, was allocated to 1 of 2 treatment groups: K5 (5 mg/kg BW of ketamine) or K7 (7 mg/kg BW of ketamine). The cats received a combination of ketamine (K5 or K7; Ketaset, Zoetis, Kirkland, Quebec), dexmedetomidine (Dexdomitor; Zoetis), 40 μg/kg BW, and midazolam (Midazolam; Sandoz, Boucherville, Quebec), 0.25 mg/kg BW, administered together into the lumbar epaxial muscles (IM) through a 1-mL syringe. The same 2 observers (TD, HR) performed the intramuscular injections and were masked to treatment.

Once lateral recumbency was achieved, a 22-gauge catheter was inserted into the cephalic vein using aseptic technique. The cat was placed in sternal recumbency and the tongue of the cat was pulled slightly rostral for intubation with a supraglottic airway device (v-gel; Docsinnovent, London, UK). Proper positioning of the supraglottic airway device was confirmed with capnography and cats were allowed to spontaneously breathe room air. The cats were then placed in dorsal recumbency on a circulating warm water vinyl blanket; the surgical site was clipped and prepared using aseptic technique.

Anesthesia was performed by the same veterinarian (ME). Physiologic parameters were measured using a multi-parametric monitor (LifeWindow 6000V veterinary multiparameter monitor; Digicare Animal Health, Boynton Beach, Florida, USA), which included electrocardiogram, capnography, pulse oximetry, and arterial blood pressure (oscillometric technique). Arterial oxyhemoglobin saturation (SpO2), end-tidal CO2 (PETCO2), respiratory rate (fR), heart rate (HR), mean arterial pressure (MAP) were recorded every 5 min throughout the anesthetic period. Rectal temperature (T) was recorded once immediately after the end of anesthesia. Lactated Ringer’s solution (Lactated Ringer’s Inj. Bag/500 mL; McCarthy & Sons Service, Calgary, Alberta) was administered intravenously at 10 mL/kg BW per hour throughout. Ovariohysterectomy was performed by an experienced veterinarian (BM) using a ventral midline incision and the feline pedicle tie technique, described elsewhere (8). Immediately following laparotomy and before ovariohysterectomy, bupivacaine HCl 0.25% USP (Sensorcaine; AstraZeneca, Mississauga, Ontario), 2 mg/kg BW, was administered intraperitoneally. The solution was equally divided into 3 parts. Each third of the solution was instilled over the left and right ovarian pedicles and the caudal aspect of the uterus. The surgery was continued approximately 1 min after the intraperitoneal administration of bupivacaine, as previously described (9). At the end of the surgical procedure, a 2-cm green line tattoo was applied lateral to the ventral midline incision for visual identification of a neutered animal.

A ketamine bolus (0.5 mg/kg BW) was administered intravenously if there were signs of an inadequate depth of anesthesia. These signs included swallowing reflex, purposeful movement or increase in MAP of ≥ 15% compared with pre-surgical values. Boluses were administered at a minimum interval of 1 min between doses. Mean arterial blood pressure was measured 1 min after administering each bolus.

Atipamezole (Antisedan 5.0 mg/mL; Zoetis), 400 μg/kg BW, IM, was administered at the end of surgery followed by meloxicam (Metacam 0.5%; Boehringer Ingelheim, Burlington, Ontario), 0.2 mg/kg BW, SC. Extubation was performed when palpebral reflexes returned. A second dose of meloxicam (Metacam 0.5 mg/mL oral suspension; Boehringer Ingelheim), 0.05 mg/kg BW, PO was administered 24 h after the first dose.

Onset of anesthesia was defined as the time from the end of IM injection with ketamine-dexmedetomidine-midazolam...
(KET-DEX-MID) until lateral recumbency and was measured with a chronometer. Duration of surgery (time from first incision to placement of the last suture) and of anesthesia (time from IM injection to atipamezole injection) and time to sternal recumbency (time from atipamezole injection to first sternal recumbency) were recorded for each cat.

Complications
Anesthetic complications were defined as any observation of the following: tachycardia (HR > 160 bpm), bradycardia (HR < 70 bpm), hypotension (MAP < 50 mmHg), bradypnea (fR < 4 rpm), tachypnea (fR > 30 rpm), hypercapnia (P ET CO 2 > 50 mmHg), desaturation (SpO 2 < 90%), and hypothermia (T < 36.0°C). Light depth of anesthesia was treated with a bolus of ketamine as previously described. Assisted ventilation with intermittent positive pressure was instituted by connecting an Ambu-bag (Portex 1st Response Adult Manual Resuscitators; Smith Medical, Markham, Ontario) to the supraglottic airway device and giving 12 breaths/min using room air for 3 min in cases of hypercapnia or desaturation. If the latter was not effective, the Ambu-bag was disconnected, and a Mapleson D circuit (Moduflex Bain Circuit Adaptor; DISPOMED, Joliette, Quebec) was attached to the supraglottic airway device with the administration of 100% oxygen. Additional external heat sources (e.g., forced warm air blanket) were used for the treatment of hypothermia.

Pain and sedation scores
Pain assessment was performed approximately 1 h before the administration of injectable anesthetics (time 0, baseline) and at 0.5, 1, 2, 3, 4, 6, 8, 12, and 24 h after the end of surgery by the same observer (TD) blinded to the treatment group. Two pain-scoring systems, the Glasgow feline composite measure pain scale (CMPS-Feline) (10) and the Feline Grimace Scale (FGS) (11), were used for pain assessment. The CMPS-Feline consists of 7 questions regarding vocalization, posture, attention to the wound, 2 facial expression features, interaction with the observer, response to palpation, and overall demeanor, adding up to a maximum score of 20 points (10). The FGS is a facial expression-based scoring system that consists of 5 action units (ear position, orbital tightening, muzzle tension, whiskers change, and head position), each one receiving a score of 0 to 2 adding up to a maximum score of 10 points (11). Because not all action units can be visualized in all cats at all time points, the final score of the FGS was recorded as a fraction (i.e., total score divided by the maximum score based on the number of the action units included in the evaluation).

Sedation was evaluated by the same individual (TD) using a Dynamic Interactive Visual Analog Scale (DIVAS) at times 0 (baseline), 0.5, 1, 2, 3, 4, 6, and 8 h after the end of surgery and before pain assessment. The DIVAS was determined as previously described (9). The DIVAS score was derived from a 10 cm bar where 0 corresponded to “no sedation” and 10 corresponded to the “maximum sedation possible.”

Rescue analgesia
Rescue analgesia using buprenorphine (Vetergesic; Champion Alstoe, Whitby, Ontario), 0.02 mg/kg BW, IV, was administered when pain scores were ≥ 5/20 (CMPS-Feline) and ≥ 0.39/1.0 (FGS). To avoid bias, data collected after the administration of rescue analgesia were not included in the statistical analysis. However, pain evaluations for all cats were continued until the end of the study.

Statistical methods
This was an exploratory study and sample size calculations were not performed beforehand. Statistical analysis was performed with standard software (SAS, version 9.3; SAS Institute, Cary, North Carolina, USA). Normality was visually assessed, and the distribution of residual values was considered symmetrical.
Demographic data between treatment groups were analyzed using equal variances t-tests. Pain and sedation scores were analyzed using linear mixed models with group and time as the fixed factors, cats nested within the treatment group as random factor and age group (kittens or adults) as a co-factor. Pairs of means were compared using priori contrasts and the alpha level for each comparison was adjusted with the sequential Benjamini-Hochberg procedure. Scores of CMPS-Feline were recorded as the total score. Scores of FGS were recorded as percentage because one or more action units could perhaps not be visible during pain assessment due to the cat’s position and/or in the presence of residual anesthetic effects. The number of cats receiving rescue analgesia and the frequency of complications were analyzed using the exact \( \chi^2 \) test. The relationship between pain scores from the CMPS-Feline and FGS was analyzed using a linear mixed model with cat as a random factor and the CMPS-Feline scores as the fixed factor. Values of \( P < 0.05 \) were considered significant.

### Results

Twenty-three cats were included in this study (Figure 1). Because age was not precise for most cats, they were categorized into 2 age groups: kitten or adult. Kittens were defined as cats between 4 and 6 mo of age. Adults were defined as cats over 6 mo of age as confirmed by dentition and the presence of all permanent teeth (12). Body weight, age group, hematocrit, total protein, onset of anesthesia, duration of surgery, anesthesia and time to sternal recumbency were not different between treatment groups (Table 1). None of the cats required a ketamine bolus.

The prevalence of anesthetic complications was not significantly different between treatment groups. Tachycardia was observed in 1 cat in K5 and none of the cats in K7 (\( P = 0.44 \)). Tachypnea was observed in 7 cats in K5 and 9 cats in K7 (\( P = 1 \)). Desaturation was observed in 3 cats in K5 and 4 cats in K7 (\( P = 1 \)). Bradycardia, hypotension, bradypnea, hypercapnia and hypothermia were not observed in any cat. All cats were discharged from hospital at least 24 h after surgery without postoperative complication.

### CMPS-Feline/FGS pain scores

Pain scores at 0.5 h and 1 h time points were discarded because of purposeless movements and restlessness during anesthetic recovery which did not allow appropriate pain assessment. There was no significant difference between treatment groups at any time points according to CMPS-Feline and FGS (\( P > 0.38 \) and \( P > 0.25 \), respectively). CMPS-Feline pain scores were significantly higher at 2 h (\( P < 0.0001 \)) and 3 h (\( P = 0.0004 \)) in K5 group; and at 2 h (\( P < 0.0001 \)), 3 h (\( P = 0.0004 \)), 4 h (\( P = 0.0001 \)), and 6 h (\( P = 0.0001 \)) in K7 group, compared with baseline values (Figure 2; Table 2). Feline grimace scale pain scores were significantly higher at 2 h (\( P < 0.0001 \)), 3 h (\( P = 0.0025 \)), 4 h (\( P = 0.0025 \)), and 6 h (\( P = 0.0025 \)) in K5 group; and at 2 h (\( P < 0.0001 \)), 3 h (\( P = 0.0004 \)), 4 h (\( P = 0.001 \)), and 6 h (\( P < 0.0001 \)) in K7 group, compared with baseline values (Figure 3; Table 2).

### Rescue analgesia

Thirteen cats required rescue analgesia; 6 cats in K5 and 7 cats in K7. Prevalence of rescue analgesia was not significantly different between treatment groups (\( P = 1 \)). According to age groups, 2 cats in the kitten group and 11 cats in the adult group required rescue analgesia (25.0% and 73.3%, respectively). The prevalence of rescue analgesia was significantly greater in adults than in kittens (\( P = 0.039 \)). Time points at which rescue analgesia was administered were 2 h (\( n = 9 \)) and 3 h (\( n = 4 \)).

### Relationship between CMPS-Feline and FGS

Data from all time points, except for times 0.5 and 1 h, including data after rescue analgesia, were included in the analysis of the relationship between both pain scales. There was a positive and significant association between CMPS-Feline and FGS scores (\( P < 0.0001 \)) (Figure 4).

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**Table 1.** Body weight, age group, hematocrit, total protein, onset of anesthesia, duration of surgery and anesthesia and time to sternal recumbency in cats undergoing ovariohysterectomy after the administration of a combination of ketamine (5 or 7 mg/kg BW; groups K5 and K7, respectively) with dexmedetomidine (40 \( \mu g/kg \) BW) and midazolam (0.25 mg/kg BW) by the intramuscular route. Data are reported as mean ± SD.

<table>
<thead>
<tr>
<th></th>
<th>K5 (n = 10)</th>
<th>K7 (n = 13)</th>
<th>( P \text{-value} )*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Body weight (kg)</td>
<td>2.3 ± 1.3</td>
<td>2.5 ± 0.7</td>
<td>0.36</td>
</tr>
<tr>
<td>Age group (number)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kitten</td>
<td>3</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Adult</td>
<td>7</td>
<td>8</td>
<td>1.0</td>
</tr>
<tr>
<td>Hematocrit (%)</td>
<td>38.5 ± 6.8</td>
<td>37.7 ± 3.4</td>
<td>0.71</td>
</tr>
<tr>
<td>Total protein (g/L)</td>
<td>62 ± 4</td>
<td>62 ± 7</td>
<td>0.92</td>
</tr>
<tr>
<td>Onset of anesthesia (min)</td>
<td>1.9 ± 0.8</td>
<td>1.9 ± 0.6</td>
<td>0.93</td>
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<tr>
<td>Duration of surgery (min)</td>
<td>15.5 ± 1.7</td>
<td>15.8 ± 1.0</td>
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<tr>
<td>Duration of anesthesia (min)</td>
<td>31.4 ± 3.8</td>
<td>30.5 ± 2.5</td>
<td>0.52</td>
</tr>
<tr>
<td>Time to sternal recumbency (min)</td>
<td>16.4 ± 9.0</td>
<td>16.8 ± 8.8</td>
<td>0.92</td>
</tr>
</tbody>
</table>

*The \( P \text{-value} \) refers to the comparison between groups.

---

**Figure 2.** Mean ± SEM scores for the Glasgow feline composite measure pain scale (CMPS-Feline) in cats undergoing ovariohysterectomy.

* Indicates significant difference when compared with baseline values. K5 group = 5 mg/kg BW of ketamine, K7 group = 7 mg/kg BW of ketamine.

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Table 2. Least square means of pain scores in cats undergoing ovariohysterectomy using the Glasgow feline composite measure pain scale (CMPS-Feline) and the Feline Grimace Scale (FGS). Anesthetic protocol comprised a combination of ketamine (5 or 7 mg/kg BW; groups K5 and K7, respectively) with dexmedetomidine (40 μg/kg BW) and midazolam (0.25 mg/kg BW) by the intramuscular route. Data are presented as mean (95% confidence interval).

<table>
<thead>
<tr>
<th>Pain scoring</th>
<th>Group</th>
<th>Baseline (0)</th>
<th>2 h</th>
<th>3 h</th>
<th>4 h</th>
<th>6 h</th>
<th>8 h</th>
<th>12 h</th>
<th>24 h</th>
</tr>
</thead>
<tbody>
<tr>
<td>CMPS-Feline</td>
<td>K5</td>
<td>0.62 (–0.25 to 1.49)</td>
<td>4.39 (3.35 to 5.43)*</td>
<td>3.19 (1.95 to 4.42)*</td>
<td>2.44 (1.20 to 3.67)</td>
<td>2.69 (1.45 to 3.92)</td>
<td>1.94 (0.70 to 3.17)</td>
<td>1.94 (0.70 to 3.17)</td>
<td>1.69 (0.45 to 2.92)</td>
</tr>
<tr>
<td></td>
<td>K7</td>
<td>0.83 (0.1 to 1.56)</td>
<td>4.99 (4.10 to 5.89)*</td>
<td>2.88 (1.87 to 3.90)*</td>
<td>2.72 (1.70 to 3.73)*</td>
<td>3.05 (2.03 to 4.07)*</td>
<td>2.38 (1.37 to 3.40)</td>
<td>1.72 (0.70 to 2.73)</td>
<td>1.88 (0.87 to 2.90)</td>
</tr>
<tr>
<td>FGS</td>
<td>K5</td>
<td>0.07 (0.0 to 0.14)</td>
<td>0.31 (0.23 to 0.39)*</td>
<td>0.21 (0.12 to 0.30)*</td>
<td>0.21 (0.12 to 0.30)*</td>
<td>0.21 (0.12 to 0.30)*</td>
<td>0.16 (0.07 to 0.25)</td>
<td>0.16 (0.07 to 0.25)</td>
<td>0.13 (0.04 to 0.22)</td>
</tr>
<tr>
<td></td>
<td>K7</td>
<td>0.08 (0.03 to 0.14)</td>
<td>0.28 (0.20 to 0.36)*</td>
<td>0.28 (0.15 to 0.38)*</td>
<td>0.26 (0.18 to 0.33)*</td>
<td>0.19 (0.11 to 0.26)</td>
<td>0.16 (0.08 to 0.23)</td>
<td>0.17 (0.10 to 0.25)</td>
<td></td>
</tr>
</tbody>
</table>

* Indicates significant difference when compared with baseline.

Figure 3. Mean ± SEM scores for the feline grimace scale (FGS) in cats undergoing ovariohysterectomy.

* Indicates significant difference when compared with baseline values. K5 group = 5 mg/kg of ketamine, K7 group = 7 mg/kg of ketamine.

**Sedation scores**

There was no significant difference between treatment groups at any time points according to the DIVAS \( (P > 0.21) \). When compared with baseline values, sedation scores were increased in K5 and K7 at 0.5 h \( (P < 0.0001 \text{ for both}) \) and 1 h \( (P < 0.0001 \text{ for both}) \) (Table 3, Figure 5). There was no effect of age \( (P = 0.13) \) but the interaction between treatment group and age group was significant \( (P = 0.0025) \). Kittens had overall lower sedation scores than adults in K5 \( (P = 0.0044) \) but not in K7 \( (P = 0.14) \). This difference was not significant after adjustment, but it could be an indication of the direction of the sedation effect between age and treatment.

**Discussion**

In this randomized clinical study, an opioid-free, low-volume injectable protocol using KET-DEX-MID provided rapid immobilization, unconsciousness and smooth induction of anesthesia in cats. The duration and depth of anesthesia were adequate for all surgical interventions after single administration with rapid antagonism by atipamezole; no additional boluses of ketamine were required. These anesthetic effects are in accordance with the Association of Shelter Veterinarians’ 2016 Veterinary Medical Care Guidelines for spay-neuter programs \( (13) \). It provides a significant advantage over the QUAD protocol (ketamine, methadone, medetomidine, and midazolam) since the latter requires volatile anesthesia after administration to induce surgical depth of anesthesia \( (14) \). However, the study showed that most adult cats require the administration of an opioid for the treatment of pain after surgery even if other analgesic drugs were administered. Though not an intended comparison, the protocol appears to provide better postoperative analgesia and fewer sedative effects in kittens. Importantly, nearly a third of all animals required oxygen supplementation or assisted ventilation due to arterial oxyhemoglobin desaturation. Therefore, this combination might not be a good option in situations in which supplemental analgesia and oxygen are not available.

The combination of KET-DEX-MID proved an effective and rapid combination for anesthesia in cats. The increased dose of ketamine \( (7 \text{ mg/kg BW versus } 5 \text{ mg/kg BW}) \) did not affect the speed of onset, duration, nor the time to recovery in this...
The combination induced lateral recumbency and general anesthesia within 2 to 3 min following IM administration. The duration of anesthesia was approximately 32 min in both treatment groups. This was sufficient to perform ovariohysterectomy in all cats without the need for ketamine boluses due to inadequate depth of anesthesia. The true duration of anesthesia was not evaluated and could be much longer since atipamezole was administered to antagonize the effects of dexmedetomidine and hasten anesthetic recovery at the end of each procedure. Time to sternal recumbency was on average 16 min, with no differences between groups. These results are in agreement with previous studies using ketamine-based injectable protocols for which minimal cardiovascular effects, excellent muscle relaxation, and smooth recoveries were observed (15–17). For use in sterilization programs, the combination KET-DEX-MID administered IM is an efficient and appropriate choice for anesthesia. When used for short procedures, the lower dose of ketamine (5 mg/kg BW) is a prudent choice. Further investigation with varied dosing of all 3 drugs is warranted to further refine the protocol.

Analgesia provided by the combination of KET-DEX-MID, intraperitoneal bupivacaine, and meloxicam in this study was inadequate. The prevalence of rescue analgesia was 6/10 in K5 and 7/13 in K7. In previous studies, the intraperitoneal administration of bupivacaine in combination with buprenorphine with or without meloxicam provided superior analgesia in cats undergoing ovariohysterectomy than in the current study, with prevalence of rescue analgesia between 0% and 27% (9,18). Interestingly, kittens in this study had a significantly lower prevalence of rescue analgesia than adults (2/8 versus 11/15, respectively). This result is in agreement with a previous study in which kittens (<4 mo of age) showed fewer behavioral signs of pain than adults (19) even if kittens could express pain behaviors differently than adults. It is not clear if better analgesia was observed in kittens than adults due to physiological differences, changes in pharmacokinetics-pharmacodynamics of anesthetics and analgesics used in the study, if there is less tissue damage and trauma during surgery in kittens than adults, if there are behavioral differences between the 2 age groups confounding pain assessment, or all the above. For example, it is now known that aging impacts thermal antinociception of hydromorphone in cats and the drug requires more frequent dosing in kittens (<6 mo of age) compared with adults, and similar differences with aging could occur with other anesthetics (20).

In the current study, the CPMS-Feline and FGS were consistently elevated at postoperative timepoints in both groups. It is not surprising since pain scores are expected to increase after tissue trauma and inflammation produced by surgery. There was a positive and statistically significant relationship between the 2 scales, supporting their use as pain assessment instruments in cats undergoing ovariohysterectomy using an injectable anesthetic protocol. A positive significant correlation ($\rho = 0.86, P < 0.001$) was also observed between these 2 scoring systems in conscious pain-free cats and those with naturally occurring pain from different sources and intensities (11). This study shows the importance of postoperative pain assessments in all cats even in a high-volume sterilization program, as the authors expected this combination to provide better analgesia than observed. Had these assumptions been used in a high-volume scenario, without postoperative pain evaluations, many cats would have been left in pain despite receiving a presumed “effective” technique. Further research is merited to compare similar anesthetic protocols using opioid versus opioid-free techniques. Additionally, it is possible that the administration of meloxicam before surgery instead of after surgery could have had an impact on postoperative pain and this should be further investigated.

Residual anesthetic effects may increase sedation scores with a potential impact in postoperative pain assessment (9,18,21). Pain assessment was difficult also due to the ketamine-induced purposeless movement and restlessness in some cats especially...
after the administration of atipamezole to antagonize the effects (e.g., muscle relaxation) of dexmedetomidine. Ketamine-based protocols are known to confound the application of pain scales in cats (22). This information has not been validated for the FGS. Based on these observations, the possible confounding effects of ketamine in pain assessment, and the significant difference of sedation scores between baseline values and 0.5 h and 1 h for both treatment groups, data from pain scores before 2 h were not included in the analysis. This was a potential limitation of the study and there is still a need for pain scoring systems that are reliable even in the presence of residual ketamine-based anesthetic protocols. Additionally, there was an interaction between treatment and age groups. In K5, kittens had overall lower sedation scores than adults. Although this difference was no longer significant after adjustment for multiple comparisons; it could be of clinical interest if rapid recovery from anesthesia with minimal sedation is desired. It could represent another advantage of using a lower dose of ketamine (i.e., K5) in cats.

Some anesthetic complications were observed in both groups using KET-DEX-MID. The 2 most common complications according to our definitions, in order, were tachypnea (7/10 in K5 and 9/13 in K7) and desaturation of peripheral arterial oxyhemoglobin (< 90%; 30% in K5 and 30.8% in K7). Desaturation has been observed in previous studies using ketamine (5 mg/kg BW) and dexmedetomidine (25 μg/kg BW) in which mean SpO₂ was 90% [interquartile range (IQR): 84 to 92%] but not with ketamine (5 mg/kg BW), dexmedetomidine (15 μg/kg BW), and hydromorphone (0.05 mg/kg BW) (23,24). Neither of these studies reported tachypnea. Although, in the former study using ketamine at 5 mg/kg BW and dexmedetomidine at 25 μg/kg BW, the mean respiratory rate was 33 ± 13 bpm, which is above our study’s definition of tachypnea (> 30 bpm). The principle of pulse oximetry states that desaturation (< 90%) indicates hypoxemia (PaO₂ < 60 mmHg) which can induce tachypnea. It is therefore possible that hypoxemia was occurring in these patients. However, the impact of peripheral vasoconstriction produced by dexmedetomidine may have caused decreased readings of peripherally measured SpO₂ (23,25). Our results could be an overinterpretation of oxyhemoglobin desaturation. The physiological impact of hypoxemia, however, is important and appropriate monitoring with the ability to provide assisted ventilation and supplemental oxygen is recommended for these protocols. Simultaneous arterial blood gas analysis would allow better interpretation of these complications and could be a subject of future studies.

In addition to some of the limitations presented, this study used a small sample size, which increases the likelihood of type II error. The lack of an opioid-based or a different anesthetic injectable protocol for comparison is also another limitation. Additionally, dexmedetomidine was considered a part of the analgesic protocol, but its effects were antagonized by atipamezole to facilitate recovery. It is not known if analgesic effects would have been better at a cost of prolonged anesthetic recoveries with other possible complications (e.g., regurgitation and aspiration pneumonia) if atipamezole had not been administered. The literature, however, supports the use of atipamezole with agonists of α₂-adrenoceptors without compromising postoperative analgesia in cats after ovariohysterectomy (15,16). Finally, the study did not investigate the quality of anesthetic recovery due to the lack of appropriate scoring systems for this purpose. It would be interesting to know if the quality of anesthetic recovery is better with comparable injectable protocols with or without opioids, or with the use of inhalant anesthesia.

In conclusion, the combination of an opioid-free, low volume, injectable anesthetic protocol using KET-DEX-MID provides rapid immobilization and unconsciousness, and appropriate depth and duration of anesthesia in cats undergoing ovariohysterectomy. Appropriate physiologic monitoring and interventions, particularly for respiratory complications, is recommended. Despite the use of intraperitoneal bupivacaine and postoperative meloxicam, the protocol did not provide adequate analgesia for all individuals with most cats requiring rescue analgesia. However, the protocol could be a suitable option for kittens (4 to 6 mo old), since it provided better analgesia and reduced sedative effects (K5 only) than it did for adults. Based on our results, the use of opioid-based analgesia is required for most adult cats undergoing ovariohysterectomy even when other analgesic drugs are being administered.

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Article

Retrospective evaluation on the outcome of perineal herniorrhaphy augmented with porcine small intestinal submucosa in dogs and cats

Natalie Swieton, Ameet Singh, Daniel Lopez, Michelle Oblak, Katie Hoddinott

Abstract — The purpose of this study was to evaluate post-operative outcome in dogs and cats undergoing perineal herniorrhaphy using porcine small intestinal submucosa (PSIS) alone and with internal obturator muscle transposition augmented with PSIS (IOMT + PSIS). Medical records were retrospectively reviewed and information collected on signalment, pre-operative signs, operative details, and hospitalization. Data on post-operative outcome were obtained from medical records and survey. Eleven dogs and 3 cats had 18 perineal hernias repaired with IOMT + PSIS and 3 using PSIS alone. Surgical site infection developed following IOMT + PSIS in 1/21 hernias (5.6%). Short- and long-term postoperative complications occurred in 9/14 animals and 3/14 animals, respectively. Among the 21 perineal hernias, 3 recurred, 2 of which were repaired with IOMT + PSIS and 1 with PSIS alone. Use of PSIS alone or augmenting IOMT was acceptable for perineal herniorrhaphy and should be considered by surgeons if there are concerns about internal obturator muscle integrity.


Introduction

Perineal hernia occurs when muscular and connective tissue components of the pelvic diaphragm weaken and separate, leading to caudal displacement of intra-pelvic and abdominal structures into the subcutaneous perineal region (1–5). Prevalence in dogs has been reported to range from 0.1% to 0.4%, with limited data available on cats (2,6–8). The majority of dogs with perineal hernias are intact males between 7 and 9 y of age (4,9–11). Several factors are suspected to cause or contribute to this condition, including gonadal hormonal influences, breed conformation, neurogenic atrophy, and tenesmus from constipation, rectal disease, or prostatomegaly (2,4,6,10,11).

Internal obturator muscle transposition (IOMT) has been considered the standard of care surgical treatment for perineal herniorrhaphy, although the efficacy of this technique has varied (12–14). Recurrence rates up to 36% have been reported for IOMT for the treatment of perineal herniorrhaphy in dogs (4,14). The internal obturator muscle (IOM) is a component of the pelvic diaphragm and may undergo atrophy as part of the disease process resulting in a perineal hernia (12,15). Atrophy of the IOM could pose a challenge in the IOMT technique, which may contribute to increased failure and complication rates (3,12,14,15). To bolster repair, synthetic implants such as polypropylene mesh (PPM), peripheral autografts (fascia...
lata), and biomaterials have been used in an attempt to reduce herniorrhaphy failure from a compromised IOM (1,10,13,14).

Porcine small-intestinal submucosa (PSIS) is an extracellular matrix biomaterial that has been used for repair and reconstruction of the abdominal body wall, diaphragm, urinary bladder, Achilles tendon, and dura mater (16–19). Porcine small-intestinal submucosa is composed of a lattice of predominantly type I collagen fibers containing glycoproteins, proteoglycans, glycosaminoglycans, cytokines, and growth factors (20). On implantation, PSIS promotes host cell ingrowth and constructive remodelling, and results in formation of functionally and histologically similar site-specific tissue (1,20,21). Growth factors within the matrix, namely transforming growth factor-beta, vascular endothelial growth factor, and fibroblast growth factor, may facilitate this process by mediating cell migration, proliferation, differentiation, and neovascularization (20). Acellularity lends the graft immunological protection and allows host accommodation, an advantage over synthetic implants (21). While less cost-effective than autogenous grafts, use of commercial PSIS implants holds more consistent graft properties, decreases donor morbidity, and may prove to be less technically challenging (22). When compared to an autogenous tunica vaginalis graft, which has been previously proposed to be obtained following castration at time of perineal herniorrhaphy, PSIS avoids the potential for spread of undiagnosed malignancy at time of surgery and can be used in signalments other than intact males (9).

Ease of handling, absorbability, resistance to infection, and success of small intestinal submucosa (SIS) in previous reports suggest it as a promising biomaterial for use in perineal herniorrhaphy (1). Biomechanical testing of pelvic diaphragms in canine models of perineal herniorrhaphy demonstrated no significant difference in post-operative strength, elasticity, and stiffness of PSIS compared to transposed normal IOM (1). One case study described use of an SIS allograft for perineal herniorrhaphy in 2 dogs with no complications (2). The purpose of our study was to further characterize the short- and long-term outcomes of dogs undergoing perineal herniorrhaphy with PSIS alone and in combination with IOMT (IOMT + PSIS).

**Materials and methods**

**Case selection**

Medical records of all canine and feline patients that underwent perineal herniorrhaphy between January 1, 2012 and December 31, 2017 at the Ontario Veterinary College Health Sciences Centre (OVCHSC) were retrospectively reviewed. Patients were selected for the study if they had perineal herniorrhaphy with PSIS alone or IOMT + PSIS in at least 1 perineal hernia. Dogs undergoing perineal herniorrhaphy using IOMT alone or any other surgical methods were excluded. Dogs with repair of the contralateral hernia at a separate date were included, even if the hernia was repaired with surgical techniques other than PSIS alone or IOMT + PSIS. Patients with cystocele, colocele, or castration staged or in conjunction with perineal herniorrhaphy were also included. Animals were excluded from the study if they had perineal herniorrhaphy performed without the use of PSIS.

**Data collection**

Data collected included age, sex, breed, body weight (BW), body condition score (BCS), pre-operative clinical signs, physical examination findings, and comorbidities at time of presentation. Data on anesthetic protocol, surgical technique, adjuvant surgical procedures, intra-operative findings, duration of surgery, anesthesia time, and hospitalization time were also collected. Bilateral perineal herniorrhaphy was defined as repair of 2 contralateral hernias under the same anesthetic episode. Staged bilateral perineal herniorrhaphy was defined as performance of unilateral perineal herniorrhaphy at an alternate date following repair of the contralateral hernia. Cystocele or colocele were also considered staged if they were performed on a separate date than the herniorrhaphy. All cystoceles and coloceles were performed before perineal herniorrhaphy. Duration of operation was defined as time from first skin incision to end of skin closure. Anesthesia time was defined as time from inhalant initiation to extubation. Hospitalization time was defined as time spent in hospital from end of surgery to discharge (hours).

All patients received cefazolin (Teva Canada, Toronto, Ontario), 16.7 to 25.0 mg/kg body weight (BW), IV, or cefoxitin (Teva Canada), 14.3 to 23.9 mg/kg BW, IV, 15 min before skin incision and every 90 min until the end of skin closure.

**Perineal herniorrhaphy**

The patient was positioned in sternal recumbency with the tail retracted. A purse-string suture pattern was placed in the anus following packing with surgical gauze to facilitate palpation of the rectum. The surgical site was aseptically prepared. A curvilinear incision was made beginning lateral to the anus extending ventrally towards the ischium. The subcutaneous tissues were dissected and hernial sac contents were reduced into the abdomen. For perineal herniorrhaphy with PSIS alone, the procedure was performed as previously described by Stoll et al (1) with modifications depending on intraoperative findings (Figure 1). A sheet of commercially available PSIS (BioSyst; Smiths Medical, Markham, Ontario and Vet BioSIS, Cook Veterinary Products, Bloomington, Indiana, USA) was folded 3 to 4× into the shape of the perineal hernia. Sutures were placed between the PSIS and the levator ani and coccygeal muscles laterally, the IOM and ischial periosteum ventrally, and the external anal sphincter medially in a simple interrupted pattern with polydioxanone suture (PDS; Ethicon, Markham, Ontario). In perineal herniorrhaphy with IOMT + PSIS, IOMT was performed as previously described by Hardie et al (12) with modifications depending on muscle atrophy (Figure 1). A sheet of commercially available PSIS (BioSyst; Smiths Medical, and Vet BioSIS, Cook Veterinary Products) was applied over the IOMT flap and sutured to the coccygeal muscle laterally, IOM ventrally, and external anal sphincter medially in a simple interrupted pattern with PDS, Glycomer 631 (Bioyson; Medtronic, Saint-Laurent, Quebec), or polyglye 6211 (Caprosyn; Medtronic) suture (Figure 2). The sacrotuberous ligament was incorporated or not incorporated based on surgeon preference. The wound was lavaged with saline. Subcutaneous tissue was closed in a simple continuous or interrupted pattern. A cruciate pattern using polypropylene suture (Prolene; Ethicon, and Surgipro,
Medtronic) or intradermal pattern using poliglecaprone suture (Monocryl; Ethicon) was used to appose skin edges. The decision to use PSIS to augment IOMT or to use PSIS alone was made by the attending surgeon based on subjective evaluation of IOM integrity.

Open cystopexy and colopexy
Patients were positioned in dorsal recumbency and the surgical site was aseptically prepared. A ventral midline incision was made from xyphoid to pubis. If the urinary bladder was retroflexed, cystocentesis was performed as necessary and the bladder was reduced to a normal intra-abdominal position. Serosa on the ventral aspect of the bladder was scarified with the blunt end of a scalpel blade. A partial thickness incision was made in the transversus abdominis muscle of the right abdominal wall approximately halfway between the linea alba and sublumbar musculature. Seromuscular and submucosal layers of the bladder were sutured to the abdominal wall incision in 2 rows with a simple continuous pattern. For the colopexy, colonic serosa was scarified as with the cystopexy. A partial thickness incision was made in the musculature of the left lateral abdominal wall. The colonic serosal and muscularis layers were sutured to the abdominal wall incision in a simple continuous pattern using PDS suture.

Orchiectomy
All intact patients were castrated either at the time of colopexy and cystopexy, or at the time of perineal herniorrhaphy. Canine orchiectomy was performed using an open pre-scrotal approach (23). Inguinal cryptorchid orchiectomy was performed through displacement of the testicle into the pre-scrotal region and proceeding as with the open pre-scrotal approach.

Postoperative care
Patients were monitored after surgery in the Intensive Care Unit, Intermediate Care Unit, or Wards of the OVCHSC. They were treated with injectable and/or oral analgesics such as hydromorphone (Sandoz Canada, Mississauga, Ontario), 0.025 to 0.05 mg/kg BW, IV or SQ, q4 to 6h, buprenorphine (Chiron Compounding Pharmacy, Guelph, Ontario), 0.005 to 0.02 mg/kg BW, IV, q6h, a continuous rate infusion (CRI) of fentanyl (Sandoz Canada), 2 to 6 \( \mu g/kg \) BW per hour, meloxicam (Metacam; Boehringer Ingelheim, Burlington, Ontario), 0.1 mg/kg BW, IV/PO, q24h, gabapentin (Auro-gabapentin; Auro, Woodbridge, Ontario), 10 mg/kg BW, PO, q8h, tramadol (Chiron), 2.8 to 5 mg/kg BW, PO, q8h. Patients were also treated with antibiotics including cefoxitin (Teva Canada), 22 to 30 mg/kg BW, IV, q8h, and amoxicillin-clavulanic acid (Clavamox; Zoetis, Kirkland, Quebec), 13.8 to 17.9 mg/kg.

![Figure 1. Diagrammatic representation of perineal herniorrhaphy with porcine small intestinal submucosa (PSIS) alone and in combination with internal obturator muscle transposition (IOMT + PSIS). a — external anal sphincter muscle; b — levator ani muscle; c — coccygeus muscle; d — internal obturator muscle; e — porcine small intestinal submucosa.](image-url)
BW, PO, q12h. Lactulose (Pharmascience, Montreal, Quebec), 0.13 to 0.25 mg/kg BW, PO, q6-12h, maropitant (Cerenia; Zoetis), 1 mg/kg BW, IV, q24h, famotidine (Pepcid AC; McNeil Consumer Healthcare, Markham, Ontario), 0.5 mg/kg BW, IV, q12-24h, metronidazole (AA Pharma, Vaughan, Ontario), 10 mg/kg BW, PO, q12h, metoclopramide (Sandoz; Boucherville, Quebec), 2 mg/kg BW/d, IV CRI, prednisone (Apo-prednisone; Apotex, Toronto, Ontario), 0.5 mg/kg BW, PO, q48h, and phenylpropanolamine (Propalin; Vétoquinol, Boucherville, Quebec), 2 mg/kg BW/d, IV CRI, prednisone (Apo-prednisone; Apotex, Toronto, Ontario), 0.5 mg/kg BW, PO, q48h, and phenylpropanolamine (Propalin; Vétoquinol, Boucherville, Quebec), 2 mg/kg BW, PO, q48h, were administered on a patient-specific basis.

All patients were discharged with amoxicillin-clavulanic acid [(Clavamox; Zoetis) or (Clavaseptin; Vétoquinol)], 10.4 to 19.5 mg/kg BW, PO, q12h for 7 to 14 d, and analgesic medications [meloxicam, robenacoxib (Onsior; Elanco, Guelph, Ontario), or tramadol]. At discharge, owners received instructions for incision care, exercise restriction, use of an Elizabethan collar, and monitoring for complications. Some patients received instructions to switch to a high fiber or low residue diet, and ice the incision site. A recheck appointment was recommended at 10 to 14 d after surgery.

Outcome
Post-operative complications, as defined by Dindo et al (24), were deemed “any deviation from the ideal post-operative course” which excluded failure to cure events and inherent surgical sequelae.

Complications were graded according to the refined Accordion classification system by Kazaryam et al (25). Data on post-operative complications were collected from medical records and by telephone and e-mail survey of referring veterinarians. Telephone survey was administered in the form of a questionnaire (Table 1) on presence of common post-operative complications described in previous studies (4,10,12,14,26). If complications occurred, the dates at which complications were noted was documented and classified as short-term (< 14 d after perineal herniorrhaphy) and long term (> 14 d after perineal herniorrhaphy). Date of last follow-up and whether the animal was currently receiving medications were obtained. Follow-up time was defined as time from surgery to last examination by a veterinarian or time of owner survey. If the patient was deceased, information on cause of death was obtained. Recurrence was diagnosed based on rectal palpation performed at the referring veterinary hospital or OVCHSC. Complications of cysteopyexy, colopexy, or castration were not considered related to herniorrhaphy. The animal was considered lost to follow-up if the clinic had not seen the patient following surgery and the owner could not be contacted following 4 telephone calls.

Statistical analysis
Surgical outcome was evaluated based on descriptive analysis. The post-operative complication and recurrence rates were determined with Kaplan-Meier analysis. Risk factors for development of post-operative complications and recurrence were evaluated with a logistical regression test. Values with P < 0.05 were considered significant.

Results
Pre-operative data
Fifteen animals, 12 dogs and 3 cats, that underwent perineal herniorrhaphy at the OVCHSC, performed between January 1, 2012 and December 31, 2017, met the inclusion criteria (Table 2). One dog was excluded due to lack of follow-up. Distribution of breeds was mixed breed (n = 1), Yorkshire terrier (n = 1), Havanean (n = 1), and greyhound (n = 1) for dogs and domestic shorthair (n = 2) and domestic longhair (n = 1) for cats. All 11 dogs were male, and 10 were intact on presentation, including a unilateral inguinal cryptorchid. Of the cats, 2 were spayed females and 1 was a castrated male. Median BW at time of surgery was 6.2 kg (range: 3.2 to 34.3 kg) for dogs and 5.3 kg (range: 3.7 to 6 kg) for cats. Body condition score was available for 9 patients. Mean BCS was 3.5 (range: 3 to 5) for animals scored on a 9-point scale and 3 (range: 2 to 4) for patients scored on a 5-point scale. Median age was 9.9 y (range: 5.1 to 12.0 y) for dogs and 9.0 y (range: 5.2 to 11 y) for cats.

Pre-operative clinical signs were as follows: perineal swelling (n = 9), vomiting (n = 6), tenesmus (n = 8), constipation (n = 5), inappetence (n = 5), soft stool or diarrhea (n = 4), altered mentation or lethargy (n = 2), dyschezia (n = 5), hematochezia (n = 3), stranguria (n = 2), oliguria to anuria (n = 2), firm stool (n = 1), pollakiuria (n = 1), urinary incontinence (n = 1), weight loss (n = 1), abnormal ambulation (n = 1), and hemorrhagic rectal discharge (n = 1). Hernias were diagnosed by rectal examination in 10 patients. The remaining 4 cases were diagnosed with a combination of ultrasound (n = 4), cysourethrogram (n = 1),...
Prostatic enlargement was present in 3 dogs. One of the cats had cutaneous asthenia at time of diagnosis.

The 11 dogs meeting the selection criteria had a total of 17 perineal hernias and had 14 repaired with IOMT + PSIS and 3 with PSIS alone. The 3 cats had 4 perineal hernias all repaired with IOMT + PSIS. Six dogs and 1 cat had bilateral perineal herniorrhaphy. Five dogs and 2 cats had unilateral perineal herniorrhaphy. Of these, 2 dogs had staged repair of bilateral hernias of which 1 side was repaired with IOMT alone. One dog had bilateral hernias, in which 1 side was repaired with PSIS alone while the other did not undergo perineal herniorrhaphy. One cat had unilateral IOMT performed and then unilateral PSIS alone on the contralateral side at a later date. In this case the IOMT repaired hernia was found to have recurred at the time of presentation for perineal herniorrhaphy by PSIS alone but was not subsequently repaired. Herniated structures included omental fat (n = 12), urinary bladder (n = 2), and colon (n = 1). Median surgical time for unilateral IOMT + PSIS was 125 min (range: 75 to 140 min) for dogs and 72.5 min (range: 60 to 85 min) for cats. Surgical time for bilateral IOMT + PSIS was 175 min (range: 90 to 190 min) for dogs and 105 min for the cat. Surgical time for unilateral PSIS alone was 70 min and bilateral PSIS alone was 210 min.

Two cats and 6 dogs had a colopexy and cystopexy performed. One cat and 3 dogs had staged colopexy and cystopexy before perineal herniorrhaphy. In these patients, median time between laparotomy and time of perineal herniorrhaphy was 31 d (range: 17 to 1424 d). Of the intact dogs, 6 were castrated at the time of perineal herniorrhaphy, including the unilateral cryptorchid. Three dogs were castrated concurrently with staged cystopexy and colopexy.

All procedures were performed by a Board-certified surgeon or by surgical residents under direct supervision of a Board-certified surgeon.

### Post-operative data

The median hospitalization time was 46.7 h (range: 23.9 to 191.2 h). Fourteen of 15 (93%) animals were available for follow-up. Owners were surveyed in 2 cases in which the patients had not been examined since the time of surgery or re-check appointment. Post-operative outcome was analyzed for
3 cats and 11 dogs (Table 3) with 21 repaired perineal hernias (3 PSIS alone and 18 IOMT + PSIS). Median post-operative follow-up time was 621 days (range: 121 to 2090 days). Five patients were deceased at the time of study. Causes of death were all unrelated to the perineal herniorrhaphy. Median time of euthanasia from date of perineal herniorrhaphy was 971 days (range: 213 to 1724 days).

One patient out of 14 (7%) had a grade 1 complication, and 8 (57%) had grade 2 complications. Eight dogs and 1 cat (64%) with a total of 13 hernias had short-term post-operative complications within 7 days of surgery. Median time of onset of clinical signs was 2 days (range: 1 to 4 days). Short-term complications included tenesmus (n = 8), diarrhea (n = 2), and fecal impaction (n = 1). In 8 animals, short-term post-operative complications resolved within 26 days with medical management. Surgical site infection of 1 perineal hernia (5.6%) occurred in 1 dog. *Pseudomonas* sp. was cultured and the patient was treated with amoxicillin-clavulanic acid (Clavamox; Zoetis), 18.7 mg/kg BW, PO, q12h for 5 days, and enrofloxacin (Baytril; Bayer, Mississauga, Ontario), 11.2 mg/kg BW, PO, q24h for 14 days. Thirteen days following initiation of antimicrobial treatment, the incision healed and the infection resolved.

Two dogs and 1 cat with 5 IOMT + PSIS hernias had long-term post-operative complications. Clinical signs included tenesmus (n = 3), fecal impaction (n = 2), dyschezia (n = 2), and hematochezia (n = 1). Median time of long-term post-operative complication since hernia repair with IOMT + PSIS or PSIS alone was 161 days (range: 26 to 897 days). One of these dogs had bilateral recurrence of IOMT + PSIS perineal herniorrhaphy diagnosed 176 days post-operatively. The cat with long-term complications had an unrepaired hernia on the contralateral side to the repair. All animals with long-term post-operative complications had previously resolved short-term complications. These animals also all had cystopexy and colopexy performed. Cystopexy and colopexy, species, pre-operative tenesmus, unilateral or bilateral herniorrhaphy, bladder herniation, and rectal sacculation were not significantly associated with development of complications or recurrence (P > 0.05). At the time of follow-up, 6/14 patients received ongoing medical management.

Two dogs had recurrence of 3 perineal hernias with perineal herniorrhaphy using PSIS. One dog had recurrence of 2 IOMT + PSIS, diagnosed bilaterally, and 1 dog had recurrence of 1 PSIS alone repaired hernia. Median time to recurrence for individual perineal herniorrhaphys was 176 days (range: 117 to 176 days). In 2 other animals, recurrence occurred on the side of IOMT repair while the IOMT + PSIS repair remained intact. Surgical revision was not pursued for any failed hernia repairs. Reasons for not attempting surgical revision were increased anesthetic risk due to intracranial disease and owner’s concern for persistence of clinical signs following surgery from concurrent rectal sacculation. None of the cats had recurrence.

### Discussion

Our report is the first to evaluate the efficacy of commercially available PSIS for augmentation of IOMT in perineal herniorrhaphy and contributes to current literature on its outcome when used alone in perineal herniorrhaphy (1,2). The canine population in our study was comparable to those in other perineal herniorrhaphy studies with the exception of having a lower median BW (4,6,10,12–14,26,27). The low body weight and BCS were representative of patients presented to the OVCHSC for perineal herniorrhaphy and may be related.

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**Table 2.** Signalment, procedure, and intra-operative findings for dogs and cats with perineal herniorrhaphy using porcine small intestinal submucosa.

<table>
<thead>
<tr>
<th>Patient number</th>
<th>Breed</th>
<th>Sex</th>
<th>Age</th>
<th>Weight</th>
<th>Hernia side</th>
<th>Procedure</th>
<th>Adjunctive procedure</th>
<th>Staged adjunct</th>
<th>Herniated structures</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Shih tzu</td>
<td>MI</td>
<td>11</td>
<td>6.7</td>
<td>Bilateral</td>
<td>PSIS alone</td>
<td>Castr</td>
<td>No</td>
<td>NA</td>
</tr>
<tr>
<td>2</td>
<td>Domestic shorthair</td>
<td>MC</td>
<td>12</td>
<td>6</td>
<td>Right</td>
<td>IOMT + PSIS</td>
<td>Cysto, Colo, Castr</td>
<td>Yes</td>
<td>NA</td>
</tr>
<tr>
<td>3</td>
<td>Yorkshire terrier</td>
<td>MC</td>
<td>6</td>
<td>5.4</td>
<td>Right</td>
<td>IOMT + PSIS</td>
<td>Cysto, Colo</td>
<td>No</td>
<td>Omental fat</td>
</tr>
<tr>
<td>4</td>
<td>Havana</td>
<td>MI</td>
<td>9</td>
<td>6.7</td>
<td>Right</td>
<td>IOMT + PSIS</td>
<td>Castr</td>
<td>No</td>
<td>Omental fat</td>
</tr>
<tr>
<td>5</td>
<td>Papillon</td>
<td>MI</td>
<td>12</td>
<td>4.9</td>
<td>Bilateral</td>
<td>IOMT + PSIS</td>
<td>Cysto, Colo, Castr</td>
<td>Yes</td>
<td>NA</td>
</tr>
<tr>
<td>6</td>
<td>Domestic longhair</td>
<td>FS</td>
<td>5</td>
<td>3.7</td>
<td>Left</td>
<td>IOMT + PSIS</td>
<td>Cysto, Colo</td>
<td>Yes</td>
<td>Omental fat</td>
</tr>
<tr>
<td>7</td>
<td>Domestic shorthair</td>
<td>FS</td>
<td>9</td>
<td>5.3</td>
<td>Bilateral</td>
<td>IOMT + PSIS</td>
<td>NA</td>
<td>NA</td>
<td>Omental fat</td>
</tr>
<tr>
<td>8</td>
<td>Papillon</td>
<td>MI</td>
<td>10</td>
<td>4.3</td>
<td>Left</td>
<td>IOMT + PSIS</td>
<td>Cryptorchid Castr</td>
<td>No</td>
<td>Omental fat</td>
</tr>
<tr>
<td>9</td>
<td>Mixed breed</td>
<td>MI</td>
<td>10</td>
<td>5</td>
<td>Bilateral</td>
<td>IOMT + PSIS</td>
<td>Cysto, Colo</td>
<td>Yes</td>
<td>Omental fat</td>
</tr>
<tr>
<td>10</td>
<td>Mixed breed</td>
<td>MI</td>
<td>10</td>
<td>23</td>
<td>Bilateral</td>
<td>IOMT + PSIS</td>
<td>Castr</td>
<td>No</td>
<td>Bladder, omental fat</td>
</tr>
<tr>
<td>11</td>
<td>Mixed breed</td>
<td>MI</td>
<td>9</td>
<td>6.2</td>
<td>Bilateral</td>
<td>IOMT + PSIS</td>
<td>Castr</td>
<td>No</td>
<td>Omental fat</td>
</tr>
<tr>
<td>12</td>
<td>Papillon</td>
<td>MI</td>
<td>11</td>
<td>3.2</td>
<td>Right</td>
<td>PSIS alone</td>
<td>Cysto, Colo, Castr</td>
<td>Yes</td>
<td>Omental fat</td>
</tr>
<tr>
<td>13</td>
<td>Australian shepherd</td>
<td>MI</td>
<td>6</td>
<td>34.3</td>
<td>Bilateral</td>
<td>IOMT + PSIS</td>
<td>Cysto, Colo</td>
<td>No</td>
<td>Necrotic calcified fat</td>
</tr>
<tr>
<td>14</td>
<td>Greyhound</td>
<td>MC</td>
<td>5</td>
<td>32</td>
<td>Right</td>
<td>IOMT + PSIS</td>
<td>Castr, Colo</td>
<td>No</td>
<td>Omental fat</td>
</tr>
</tbody>
</table>

*Only hernias with PSIS alone or IOMT + PSIS perineal herniorrhaphy.

*PSIS* — Porcine small intestinal submucosa; *Cysto* — Cystopexy; *Castr* — Castration; *NA* — Not applicable.

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"FOR PERSONAL USE ONLY"
Complications for dogs and cats with perineal herniorrhaphy (PH) using porcine small intestinal submucosa.

<table>
<thead>
<tr>
<th>Patient number</th>
<th>Follow-up (d)</th>
<th>Complication</th>
<th>Complication grade</th>
<th>Recurrence</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>912</td>
<td>ST: diarrhea</td>
<td>2</td>
<td>No</td>
<td>IOMT of left perineal herniorrhaphy 564 d pre-IOMT + PSIS left perineal herniorrhaphy recurrence at time of right herniorrhaphy</td>
</tr>
<tr>
<td>2</td>
<td>575</td>
<td>ST: rectal prolapse, tenesmus LT: fecal impaction, tenesmus, hematochezia</td>
<td>2</td>
<td>No</td>
<td>IOMT of left perineal herniorrhaphy 1433 d post-IOMT + PSIS left perineal herniorrhaphy recurrence 2127 d post-IOMT + PSIS</td>
</tr>
<tr>
<td>3</td>
<td>2090</td>
<td>ST: tenesmus</td>
<td>0</td>
<td>No</td>
<td>Infected wound cultured Pseudomonas sp.</td>
</tr>
<tr>
<td>4</td>
<td>1797</td>
<td>ST: incisional infection</td>
<td>2</td>
<td>No</td>
<td>Cutaneous asthenia, suspected dehiscence colopexy site</td>
</tr>
<tr>
<td>5</td>
<td>1132</td>
<td>None</td>
<td>NA</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>651</td>
<td>None</td>
<td>NA</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>601</td>
<td>None</td>
<td>NA</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>681</td>
<td>ST: tenesmus</td>
<td>0</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>174</td>
<td>ST: tenesmus LT: dyschezia, tenesmus, fecal impaction</td>
<td>2</td>
<td>Yes</td>
<td>Unrepaired left perineal herniorrhaphy</td>
</tr>
<tr>
<td>10</td>
<td>182</td>
<td>ST: fecal impaction, tenesmus</td>
<td>2</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>121</td>
<td>ST: tenesmus, dyschezia LT: dyschezia, tenesmus</td>
<td>2</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>213</td>
<td>ST: diarrhea, tenesmus</td>
<td>2</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>640</td>
<td>None</td>
<td>0</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>584</td>
<td>ST: tenesmus</td>
<td>2</td>
<td>No</td>
<td>IOMT of left perineal herniorrhaphy 18 d post-IOMT + PSIS</td>
</tr>
</tbody>
</table>

ST — Short-term; LT — Long-term; NA — Not applicable; IOMT — Internal obturator muscle transposition; PSIS — Porcine small intestinal submucosa.

To frequently reported pre-operative vomiting, inappetence, and soft stool. This study shows that IOMT + PSIS and PSIS alone are acceptable methods for use in perineal herniorrhaphy in the dog and cat. Furthermore, surgeons should consider the use of IOMT + PSIS should they judge the IOM to be atrophied.

Previous reports of IOMT have described complication rates ranging from 12% to 53% (4,14,28). Most animals herein (9/14) had short-term complications. Many of these complications were Grade 2, which resolved with medical management and had good long-term clinical outcomes. Tenesmus was the most frequent short-term post-operative complication observed, as has been commonly reported for IOMT (4,14). Pain, local inflammation, and unrepaired rectal defects are possible contributing factors for development of post-operative tenesmus and are inherent to perineal herniorrhaphy (7,27). Thus, tenesmus and other transient clinical signs observed in the early post-operative period may be considered unavoidable sequelae to the procedure and not true complications (29).

Long-term outcome provides further valuable information in determining a benefit to the use of IOMT + PSIS and PSIS alone techniques (13). In our study, 3/14 animals had long-term complications, with tenesmus, fecal impaction, and dyschezia being the most common. This complication rate is consistent with previous reports on outcome following perineal herniorrhaphy in the literature. (4,6,10,12–14,26). Two animals with long-term complications either had a recurrence or a coexisting unrepaired hernia on the contralateral side. Retrospectively, we are unable to discern whether clinical signs developed first and promoted recurrence, or whether failure of repair, undiagnosed at the time, led to clinical signs. As a consequence, the present study may overestimate long-term complications occurring prior to recurrence.

Based on the results of our study, animals with bilateral perineal hernia may benefit from bilateral perineal herniorrhaphy under the same anesthetic episode as, from the authors’ experience, repair of the contralateral side is not always pursued later. One study identified evidence of contralateral hernias in all patients with unilateral disease presentation (30). These patients had a successful outcome following bilateral perineal herniorrhaphy (30). In our study, 1 animal with long-term complications had a coexisting unrepaired hernia and may have had improvement in clinical signs had bilateral perineal herniorrhaphy been performed.

Most complications in our study were classified as Grade 2 according to the Accordion classification scheme. Routinely, animals are maintained on a low-residue diet, stool softeners, analgesics, and antibiotics following perineal herniorrhaphy, independent of whether complications developed (29). As such, most patients with short-term complications had clinical signs resolve within 26 d of surgery with standard medical management. Persistent clinical signs were present in 1 patient (7.1%) and this was lower than in previous studies, in which
there were observed persistent signs in 9% to 17% of patients (4,14). Fecal incontinence, a commonly noted complication in previous studies, was not observed, but may be a result of a small sample size (28).

In our study, 3/21 perineal hernias recurred following IOMT + PSIS or PSIS alone. These recurrence rates are comparable to IOMT recurrence rates reported in the literature, which ranged from 9.7% to 27.4% (4,13,14). A previous study identified post-operative tenesmus as a significant risk factor associated with recurrence and proposed it as a complication related to inadequate repair (13). This was not identified in our study although this may be due to type II error and it is certainly possible that forces exerted with tenesmus during early stages of healing affect the integrity of repair and have consequences on long-term outcome.

Perineal hernias occur rarely in cats and have been associated with conditions such as megacolon, chronic fibrosing colitis, pelvic canal stenosis, and apocrine gland anal sac adenocarcinoma (7,8). Only 1 of the 3 cats in our study had a pre-existing medical condition, namely cutaneous asthenia, which may have predisposed to perineal herniorrhaphy development. Cutaneous asthenia is a rare hereditary disorder of collagen dysplasia, characterized by thin, hyperextensible, and fragile cutaneous tissue prone to laceration (8,31). Several reports have described non-traumatic diaphragmatic, perineal, and inguinal hernias in cutaneous asthenia cases and patients with cutaneous asthenia may be prone to hernia formation (8,32). Attraumatic tissue handling is crucial in preventing inadvertent tearing (32). While delayed wound healing, dehiscence, and scarring are noted in human Ehlers-Danlos syndrome (EDS), several reports have described unremarkable primary intention wound healing in cats with cutaneous asthenia (8,32). A previous report of bilateral perineal herniorrhaphy in a cat with cutaneous asthenia described unilateral recurrence within 4 mo of IOMT (8). Regardless, the cat in our study with cutaneous asthenia had an excellent outcome following IOMT + PSIS with no recurrence, problems with wound healing, or other complications.

The infection rate in our study was 5.6%, which is comparable to previous reports for IOMT (4,12–14,26). A previous report of PPM-reinforced IOMT described a similar infection rate to our study; however, the affected patients required surgical debridement of the infected wound (3). By contrast, infection in our patient resolved following antibiotic therapy. While PSIS lacks in vitro antimicrobial properties, it has shown increased resistance against infection in contaminated sites compared to synthetic implants (15,33–35). This has been attributed to early neovascularization, which allows host defences and antibiotics to readily access the site of bacterial infection (16). While lack of degradability of synthetic implants provides a long-term substrate for bacterial colonization and poses a challenge for elimination of infection, PSIS is completely absorbable (15,35,36). Porcine small intestine submucosa was histologically indistinguishable from transposed internal obturator muscle at 12 wk following perineal herniorrhaphy (1).

This study’s retrospective nature poses several limitations on outcome assessment. The absence of a control group in this study limits our ability to compare outcomes between herniorrhaphy techniques. Inherent biases in the survey method, medical record quality, owner observational acuity, and accuracy of recollection influenced the collected data. Non-specific or minor complications may have been attributed to another cause, not reported by owners, or remained undocumented. This limited our ability to compare pre- and post-operative clinical signs to assess clinical improvement. Justification for technique selection remained largely undocumented. A previous study showed a significant reduction in herniorrhaphy recurrence with increasing surgical experience (26). The distribution of roles between residents and faculty in surgery is unknown and so the effect of experience on outcome was unaccounted for.

Our results suggest that IOMT + PSIS and PSIS alone are acceptable methods for perineal herniorrhaphy in the dog and cat and may be helpful where the IOM is atrophied. A larger prospective controlled study would be beneficial in comparing outcome to other perineal herniorrhaphy methods.

References


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**New Products**

**Nouveaux produits**

Modern Veterinary Therapeutics, LLC announces that the Veterinary Drugs Directorate (VDD) has approved Maprelin™ XP-10 (peforelin injection – 75 μg/mL; DIN 02465078) in Canada.

Maprelin™ XP-10, approved for use in swine, is presented in 10 mL and 50 mL vials. Maprelin™ XP-10 is a sterile injectable synthetic gonadotropin releasing hormone for the induction of the estrus cycle in sows after weaning, and in sexually mature gilts following therapy to inhibit the estrus cycle with progestogens.

“Modern Veterinary Therapeutics, LLC is pleased to announce this new approval in Canada demonstrating our commitment to the ethical animal production and animal welfare in Canada. Indeed, peforelin is produced synthetically. Finally, the Canadian swine industry has an alternative to the Pregnant Mare Serum Gonadotropin (PMSG) which is obtained via abortion of pregnant mares. The use of Maprelin™ XP-10 is an ethical choice” said Dr. Cuong Tu Ba, President of Modern Veterinary Therapeutics, LLC.

**Contact:** Nicole Saren, Director of Sales & Marketing, Modern Veterinary Therapeutics, 14343 SW 119th Avenue, Miami, FL 33186 USA; telephone: (407) 852-8039; e-mail: nsaren@modernveterinarytherapeutics.com; website: www.ModernVeterinaryTherapeutics.com
3D-printed bolus improves dose distribution for veterinary patients treated with photon beam radiation therapy

Tiffany Wormhoudt Martin, Mary-Keara Boss, Susan M. LaRue, Del Leary

Abstract — Commercial bolus is frequently used to increase dose at the patient’s surface for superficial radiotherapy; however, uneven surfaces can create air gaps and discrepancies between prescribed and delivered dose. The purpose of this study was to determine if a customizable, 3D-printed bolus would improve dosimetry compared with a commercial bolus. For each patient, a planned bolus was generated within planning software, then created with 3D-printing. The treatment plan was recalculated with each bolus in situ. When evaluating tumor volumes at prescription, the 3D-printed bolus was closer to prescription compared to the commercial bolus. There was a significant difference in air gaps in patients receiving radiotherapy to the head (P < 0.001) but the difference was not significant for air gaps in caudal body sites (P = 0.05). Overall, the 3D-printed bolus resulted in reduced air gaps, dosimetry closer to prescription, and should be considered for superficial treatment areas of high irregularity.

Résumé — Un bolus obtenu par impression 3D améliore la distribution de la dose de patients vétérinaires traités par radiation de faisceau de photons. Un bolus commercial est fréquemment utilisé pour augmenter la dose à la surface d’un patient lors de radiothérapie de surface; toutefois, des surfaces inégales peuvent créer des espaces d’air et ainsi des différences entre la dose prescrite et la dose livrée. Le but de la présente étude était de déterminer si un bolus sur mesure, obtenu par impression 3D, améliorerait la dosimétrie comparativement à un bolus commercial. Pour chaque patient, un bolus planifié fut généré à l’aide d’un logiciel de planification, puis créé avec une imprimateur 3D. Le plan de traitement fut recalculé avec chaque bolus in situ. Lors de l’évaluation du volume des tumeurs à la prescription, le bolus obtenu par impression 3D était plus près de la prescription comparativement au bolus commercial. Il y avait une différence significative dans les espaces d’air chez les patients recevant la radiothérapie à la tête (P < 0.001) mais la différence n’était pas significative pour les espaces d’air sur les sites corporels en partie caudale (P = 0.05). De manière globale, le bolus obtenu par impression 3D a résulté en une diminution des espaces d’air, une dosimétrie plus près de la prescription et devrait être considéré lors du traitement de surfaces superficielles hautement irrégulières. (Traduit par Dr Serge Messier)

Introduction

One feature of megavoltage (MV) photons for radiation therapy is the natural skin sparing abilities due to an initial dose buildup with depth (1), and as energy increases, the point of maximum dose lies deeper into the tissue (1). The maximal absorbed dose (d_max) for photons from a 6-MV accelerator is approximately 1.5 cm (1). This presents a challenge when treating superficial lesions or scars and ultimately requires synthetic tissue-equivalent material in direct contact with the skin where dose buildup can occur and effectively increase dose closer to the surface of the patient.

Currently the most commonly used bolus in human and veterinary medicine is commercial sheet bolus, such as Superflab (Eckett & Ziegler, Hopkinton, Massachusetts, USA), which has nearly identical radiation attenuation and scattering properties of tissue and a specific gravity of 1.02 g/cm³ (2). This material generally conforms to flat uniform surface contours and maintains uniform thickness; however, in highly uneven areas, commercial bolus lacks the flexibility needed to lay flush against the surface resulting in air gaps. Increased air gaps result in a potentially consequential decrease in surface dose which could lead to underdosing of superficial tumors (3–5). In particular, field sizes of 5 × 5 cm² will be more sensitive to air gaps > 5 mm compared to larger fields in which the lateral scattering can compensate for the dose within the air gap (3).

Previously Play-Doh (Hasbro, Pawtucket, Rhode Island, USA), wet gauze, petroleum jelly, Super Stuff (Radiation Products Design, Albertville, Minnesota, USA) and Superflab (Eckett & Ziegler) have been evaluated for increasing surface...
dose in highly irregular areas in veterinary patients (6–8). These products improve dose to superficial lesions, although there are challenges in reproducibility due to material drying out, inconsistent shape, and difficulty with maintaining uniform thickness (6–8). As an alternative, we evaluated the use of a 3D-printed bolus derived from computer planning software compared to commercial sheet bolus. Our objectives were to develop printing standards for achieving tissue equivalent Hounsfield units (HU) as determined using our computed tomography (CT) treatment simulator and assess the change in the dose distribution to tumor volumes when using the 3D-printed bolus compared with commercial bolus. Cone beam computed tomography (CBCT) images acquired before treatment were used to adjust and confirm placement of the bolus used at the time of treatment and to assess the surface dose as well as the maximum air gap for both the commercial bolus and the 3D-printed bolus. We hypothesized that the 3D-printed bolus would result in improved dose to defined tumor volumes compared with a commercial bolus when compared to the predicted plan.

**Materials and methods**

**Study design and inclusion criteria**

A retrospective, observational analysis of data from dogs and cats treated with photon therapy requiring a bolus at the Flint Animal Cancer Center at Colorado State University (CSU-FACC) between January 2018 and July 2018 was performed. Clients provided written consent for treatment at the time of admission and all reported procedures in this study were part of that treatment. For inclusion in the study, patients required a superficial tumor or scar line and had to be treated with either intensity-modulated radiation therapy (IMRT) or 3-dimensional conformal radiation therapy (3D-CRT). Patients with flat treatment surfaces that could be adequately covered without air gaps with commercial bolus (Superflab) were excluded. Macrophagic or microscopic tumors of any histologic tumor type were eligible for enrollment.

The thickness selection was kept to standard sizes for this study even though any bolus thickness could be generated using 3D printing. We chose standard commercial thicknesses of either 0.5 cm or 1 cm based on clinician preference during the planning process to improve dose distribution for treatment.

**Bolus customization using a 3D printer**

Computed tomography scans of the patients using Philips Gemini TF Big Bore 16-slice scanner (Philips Medical Systems, Eindhoven, The Netherlands, B.V.) or on-board cone beam CT (CBCT) using Varian Trilogy (Varian Medical Systems, Palo Alto, California, USA) linear accelerator were used for radiation and bolus planning purposes. Based on these CT images, a planned bolus was virtually created within the treatment planning system to achieve the most appropriate dose coverage of the given target volume. The bolus was created directly onto the external body contour in the treatment field using Varian Eclipse treatment planning system version 13.7 using the AAA algorithm (Varian Medical Systems). An IMRT or 3D-CRT plan was generated with the idealized planned bolus created by the treatment planning software. To create a physical 3D-printed bolus, the virtual structure needed to be converted into a stereolithography format. To accomplish this, structures defined within the Eclipse treatment planning system were converted using Eclipse scripting application programming interface (ESAPI) that exports in-memory structures to *.vtk formatted files. Stereolithography (*.stl files) is a prototyping process that allows for the ability to create complex 3-dimensional shapes with internal architecture, ease of removal of unpolymerized resin, and extremely high feature resolution (9). Afterwards, a third-party file converter (Spin3D; Greenwood Village Colorado, USA; or Meshmixer via Autodesk, San Rafael, California, USA) was used to convert the *.vtk files into *.stl files which were directly compatible for 3D printing. The printing was accomplished using a Lulzbot TAZ 6 FDM printer (Aleph Objects, Loveland, Colorado, USA) using Ninjaflex 85A (Ninjatek, Mahheim, Pennsylvania, USA). Ninjaflex 85A is a specially formulated thermoplastic polyurethane (TPU) material that results in a flexible, but durable bolus (10). Previous publications have also found that material properties of the 3D-printed bolus can have a near water equivalent dosimetric transmission (11–13).

**Clinical evaluation of the 3D-printed bolus**

As a standard of practice, an experienced veterinary radiation therapist would place a standard bolus on the surface of the treatment area to emulate the planned bolus generated by the planning system. This would be followed by a CBCT (Varian OBI 1.6) to determine proper anatomical alignment. A full fan bowtie filter would be used for tumors on the head and a half fan bowtie filter for treatments of the caudal body. For our study, successive fractions used a patient specific 3D-printed bolus in place of the standard bolus. This would be done on the earliest treatment day depending on the printing time of the 3D-printed bolus. The boluses could then be compared and evaluated in Eclipse External Beam Planning with the corresponding CBCT images as follows.

For each patient the original structure set, outlining the tumor and organs at risk, from the original treatment plan was copied onto CBCT image. This was done for both the commercial bolus and then again to the 3D-printed bolus, creating 2 new plans. For each plan, the body contour structure was modified to include the bolus, as required for an accurate calculation process within Varian’s Eclipse treatment planning system. The skin contour was also adjusted to the CBCT to allow for the most accurate interpretation of the dose to this structure, which at this institution is a 2-mm thick inward margin from the outer boundary of the skin surface of the patient. The tumor volume structures were unchanged throughout. Couch structures were added to mimic the original approved plan. The original approved plan, including optimized modulated fields and constant MUs for each field, was copied onto the new CBCT with the commercial and 3D-printed bolus plans. Each plan was recalculated using the appropriate calibration function for the CBCT relating the HU to electron density to assess and compare the dose to the tumor and skin that was delivered with each of the boluses.
Data recording
The dose to the gross tumor volume (GTV), dose to clinical target volume (CTV), dose to planned target volume (PTV), relative volume of GTV, CTV, and PTV to prescription, maximum global dose, maximum dose to the skin, and dose at 1 cm³ of skin were simulated from the CBCT, recorded and compared on all head plans. For patients with scars that were being treated, the scar with 2 mm under the scar was contoured as the GTV which was included in the evaluation. The scar was identified by placing fiducial markers on the scar during the simulation CT scan. Due to patient matching challenges with the caudal body tumors, the dose to tumor volumes was not evaluated. The maximum global dose, dose at 1 cm³ of skin, and maximum dose to skin were recorded and compared for all simulated plans involving the caudal half of patients. Additionally, the maximum gaps between the skin and the commercial bolus and between the skin and the 3D-printed bolus were measured and recorded for each 2-mm slice on CBCT. The maximum gap location was based on the largest gap on both the commercial bolus scan and the 3D-printed bolus scan (Figure 1).

Hounsfield units of the 3D-printed bolus were recorded from the Phillips Gemini CT planning scanner. To measure the HU, 10 random points were selected and recorded. The points were evaluated to gather the mean, median, and confidence intervals.

Statistics
Wilcoxon signed-rank test and 95% confidence interval (CI) were used to compare the maximum air gap for the commercial bolus and the 3D-printed bolus for all patients. The recorded values for dose-to-tumor volumes and skin for each bolus type were also evaluated with the Wilcoxon signed-rank test with a P-value < 0.05 being significant. The analysis was performed by T.W.M. using GraphPad Prism version 8.00 for Windows (GraphPad Software, La Jolla, California, USA).

Results
Patient data
Data from 9 patients, 5 dogs and 4 cats, were included in this analysis. Tumor types included 2 incompletely excised soft tissue sarcomas, a maxillary fibrosarcoma, an incompletely excised high-grade sarcoma of the maxilla (pathologist favoring a poorly melanotic melanosarcoma), a nasal planum squamous cell carcinoma, a suspected nasal sarcoma, a nasal chondrosarcoma, and 2 injection site sarcomas. The head was treated in 6 patients and the caudal body region was treated in 3 patients. The caudal body region included 2 patients with treatment areas of the tail base and caudal abdomen and 1 patient with a treatment area of the flank. Six patients received definitive-intent radiation therapy, receiving a total of 18 fractions, and 3 had palliative-intent radiation therapy, with 2 patients receiving 5 fractions and 1 receiving 6 fractions. All patients required a 0.5-cm bolus with the exception of 1 patient which required a 1-cm bolus for a caudal body scar. Six patients received at least 1 treatment with commercial sheet bolus and 3 patients received all treatments with the customized 3D-printed bolus. The patients that received all treatments with the customized bolus in place had 2 CBCTs performed on the initial day of treatment, 1 with commercial bolus and 1 with the customized 3D-printed bolus. Figure 2 shows images representing a single individual and the differences between the commercial bolus and the 3D-printed bolus.

Dose data
There was a significant difference between the planned bolus, the commercial bolus, and the 3D-printed bolus (P = 0.03) when comparing the dose to 99% of the CTV, dose to 95% of the PTV, percentage of GTV to prescription, and percentage of CTV to prescription. When comparing dose to 99% of the GTV there was a significant difference between the planned and commercial bolus (P = 0.03) and between the commercial
bolus and the 3D-printed bolus ($P = 0.03$), but no significant difference was found between the planned bolus and the commercial bolus ($P = 0.03$), but no significant difference was found between the planned and 3D-printed bolus or the commercial bolus and the 3D-printed bolus ($P = 0.06$, Figure 3). When evaluating the maximum point dose to the skin, there was no significant difference between the 3 different boluses ($P = 0.25, > 0.99, 0.16$). When evaluating the dose to 1 cm$^3$ of skin, no significant difference was found between the planned, commercial, or the 3D-printed bolus ($P = 0.16, 0.12, 0.72$). The maximum point dose was not significantly different between the planned and the commercial bolus ($P = 0.08$) or the commercial bolus and the 3D-printed bolus ($P = 0.94$); however, there was a significant difference between the planned and the 3D-printed bolus ($P = 0.004$).

All 3D-printed boluses were evaluated with the Phillips Gemini CT scanner with the exception of one. The mean Hounsfield unit for all boluses was $-43.4$ HU (95% CI: $-143.5$ to $42.3$ HU, median: $-28.9$ HU).

Conformity of bolus to patient surface

Figure 4 shows a frequency histogram of the CBCT-measured maximum air gap observed from each slice on a single treatment day for patients receiving radiation to the head. These distributions exhibit significantly different values ($P < 0.0001$). For the commercial bolus on head patients, an average of 25% of slices from the CBCT across all patients involved an air gap of $> 5$ mm; this is reduced to 7% for patients using a 3D-printed bolus. The median air gap with commercial bolus was $3.6$ mm (95% CI: 3.4 to 4.0 mm) compared to $2.3$ mm (95% CI: 2.3 to 2.7 mm) for the 3D-printed bolus. The median air gap for commercial bolus was $4.2$ mm (95% CI: 4.1 to 5.0 mm) compared to $4.6$ mm...
Figure 3. Bar graph displaying the mean relative prescription dose to 99% of the GTV, 99% of the CTV, and 95% of the PTV for the first 3 columns and the mean percentage of the GTV, CTV, and PTV that received the prescription dose for the remaining 3 columns for patients treated with radiotherapy for tumors of the head. The y-axis indicates the percentage, while the x-axis shows the parameters evaluated. The asterisk (*) connecting the values indicates significant differences with a P-value < 0.05. For all parameters, the 3D-printed bolus showed dosimetry closer to that of the planned bolus compared with the commercial bolus.

Discussion

This study evaluated the clinical efficacy of a 3D-printed bolus for veterinary patients. In agreement with previous work, we found that the 3D-printed bolus was more conformal than the conventional bolus with similar dose to the skin (12). Previous work has also investigated the conformity and efficiency of a customized 3D-printed bolus for postmastectomy chest wall irradiation for human patients as well as studies using phantom models (4,11,14,15). Here we have further improved on this area of knowledge by investigating the comparative impact on dosimetry to tumor volumes with respect to each bolus type in place.

This study evaluated the use of 3D-printed bolus over the head region as well as the caudal portion of the body including the flank and body wall of veterinary patients. Patients that had a bolus printed for the head had a more substantial, and significant (P < 0.0001) decrease in air gap measurements compared with patients in which the caudal body was treated. This is believed to be caused by more stringent immobilization of the head with the patient placed in sternal recumbency with a carbon fiber stand, fixed dental mold, and a facial mask (16). Patients receiving radiation to the caudal body were placed in Vac-Lok Nylon Cushions (Civco Radiotherapy, Coralville, Iowa, USA) resulting in more variability in patient movement. In addition to the variability with patient positioning, patient anatomy of the specific region is likely to be an additional factor in achieving desirable replicability. The caudal body has increased flat and more uniform surface areas and may be better suited with commercial bolus.

A 0.5-cm thick 3D-printed bolus was used in all cases with the exception that a 1-cm bolus was required in a cat with an incompletely excised injection site sarcoma of the caudal body wall including a portion of the tail. The additional weight of the thicker bolus was notable when placed on the patient and resulted in skin displacement due to the appreciable pressure of the bulky bolus. Although this is not commonly seen in humans or uniform bolus types, this may be a clinical issue with veterinary patients that tend to have a larger subcutaneous layer resulting in more variability of skin. While 1 cm thickness is needed in many cases, the weight of the bolus and size of the patient should be considered before execution. Another obvious advantage of printing the patient-specific bolus is that fixed sizes are not required, and optimum thickness can be chosen during
the planning stage. With this relaxation of indexed thickness and composition, more can be done to optimize and improve dose to the tumor that was not deeply explored in this work.

The differences in dose data between the 3D-printed bolus and commercial bolus were significant in 4 of the 6 parameters that were evaluated, including dose to 99% of the CTV, dose to 95% of the PTV, percent of GTV to prescription, and percent of CTV to prescription. Both the 3D-printed bolus and commercial bolus were significantly different from the planned bolus in all parameters. In all tumor volume parameters, the mean dose was higher with the 3D-printed bolus compared to the commercial bolus and closer to the dose predicted with the planned bolus. The difference in the planned bolus and the 3D-printed bolus is suspected to be due to variations in hair or fur which we believe to have contributed to the air gaps that were measured. Depending on the patient, this can account for an additional air gap that has not been considered in human medicine. While several of our long-haired patients were shaved to aid in the placement of the bolus, the 3D-printed bolus was not completely flush in most cases. One way to take this into consideration in planning, is to change the body contours to include 1 mm. This was performed in a similar study resulting in a mean surface deviation of 1.4 mm in contrast to our mean of 2.3 mm in patients with head treatments (12). While the 2 studies cannot be directly compared, this difference suggests that a retraction of 1 mm for patients’ fur may impact the conformity of the bolus.

The authors recognize the limitations with using a CBCT to evaluate dose distribution; however, in this study, the dose was compared between the commercial and the customized 3D-printed bolus using the acquired kV CBCT and appropriate calibration curve to convert HU to electron density. While this comparison to the planning CT and computer-generated bolus may result in changes of up to 3% of the dose (17–19), this should be considered a systematic shift between the 2 experimental bolus types yielding identical comparison for these boluses.

The surface dose was evaluated for each patient. No significant difference was detected between the dose at 1 cm³ of skin with the commercial, 3D-printed, or planned bolus. An additional parameter that was evaluated was the maximum point dose within the skin and no difference was seen between all 3 groups. Given this information, a reasonable assumption would be that the skin side effects would be similar between the groups.

In this study, we did not evaluate differences in set-up time before treatment with respect to the commercial bolus versus 3D-printed bolus; however, this was performed in a similar study and had minimal implications on workflow (12). In our experience, patients requiring sheet bolus often require additional time to set-up and occasionally require more than 1 CBCT for matching purposes.

In terms of quality assurance, the bolus was visually inspected after printing for rough or sharp edges. This can occur from filament clogging at times during the print which produced small projections that could be easily cut off to smooth the surface. Afterwards the bolus should be scanned to verify that HU are within tissue equivalent range. For our patients we accepted +/- 100 HU, since we found this would produce a negligible impact on the dose distribution and DVH values within the planning system. Similar studies evaluating the use of 3D-printed materials in imaging found comparable HU values, most having negative values (15,21). In addition, we would measure density by simply weighing the bolus and using the volume of the structure calculated by the treatment planning system. Provided the print is homogeneous, simply measuring the density may be a more straightforward yet reliable means to verify the printing consistency. Depending on the size of the bolus, the print can take 2 to 48 h, so delays in treatment or 3D-printed bolus use can be considerable. However, in our experience the dependability was clinically acceptable, and a revision of the print was rare. The cost of the printer and printing material was nominal within the overall cost of the radiation therapy. We found the cost benefit to be easily justified within our service.

This study evaluates the use of 3D-printed bolus in veterinary medicine. In conclusion, the 3D-printed bolus resulted in decreased air gaps and improved agreement to predicted dose to tumor volumes within the head compared with the commercial bolus.

Acknowledgments

The authors thank Sarah Bruns, Wendy Mullins, and Amber Prebble for their assistance with patient set-up, bolus replication, and bolus printing.

References

A new cancer imaging technique could significantly improve the ability to diagnose the disease's spread to lymph nodes in dogs with head and neck tumors. The technique, which involves injecting iron nanoparticles into a dog then using magnetic resonance imaging (MRI) to detect the particles, is being tested by Morris Animal Foundation-funded researchers at Colorado State University. If successful, it could help guide therapeutic decisions for canine cancer patients.

“Cancer is a game of numbers, and if you want to cure it you have to get rid of 100% of the cancer cells that are in the body,” said Dr. Lynn Griffin, Assistant Professor at Colorado State University’s College of Veterinary Medicine and Biomedical Sciences, and principal investigator on the study. “This method could non-invasively and more accurately determine where cancer is still hiding so we can do something about it.”

The technique would be used during cancer staging, a process to determine the extent of a tumor's metastasis before undergoing any kind of treatment. This allows veterinarians to develop optimum treatment plans to maximize a patient’s chance for a positive outcome. For the study, the team injects nanoparticles — in this case, microscopic bits of iron — into a dog’s bloodstream. The particles are then engulfed by macrophages, white blood cells that clear blood of cellular debris, before moving into nearby lymph nodes.

Iron appears black on certain MRI images, so if a completely healthy lymph node is full of the macrophages holding the nanoparticles, it too would appear all black. Cancer cells, though, push macrophages out of lymph nodes. If cancer has invaded even a small portion of a lymph node, that portion should appear white on an MRI. Results would be detectable in less than 48 hours after injection.

In the initial pilot study, the team tested the technique on six dogs, and it was 88% accurate at detecting cancer, which is higher than most previously reported imaging modalities. For the current study, the team just opened enrollment for dogs with oral cancers that have the potential to metastasize to the lymph nodes. They hope to enroll 50 dogs with head and neck cancers.

Current imaging techniques to diagnose cancer spread to lymph nodes in dogs with head and neck cancers, which include palpation and ultrasound, are not very reliable. Cancer cells can sit on one side of an otherwise healthy lymph node without distorting it, allowing it to feel normal to human touch. Similarly, ultrasounds have difficulty spotting the disease if it isn’t blatant. Head and neck cancers, such as fibrosarcoma and oral melanoma, account for 6% to 7% of canine tumors, according to Withrow and MacEwen's Small Animal Clinical Oncology. While this technique could be used in any part of the body, the team is first focusing on head and neck tumors due to the accessibility of that area’s lymph nodes.

Nanoparticle MRIs were first attempted in human medicine for prostate cancer, but the technique is still being used at an experimental level. If successful in dogs, Dr. Griffin said her team will evaluate its use in detecting the spread of feline oral squamous cell carcinoma, the most common oral cancer in cats.

Contact: Morris Animal Foundation, Denver, Colorado USA; website: morrisanimalfoundation.org
Uveal amelanotic melanoma in a ragdoll cat

Sarah Jajou

Abstract — A 13-year-old castrated male ragdoll cat's left eye was evaluated for dyscoria, iridal thickening and color change of 2 years duration, as well as elevated intraocular pressure. The primary lesion seen on ophthalmic examination was a pale pink-white mass observed in the dorsomedial aspect of a diffusely thickened iris. Metastatic workup revealed hepatic and splenic nodules, but cytology was inconclusive. The left eye was enucleated, and histopathology was consistent with uveal amelanotic melanoma.


A 13-year-old castrated male ragdoll cat was presented to the ophthalmology service of the Ontario Veterinary College Health Sciences Centre (OVC-HSC) for evaluation of iris color change and elevated intraocular pressure in the left eye. Approximately 2 years earlier, the left iris had changed in color from blue to yellow. One week before presentation, the iris began to bulge toward the pupil resulting in dyscoria. At that time, the intraocular pressure (IOP) in the left eye was elevated (26 mmHg; normal mean IOP: 18.4 +/- 0.5 mmHg) based on applanation tonometry (Tono-Pen Vet; Veterinary Tonometer: Reichert, Buffalo, New York, USA) (1). A tentative diagnosis of uveitis with secondary glaucoma was made by the referring veterinarian, and the patient was started on topical dorzolamide 2% (Trusopt; McKesson, Brampton, Ontario), 1 drop oculus sinister (OS) (left eye), q8h and topical prednisolone acetate 1% (Sandoz Prednisolone; Sandoz, Boucherville, Quebec), 1 drop OS q8h. There was no known history of ocular trauma or infectious systemic disease. Previously diagnosed medical conditions included feline asthma, intermittent episodes of constipation, and impaired left ventricular diastolic function.

On admission, the patient was bright, alert, and responsive, with vital parameters within normal limits. A grade III/VI left systolic heart murmur was auscultated, with strong synchronous femoral pulses. The remainder of the physical examination was unremarkable.

On ophthalmic examination, the dazzle reflex, menace response, palpebral reflex, and pupillary light reflexes (direct and consensual) were present in both eyes. There was marked left-sided conjunctivitis. Mild aqueous flare was noted within the left anterior chamber. The left iris was swollen and diffusely green/yellow in color, with a 2-mm, pale pink opacity infiltrating the dorso-medial aspect of the iris (Figure 1). In comparison, the right iris was blue in color and aside from mild iris scalloping, no anomalies were noted. Nuclear sclerosis was present bilaterally. No abnormalities were noted on fundic examination in either eye. Both eyes had normal tear production and were fluorescein stain negative. The intraocular pressure in both eyes was within the reference range.

Given the extensive intraocular changes in the left eye, a uveal tumor with secondary iritis and glaucoma was suspected. The differential diagnoses at the time consisted of uveal lymphoma, feline diffuse iris melanoma, traumatic intraocular sarcoma, and ciliary body adenoma/carcinoma. Staging was performed, including 3-view thoracic radiographs and abdominal ultrasound. No anomalies were noted on radiographs and the ultrasound examination revealed 3 hepatic nodules and several splenic nodules. There was no other evidence of metastasis in the imaging performed.

Under general anesthesia, a trans-conjunctival enucleation of the left eye was conducted, along with ultrasound-guided fine-needle aspirates of the hepatic and splenic nodules. The eye was fixed in 10% neutral buffered formalin and embedded in paraffin for histological examination. Cytology from the liver was poorly cellular with a clotted, markedly hemodiluted background and rare ruptured clusters of hepatocytes.
melanoma is relatively rare, diffuse iris melanoma is the most common primary feline intraocular tumor (2–5). There is no evidence of breed or sex predisposition, and most cases are detected in middle-aged to older cats (2,4,6). The tumor cells originate on the anterior surface of the iris, and classically are recognized as multifocal or diffuse golden or dark brown-black hyperpigmentation (2,3,7). The lesions may remain unchanged, but in most cases will progress in size, number, and/or thickness over months to years. Dyscoria may be observed due to involvement of the iridal constrictor muscles, and extension into the ciliary body and sclera, or other intraocular structures. Affected cats may be presented with uveitis secondary to tumor promotion of inflammatory mediators, or glaucoma due to infiltration of the iridocorneal angle and obstruction of aqueous outflow.

Exfoliation of tumor cells into the aqueous humor or invasion of the tumor into the intraocular vasculature can result in metastasis. A metastatic rate of 16% to 66% has been reported, with the most common sites being the lung and liver, although regional lymph node, splenic, omental, and osseous metastasis have been reported (4,8,9). Metastatic disease may take several years to become clinically apparent, suggesting the need for early recognition and potential enucleation (2). Furthermore, extent of the tumor has a significant impact on survival times, with 1 study showing that invasion of the neoplastic melanocytes into the ciliary body was associated with reduced survival compared to age-matched controls and cats with tumor cells limited to the iris stroma and trabecular meshwork (10). Similarly, patients with secondary glaucoma had a 21% survival rate compared to 73% for those without (10).

The unusual presentation of this case illustrates the importance of including melanoma as a differential diagnosis for non-pigmented or minimally pigmented intraocular neoplasms. As far as the author is aware, this is the first published case of amelanotic uveal melanoma in a cat. A few cases of periocular feline amelanotic melanoma also exist in the literature. Wolfer (11) reported the case of an 8-year-old spayed female domestic short hair cat which was presented for a periocular mass under the

Discussion

This case represents an unusual presentation of feline diffuse iris melanoma, as the tumor consisted of an amelanotic mass rather than an area of hyperpigmentation. Although feline malignant melanoma is relatively rare, diffuse iris melanoma is the most common primary feline intraocular tumor (2–5). There is no evidence of breed or sex predisposition, and most cases are detected in middle-aged to older cats (2,4,6). The tumor cells originate on the anterior surface of the iris, and classically are recognized as multifocal or diffuse golden or dark brown-black hyperpigmentation (2,3,7). The lesions may remain unchanged, but in most cases will progress in size, number, and/or thickness over months to years. Dyscoria may be observed due to involvement of the iridal constrictor muscles, and extension into the ciliary body and sclera, or other intraocular structures. Affected cats may be presented with uveitis secondary to tumor promotion of inflammatory mediators, or glaucoma due to infiltration of the iridocorneal angle and obstruction of aqueous outflow.

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right eyelid. The cytology from fine-needle aspirates of the mass was consistent with a round cell tumor, such as a melanoma or plasmacytoma. A plasmacytoma was ruled out with plasma electrophoresis. In 2006, de Lorimier described a 6.5-year-old spayed female Balinese cat with a large, locally invasive primary orbital melanoma (12). Cytology from a fine-needle aspirate sample revealed spindle-shaped cells with dark cytoplasmic granules consistent with melanoma. Histopathology of the tumor showed atypical cells that appeared highly vacuolated, had poorly defined borders, and contained pleomorphic nuclei consistent with an undifferentiated sarcoma. Immunohistochemistry was needed to confirm the diagnosis of a poorly differentiated, amelanotic melanoma of the orbital tissues (12).

Other intraocular tumors such as uveal lymphoma and feline post-traumatic sarcoma can mimic the gross appearance of amelanotic melanoma and for this reason were considered primary differential diagnoses in the case presented. Lymphoma is one of the most common neoplasms found in cats, with feline primary differential diagnoses in the case presented. Lymphoma of amelanotic melanoma and for this reason were considered feline post-traumatic sarcoma can mimic the gross appearance consistent with an undifferentiated sarcoma. Immunohistochemistry was necessary when diagnosing intraocular neoplasms based on morphology, histochemical staining, and immunohistochemical labeling. In addition to histopathology. For this reason, immunohistochemistry was recommended in the case presented to confirm the diagnosis of amelanotic diffuse iris melanoma, especially given the lack of pigmented within the tumor cells.

In conclusion, amelanotic iris melanoma should be included as a differential diagnosis for any feline intraocular tumor that is poorly pigmented or nonpigmented. As exemplified in this case, histopathology is a necessary diagnostic technique when investigating intraocular neoplasms as gross examination alone can be misleading.

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References
The following books are yours to keep free of charge in exchange for a book review that will be published in *The CVJ*. To order a book and receive suggestions on how to do a book review, please contact Kelly Gray-Sabourin, Editorial Coordinator, Journals, Canadian Veterinary Medical Association, at kgray@cvma-acmv.org


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Practitioners’ Corner  Le coin des praticiens

Veterinary volunteerism — From the tundra to the tropics

Samyra Stuart-Altman

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When I graduated from veterinary school in 2012 my primary focus was to become a good veterinarian, whilst navigating the tumultuous waters that all new graduates must encounter. Once I found myself to be steadily on my path, I realized that something was missing. I wanted to give back to my community, but I wasn’t quite sure how. Since then I have been able to volunteer with multiple organizations which has taken me to remote northern communities, to the tundra of the Hudson Bay, and an island off the coast of Mexico.

If you are a veterinary professional, or aspiring to become one, then this message is for you: Let me save you a bit of time, and let’s fast-track the volunteer process with my “How To” guide on Veterinary Volunteerism.

1. Make a list of your skills.

Do you love medicine? A community outreach event may be up your alley. Are you an animal welfare warrior? Your local SPCA may have animal advocacy opportunities for you. Are you a surgery fanatic? Look for remote spay/neuter opportunities. I have had the pleasure of volunteering with Isla Animals, which is based in Isla Mujeres, Mexico. Once per year about 15 veterinarians and countless other volunteers rally to put on a massive spay/neuter campaign. This year we performed 1847 surgeries in 6 days. The days are long, and the challenges we encounter can be humbling. But the experience is priceless.

2. Do you want to travel, and if so, how far?

Consider whether you are willing to drive or fly. If you’re really adventurous, World Vets sets up initiatives in places such as Nicaragua, Peru, Nepal, India…just to name a few. My rec-

ommendation is start close to home, and then expand your horizons. The world is your oyster.

3. If you’re travelling, how picky are you with accommodations?

Do you require a hotel room with your own bathroom, or are you willing to camp out in a hunting cabin with no electricity or running water for 3 days? It’s an important question. One of my fondest memories is when I was stranded in a cabin while working as a trail vet for the Hudson’s Bay Quest. This is a wilderness sled dog race that takes place in the beautiful and sometimes inhospitable northern tundra near the town of Churchill, Manitoba. An unexpected turn of events had me, a team of 10 dogs, a South African musher and the Canadian Rangers, waiting out a snowstorm in a remote cabin. Our entertainment? The stunning aurora borealis and learning how to track the wolf prints that encircled our cabin.

4. Search online for veterinary volunteer organizations. Ask for recommendations on your social media accounts.

My first remote clinic was the result of my response to an ad in our local veterinary medical Board’s newsletter. My second opportunity came when a friend tagged me in a post on Facebook for a group that spays and neuters inner city cats for low-income families. My third opportunity was to become a Board member for our local humane society after a conversation with a current Board member on an overnight train to Churchill. Opportunities are everywhere; you just need to know where to look. Local Facebook groups for rescues can be helpful. Contacting your local veterinary Board is a good start, as well as a good way to network with your peers. And once you get involved, the opportunities tend to find you.

5. Ask for a veterinary reference

Before you get started with an organization, ask them for a reference. Speak to another veterinary professional and find out about what to expect, and how to prepare so that everyone can benefit from your future participation. There are a lot of things to learn, and it’s easier if you don’t have to learn the hard way. Speaking of which, here are a few things that I have learned the hard way:

a. Always bring a headlamp to a spay/neuter clinic;

b. Bring extra batteries for your headlamp;

c. You may not have the surgical instruments or suture you are used to — take it slow and get used to what you have before you worry about speed;

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d. Dogs with *Ehrlichia* bleed...a lot;
e. Caribou stew tastes best when served by candlelight on the tundra;
f. Bring your own toilet paper; and
g. Ask questions before you get there.

Some of the best lessons I have learned in veterinary medicine have been the result of my diverse volunteer experiences.

I am constantly humbled by the strength of the human-animal bond, and I am infinitely excited to meet new friends and learn new things. I hope that my experiences can help guide others to explore the world from a new perspective, and to give back to the world that has given us so much.

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**Answers to Quiz Corner**

**Les réponses du test éclair**

1. A) Only skin pigmentation, solar radiation, and advancing age have been shown to be associated with the development of SCC in horses. The other answers do not contain accurate etiologic agents for SCC.

   A) Seulement la pigmentation de la peau, les rayons du soleil et l’âge sont des facteurs qui ont été associés au développement du carcinome spinocellulaire chez le cheval. Les autres réponses contiennent des éléments qui ne sont pas des agents étiologiques du carcinome spinocellulaire.

2. C) Histiocytic ulcerative colitis is a disease of young boxer dogs.

   C) La colite ulcérative histiocytaires est une maladie des jeunes chiens boxers.

3. D) Feeding is the most important component of therapy for idiopathic feline hepatic lipidosis.

   D) L’alimentation est la composante la plus importante pour le traitement de la lipidose hépatique idiopathique féline.

4. A) Clinical signs usually resolve.

   A) Les signes cliniques se résorbent habituellement.

5. C) Ovsynch is widely adopted because it allows a 100% submission rate (i.e., all cows injected are inseminated), in comparison to synchronization protocols based on insemination after estrus detection, which have lower submission rates because of heat detection errors. Probability of conception is reduced with Ovsynch, but because of the higher submission rates, pregnancy rates can be equivalent to or higher than other protocols. A disadvantage of Ovsynch is that it is labor intensive. Ovsynch has no effect on the intensity or duration of estrus.

   C) La synchronisation de l’ovulation par le protocole OvSynch est largement adoptée parce qu’elle permet un taux de saillie de 100 % (toutes les vaches injectées sont inséminées) par rapport aux protocoles de synchronisation basés sur l’insémination après la détection de l’œstrus, qui sont associés à des taux de saillie moins élevés en raison d’erreurs dans la détection des chaleurs. La probabilité de conception est réduite avec le protocole OvSynch, mais en raison du taux de saillie plus élevé, les taux de gestation peuvent être équivalents ou supérieurs à ceux observés avec d’autres protocoles. Un inconvénient du protocole OvSynch est qu’il nécessite beaucoup de travail. Il n’a aucun effet sur l’intensité ou la durée de l’œstrus.
Managing change in a changing world
Part 1: Moving with the change

Debbie L. Stoewen

**Introduction**

We find ourselves in extraordinary times. We’re facing what we have never faced before, a global pandemic. Within weeks, the novel coronavirus, COVID-19, spread worldwide. Nobody knows how long it will last or how long it will be until we can resume our usual lives. With so many unknowns, it’s hard to imagine what’s on the other side. For now, all we have is today, and for today, we can, and should, do all we can, individually and collectively, to carry us through these times in the best ways possible — for ourselves, our families, and our communities. We are, after all, in this together.

The key word that comes to mind with the pandemic is “change.” Our world has changed, and it is clear it will never — cannot possibly — go back to normal. To go back to “normal” would be like going back in time. Impossible. So when the pandemic is over — recognizing that it will likely occur in waves — we’ll find ourselves in a “new normal.” Change, of course, is pervasive. As Heraclitus, the Greek philosopher said, “Change is the only constant in life.” When a simple saying such as this remains alive for centuries, it’s a good idea to pause and acknowledge its truth. Even as we do so, we realize that the order of magnitude of this change cannot but have lasting impacts, and in ways we can’t yet possibly imagine.

Who ever imagined telemedicine to become the modus operandi for the delivery of veterinary services? The concept of screening clients has taken on a whole new meaning. Who ever imagined the extent to which we would alter operations, providing urgent care only? Who would have imagined outdoor appointments and curbside services as the norm? Infection management protocols never seen before. Limits on filling orders, shortages of medical supplies, and delays with deliveries of inventory. The call to fulfill civic duty by donating personal protective equipment and loaning ventilators and anesthetic gas machines. The very face of companion animal practice has changed, and virtually overnight. It would seem we are at war in a time of peace.

Change doesn’t come easy at the best of times. Change typically takes time, but in this case, there was no time — not even to prepare for it. So what do circumstances such as these call for? And especially unprecedented circumstances? Resilience. The ability to flex with the times, to move with the change.

Moving with the change

To move with the change, paradoxically, the first thing we need to do is stop moving. Not what you expected to hear, right?!

Listen on.

We need to pause. We need to take the time to pull out from the chaos, the changes, and the upheaval of our lives so we can, from a balanced mindset, choose how to carry ourselves forward. Without choice, without setting a direction, we are just like leaves on a stream, randomly being carried along by the current. It’s no longer life as usual. We need a new game plan. But we can’t create one without pulling out, without distancing ourselves to reflect on the circumstances, take perspective, and regain balance. So amid these changes, as unsettling as they are, take the opportunity to pause — to slow down, check in with yourself, and get grounded. There are many ways to do this.

**Take time in solitude**

Take time in solitude to pause and let the thoughts that may be whirling in your mind settle. Fears can get us racing in so many directions that we can feel overwhelmed and out of control. But when you stop and really look at the situation, you can see it for what it is. You can gain perspective. Maybe it’s a catnap on the couch; a hot bath with candlelight and soft music; meditation or prayer; hiking through the woods, walking the dog, or sitting on the porch after the kids have been put to bed. Maybe it’s engaging in activities that you enjoy, like gardening, carpentry, or knitting, when your mind can wander. Maybe you reflect best when you’re in the rhythm of jogging. Whatever it is, take the time to pause within and put things in perspective. What is the worst that could happen? How could things be worse right now? Where are the silver linings? What do you have to be thankful for?

**Craft your life narrative**

Writing about stressful events can help you come to terms with them. The act of writing accesses your left brain (which is analytical and rational), and while your left brain is busy, your right brain is free to create, intuit, and feel. In this way, writing removes mental blocks, allowing you to use all your brainpower
to better understand yourself, others, and the world around you (1). Journaling your thoughts and feelings will help you understand them more clearly and gain new insights on the challenges you’re facing. And as you craft your own life narrative, you gain a sense of control.

**Practice yoga**
Yoga offers a variety of physical, psychological, and spiritual benefits (2). It combines physical movement, meditation, light exercise, and controlled breathing — all of which calm the mind and relieve stress. Even a single yoga session can be of benefit, so give it a try. Enroll in an online program or use an app to help you begin. And if you blend it into your lifestyle, the benefit will be that much more. If yoga doesn’t interest you, try something else. Yoga is only one form of mind/body exercise, “exercise with an inwardly directed focus.” Do some simple stretches, turn up the music to lose yourself in dance, or go for a meditative walk.

**Just breathe**
There are many kinds of breathing exercises that calm the mind. They’re a great way to ground yourself so you can think clearly and maintain perspective. Try the “one-moment meditation” (3). It really does just take a moment, although starting off with a minute can help you get used to it. Relax your body, quiet your mind, and take even breaths. You can use it anytime to create an instant shift.

**Accept your feelings**
It is natural to feel stress, anxiety, grief, and worry during this time. It is important to accept them rather than try to push them away (4). You may be sad with the loss of your usual ways of living, worried about a lack of resources, or concerned about the kids getting cabin fever. If you avoid these emotions, they will only get stronger and last longer. Instead, notice these emotions, thoughts, and physical sensations, look into them with curiosity, describe them without judgment, and then let them go. Envision them as seeds blowing off a dandelion in a gentle breeze.

**Accept what you cannot control**
There are circumstances that are not in your power to control. Focusing on what you have no control over will leave you frustrated and exhausted. Instead, let them go. Doing so will help you move on and focus your energy constructively. Remember, you may not be able to change the circumstances, but you can change how you respond to them.

**The power to choose**
When we pause, taking the time to slow down, reflect, take perspective, and regain balance, we can accept the changes for what they are, quiet the fears, and get grounded. And from a place of calm, of collectiveness, we can choose our response. It is what it is — we are in a pandemic. We can’t change that. But we can choose how to carry ourselves “in” and “through” this. As Viktor Frankl said, “Between stimulus and response there is a space. In that space is our power to choose our response” (5).

There will always be change. Instead of focusing on the disruptions, accept that change is a natural part of life and that it can also bring opportunities and positive outcomes. The next article will focus on choosing our response, on making the choices that will support us through these times in the best ways possible — for ourselves, our families, and our communities.

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Client assumption-based communication

Myrna Milani

Many practitioners have specific ideas regarding the kinds of information they expect their clients to communicate to them. Most also recognize that the best way to gain that information means asking specific questions designed to elicit it. They would not assume that clients would provide all the necessary information without prompting of some sort. On the other hand, clients may have equally specific ideas regarding the kinds of information they want their veterinarians to provide. However, some clients do assume that their veterinarians will communicate this information without any prompting from them. This is based on the belief that, if anything related to their animals is important to them, it also will be important to their veterinarians. When the veterinarian fails to fulfill these client assumptions, the quality of practitioner-client communication may deteriorate. When this occurs, it also may impact the quality of the client’s care of the animal and, by extension, the animal’s health.

Such time- and energy-consuming scenarios fundamentally reflect a practitioner-client variation on the in vivo/in vitro theme. For example, Dr. Dubreuil’s clients, the Gleasons, live on a small farm with their 2 toddlers, 3 dogs, 2 cats, a flock of chickens, and 4 goats. This and everything related to it represent their in vivo, i.e., the whole “organism” or physical, behavioral, and emotional environment in which the couple must implement any treatment Dr. Dubreuil prescribes. On the other hand, Dr. Dubreuil’s prescribed treatment is science-based. It arises from a controlled in vitro environment in which most of the variables associated with the world the Gleasons share with their animals are eliminated if possible, or ignored if not. When the veterinarian reads journal articles or listens to presentations about a certain treatment’s benefits, she perceives this only as it affects the animal and the medical condition for which it is prescribed.

Similarly, when Dr. Dubreuil discusses a case with other practitioners who have used that same treatment, they also may focus on the problem and its treatment. In this situation, however, her colleagues who have used the treatment may offer information about animals that did not respond to the treatment as well as expected. This may include the animal’s species, breeding, reproductive status, any concurrent medical problems, plus any other medications the animal might be receiving that could interfere with the treatment in question.

From Dr. Dubreuil’s perspective, her job is to examine the animal, perform any diagnostic tests necessary, make the diagnosis, determine the best treatment, and educate her clients about when to medicate or otherwise provide treatment for the animal. Once she accomplishes that, she considers her job done. It is now her clients’ responsibility to do what she asked them to do. That her clients’ perspective regarding the veterinarian’s perception of the problem may differ never crosses her mind. This results in an unacknowledged communication gap, the resolution of which depends on the ability of those in both groups to recognize and breach this void.

When Dr. Dubreuil greets the Gleasons and examines their geriatric house cat which isn’t using the litter box, she immediately thinks about multiple possible medical conditions that could cause the cat to do this. But although Ms. Gleason cares for the cat, that is not her first priority when she discovers the cat peeing on the bathroom rug. From then on, she becomes focused on what she considers different, but more important concerns: whether the cat’s urine poses a threat to her active, cat-loving twin toddlers, and how best to clean the soiled rug and locate any other areas where the cat may have urinated.

Even though the other issues may not register on the practitioner’s radar, these may be so important to her client that the latter cannot imagine that these will not be discussed. If the veterinarian ends the appointment without providing this information, these clients may become frustrated or even panicky and suddenly blurt out their concerns. Practitioners then suddenly may feel confused or panicky themselves knowing there are clients and animals waiting for them in the waiting room.

Dr. Milani is a behavior and bond practitioner, teacher, and author of several books on the interaction of animal behavior, health, and the human-animal relationship.

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Most concerns clients assume their veterinarians will address fall into 4 basic categories: medical, behavioral, environmental, and bond effects related to the animal’s problem. In general, their education prepares most practitioners to focus the bulk of their attention on issues related to an animal’s medical condition. However, veterinarians need not be in practice long to discover how, for example, aggressive behavior in animals of all species can foil even the most perfect medical diagnosis and treatment program.

Practitioners also increasingly are aware that some animal behavior problems may mimic or contribute to medical ones. Good examples of this are those involving house-soiling with urine or stool. Some practitioners still only may think in terms of strictly medical conditions that may result in symptoms akin to those experienced by the Gleasons’ cat. However, many recognize that using urine or stool to mark their territories is a normal animal behavior under certain circumstances. Some practitioners also recognize how behavior-based inappropriate elimination problems sometimes may segue into medical problems as well as *vice versa*. And practitioners with an interest in animal behavior additionally may be prepared to address environmental factors — such as changes within the household or the area immediately around it that make the animal feel vulnerable — that may trigger inappropriate elimination behavior.

Similarly, many presentations or articles discussing this topic for any reason discuss proper clean-up procedures. Savvy practitioners also include this information in their verbal or written client education material.

Mr. Gleason’s top priority — the long-term implications of the problem for an aged cat loved by all family members — reflects practical bond considerations. Nor are his concerns unique. Regardless whether clients value an animal for strictly emotional, utilitarian, or monetary reasons, chronic or serious medical problems will cause clients to seek to answer the question, “What does my animal’s condition mean to me/my family/ the future of this household/my business?” At the same time, though, this is a question that practitioners may be hesitant to answer. And especially not when they lack the time to consider any answer carefully before they share it with the client.

An on-going challenge for practitioners is striking a balance between a professional image that may position them in the public psyche as “most knowledgeable in all things animal,” and the impossibility of fulfilling that expectation. Among its pitfalls, it encourages clients to assume that practitioners know — or should know — far more about their clients’ individual needs than the veterinarian realistically can.

After discussing the dilemma and the communication problems this orientation created with more experienced colleagues, Dr. Dubreuil ultimately decided to reframe her professional relationship with her clients as a working partnership.

“I also acknowledge upfront that, when it comes to all the different variables that influence their animals’ health and treatment in their homes, I consider them the ultimate authority because they know what’s going on in their homes far better than I ever could,” she adds. “That was the most difficult part for me. I irrationally had believed that I *should* know all that information and felt I was letting my clients down when I admitted that I didn’t and needed their help.”

A few clients did confirm her fears. But the veterinarian came to realize that these clients did so because they had no desire to participate in their animal’s wellbeing. They did not reject this responsibility because they cared so much about their animals. They did it because they wanted her to do the impossible: accept full responsibility for all aspects of their animals’ health because it made their lives easier.

“I could appreciate the benefits of this approach for them,” the practitioner readily acknowledged. “But the only way I could do that would be to hospitalize their animals anytime the animal developed any problem of any kind. And doing that would be a disservice to the animals that truly needed the benefits of hospitalization, including the full attention of the staff to treat them.”

Ultimately, the majority of clients embraced the idea of working in tandem with the veterinarian and doing their part to ensure their animals’ health. Granted, Dr. Dubreuil initially had to set aside time to address the Gleasons’ and other clients’ not-strictly-medical concerns regarding their animals’ welfare. However, she soon became familiar enough with their situations and related concerns that she could integrate this material — and questions related to it — into her treatment discussion. Once she and her clients became familiar with this more inclusive form of communication, the process took no longer than her previous approach. More importantly, giving this client communication problem the same thoughtful consideration she gave to the diagnosis and treatment of their animals’ medical problems, enabled her to find solutions that enabled practitioner and clients to use their time together more productively.
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