Bilateral intracorporeally sutured inguinal herniorrhaphy using 3-dimensional laparoscopy in a dog

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Pure cystine and urate calculi can be clearly visible using survey digital radiography

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Potomac horse fever in Ontario: Clinical, geographic, and diagnostic aspects

Diagnostic testing patterns for Streptococcus equi subsp. equi in Ontario horses during the years 2008 to 2018

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"Instructions for authors" are available online (www.canadianveterinarians.net).

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**Editorial**  
**Éditorial**

**Are you planning to get your case report published in The Canadian Veterinary Journal?**  
**Envisagez-vous de publier un rapport de cas dans La Revue vétérinaire canadienne?**

Veterinarians and veterinary students frequently encounter situations that may warrant communication to their colleagues in the form of a case report. In addition, many trainees are required to publish case reports as part of their board-certification process. As the national voice of Canadian veterinarians, *The Canadian Veterinary Journal* has a long history of publishing these articles. Furthermore, there was strong support for such articles in a survey of our readership (1).

The journal’s Instructions for Authors (2) includes a section describing the preparation of a case report; as with any submission to the journal, these instructions should be carefully consulted so that the submitted article complies with the journal’s formatting requirements. The purpose of this editorial is to provide further insights into the impetus for writing a case report and offer some guidance to assist authors.

What constitutes a case report? It was noted (3) that case reports can generally be allocated into 3 categories: description of a novel disease or condition; an unusual complication of a well-characterized disease or condition; or a new approach to treatment or management of a disease or condition.

Case reports published in *The CVJ* are peer-reviewed. Since we receive roughly twice as many unsolicited submissions as we can publish, we initially screen all submitted articles to determine whether they are worthy of sending to review, so that we do not overwhelm our reviewers and to provide a prompt response to authors when the article is deemed unsuitable for publication. For case reports (and indeed any article) sent for review, efforts are made to identify persons with the knowledge and expertise to critically evaluate the article and provide advice.

What are the guiding principles regarding whether a case report is likely to be published in *The CVJ*? These articles are likely to be of greatest interest to practitioners, and as such, the article should be written to attract their interest and enable them to learn something from the case. In that regard, the key clinical message (located after the Abstract) should help in making

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this assessment. In general, the case should involve a challenge or novel features regarding diagnosis, management, and/or treatment. It is critically important that the case be relevant to Canadian veterinarians, including animals, diseases, conditions, and commercial availability of specialized therapies used. Although a traditional case report most commonly describes a condition or disease in a single animal, and we certainly do publish some of those, we strongly prefer a case series involving several animals. Furthermore, we usually deny case reports in which attempts are made to draw conclusions about the effectiveness of treatment based on a single animal.

There are comprehensive guidelines for preparing medical case reports (4), which set high standards. In veterinary medicine, in addition to regulatory requirements for maintaining medical records, if there is potential for a case report, there should be detailed, comprehensive notes and records and appropriate images. In addition, the notion that a case report may arise is also likely to prompt additional testing, or at the least, the collection and retention of appropriate samples for subsequent analyses.

There are many sources of information regarding how to write and submit a case report. Obviously, one of the first priorities is a thorough awareness of the literature to determine the inherent novelty of the case. Once a target journal has been chosen, the article should be written in accordance with the requirements of that journal, as detailed in Instructions for Authors. Critical reading of recent case reports in that journal will provide additional ideas and insights. Preparation of a detailed outline will help to maintain focus and flow.

In our roles as Co-Editors of *The Canadian Veterinary Journal*, we encourage our colleagues to consider publishing case reports in our journal. We recognize that for many persons, a case report may be their first scientific publication. Therefore, we are always prepared to provide some guidance and assistance in the preparation of case reports, particularly for authors with little or no previous experience in scientific writing and publication.

**References**

2. https://www.canadianveterinarians.net/documents/instructions-to-authors-cvj

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As an aspiring assistant professor at a large university, you are anxious to demonstrate your expertise in research. You have several research grants, some as the lead investigator and others as a collaborator. On one grant for which you are part of the research team, the lead investigator, a senior scientist, is deviating significantly from the original objectives and methodology in the grant. This is creating difficulties for you in fulfilling your co-investigator responsibilities under the terms of the grant. When you discuss this matter with the senior scientist, he is dismissive and says it is easy to disguise how the money was spent and exactly what work was done and what was not. He tells you he has done this for years. You are not comfortable being part of this arrangement but believe that reporting this activity to the department chair will almost certainly work against your career advancement. How should you proceed?

An ethicist's commentary on March 2021 CVJ — Senior scientist encourages cheating

We learn ethics in a variety of ways, from the time we are children. If we have reasonable parents, respectful of a child's developing mind, they will take the trouble to explain that a world in which people fail to respect the interests of others would likely be a world in which your interests would suffer the same fate, and you are not likely to wish to live in such a world. Other, less intelligent parents, will affirm that one should not act that way on the pain of parental punishment. Different children will learn the hard way, by suffering the same fate they inflict on others. But the key point is that social life would be untenable under those circumstances.

As an adult, one learns substantially the same lesson if one works in a large organization such as a university. By the time one reaches the position described in the case, it is very likely that you will have learned the unspoken nuances of doing research under a grant, and what sort of behavior is considered wrong. You should further have this understanding confirmed by the senior researcher's boasting that he had done this sort of cheating for years. Regardless of whether this is or is not the case, it is clearly a violation of your self-interest to run the risk of being identified as a cheat and a liar at this point in your career. In fact, it is not inconceivable that, if caught, the senior researcher will shift the blame to you. If he or she is sufficiently dishonorable to build a career on duplicity, one can be morally certain that he or she will do whatever it takes to protect themselves and their reputation.

Being a teacher or researcher is a career built on a reputation of honorable behavior. One scandal involving the sort of behavior described is virtually certain to wreck one's career in an irremediable way.

Were I the young instructor, I would share what is happening with my department head. However much the department head fears or respects the senior faculty member, no department head will risk bringing down the wrath of a granting agency on his or her own career or department. If the department head is wise, he or she will explain to the senior faculty member the risk that is being run to his or her career, to your career, and to the department. In this day and age, the chance of people and granting agencies forgiving and forgetting is virtually nil. Under the worst circumstances, your career in the department is likely to suffer. But your reputation will remain intact. Under those circumstances, it is quite likely that you will be able to find another job, or at least quietly shift positions from one institution to another.

Bernard E. Rollin, PhD

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**Ethical question of the month — June 2021**

You are a recent graduate and have taken on a new client who has several “rescue” horses. The patient presented is a miniature horse that is having difficulty walking. You diagnose the horse with chronic, severe laminitis with secondary tendon contracture. The client informs you that the horse had a tenotomy procedure 4 years ago, but it did not improve the condition. The horse can now barely stand. You request the medical record and observe that the horse has not been assessed since the surgery, and the previous veterinary providers have regularly been supplying oral tranquilizer as the horse is unable to stand on 1 leg for hoof trimming without sedation.

You advise the client that the horse is in significant pain and that the prognosis is poor. The client challenges this assertion, as the previous veterinary service never commented on this horse’s condition when on farm for other horses. You insist that the horse needs referral to a specialist, or euthanasia. Despite polite follow-up messages, the owner’s husband informs you that your calls are making his wife’s fragile mental condition worse and tells you not to contact them again. **What is your next step?**

**Les réponses au cas présenté sont les bienvenues. Veuillez limiter votre réponse à environ 50 mots et nous la faire parvenir par la poste avec vos nom et adresse à l’adresse suivante : Choix déontologiques, a/s de la Dr Bettina Bobsien, 4353 rue Yellowpoint, Ladysmith (Colombie-Britannique) V9G 1G5; courriel : bettinadvm@gmail.com**

Les propositions de questions déontologiques sont toujours bienvenues! Toutes les questions et situations présentées dans cette chronique s’inspirent d’événements réels dont nous modifions certains éléments, comme les noms, les endroits ou les espèces, pour protéger l’anonymat des personnes en cause.
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1. A left shift with neutropenia suggests which of the following?
   A. Aggressive inflammation with severe consumption of neutrophils
   B. Mild inflammation
   C. Leukemia
   D. Steroid administration
   E. A stress response

2. Loss in skin turgor is detected at which point first. When:
   A. There is 1% to 2% dehydration?
   B. There is 3% to 5% dehydration?
   C. There is 5% to 10% dehydration?
   D. There is 12% to 15% dehydration?
   E. There is 15% to 20% dehydration?

3. Which of the following is the most common gastric neoplasm in cats?
   A. Adenocarcinoma
   B. Lymphoma
   C. Mastocytoma
   D. Leiomyoma

4. Some species of lupine plants (Lupinus spp.) have been associated with a particular clinical condition in calves whose dams graze this plant during days 30 to 100 of gestation. Which of the following is the name of this clinical condition?
   A. Mannosidase deficiency
   B. Crooked calf disease
   C. Tetralogy of Fallot
   D. Systemic granulomatous disease
   E. Cyclopia

1. Un virage à gauche accompagné de neutropénie suggère lequel des problèmes suivants?
   A. Une inflammation agressive avec consommation sévère de neutrophiles
   B. Une inflammation légère
   C. Une leucémie
   D. L’administration de stéroïdes
   E. Une réponse au stress

2. Une perte du signe du pli cutané est décelée d’abord à quel moment?
   A. Lorsqu’il y a de 1 % à 2 % de déshydratation
   B. Lorsqu’il y a de 3 % à 5 % de déshydratation
   C. Lorsqu’il y a de 5 % à 10 % de déshydratation
   D. Lorsqu’il y a de 12 % à 15 % de déshydratation
   E. Lorsqu’il y a de 15 % à 20 % de déshydratation

3. Lequel des néoplasmes suivants est le néoplasme gastrique le plus commun chez le chat?
   A. Adénocarcinome
   B. Lymphome
   C. Mastocytome
   D. Léiomyome

4. Certaines espèces de lupins (Lupinus spp.) ont été associées à une affection clinique particulière chez les veaux dont les mères ont brouté ces plantes durant les jours 30 à 100 de la gestation. Quel est le nom de cette affection?
   A. Carence en mannosidase
   B. Maladie du veau crochu
   C. Tétralogie de Fallot
   D. Maladie granulomateuse généralisée
   E. Cyclopie
5. A necropsy is performed on a feedlot calf that died from respiratory disease. The lungs are hyperinflated and the primary gross lesion is interstitial emphysema with emphysematous bullae. Which of the following viruses should be on the differential diagnosis list?

A. Bovine respiratory corona virus  
B. BVD virus  
C. Bovine respiratory adenovirus  
D. Bovine respiratory syncytial virus (BRSV)  
E. Bovine herpesvirus 1

(See p. 636 for answers./Voir les réponses à la page 636.)

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.
As part of the CVMA’s virtual Committee Weekend, Council met in March to provide policy directions and make required decisions. Council is comprised of representatives from all provinces, veterinary colleges, veterinary students, and the Registered Veterinary Technologists and Technicians of Canada (RVTTC).

**Position statements**

**Use of Thermocautery for the Treatment of Lameness in Horses:** Council approved the following revised position statement:

“The Canadian Veterinary Medical Association (CVMA) is opposed to the painful treatment of lameness using thermocautery (‘pin firing’ or ‘firing’) in horses, as the practice is ineffective and is inconsistent with evidence-based medicine.”

**Care of Neonatal Dairy Calves:** Council approved the following new position statement:

“The Canadian Veterinary Medical Association (CVMA) supports restrictions contained in the Health of Animals Regulations on the age at which neonatal calves can be transported on long journeys and at what age they can be transported to auction markets. The CVMA recognizes that these changes may result in the retention of some surplus calves on dairy farms for a longer period than in the past. The CVMA maintains that producers have an obligation to provide the same appropriate standard of care to all calves on their farm irrespective of their economic value. Veterinarians should support their clients by providing advice on how to meet appropriate health and welfare standards, and if necessary, how to provide appropriate methods of euthanasia/humane killing.”

**Animals in Science:** Council approved the following revised position statement:

“The Canadian Veterinary Medical Association (CVMA) recognizes that animals play an important role in scientific advancement. Science involving animals must be conducted within an ethical framework (including the principles of replacement, reduction, and refinement), and in compliance with animal welfare guidelines, including those incorporated into provincial and federal legislation and contractual obligations. It must also

**Énoncés de position**

**Utilisation de la thermocautérisation pour le traitement de la boiterie chez les chevaux :** Le Conseil a approuvé l’énoncé de position révisé suivant :

« L’Association canadienne des médecins vétérinaires (ACMV) s’oppose au traitement douloureux de la boiterie par thermocautérisation (‘application de pointes de feu’) chez les chevaux, car la pratique est inefficace et n’est pas conforme à la médecine factuelle. »

**Soins aux veaux laitiers nouveau-nés :** Le Conseil a approuvé le nouvel énoncé de position suivant :

« L’Association canadienne des médecins vétérinaires (ACMV) appuie les restrictions imposées par le Règlement sur la santé des animaux concernant l’âge auquel les veaux nouveau-nés peuvent être transportés sur de longues distances et l’âge auquel ils peuvent être transportés vers les encans. L’ACMV reconnaît que ces changements peuvent entraîner la rétention de certains veaux laitiers excédentaires dans les fermes pendant une période plus longue que par le passé. L’ACMV soutient que les producteurs ont l’obligation de fournir les mêmes soins adéquats à tous les veaux de leur ferme, quelle que soit leur valeur économique. Les médecins vétérinaires devraient appuyer leurs clients en leur donnant des conseils sur la manière de respecter les normes de santé et de bien-être appropriées et, si nécessaire, sur les méthodes appropriées d’euthanasie ou d’abattage sans cruauté. »

**Utilisation des animaux à des fins scientifiques :** Le Conseil a approuvé l’énoncé de position révisé suivant :

« L’Association canadienne des médecins vétérinaires (ACMV) reconnaît que les animaux jouent un rôle important dans l’avancement scientifique. L’utilisation des animaux à des fins scientifiques doit être faite dans un cadre éthique (intégrant le principe des
have the potential to contribute to the understanding of biological principles, or to the development of knowledge, skills, and products that can reasonably be expected to benefit humans, animals or the environment.

**Humane destruction/depopulation:** Council approved the following revised position statement:
“The Canadian Veterinary Medical Association (CVMA) holds that when mass depopulation of domesticated animals is undertaken, methods must be used as humane as achievable in the situation. Mass depopulation must only be performed by trained personnel who are supervised by persons competent in depopulation and knowledgeable in animal welfare. Methods of restraint and killing must be adapted to the specific circumstances of the situation and the species, size, and age of animal. The CVMA recognizes the potential for emotional impacts on everyone involved in mass depopulation activities and strongly recommends that resources be available to support these individuals.”

**Induced Moulting of Poultry:** Council approved the following revised position statement:
“The Canadian Veterinary Medical Association (CVMA) is opposed to moult induction by methods involving deprivation of food and/or water and recommends that induced moulting only be used in response to unforeseen emergency situations.”

**Service Animals:** Council approved the following new position statement:
“The Canadian Veterinary Medical Association (CVMA) holds that the veterinary profession should contribute to the development and maintenance of a national standard for service animals. Furthermore, veterinarians should provide expert advice on the proper care of service animals to support animal health and welfare, and public health and safety.”

**Extra-label Drug Use (ELDU):** Council approved the following revised position statement:
“The Canadian Veterinary Medical Association (CVMA) holds that Extra Label Drug Use (ELDU) is an important and legally acceptable strategy for the effective treatment of animals only by a licensed veterinarian within the confines of a valid veterinary-client-patient relationship (VCPR) and only in circumstances where an approved veterinary product or drug is not available or is not suitable.”

**Antimicrobial Stewardship in Veterinary Medicine:** Council approved the following revised position statement:
“The Canadian Veterinary Medical Association (CVMA) strongly supports antimicrobial stewardship by veterinarians to help protect the health and welfare of animals, public health, and the environment.”

**Use of Lead Fishing Tackle and Lead Shot in Canada:** Council approved the following revised position statement:
“The Canadian Veterinary Medical Association (CVMA) strongly supports a ban on the use of lead fishing weights, jigs and lead shot because of the direct and indirect harm they may induce in humans, wildlife and the environment. The CVMA strongly supports the development and use of non-toxic materials for hunting and angling purposes.”

**Dépopulation de masse d’animaux de manière non cruelle:** Le Conseil a approuvé l’énoncé de position révisé suivant :
« L’Association canadienne des médecins vétérinaires (ACMV) estime que, lorsqu’une dépopulation de masse d’animaux domestiqués est entreprise, les méthodes utilisées doivent être les moins cruelles possibles. La dépopulation de masse ne doit être effectuée que par du personnel formé et supervisé par des personnes compétentes en matière de dépopulation et de bien-être animal. Les méthodes de contention et de mise à mort doivent être adaptées aux circonstances spécifiques de la situation ainsi qu’à l’espèce, à la taille et à l’âge des animaux. L’ACMV reconnaît que les activités de dépopulation de masse présentent un risque d’impact sur la santé mentale des personnes y participant et recommande fortement que des ressources soient disponibles pour soutenir ces personnes. »

**Mue induite de la volaille:** Le Conseil a approuvé l’énoncé de position révisé suivant :
« L’Association canadienne des médecins vétérinaires (ACMV) s’oppose à l’induction de la mue de la volaille par des méthodes impliquant la privation de nourriture et/ou d’eau et recommande que l’induction de la mue ne soit utilisée qu’en réponse à des situations d’urgence imprévues. »

**Animaux d’assistance:** Le Conseil a approuvé le nouvel énoncé de position suivant :
« L’Association canadienne des médecins vétérinaires (ACMV) soutient que la profession vétérinaire devrait contribuer à l’élaboration et au maintien d’une norme nationale concernant les animaux d’assistance, et que les médecins vétérinaires devraient être appelés à fournir des conseils d’experts sur les soins appropriés à prodiguer aux animaux d’assistance afin de soutenir la santé et le bien-être des animaux, ainsi que la santé et la sécurité du public. »

**Utilisation de médicaments en dérogation des directives de leur monographie:** Le Conseil a approuvé l’énoncé de position révisé suivant :
« L’Association canadienne des médecins vétérinaires (ACMV) soutient que l’utilisation de médicaments en dérogation des directives de leur monographie est une stratégie importante et légalement acceptable pour le traitement efficace des animaux seulement par un médecin vétérinaire agréé dans le cadre d’une relation vétérinaire-client-patient (RVCP) valable et seulement dans les cas où aucun produit ou médicament vétérinaire homologué n’est disponible ou approprié. »
2021 CVMA Award winners
CVMA Council chose to honor the following 2021 CVMA Award winners:
Small Animal Practitioner Award: Dr. Ameet Singh
Merck Veterinary Award: Dr. Claire Windeyer
Humane Award: Dr. Emilia Wong Gordon
Practice of the Year Award: Mountain View Veterinary Hospital (Dr. Renee Ferguson)
Industry Award: Dr. Walt Ingwersen
Life Membership: Dr. Wayne McDonell
RVL Walker Award: Ms. Svetlana Ponsin
President’s Award: Dr. Carlton Gyles

All CVMA members are invited to attend the virtual CVMA Awards Ceremony scheduled for Thursday, July 22.

Other discussions
Veterinary Workforce: Council struck a Working Group (WG) with the following mandate: “Based on the CVMA Workforce Study 2020 results and recommendations, and the knowledge and experience of the WG members, make viable recommendations on how CVMA could help address the forecasted shortage of veterinarians in the best interest of the profession, the clients and patients.”

The WG submitted a report that included the following 10 recommendations:
1. The CVMA engages and collaborates with provincial veterinary medical associations (VMAs), regulatory bodies, and colleges to develop shared vision and strategy on domestic veterinary education in Canada. This initiative is a 2-part collaboration that includes drafting a “Veterinary Workforce White Paper” and holding a “Veterinary Workforce Summit.”
2. The CVMA supports provincial VMAs in efforts to increase funding of Canadian veterinary colleges.
3. The CVMA investigates the number of Canadian students enrolled in veterinary education at international schools to project return to Canada.
4. The CVMA maintains/expand/furthers develops CVMA student chapters at accredited colleges, and identifies a network of champions at these schools.
5. The CVMA promotes the new pathways to C of Q (clinical year option) to graduates of international non-accredited programs. Working with key stakeholders, the CVMA investigates training opportunities/bridging programs for graduates of international non-accredited schools, including funding.
6. The CVMA supports an inter-disciplinary team of researchers (medical, business, technology, behavior) to conduct research, make recommendations and promote veterinary healthcare delivery models that are efficient and sustainable (financially, emotionally, and physically).
7. The CVMA supports research that specifically addresses the utilization of unregistered practice staff in veterinary practice delivery.
8. The CVMA supports research that benchmarks how high-functioning veterinary practices utilize registered veterinary technologists/technicians.

Utilisation judicieux des antimicrobiens en médecine vétérinaire: Le Conseil a approuvé l’énoncé de position révisé suivant:
« L’Association canadienne des médecins vétérinaires (ACVM) appuie fortement l’utilisation judicieux des antimicrobiens par les médecins vétérinaires pour aider à protéger la santé et le bien-être des animaux, la santé publique et l’environnement. »

Utilisation du plomb pour la chasse et la pêche au Canada: Le Conseil a approuvé l’énoncé de position révisé suivant:
« L’Association canadienne des médecins vétérinaires (ACVM) appuie fortement l’interdiction de l’utilisation de munitions au plomb pour la chasse et de poids et de leurres en plomb pour la pêche, en raison des dommages directs et indirects qu’ils peuvent causer aux humains, à la faune et à l’environnement. L’ACVM appuie vigoureusement le développement et l’utilisation de matériaux non toxiques pour les besoins de la chasse et de la pêche. »

Lauréats des prix de l’ACMV de 2021
Le Conseil a choisi d’honorer les personnes ci-dessous en leur décernant les prix de l’ACMV de 2021 suivants:
Prix du praticien des petits animaux : Dr. Ameet Singh
Prix vétérinaire Merck : Dr. Claire Windeyer
Prix humanitaire : Dr. Emilia Wong Gordon
Prix de la pratique de l’année : Mountain View Veterinary Hospital (Dr. Renee Ferguson)
Prix de l’industrie : Dr. Walt Ingwersen
Membre à vie : Dr. Wayne McDonell
Prix R.V.L. Walker : Mme Svetlana Ponsin
Prix de la présidente de l’ACMV : Dr. Carlton Gyles

Tous les membres de l’ACMV sont invités à assister à la cérémonie virtuelle de remise des prix de l’ACMV prévue le jeudi 22 juillet.

Autres discussions
Main-d’œuvre vétérinaire : Le Conseil a formé un groupe de travail ayant pour mandat de faire des recommandations viables sur les façons dont l’ACMV pourrait aider à remédier à la pénurie prévue de médecins vétérinaires, dans l’intérêt de la profession, des clients et des patients, à la lumière des résultats et des conclusions de l’étude sur le marché du travail menée en 2020 par l’ACMV ainsi que des connaissances et de l’expérience des membres du groupe de travail.

Le groupe de travail a soumis un rapport décrivant les 10 recommandations suivantes:
1. L’ACMV devrait collaborer avec les associations provinciales de médecine vétérinaire, les organismes de réglementation et les facultés de médecine vétérinaire pour élaborer une vision et une stratégie communes sur l’enseignement vétérinaire au Canada; cette initiative comporterait deux volets : la rédaction d’un livre blanc et la tenue d’un sommet sur la main-d’œuvre vétérinaire.
2. L’ACMV devrait appuyer les associations provinciales de médecine vétérinaire dans leurs efforts visant à accroître le financement des écoles canadiennes de médecine vétérinaire.
9. The CVMA collaborates to promote optimal utilization of registered veterinary technologists/technicians in practice, recognizing that the barrier to optimal utilization of technologists/technicians is mainly cultural and not regulatory.

10. The CVMA supports research to understand the factors associated with current practice models that make veterinary professionals susceptible to mental illness.

Council decided that the CVMA prioritize the following actions from the WG’s report:

- Collaborate to promote optimal utilization of RVTs in practice, recognizing the barrier to optimal utilization is mainly cultural not regulatory.
- Support provincial VMAs in efforts to increase funding of Canadian veterinary colleges.
- Support research that benchmarks how high-functioning veterinary practices utilize registered technicians/technologists.

In addition, the CVMA will continue expanding its student chapters at international, accredited veterinary colleges; promote Canada as a welcoming marketplace for graduates from such colleges; continue providing an effective national exam process for internationally trained veterinarians, making them eligible to apply for licensure in Canada.

**Diversity, Equity, Inclusion (DEI):** The CVMA appointed a Working Group (WG) with the mandate to “Make suggestions regarding the CVMA’s role regarding Diversity, Equity and Inclusion related to veterinary medicine.” The WG submitted a report and recommendations for Council’s consideration. From that report, Council prioritized the following items:

- **Short term:** Focus CVMA social media and website content on existing diversity within the veterinary community in Canada instead of stock veterinary illustrations.
- **Medium term:** Integrate concepts of DEI in CVMA’s Emerging Leaders Program, Convention, and Student Symposium.
- **Long term:** Interact with educational institutions/policy makers at the elementary level, high school level, post-secondary level (post-secondary institutions and veterinary colleges), especially related to recruitment and admission.

**2021 CVMA Convention:** Due to COVID-19, and keeping in mind the CVMA’s social responsibility, and government directions and actions on the federal, provincial, and municipal levels, Council decided to host the 2021 Convention in a 100% virtual format. More than 80 RACE-approved continuing education (CE) sessions will be provided online live by 31 presenters. All sessions will be recorded and accessible on the CVMA website until the end of 2021.

CVMA Council decided to set registration fees for the full virtual program as follows: $49 for members and RVTTTC affiliates; $149 for non-members.

The **CVMA AGM** will take place on **Thursday, July 22, 12:00 noon to 2:00 pm EDT.**

**CVMA Summit:** The virtual, live Summit, entitled *Changes in Societal Expectations towards Animals, and Influence on Veterinary Team Wellness* will take place on **Thursday, July 22.** It will be chaired by Dr. Louis Kwantes, President-Elect.

3. L’ACMV devrait s’informer du nombre d’étudiants canadiens inscrits dans des écoles de médecine vétérinaire à l’étranger pour projeter leur retour au Canada.

4. L’ACMV devrait maintenir/élargir/développer davantage ses sections étudiantes dans les écoles de médecine vétérinaire agréées et créer un réseau de représentants dans ces écoles.

5. L’ACMV devrait faire la promotion des nouvelles voies vers l’obtention du certificat de compétence (possibilité d’année clinique) auprès des diplomés d’écoles vétérinaires internationales non agréées. En collaboration avec les principaux intervenants, l’ACMV devrait étudier les possibilités de formation et les programmes de transition pour les diplomés des écoles internationales non agréées, y compris les options de financement.

6. L’ACMV devrait soutenir une équipe interdisciplinaire de chercheurs (dans les domaines de la médecine, des affaires, des technologies et du comportement) ayant le mandat de mener des études, de faire des recommandations et de proposer des modèles de prestation de soins vétérinaires efficaces et durables (financièrement, émotionnellement et physiquement).

7. L’ACMV devrait soutenir la recherche portant précisément sur l’utilisation du personnel non agréé dans les établissements vétérinaires.

8. L’ACMV devrait soutenir la recherche qui évalue la façon dont les pratiques vétérinaires exemplaires utilisent les technologues/techniciens vétérinaires agrées.

9. L’ACMV devrait promouvoir l’utilisation optimale des technologues/techniciens vétérinaires agrées dans la pratique, en reconnaissant que les obstacles à l’utilisation optimale de ces employés sont principalement liés à la culture et non à la réglementation.

10. L’ACMV devrait soutenir la recherche visant à comprendre les facteurs associés aux modes de pratique actuels qui rendent les professionnels vétérinaires vulnérables aux problèmes de santé mentale.

Le Conseil a décidé que l’ACMV accorderait la priorité aux actions suivantes proposées dans le rapport du groupe de travail :

- Promouvoir l’utilisation optimale des technologues/techniciens vétérinaires agrées dans la pratique, en reconnaissant que les obstacles à l’utilisation optimale de ces employés sont principalement liés à la culture et non à la réglementation.
- Appuyer les associations provinciales de médecine vétérinaire dans leurs efforts visant à accroître le financement des écoles canadiennes de médecine vétérinaire.
- Soutenir la recherche qui évalue la façon dont les pratiques vétérinaires exemplaires utilisent les technologues/techniciens vétérinaires agrées.

De plus, l’ACMV continuera d’élargir son réseau de sections étudiantes dans les écoles vétérinaires internationales agréées, de promouvoir le Canada en tant que marché accueillant pour les diplomés de ces écoles, et d’offrir un processus d’examen national efficace pour les médecins vétérinaires formés à l’étranger afin de leur permettre de présenter une demande de permis d’exercice au Canada.
The CVMA National Issues Forum: The virtual, live National Issues Forum, entitled Veterans as Community Leaders on Adaptation to Climate Change will also take place on Thursday, July 22. The topic of the Forum is meant to initiate discussion on the role of veterinarians in Canada's adaptation to climate change.

The CVMA ELP: The Emerging Leaders Program (ELP) has secured a 3-year funding commitment from Royal Canin and the Atlantic Veterinary College. The renewed ELP concept will move the program from a single event to a 1-year journey that will include the in-person experience during the CVMA Convention, 2 in-person regional outreach events, plus 6 leadership webinars. In 2021, the in-person events will be provided virtually.

COVID-19: The CVMA maintains its participation in the Public Health Agency of Canada (PHAC), Canadian Food Inspection Agency (CFIA), and canine organizations of Canada, Humane Canada, Ontario Ministry of Agriculture, Canadian Kennel Club, Pet Industry Joint Advisory Council Importation Working Group that includes participants from the CVMA leads the National Dog Protection Task Force. A new, comprehensive, and easily accessible website that is visually appealing, is to provide the CVMA, its members, and stakeholders with companion animals. These enhanced guidelines are located on the new website (www.savi.vet). In future, they will be accessible via the new CVMA website. The guidelines will also be made accessible through an app later this spring.

Mental wellness: The CVMA continues its annual mental health and wellness awareness campaign, plus quarterly seminars. These webinars are also being promoted to students. The delivery of a specific webinar for students on Imposter Syndrome is planned. The references to college and provincial VMA mental wellness services on the CVMA website have been updated recently. In addition, a group of volunteers, including members of the CVMA Wellness Advisory Group, is exploring the development of a peer-to-peer support program.

SAVI: The CVMA’s Stewardship of Antimicrobials by Veterinarians Initiative (formerly NVOS, Veterinary Oversight System for AMU) is underway through to March 31, 2023, and includes antimicrobial surveillance, stewardship, and communications activities for beef, swine, and poultry, and enhancement of the CVMA antimicrobial prudent use guidelines for food and companion animals. These enhanced guidelines are located on the new website (www.savi.vet). In future, they will be accessible via the new CVMA website. The guidelines will also be made accessible through an app later this spring.

Website: As per Council direction, the CVMA started the process of renewing its English and French website. The objective is to provide the CVMA, its members, and stakeholders with a new English and French website that is visually appealing, engaging, and easily accessible. The new website is scheduled to be launched in February 2022.

Importation of dogs: The CVMA leads the National Dog Importation Working Group that includes participants from Canadian Kennel Club, Pet Industry Joint Advisory Council of Canada, Humane Canada, Ontario Ministry of Agriculture, Food and Rural Affairs, Agriculture and Agri-Food Canada, PHAC, Canadian Food Inspection Agency (CFIA), and canine rescue organizations. With PHAC funding, the CVMA conducted a study on public health implications of dog importation in the form of a qualitative risk assessment. The results Diversité, équité et inclusion: L’ACMV a mandaté un groupe de travail pour faire des suggestions relatives au rôle de l’ACMV concernant la diversité, équité et l’inclusion en médecine vétérinaire. Le groupe de travail a soumis un rapport et des recommandations au Conseil aux fins d’examen. Le Conseil a donné la priorité aux éléments suivants de ce rapport :

- À court terme : Mettre en évidence la diversité existante au sein de la communauté vétérinaire au Canada dans les publications sur les réseaux sociaux et le contenu du site Web de l’ACMV au lieu d’utiliser des photos de banques d’images.
- À moyen terme : Intégrer les concepts de la diversité, de l’équité et de l’inclusion dans le Programme des futurs leaders, le Congrès et le Symposium des étudiants de l’ACMV.
- À long terme : Intégrer avec les établissements d’enseignement et les décideurs aux niveaux élementeire, secondaire et post-secondaire (y compris les écoles vétérinaires), en particulier en ce qui concerne le recrutement et l’admission.


Le Conseil de l’ACMV a décidé de fixer les frais d’inscription pour le programme virtuel complet à 49 $ pour les membres de l’ACMV et des TVTAC et à 149 $ pour les non-membres.

L’assemblée générale annuelle de l’ACMV aura lieu le jeudi 22 juillet, de midi à 14 h (HAE).

Sommet de l’ACMV : Le Sommet virtuel en direct, intitulé Changements dans les attentes de la société envers les animaux et influence sur le bien-être de l’équipe vétérinaire, aura lieu le jeudi 22 juillet. Il sera présidé par le Dr Louis Kwantes, président désigné de l’ACMV.

Forum national sur les enjeux de l’ACMV : Le Forum virtuel en direct sur les enjeux nationaux, dont le thème sera Le rôle des médecins vétérinaires en tant que leaders communautaires sur l’adaptation aux changements climatiques, aura également lieu le jeudi 22 juillet. Ce thème a été choisi pour amorcer une discussion sur le rôle des médecins vétérinaires dans l’adaptation aux changements climatiques au Canada.

PFL de l’ACMV : Le Programme des futurs leaders (PFL) a obtenu un engagement de financement de trois ans de Royal Canin et de l’Atlantic Veterinary College. Le concept renouvelé du PFL fera passer le programme d’un événement unique à un parcours d’un an qui comprendra l’expérience en personne pendant le Congrès de l’ACMV, deux événements régionaux en personne et six webinaires sur le leadership. En 2021, les événements en personne auront lieu virtuellement.

COVID-19 : L’ACMV continue de faire partie du groupe fédéral/ provincial/territorial de consultation sur la COVID-19 piloté par l’Agence de la santé publique du Canada (ASPC), ce qui permet à l’ACMV de participer et d’obtenir de l’information fiable en temps
will be published in the near future. The CVMA will continue its collaboration with PHAC and CFIA with the goal of data collection improvements on dog importation and developing best practices for importation. The CFIA invited the CVMA to discuss the proposed interim measures for the import of commercial dogs less than 8 months of age. The CVMA developed a dog importation checklist aimed at veterinarians and rescue organizations.

**ASF:** So far, African Swine Fever (ASF) has not been detected in North America. The CVMA has been working with the CFIA and other stakeholders to educate the public and producers on how to keep Canadian pigs safe from ASF. In partnership with the CFIA, the CVMA hosted a series of ASF webinars directed at veterinarians, which focused on disease overview and recognition, disease response, and prevention and preparedness. The CVMA has also offered the CFIA the assistance of the Canadian Veterinary Reserve (CVR).

**Tick awareness:** For the 6th year, in partnership with Merck Animal Health, the CVMA, declared March as National Tick Awareness Month and produced communication material and support tools to help veterinary teams highlight the unique seasonality of ticks, to provide pet parents 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 theme of the 2021 *National Tick Awareness Month (NTAM)* campaign, *Could ticks be there? Be tick aware*, raised awareness regarding the established and expanding geographic range of tick species throughout Canada, highlighting the common habitats where ticks can be encountered.

**NEB:** The North American Veterinary Licensing Examination (NAVLE) and Basic and Clinical Sciences Examination (BCSE) will continue to be offered while observing public health and safety requirements. Because of COVID-19, the clinical in-person exams, Preliminary Surgical Assessment (PSA) and Clinical Proficiency Examination (CPE) can only be offered on a reduced schedule. The opportun qu'elle partage avec les médecins vétérinaires sur la page d'accueil de son site Web. L'ACMV poursuit également sa série de webinaires liés à la pandémie avec le Dr Scott Weese et la Dr Enid Stiles.

**Mieux-être et santé mentale:** L'ACMV poursuit sa campagne annuelle de sensibilisation à la santé mentale et au mieux-être, en plus d'organiser des séminaires trimestriels. Les webinaires sont également proposés aux étudiants. D'ailleurs, un webinaire conçu spécialement pour les étudiants sur le syndrome de l'imposteur est prévu. Les références aux services de mieux-être des écoles de médecine vétérinaire et des associations provinciales publiées sur le site Web de l'ACMV ont été mises à jour récemment. De plus, un groupe de bénévoles, composé entre autres de membres du groupe consultatif du bien-être des vétérinaires de l'ACMV, étudie l'élaboration d’un programme de soutien entre pairs.

**IVUJA:** L’Initiative vétérinaire pour l’usage judicieux des antimicrobien (anciennement appelée SNSV ou Système national de surveillance vétérinaire de l'utilisation des antimicrobien) de l’ACMV, qui est en cours jusqu’au 31 mars 2023, comprend des activités de surveillance de l'utilisation des antimicrobien, d'antibiogouvernance et de communication dans les secteurs des bovins de boucherie, des porcs et de la volaille, ainsi que l’amélioration des lignes directrices de l’ACMV sur l’utilisation prudente des antimicrobien pour les animaux destinés à la production d’aliments et les animaux de compagnie. Les lignes directrices mises à jour peuvent être consultées sur le nouveau site Web de l’IVUJA (www.ivuja.vet). À l’avenir, elles seront aussi accessibles sur le nouveau site Web de l’ACMV, ainsi qu’à partir d’une application plus tard ce printemps.

**Site Web :** Conformément aux directives du Conseil, l’ACMV a entamé le processus de renouvellement de son site Web en anglais et en français. L’objectif est de fournir à l’ACMV, à ses membres et aux divers intervenants un nouveau site Web en anglais et en français qui soit visuellement attrayant, convivial et accessible. Le nouveau site Web devrait être lancé en février 2022.


**PPA :** À ce jour, la peste porcine africaine (PPA) n’a pas encore été détectée en Amérique du Nord. L’ACMV collabore avec l’ACIA et d’autres intervenants pour éduquer le public et les producteurs sur la façon de protéger les porcs canadiens de la PPA. En partenariat avec l’ACIA, l’ACMV a présenté une série de webinaires sur la PPA pour les médecins vétérinaires qui étaient axés sur la reconnaissance et la prévention de la maladie ainsi que sur la préparation de la lutte contre cette dernière. L’ACMV a également offert à l’ACIA l’aide de la Réserve vétérinaire canadienne (RVC).

**Sensibilisation aux tiques :** Pour la sixième année et en partenariat avec Merck Santé animale, l’ACMV a célébré en mars le Mois national de sensibilisation aux tiques et 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 des mises à jour sur 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. Le thème de la campagne du *Mois national de la sensibilisation aux...*
National Examining Board (NEB) will pilot a PSA shortly with skin models that will address the difficulties of sourcing cadavers.

**AHTVTPAC:** Due to restrictions caused by COVID-19, the Animal Health Technology/Veterinary Technician Program Accreditation Committee is conducting site visits remotely.

(by Jost am Rhyn, CEO, CVMA)

**2021 CVMA Virtual Convention — July 22–25**

You may have heard — the CVMA Convention is now going 100% virtual for 2021! Online registration is open until June 30th — and the first 500 registrations will receive a special welcome box at their home or office prior to the event.

The CVMA Professional Development Committee (PDC) has updated the current program to enhance your virtual experience. Every attendee will have access to over 80 hours of continuing education (CE) and can choose from a mix of live-streamed and pre-recorded presentations hosted on the virtual platform. The CVMA is excited to offer extended access for registered attendees until December 31, 2021.

In addition to the CE program, every Convention attendee will have access to the virtual exhibit hall where you will have the chance to interact with industry through live chat, video, tiques (MNST) de 2021, « Les tiques peuvent être partout! Méfiez-vous! », mettait l'accent sur l'aire de répartition géographique établie et en expansion des espèces de tiques à travers le Canada et soulignait les habitats typiques où des tiques peuvent être rencontrées.

**BNE :** L'examen nord-américain d'agrément en médecine vétérinaire (NAVLE) et l'examen de sciences de base et cliniques (ESBC) continueront d'être offerts tout en respectant les exigences en matière de santé et de sécurité publiques. En raison de la COVID-19, les examens cliniques en personne, l'évaluation chirurgicale préliminaire (ECP) et l'examen de compétences cliniques (ECC) ne peuvent être offerts que selon un horaire réduit. Le Bureau national des examinateurs mènera sous peu un projet pilote d'ECP utilisant des modèles cutanés pour pallier les difficultés d'approvisionnement en cadavres.

**Comité d'agrément des programmes de technologie vétérinaire et de techniques en santé animale :** En raison des restrictions causées par la COVID-19, le Comité effectue les visites d'agrément à distance.

(par Jost am Rhyn, président-directeur général de l’ACMV)

**Congrès virtuel de l’ACMV du 22 au 25 juillet 2021**

Vous le savez sans doute déjà : le Congrès de l’ACMV aura lieu de façon virtuelle à 100 % en 2021! L'inscription en ligne est ouverte jusqu'au 30 juin, et les 500 premières personnes à s'inscrire recevront un cadeau de bienvenue spécial à leur domicile ou à leur lieu de travail avant le début de l'événement.

Le Comité de perfectionnement professionnel de l'ACMV a mis à jour le programme du Congrès pour améliorer votre expérience virtuelle. Chaque participant aura accès à plus de 80 heures de formation continue et pourra choisir parmi des présentations diffusées en direct et préenregistrées hébergées sur la plateforme virtuelle. Les participants inscrits auront accès au contenu jusqu'au 31 décembre 2021.

Les congressistes pourront également visiter virtuellement le salon des exposants et interagir avec les représentants de
The CVMA Provides Access to Valuable Programs and Resources for Members

There has been a wealth of discussion on the topic of wellness and mental health in veterinary medicine and the CVMA is committed to continue the conversation and to be offering meaningful and supportive programs and resources to members. The CVMA created a dedicated section on its website (www.canadianveterinarians.net) where members can access resources and information from numerous sources to help support the personal well-being of veterinarians and veterinary students, with a focus on education, awareness, and prevention.

Resources offered in this section include:

**I Matter: An Online Resource created by the Ontario Veterinary Medical Association**

I Matter is about building up yourself and your team members. It’s about recognizing that focusing on your own mental wellness will help you offer more value and better care. More importantly, these strategies can be used by everyone, regardless of whether they are currently struggling with mental wellness.

To access this resource, go to (www.i-matter.ca).

**Mental Health Awareness Resources**

There are important reasons to start talking about mental health in the veterinary profession. Difficult to see, mental health issues, problems, and illnesses affect many people working in veterinary clinics. Resources included in this section include a mental health illness checklist, mental health videos, access to the industry by clavardage in direct, appel vidéo ou messagerie instantanée. The PDC is also thrilled to be able to offer wellness breaks, themed social nights, and opportunities for you to network with colleagues on the virtual platform — all included in your registration.

If it has been a few years since you last attended, or if you have never attended the Annual Convention, this is the year to reconnect, and start your CVMA online CE journey and see what we have to offer. With special low rates for 2021, you now have access to all the sessions, social programs, and the virtual exhibit hall for $49 for CVMA Members. That's less than $0.60/CE hour.

Check out the Convention website for a full list of the schedule, speakers, and special programs (https://pheedloop.com/cvma21/site/home/).

Hope to “see” you during the Annual Convention this July.

(by Sarah Cunningham, Manager, Conventions, CVMA)

L’ACMV donne accès à des programmes et à des ressources utiles à ses membres

Il y a eu de nombreuses discussions sur le thème du mieux-être et de la santé mentale en médecine vétérinaire, et l’ACMV s’est engagée à poursuivre la conversation et à offrir des programmes et des ressources utiles pour soutenir ses membres. L’ACMV a créé une section spéciale sur son site Web (www.veterinairesaucanada.net) où les membres peuvent accéder à des ressources et à de l’information provenant de diverses sources visant à soutenir le bien-être personnel des médecins vétérinaires et des étudiants en médecine vétérinaire, en mettant l’accent sur l’éducation, la sensibilisation et la prévention.

Voici des exemples des ressources proposées.

**I Matter : une ressource en ligne créée par l’Ontario Veterinary Medical Association**

L’initiative « I Matter » a été conçue pour vous aider, les membres de votre équipe et vous. Reconnaitre que vous devez prendre soin de votre propre bien-être mental vous aidera à offrir plus de valeur et de meilleurs soins. Plus important encore, les stratégies proposées peuvent être utilisées par tout le monde et ne s’adressent pas uniquement aux personnes aux prises avec des difficultés liées à leur bien-être mental. Pour accéder à cette ressource, visitez le site de l’initiative « I matter » (www.i-matter.ca).

**Ressources sur le bien-être en santé mentale**

Il y a des raisons importantes de commencer à parler de santé mentale dans la profession vétérinaire. Ils sont difficiles à voir,
mental health webinars, a document on how to recognize suicide and burnout compassion fatigue, a mental health resource list, and “ASK” suicide prevention steps and resources. To access these resources, go to (www.canadianveterinarians.net/mental-health-awareness-week).

Under the CVMA Insurance Program, employees enrolled in the group health benefits plan have access to Stronger Minds, a no-cost health program that provides crucial mental health support for Canadians. CVMA members will have access to MindBeacon, an online resource that offers a Therapist Guided program and live therapy sessions. To find out more, go to (www.mindbeacon.com).

Additional resources and professional support services may also be available through your provincial veterinary association or veterinary college.

If you or someone you know needs help, consult the list of Helplines and Professional Support Services available in your region (www.canadianveterinarians.net/mental-health-resource-list). In an emergency or crisis situation, go to the nearest hospital or call 911. To view all wellness resources please visit our website (www.canadianveterinarians.net/veterinarian-health-and-wellness-resources).
Case Report  

Bilateral intracorporeally sutured inguinal herniorrhaphy using 3-dimensional laparoscopy in a dog

Maureen A. Griffin, Ingrid M. Balsa, Philipp D. Mayhew

Abstract — A 7-month-old, intact male, mixed breed dog with bilateral inguinal hernias underwent general anesthesia for laparoscopic bilateral inguinal herniorrhaphy via a 3-port approach. A 3-dimensional laparoscopic system was used to perform the procedure immediately following prescrotal open castration. Intracorporeal suturing with polypropylene was performed, and 2 cruciate sutures were placed to close each inguinal ring. The caudal aspect of each inguinal ring was left slightly open so as not to disrupt the passage or patency of vessels and nerves. No intra- or post-operative complications occurred. One year after surgery, the dog has no evidence of recurrence of the inguinal hernias.

Key clinical message:
This case report demonstrates a novel minimally invasive approach to inguinal herniorrhaphy in a dog with no reported complications and a good long-term outcome. Intracorporeally sutured inguinal herniorrhaphy is feasible in dogs with good results, although additional cases are needed to gain experience with this technique in dogs with varying presentations of inguinal hernias.

Résumé — Herniorraphie inguinale bilatérale suturée intra-corporellement par laparoscopie tridimensionnelle chez un chien. Un chien de race mixte, mâle, intact, âgé de 7 mois, avec une hernie inguinale bilatérale, fut mis sous anesthésie générale pour une herniorraphie inguinale bilatérale laparoscopique via une approche à trois voies. Un système laparoscopique tridimensionnel a été utilisé pour effectuer la procédure immédiatement après la castration préscrotale ouverte. Une suture intracorporelle avec du polypropylène a été réalisée et deux sutures croisées ont été effectuées pour fermer chaque anneau inguinal. L’aspect caudal de chaque anneau inguinal a été laissé légèrement ouvert afin de ne pas perturber le passage ou la fonctionnalité des vaisseaux et des nerfs. Aucune complication per- ou postopératoire n’est survenue. Un an après la chirurgie, le chien ne présente aucun signe de récidive des hernies inguinales.

Message clinique clé :
Ce rapport de cas démontre une nouvelle approche minimalement invasive de la herniorraphie inguinale chez un chien sans complications signalées et un bon résultat à long terme. Une herniorraphie inguinale suturée de manière intracorporelle est réalisable chez les chiens avec de bons résultats, bien que des cas supplémentaires soient nécessaires pour acquérir de l’expérience avec cette technique chez les chiens présentant des présentations variables de hernies inguinales.


Inguinal herniorrhaphy in dogs is typically performed via an open surgical approach, either directly over the inguinal ring or alternatively on the ventral abdominal midline to allow for concurrent abdominal exploration. Herniorrhaphy involves appropriate reduction of herniated contents (with possible additional treatment/excision of those contents depending on viability) and creation of a secure closure of the defect using strong, healthy, surrounding native tissues if possible (1). In humans, laparoscopic techniques, including laparoscopic intracorporeally sutured herniorrhaphy, are commonly used for treatment of inguinal hernias and are associated with good outcomes and low recurrence rates (2,3). To date, few reports of minimally invasive inguinal herniorrhaphy exist in dogs and are limited to experimental models of the disease. One experimental study on 12 beagle dogs (11 females, 1 male) with indirect inguinal hernias used laparoscopic closure of the abdominal opening of the patent processus vaginalis via staple application. Seven of these dogs were euthanized 7 to 14 wk after surgery, and no recurrence of herniation was detected at the time of euthanasia; however, long-term follow-up data were not obtained (4).
Two other experimental studies on healthy, male, mixed breed dogs without inguinal hernias were done using a natural orifice transluminal (transgastric) endoscopic approach for bilateral inguinal herniorrhaphy using several implant systems: AlloDerm (Lifecell; Branchburg, New Jersey, USA) and Bioglue (CryoLife; Kennesaw, Georgia, USA) (5,6). All dogs in these studies were euthanized immediately after or 14 d following the procedure, and evaluation afterwards showed adequate placement and coverage of the implants (5,6). No long-term data were available, and these treatments were not performed on dogs with naturally occurring disease (5,6).

To date, there are no documented reports of laparoscopic intracorporeally sutured herniorrhaphy for treatment of inguinal hernias in dogs. Minimally invasive surgery in dogs is commonly associated with multiple benefits including reduced post-operative pain, faster return to function, smaller and more cosmetic incisions, and potentially reduced morbidity including reduced surgical site infection (7–11). In addition, 3-dimensional (3D) laparoscopy has been used increasingly in human minimally invasive surgery and provides improved precision, hand-eye coordination, and depth perception compared with traditional laparoscopy (12).

The authors theorize that a laparoscopic intracorporeally sutured inguinal herniorrhaphy technique in dogs may provide these benefits and allow adequate exposure, permanent herniorrhaphy, and good outcomes with low risk of recurrence. Furthermore, the authors postulate that the use of a 3D telescope during inguinal herniorrhaphy provides similar benefits to those reported in human surgery.

Case description

A 7-month-old, intact male, mixed breed dog was presented to our institution for evaluation and treatment of bilateral inguinal hernias as well as castration. The dog was adopted from a shelter 5 mo prior to presentation and was noted to have bilateral inguinal hernias at that time. No previous history was known, and the hernias were presumed to be congenital. The dog was systemically healthy with no vomiting, diarrhea, coughing, or sneezing, a normal appetite and energy level, and normal urination and defecation. On physical examination, the dog weighed 3.7 kg and had a body condition score of 4/9. His vital parameters were within normal limits (temperature: 38.4°C, heart rate: 140 beats/min, panting). The bilateral inguinal hernias were ~2 to 4 cm in diameter and the contents were readily reducible. The dog had bilaterally descended scrotal testes. The remainder of his examination was unremarkable.

Results of pre-anesthetic laboratory tests were within normal limits. An abdominal ultrasound showed bilateral inguinal hernias with fat and a segment of jejunum extending through the left inguinal ring. The remainder of the abdominal ultrasound findings were unremarkable. Based on the presumed congenital nature of the hernias, the cardiovascular stability of the patient and the lack of vital sutures in the hernias, laparoscopic repair of the hernias was deemed reasonable.

The dog underwent general anesthesia: premedication with hydromorphone (Dilaudid; Fresenius Kabi USA, Lake Zurich, Illinois, USA), 0.05 mg/kg body weight (BW), IM, and dexmedetomidine (Dexdomitor; Zoetis, Parsippany, New Jersey, USA), 3.0 μg/kg BW, IM. Anesthesia was induced with propofol (Diprivan; Fresenius Kabi USA), 2.0 mg/kg BW, IV, and midazolam HCl (Hospira; Lake Forest, Illinois, USA), 0.2 mg/kg BW, IV, and was maintained with sevoflurane (Ultane; Abbott Laboratories, Chicago, Illinois, USA) in 100% oxygen. The dog was positioned in dorsal recumbency, and the ventral abdomen and preputial regions were clipped, prepared for aseptic surgery, and draped. The dog’s urinary bladder was voided before surgery. Upon positioning the dog in dorsal recumbency, no herniated contents were palpable in the inguinal sites due to the easily reducible nature of the hernias. The dog was placed in a
Trendelenburg position, and the laparoscopy tower and monitor were positioned at the dog’s caudal aspect (Figure 1).

A routine prescrotal open castration was performed bilaterally. The 2 surgeons were then positioned at each lateral aspect of the dog facing the monitor caudally, and both surgeons wore 3D glasses throughout the procedure. A 3-port technique was used. A 6-mm telescope portal was established 2 cm cranial to the umbilicus using a modified Hasson technique with a threaded trocarless cannula (Endotip; Karl Storz, Tuttingen, Germany). The peritoneal cavity was insufflated to 8 to 10 mmHg. The abdomen was briefly explored with a 4-mm 3D Storz telescope (TipCAM 1 S 3D LAP; Karl Storz). A second 6-mm Endotip cannula was placed in the left lateral abdominal wall slightly caudal to the umbilicus and approximately 10 to 15 cm cranial to the left inguinal ring region under visual guidance. A third 6-mm Endotip cannula was inserted in similar fashion in the right lateral abdominal wall. Abdominal insufflation resulted in concurrent insufflation of both inguinal regions (Figure 2).

Right-angle laparoscopic forceps (Karl Storz) were placed through each of the lateral ports, and the vas deferens with adjacent testicular vasculature was grasped and retracted cranially. The spermatic cord sutures placed in the prescrotal region were visible through each inguinal ring but could not be released into the abdomen due to additional tissue attachments superficial to the deep inguinal ring (Figure 3).

Laparoscopic atraumatic grasping forceps were removed and laparoscopic needle drivers (Microline Surgical, Beverly, Massachusetts, USA) were inserted into each lateral cannula. Approximately 10 cm of 2-0 Prolene suture on a CT-2 needle (Ethicon; Johnson & Johnson) was passed transabdominally. The dog was administered hydromorphone (Dilaudid; Fresenius Kabi USA), 0.05 mg/kg BW, IM, and meloxicam (Metacam; Boehringer Ingelheim, Duluth, Georgia, USA), 0.1 mg/kg BW, PO, once after surgery. The dog was hospitalized for monitoring overnight, no evidence of recurrence of herniation or complications were noted. The dog was discharged.

The pneumoperitoneum was subsequently relieved. The port sites were closed with 2-0 PDS (Ethicon; Johnson & Johnson) in an interrupted pattern in the linea and abdominal musculature. The subcutaneous tissue and skin were closed with 3-0 Monocryl (Ethicon; Johnson & Johnson) in a buried cruciate pattern.

No intraoperative complications were noted and appropriate herniorrhaphy was confirmed after surgery. The total procedure time was 172 min.
CASE REPORT

1 d after surgery with instructions for restriction of activity for 10 to 14 d, E-collar use, and general and incisional monitoring. He was discharged with meloxicam 0.1 mg/kg BW, PO, to be given once daily for 7 d.

The dog was re-presented to our hospital 2 wk after surgery for incision recheck. He was reported to be doing well with a good energy level and appetite and no signs of systemic illness. On physical examination, his vital parameters were within normal limits (temperature: 37.5°C, heart rate: 112 beats/min, respiratory rate: 24 breaths/min). His incisions appeared healed with no evidence of complications. Upon palpation of the inguinal hernia sites, there was no evidence of failure of the repair or recurrence of herniation (Figure 5).

Communication with the dog’s owner at 9 wk after surgery revealed no evidence of hernia recurrence or systemic illness. Nearly 1 y after surgery, communication with the dog’s owner similarly reported no evidence of hernia recurrence or systemic illness.

**Discussion**

This report represents the first documented case of laparoscopic intracorporeally sutured inguinal herniorrhaphy in a clinical dog. Results of the case demonstrate that this technique is technically feasible, and the authors felt that it provided excellent visualization of the caudal abdominal structures including the inguinal ring and its contents (Figure 6). In addition to placing the dog in Trendelenberg position, placement of a urinary catheter to maintain a deflated urinary bladder would enhance the exposure to the caudal abdomen in dogs if needed for visualization. The procedure resulted in excellent short- and long-term outcomes, as the dog appeared comfortable and was discharged 1 d after surgery with no intra-operative or post-operative complications. One year after surgery, the dog is doing well with no evidence of hernia recurrence.

Based on the findings and results of this case, laparoscopic intracorporeal inguinal herniorrhaphy may be considered as a minimally invasive option for treatment of inguinal hernias in dogs. This technique can be performed on intact male dogs following castration and for repair of bilateral hernias. In this case, open castration was elected to potentially allow for manipulation of the vas deferens, testicular artery, and pampiniform plexus at the level of the inguinal ring to improve exposure during intracorporeal suturing. For patients with unilateral inguinal hernia, port placement may be altered to allow triangulation around the inguinal ring. In general, a 3-port technique will be required to allow for placement of a camera as well as 2 instruments with adequate triangulation and working space. As with all minimally invasive procedures, case selection is important and the authors suggest that this technique, at least in the early part of the learning curve, is likely best suited for dogs with congenital inguinal hernias that are readily reducible. In addition, this technique should be limited to dogs with no or minimal systemic clinical signs, no trauma history, and small to moderately sized hernia sacs (13). In more complicated cases, adhesions or devitalized tissues may complicate the minimally invasive approach.

Additional cases are required to gain knowledge and experience in the minimally invasive treatment of this condition in female dogs, previously castrated dogs, and dogs of varying body weight and conformation. As with many minimally invasive techniques, a learning curve is likely to be encountered during initial cases of laparoscopic intracorporeal inguinal herniorrhaphy that are pursued. For example, in this procedure, the suture length and needle conformation were altered in ways that were deemed advantageous in optimizing efficiency. It is likely that with additional cases, the surgical time will decrease with...
similarly good outcomes (i.e., a low recurrence rate) and low complication rates. Additional techniques and equipment could also be considered. For instance, the authors chose to perform an interrupted cruciate pattern with a nonabsorbable monofilament suture; however, nonabsorbable barbed suture may also be acceptable and could help to facilitate intracorporeal suturing for inguinal herniorrhaphy in some cases. Barbed suture was not used in this case due to lack of availability of nonabsorbable barbed suture at our institution. The authors recommend the use of nonabsorbable suture for congenital and chronic hernias. Additionally, there was concern that with the short length of the hernia there would be an insufficient number of suture bites with the barbed suture to create a secure herniorrhaphy. Another technique that may be of benefit during intracorporeally sutured inguinal hernias involves partial release of the pneumoperitoneum during tightening of the herniorrhaphy suture to achieve a tension-free environment. However, this must be balanced by the relative loss of working space that will occur when pneumoperitoneum pressure is decreased.

An additional consideration with any herniorrhaphy involves techniques that may contribute to or enhance the durability and longevity of the repair. In some studies on minimally invasive inguinal hernia repair in children, the laparoscopic approach was associated with a greater recurrence rate compared with open surgery (14). It is theorized that laparoscopic closure may not cause as much tissue damage and scar formation as the open surgical technique, such that the minimally invasive repair may rely on the sutures themselves (rather than scarification with tissue fibrosis/adhesions) to prevent recurrence (15). In support of this theory, in a rabbit model, sharp peritoneal trauma at the time of minimally invasive repair resulted in a greater percentage of repairs that remained intact after removal of the sutures at 2 and 4 wk after surgery (87.5 compared to 25% and 100 compared to 12.5%, respectively) (15). Therefore, the addition of minor sharp trauma to the inguinal ring at the time of laparoscopic herniorrhaphy may be considered in future cases to maintain the herniorrhaphy in the event that the sutures themselves fail.

A 3D laparoscopic camera was used for this procedure. At the time of the writing, 4-mm 30° and 10-mm 0° or 30° 3D laparoscopic cameras were available to the authors. Given the small size of the dog, the 4-mm 30° camera was selected. For case documentation purposes, images were taken with a 2-dimensional (2D) laparoscope. Studies on minimally invasive surgery in humans have demonstrated improved surgical precision, hand-eye coordination, and depth perception with 3D than with 2D laparoscopy (12). However, the use of 3D laparoscopy in veterinary patients has rarely been reported. One study in dogs evaluated the effects of 3D (relative to 2D) laparoscopy for intracorporeally sutured gastropexy in dogs (16). Although this study reported no significant difference between 2D and 3D laparoscopy with respect to surgical time or surgeon workload, there were no reported disadvantages with use of the 3D telescope and results may or may not be transferrable to other minimally invasive procedures in veterinary medicine (16). Similar to findings in human studies, the 3D feature in this study enhanced depth perception and thereby surgical precision and efficiency, although these findings were subjective in nature. Additional cases of intracorporeal inguinal herniorrhaphy in dogs using both 2D and 3D cameras are needed to further assess any benefit of this technology for this procedure.

In conclusion, this report marks the first documented case of a dog with bilateral inguinal hernias that underwent laparoscopic intracorporeally sutured herniorrhaphy and concurrent castration. Results demonstrate a possible low risk for surgical complications and the potential for good long-term outcomes without recurrent herniation. Additional cases are needed to gain more experience with this technique in dogs with varying presentations of this disease.

Acknowledgment

The authors acknowledge Karl-Storz for loaning the TIPCAM® 1 S 3D system used in this case.

References

Case Report  Rapport de cas

Laparoscopic esophagopexy, fundopexy, and hiatal herniorrhaphy for refractory regurgitation in a racing Alaskan husky sled dog

Nathan L. Cherzan, Boel A. Fransson

Abstract — A 2-year-old intact female Alaskan husky sled dog was presented with a history of chronic exercise-induced regurgitation refractory to medical management. Previous diagnostics were unremarkable except for an endoscopic examination and histopathologic evaluation of the upper gastrointestinal tract that revealed the presence of Helicobacter spp. and mild non-specific inflammation of the proximal duodenum. A laparoscopic hiatal herniorrhaphy, esophagopexy, fundopexy, and ovariectomy were performed without complications in anesthesia or surgery and clinical improvement was observed with continued follow-up for 8 months after surgery.

Key clinical message:
Surgical treatment for hiatal hernia may be considered in racing Alaskan sled dogs with regurgitation refractory to gastric protectant therapy.

Résumé — Oesophagopexie laparoscopique, fundopexie et herniorrhaphie hiatale pour régurgitation réfractaire chez un chien de course de traîneau husky de l’Alaska. Une chienne de traîneau husky de l’Alaska, âgée de 2 ans, a présenté des antécédents de régurgitation chronique induite par l’effort réfractaire à la prise en charge médicale. Les diagnostics antérieurs n’étaient pas remarquables, sauf pour un examen endoscopique et une évaluation histopathologique du tractus gastro-intestinal supérieur qui a révélé la présence d’Helicobacter spp. et une légère inflammation non spécifique du duodénum proximal. Une herniorrhaphie hiatale laparoscopique, une oesophagopexie, une fundopexie et une ovariectomie ont été réalisées sans complications sous anesthésie ou en chirurgie et une amélioration clinique a été observée avec un suivi continu pendant 8 mois après la chirurgie.

Message clinique clé :
Un traitement chirurgical de la hernie hiatale peut être envisagé chez les chiens de traîneau de course de l’Alaska présentant une régurgitation réfractaire au traitement protecteur gastrique.

Can Vet J 2021;62:577–580

Case description

A 2-year-old 19.8 kg intact female Alaskan husky dog was presented to the Washington State University Veterinary Teaching Hospital (WSU-VTH) Internal Medicine service for evaluation of chronic exercise-induced regurgitation. The dog was used as a part of a sled dog team. During the season, training consisted of runs on a sled dog team that gradually increased in distance as the training season progressed, pulling heavier loads, and moving at faster paces, depending on the training goal for the day. The team included approximately 20 dogs that lived in large kennels; they were frequently let out to exercise in a fenced yard. However, this dog had been kept indoors to monitor more closely for regurgitation episodes.

The dog had been regurgitating during ~50 to 75% of the runs within the first 11.2 km, during which she would vocalize, then regurgitate what appeared to be food and water. There were no remarkable abnormalities detected by the primary care veterinarian during a physical examination on initial presentation. A fluoroscopic barium swallow study was unremarkable and thoracic radiographs showed a persistent cranial displacement of
the right diaphragmatic crus approximately 5 mo before presentation. Endoscopy of the esophagus, stomach, and proximal duodenum showed regions that were grossly unremarkable aside from small amounts of grass present in the stomach. Histologically, *Helicobacter* spp. were present in the stomach and duodenum. In the proximal duodenum there was evidence of mild, non-specific inflammation with infiltration of eosinophils. The clinical signs were refractory to medication trials for more than 1 y with famotidine (Pepcid; Johnson and Johnson, New Brunswick, New Jersey, USA), 1 mg/kg body weight (BW) PO, q12h, omeprazole (Prilosec; Proctor and Gamble, Cincinnati, Ohio, USA), 1 mg/kg BW, PO, q12h, and maropitant (Cerenia; Zoetis, Parsippany, New Jersey, USA), 12 mg/kg BW, PO, 1 h prior to travelling or training) in combination and separately for various intervals during the racing season. Dogs in the team also received fenbendazole (Panacur; Merck, Kenilworth, New Jersey, USA), 55.5 mg/kg BW, PO, for 3 d, pyrantel (Strongid; Zoetis, Parsippany, New Jersey, USA), 5 mg/kg BW, PO, once, and praziquantel (Biltricide; Bayer USA, Whippany, New Jersey, USA), 3.4 mg/kg BW, PO, once to prevent endoparasites during the racing season. The only other abnormality reported was intermittent self-limiting diarrhea during competition season. The dog was not treated for *Helicobacter* spp. before further diagnostics and eventual surgical treatment, as clinical signs occurred only during exercise and the relevance of this bacterium to gastrointestinal disease in dogs is unknown (1). The dog was referred to the WSU-VTH Soft Tissue Surgery service for a laparoscopic spay and discussion of an abdominal exploration with surgical repair of a potential sliding hiatal hernia. The fluoroscopic barium swallow study was not repeated because the working differential diagnoses were thought to be a result of exercise-induced gastrointestinal disease and not a process that we would capture under fluoroscopy with repeat examination.

The main differential diagnoses for the dog’s suspected regurgitation before surgery consisted of a sliding hiatal hernia, or lower esophageal sphincter dysfunction, both of which could result in gastroesophageal reflux. After discussion, the owner elected a laparoscopic spay and a therapeutic trial consisting of hiatal hernia herniorrhaphy, esophagopexy, and fundopexy.

The dog was premedicated with hydromorphone (Hydromorphone; Pfizer; New York, New York, USA), 0.1 mg/kg BW, dexmedetomidine (Dexdomitor; Zoetis; Parsippany, New Jersey, USA), 5 µg/kg BW, and acepromazine (Acepromazine; VetOne; Boise, Idaho, USA), 0.02 mg/kg BW, intramuscularly. Anesthesia was induced with propofol (Propoflo; Zoetis; Parsippany, New Jersey, USA), 3.5 mg/kg BW, IV, and maintained on 1% isoflurane (Isothesia; Henry Schein; Melville, New York, USA). Prior to surgery, cefazolin (Cefazolin; Pfizer; New York, New York, USA), 22 mg/kg BW, IV, was given and repeated every 90 min as a perioperative antibiotic. The ventral abdomen was shaved and prepared for surgery in a routine fashion with 70% isopropyl alcohol and a 2% chlorhexidine solution (Bactoshield; VetOne; Boise, Idaho, USA). Laparoscopic entry was performed using visually guided closed entry with Ternamian cannula (EndoTIP; Storz, Goleta, California, USA) placement followed by insufflation. The surgery was performed with Ternamian (threaded) reusable cannulas (EndoTip; Storz); three 6-mm cannulas and one 11-mm cannula (Figure 1). The hiatus-diaphragm interface was thermaeffect scarring a laparoscopic monopolar electrocautery L-hook (Figure 2). Care was taken to not perforate the hiatus in order to avoid a tension pneumothorax from the CO₂ insufflation. A herniorrhaphy was performed using 2 isolated 2-0 prolene (Ethicon; Johnson and

**Figure 1.** Portal placement for hiatal hernia surgical correction. a – visual entry 6-mm cannula; b, c – working 6-mm cannulae; d – 11-mm cannula. Portals were placed in order of a through d.

**Figure 2.** The esophageal hiatus was scarred along the periphery (marked with gray dots) using a monopolar laparoscopic L-hook. The first thermal scar is marked.
Johnson; New Brunswick, New Jersey, USA) sutures in a simple interrupted pattern in the ventral esophageal hiatus to decrease the esophageal hiatus diameter (Figure 3). The esophagus was in proper anatomic position during surgery, so no repositioning of the esophagus was required prior to the herniorrhaphy and esophagopexy. The esophageal hiatus appeared to have, highly subjectively, more laxity than would be anatomically appropriate. An esophagopexy was performed using 2-0 polyglyconate 6\textsuperscript{0} barbed suture (V-loc\textsuperscript{TM}180; Codien, Medtronic, Minneapolis, Minnesota, USA) on the left crura of the esophageal hiatus to the left wall of the esophagus, with partial thickness sutures engaging the submucosal layer of the esophagus for approximately 5 bites, in a simple continuous pattern (Figure 4). A large bore orogastric tube was placed to aid in assessing thickness of the esophageal wall. A fundopexy was performed after monopolar electrosurgery to coagulate serosa on the stomach wall and peritoneum and transversus abdominus on the body wall. In a simple continuous pattern, 2-0 barbed 6\textsuperscript{0} suture (V-loc\textsuperscript{TM}180; Codien) was placed 5 cm caudal to the termination of the diaphragm. This technique was similar to a recently described technique for pyloric gastropexy (2). Thereafter, an elective routine laparoscopic ovariectomy was performed using a vessel sealing device for pedicle ligation. No complications were encountered during the surgery or general anesthesia, and the dog recovered uneventfully. Liposome-encapsulated bupivacaine (Nocita; Aratana Therapeutics, Leawood, Kansas, USA) was infiltrated into the incision, and carprofen (Rimadyl; Zoetis; Parsippany, New Jersey, USA), 2.2 mg/kg BW, PO, q12h, was administered for analgesia. The dog was given a gastrointestinal support soft food diet (Hill’s Pet Nutrition, Topeka, Kansas, USA) for the first 12 h following surgery and then returned to the normal diet.

Approximately 6 mo after surgery, i.e., 3 mo into the training season, the owner reported that the dog had improved substantially. A questionnaire was created and presented in a follow-up telephone conversation with one of the authors (NLC) 186 d after surgery. The owner had noted a total of 3 regurgitation episodes out of 31 separate runs (10%), with regurgitation occurring 9.6 to 19.3 km into the run. In contrast, prior to surgery, the dog regurgitated during 50 to 75% of the runs, and these events occurred in the first 4.8 to 11.2 km of a run. The 3 episodes of regurgitation that had been reported after surgery were preceded by ingestion of snow, in contrast to the episodes before surgery that were not always preceded by snow ingestion. Also, before surgery, the dog tended to vocalize prior to the regurgitation episodes, and this only occurred in 1 of the 3 reported episodes after surgery. Follow-up was repeated 245 d after surgery (near the end of the racing season) and revealed no more clinical signs or regurgitation episodes after the initial 3 previously reported in the first 6 mo. At the 8 mo follow-up, the dog had completed more than 800 km in harness and its weight and appetite remained appropriate. The dog continued to receive omeprazole through periods of training, as before surgery, and remained on the same empirical antiparasitic protocol as the rest of the team throughout the racing season.

Gastrointestinal disease in racing Alaskan sled dogs is a well-reported and common problem in this population of dogs, with a reported prevalence of gastric erosions or ulcers in 48.5 to 61% of dogs (3,4). In these dogs, commonly reported lesions are gastric erosions, gastric ulceration, congestion or hemorrhage of the gastric mucosa, gastritis, enteritis, and aspiration pneumonia, with the latter being the most reported cause of death in this population (3,5). Strenuous exercise-induced functional changes, such as gastrointestinal barrier dysfunction, have been demonstrated to occur in both stomach and intestines in sled dogs (6,7). Immune-mediated disease delayed gastric emptying due to high-fat diets leading to gastric hyperacidity, pathogens such as *Helicobacter pylori*, elevated concentrations of endogenous glucocorticoids, and medications such as COX-2 inhibitors have all been suggested mediators of pathophysiologic mechanisms of these changes (3,8,9). Management of this disease-complex has generally involved medications that decrease gastric acidity, the most efficacious being omeprazole (10).

Figure 3. The hiatal herniorrhaphy was performed using intracorporeally tied sutures with prolene 2-0 (Ethicon; Johnson and Johnson, New Brunswick, New Jersey, USA).

Figure 4. The esophagopexy was performed using a barbed suture in a simple continuous pattern along the left crura of the diaphragm.
Medical management had been attempted in this dog, but the regurgitation was refractory to treatment for more than 1 y. The distinct decrease in clinical signs after surgical treatment for hiatal hernia suggests that this dog’s regurgitation episodes resembled those associated with a sliding hiatal hernia. The clinical signs only appeared during long periods of strenuous exercise, and may have resulted from more negative intrapleural pressure because of increased respiratory rate and effort. This has previously been reported in dogs, as well as increased external pressure that the harness may put on the thorax during races (11). However, a hiatal hernia was never definitively diagnosed in this dog. Further diagnostics after the fluoroscopic barium swallow study and endoscopic evaluation with histopathologic samples of the stomach and duodenum were declined because it was believed the disease process causing clinical signs was only occurring during strenuous exercise. Although fluoroscopic swallow studies have been of diagnostic value for sliding hiatal hernias in brachycephalic breeds, it is not known if this would be a sensitive and specific diagnostic test for an exercise-induced hiatal hernia, as the signs would likely not occur at rest as is standard for this diagnostic test (12). A method for the diagnosis of regurgitation during exercise was not known or available. Fluoroscopic evaluation of sled dogs with gastrointestinal disease symptoms may warrant further exploration, as endoscopic evaluation is generally used to identify gastrointestinal inflammation and fluoroscopic studies are not pursued. A therapeutic surgical trial was determined to be the most appropriate next step for the dog, as her perceived sledding performance value was high, and her quality of life was considered dependent on continued performance. A laparoscopic abdominal exploration and prophylactic hiatal herniorrhaphy, esophagopexy, and fundopexy were elected. The surgery took place during the summer season, and the owner slowly returned the dog to training the following season to assess the outcome. esophagopexy, and fundopexy were elected. The surgery took place during the summer season, and the owner slowly returned the dog to training the following season to assess the outcome. The surgery took place during the summer season, and the owner slowly returned the dog to training the following season to assess the outcome.

Hiatal hernias involve complex disease processes with 4 described types and varying medical and surgical treatments. Type 1 hiatal hernias are sliding hernias, or those in which there is a dynamic cranial displacement of the abdominal esophagus, esophagogastric junction, and a portion of the stomach into the abdomen. Type 2 hiatal hernias are paraesophageal hernias, in which the esophagogastric junction and abdominal esophagus remain in a normal position, and a portion of the stomach displaces cranially, adjacent to the thoracic esophagus. Type 3 hiatal hernias are a combination of Types 1 and 2, with sliding and paraesophageal portions. Type 4 hernias are a combination of a Type 3 hernia with herniation of other abdominal organs into the thoracic cavity (13). There is no clear agreement in the human or veterinary literature regarding management of this group of diseases and the case selection for surgery. In general, surgical techniques focus on reducing the hernia through the esophageal hiatus and maintaining proper anatomy and esophageal sphincter function through herniorrhaphy, esophagopexy, gastropexy, and anti-reflux procedures (13). Based on the normal findings on dynamic imaging, this dog was suspected to have either a Type 1 sliding hiatal hernia or exercise-induced gastroesophageal reflux, and surgical correction was elected due to the failed medical therapy trials.

This is, to the authors’ knowledge, the first reported case of hiatal herniorrhaphy, esophagopexy, and fundopexy used to manage regurgitation refractory to medical management in a racing Alaskan sled dog. A definitive diagnosis of an exercise-induced sliding hiatal hernia, gastroesophageal reflux, or another cause of regurgitation was not identified in this case. The significant clinical improvement in this case following surgical correction of a presumed sliding hiatal hernia warrants further investigations into a larger number of racing Alaskan sled dogs to determine if some of the gastrointestinal disease in this population of dogs may be associated with sliding hiatal hernia. If so, this could be information of high impact, as there are serious consequences to vomiting and regurgitation during a sled dog race. Surgical treatment for hiatal hernia may be considered for treatment of racing Alaskan sled dogs showing regurgitation refractory to standard gastric protectant therapy.

References
Successful management of suspected acorn (Quercus petraea) toxicity in a dog

Fernanda Camacho, Sarah Stewart, Erica Tinson

Abstract — A 7-year-old neutered male Labrador retriever dog was referred to a tertiary care veterinary hospital because of gastrointestinal signs and icterus. The dog developed a hepatopathy and acute kidney injury after ingesting acorns (Quercus petraea) 4 days prior to referral. The dog required hospitalization in an intensive care unit but made a full clinical recovery and was discharged after 6 days. This report documents that dogs can be affected by this toxicity and highlights the need for veterinarians to consider acorns as a potential cause of acute hepatotoxicity and renal injury. To the authors’ knowledge, this is the first reported case of acorn toxicity in a dog.

Résumé — Prise en charge réussie d’une toxicité présumée par des glands (Quercus petraea) chez un chien. Un chien labrador retriever mâle stérilisé âgé de 7 ans a été référé à un hôpital vétérinaire de soins tertiaires en raison de signes gastro-intestinaux et d’ictère. Le chien a développé une hépatopathie et une lésion rénale aiguë après avoir ingéré des glands (Quercus petraea) 4 jours avant d’être référé. Le chien a dû être hospitalisé dans une unité de soins intensifs mais s’est complètement rétabli et a obtenu son congé après 6 jours. Ce rapport documente que les chiens peuvent être affectés par cette toxicité et souligne la nécessité pour les vétérinaires de considérer les glands comme une cause potentielle d’hépatotoxicité aiguë et de lésions rénales. À la connaissance des auteurs, il s’agit du premier cas signalé de toxicité par des glands chez un chien.

Acorns are the nuts produced by oak trees (Quercus spp.). Intoxications are well-documented in large animals and are caused by ingestion of oak buds, leaves, or acorns (1–4). More reports exist for cattle, which may represent species variability in susceptibility to the toxicity (1–3). There may also be variability in susceptibility among individuals (5). The full mechanism of acorn toxicity is unknown; however, the toxicity of oak leaves and acorns is suspected to be due to high concentrations of tannins, including the poisonous metabolites pyrogallol and gallic acid (6). Early effects are due to the ability of these metabolites to form complexes with various compounds in the gastrointestinal tract, including salivary proteins and gastrointestinal mucosal proteins; this causes nitrogen loss and altered enzyme function impairing digestion. Binding with carbohydrates, cellulose, and minerals also occurs, further reducing digestibility of essential nutrients (7–9). Gastrointestinal signs early in the clinical course result from damage to the gastrointestinal mucosa and epithelium, reduced digestibility, and the effects of tannin metabolites on gastrointestinal flora (7,8,10). Gallic acid (released by hydrolysis of tannins) can be absorbed from the intestine, causing acute renal and hepatic damage (7,8). Kidney injury in acorn toxicity is believed to be due to the hydrolyzable metabolites of tannins that cause renal proximal tubular necrosis (11). Gallic acid is metabolized to pyrogallol, which can cause oxidative damage, hepatotoxicity, and induce mutagenesis (11). Pyrogallol causes altered expression of cytochrome p450, glutathione reductase, S-transferase, and peroxidase. A reduction in antioxidant enzymes promotes an oxidative state (12). Lesions that develop can differ among species (11). Monogastric animals are thought to suffer gastrointestinal and hepatic consequences more commonly, whereas in ruminants, renal effects can predominate (11).

In large animals, the time course of progression to liver and kidney injury can vary from a few days after ingestion to over 1 wk (1,13). Ultimately, a common consequence of oak-induced hepato-renal injury is death (1,2,4,7,11,12).

Some herbivores have developed various protective mechanisms against tannins. Tannin-binding proteins in herbivore saliva, such as proline-rich protein, have high affinity for binding to tannins. Tannins bind preferentially with these proteins, preventing their deleterious effects on digestive enzymes and the gastrointestinal mucus (7). Additional defence mechanisms in some herbivores include increased gastrointestinal mucus production, rapid degradation of tannins by gastrointestinal flora.
activation of detoxifying enzymes and an increased capacity of intestinal permeability glycoprotein, which can reduce absorption of the toxin (7,14). Despite these mechanisms, the mortality rate in clinically affected cattle can be as high as 85% (12). Intrinsic resistance to tannins, such as tannin-binding proteins, have not been detected in cats or dogs (7,15).

With only anecdotal reports of suspected acorn toxicity in dogs to date, the objective of this report is to describe clinical course and outcome of the first case of suspected acorn hepatonephrotoxicity in a dog.

Case description

A 7-year-old neutered male Labrador retriever dog weighing 23.4 kg was presented to the emergency department of a referral hospital in the UK for further management of acute onset of vomiting, diarrhea, lethargy, and icterus. Four days before being presented to the primary care veterinarian, the owners documented the dog vomiting 10 to 15 cracked acorns. No acorn material was noted in the feces. The dog had free run on a farm and the owners were questioned on the potential for alternative toxin exposure. Although other toxins could not be ruled out, the owners were sure the vomitus only contained cracked acorns. The dog was up-to-date with his vaccinations, having received a 4-strain leptospirosis booster 52 d before presentation. Two months before presentation, the dog had received 1 injection of meloxicam for an acute onset lameness, with no side effects of the medication noted.

Over 3 d after ingesting the acorns, the dog became lethargic, hyporexic, and continued to vomit. On physical examination at the time of presentation to the referring veterinarian, the dog was lethargic, and the only abnormality detected on physical examination was icteric sclera. In-clinic blood analysis included biochemistry and hematology (without blood smear evaluation). The biochemistry revealed an increase in alkaline phosphatase (ALP), alanine aminotransferase (ALT) activities, and total bilirubin concentration (Table 1). A hematology panel revealed mild thrombocytopenia [platelet count: 103 \times 10^9/L, reference range (RR): 148 to 484 \times 10^9/L]. After 24 h of hospitalization at the primary care practice, the dog was referred for further investigation and management of a hepatopathy.

At presentation to the referral hospital, the dog was quiet, alert, and responsive. Cardiac auscultation was unremarkable and heart rate was 80 beats/min, pulses were strong and synchronous. Mucous membranes were tarry, sclerae were icteric, and the capillary refill time was < 1.5 s. The respiratory rate was 16 breaths/min with normal thoracic auscultation. Abdominal palpation was comfortable, but nausea (hypersalivation and lip smacking) was noted at that time. No abnormalities were detected on oral or rectal examination, and rectal temperature was normal (38.3°C). There was no peripheral lymphadenopathy, the body condition score was 4/9, and the dog had a normal muscle condition score. Non-invasive blood pressure (NIBP) doppler measurement was 170 mmHg.

Blood analysis (packed cell volume (PCV) and total solids (TS), blood gas, and electrolytes (ABL800 FLEX; Radiometer, Brønshøj, Denmark), serum biochemistry (AU680; Beckman Coulter, High Wycombe, UK), a complete blood (cell) count (CBC) (Advia 2120i; Siemens, Camberley, UK), coagulation times (Coag Dx; IDEXX, Westbrook, Maine, USA)], and urinalysis were performed. Initial PCV and TS were within normal limits. Blood gas and electrolytes were unremarkable. The CBC revealed a normal neutrophil count with evidence of neutrophil toxicity, mild thrombocytopenia (110 \times 10^9/L; RR: 150 to 900 \times 10^9/L), mild lymphopenia (0.92 \times 10^9/L; RR: 1 to 4.8 \times 10^9/L), and mild monocytosis (1.72 \times 10^9/L; RR: 0.15 to 1.5 \times 10^9/L). On biochemistry, there was mild hypoalbuminemia, moderate hyperbilirubinemia, a marked increase in ALT activity, and a moderate increase in ALP activity (Table 1). The C-reactive protein concentration was 20 mg/L (RR: < 25 mg/L). Coagulation times were abnormal, with significantly prolonged prothrombin time and an out-of-range activated partial thromboplastin time (Table 1).

Abdominal

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<th>Table 1. Progression of blood analysis during hospitalization and post-discharge.</th>
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<td>Proteinuria</td>
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a Results from an external referral laboratory.

b Results obtained on the point-of-care emergency database (ABL800 FLEX, Radiometer).

c Reference ranges are the normal reported for animals according to the referral external laboratory.

TP — Total protein; Alb — Albumin; Tbil — Total bilirubin; Creat — Creatinine; ALT — Alanine aminotransferase; ALP — Alkaline phosphatase; PT — Prothrombin time; aPTT — Activated partial thromboplastin time; PCV — Packed cell volume.
point-of-care ultrasound revealed scant peritoneal and moderate retroperitoneal effusion, subjectively edema of the gall bladder wall, cystic lesions on the kidneys, and a small urinary bladder. The thoracic point-of-care ultrasound, however, was unremarkable. Urinalysis, before initiation of intravenous fluid therapy (IVF), revealed a urine specific gravity (USG) of 1.045, glucosuria 4+ (in the presence of normoglycemia), and proteinuria 3+; this was most consistent with acute tubular injury and the sediment examination revealed epithelial cells, granular casts, and bilirubin crystals. Urine culture (cystocentesis sample) was negative.

Full abdominal ultrasonographic examination performed by a Board-certified radiologist, confirmed an abnormal appearance to the liver, gallbladder, and kidneys. The liver parenchyma was diffusely mildly hyperechoic. The gallbladder wall was thickened (4 mm) and had an outer hypoechoic layer. The cranial pole of the left kidney had a well-demarcated, 1.3 × 1.5 cm anechoic round structure, with distal acoustic shadowing. The renal cortex was diffusely hyperechoic, and normal corticomedullary definition was present. The right kidney was similar to the left kidney in appearance and had multiple, variably sized parenchymal cysts. There was a moderate amount of anechoic retroperitoneal fluid streaking between fascial planes. A scant volume of peritoneal fluid was also present. The appearance of the spleen was unremarkable. Cystoscitesis of the bladder and fine-needle aspirates (FNA) of spleen and liver were obtained without complication. Spleen FNA was performed to aid in the diagnosis of a possible neoplastic process. Peritoneal fluid was not sampled, as the amount was too small to obtain at the time of scanning. Coagulation times were not rechecked at the time of sampling. Cytology revealed hepatic vacuolar degeneration (glycogen/water type), mild cholestasis, and evidence of mild necrosis with mild hepatocellular atypia. Rhodamine staining revealed only rare hepatocytes containing small amounts of copper. This suggested that the hepatopathy was not associated with copper deposition, and a diagnosis of breed-associated copper storage hepatopathy as a potential cause of the hepatic insult and renal tubular injury was considered unlikely (16). Splenic cytology revealed a predominance of small reactive lymphocytes and presence of plasma cells, most consistent with a reactive spleen and suggestive of strong antigenic stimulation.

Testing for leptospirosis [urine polymerase chain reaction (PCR) and serum microagglutination testing (MAT) (L. australis, L. autymnalis, L. ballum, L. brasiliana, L. canicola, L. copenhageni, and L. icterohaemorrhagiae) were also submitted] and empiric amoxicillin clavulanic acid (Augmentin; GlaxoSmithKline UK, Uxbridge, UK) 20 mg/kg BW per hour (maintenance fluid rate), omeprazole (Sandoz, Camberley, UK), 1 mg/kg BW, IV, q12h, ondansetron (Demo S.A., Athens, Greece), 0.5 mg/kg BW, IV, q12h, and vitamin K1 (TVM UK Animal Health, Kirtlington, UK), 1 mg/kg BW, IV, q24h. The dog’s NIBP was persistently significantly elevated, 170 to 180 mmHg systolic, and amlodipine (Aurobindo Pharma-Milpharm, South Ruislip, UK), 0.1 mg/kg BW, PO, q24h, was subsequently started.

On Day 2 of hospitalization, repeat blood analysis revealed an increase in creatinine concentration despite adequate IVF and a stable body weight. Total bilirubin concentration had increased further and there were no electrolyte abnormalities. The creatinine concentration continued to rise until Day 3 of hospitalization and the total bilirubin concentration remained high (Table 1). In-clinic urinalysis revealed improvements in both glucosuria and proteinuria. The urine remained concentrated (> 1.030 urine specific gravity (USG)), S-adenosylmethionine (SAME) and Silybin (Demarmin; Protexin Veterinary, Somerset, UK), 20 mg/kg BW, PO, q24h and ursodeoxycholic acid (Destolit; Norgine, Harefield, UK) 12.5 mg/kg BW, PO, q24h, were added as empirical hepatoprotectants. At this time, the dog was stable but remained in a critical state. A naso-esophageal feeding tube was placed to provide supplemental nutrition. By the third day of hospitalization, the dog was eating on his own and clinically brighter.

Once the dog was eating 100% of his resting energy requirements, he was discharged after 6 d of hospitalization, with amoxicillin-clavulanic acid (Noroclav; Norbrook Laboratories, Newry, Northern Ireland), 20 mg/kg BW, PO, q12h, for another 7 d as leptospirosis testing was still pending. He was then transitioned to doxycycline (Boehringer Ingelheim Animal Health UK, Bracknell, UK), 10 mg/kg BW, PO, q24h until the convalescent serum MAT was available. Amlodipine (Aurobindo Pharma-Milpharm, South Ruislip, UK), 0.1 mg/kg BW, SAME

**Figure 1.** Acorns from the farm where the dog lives, identified as *Quercus petraea* (sessile oak).
(Denamarin; Protexin Veterinary) 20 mg/kg BW, and ursodeoxycholic acid (Destolit, Norgine) 12.5 mg/kg BW all given PO once daily, were continued. Focused serum biochemistry was performed on the day of discharge revealed increased urea, an improvement in bilirubin and creatinine concentrations, static ALP, and a much improved but still increased ALT activity (Table 1).

Improvement continued after discharge and a recheck by the referring veterinarian 2 wk later revealed a continued reduction of liver parameters, but further improvement in total bilirubin concentration (Table 1). On in-clinic CBC without blood smear, there was a mild lymphopenia (3.7 × 10⁹/L, RR: 4.9 to 17.6 × 10⁹/L), with mature neutropenia (neutrophils: 1.78 × 10⁹/L, RR: 2.94 to 12.67 × 10⁹/L), consistent with an ongoing inflammatory process; however, the platelet count was normal (platelets: 283 × 10⁹/L, RR: 143 to 448 × 10⁹/L). Doxycycline was continued until the convalescent MAT leptospirosis results were available, whereas SAMe and ursodeoxycholic acid were continued until liver values normalized. Amlodipine was stopped when hypertension resolved, and the NIBP was monitored following discontinuation, without relapses noted.

A further recheck was performed by the referring veterinarian 1 mo after discharge, and the dog had completely recovered. All values on hematology and biochemistry, performed through an external laboratory, were within normal reference intervals and no further medications were required (Table 1). Ten months after the event, in-clinic urinalysis revealed a USG of 1.046 and resolution of glucosuria, proteinuria, and casts. The dog continues to have a normal life and has no apparent health concerns related to this episode.

**Discussion**

To the authors’ knowledge, acorn toxicity in dogs has not previously been reported in the veterinary literature. Internet searches of “acorn toxicity in dogs” does, however, reveal multiple veterinary webpages acknowledging acorn toxicity, and veterinary message boards on the Veterinary Information Service (VIN) also discuss a number of anecdotal cases. The Veterinary Poisons Information Service (VPIS) in the UK, has anecdotally reported suspected intoxications are occurring in this species. Some of these cases presented with gastrointestinal clinical signs, including vomiting, abdominal discomfort, and diarrhea. Of these cases, renal involvement was reported in 2% and hepatic involvement in 5%. There was 1 report in the VPIS database of both hepatic and renal involvement, similar to our patient. Other clinical signs such as muzzle urticaria, edema, and gastrointestinal mechanical obstruction were also reported. According to the VPIS records, only 1 patient died, and another was euthanized.

The dog’s initial clinical signs were gastrointestinal in nature. Vomiting of the cracked acorns was suspected to be due to the disruption of the shell and release of tannins. These signs progressed to lethargy, ongoing vomiting, and diarrhea. Within a few days, the dog suffered acute hepatic injury and acute kidney injury, with no other obvious identifiable cause. The clinical signs in this dog were consistent with signs of gallotoxicity, typically reported in large animals. In the large animal literature, initial clinical signs can vary from localized oral lesions to diffuse gastrointestinal signs (1). This case demonstrated signs of renal injury, as described in the large animal literature, as evidenced by the azotemia with no appreciable pre-renal component based on clinical evaluation and lack of improvement or change in body weight on IVF diuresis, along with the urinalysis results and urine sediment examination (glucosuria without hyperglycaemia and granular casts) (1,17). A USG < 1.030 was not documented during hospitalization. Measurement of USG is often used to help differentiate between pre-renal and renal azotemia (17). Usually, dogs with a USG > 1.030 are considered to have pre-renal azotemia (17–19). Unfortunately, the USG was only checked early in hospitalization, and it was not possible to determine if the dog did lose the ability to concentrate urine. However, the dog had persistent mild azotemia that did not initially improve with IVF diuresis, along with persistent glucosuria (in the face of normoglycemia) and documented granular casts along with acute repeatable hypertension with no other apparent cause that responded to amlodipine. We inferred that these changes were most likely secondary to acute kidney injury (17). Perirenal effusions and increased renal echogenicity, both noted in our patient, have also been associated with acute kidney injury in dogs (20).

In large animals, gross post-mortem findings associated with fatal acorn toxicity include fluid accumulation within body cavities, edema within the subcutaneous, mesenteric, and retroperitoneal spaces (especially peri-renal congestion), erosions and ulcerations of the alimentary tract, and in some cases, hepatocellular degeneration. The kidneys can appear swollen, pale, and can have petechiation of the cortex (13). Evidence of similar fluid accumulation was also seen in this case on initial abdominal imaging, but the volume of fluid present on reassessment was not enough to attempt sampling. Gall bladder wall edema was considered to be secondary to the generalized inflammatory process (21).

Leptospirosis was considered as a differential diagnosis because of the concurrent acute hepatic injury, renal injury, and thrombocytopenia, but was excluded based on a negative urine PCR and serum MAT convalescent testing. The dog had received a single dose of cefuroxime, while hospitalized at the referring veterinarian, 24 h before collection of the urine sample for PCR testing. Although it is generally expected that multiple doses of antibiotics are needed to impact the yield of a urine PCR in this setting, blood PCR may have been a more appropriate choice at this stage (22). Based on the urine PCR combined with the MAT testing, leptospirosis was unlikely (22). Other differentials such as a primary hepatopathy including, but not limited to, cholangiohepatitis, infiltrative neoplasia, and copper storage disease were also considered. The dog did not have signs consistent with an infectious etiology, and an underlying primary hepatopathy was not identified on FNA of the liver. Other hepatotoxins were considered as a possibility (e.g., Amanita mushrooms); however, with the identification of the acorns in the vomitus, concurrent suspected acute kidney injury, absence of any reported mushroom exposure, and complete clinical recovery from hepatotoxicity (uncommon with
amatoxin-containing mushrooms such as *Amanita phalloides*), acorn toxicity was considered the most likely culprit (23).

Further diagnostic steps considered in this case included serum and urine toxicology testing for acorn metabolites. One method for quantitative analysis of pyrogallol and gallic acid in serum and urine in cows has been validated (6,24,25). Unfortunately, no human or veterinary laboratories based in the UK were testing for tannins at the time this case was presented to us, but this could be considered in future similar cases presenting with a suspicion of this condition.

There is no specific treatment for acorn toxicity, and this case responded to supportive care, with treatments including IVF, nutritional support with early enteral feedings, and liver support, including SAMe to address oxidative hepatic injury. Hypertension was treated with amlodipine, and discontinued 2 wk after discharge, with regular monitoring of the blood pressure. The favorable recovery in this dog was at odds with the high mortality rate typical in cattle showing clinical signs (5). It is unknown whether dogs might have intrinsic resistance mechanisms favoring improved clinical outcome, or whether the availability of intensive care in this case made survival more likely. It is also possible that variability in toxicity among acorn types, their maturity at the time of ingestion, and the quantities that dogs are exposed to compared to large animals, could explain discrepancies in expected survival rates between species (8,26,27).

To the authors’ knowledge, this is the first report describing the clinical course and successful treatment of suspected acorn toxicity in a dog. The documented ingestion of cracked acorns resulting in initial gastrointestinal signs with a progression to acute kidney and liver injury in this dog were similar to those reported in other species, including horses and cattle. Hepatic and renal injury due to acorn ingestion appear to be uncommon in dogs. This case report, however, raises the awareness of acorn toxicity as a potential differential diagnosis for concurrent hepato-renal injury in this species. It also describes a favorable outcome with appropriate supportive treatment.

Acknowledgments

We thank the Veterinary Poisons Information Service (VPIS) in the UK for the information provided regarding their cases with reported acorn ingestion. The VPIS assumes no responsibility for the interpretation of the registered data. We also thank Elena Suárez-Bonnet BSc Biology, PhD, PostDoc Fellow, for help in identifying the *Quercus* spp., based on the photographs available.

References

Complications and management of a long-term pleural access port in a dog with chronic chylothorax associated with lung lobe torsion

Fenway Chang, Andrew K.J. Linklater

Abstract — A 2-year-old neutered male 35-kg golden retriever mixed breed dog was presented because of a 3-day history of increased respiratory effort. The patient was subsequently diagnosed with a lung lobe torsion and underwent lung lobectomy. Chylothorax developed after surgery and persisted for 3.5 y. Pleural access port (PAP) placement was used for long-term medical management. Several complications were encountered, including 2 episodes of PAP occlusion that were successfully treated with unfractionated heparin. The dog had a surgical site seroma and 2 episodes of pleuritis; euthanasia was elected after the second episode.

Key clinical message:
This case demonstrates successful long-term management of chylothorax with a pleural access port and management of 3 complications. Instead of the less accessible and more expensive tissue plasminogen activator, unfractionated heparin was used as an effective treatment for PAP occlusions.

Résumé — Complications et prise en charge d’un port d’accès pleural à long terme chez un chien atteint de chylothorax chronique associé à une torsion d’un lobe pulmonaire. Un chien de race mélangée golden retriever mâle stérilisé âgé de 2 ans de 35 kg a été présenté en raison d’une histoire de 3 jours d’effort respiratoire accru. Le patient a été diagnostiqué avec une torsion du lobe pulmonaire et a subi une lobectomie pulmonaire. Un chylothorax s’est développé après la chirurgie et a persisté pendant 3,5 ans. Le placement du port d’accès pleural (PAP) a été utilisé pour la prise en charge médicale à long terme. Plusieurs complications ont été rencontrées, dont deux épisodes d’occlusion du PAP qui ont été traités avec succès avec de l’héparine non fractionnée. Le chien avait un séroma au site opératoire et deux épisodes de pleurésie; l’euthanasie a été choisie après le deuxième épisode.

Message clinique clé :
Ce cas démontre une prise en charge à long terme réussie du chylothorax avec un port d’accès pleural et une prise en charge de trois complications. Au lieu de l’activateur de plasminogène tissulaire moins accessible et plus coûteux, l’héparine non fractionnée a été utilisée comme traitement efficace pour les occlusions du PAP.

Case description

A 2-year-old neutered male 35-kg golden retriever mixed breed dog was presented because of a 3-day history of increased respiratory effort. On physical examination, an elevated body temperature of 39.6°C and decreased heart and lung sounds on the left side were noted. Thoracic radiographs revealed soft tissue density and pleural fluid in the left middle lung field, obscuring the cardiac silhouette. Baseline complete blood (cell) count (CBC) and serum biochemical analysis, clotting times (prothrombin time, partial thromboplastin time), and urinalysis were normal. A thoracentesis was performed, and 800 mL of serosanguinous fluid was obtained. Post-thoracentesis thoracic radiographs revealed pleural effusion with consolidation of the left cranial lung lobe. Cytologic and radiographic findings were consistent with an inflammatory, necrotic, space-occupying lesion, and/or torsion or atelectasis of a lung lobe. A left cranial lung lobe torsion (LLT) was confirmed with computed tomography (CT) and exploratory thoracotomy revealed the caudal part of the left cranial lung lobe had rotated 180° and was devitalized. The caudal part of the left cranial lung lobe was removed, and a 20 Fr thoracostomy tube was placed at the 8th intercostal space and intermittent thoracostomy tube suction was performed. A pleural catheter was also placed more dorsally to administer intrapleural analgesia. Several small nodules were noted on the pleura and were biopsied at the same time.

Histology results of
the lung lobe and nodules were consistent with LLT and granulation tissue; no etiologic agents were identified.

The dog recovered uneventfully, but the pleural effusion changed in appearance 2 d after surgery. It became more opaque and was confirmed to be chyle, based on cytology and paired triglyceride concentrations (1.07 and 9.25 mmol/L in peripheral blood and pleural fluid, respectively). A large volume of chylous fluid continued to be drained from the thoracostomy tube over the next 7 d, peaking at 1200 mL/d [34 mL/kg body weight (BW) per day]. The owners elected to have a pleural access port (PAP) device (PleuralPort; Norfolk Vet Products, Le Grande Kit, Skokie, Illinois, USA) placed to facilitate home care and did not wish to pursue the recommended combination surgical procedures of thoracic duct ligation, pericardectomy, and ablation of the cisterna chyli. The day after PAP placement, the dog was discharged with instructions on medical management of chylothorax (medium-chain triglyceride oil, 2 tsp per meal and a low-fat diet) and management of the PAP as recommended by the manufacturer and relevant publications (1–3). The skin over the subcutaneous (SC) port was shaved and continued to remain shaved while the PAP was in use. The owners were given instructions on how to aspirate the pleural drainage port in an aseptic fashion, using gloves along with alcohol and betadine swabs. They were also given directions on how to aseptically insert and stabilize the Huber point needle and aspirate from the PAP using a 60-mL syringe connected to a 3-way stopcock and a collection bag, followed by a saline/heparin flush at completion. The owners were instructed to record the character and volume of the recovered fluid and to monitor respiratory rate, pattern, temperature, and development of any new signs at home.

One week after the PAP placement, the dog developed a firm swelling around the subcutaneous port and the owners were not able to palpate the port nor drain fluid. Ultrasound examination identified a fluid pocket around the port. In-house cytology of the fluid revealed mature inflammatory cells with no intracellular bacteria; glucose concentration was 5.1 mmol/L, and it was determined that the swelling was a seroma. Serosanguinous fluid was removed in an aseptic fashion from the SC space. The PAP was accessed with ultrasound assistance and 270 mL of pink opaque fluid removed. A compression bandage was placed to decrease further fluid accumulation for the next few days. The owners were advised to warm compress the area after the compression bandage was removed and continue to monitor the dog’s temperature and respiratory rate and effort. After 2 more ultrasound-guided PAP aspirations over the next 2 wk, the seroma gradually resolved, and the owners were able to palpate the SC PAP port and drain the chyle. Over the next several months, the owners removed chyle from the port every 48 to 72 h, based primarily on increases in the dog’s respiratory rate. Fluid production averaged about 300 to 400 mL/d (~10 mL/kg BW per day) and the fluid was usually opaque with a light pink coloration.

Eight and a half months after the PAP placement, the dog became lethargic and febrile. The amount of fluid obtained from the port increased and became more red. Cytology reviewed by a clinical pathologist revealed neutrophilic exudate with no infectious agent. Baseline CBC and serum biochemical analysis were normal. The tentative diagnosis was pleuritis secondary to the chronic chylous fluid. A 7-day course of amoxicillin/clavulanic acid (Clavicillin; Dechra Veterinary Products, Overland Park, Kansas, USA), 11.4/2.8 mg/kg BW, PO, q12h, had been started while waiting for bacterial culture results. Both aerobic and anaerobic bacterial culture results were negative, and no further therapy was administered as the dog’s clinical signs resolved.

Twenty-one months after the PAP placement, the owners reported the port became difficult to drain and fluid production decreased. The patient also started to develop an increased respiratory effort. A large amount of free fluid in the pleural space along with what appeared to be fibrinous material were noted on thoracic ultrasound. Sterile saline could be flushed into the PAP, but not aspirated. A routine thoracentesis was performed and 3200 IU unfractionated heparin (UH, Heparin sodium injection, USP; SAGENT Pharmaceuticals, Schaumburg, Illinois, USA), 100 IU/kg BW was injected into the port after the thoracentesis was performed and left for 2 d. The PAP became functional at the next centesis.

Twenty-seven months after the PAP placement, the owners reported a similar incident wherein fluid could be injected, but no fluid could be aspirated. Three separate doses of 3200 IU heparin (UH) were injected into the port and left in place for 2 d each over the next 15 d. Two days after the first injection, it remained difficult to aspirate fluid from the port; therefore, the additional 2 doses of 3200 IU heparin (UH) were dispensed in the following 10 d after the first injection and the occlusion resolved. A written prescription for tissue plasminogen activator (tPA) was also provided to the owners and replacement of the PAP was discussed, but these interventions were not required. There were no further occlusions of the PAP.

Three and a half years after the PAP placement, the fluid became more opaque and increased in volume (1200 mL/d, 34 mL/kg BW per day), the patient also became febrile at 39.8°C, developed an increased respiratory rate and effort and had a decreased appetite. In-house cytological examination of the pleural fluid revealed neutrophilic inflammation with no infectious agent, the owners declined further diagnostics including bacterial culture. Tramadol (traMADOL hydrochloride USP; Sun Pharmaceutical Industries, Cranbury, New Jersey, USA), 2.5 to 4.2 mg/kg BW, PO, q8 to 12h as needed for analgesia and amoxicillin/clavulanic acid (Clavicillin; Dechra Veterinary Products), 12/1.7 mg/kg BW, PO, q12h, were initiated. Baseline CBC and serum biochemical analysis from the referring veterinarian were normal. Further diagnostics were declined by the owners. One week later, the owners elected euthanasia as they had to aspirate the PAP once per day (increased from once every 3 d) and there was a perceived deterioration of quality of life; euthanasia occurred 1258 d after the PAP placement.

The findings of an in-house key-hole postmortem examination included diffuse, large amounts of fibrinous material covering all pleural surfaces. The peripheral edges of the thoracic cavity were rounded with white discoloration. Findings of the gross post-mortem examination were consistent with acute on chronic non-infectious pleuritis with chronic fibrosing pleuritis. Histopathology of lung, diaphragm, and SC port site were consistent with the diagnosis of non-infectious chronic pleuritis.
Discussion

Lung lobe torsion is a rare life-threatening condition in dogs that requires surgical removal of the affected lung lobe. A recent study reported a 100% survival rate after lung lobectomy and 92% survival to discharge (4). Chylothorax is not an uncommon finding with LLT in pre- and post-operative states (4,5). In one study of LLTs (50 cases), chylothorax was reported to occur either before surgery (9 cases, 18%) or after surgery (4 cases, 8%). The occurrence of chylothorax after lung lobectomy is suspected to be due to trauma to the thoracic duct during surgery or pleuritis from the lung lobe torsion itself (5,6). The presence of chylothorax is not reported to change the prognosis with respect to surgical management of LLT (7,8).

Treatment options for chylothorax include medical and surgical therapy as well as the use of indwelling pleural catheters (IPCs) in human medicine (9) and similar devices in veterinary medicine (1,2,10). Medical management includes treatment with octreotide, rutin, and dietary changes but is met with less success than surgical options (11). This may be paired with intermittent pleural evacuation via pleurocentesis or placement of a pleural access device. Common surgical options most often include a combination of open or thoracoscopic procedures, including thoracic duct ligation, pericardectomy, and ablation of the cisterna chyli. This combination of procedures has been associated with a reasonable outcome but does not resolve chylothorax in all dogs (12,13). The success rate has ranged from 53 to 72% in previous studies (7,14).

In this case, the owners declined further invasive surgical treatment to address the chylothorax, so a PAP was subsequently placed to assist continued medical management. Although complications occurred, the long-term outcome was at the upper end of reported time frames and provided further support of its use as a long-term method to manage patients with chylothorax. This is important, especially when owners are not willing or financially able to pursue more aggressive options, when surgical options are unsuccessful, or when definitive therapy is not possible or practical.

In the past decade, the use of IPCs has emerged in human medicine as a very effective modality to manage malignant pleural effusion (15,16) and has also in recent years been used in cases of non-malignant pleural effusion (17,18). Although IPCs are readily available and have been tolerated well in human patients, due to its exposed external portion, it is not practical for use in veterinary patients. Similar devices such as PAPs have been developed and used in veterinary medicine to manage recurrent pleural effusion or pneumothorax (1,2,10). The principle of PAPs is similar to that of IPCs; however, instead of an external portion of the catheter and an exposed draining port/valve outside the body, a port is placed subcutaneously while the connecting silicon catheter is inserted into the pleural space (3).

Advantages of using IPCs in human medicine include fewer hospitalization days, decreased effusion recurrence rate, lower failure rate, improved quality of life, lower initial cost, and shorter initial admission time (9,19). However, there are also associated complications (9,20), such as pneumothorax during placement, pleural infection, catheter tract metastases/seeding in cases of malignancy, loculation (fibrinous material that forms septations), chest pain, immunosuppression/malnutrition due to chronic drainage, dislodgement, blockage, peri-catheter leakage, and catheter fracture.

In veterinary medicine, the sample size is much smaller, and complications associated with catheter obstruction have been reported (1,10). In 1 case (10), although obstruction was not confirmed, it resolved by injecting tPA (0.15 mg/kg BW) and waiting for 30 min. In human literature, 1 study (21) reported 18% of IPC placed encountered catheter obstruction. The treatment protocol for restoring function of nondraining indwelling pleural catheters after attempting saline flush is intra-catheter instillation of fibrinolytic therapy (tPA), which was effective with minimal complications (9,21–23). Urokinase and streptokinase have also been effective in treating fibrin obstruction in central venous catheters, but due to the potential side effects, they have fallen out of favor in human medicine (24,25).

In our case, although tPA was thought to be a more effective treatment, due to cost and accessibility, UH was elected as a first-line treatment during the 2 episodes of catheter occlusion when fibrin clot was suspected. A prescription for tPA was provided to the owners in case the occlusion persisted, and replacement of the PAP was also discussed. However, in both instances, the indwelling UH in the catheter was effective in alleviating the obstruction, and further interventions were not necessary. There are more recent reports on the use of heparin in catheters for humans to prevent occlusion; however, the dose is not always clearly listed (26–28). We elected to start with 100 IU/kg BW, which is at the lower end of the recommended dose for systemic anticoagulation.

Both UH and low molecular weight heparin (LMWH) possess anticoagulation properties through binding to antithrombin (AT) and inactivating factor IXa and Xa which eventually causes decreased production of fibrin by indirectly inactivating thrombin (IIa). Due to UH’s high-affinity pentasaccharide that consists of a chain length of more than 18 saccharides, it can also bind to AT and thrombin (IIa) at the same time and directly inhibit thrombin (IIa), thus further preventing fibrin formation. This results in UH being more effective in decreasing fibrin production than LMWH (29). Conversely, fibrinolytic agents such as streptokinase, urokinase, and tPA promote the formation of plasmin and actively increase the breakdown of fibrin. There have also been reports on UH enhancing the activity of tPA, plasminogen, and urokinase-type plasminogen activator (uPA) and enhancing their fibrinolytic properties (30); this only seems to apply to UH and not LMWH (31). We hypothesized that the use of UH in this case may have decreased the rate of fibrin production while normal to possibly enhanced fibrin degradation processes continued to take place. This may be a slower process compared to the effects of fibrinolytic agents; however, UH is more readily available in most veterinary facilities and may present an interim option with minimal complications.

Another common complication causing decreased drainage from the IPCs is loculation. This is related to the accumulation of fibrinous material that eventually forms septae in the pleural space and causes impaired fluid removal from the catheter (9,23). Due to the increased intra-pleural fibrin observed...
in our case, this could also explain the 2 episodes of impaired PAP patency and UH could have contributed to resolving the occlusion through similar mechanisms described.

Chyle has been established as an irritant to the pleural and pericardial surfaces; in chronic cases of chyloous effusion, life-threatening fibrosing pleuritis and pericarditis can occur (23,32). The dog herein displayed clinical signs of pleuritis twice during the follow-up period. Upon the postmortem and histopathological examinations, there was a large amount of fibrin that had accumulated in the pleural space and clear evidence of chronic pleuritis. Although there was no significant histopathological evidence of fibrosing pleuritis, the presence of large amounts of fibrin may have resulted in fibrosis over time (33,34). Due to the diffuse nature of the inflammation in this case, it is suspected that the chronic pleuritis was mainly due to long-term chyle accumulation rather than the presence of the PAP device.

Although there was no evidence of infection in the pleural fluid with cytological examinations in both instances, negative bacterial cultures in the first instance and histopathology of the pleural tissue in the second instance, an iatrogenic infection cannot be completely ruled out; the dog’s response coincided with antibiotic therapy in the first instance, but not the second. An infection may have also contributed to the development of the dog’s chronic pleuritis; however, we did not have any diagnostic evidence to support this.

Another complication associated with our PAP placement was the seroma that developed shortly after placement. This has not been a complication reported in the veterinary literature, but it is not unexpected given the necessary surgical placement. Although a seroma is a relatively benign complication and typically requires minimal intervention, the location of this seroma affected the accessibility of the PAP and could have led to catheter failure or requirement of repeated centeses. Therefore, it was elected to aseptically aspirate and then bandage the seroma, despite a risk of iatrogenic contamination.

In previously reported cases of PAP placement, the duration of use of the port was reported to range from 1 to 391 d (1,2). To the authors’ knowledge, the case presented here has one of the longest reported duration of use (1258 d), and besides the 2 episodes of obstruction, the port was used frequently, an estimated > 400 uses with large volumes removed at every use (~400 mL/d aspiration once every 2 to 3 d) and functioned well throughout the course of treatment. Two other cases were reported in the literature with similar survival times to the one presented here, this could also explain the 2 episodes of impaired PAP patency and UH could have contributed to resolving the occlusion through similar mechanisms described.

This case demonstrated successful long-term management of post-lung lobectomy chylothorax (1258 d) along with management of 3 complications: a local seroma, pleuritis, and resolution of PAP catheter obstruction with indwelling unfracturated heparin injections, aspects that have not been demonstrated with a PAP that has been managed for this duration. Although the standard treatment of chylothorax is surgery, which may mitigate some of the complications noted here, PAP placement may be considered as a reasonable palliative treatment option when surgical options are not possible and the risks, complications, and complications of using a PAP have been thoroughly communicated with the owners.

References

Erratum
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Protothecosis in a dog

Andrew R. Vince, Chantale Pinard, Adam T. Ogilvie, Emmeline O. Tan, Anthony C.G. Abrams-Ogg

The captions for Figures 2 and 3 have been switched in error. Here are the correct captions.

Figure 2. Colon and rectum, mucosal surface. There is segmental dark discoloration of the colonic wall, throughout which are multiple poorly defined white-tan nodules. Some green discoloration is present as a result of both local hemorrhage and autolysis.

Figure 3. Heart, cut section of apex. At all levels of the myocardium there are numerous poorly defined pale tan-white nodules.
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Case Report  

Diagnosis and treatment of epidural empyema in a pygmy goat

Marc Kent, Erin M. Beasley, Karine P. Gendron, Maëva C.M. Barozzi, Christina Marino

Abstract — A mixed-breed pygmy goat was presented for nonambulatory tetraparesis. Neurological examination was consistent with a C6 to T2 myelopathy. Initially, the goat was treated medically. Forty-three days later, magnetic resonance imaging (MRI) revealed an extradural mass compressing the cervical spinal cord. Magnetic resonance attributes of the mass were consistent with a slow-growing, fluid-poor lesion. The spinal cord was surgically decompressed. Epidural empyema secondary to *Fusobacterium necrophorum* was identified. Postoperative care consisted of anti-inflammatory medication, antimicrobials, and physical therapy. Ability to walk occurred by day 14 after surgery. Despite prolonged recumbency before surgery, the goat was clinically normal, and antimicrobials were discontinued on day 60 after surgery.

Key clinical message: Epidural empyema can cause a compressive myelopathy which may result in varying degrees of paresis/paralysis. Clinical resolution and return of normal function occurred following the use of MRI to plan surgical decompression combined with extended use of antimicrobials.


Message clinique clé : L’empyème épidural peut provoquer une myélopathie compressive pouvant entraîner divers degrés de parésie/paralysie. La résolution clinique et le retour de la fonction normale sont survenus après l’utilisation de l’IRM pour planifier la décompression chirurgicale combinée à une utilisation prolongée d’antimicrobiens.

Epidural empyema has been reported in dogs (1–8), cats (9–11), calves (12–14), a horse (15), sheep (11,16,17), and other species (18,19). Etiologies associated with epidural empyema common to many species include discospondylitis (2,4,6) and foreign body migration (9,20–22). Other etiologies may be species-specific or may be due to management practices particular to a species such as tail-docking in lambs (11,17,23) or intramuscular injections in the neck in horses and cattle (12). To the authors’ knowledge, this is the first report of epidural empyema in a goat. In the case herein, infection with *Fusobacterium necrophorum* likely occurred secondary to a traumatic event.

Case description

A 4-year-old, 21.4-kg, mixed-breed pygmy goat doe was evaluated for tetraparesis. Three days before presentation, the owner witnessed a donkey attacking the pet goat. The donkey bit and shook the goat by the neck. Following the attack, the goat was not able to stand or walk. The vaccination and deworming history were unknown.

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On presentation, the goat was tachycardic (150 beats/min), tachypneic (36 breaths/min), and normothermic (38.1°C). On physical examination, no abnormalities were detected except for a subjective decrease in the intensity of rumen contractions. On neurological examination, the goat displayed normal mentation but was nonambulatory tetraparetic. Postural reactions were absent in all 4 limbs. The thoracic limbs had reduced withdrawal reflexes and decreased muscular tone. The pelvic limbs had normal patellar and withdrawal reflexes and increased muscular tone. The cutaneous trunci reflex was present bilaterally. Cranial nerves were normal. No pain was noted on manipulation of the head or neck. The anatomic diagnosis was consistent with a lesion affecting the C6 through T2 spinal cord segments. Given the history, traumatic fracture or luxation of the caudal cervical vertebral column was considered; however, traumatic intervertebral disc herniation or an ischemic myelopathy was also considered. A complete blood (cell) count (CBC) and serum glucose, creatinine, and electrolyte concentrations were normal. Overnight, the doe was able to maintain sternal recumbency and made attempts to stand. Due to financial constraints, the owner transferred ownership of the doe to a rescue organization that managed the doe conservatively with meloxicam (Metacam; Covetrus, Dublin, Ohio, USA), 0.5 mg/kg body weight (BW), PO, q24h. In addition, the doe was treated with fenbendazole (Panacur; Merck Animal Health, Madison, New Jersey, USA), 20 mg/kg BW, PO, q24h for 5 d and ivermectin (Ivomec; Boehringer Ingelheim, Vetmedica, St. Joseph, Missouri, USA), 0.4 mg/kg BW, SC, once because the signs could have been related to migration of Parelaphostrongylus tenuis. One month after examination, the doe's neurological condition remained static, and euthanasia was recommended but was declined. Forty-three days after the injury, the doe was evaluated due to neurological decline. On physical examination, the goat was normal except for tachypnea (44 breaths/min). Neurological examination was similar to the initial presentation except that the thoracic limbs lacked voluntary movement and the degree of paresis in the pelvic limbs was subjectively worse. A CBC revealed a leukocytosis, $[25.5 \times 10^3 \text{ cells/\mu L}, \text{ reference range (RR): 4.0 to } 13.0 \times 10^3 \text{ cells/\mu L}]$ and neutrophilia ($[20.4 \times 10^3 \text{ cells/\mu L}, \text{ RR: 1.2 to } 7.2 \times 10^3 \text{ cells/\mu L}]$ with a normal fibrinogen concentration ($3 \text{ g/L}; \text{ RR: } 2 \text{ to } 3 \text{ g/L}$). Serum biochemistry profile was normal. Radiographs of the cervical vertebral column revealed smooth outward expansion of the left C5-C6 intervertebral foramen and scalloping of the dorsal surface of the body of C6, consistent with pressure atrophy. The left pedicle and cranial articular process of C6 were irregularly shaped, and the left C5-C6 articular process joint was ill-defined. A dense aggregate of granular mineral was present in the vertebral canal at the C5-C6 articulation (Figure 1). Magnetic resonance imaging (MRI) of the cervical vertebral column from the caudal aspect of the skull to the 3rd thoracic vertebra was performed using a 3.0T MR unit (Skyra MR; Siemens, Malvern, Pennsylvania, USA) and a phased array and surface coil. T2-weighted (T2w) using Dixon method for fat suppression, short tau inversion recovery (STIR) sequence, and T1-weighted (T1w) sequences were obtained. Following administration of gadopentetate dimeglumine (Magnevist; Bayer Healthcare Pharm, Wayne, New Jersey, USA), 0.2 mmol/kg BW, IV, T1w sequences using Dixon method for fat suppression also were acquired. A 2.6 $\times$ 2.2 $\times$ 2.8 cm epidural mass was present centered at the level of the left C5-C6 articular process joint (Figure 2). The mass severely expanded the diameter of the vertebral canal and compressed the spinal cord to a $< 1 \text{ mm}$ lenticular shape (Figure 3). The mass had a heterogeneously low T2w and T1w intensity core which did not enhance, suggestive of desiccated material, mineral, or bone, around which was a thin T2w, STIR, and T1w hyperintense rim which homogeneously enhanced. Within the mass were small fluid pockets (T2w hyperintense, T1w hypointense, and non-enhancing). At the level of the C5 vertebral body, the dorsal aspect of the spinal cord was diffusely T2w hyperintense. Like the radiographic findings,
enlargement of the left intervertebral foramen and modelling of the left C5 and C6 pedicles and articular process joint were present. The C5-C6 intervertebral disc was narrow but had normal signal intensity. Between the level of the C4 to C7 vertebrae, the left scalenus and longus capitis muscles contained ill-defined T2w hyperintensity and contrast enhancement. Differential diagnosis included epidural empyema and neoplasia such as a solitary osteochondroma.

Following the MRI, the skin over the caudal cervical to cranial thoracic vertebral column was clipped and aseptically prepared for surgical decompression. At approximately the C6 vertebra, there was a large area of scarred skin on the left lateral side of the neck. A standard dorsal approach to the cervical vertebral column was performed followed by a laminectomy using a high-speed pneumatic drill (24,25). The extent of the laminectomy over C5 and C6 was determined based on the location of the lesion on MRI. Likewise, the location of the lesion on MRI predicted a need to access the left lateral epidural space for removal of the mass. Therefore, the caudal aspect of the C5 and cranial aspect of the C6 pedicles and the C5-C6 articular process joint were removed on the left side. Within the epidural space, an encapsulated mass was encountered that was attached to the left C6 spinal nerve. The capsule was punctured allowing aspiration of a central core of material that was malodorous and had the consistency of inspissated exudate. Traction was applied to the capsule using forceps which enabled it to be dissected from the C6 spinal nerve and vertebral canal. The capsule was strongly adhered to the meninges medially. During dissection, the meninges was inadvertently torn creating a durotomy. The durotomy was converted into a durectomy, enabling removal of nearly all of the capsule except for a hard-to-visualize portion attached to the ventral meninges. Once the mass was removed, the epidural space was lavaged with 0.9% sterile saline. A standard closure was performed.

Cytologically, the exudate consisted of markedly degenerate neutrophils, some containing intracellular cocci, extracellular cocci, and a background of necrotic debris. Anaerobic culture grew *Fusobacterium necrophorum*.

After surgery, the goat was treated with hydromorphone (Hydromorphone; Westward, Eatontown, New Jersey, USA), 0.05 mg/kg BW, IV, q4h for 3 d, flunixin meglumine (Banamine; Merck Animal Health), 2.2 mg/kg BW, IV, q24h for 6 d, thiamine hydrochloride (Henry Schein Animal Health, Dublin, Ohio, USA), 20 mg/kg BW, IV, q12h for 5 d, and Lactated Ringers solution (Hospira, Lake Forest, Illinois, USA), 1.9 mL/kg BW per hour for 1 d. Antimicrobial therapy consisted of ampicillin (Auromedics Pharm, East Windsor, New Jersey, USA), 25 mg/kg BW, IV, q6h for 8 d and florfenicol (Nuflor; Merck Animal Health), 40 mg/kg BW, SC, q72h.

Following surgery, the goat was tetraplegic with normal mastication and cranial nerve function. The thoracic limbs had absent withdrawal reflexes and flaccid paralysis. The pelvic limbs had normal patellar and withdrawal reflexes and normal muscular tone. Neurologically, the goat remained static for 5 d. Physical therapy was initiated on day 3 after surgery. Physical therapy consisted of passive range of motion of all limbs, massage of

![Figure 2. Sagittal MR images of the cervical vertebral column of a goat with epidural empyema. An extradural lesion (arrow) is present which is hypointense on T2w (A), T1w (B), and T2w Dixon fat suppression (C) images. Peripheral enhancement is seen on T1w Dixon fat suppression after administration of contrast (D).](image-url)
the brachial and shoulder muscles, and posturing exercises with the goat being supported with a harness (Rufwear, Bend, Oregon, USA) in a standing position while positioned over an exercise ball (Fitpaws trax peanut; Fitpaws, Denver, Colorado, USA). Additionally, low level laser therapy using a class IV laser (Litecure; Companion Animal Health, New Castle, Delaware, USA), 6.5 watts, power density of 10 J/cm², delivered for 5 min q24h was used over the surgical area. Physical therapy was performed q8–12h daily during hospitalization.

On day 6 after surgery, the goat displayed voluntary movements in all 4 limbs. Flunixin meglumine was replaced with meloxicam (0.5 mg/kg BW, PO, q24h for 14 d). By day 10 after surgery, the goat could support weight when held in a standing position and would attempt to replace its limbs when knuckled. By day 13 after surgery, the goat was able to stand and walk a few steps without assistance. On day 14 after surgery, a CBC and fibrinogen concentration (3 g/L) were normal. Given the normal CBC and improving ability to walk, the goat was discharged with instructions to continue florfenicol and physical therapy for 1 mo.

On day 31 after surgery, physical examination was normal. Rectal temperature was 39.4°C. The goat was able to walk well unassisted. She was able to step up and down from an elevated platform. Results of a neurological examination were normal except for mild postural reaction deficits in all 4 limbs. A CBC revealed a neutrophilic leukocytosis (WBC = 19.3 × 10³ cells/µL; RR: 4.0 to 13.0 × 10³ cells/µL, and neutrophilia = 9.8 × 10³ cells/µL; RR: 1.2 to 7.2 × 10³ cells/µL, and lymphocytosis 8.6 × 10³ cells/µL; RR: 2.0 to 9.0 × 10³ cells/µL) with 2 g/L fibrinogen. Cerebrospinal fluid (CSF) obtained via lumbosacral puncture was normal (WBC = 0 cells/µL; reference range: 0 to 5 cells/µL with 0.27 g/L protein). Given the CBC results, florfenicol was discontinued and treatment with tulathromycin (Draxxin; Zoetis US, Kalamazoo, Michigan, USA), 2.5 mg/kg BW, SC, q7d for 4 wk (total of 4 doses) and rifampin (Versa Pharm, Lake Forest, Illinois, USA), 30 mg/kg BW, PO, q12h for 14 d was initiated. An extended withdrawal period (365 d) was discussed with the owners. Several hours following administration of tulathromycin, the goat developed an intermittent head tilt that changed sides. When her head was tilted, she would repeatedly hold the opposite thoracic limb off the ground for up to 5 to 10 s. Twenty-four hours later, the head tilt and the abnormal limb elevation resolved. On day 60 after surgery (1 wk following tulathromycin administration), no abnormalities were detected on physical examination. A neurological examination showed normal findings apart from a mild delay in postural reactions in the right thoracic limb. A CBC was normal, and fibrinogen was 2 g/L. Given the improved neurological function, normal rectal temperature, normal CBC and fibrinogen concentration, antimicrobial therapy with tulathromycin was discontinued.

**Discussion**

In the present case, epidural empyema likely was the consequence of a wound on the lateral side of the neck immediately adjacent to the infected site. Bacteria may have tracked along the course of nerves in a process called perineural spread, which explains neoplastic extension of head and neck cancers in humans (26). Fungi also may track along the course of nerves (27). Perineural spread is similar to how *Listeria* gains access to the central nervous system (CNS) through migration within axons (28). In contrast to intra-axonal migration, perineural spread occurs within the perineurium and/or endoneurium (29,30). While speculative, the cervical wound may have exposed cutaneous or motor nerves allowing bacterial contaminants to track along nerves coursing to the spinal cord, thereby affording a pathway to the epidural space. *Fusobacterium necrophorum* is an obligate anaerobic bacterium that is a normal

**Figure 3.** Magnetic resonance imaging study of the C6 vertebral region of a goat with epidural empyema. A – On transverse T2w at the cranial aspect of C6 vertebra, the spinal cord (white arrow) is severely flattened, taking on a crescent shape, and is displaced to the right by an extradural mass (open arrow) that has expanded the C6 vertebral foramen and depressed the left dorsal aspect of the vertebral body. Small fluid spaces are present at the center of the lesion (open arrowhead). Despite the remodelling of C6, the signal intensity of the C6 vertebra is normal. B – On the corresponding T1w image, a thin hyperintense rim (arrow) surrounds the mass. C – There is peripheral enhancement of the mass on post-contrast, T1w Dixon fat suppression images (arrowhead).
inhabitant of the alimentary and respiratory tracts but does survive in soil (31). It is possible that *F. necrophorum* was inoculated into the neck from the oral cavity of the donkey that attacked the goat. More likely, soil containing *F. necrophorum* may have contaminated a skin wound sustained during the attack. Although not observed initially, evidence of a skin wound was later discovered as a scar on the lateral side of the neck in the region of the C6 vertebra. Perineural spread of *F. necrophorum* was supported by the location of empyema which was centered in the epidural space at the C5-C6 intervertebral foramen and was invested around the C6 spinal nerve. Alternatively, bacteria may have gained access to the epidural space through direct penetration or extension along fascial planes. Had bacteria gained access to the epidural space by direct penetration or extension along fascial planes, abscessation in the cervical musculature likely would have occurred. Neither external drainage from an abscess nor identification of abscessation of cervical muscles on MRI was observed.

Although tetraparesis was explained by spinal cord compression, what remains unclear is an explanation for the immediate onset of tetraparesis following the initial trauma. Imaging findings consistent with a traumatic injury were lacking. Had MRI been performed at the time of the initial trauma evidence of spinal cord injury may have been identified. However, 43 d later, imaging findings of trauma had resolved or had become obscured due to bone modelling from pressure atrophy by the empyema.

Ampicillin initially was selected for perioperative antimicrobial therapy. Florfenicol was added to extend the anaerobic coverage, given the malodor of the exudate. Florfenicol and tulathromycin are both labeled for the treatment of interdigital necrobacillosis caused by *F. necrophorum* in cattle. As no antimicrobials are labeled in goats for the treatment of *F. necrophorum* infections, extra-label use of florfenicol was selected based on the organism and later altered to tulathromycin given hyperthermia and leukocytosis. Importantly, an extended withdrawal period (365 d) was prescribed, given prolonged antimicrobial usage. Determining an endpoint for antimicrobial therapy was based on clinical response and the absence of clinicopathologic data consistent with systemic inflammation. Repeated MRI also would have aided in determining a treatment end point.

Although cervical radiography revealed extensive bone modelling (expansion of the vertebral canal and intervertebral foramen) consistent with chronic pressure atrophy, MRI provided a more detailed assessment. In humans, epidural empyema appears as a T1 hypointense and T2 hyperintense extradural mass. In dogs, the MRI appearance of epidural empyema is similar to that in humans (2). Occasionally, T2-hyperintensity also is present in the spinal cord along with changes in the paraxial musculature (2). Post-contrast imaging varies with chronicity. Early on, homogeneous to heterogeneous enhancement of the entire mass is seen (32,33). As in the present case, a non-contrast enhancing central core of liquid or inspissated pus surrounded by a peripheral enhancing rim of granulation tissue is seen chronically (32,33). Similar patterns of peripheral and diffuse contrast enhancement are seen in dogs with epidural empyema but may not correlate with chronicity (2). The MRI characteristics of the lesion described herein differ in that the bulk of the lesion displayed low intensity in T2w and T1w images. This combination of signal intensities was likely related to a fluid-poor composition of the desiccated/inspissated purulent material. In nonpyogenic infections such as fungi that contain paramagnetic and ferromagnetic elements, low intensity T2w and T1w lesions may be observed (34).

The MRI helped guide the decision to pursue surgical decompression. Factors such as the discrete nature of a lesion, its craniocaudal extent, and resultant degree of spinal cord compression are crucial features that guide surgical decisions in humans with epidural empyema (35). Affected dogs are often treated by surgical decompression; however, affected dogs also may be treated with antimicrobials alone (4,5). Given the severity and progression of the neurologic deficits combined with the location and extent of spinal cord compression in the present case, spinal cord decompression by a dorsal laminectomy was pursued. Dorsal laminectomy has been used successfully in a calf with epidural empyema at C3-C4 (13). In the present case, removal of the articular process joint and portions of the pedicles provided greater access to the empyema and likely assisted in the extirpation of the lesion without apparent adverse effects. Moreover, the thick capsule was strong enough to be grasped and to have traction applied, which facilitated removal of the empyema. Except for the aspect of the capsule that was strongly adhered to the ventral meninges, most of the empyema could be removed en bloc. The inadvertent meningeal tear negated the need to consider whether to perform a durotomy to remove the aspect of the capsule attached to the meninges. Clearly, the potential consequence of performing a durotomy was creating septic meningitis/myelitis which was presumed not present before surgery. Although preoperative analysis of CSF was not performed, evidence of meningomyelitis such as extensive meningeal enhancement was absent on the MRI. The persistent leukocytosis may have reflected meningomyelitis, may have been a consequence of empyema that remained after surgery, or may have reflected an inflammatory focus elsewhere in an unrelated organ system such as pneumonia or pulmonary abscessation. One month after surgery, CSF was normal. Despite this, it remains unknown whether meningomyelitis developed after surgery. However, the long-term success of the goat herein suggested that if meningomyelitis had developed, prolonged antimicrobial therapy aided in the elimination of the infection.

In summary, the observation made with MRI played a valuable role in the decision to pursue decompressive surgery and in guiding the extent of the laminectomy and pediculectomy. While early surgical intervention is performed in humans, successful outcomes may occur in chronically affected people (36). Despite a prolonged nonambulatory state, surgical decompression and prolonged antimicrobial therapy in this case were successful in the return of normal function. It is difficult to extrapolate the success of a single case to treatment recommendations for other affected animals. In the case of epidural empyema, it is unlikely that many similar cases in goats will be identified, imaged, and treated to enable critical evaluation of a large case series. Moreover, failed efforts are unlikely to be reported in the literature. Recognizing the inherent weakness
of anecdotal experience, the present case may provide practitioners with valuable information to remain optimistic in an area otherwise devoid of evidence-based data.

References

Commercial diet recommendations and follow-up for a large breed puppy with an intrahepatic portosystemic shunt

Caitlin E. Grant, Sarah Dodd, Sarah K. Abood, Adronie Verbrugghe

Abstract — A 6-month-old, intact male Great Dane dog fed a veterinary therapeutic liver diet was evaluated after diagnosis of an intrahepatic portosystemic shunt and hind limb angular limb deformity to determine appropriateness of diet. Evaluation of the current diet revealed it to be inadequate to meet the nutrient requirements of a large breed puppy. The dog clinically improved following a change in diet. There was no longer any angular limb deformity and no reported neurological signs. This report highlights the importance of appropriate feeding management during growth and demonstrates that although veterinary therapeutic diets may appear to be an appropriate choice initially, they may not be ideal for growing puppies as a long-term feeding option.

Key clinical message: A 6-month-old, intact male Great Dane dog was presented to the Ontario Veterinary College- Health Sciences Centre (OVC-HSC), Companion Animal Surgery Service for discussion of surgical correction of a previously diagnosed intrahepatic portosystemic shunt (PSS).

The dog had been surrendered by the breeder to a veterinarian in Michigan, USA at 8 wk of age for failure to thrive. The veterinarian elected to pursue further testing including a complete blood (cell) count (CBC), serum biochemistry, and measurement of bile acids. The dog was anemic with decreased hemoglobin. There were abnormalities with mean corpuscular hemoglobin (MCH), mean corpuscular hemoglobin concentration (MCHC), and reticulocyte hemoglobin. Other abnormal findings included leukocytosis, monocytosis, hypernatremia, hypoproteinemia, hypoalbuminemia, hypoglobulinemia, hypocholesterolemia, decreased amylase and lipase, increased creatine kinase (CK), and elevated pre-prandial bile acids (Tables 1, 2).

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A second bile acid panel was performed, and pre- and post-prandial bile acids were elevated (Table 2). It was reported in the medical record that the dog had demonstrated neurological signs, consistent with hepatic encephalopathy, but these signs were controlled with medical management. No details regarding a description of the neurological signs observed or the medications prescribed were recorded in the medical history provided. The dog was referred to the Animal Surgical Center of Michigan for a contrast computed tomography (CT) scan, which showed a large intrahepatic shunt entering the right lateral liver lobe. A diagnosis of congenital portosystemic shunt was made, and surgical correction was recommended. At this time, responsibility of the case was transferred from the primary care veterinarian to a Great Dane rescue service in Ontario, Canada. At 15 wk of age, the dog was taken to a primary care veterinarian in Ontario, Canada and blood analysis was performed to assess response to medical management. Findings included improvement in several parameters (Tables 1, 2). New findings included decreased urea and an increase in reticulocytes, which indicated a regenerative response to the anemia (Tables 1, 2). Bile acids were assessed and were increased compared to previous results (Table 2).

At 6 mo of age, the dog was presented to the OVC-HSC Surgery Service for evaluation of surgical corrective options for the diagnosed intrahepatic shunt. Physical examination was unremarkable except for a valgus angular limb deformity of both pelvic limbs noted on orthopedic examination. No clinical signs of hepatic encephalopathy were noted. Medical management included metronidazole [7.5 mg/kg body weight (BW), PO, q12h] and lactulose (dose not listed in medical history). Surgical options were discussed; in particular, transvenous coil embolization. This procedure is performed when dogs are close to mature size to ensure that the stent is not too small (1) and involves the placement of a vascular stent in the vena cava at the level of the shunt (2). Embolic coils are then introduced to promote gradual occlusion. This can sometimes require multiple procedures to achieve adequate occlusion of the vessel (2). For some patients, the embolization procedure is enough to resolve clinical signs but in others, continued medical and dietary management are required (2).

Nutritional management of intrahepatic PSS was essential to consider in this case given the dog’s young age. The OVC-HSC Clinical Nutrition Service performed a nutritional assessment and identified risk factors using the WSAVA Nutritional Assessment Checklist (3). A comprehensive diet history was taken using a standard diet history form. After diagnosis of the intrahepatic PSS at 8 wk of age and until 19 wk of age, the dog was fed a veterinary therapeutic liver diet (Diet A; Hill’s Prescription Diet L/d canine (Dry), Hill’s Pet Nutrition, Topeka, Kansas, USA). Details about amount and feeding regimen were not reported and diet history before that time was not known. From 19 wk of age until 6 mo of age, the puppy was fed a different veterinary therapeutic liver diet (Diet B; Royal Canin Veterinary Exclusive Hepatic (Dry), Royal Canin Canada, Guelph, Ontario). He was fed a total of 2.5 cups 3 times per day at the time the diet history was taken, and any adjustments of amounts fed before that were not reported. For treats, he received a few small pieces of cheddar cheese, a veterinary therapeutic multi-purpose diet (Diet C; Hill’s Prescription Diet w/d Multi-Benefit Canine dry, Hill’s Pet Nutrition), and 2 tablespoons of Kraft smooth peanut butter delivered in a Kong toy each day. The dog weighed 27 kg and he had a body condition score (BCS) of 4 on a 9-point scale (4). The dog was also noted to have bilateral angular limb deformity in the hind limbs.

According to the Association of American Feed Control Officials (AAFCO) Nutritional Adequacy Statement on the product label, Diet B is formulated to meet the nutritional requirements for adult maintenance (5). Diet A has an AAFCO nutritional adequacy statement for growing puppies based on feeding trials, even though the nutrient content does not fit with the AAFCO puppy growth profile. Puppy feeding trials do not typically use large breed puppies; therefore, Diet A was...
also not an ideal choice for this dog. Requirements for essential nutrients for growth according to AAFCO and the United States National Research Council (US NRC) (6) are listed in Table 3 and compared to the nutrient content of the diets as provided by the manufacturers. Due to inadequate protein, calcium (Ca), phosphorous (P), and copper (Cu), neither Diet A nor B met the requirements for growth. Thus, through evaluation of the current diet and assessment of the dog’s nutritional needs, the diet was deemed to be inappropriate.

Based on the diet history provided, it was estimated that the puppy was receiving approximately 2700 kcal metabolizable energy (ME) per day from his daily allotment of 7.5 cups of food. This did not include any food used as treats or fed in the Kong toy. The total calories from these sources was unknown because the amount of Diet C used in the Kong toy was not measured. However, 2 tablespoons of peanut butter would equal approximately 192 kcal ME. A range of estimated energy requirement was calculated using the equation 70 × body weight in kg0.75 multiplied by a factor of 2 or 3 (2 for puppies over 4 mo of age and 3 for puppies younger than 4 mo of age) (7). The dog in this case was over 4 mo of age at the time of the nutritional assessment and, using a daily energy requirement (DER) factor of 2, yielded 1658 kcal/d (over 1000 kcal lower than the current estimated calorie intake). It was discussed with the owner that this energy intake seemed high and would likely need to be decreased to prevent rapid growth. Still, given the lack of diet history during the early months of puppyhood and since the dog had an ideal body fat percentage based on BCS assessment (8), the initial plan was to meet the dog’s current energy intake and change the food type first. Close follow-up and re-assessment of food intake, body weight (BW), and BCS were recommended to inform adjustment of the food amount if needed.

A veterinary therapeutic diet indicated for liver dysfunction [Diet D; Royal Canin Veterinary Exclusive Vegetarian (Dry), Royal Canin Canada] was selected (Table 3). At the time of recommendation, this diet had undergone feeding trials for growth, although it did not meet the AAFCO nutrient profile for growth. To meet a calorie intake of 2700 kcal ME, a daily food amount of 143 g was prescribed. Gradual transition from Diet B to Diet D was recommended over 15 d to monitor for any neurological symptoms with a higher amount of dietary protein. To minimize the amount of protein delivered in one meal, a feeding management strategy of smaller portions fed in a greater number of meals per day was recommended. In Table 4, the US NRC recommended allowance (RA) for protein is compared to the total protein intake when the dog was fed to maintain body weight using Diet B compared to Diet D. The dog was not able to meet the US NRC RA for protein when consuming Diet B but was above the US NRC RA when fed Diet D. Furthermore, intake of nutrients essential for skeletal growth (Ca, P, and Cu) were much improved with Diet B but was above the US NRC RA when consum-

### Table 2. Serum biochemistry and pre- and post-prandial bile acids at time of diagnosis (8 wk of age) and following medical and nutritional intervention (15 wk and 12 mo of age) in a Great Dane puppy with an intrahepatic portosystemic shunt.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>8 wk</th>
<th>15 wk</th>
<th>12 mo</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Serum biochemistry</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Glucose (mmol/L)</td>
<td>L 5.83 (6.8 to 8.8)</td>
<td>8.6 (5.4 to 9.2)</td>
<td>5.79 (4.2 to 6.6)</td>
</tr>
<tr>
<td>Urea (BUN) (mmol/L)</td>
<td>8.57 (6.43 to 22.1)</td>
<td>L 2.3 (3.2 to 11)</td>
<td>2.7 (2.5 to 9.6)</td>
</tr>
<tr>
<td>Creatinine (μmol/L)</td>
<td>26.5 (23 to 58)</td>
<td>L 23 (24 to 78)</td>
<td>H 83 (19 to 79)</td>
</tr>
<tr>
<td>P (mmol/L)</td>
<td>3.39 (2.7 to 3.6)</td>
<td>2.9 (1.8 to 3.1)</td>
<td>1.57 (1.1 to 2.5)</td>
</tr>
<tr>
<td>Ca (mmol/L)</td>
<td>H 158 (142 to 152)</td>
<td>L 2.4 (2.5 to 3.3)</td>
<td>2.37 (2.6 to 3.0)</td>
</tr>
<tr>
<td>Sodium (mmol/L)</td>
<td>4.5 (4 to 5.4)</td>
<td>4.9 (3.9 to 6.1)</td>
<td>4.9 (4.2 to 5.6)</td>
</tr>
<tr>
<td>Potassium (mmol/L)</td>
<td>35</td>
<td>30</td>
<td>31</td>
</tr>
<tr>
<td>Na+/K</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chloride (mmol/L)</td>
<td>H 124 (108 to 119)</td>
<td>114 (108 to 119)</td>
<td>112 (109 to 122)</td>
</tr>
<tr>
<td>Total protein (g/L)</td>
<td>L 2.6 (4.0 to 5.3)</td>
<td>40 (45 to 73)</td>
<td>H 85 (19 to 79)</td>
</tr>
<tr>
<td>Albumin (g/L)</td>
<td>L 12 (27 to 39)</td>
<td>23 (22 to 35)</td>
<td>35 (22 to 45)</td>
</tr>
<tr>
<td>Globulin (g/L)</td>
<td>L 14 (24 to 40)</td>
<td>0.7</td>
<td>0.7</td>
</tr>
<tr>
<td>A/G Ratio</td>
<td>0.9</td>
<td>9 (&lt; 32)</td>
<td>H 54 (5 to 45)</td>
</tr>
<tr>
<td>ALT (IU/L)</td>
<td>16 (10.3 to 24.3)</td>
<td>H 24 (3 to 23)</td>
<td>—</td>
</tr>
<tr>
<td>AST (IU/L)</td>
<td>30 (16 to 55)</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>ALP (IU/L)</td>
<td>485 (153 to 527)</td>
<td>291 (126 to 438)</td>
<td>252 (4 to 252)</td>
</tr>
<tr>
<td>T. Bili (Total) (μmol/L)</td>
<td>1.7 (0.0 to 5.13)</td>
<td>2.1 (0.0 to 5.13)</td>
<td>&lt; 2 (0 to 15)</td>
</tr>
<tr>
<td>D. Bili (Conj.) (μmol/L)</td>
<td>&lt; 1.7 (0.0 to 3.42)</td>
<td>0.6 (0 to 3.42)</td>
<td>—</td>
</tr>
<tr>
<td>Cholesterol (mmol/L)</td>
<td>L 1.5 (3.8 to 9.0)</td>
<td>4.1 (2.6 to 12.9)</td>
<td>L 2.4 (3.5 to 7.2)</td>
</tr>
<tr>
<td>Amylase (IU/L)</td>
<td>L 221 (337 to 1469)</td>
<td>391 (337 to 1469)</td>
<td>690 (500 to 1500)</td>
</tr>
<tr>
<td>Lipase (IU/L)</td>
<td>L 123 (138 to 755)</td>
<td>128 (&lt; 139)</td>
<td>H 426 (&lt; 154)</td>
</tr>
<tr>
<td>Creatinine kinase (IU/L)</td>
<td>H 304 (10 to 200)</td>
<td>H 280 (40 to 192)</td>
<td>—</td>
</tr>
<tr>
<td><strong>Bile Acids</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bile acids — pre-prandial (μmol/L)</td>
<td>H 41.3 (0 to 6.9)</td>
<td>H 115 (0 to 6.9)</td>
<td>H 312 (0 to 6.9)</td>
</tr>
<tr>
<td>Bile acids — post-prandial (μmol/L)</td>
<td>H 75.9 (0 to 14.9)</td>
<td>—</td>
<td>—</td>
</tr>
</tbody>
</table>

* Reference range from von Dehn 2014 (37).  
H — High (above reference range); L — Low (below reference range); ALT — alanine aminotransferase; AST — aspartate aminotransferase; ALP — alkaline phosphatase.
Follow-up contact was available for 7.5 mo during which the patient had been fed the prescribed diet. After transition, he was weighed frequently to establish a growth curve. The dog had gained 6 kg in less than 1 mo from the initial nutrition consultation at 6 mo of age, so his daily caloric intake was reduced by 10%. This weight gain was larger than expected, although it is important to note that the second weight was obtained by the owner, using a different scale and might have been recorded at a different time during the day. Nevertheless, such a growth spurt should be avoided because rapid growth can harm skeletal development and close follow-up, especially after starting a diet plan, is important. From then on, the dog’s owner felt comfortable monitoring his BW and BCs and would adjust daily food amounts as needed. The owner followed up monthly with a BW to include in a growth curve (Figure 1). At 12 mo of age, the dog weighed 54.5 kg and had a BCS of 4/9. His angular limb deformity had completely resolved as noted on orthopedic examination. Blood analysis was performed by the family veterinarian (Table 1); anemia had completely resolved, and total protein, albumin, and globulin were within normal ranges. Bile acids were still markedly elevated (Table 2); however, the dog showed no clinical symptoms associated with decreased liver function and was deemed to be thriving on medical and nutritional management. Surgical correction of the PSS was completed at 15 mo of age, and the dog made an uneventful recovery. At the time of surgery, the dog’s body weight was 57 kg.

### Table 3. Comparison of 3 veterinary exclusive therapeutic diets fed to a Great Dane puppy with a portosystemic shunt, to the US NRC 2006 RA and 2019 AAFCO growth requirements.

<table>
<thead>
<tr>
<th></th>
<th>US NRC 2006 RA (6)</th>
<th>AAFCO Growth 2019 (5)</th>
<th>Diet A</th>
<th>Diet B</th>
<th>Diet D</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy (kcal ME/kg)</td>
<td>—</td>
<td>—</td>
<td>405</td>
<td>395.5</td>
<td>359.4</td>
</tr>
<tr>
<td>Protein (g)</td>
<td>43.8&lt;sup&gt;a&lt;/sup&gt;</td>
<td>56.3</td>
<td>41</td>
<td>40.5</td>
<td>52.9</td>
</tr>
<tr>
<td>Ca (g)</td>
<td>3.0</td>
<td>3.0 to 4.5&lt;sup&gt;b&lt;/sup&gt;</td>
<td>1.8</td>
<td>1.9</td>
<td>2.3</td>
</tr>
<tr>
<td>P (g)</td>
<td>2.5</td>
<td>2.5 to 4.0</td>
<td>1.4</td>
<td>1.3</td>
<td>1.5</td>
</tr>
<tr>
<td>Copper (mg)</td>
<td>2.7</td>
<td>3.1</td>
<td>1.1</td>
<td>1.0</td>
<td>4.2</td>
</tr>
<tr>
<td>Zinc (mg)</td>
<td>25</td>
<td>25</td>
<td>69</td>
<td>62</td>
<td>53.4</td>
</tr>
<tr>
<td>Ca:P ratio</td>
<td>—</td>
<td>1:1 to 1.8:1&lt;sup&gt;b&lt;/sup&gt;</td>
<td>1.3</td>
<td>1.5</td>
<td>1.5</td>
</tr>
<tr>
<td>Vitamin D (IU)</td>
<td>300</td>
<td>125 to 750</td>
<td>227</td>
<td>253</td>
<td>278</td>
</tr>
<tr>
<td>EPA + DHA (g)</td>
<td>0.13</td>
<td>0.1</td>
<td>0.134</td>
<td>0.5</td>
<td>0</td>
</tr>
</tbody>
</table>

<sup>a</sup> For puppies > 14 wk of age.
<sup>b</sup> For puppies with adult weight > 70 lbs.
Diet A — Hill’s Prescription Diet L/d Canine (Dry).
Diet B — Royal Canin Veterinary Exclusive Hepatic (Dry).
Diet D — Royal Canin Veterinary Exclusive Vegetarian (Dry).

### Discussion

Nutritional management for growing animals with liver shunts can be challenging. A key nutrient of concern for both growth and liver disease is protein. If the liver is not functioning well, its ability to metabolize protein and amino acids can be compromised (11). Improper amino acid metabolism can result in a build-up of waste products (ammonia) in the blood (12). Ammonia can cross the blood brain barrier and hyperammonemia can then cause neurologic signs such as lethargy, ataxia, hypersalivation, head pressing, and seizures (12). If animals are showing these signs, this is an indication to modify dietary protein intake (13). One approach is to switch the patient directly to a restricted-protein diet. An individualized method in which protein intake is estimated and reduced is preferred. Growing animals provide a specific challenge because protein requirements for growth are higher than in adult animals. A second approach is to consider the sources of dietary protein (10,14,15). The liver is the site for degradation of aromatic amino acids but not branched chain amino acids; thus, using protein ingredients with a higher proportion of branched chain amino acids compared to aromatic amino acids could be beneficial (14). These ingredients are usually vegetarian (non-animal tissue) protein sources such as egg or soy, which was also the case for all 3 diets (Diets A, B, and D) considered for this dog. Although the source of protein has been suggested as a consideration for dogs with liver disease, research determined no difference in improvement of neurologic signs when a low protein vegetarian diet was compared to an equally low protein diet with chicken (15). This suggests that a lower protein level is more important than the source of protein for patients with hepatic encephalopathy. It is important to note that dogs have requirements for several indispensable amino acids and not just an absolute requirement for protein. A side effect of decreasing protein intake is that intake of the indispensable amino acids will also be decreased. The consequence of deficient amino acid intake depends on the amino acid, but in general deficiency can cause depressed growth (6). This is another reason why it is essential to consider the protein intake of growing puppies and to avoid restriction of protein if possible. If restriction is necessary, then the profile of amino acids must be carefully considered. Furthermore, selecting a low protein diet formulated for adult dogs may create a problem for growing puppies not only because of the lower protein content, but because concentrations of other nutrients important for skeletal development may be lower. This was the case with the dog described.

Calcium and phosphorus are essential for skeletal development. The literature in this area focuses on consequences of excess intake, although in this case the dog likely had a deficient intake of both Ca and P. Growing puppies require higher levels...
Table 4. Comparison of nutrient intake at 2700 kcal ME for 3 veterinary exclusive therapeutic diets fed to a 27 kg Great Dane puppy with a portosystemic shunt, to US NRC 2006 RA growth requirements.

<table>
<thead>
<tr>
<th>Amount per kg BW&lt;sup&gt;0.75&lt;/sup&gt;</th>
<th>US NRC 2006 RA (g)</th>
<th>Intake Diet A (g, 3 meals)</th>
<th>Intake Diet B (g, 4 meals)</th>
<th>Intake Diet D (g, 6 meals)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Protein (g)</td>
<td>12.2</td>
<td>9.35</td>
<td>9.23</td>
<td>12.06</td>
</tr>
<tr>
<td>Ca (g)</td>
<td>0.68</td>
<td>0.41</td>
<td>0.43</td>
<td>0.52</td>
</tr>
<tr>
<td>P (g)</td>
<td>0.68</td>
<td>0.32</td>
<td>0.30</td>
<td>0.34</td>
</tr>
<tr>
<td>Copper (mg)</td>
<td>0.76</td>
<td>0.25</td>
<td>0.23</td>
<td>0.26</td>
</tr>
<tr>
<td>Zinc (mg)</td>
<td>6.84</td>
<td>15.73</td>
<td>14.13</td>
<td>12.17</td>
</tr>
<tr>
<td>Vitamin D (IU)</td>
<td>38.4</td>
<td>51.74</td>
<td>57.67</td>
<td>63.37</td>
</tr>
<tr>
<td>EPA + DHA (g)</td>
<td>0.0036</td>
<td>0.03</td>
<td>0.11</td>
<td>0</td>
</tr>
</tbody>
</table>

US NRC — United States National Research Council; RA — Recommended allowance; Ca — Calcium; P — Phosphorus; DHA — Docosahexaenoic acid; EPA — Eicosapentaenoic acid.

* For puppies ≥ 14 wk of age.

Diet A — Hill’s Prescription Diet L/d Canine (Dry).
Diet B — Royal Canin Veterinary Exclusive Hepatic (Dry).
Diet D — Royal Canin Veterinary Exclusive Vegetarian (Dry).

Table 5. Protein intake in a Great Dane puppy with a portosystemic shunt using 2 veterinary therapeutic foods when fed 1, 3, 4, or 6 meals.

<table>
<thead>
<tr>
<th>Manufacturer/Brand</th>
<th>Total protein per meal (g, x meals)</th>
<th>Total protein per meal (g, x meals)</th>
<th>Total protein per meal (g, x meals)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diet B</td>
<td>118&lt;sup&gt;a&lt;/sup&gt;</td>
<td>109</td>
<td>36</td>
</tr>
<tr>
<td>Diet D</td>
<td>143</td>
<td>48</td>
<td>36</td>
</tr>
</tbody>
</table>

<sup>a</sup> Based on US NRC RA of 43.8 g/1000 kcal ME.

<sup>b</sup> Based on 2700 kcal ME.

Diet B — Royal Canin Veterinary Exclusive Hepatic (Dry).
Diet D — Royal Canin Veterinary Exclusive Vegetarian (Dry).

Figure 1. Growth curve in a Great Dane puppy with an intrahepatic portosystemic shunt following medical and nutritional intervention starting at 26 wk of age weighing 27 kg ending at 66 wk of age (15 mo) weighing 57 kg.

of dietary Ca and P compared to adult dogs; however, large breed puppies do better when dietary Ca intake is kept below the maximum level accepted for small- and medium-sized breed puppies (5,16–19). The range of dietary Ca acceptable for growth in puppies is 3.0 to 6.25 g/1000 kcal ME, whereas the range for large breed puppies is 3.0 to 4.5 g/1000 kcal ME (6,16). Phosphorus deficiency has been reported in puppies with clinical signs ranging from reduced growth (6,20) to poor appetite, emaciation, and bowing and swelling of forelimbs and carpi (6,21). Phosphorous is required in amounts between 2.5 and 4 g/1000 kcal ME for growing puppies (5) and recommendations should be made with consideration of the calcium level (16). On a body weight basis, US NRC recommends a Ca and P intake of 0.68 g/kg BW<sup>0.75</sup> and in this case, intake was much lower for Ca and P (Table 4).

A narrower range of dietary Ca and the Ca:P ratio (1.1:1 to 1.8:1 rather than 1:1:1 to 2:1), have been shown to decrease the risk of bone deformities in large breed puppies (18,22,23). A Ca:P ratio that is too low can lead to nutritional secondary hyperparathyroidism, although this is more related to Ca deficiency rather than an excess of phosphorus (18). When there is low circulating Ca, this signals parathyroid hormone to upregulate the metabolism of vitamin D to its active metabolite 1,25-dihydroxyvitamin D [1,25(OH)2D]. This increase in 1,25(OH)2D stimulates increased intestinal absorption and decreased renal excretion of both Ca and P. Also, 1,25(OH)2D stimulates increased osteoclast activity and releases Ca and P from bone (24). This keeps circulating levels of Ca within a tight biological range (24).

Copper is required in the diet of growing puppies and is recommended in the amount of 0.76 mg/kg BW<sup>0.75</sup> daily (Table 4) (6). Copper intake in the dog described herein was below this amount and at 0.23 mg/kg BW<sup>0.75</sup> when fed Diet B. Low dietary copper intake for 3 months’ duration in growing puppies affects pigmentation of hair and skin (25). In this same study, dogs showed evidence of skeletal injury as noted by hyperextension of distal phalanges after only 1 additional month of low dietary copper intake (25).

Accelerated growth rates cause a rapid change in body size during the growth period and increase the risk of bone deformities in large breed puppies (1,9,16). High energy intake negatively affects the musculoskeletal system development during growth including development of angular limb deformities (8,16,17,26). Thus, to reduce the risk of bone deformities in young, large breed dogs, control of energy intake to prevent rapid weight gain is key. This can be achieved by accurately measuring food portions, meal feeding instead of ad libitum feeding, and not overfeeding treats and snacks (16). In this...
case, energy intake was calculated to be 2700 kcal ME/d from the diet alone. This energy intake is high when compared to requirements using various energy equations (27,28). More than 25 y ago researchers reported that Great Danes between the ages of 2 and 6 mo have an energy requirement equal to 0.74 to 0.81 MJ/body weight in kg^{0.75} per day (29). Using that equation for this patient would yield between 2100 and 2300 kcal ME/d. According to the US NRC, the daily metabolizable energy requirements for growth of puppies after weaning is equal to

\[ 130 \times BW_a^{0.75} \times 3.2 \times [e^{-0.87p} - 0.1] \]

where: \( p \) is BW_{m}/BW_{a}, BW_{a} represents actual body weight, BW_{m} represents expected mature weight, and \( e \) is the base of natural log (\( \approx 2.718 \)) (6). A more recent study investigated energy intake and growth in privately owned dogs (30). The ME intake was determined to be considerably lower than the US NRC recommendations and researchers developed a linear equation to predict energy requirements (30). Using this equation, energy intake for the dog in this case should be close to 2200 kcal ME. The equation used in this case study was 70 \( \times BW^{0.75} \) multiplied by a factor of 2 or 3 to give an estimated range (27). Although these equations are important for estimating energy requirements, a review of energy requirements of adult dogs determined that estimations based on body weight alone may not be accurate and that other factors such as husbandry, neuter status, and activity level may be more important (31). Thus, energy requirements based on body weight could be considered starting points since individual animals differ in activity level and husbandry.

The use of BCS and expected adult weight have been the most common methods for assessing optimal growth in puppies. Body condition scoring as a tool to assess growth should be used with caution, however, as puppies can have a normal BCS but weigh too much for their age. A more appropriate assessment is to use a growth curve (32,33). Growth curves are useful tools for determining if a puppy is following an expected pattern of growth; dog standards charts have been developed for dogs of different sizes (33). These charts have been established for dogs with an adult body weight up to 40 kg but have not yet been established for giant breed dogs with adult body weights \( > 40 \) kg. A study in 2004 investigated growth curves for 12 different sized dog breeds, including Great Danes, and it was determined that their average mature weight was 51.1 kg (32). The sample size for this study was small (11 Great Danes; 6 males and 5 females) and the averages were not reported for each sex. More recently, researchers reported that by using the adult body weight of a patient, the target BW during growth could be calculated as a percentage of adult body weight (34). A limitation with this method is that adult body weight must be known and if a patient was below or above average as an adult; the targets for growth may not be as accurate.

A growth curve was made for this dog using body weights provided by the owner as shown in Figure 1; however, there were several limitations. These included infrequent weight updates from the owner and lack of body weight data before 6 mo of age. Under ideal conditions, body weight data would be available from birth and would be monitored weekly or biweekly until mature weight was reached.

Nutrient comparisons for this case study were made between AAFCO and US NRC recommendations and nutrient profiles of the diets. There are some differences between AAFCO requirements and US NRC requirements, particularly for protein. The protein requirement differs because the AAFCO minimum is for puppies of all ages, whereas the US NRC has separate requirements for puppies younger and older than 14 wk. Also, the US NRC reports nutrient content in the food as well as individual animal requirements, whereas AAFCO only recommends nutrient content in the food. Most nutrient requirements according to AAFCO are higher than the US NRC requirements, due to consideration of digestibility and bioavailability. Another consideration is to compare the actual nutrient intake based on energy intake relative to US NRC requirements on a per kg BW^{0.75} basis. This dog’s energy intake was high, and it could be assumed that intake of key nutrients would be greater than expected if the animal were eating more calories. As illustrated in Table 4, even though the dog was consuming a high number of calories, the intake of protein, Ca, P, and Cu was still below the US NRC RA.

Diets options for this dog included supplementation of the current diet, formulation of a balanced homemade diet, or selection of a more appropriate therapeutic diet. Each of these options was considered for this dog and discussed (or presented) to the owner. Although key nutrients were still less than the US NRC RA for a 27 kg growing dog, consuming Diet D would result in intakes of protein, Ca, P, and Cu better than Diet A or Diet B. The owner thought that a homemade diet would be too labor-intensive and elected to feed a single commercial diet; therefore, the authors felt Diet D was the better option.

It is important to consider feeding management strategies that could have a positive effect on disease treatment or management. A feeding management strategy used in this case was feeding more frequent, smaller meals throughout the day (Table 5). When protein cannot be restricted to the level in the therapeutic liver diets, titrating postprandial blood ammonia peak through multiple small meals, with the addition of soluble fiber if needed, can be another approach. This strategy of feeding multiple small meals will help to optimize blood nitrogen concentration in the liver and minimize episodes of hepatic encephalopathy (35). Furthermore, multiple feedings will reduce the volume of ingested food entering the colon, the site of bacterial fermentation, at a given time (10). Studies in humans with liver failure have shown that multiple small meals can improve nitrogen balance (36); therefore, there is good reason to suspect that the same might be true in dogs with liver disease.

In conclusion, it is of utmost importance to provide adequate nutrition during the nutrient sensitive growth period to support development of puppies. Many commercial foods have been formulated to meet the nutritional requirements for growth or have undergone feeding trials to demonstrate adequacy when fed to puppies. Unfortunately, growing animals are not immune to development of clinical conditions for which nutrient intake should be considered and modified. This poses a problem that can be challenging for pet owners and veterinarians when determining the best food to feed a growing dog that also has a medical condition necessitating the restriction of a nutrient essential for growth.
This case report featured a large breed puppy diagnosed with a PSS and requiring modification of dietary protein intake. It also highlights the importance of individualized nutritional management. Through careful consideration of key nutrients of concern and through feeding management strategies, a strategy was developed to meet the needs for optimal growth and correct a bone deformity from inappropriate nutrition. The diet was selected in this specific case to provide improved nutrition, balancing various nutritional goals, although this diet may not be considered appropriate for a healthy puppy. It is also important to note that since this time, changes to the diet formulation have been made and the growth claim no longer applies. Veterinary professionals must be aware that diet composition can change under the same circumstances in the future. This solution also assisted in management of a PSS through elimination of all neurological signs until surgical correction was performed.

Acknowledgments
We thank the dog’s owner for compliant follow-up and commitment to the nutrition plan. We also thank all members of the veterinary health care teams who had a role in the care of this dog, including the OVC-HSC Surgery Service who performed the surgical correction of the dog’s shunt.

References
Brief Communication Communication brève

Pure cystine and urate calculi can be clearly visible using survey digital radiography

Esther Nell, Stephen Q. Garofolo, Christopher Ober

Abstract — Cystine and urate calculi are considered nonradiopaque to faintly radiopaque. Two canine cases in which these types of calculi are radiopaque and clearly apparent in vivo on survey digital radiography are described. The densities of cystine and urate calculi, as determined in vitro with computed tomography, are compared to other pure calculi and mixed or compound calculi to further explore the relative attenuation characteristics.

Résumé — Les calculs de cystine et d’urate purs peuvent être clairement visibles à l’aide de la radiographie numérique standard. Les calculs de cystine et d’urate sont considérés comme non radio-opaques à faiblement radio-opaques. Deux cas canins dans lesquels ces types de calculs sont radio-opaques et clairement apparents in vivo sur la radiographie numérique standard sont décrits. Les densités de calculs de cystine et d’urate, telles que déterminées in vitro par tomodensitométrie, sont comparées à d’autres calculs purs et des calculs mixtes ou composés pour explorer davantage les caractéristiques d’atténuation relatives.


Urolithiasis is common in dogs (1). Cystine and urate urinary calculi are considered to be nonradiopaque to faintly radiopaque (2). The main goal of this brief communication is to report 2 cases of in vivo survey digital radiographic identification of cystine and urate urinary calculi in 2 canine patients. There are few peer-reviewed reports of cystine or urate calculi detected in vivo on survey radiography in dogs and cats, with even fewer available radiographic images (3–6). A secondary aim is to report computed tomographic attenuation values of cystine and urate calculi compared with other calculi to explore the role of density in the radiographic findings described in vivo.

The first case is a 2-year-old, intact male American pit bull terrier that was presented to the University of Minnesota 2 times over a period of 6 mo for stranguria. At each episode, multiple small calculi were identified within the urinary bladder on survey digital radiography (Vet Ray; Sedecal, Arlington Heights, Illinois, USA and Canon CXDI unspecified model, Melville, New York, USA) (Figure 1A). Urethral calculi were suspected, although not definitively identified due to soft tissue superimposition. Following retropulsion and stabilization, the calculi were subsequently removed via cystotomy and analyzed to be 100% cystine in both episodes.

The second case is an 8-year-old, neutered male Dalmatian dog that was presented with vomiting, anorexia, and straining to urinate. An 11 × 6 mm calculus was clearly identified within the plane of the urethra on survey digital radiography (Vet Ray; Sedecal) (Figure 1B). Two smaller urethral calculi, radiographically faint urinary bladder calculi, and a nephrolith were also seen. Following retropulsion and stabilization, calculi were removed via cystotomy and analyzed to be 100% ammonium urate. All calculus analyses were conducted by the Minnesota Urolith Center (University of Minnesota, St. Paul, Minnesota, USA).

To further explore the relationship between radiographic opacity and material density, several groups of calculi were evaluated in vitro using computed tomography (CT). The calculi were provided by the Minnesota Urolith Center. A urolith without a nidus, shell, or surface crystal layer that contained ≥ 70% of one type of mineral was identified by that mineral. A urolith with < 70% of one mineral but without a nidus, shell, or surface crystals was referred to as a mixed urolith. A urolith with an identifiable nidus and/or stone with ≥ 1 surrounding layer(s) of different mineral composition was called a compound urolith (7).

Uroliths were placed into individual plastic cups that had been partially filled with a clear gelatin substrate (Gelatine; Knox, Parsippany, New Jersey, USA), allowing the uroliths to rest approximately 5 mm above the bottom of the cups. Uroliths were then covered with 0.9% saline (8). Cups were arranged in a grid and then scanned using a helical CT scanner (Toshiba Aquilion 64 CFX CT; Toshiba, Tustin, California, USA) at 120 kV and 100 mAs and reconstructed in 0.5-mm slices using a soft tissue algorithm. Freeform regions of interest (ROI) were drawn on each sample calculus or the largest calculus in a sample...
of multiple calculi to obtain average Hounsfield units (HU), evaluated with a window level of 25 and a window width of 350. The ROI were drawn just within the visible calculi borders to ensure that the surrounding saline was not inadvertently included in the measurements.

Computed tomographic density values (HU) were evaluated using commercially available statistical software (JMP Pro 13.2.1; SAS Institute, Cary, North Carolina, USA). Means and standard deviations of HU for all non-mixed, non-compound calculi types with at least 3 specimens were calculated. One-way analysis of variance (ANOVA) procedures were performed to compare HU values among the groups of calculi, and when the ANOVA demonstrated significant differences among calculi, differences between pairs of groups were assessed using the Tukey-Kramer HSD Experiment-wise test. Statistical significance for analyses was set at $P < 0.05$.

Thirty-five calculi samples were obtained from 34 dogs. Two of the cystine samples were obtained from the first case described in this report. Twenty-nine of the samples were analyzed to be 100% pure in composition, including calcium oxalate ($n = 9$), cystine ($n = 6$), urate ($n = 3$), struvite ($n = 3$), silica ($n = 3$), xanthine ($n = 1$), potassium magnesium phosphate (PMP, $n = 1$), and calcium phosphate carbonate (CPC, $n = 1$). An additional struvite sample had a nidus composed of 5% CPC and a brushite sample had a nidus of 15% calcium oxalate; these samples did not meet criteria for categorization of mixed or compound. The remaining 6 samples were mixed or compound in composition.

Hounsfield units ranged from 219 to 1848, depending on the calculus type (Table 1). Brushite and calcium oxalate were the highest attenuating calculi, similar to previous results (8,9). The HU ranges for struvite, cystine, and urate in this study were similar to previous results (8,9). The HU obtained for the PMP, CPC, brushite, and xanthine samples were excluded from statistical analyses as only 1 sample for each of these calculi types was available. The HU obtained for silica, cystine, urate, and struvite were not statistically different from one another ($P > 0.2$ for all ordered differences). To the authors’ knowledge, measured HU of silica calculi has not been reported in veterinary medicine. The HU range for calcium oxalate was statistically different from silica, cystine, urate, and struvite calculi (all $P < 0.001$). The range of HU for mixed and compound calculi was broad and overlapped with ranges obtained for the other calculi types. For reference; distilled water is defined as having a value of 0 HU, the reported mean HU of canine urine is 35.6 and the HU of non-contrast enhanced liver is approximately 50 to 70 (10,11).

This report provides 2 examples in which calculi types that are historically considered to be non-radiopaque were readily identified in vivo on survey digital radiography. When evaluating the densities of representative cystine and urate calculi

of multiple calculi to obtain average Hounsfield units (HU), evaluated with a window level of 25 and a window width of 350. The ROI were drawn just within the visible calculi borders to ensure that the surrounding saline was not inadvertently included in the measurements.

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<table>
<thead>
<tr>
<th>Type</th>
<th>Hounsfield units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calcium oxalate</td>
<td>969 to 1496 (1141)</td>
</tr>
<tr>
<td>Struvite</td>
<td>487 to 643 (637)</td>
</tr>
<tr>
<td>Urate</td>
<td>431 to 539 (431)</td>
</tr>
<tr>
<td>Cystine</td>
<td>344 to 544 (427)</td>
</tr>
<tr>
<td>Silica</td>
<td>333 to 535 (408)</td>
</tr>
<tr>
<td>Brushite</td>
<td>1740</td>
</tr>
<tr>
<td>CPC</td>
<td>1123</td>
</tr>
<tr>
<td>PMP</td>
<td>908</td>
</tr>
<tr>
<td>Xanthine</td>
<td>219</td>
</tr>
<tr>
<td>Mixed/compound</td>
<td>332 to 1848</td>
</tr>
</tbody>
</table>

PMP — Potassium magnesium phosphate; CPC — Calcium phosphate carbonate.

Figure 1. Survey radiographs of dogs with cystine and urate urolithiasis. A — Cystine urinary bladder calculi (arrow) (kVp 81, mAs 10.2). B — A urate urethral calculus (arrow) (kVp 92, mAs 3.2).
as determined with CT, there was no difference between the density of cystine and urate calculi and reportedly radiopaque calculi. This supports the ability to recognize cystine and urate calculi radiographically, as density is one of the main factors determining radiographic attenuation (12). A previous study of urinary calculi obtained from dogs demonstrated poor accuracy of detection of cystine and urate calculi in vitro when evaluated using screen-film radiography (13). It is speculated that the relatively radiopaque nature of the calculi of the 2 in vivo cases herein is due in part to the greater contrast resolution of digital radiography compared to screen-film systems, acknowledging that direct comparison between screen-film and digital radiography was not made in these 2 cases (14). The greater contrast resolution in digital radiography is related to the wider dynamic range associated with digital imaging receptors when compared to the silver halide crystal system of screen-film radiography. The effect of other variables such as calculus size is also acknowledged (13). Large-scale, ideally in vivo, studies evaluating the accuracy of survey digital radiography (potentially with comparison to screen-film radiography) in the diagnosis of various types and sizes of urolithiasis are warranted for further exploration of this subject, as in vivo prediction of urolith composition is used to guide case management (15).

Acknowledgments

The authors thank the Minnesota Urolith Center which provided urolith analysis at no cost and the support from Hill’s Pet Nutrition and voluntary donors.

References

Evaluation of selective media in antimicrobial surveillance programs capturing broad-spectrum β-lactamase producing *Escherichia coli* from chickens at slaughter

Kazal K. Ghosh, Nicol Janecko, Agnes Agunos, Anne Deckert, Richard J. Reid-Smith, Sheryl Gow, Joseph E. Rubin

**Abstract** — Antimicrobial resistance surveillance targeting agricultural animals is practiced in many countries but does not often include media selective for cephalosporin resistance. Here, we compared the frequency of recovery of resistant *Escherichia coli* using selective and non-selective media from the cecal contents of 116 chickens collected by the Canadian Integrated Program for Antimicrobial Resistance Surveillance (CIPARS). Third generation cephalosporin resistance was detected in 24 samples including 12, 10, and 2 on selective, non-selective, and both media, respectively. Isolates producing the CTX-M-1 ESBL were grown from 11 samples, 10 on selective medium only. Our results suggest that current surveillance approaches underestimate the true prevalence of resistance to critically important antimicrobials.

**Résumé** — Évaluation de milieux sélectifs dans des programmes de surveillance antimicrobienne isolant *Escherichia coli* produisant des β-lactamas à large spectre provenant de poulets à l’abattage. La surveillance de la résistance aux antimicrobiens ciblant les animaux d’élevage est pratiquée dans de nombreux pays mais n’inclut pas souvent les milieux sélectifs pour la résistance aux céphalosporines. Ici, nous avons comparé la fréquence d’isolement d’*Escherichia coli* résistants à l’aide de milieux sélectifs et non sélectifs à partir du contenu caecal de 116 poulets collectés dans le cadre du Programme intégré canadien de surveillance de la résistance aux antimicrobiens (PICRA). Une résistance aux céphalosporines de troisième génération a été détectée dans 24 échantillons dont 12, 10 et 2 sur des milieux sélectifs, non sélectifs et les deux, respectivement. Les isolats produisant les BLSE CTX-M-1 ont été cultivés à partir de 11 échantillons, 10 sur un milieu sélectif uniquement. Nos résultats suggèrent que les approches de surveillance actuelles sous-estiment la prévalence réelle de la résistance aux antimicrobiens d’importance critique.

(Traduit par Dr Serge Messier)

The emergence of broad-spectrum β-lactamases including the extended-spectrum β-lactamases (ESBLs) and AmpC type enzymes among *Escherichia coli* is a concern in both human and veterinary medicine as these confer resistance to most β-lactam compounds including 3rd generation cephalosporins (3GC) (1). A recent study describing *E. coli* isolates from chickens raised in small flocks in Ontario, Canada identified ESBL and AmpC producing strains in 12.7% and 15.1% of flocks, respectively; CTX-M-1 was the most commonly identified ESBL (2). In Canada, *bla* _CMY-2_ has been reported to be the most common AmpC type β-lactamase gene in *E. coli* from hospitalized human patients (3). In Norway and the Netherlands, *bla* _CMY-2_ positive and ESBL-producing *E. coli* from retail chicken meat were closely related to human clinical isolates, suggesting that transmission from chickens may represent a source of broad-spectrum β-lactamase producing *E. coli* (4,5). The Canadian Integrated Program for Antimicrobial Resistance Surveillance (CIPARS) is a national surveillance program...
monitoring antimicrobial use and resistance in enteric bacteria along the food chain (farm, abattoir, retail) and in human clinical isolates in Canada. In this program, no media specifically selective for antimicrobial resistant *E. coli* are used. The magnitude of the impact of this analytical strategy on the ability to identify β-lactamase-producing resistant sub-populations in Canada is unknown, although the benefits of including such media for the detection of broad-spectrum β-lactamase producing *E. coli* in food animal resistance surveillance have been demonstrated (6–9). The purpose of this study was to determine whether the inclusion of antimicrobial-containing media would allow the discovery of ESBL-producing *E. coli* that would not be detected using standard surveillance methodologies alone in a Canadian context. 

Chicken cecal contents included in this study were collected as part of the 2013 CIPARS abattoir program in Ontario. Under the CIPARS program, cecal content from chickens are collected to reduce the chances of cross contamination from the environment and to ensure that the antimicrobial resistant bacteria detected originated on farm (6). Samples were directly plated onto MacConkey agar and *E. coli* were identified as described (6). Antimicrobial minimum inhibitory concentrations (MICs) were determined by broth microdilution with the National Antimicrobial Resistance Monitoring Surveillance (NARMS) Gram-negative plate and interpreted using the Clinical and Laboratory Standards Institute (CLSI) guidelines (10). Following routine processing, cecal contents and *E. coli* isolates (1 per sample) were archived at −80°C (6). In this study, all 116 frozen cecal samples from the 2013 collection year were streaked onto CHROMagar ESBL (CHROMagar, Paris, France), a medium designed to select for ESBL producing *E. coli* (5). Among those identified only on selective medium, 9 possessed only *bla*$_{CTX-M-1}$ and single isolates each possessed gene patterns of *bla*$_{CMY-2}$, *bla*$_{CMY-2} +$ *bla*$_{CTX-M-1}$, and both AmpC type resistance. CHROMagar ESBL is designed to be selective for ESBLs (inhibitory towards growth of both ESBL-producing strains, this study highlights that the methodology employed in current surveillance programs favor detection of AmpC type resistance. CHROMagar ESBL is designed to be selective for ESBLs (inhibitory towards growth of both susceptible organisms and resistant strains possessing only AmpC type β-lactamases); the relative ability of selective and non-selective media to detect this resistance has not been evaluated in a surveillance application (14). In this study, 50% of the samples from which 3GCR isolates were detected in selective medium, whereas 2 were identified using both methodologies. Polymerase chain reaction revealed that 11/12 resistant isolates recovered on non-selective media possessed *bla*$_{CMY-2}$. Among those identified only on selective medium, 9 possessed only *bla*$_{CTX-M-1}$ and single isolates each possessed gene patterns of *bla*$_{CMY-2}$, *bla*$_{CMY-2} +$ *bla*$_{CTX-M-1}$, and both AmpC nor CTX-M type ESBL genes (Table 1). Using both antimicrobial-containing and antimicrobial-free media, the identification of CTX-M and AmpC type β-lactamase-producing *E. coli* was higher than when antimicrobial-free medium alone was used (n = 23; P = < 0.01).

By describing the failure of a non-selective medium to detect ESBL-producing strains, this study highlights that the methodologies employed in current surveillance programs favor detection of AmpC type resistance. CHROMagar ESBL is designed to be selective for ESBLs (inhibitory towards growth of both susceptible organisms and resistant strains possessing only AmpC type β-lactamases); the relative ability of selective and non-selective media to detect this resistance has not been evaluated in a surveillance application (14). In this study, 50% of the samples from which 3GCR isolates were detected on selective medium, suggesting that current estimates of the frequency of 3GCR resistance may be low when only non-selective medium is employed. Indeed, the addition of CHROMagar ESBL increased the overall frequency of 3GCR resistance to 21% compared to 10% with MacConkey alone, with most of this difference being *bla*$_{CTX-M-1}$ positive isolates.

Overall, this study demonstrated that surveillance programs would increase the sensitivity of detecting 3GCR by supplementing surveillance efforts with selective media targeting resistance phenotypes or genes of interest. Adding this targeted screening to routine surveillance would be useful for monitoring the impact of interventions designed to reduce the use of 3rd generation cephalosporins in livestock. The impact of selective media on the recovery of organisms resistant to other drugs of public health importance (e.g., carbapenems, fluoroquinolones, and colistin) should be similarly evaluated.

### Table 1. Number of ESBL and AmpC β-lactamase producing *E. coli* in broiler chickens from Ontario, Canada using selective and non-selective media.

<table>
<thead>
<tr>
<th>Culture media</th>
<th>Number of samples from which a 3GCR resistant isolate was recovered (N = 116)</th>
<th>Frequency (number) of detection of β-lactamases</th>
</tr>
</thead>
<tbody>
<tr>
<td>Selective media (CHROM agar ESBL)</td>
<td>12 (10.3%)$^a$</td>
<td>CTX-M-1 (n = 9)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>CMY-2 (n = 1)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>CTX-M-1 &amp; CMY-2 (n = 1)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Undetermined$^b$ (n = 1)</td>
</tr>
<tr>
<td>Non-selective media (MacConkey agar)</td>
<td>10 (8.6%)$^b$</td>
<td>CMY-2 (n = 10)</td>
</tr>
<tr>
<td>Both selective and non-selective media</td>
<td>2 (1.7%)</td>
<td>CTX-M-1 (n = 1)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>CMY-2 (n = 1)</td>
</tr>
</tbody>
</table>

$^a$ *E. coli* isolated from the samples with selective media were different (P < 0.01) from non-selective media.

$^b$ One isolate possessed neither CTX-M nor CMY-2 type β-lactamases.
Acknowledgments
This work was supported by the Ontario Ministry of Agriculture, Food and Rural Affairs (OMAFRA) (grant number FS2013-1866) and the Natural Sciences and Engineering Research Council of Canada (NSERC) Discovery Grant program (#RGPIN-2016-04428). The funders had no role in study design, data collection, and interpretation, or the decision to submit the work for publication. The authors have no conflicts of interest to declare.

References
Diseases associated with hypercobalaminemia in dogs in United Kingdom: A retrospective study of 47 dogs

Fiona Da Riz, Paul Higgs, Guillaume Ruiz

Abstract — Cobalamin concentration is often assessed in clinical practice but little is known about the significance of hypercobalaminemia. The objective of this retrospective study was to identify the conditions associated with hypercobalaminemia in dogs and to investigate association with clinicopathological variables. Medical records of dogs having serum cobalamin measured between 2016 and 2018 were reviewed. One hundred sixty dogs were included and 47 (29%) showed hypercobalaminemia. Dogs with hypercobalaminemia had gastrointestinal (57%), hepatic (11%), neurological (11%), endocrine (9%), renal (4%), pancreatic (2%), and miscellaneous (6%) diseases. Overall, 11% had neoplasia. This distribution was not significantly different from that for hypocobalaminemic and normocobalaminemic dogs. There were significantly more dogs with hyperfolatemia in the hypercobalaminemia group. These results suggest that in clinical practice hypercobalaminemia is commonly identified in gastrointestinal and hepatic disease in dogs, but can also be seen with endocrine and neurological conditions. The frequency of hyperfolatemia alongside hypercobalaminemia may reflect common metabolic pathways.

Résumé — Maladies associées à l’hypercobalaminémie chez des chiens au Royaume-Uni : étude rétrospective de 47 chiens. La concentration de cobalamine est souvent évaluée dans la pratique clinique, mais on en sait peu sur l’importance de l’hypercobalaminémie. L’objectif de cette étude rétrospective était d’identifier les conditions associées à l’hypercobalaminémie chez le chien et d’étudier l’association avec des variables clinicopathologiques. Les dossiers médicaux des chiens eu ayant une cobalamine sérique mesurée entre 2016 et 2018 ont été examinés. Cent soixante chiens ont été inclus et 47 (29%) ont présenté une hypercobalaminémie. Les chiens atteints d’hypercobalaminémie avaient des maladies gastro-intestinales (57%), hépatiques (11%), neurologiques (11%), endocriniennes (9%), rénales (4%), pancréatiques (2%) et diverses (6%). Dans l’ensemble, 11% avaient une néoplasie. Cette distribution n’était pas significativement différente de celle des chiens hypocobalaminémiques et normocobalaminémiques. Il y avait significativement plus de chiens atteints d’hyperfolatémie dans le groupe hypercobalaminémie. Ces résultats suggèrent qu’en pratique clinique, l’hypercobalaminémie est couramment identifiée dans les maladies gastro-intestinales et hépatiques chez le chien, mais peut également être observée avec des conditions endocriniennes et neurologiques. La fréquence de l’hyperfolatémie associée à l’hypercobalaminémie peut refléter des voies métaboliques communes.

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Introduction

Cobalamin or vitamin B12 is a water-soluble vitamin involved in numerous metabolic pathways. The main source of cobalamin in animals is dietary intake, and this vitamin is absorbed in the ileum facilitated by binding to intrinsic factor produced by the pancreas and, to a lesser extent, by the stomach in dogs. Serum cobalamin concentration is commonly measured in canine and feline patients presenting with gastrointestinal signs, as hypocobalaminemia can assist assessment of disease localization and severity in chronic enteropathies (1–3). It is commonly accepted that hypocobalaminemic patients require supplementation as part of management of their enteropathy (4). However, little is known about the potential significance of elevated serum cobalamin concentration in companion animals.

Studies in human medicine have shown that hypercobalaminemia can be associated with neoplasia, liver diseases, hematologic disorders, or kidney failure (5,6). Moreover, in some cases,
hypercobalaminemia was associated with signs of functional deficit, potentially arising from decreased delivery to the tissues or reduced uptake by the liver. A previous retrospective study in cats found an association between hypercobalaminemia, solid neoplasms, and liver disease (7). These data suggest that elevated serum cobalamin concentration could be associated with clinically important diseases and therefore should not be ignored, as is often the case. To the authors’ knowledge, there is no similar published study on the potential significance of hypercobalaminemia in dogs. This lack of data has been outlined in a recently published review on cobalamin in dogs (8). Data presented at a recent European College of Veterinary Internal Medicine (ECVIM) congress (9) suggested that hypercobalaminemia was not uncommon (36.26% of 221 dogs) and could be associated with gastrointestinal (e.g., inflammatory bowel disease in 35 dogs), pancreatic (pancreatitis in 13 dogs), and liver diseases (10 cases) in dogs. The aim of our study was therefore to further identify conditions associated with hypercobalaminemia in dogs, to compare them with dogs having normal or low serum cobalamin concentration, and to determine whether it correlates with other biochemical and hematological markers such as alanine aminotransferase (ALT), albumin, folic acid, packed cell volume (PCV), white blood cell (WBC) count, and pancreatic enzymes.

Materials and methods

Study design

This was a retrospective, cross-sectional study conducted between November 2016 and December 2018. Cases were selected from 14 veterinary practices in the United Kingdom, including 13 first opinion and 1 referral center. Owners gave their written consent at the time of investigation for all procedures and anonymized sources of data.

Case selection

Medical records of dogs having serum cobalamin measured during the study period were reviewed. Dogs were excluded if they had received cobalamin supplementation at any time before analysis or if no clinical record was available for review. Information was recorded regarding signalment (age, gender, neutering status, breed), clinical signs, clinicopathological results, other diagnostic investigations such as, imaging (e.g., abdominal ultrasound), fecal analysis, endoscopic procedure, histopathological analysis, and final diagnosis when available. Breeds were classified as small (< 15 kg) and large (> 15 kg). These patients were then grouped into one of the following disease categories for statistical analysis: gastrointestinal, hepatic, pancreatic, renal, endocrine, hematological, neurological, or miscellaneous. Cases with neoplasms were classified into one of these categories depending on the location of the tumor. Cases were then considered as a separate category “neoplasia” for specific analysis. When no final diagnosis was noted in the records, the case was classified into one of the aforementioned categories based on all clinical and paraclinical data available by consensus amongst all authors including 2 ECVIM-CA (Internal Medicine) Diplomates.

Cobalamin assays

Due to its multicentric and retrospective nature, 2 external laboratories using 2 different validated assays were used in this study to measure cobalamin concentration. The first laboratory used a solid-phase, competitive chemiluminescent enzyme immunnoassay Immulite 2000 analyzer (Siemens Medical Solutions Diagnostics, Flanders, New Jersey, USA), which had already been validated and used in previous studies. Reference intervals of the laboratory were 200 to 408 pmol/L. The second laboratory used a 2-site immunoenzymometric assay AIA-900 analyzer (Tosoh Bioscience, Tessenderlo, Belgium). The reference intervals for this laboratory were 204 to 490 pmol/L. This assay has good analytical performance and is applicable for cobalamin measurement with a good correlation with the Immulite, although for high cobalamin concentrations, the agreement between the 2 assays was poor (10). Cobalamin status among dogs in our study, therefore, was compared in a semi-quantitative manner (classified as hypocobalaminemia, normocobalaminemia, or hypercobalaminemia based on the laboratory’s reference ranges) and not in a quantitative manner.

Severity of disease

Among all clinicopathological variables recorded, the following parameters were selected before data analysis as potential markers of disease: hypoalbuminemia, elevated serum ALT activity, and anemia. These variables and diagnostic categories were then compared in dogs having low, normal, or high serum cobalamin concentrations to assess a potential association between hypercobalaminemia and other biomarkers. Folate concentration (hypofolatemia, normofolatemia, or hyperfolatemia) and elevated pancreatic lipase [either canine Pancreatic Lipase immunoreactivity (cPLI) or 1,2-0-dilauryl-glycerol-3-glutaric acid (6’-methylresofurin) ester (DGGR lipase), as available] were also compared between the 3 serum cobalamin concentration groups.

Statistical analysis

Values were expressed as percentage values for qualitative variables and median values for quantitative variables. Variables were compared between groups using a Kruskal-Wallis, Chi-squared, or Fischer’s exact test, as appropriate using a statistical software (GraphPad Prism version 8.00 for Windows; GraphPad Software, La Jolla, California, USA). Results were considered statistically different when $P < 0.05$.

Results

After exclusion of 25 dogs due to previous cobalamin supplementation, 160 dogs were included in the study and classified according to their cobalamin status. Thirty-nine dogs were found to be hypocobalaminemic (24.3%), 74 dogs to be normocobalaminemic (46.3%), and 47 dogs to be hypercobalaminemic (29.4%).

Signalment

Hypercobalaminemic dogs were significantly younger (median age: 79 mo; range: 2 to 207 mo) than hypo- and normocobalaminemic dogs (median age: 102 mo; range: 3 to 167 mo),
Clinical signs

Dogs with hypercobalaminemia were presented with diarrhea (49%), vomiting (47%), inappetence (38%), lethargy (40%), or weight loss (38%); the frequency of the clinical signs was not statistically different between groups. Clinical signs were chronic (> 3 wk duration) in most cases and, although dogs in the hypercobalaminemia group had a higher proportion of acute signs, this was not statistically different (40% versus 20% in the normocobalaminemia and 31% in the hypocobalaminemia group; \( P = 0.055 \)). Less frequent clinical signs included polyuria-polydipsia, hematochezia, melena, hematemesis, regurgitation, flatulence, borborygm, lip smacking, pica, halitosis, pyrexia, abdominal pain, pallor, jaundice, neurological signs (seizures, vestibular signs, pacing, ataxia), syncope, or cough.

Clinicopathological data. The frequency of elevated ALT activity, hypoalbuminemia, anemia, abnormal pancreatic screen was not significantly different among groups (Table 1). Conversely, folate status was statistically different among groups, with hypercobalaminemic dogs presenting more frequently with hyperfotalemia (14/43, 33%) than hypo- and normocobalaminemic dogs [4/37 (11%) and 8/68 (12%), respectively; \( P < 0.01 \)] (Table 1).

Diagnosis. Gastrointestinal diseases in dogs with hypercobalaminemia included food-responsive enteropathy (\( n = 6 \)), steroid-responsive enteropathy (\( n = 4 \), including protein-losing enteropathy in 1 case), hemorrhagic gastroenteritis (\( n = 4 \)), acute gastroenteritis (\( n = 3 \)), gastrointestinal foreign body (\( n = 2 \), esophagitis (\( n = 1 \)), esophageal stricture (\( n = 1 \)), hiatal hernia (\( n = 1 \)), gastrointestinal mass (\( n = 1 \), and unclassified chronic enteropathy (\( n = 4 \)). Hypercobalaminemic dogs with hepatic disease were diagnosed with chronic hepatitis (\( n = 2 \)), portosystemic extrahepatic shunt (\( n = 1 \)), chronic cholelithiasis (\( n = 1 \)), and vacuolar hepatopathy with bridging fibrosis (\( n = 1 \)). One dog was diagnosed with acute pancreatitis.

Endocrine conditions encompassed 2 cases of diabetes mellitus and 2 cases of hyperadrenocorticism. Neurological diseases included idiopathic epilepsy (\( n = 2 \)), left-sided peripheral vestibular disease (\( n = 1 \)), acute neuromuscular disease suspected to be a reaction to vaccination (\( n = 1 \)), and focal cortical dysplasia (\( n = 1 \)). Finally, 2 hypercobalaminemic dogs had a diagnosis of kidney disease (1 renal dysplasia and 1 chronic kidney disease with urinary tract infection). Neoplasia included a pituitary macroadenoma, 1 hepatic carcinoma, 1 mammary carcinoma, 1 cutaneous mast cell tumor, and 1 soft tissue sarcoma.

Gastrointestinal disease was the most frequent category among groups, followed by neoplasia, liver disease, neurological disease, endocrine, kidney, and pancreatic disease. Table 2 shows the proportion of dogs in each category among groups. There was no significant difference between groups regarding the proportion of different disease categories (\( P \)-values are shown in Table 2).

Discussion

Hypercobalaminemia is often ignored in clinical practice, despite being encountered sometimes in dogs with significant diseases. Several conditions were diagnosed in dogs with hypercobalaminemia, with gastrointestinal diseases and hepatic diseases representing almost 70% of the cases, which is similar to a previous study in cats (7) and dogs (9). In another study, extreme serum cobalamin concentrations were reported in some dogs with gastrointestinal disease (11). Several dogs were presented with neurological or endocrine diseases in our study; this has not been previously described.

In humans, an association has been reported between hypercobalaminemia and liver diseases, as well as hematological disorders, solid neoplasms, and kidney disease (5). In 1 report on dogs, 37.5% of dogs with hepatic disease had increased serum cobalamin concentration (12). We did not identify a statistically significant association with any specific disease category in this study. Rather, a variety of diseases were represented and some dogs had several conditions concomitantly. Dogs were eventually classified depending on the condition that was the most likely to be responsible for the clinical signs, which may have prevented the detection of a significant association between hypercobalaminemia and some conditions. It is possible that some disease categories, such as hepatopathies, were underestimated, as vacuolar hepatopathy is a frequent lesion identified in dogs with systemic disease such as diabetes mellitus or hyperadrenocorticism. Chronic hepatopathy was also suspected in 1 dog with pancreatitis, 1 dog classified in the miscellaneous category, and another dog with chronic enteropathy. This may have underestimated the association between hypercobalaminemia and liver disease, although the same classification method was used for all cobalamin groups and would therefore have
underestimated the impact of liver disease in all groups, not only in hypercobalaminemic dogs. Similarly, serum cobalamin is mainly measured in patients with gastrointestinal signs, introducing a bias in case recruitment which doesn't allow us to make definitive statements regarding the true prevalence of hypercobalaminemia in the entire dog population. A prospective study including serum cobalamin as a routine parameter on biochemistry for all dogs would be useful to determine whether hypercobalaminemia could be associated with other conditions for which serum cobalamin is not currently measured.

It is likely that multiple concurrent conditions may contribute to increased serum vitamin B12. The proposed mechanisms for increased cobalamin concentration include; increased dietary intake or supplementation, release from an internal reservoir (such as hepatic storage), excess of transcobalamin by increased production or lack of clearance, and quantitative deficiency or lack of affinity of transcobalamin for vitamin B12 (5). Therefore, when multiple comorbidities are present, several mechanisms may contribute to increasing serum cobalamin concentration, such as release from hepatocytes in liver disease and lack of renal clearance with kidney failure. The specific mechanism of increased serum cobalamin in gastrointestinal disease has not been described, although direct diffusion and absorption through a disrupted mucosal barrier in acute disease or dysbiosis are possible explanations.

Dogs with hypercobalaminemia were significantly younger than dogs in other groups in our study; this may reflect physiological changes, shorter duration of disease, or presence of different conditions, although no statistical difference was determined among groups. Gender and neuter status were similar among groups, and dog size, as classified depending on weight (<15 kg or >15 kg), was not statistically different. However, a specific effect of breed could not be assessed due to the small number of dogs in each category. A previous study did not show any specific canine breed at risk for elevated cobalamin concentration (13). A study in cats (14), however, reported that cobalamin concentration was inversely correlated with age and that males tended to have higher cobalamin concentration than females. In our study, there was a trend for dogs with hypercobalaminemia to have more acute disease than normocobalaminemic and hypocobalaminemic dogs.

### Table 1. Clinicopathological findings in the 3 groups of dogs.

<table>
<thead>
<tr>
<th>Category</th>
<th>Hypocobalaminemia group (N = 39 dogs)</th>
<th>Normocobalaminemia group (N = 74 dogs)</th>
<th>Hypercobalaminemia group (N = 47 dogs)</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elevated ALT</td>
<td>13 (34%) n = 38</td>
<td>21 (28%) n = 74</td>
<td>14 (30%) n = 47</td>
<td>0.815</td>
</tr>
<tr>
<td>Hypo-albuminemia</td>
<td>12 (31%) n = 39</td>
<td>22 (30%) n = 74</td>
<td>18 (38%) n = 47</td>
<td>0.597</td>
</tr>
<tr>
<td>Anemia</td>
<td>8 (21%) n = 39</td>
<td>7 (10%) n = 73</td>
<td>4 (9%) n = 44</td>
<td>0.198</td>
</tr>
<tr>
<td>Abnormal pancreatic screen</td>
<td>2 (8%) n = 25</td>
<td>5 (14%) n = 35</td>
<td>3 (12%) n = 26</td>
<td>0.755</td>
</tr>
<tr>
<td>Folate status</td>
<td></td>
<td></td>
<td></td>
<td>&lt; 0.01</td>
</tr>
<tr>
<td>Low B9</td>
<td>10 n = 44</td>
<td>4 n = 35</td>
<td>2 n = 26</td>
<td></td>
</tr>
<tr>
<td>Normal B9</td>
<td>23 n = 44</td>
<td>56 n = 68</td>
<td>27 n = 43</td>
<td></td>
</tr>
<tr>
<td>High B9</td>
<td>4 (11%) n = 37</td>
<td>8 (12%) n = 68</td>
<td>14 (33%) n = 43</td>
<td></td>
</tr>
</tbody>
</table>

* Due to the retrospective nature of this study, some data could not be retrieved for some cases.

### Table 2. Categories of disease for the 3 groups of dogs.

<table>
<thead>
<tr>
<th>Category</th>
<th>Hypocobalaminemia group (N = 39 dogs)</th>
<th>Normocobalaminemia group (N = 74 dogs)</th>
<th>Hypercobalaminemia group (N = 47 dogs)</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gastrointestinal disease</td>
<td>28 (72%) n = 39</td>
<td>45 (61%) n = 74</td>
<td>27 (57%) n = 47</td>
<td>0.361</td>
</tr>
<tr>
<td>Hepatic disease</td>
<td>3 (8%) n = 39</td>
<td>4 (5%) n = 73</td>
<td>5 (11%) n = 44</td>
<td>0.350</td>
</tr>
<tr>
<td>Pancreatic disease</td>
<td>2 (5%) n = 39</td>
<td>3 (4%) n = 73</td>
<td>1 (2%) n = 44</td>
<td>0.753</td>
</tr>
<tr>
<td>Renal disease</td>
<td>0 n = 1</td>
<td>1 (1%) n = 44</td>
<td>2 (4%) n = 44</td>
<td>0.316</td>
</tr>
<tr>
<td>Neurological disease</td>
<td>1 (3%) n = 1</td>
<td>5 (7%) n = 73</td>
<td>5 (11%) n = 44</td>
<td>0.337</td>
</tr>
<tr>
<td>Hematological disease</td>
<td>2 (5%) n = 39</td>
<td>2 (3%) n = 39</td>
<td>0 n = 1</td>
<td>0.529</td>
</tr>
<tr>
<td>Endocrine disease</td>
<td>0 n = 1</td>
<td>3 (4%) n = 73</td>
<td>4 (9%) n = 44</td>
<td>0.155</td>
</tr>
<tr>
<td>Miscellaneous</td>
<td>3 (8%) n = 39</td>
<td>10 (14%) n = 74</td>
<td>3 (6%) n = 44</td>
<td>0.38</td>
</tr>
<tr>
<td>Neoplasia (among all above categories)</td>
<td>3 (8%)</td>
<td>5 (7%)</td>
<td>5 (11%)</td>
<td>0.743</td>
</tr>
</tbody>
</table>

* Percentages do not add up to 100% because of rounding.
hypocobalaminemic dogs; even though this was not statistically significant. One possible explanation could be an increase in passive intestinal absorption of cobalamin secondary to intestinal mucosal disruption in acute disease.

In this study, we did not demonstrate an association between cobalamin status and the parameters chosen to assess for disease severity. These parameters were selected as they are commonly altered with severe disease and are easily accessible during retrospective data collection. Other parameters, such as biomarkers or specific parameters adapted to each patient's disease [e.g., Canine Chronic Enteropathy Clinical Activity Index (CCECAI) or Canine Inflammatory Bowel Disease Activity Index (CIBDAI) assessment tools for chronic enteropathies, C-reactive protein] may have allowed better assessment of disease severity. However, due to the retrospective nature of our study and the small number of cases in each subgroup, further analysis was not possible.

Two laboratories using 2 different validated assays were used to measure serum cobalamin concentration. This precluded quantitative analysis and direct comparison of the serum cobalamin concentration among dogs. Therefore, results were compared only in a semi-quantitative manner; classifying dogs in the 3 categories depending on the laboratory’s reference range and comparing variables among groups. Performing a quantitative analysis may have allowed the detection of an association between serum cobalamin concentration and some specific conditions or disease severity by determining a cut-off value. However, we elected to include patients that had serum cobalamin measured in any of these 2 laboratories to optimize the number of cases recruited and improve the power of the analysis. In addition, reference ranges used by the 2 reference laboratories were different from those used in other studies; the upper limit was lower. It is possible that some cases classified as hypercobalaminemic would have been classified as normal with wider reference ranges as previously published. However, values had to be compared to the laboratory’s reference ranges, which were established on their reference population.

There was a positive association between hypercobalaminemia and hyperfolatemia in dogs of this study. Cobalamin and folate concentrations have traditionally been used as non-specific markers of intestinal disease and as potential markers of dysbiosis. Although described under different terminologies (small intestinal bacterial overgrowth, antibiotic-responsive enteropathy or, more generally, dysbiosis), disturbances in gastrointestinal microbiota are suspected in many cases of canine chronic enteropathies and are likely to change the vitamin profile. A classical combination of hypocobalaminemia (consumed or fixed by bacteria) and hyperfolatemia (produced by bacteria) has been historically described with intestinal dysbiosis. In one study, increased folate and decreased cobalamin concentration had a sensitivity of 5% and a specificity of 100% for intestinal overgrowth, whereas increased folate alone had a sensitivity of 50% with a specificity of 80% (15). In a more recent study, increased folate had a sensitivity between 50% and 66% for small intestinal dysbiosis (16). However, as research on gut microbiota and metabolism is ongoing, the pattern of “hypocobalaminemia and hyperfolatemia” indicating dysbiosis is under question and may be inaccurate. It is therefore no longer recommended as a sole indicator (17). In addition, studies have shown that some bacterial strains are able to produce corrinoids including cobalamin and pseudocobalamin (18–21), although their bioavailability remains unclear. It is therefore possible that bacterial production of cobalamin or pseudocobalamin could contribute to hypercobalaminemia in dogs with gastrointestinal disease, associated or not with dysbiosis. Moreover, increased cobalamin itself can modulate gut microbial ecology (22,23).

Prospective studies are needed to determine whether intestinal bacterial production of vitamin B12 plays a significant role in serum cobalamin concentration.

There was no significant association between hypercobalaminemia and solid neoplasms in this study; however, this has been previously described in humans and cats (5,7). It could be that there are actual differences between species, or that the study design lacked statistical power due to the small number of dogs in each group diagnosed with neoplasia. The proposed mechanisms for hypercobalaminemia in humans with solid neoplasm are; an increased synthesis of transcobalamin by the tumor and/or an increase in haptocorins due to induced leukocytosis. In the case of liver tumors, it is proposed to be due to decreased hepatic clearance of cobalamin and increased release during hepatocyte lysis. In humans with hepatic tumors, the level of hypercobalaminemia has been suggested to be a negative prognostic marker, outlining its clinical significance (24).

Another limitation in this study was the absence of information available regarding the diet for some dogs; therefore, cobalamin and folate dietary intake could not be assessed. Although it is possible that some dogs had increased serum cobalamin due to their diet, it was not considered likely as most dogs were fed a balanced commercial diet and any dog having received cobalamin supplementation at any time was excluded from the study. Analytical information about the diet of each dog would have been required to assess this potential effect.

No survival analysis was performed due to the lack of information about follow-up or survival in most cases. It would be interesting to determine if hypercobalaminemia is a prognostic indicator in chronic enteropathies, hepatic diseases, neurological conditions, or endocrine diseases.

In conclusion, our results suggest that hypercobalaminemia in dogs is seen with gastrointestinal and hepatic disease, as previously reported in other species, but is also seen with endocrine and neurological conditions. Interestingly, hyperfolatemia was most commonly seen alongside hypercobalaminemia but it is unknown whether this reflects dysbiosis or common metabolic pathways. Further studies are needed to understand the potential clinical implications of hypercobalaminemia as a prognostic indicator in dogs.

References


Evaluation of concurrent perineal hernia in adult male dogs presenting with nontraumatic, acquired inguinal hernias

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Abstract — A possible association between the development of nontraumatic, acquired inguinal hernias (NAIH) and perineal hernias (PH) has been postulated in adult dogs. The objective of this study was to evaluate the frequency of concurrent diagnosis of PH in dogs presented with NAIH and determine potential risk factors for concurrent PH and NAIH. Medical records of adult male dogs presented for NAIH to 4 hospitals between 2007 and 2017 were retrospectively reviewed. Twenty-one dogs with NAIH were included, 8 of which had concurrent PH. There were no significant differences between dogs with and without PH; however, among dogs with both conditions, intact dogs (8.1 ± 1.4 years) were younger than neutered dogs (11.7 ± 1.0 years; $P = 0.007$). Thirty-eight percent of male dogs presenting for NAIH had concurrent PH, indicating that these conditions commonly occur together. Dogs presenting for NAIH should be carefully evaluated for concurrent PH before surgical intervention.

Résumé — Évaluation d’hernie périnéale concomitante chez des chiens mâles adultes présentant des hernies inguinales acquises non traumatiques. Une association possible entre le développement d’hernies inguinales acquises non traumatiques (NAIH) et les hernies périnéales (PH) a été postulée chez les chiens adultes. L’objectif de cette étude était d’évaluer la fréquence des diagnostics simultanés d’HP chez les chiens présentés avec NAIH et de déterminer les facteurs de risque potentiels de PH et NAIH concomitantes. Les dossiers médicaux de chiens mâles adultes présentés pour NAIH à quatre hôpitaux entre 2007 et 2017 ont été revus rétrospectivement. Vingt et un chiens atteints de NAIH ont été inclus, dont huit avaient une PH concomitante. Il n’y avait aucune différence significative entre les chiens avec et sans PH; cependant, parmi les chiens atteints des deux conditions, les chiens intacts (8,1 ± 1,4 ans) étaient plus jeunes que les chiens castrés (11,7 ± 1,0 ans; $P = 0,007$). Trente-huit pour cent des chiens mâles se présentant pour NAIH avaient une PH concomitante, ce qui indique que ces conditions se produisent généralement ensemble. Les chiens présentant un NAIH doivent être soigneusement évalués pour une PH concomitante avant une intervention chirurgicale.

(Traduit par D’ Serge Messier)

Introduction

Nontraumatic, acquired inguinal hernias (NAIH) occur rarely in older male dogs. These acquired hernias are most common in intact female dogs, suspected to be due to hormonal influences during estrus or pregnancy (1). Other factors such as anatomical abnormalities and obesity have also been considered in the pathogenesis of NAIH (2).

Perineal hernias (PH) are known to occur most commonly in intact male dogs, leading to tenesmus, dyschezia, and in some cases, obstruction secondary to urinary bladder retroflexion (3,4). Although the pathogenesis is unknown, theories regarding etiology of perineal hernia formation have revolved around hormonal influences leading to tenesmus secondary to prostatic disease, increased relaxin receptors, and weakness of...
the pelvic diaphragm musculature (4). Surgical correction is typically recommended to alleviate clinical signs (4).

A possible association between NAIH and PH has been postulated. In 1 study, evaluation of cases from a single hospital, combined with a literature review, identified 14 dogs with NAIH, 9 of which had concurrent PH, leading the authors to suggest a possible association between NAIH and PH (5). However, in another study focused on inguinal hernias in a population of male and female dogs, the association between NAIH and PH was less evident with only 2 of 16 male dogs having both conditions concurrently (1). The disparity between occurrence rates in these 2 studies makes it difficult to draw a conclusion regarding whether or not these 2 conditions are likely to occur concurrently.

The objective of this study was to evaluate the frequency of diagnosis of PH in dogs presenting for NAIH and determine potential risk factors for concurrent PH in dogs presenting with NAIH. The hypothesis was that intact male dogs with NAIH are more likely to have concurrent PH than neutered male dogs with NAIH.

**Materials and methods**

Adult male dogs older than 1-year-of-age presented to the University of Georgia, University of Illinois, Texas A&M University, and North Carolina State University veterinary teaching hospitals between January 2007 and June 2017 for evaluation of NAIH were included in the study. Dogs with any history of trauma were excluded.

Data collected included age, weight, neuter status, presence of PH, duration of NAIH, duration of PH, lateralization of NAIH and/or PH, clinical signs, concurrent disease processes, surgical procedures performed, and complications or hernia recurrence. Follow-up was obtained from available medical records and was defined as the time from the initial surgical procedure for NAIH to last contact with the owner or last evaluation of the dog, whichever occurred last.

Commercially available software was used for statistical analysis (SPSS Statistics for Windows, Version 25.0; IBM, Armonk, New York, USA). Continuous data were tested for normality using the Shapiro-Wilk test. Non-normally distributed data (weight, duration of NAIH) were analyzed using the Mann-Whitney U-test. Nominal data (neuter status, presence of prostatic disease, clinical signs) were analyzed using Fisher’s Exact test. Descriptive statistics are reported as mean ± standard deviation (SD) for normally distributed data and median (range) for non-normally distributed data. Statistical significance was set at \( P < 0.05 \).

**Results**

Twenty-one male dogs with NAIH were identified. Nine were neutered and 12 were intact at the time of presentation. Mean (± SD) age at diagnosis was 8.7 ± 2.7 y. Median weight was 9.8 kg (range: 2.6 to 49.9 kg). Fourteen breeds were represented including 4 dachshunds, 3 Yorkshire terriers, 3 beagles, and 1 each of 11 other breeds.

Eight of the 21 dogs (38.1%) had both NAIH and PH. Four were neutered males and 4 were intact. There were no significant differences in age [9.9 ± 2.2 y (PH) versus 8.0 ± 2.8 y (no PH); \( P = 0.113 \)] or weight [21.2 kg (range: 2.6 to 41.3 kg) (PH) versus 8.4 kg (range: 2.6 to 49.9 kg) (no PH); \( P = 0.210 \)] between dogs with and without PH. Neuter status between dogs with and without PH also was not different \( (P = 0.673) \); however, among dogs with concurrent NAIH and PH, intact dogs (8.1 ± 1.4 y) were younger than neutered dogs (11.7 ± 1.0 y; \( P = 0.007 \)).

The duration of time the NAIH was present was known for all dogs. Median duration of NAIH was 1 mo (range: 0 to 6 mo). There were no differences in length of time NAIH was present between groups when comparing male dogs with PH (2.3 mo (range: 0 to 7 mo)) to male dogs without PH (1 mo (range: 0 to 60 mo); \( P = 0.697 \)). The duration the PH was present was known for all dogs. Median duration of PH was 0 mo (range: 0 to 6 mo), with most being diagnosed at the time of presentation for NAIH evaluation.

Laterality of the NAIH was available from the medical record in 20 dogs. Unilateral NAIH was present in 17/20 dogs (85%), including 10 left-sided hernias and 7 right-sided hernias. Bilateral NAIH was present in 3/20 dogs (15%). Laterality of PH was known for all dogs and was left-sided \( (n = 1) \), right-sided \( (n = 5) \), and bilateral \( (n = 2) \). When comparing concurrent NAIH and PH, 3 dogs had ipsilateral NAIH and PH, 3 had contralateral NAIH and PH, and 2 dogs had unilateral NAIH and bilateral PH.

The most common clinical sign in all dogs with NAIH was swelling in the inguinal region \( (n = 7) \). Nine of 13 (69.2%) male dogs without PH and 2 of 8 (25%) male dogs with PH had no reported clinical signs beyond inguinal swelling. There was no difference in the presence of signs beyond inguinal swelling between dogs with and without PH \( (P = 0.081) \). In dogs without PH, scrotal swelling \( (n = 2) \), hyporexia \( (n = 1) \), testicular swelling \( (n = 1) \), vomiting \( (n = 1) \), and tenesmus \( (n = 1) \) were reported as clinical signs, in addition to inguinal swelling. In dogs with PH, diarrhea \( (n = 2) \), lethargy \( (n = 2) \), tenesmus \( (n = 2) \), pain \( (n = 2) \), constipation \( (n = 1) \), anorexia \( (n = 1) \), hematochezia \( (n = 1) \), vomiting \( (n = 1) \), and urinary incontinence \( (n = 1) \) were reported in addition to inguinal swelling.

Prostatic disease was described in 7/21 dogs (33.3%), including 4/8 dogs with PH (50%) and 3/13 dogs without PH (23.1%). Prostatic diseases reported included prostatic cysts \( (n = 4) \), benign prostatic hyperplasia \( (n = 4) \), and prostatomegaly with no specific cause noted \( (n = 1) \). Presence of prostatic disease was not different between dogs with or without PH \( (P = 0.346) \).

Surgical correction of NAIH was performed in 6/8 dogs with PH (75.0%) and 10/13 dogs without PH (76.9%). Direct muscle apposition (true herniorrhaphy) was the most common surgical technique employed for NAIH (15/16) with only 1 dog requiring mesh to close the defect \( (1/16) \). Concurrent procedures in dogs undergoing surgical correction of NAIH that also had PH included cystopexy \( (n = 3) \), colopexy \( (n = 3) \), castration \( (n = 2) \), cystotomy \( (n = 1) \), and scrotal ablation \( (n = 1) \). Concurrent procedures in dogs undergoing surgical correction of NAIH that did not have PH included castration.
In the current study, 38% of dogs presented for NAIH were concurrently diagnosed with PH. No significant differences were present between dogs having both diseases compared to those having NAIH only; therefore, the hypothesis that a significantly higher percentage of intact males have concurrent NAIH and PH when compared to neutered male dogs was rejected. Interestingly, among dogs having both diseases, intact dogs were significantly younger at presentation for these diseases than were neutered dogs.

Previous studies have suggested a potential link between NAIH and PH (1,5). When comparing this study to those previous reports, the frequency of patients with NAIH having concurrent PH in the current study was 38%, whereas the frequencies in previous reports were 12.5% (1) and 64.3% (5). If the patient numbers in the previous studies are combined to create a larger population, this would result in 11 male dogs having both diseases out of 30 total male dogs with NAIH, which is 36.7% overall. That is similar to the frequency of 38% reported in this study alone, indicating that this frequency may be the most accurate; however, larger patient numbers need to be studied to confirm this theory.

Although several theories for the increased incidence of PH in male dogs have been investigated, there has been difficulty in proving the pathogenesis. Perhaps PH and NAIH in male dogs may have a similar pathogenesis leading to their concurrent development in a portion of the population. One group evaluated the role of relaxin in the development of PH in intact male dogs and determined that although relaxin concentrations in the pelvic diaphragm muscles and internal obturator muscle were not significantly different between dogs with PH and those without, dogs with PH had significant upregulation of relaxin receptors in those muscles (6). An association between relaxin and NAIH has not been investigated. Pelvic diaphragm muscle atrophy is present in dogs with PH and is thought to be due to either hormonal influence or neurogenic atrophy (2,7). Atrophy of the abdominal musculature from similar processes could predispose male dogs to development of inguinal hernias as well. Although hormonal influence has not been evaluated in male dogs for development of inguinal hernias, in other species, including mice, sex hormone imbalance was a predisposing factor for development of inguinal hernias (8). Another factor considered in the development of PH is the presence of prostatic disease, which is present in up to 59% of PH cases (4). In the current study, prostatic disease was present in 50% of the dogs with PH and only 23.1% of the dogs without PH; however, this was not a significant difference. It is thought that prostatic enlargement with or without caudal displacement could cause straining during basic functions such as urination and defecation resulting from increased pressure on the urethra or colon (4). Similarly, this straining could also place increased pressure and workload on the abdominal musculature making an inguinal hernia more likely to develop; however, an association between prostatic disease and NAIH in male dogs has not been evaluated.

The number of dogs undergoing primary PH repair was low in this study, and the median time to PH repair from the time of diagnosis in those dogs that did undergo primary repair was longer than expected. The low number of dogs undergoing PH repair may be due to 3/8 dogs undergoing cystopexy and colopexy at the time of surgical repair of the NAIH that never had primary PH repair done. Having those procedures conducted may have reduced clinical signs of PH, leading to the owners electing to not move forward with primary PH repair. It is unknown why the median time to primary PH repair was longer than would be expected. This may be due to mild or non-existent clinical signs, owner unwillingness to have another surgical procedure after NAIH repair, or owner financial constraints; however, this information was not available in the medical records reviewed.

Although no potential risk factors for development of NAIH and PH could be identified, there was a significant association between age at development of both conditions and neuter status. Intact male dogs developed concurrent NAIH and PH at a significantly younger age than neutered males, which may indicate that neutering is protective for the development of these conditions, or at least may delay development. No association could be made between age at the time of castration and development of these conditions in neutered males, as age at the time of castration was unavailable from the medical record for most dogs in this study.

Limitations of this study include the retrospective nature and the limited number of dogs with concurrent NAIH and PH. Medical record searches may have failed to identify all dogs with NAIH or PH, as these conditions may not have been specifically evaluated or recorded during physical examinations. Although cases were collected from multiple institutions and a wide timeframe was included, only a few dogs with concurrent NAIH and PH were identified. This may have limited the ability to identify risk factors for development of both diseases. Overall,
it seemed somewhat common for dogs to have both NAIH and PH; however, the occurrence of NAIH in male dogs seemed rare.

Based on the results of this study, concurrent PH may be present in up to 38% of adult male dogs with NAIH. Male dogs presenting with NAIH should be carefully evaluated for concurrent PH before surgical correction to determine if any additional surgical correction should be considered. Knowledge of concurrent disease may aid owners in the decision-making process regarding available treatment options. Future studies are indicated to determine if these 2 conditions share a common pathogenesis, which could lead to directed treatment for prevention of disease.

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Potomac horse fever in Ontario: Clinical, geographic, and diagnostic aspects

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Abstract — Clinical findings, geographic locations, laboratory diagnoses, and culture isolation of Neorickettsia spp. in Potomac horse fever (PHF) cases diagnosed in Ontario between 2015 and 2019 are described. Forty-six confirmed PHF cases occurred from late June to early September. Of 41 horses admitted to the Ontario Veterinary College, 28 (68%) survived and 13 (32%) were euthanized due to poor prognosis or financial constraints. Most cases were in southern Ontario along the Canada-USA border. Blood and fecal samples from 43 suspect PHF cases were submitted to 2 laboratories for polymerase chain reaction (PCR) testing for Neorickettsia risticii. Agreement between both laboratories for detection of N. risticii DNA was excellent for feces ($k = 0.932$, 95% confidence interval (CI): 0.80 to 1), and fair for blood samples ($k = 0.494$, 95% CI: 0.13 to 0.85). Neorickettsia spp. were isolated from 16 of 41 (39%) blood samples. DNA analysis confirmed 14 isolates were N. risticii and 2 were N. findlayensis, a novel species of Neorickettsia recently demonstrated to cause PHF.

Introduction

Potomac horse fever (PHF) is an acute and potentially fatal enterotyphlocolitis of horses caused by infection with the monocytotropic rickettsia Neorickettsia risticii (formerly Ehrlichia risticii) (1). The disease is seasonal, and is characterized by depression, anorexia, fever, dehydration, diarrhea, laminitis, and occasionally abortion (2,3). Potomac horse fever was first recognized as a clinical entity in 1979 by veterinarians in an area adjacent to the Potomac River in Maryland and Virginia in the United States (3–5). Review of investigations conducted by Dr. Frank W. Schofield into an endemic disease of horses in the Kent and Essex counties of Ontario in the summer of 1924 strongly suggests that this endemic disease was PHF (6,7). Interestingly, Schofield stated that some of the oldest inhabitants in those counties suggested that the disease had existed for nearly half a century before 1924 (6,7).
The serum indirect fluorescent-antibody (IFA) test was the only test available for the diagnosis of PHF in Ontario through the 1990’s (8,9). Every summer, suspected cases of PHF are reported by veterinarians in many regions throughout Ontario and there is an apparent regional variation in the number of cases each year (7,10–11). A presumptive diagnosis of PHF is made by veterinarians based on clinical signs, month of the year, historical evidence of the disease in the area, and response to antimicrobial therapy; however, laboratory testing is often not requested due to the cost of testing and a perceived low number of positive results. Ideally, these cases should be confirmed by molecular detection and quantitation of N. risticii genomic DNA from blood and/or feces by polymerase chain reaction (PCR) (12–14). Which sample to submit (blood or feces) is a common concern of equine veterinarians, particularly those working within financial constraints. In horses that were experimentally infected with N. risticii, there was a difference between blood and feces in the time when the PCR test was positive (12,15–17). These differences in detection times have not been examined in blood and fecal samples from clinical PHF cases. In addition, there has been no inter-laboratory comparison of N. risticii PCR results previously reported.

Isolation of the agent in cell culture is the gold standard for diagnosis, but it is time-consuming and not readily available as a commercial service (14). Thus, practicing veterinarians must rely on a PCR diagnosis for PHF. However, this becomes frustrating and misleading if the PCR does not detect the organism causing disease in their area.

The aims of this study were: i) to review the clinical findings, geographic locations, and laboratory results of 46 horses with a confirmed PCR diagnosis of PHF in Ontario between 2015 and 2019, ii) to assess the level of agreement between 2 diagnostic laboratories for molecular detection of N. risticii DNA in blood and fecal samples from horses with clinical signs consistent with a diagnosis of PHF, and iii) to report on the cultural isolation of Neorickettsia spp. from blood, from horses suspected of having PHF.

The hypothesis is that PHF is widely distributed throughout Ontario with areas of increased occurrence in southwestern and eastern Ontario, and that the results of PCR testing on blood and feces between 2 laboratories will be similar.

Materials and methods

Retrospective study of horses diagnosed with PHF in Ontario (2015–2019): Geographic location and clinical findings

All horses that tested positive for N. risticii by laboratory diagnosis at the Ontario Veterinary College Veterinary Teaching Hospital (OVC-VTH) and/or the Animal Health Laboratory (AHL) at the University of Guelph, from June 2015 to September 2019, were included in this study. All horses were tested for N. risticii using either a PCR assay on samples of blood and/or feces and/or culture isolation of Neorickettsia spp. from blood. The following information was provided by the attending veterinarian: year, month, age, sex, breed, location of the farm, presenting complaint, treatments prior to admission, and time since first clinical signs were noted. Data from the OVC-VTH medical record, including clinical signs, in-hospital treatments, duration of hospitalization and outcome, were recorded. For horses that died or were euthanized, post-mortem findings were recorded. Descriptive statistics were generated for all variables in the dataset. Population characteristics were described using median and range values.

Prospective study testing the level of agreement of 2 diagnostic laboratories for detection of N. risticii by PCR on both blood and fecal samples

In 2018, equine practitioners in Ontario were contacted and asked to submit samples of blood and feces from horses suspected of having PHF. Samples were collected by the attending veterinarian at the farm and shipped on ice overnight for next day delivery. Upon arrival, the samples were aliquoted and a pair of blood and fecal samples was submitted to Laboratory A (university-based laboratory) and Laboratory B (commercial laboratory). All horses sampled were located in the province of Ontario and sample collection took place between June 1, 2018 and September 30, 2018. The geographic location of each horse was recorded. The Animal Care Committee at the University of Guelph approved the study which conformed to the standards of the Canadian Council on Animal Care.

Differences in the proportion of animals with a positive PCR for N. risticii DNA detected by each laboratory were examined using Fisher’s exact test. McNemar’s test was used to evaluate whether the PCR assays in the 2 laboratories were equally likely to identify horses with PHF. The level of agreement between the 2 laboratories in detecting PCR positive samples for PHF was explored using the Kappa coefficient test. Similarly, the level of agreement between laboratories for detecting PHF in blood and fecal samples was assessed using the Kappa coefficient test. The Kappa agreement was judged as poor when 0 ≤ κ ≤ 0.40, fair when 0.41 ≤ κ ≤ 0.59, good when 0.60 ≤ κ ≤ 0.74, and excellent when 0.75 ≤ κ ≤ 1.0 (18).

Prospective study of blood culture from horses suspected of having PHF

Blood samples were obtained in the summer months of 2015 to 2018 from 41 horses suspected by equine practitioners to have PHF based on a combination of clinical signs including fever and/or diarrhea, and geographical locations that had previously confirmed PHF cases (6–9). Two of the authors (JDB, LGA) identified horses through clinical examination or a referral telephone consultation requested by the attending veterinarian. All blood samples obtained from horses that met the inclusion criteria were submitted for both PCR for N. risticii DNA and blood culture for isolation of Neorickettsia spp. Samples were not submitted for culture if the horses had been previously treated with antimicrobials. Ethylenediaminetetraacetic acid (EDTA) blood samples (~30 mL) packed in ice were submitted for Neorickettsia spp. culture by overnight delivery to the Molecular, Cellular, and Environmental Rickettsiology Laboratory, Department of Veterinary Biosciences, College of Veterinary Medicine, The Ohio State University.
Results

Retrospective study of horses diagnosed with PHF in Ontario (2015–2019): Geographic location and clinical data

During 2015 to 2019, 46 horses were confirmed by laboratory testing with a diagnosis of PHF in Ontario (Figure 1). Of the 46 horses, 22 were females, 20 were geldings, and 4 were stallions. One horse was positive in 2015, 9 in 2016, 15 in 2017, 13 in 2018, and 8 in 2019 (Figure 2). Regarding the month of presentation, 2 cases were presented in June, 21 in July, 15 in August, and 8 in September. The median age was 9 y (range: 1.2 to 27 y). Breed information was available for 26 horses, with Thoroughbreds (n = 9) being the most frequent. The medical history for seeking veterinary attention included diarrhea in 29 (63%) horses, fever in 14 (30%), and colic in 3 (7%). The duration (median) of the clinical signs before veterinarian evaluation was 2 d (range: 6 h to 7 d). Seven horses had laminitis at the initial veterinary evaluation. Outcomes were available for 41 horses, 28 (68%) horses survived and 13 (32%) were euthanized due to poor response to therapy, prognosis, or financial constraints.

The exact location of affected horses was recorded in 34/46 cases (Figure 1). Most cases occurred in southern Ontario, along the Canada-USA border, where PHF has been previously diagnosed (7); however, 1 case was identified further north in Simcoe County (Figure 1). Of the 46 PHF cases diagnosed in Ontario, 23 were treated at the Large Animal Hospital, OVC-VTH. The 23 horses had multiple clinical findings on admission, with the most common being diarrhea and fever in 10 (43%), fever in 6 (26%), diarrhea and colic in 3 (13%), diarrhea, colic, and fever in 2 (9%), and fever and colic in 2 (9%). The duration (median and range) of signs before admission (reported by the owner or referring veterinarian) was 2 d (range: 1 to 7 d). Of the 23 horses, 39% (9/23) received 1 or more antimicrobial agents before admission. Three of 9 horses received intravenous (IV) oxytetracycline, 3 IV sodium cefiotur, 2 oral metronidazole, 2 oral trimethoprim-sulfa (TMS), and 1 a combination of IV penicillin and gentamicin. Eighteen (78%) horses received anti-inflammatory therapy; 12 (52%) received flunixin meglumine, 2 received phenylbutazone, and 4 received a combination of phenylbutazone and flunixin meglumine.

At admission, 5 horses received hypertonic sodium chloride solution (5%), and all horses received IV fluid therapy with lactated Ringer’s solution (Baxter, Mississauga, Ontario) continuous rate infusion (CRI) at a rate of 100 mL/kg body weight (BW) per day during the first 24 h, then adjusted accordingly to the hydration status. Intravenous fluid therapy was administered to the hospitalized cases for a median duration of 4 d (range: 2 to 10 d). Two horses received a polyimmune equine plasma transfusion (Equi-Plas; Plasvac USA, Templeton, California, USA). All 23 horses were treated with oxytetracycline (Liquamycin LA-200; Zoetis Canada, Kirkland, Quebec), 6.6 mg/kg BW, IV q12h or q24h. Seventeen (74%) horses that were presented to the hospital without signs of laminitis were treated with cryotherapy using sleeve-style digital cryo therapy and equine comfort boots (Soft-ride; Bacliff, Texas, USA).

Despite cryotherapy, 4 of 17 horses developed laminitis during hospitalization. Horses with laminitis were managed using pain control protocols that included non-steroidal anti-inflammatory drugs (NSAIDs) (flunixin meglumine or phenylbutazone), morphine, or CRI of butorphanol. Fourteen (61%) of the 23 horses were discharged from the hospital, whereas 9 (39%) were euthanized. Seven of 10 horses with laminitis (either identified at presentation or developed during hospitalization) were euthanized due to this complication. Autopsy results for 6 horses included a diagnosis of necro-hemorrhagic and ulcerative enterocolitis (n = 1), severe necrotizing neutrophilic colitis (n = 5) consistent with N. risticii infection, and acute laminar epidermal necrosis and fibrinous, neutrophilic laminitis with hemorrhage.

Study comparing results from 2 laboratories for PCR testing of blood and feces

Detection of N. risticii in blood samples. Paired blood samples (n = 43) were submitted to compare the level of agreement between Laboratory A and Laboratory B for detection of N. risticii by PCR assay. Overall, 8 horses tested positive for N. risticii in blood when results from both laboratories were combined. Laboratory A detected 8/43 (19%) horses positive for PHF; whereas Laboratory B identified 3/43 (7%) (P = 0.0045). Kappa coefficient analysis showed a fair agreement between both laboratories for detection of N. risticii using PCR assay (κ = 0.494, 95% CI: 0.13 to 0.85). McNemar’s test showed that both laboratories were not equally likely to detect N. risticii by PCR (P = 0.025).

Detection of N. risticii in fecal samples. Paired fecal samples (n = 42) were submitted for PCR assay for the detection of N. risticii and the level of agreement was compared between Laboratory A and Laboratory B. Overall, 11 horses tested positive for N. risticii in feces. Laboratory A detected 11/42 (26%) horses positive for N. risticii, whereas Laboratory B identified 9/42 (21%) (P < 0.001). Kappa coefficient analysis showed an excellent agreement between the laboratories for detection of N. risticii DNA (κ = 0.932, 95% CI: 0.80 to 1). McNemar’s test showed that both laboratories were equally likely to detect N. risticii DNA (P = 0.317).

Detection of N. risticii DNA in blood and fecal samples at Laboratory A. At Laboratory A, 42 blood and 43 fecal samples were analyzed. This laboratory detected 11/42 (26%) horses positive for PHF in feces and 8/43 (19%) in blood (P = 0.05). Kappa coefficient analysis showed a good agreement between both samples for detection of N. risticii DNA (κ = 0.632, 95% CI: 0.434 to 0.812).

Detection of N. risticii DNA in blood and fecal samples at Laboratory B. At Laboratory B, 42 paired blood and feces were analyzed for detection of N. risticii DNA. Three (3/42) (7%) horses were positive in blood and 9/42 (21%) were positive in feces (P < 0.001). Kappa coefficient analysis showed a poor agreement between both samples for detection of N. risticii nucleic acids (κ = 0.308, 95% CI: 0.20 to 0.53).

Culture for Neorickettsia spp. from blood samples of horses suspected of having PHF. Sixteen of 41 (39%) samples yielded a positive culture for Neorickettsia spp. organisms. Two of the 16 isolates were classified as a novel Neorickettsia spp. now
designated *N. findlayensis* (11). Phylogenetic analysis of 12/16 of these Ontario isolates demonstrated clustering according to the geographic area of origin (11). These horses were located 200 to 6000 m (median: 2000 m) from water sources, such as lakes, rivers, or large ponds.

**Discussion**

This study documents the increasing number of PHF cases confirmed in Ontario over recent years and the challenges in confirming this diagnosis. In a previous report, 20 cases of PHF were confirmed at OVC over a 15-year period (7). Between 2015 and 2019, the number of cases of PHF confirmed at the Animal Health Laboratory, University of Guelph has increased. The number of PHF cases referred to OVC-VTH (*n* = 23) has also increased (7). There is now a greater awareness of the risk of the occurrence of PHF across southern Ontario, and this may explain, at least in part, the increased case numbers. Further, rapid and improved diagnostic tests, such as PCR, may also have played a role in the greater number of confirmed cases. However, an increased incidence of the disease should also be considered. There is an apparent year-to-year fluctuation in the number of PHF cases, and this warrants further epidemiological investigation in Ontario.

Most cases of PHF originated from areas previously recognized as endemic regions of the province for this disease (Figure 2). Clusters of cases were identified around Lake St. Clair and Lake Erie (Figure 2) as previously reported by Schofield in 1925. Culture-positive horses lived near (< 6 km) fast-running (rivers, creeks) and/or standing water (lakes, ponds). *Neorickettsia* infections, including those by *N. risticii*, have invariably been connected to lotic ecosystems; however, snails that live in lentic habitats have also tested positive for *N. risticii* (19,20). Both lotic and lentic ecosystems have been identified in association with this subset of Ontario horses; however, the source of infection remains unknown. One PHF-affected horse resided in a northern Ontario region (Simcoe County) where the disease has not been previously confirmed (11).

In recent years, major environmental efforts have been made to decrease water pollution in the Great Lakes and other bodies of water throughout Ontario. This may have positively impacted the number of emerging *Hexagenia* spp. (mayflies) (21). These

![Figure 1. Map of southern Ontario showing the geographic origins of Potomac Horse Fever cases. The colored dots depict the sample tested and the method of diagnosis.](image-url)
aquatic insects play an important role in the life cycle of Neorickettsia spp., and after their emergence they can travel inland for up to 8 km onto farms (22). This may in part account for the increasing reports of PHF throughout Ontario; however, this hypothesis remains to be tested.

As expected, and widely reported, PHF is a seasonal disease with higher incidence during the summer months. Although most cases cluster during the months of July and August (78%), some cases may appear as early as June and as late as October (7–9). Equine veterinarians and horse owners should be made aware of the disease pattern and the clinical signs for early case identification, prompt treatment, and/or referral. Similar to other studies, there was no breed or sex predilection for the development of PHF in the present study. All horses in this study were older than a year, with a median and age range similar to previous reports (23). Although this disease is known to affect foals as young as 4 mo of age (23), PHF has not been diagnosed in foals at the OVC-VTH.

The clinical presentations of PHF in Ontario were similar to those previously reported (2,23) with diarrhea and fever among the most common signs of PHF, and when combined, these signs represent 93% of the cases. Leukopenia, characterized by neutropenia, was the most remarkable hematological abnormality. However, this finding is typical of most horses with colitis. Serum biochemistry abnormalities including hyponatremia, hypochloremia, and hypoalbuminemia are commonly observed in diarrheic horses and have been previously reported in PHF cases (23,24). Supportive therapy with IV fluids is critical for horses with enterotoxphlocolitis and therefore it is not surprising that all horses referred to OVC received IV fluid therapy. Oxytetracycline is the antibiotic of choice for infections with Neorickettsia spp. and all horses admitted were treated with IV oxytetracycline at the prescribed dose of 6.6 mg/kg BW, q12 to 24h, usually for 5 d. Potomac horse fever cases generally improve markedly within 24 h to 48 h after the commencement of antimicrobial therapy; however, some horses may take longer to respond.

Molecular detection of N. risticii from clinically suspected PHF cases is the widely used and preferred diagnostic test, and was assessed simultaneously at 2 veterinary diagnostic laboratories in Ontario. The number of positive PCR tests for fecal samples was similar between the 2 laboratories; however,
there was a marked discrepancy in the proportion of positive PCR tests in blood samples (Table 1). In addition, Laboratory A had a good level of agreement for the detection of *N. risticii* in blood or feces, while Laboratory B had a low level of agreement between the results for the 2 samples. A difference in the time and duration of molecular detection of *N. risticii* in blood versus fecal samples has been demonstrated in experimentally infected horses (Table 2) (12,14–15). Therefore, the difference in the positive rate between blood and fecal samples was expected. However, the difference between laboratories was distinct and the reasons for this discrepancy are not known. Sample processing, methodological variations, reagents used, for example, may account for the differences in the rate of detection. It is reasonable to expect that in naturally occurring cases, however, both blood and fecal samples are adequate for molecular detection of PHF. It has been recommended that both blood and feces be submitted in order to increase the chances of detecting *N. risticii* (17). To the authors’ knowledge, studies comparing the *N. risticii* DNA positive rate between blood and fecal samples from clinical cases as well as the detection rate by different laboratories have not been previously reported.

Between 2015 and 2018, *Neorickettsia* spp. was isolated from the blood of 16 horses in Ontario. Fourteen of these isolates were identified as *N. risticii* and 2 were classified as a novel *Neorickettsia* spp., now designated as *N. findlayensis*. Experimental transmission studies in ponies confirmed that *N. findlayensis* was capable of causing PHF (10). Phylogenetic analysis of 12/16 *Neorickettsia* cultured isolates from Ontario showed some regional clustering according to strain relatedness in southwestern and central Ontario (11). The 2 cases with the novel *Neorickettsia* spp. clustered together, separated from the *N. risticii* clades, and from other horses located in Ontario (11). With the discovery of this novel species, PHF should be investigated for both *Neorickettsia* spp. in Ontario in order to determine the potential infection rates for each species and/or co-infections, and other important disease variables such as disease severity, associated complications, and outcomes.

Although culture isolation of causative pathogens is considered a gold standard of disease diagnosis, this approach can be challenging for intracellular microorganisms such as *Neorickettsia* spp. Cell culture is a sensitive method for diagnosing PHF, with comparable results to molecular testing (12). However, this approach requires laboratories that are capable of cell culture and that have the necessary technical expertise. Since culture isolation is labor-intensive and the organism may take weeks to grow, this approach cannot be used for clinical diagnostic purposes. A comparison between culture isolation and molecular diagnosis of clinical cases was originally planned but could not be performed due to the large number of samples which would require culture isolation.

In summary, PHF is endemic and widely distributed in southern Ontario. Laboratory confirmation of this disease may vary among veterinary diagnostic laboratories which warrants periodic assessment of diagnostic methods in place. It has been almost 100 y since a report was made of an endemic disease of horses in southwestern Ontario that had clinical, seasonal, and geographic similarities to PHF (6). A novel species, *N. findlayensis*, first isolated from a horse in Findlay, Ohio in 1991 was isolated in 2017 from 2 horses in eastern Ontario. As these 2 horses were culture positive for *N. findlayensis*, the negative PCR results for *N. risticii* were not unexpected. This species has been confirmed experimentally to cause clinical PHF (11). Future studies in Ontario should focus on the diagnostic techniques, epidemiology, and natural history of this organism as well as disease prevention strategies.

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Article

Diagnostic testing patterns for Streptococcus equi subsp. equi in Ontario horses during the years 2008 to 2018

Gabrielle Brankston, Tanya M. Rossi, Terri L. O’Sullivan, Amy L. Greer

Abstract — This retrospective study describes testing patterns and the incidence of Streptococcus equi subsp. equi in Ontario to assess the utility of laboratory data for surveillance purposes. Laboratory records for equine infectious disease test submissions were extracted from the Animal Health Laboratory (AHL) at the University of Guelph for the years 2008 to 2018. Yearly and seasonal trends in S. equi testing and the proportion of tests that returned positive results were assessed. The number of samples submitted for S. equi testing decreased over the 11-year period (odds ratio = 0.96, 95% confidence interval: 0.92 to 0.999; \( P = 0.04 \)). A generalized linear model identified a significant seasonal effect for animals recognized as clinically ill, with the highest test positivity noted in the winter. Although this study identified important trends in the incidence of S. equi in Ontario, the variability in information accompanying test submissions made the data challenging to interpret, highlighting the need for more complete diagnostic submission data for S. equi.

Résumé — Tendance des tests diagnostiques pour Streptococcus equi subsp. equi chez les chevaux de l’Ontario au cours des années 2008 à 2018. Cette étude rétrospective décrit les tendances des tests et l’incidence de Streptococcus equi subsp. equi en Ontario pour évaluer l’utilité des données de laboratoire à des fins de surveillance. Les dossiers de laboratoire pour les soumissions de tests de maladies infectieuses équines ont été extraits des données du Animal Health Laboratory (AHL), University of Guelph pour les années 2008 à 2018. Les tendances annuelles et saisonnières des tests de S. equi et la proportion de tests qui ont donné des résultats positifs ont été évaluées. Le nombre d’échantillons soumis pour la recherche de S. equi a diminué au cours de la période de 11 ans (rapport de cotes = 0,96, intervalle de confiance à 95% : 0,92 à 0,999; \( P = 0,04 \)). Un modèle linéaire généralisé a identifié un effet saisonnier significatif pour les animaux reconnus comme cliniquement malades, la positivité de test la plus élevée étant notée en hiver. Bien que cette étude ait identifié des tendances importantes dans l’incidence de S. equi en Ontario, la variabilité des informations accompagnant les soumissions a rendu les données difficiles à interpréter, soulignant le besoin de données plus complètes lors de soumission pour le diagnostic S. equi.

(Traduit par D’ Serge Messier)
Prevention of disease transmission requires a robust barn biosecurity program that includes measures such as quarantine and screening of new arrivals, detection and isolation of cases, disinfection of equipment, and education on proper hygiene for all caregivers (3). Two vaccines are available in Ontario, Canada to prevent disease transmission (8); however, the recommendation to vaccinate individual horses against *S. equi* is based on the risk management practices of individual owners which may vary from year to year (9). In some cases, Ontario horse shows have been cancelled to prevent transmission amid concerns of increased incidence of *S. equi* infections (10).

An understanding of the distribution of *S. equi* in the equine population is essential to determine disease risk and to identify and implement appropriate disease management and biosecurity measures. Experts in other countries have initiated surveillance programs for *S. equi* (5) but no such system exists in Canada. The Canadian Animal Health Surveillance System collects and reports information about cases of *S. equi*; however, this system relies on voluntary reporting from veterinarians (11) and thus, information is limited. The Ontario Animal Health Network reports cases of *S. equi* in some of their quarterly reports, although information about the number of animals tested is not reported, making inference about the true disease burden challenging (12).

Given the paucity of empirical data on the patterns of *S. equi* incidence there is a need to enhance surveillance of the pathogen. To assess the utility of laboratory data for surveillance purposes, the objective of this analysis was to describe testing patterns and the incidence of *S. equi* in the province of Ontario over an 11-year period (2008 to 2018) using diagnostic laboratory submission data from the Animal Health Laboratory (AHL) at the University of Guelph.

**Materials and methods**

**Data source**

Diagnostic submission data records for all equine infectious disease test submissions were extracted from the AHL at the University of Guelph for the period 2008 to 2018. Based on an informal comparison of test submissions to the AHL and the largest private laboratory in Ontario, the authors estimate that...
the AHL receives approximately 25% of samples submitted to these 2 laboratories for equine infectious disease testing for Ontario horses. Records with the test type *S. equi* polymerase chain reaction (PCR) or bacterial culture submitted for respiratory pathogens were included in the dataset. Data fields requested included demographic information about the animal, sample submission identifier, submission date, test result, and clinical history.

Data were examined for inclusion in the dataset. Records that were duplicated, were associated with horses located outside of Ontario, and/or samples that were submitted solely to support a research project were removed from the dataset. Multiple samples that were submitted on the same date for the same animal were combined into a single record.

**Analysis**

Clinical history information was not universally included by submitting veterinarians; however, an attempt was made to categorize laboratory records according to the reason for sample submission. The categorization process for all samples, based on the clinical history included with the sample submission, is shown in Figure 1.

Unless the clinical history explicitly stated that the sample was submitted for post-infection follow-up, after the first swab in a series, subsequent swabs for the same animal within 4 wk of each other were considered submitted for general screening.

Using the number of samples submitted for testing as the denominator, the proportion of tests by reason for sample submission and the proportion of tests that were positive for *S. equi* were calculated. The latter was calculated by year from 2008 to 2018 and by month for all years combined. The Cochran-Armitage test was used to assess the trend in the proportion of tests that returned positive results (test positivity) by year. The Mann-Whitney test was used to compare the number of samples tested in years in which test positivity was $\geq 14\%$ to those in which test positivity was $< 14\%$. This cut-off was established based on the observation of a distinct difference in the number of samples tested above and below this value.

Seasonal trends in the number of tests submitted for *S. equi* were evaluated using negative binomial regression models that predicted monthly and quarterly test counts in relation to observed monthly and quarterly test counts. Seasonal trends in the proportion of tests that were positive for *S. equi* were assessed using general linear models. A logit-link function and a binomial distribution were used with the total monthly or quarterly count of *S. equi* tests as the denominator. Year was included as a covariate in each of the models. Oscillatory seasonal smoothers, using sine and cosine terms, were included to control for non-seasonal oscillation of disease occurrence. For seasonal trends examined by quarter, each year was divided into quarters as follows: Q1 — January to March; Q2 — April to June; Q3 — July to September; Q4 — October to December. All analyses were conducted using Stata version 16.0 (StataCorp, College Station, Texas, USA).

**Results**

**Test type**

A total of 2799 samples were submitted to the AHL for *S. equi* testing between 2008 and 2018 (range: 83 to 519 per year). Overall, 62.5% of samples submitted were requested for testing by PCR only, 16.3% were submitted for bacterial culture only and 21.2% were submitted for testing by both procedures.

The proportion of samples submitted for bacterial culture decreased from 53.2% in 2008 to 8.6% in 2018. Conversely, the proportion of samples submitted for PCR increased from 45.0% in 2008 to 85.3% in 2018. A combination of the 2 methods accounted for 47.4% of samples in 2009 and 6.1% in 2018 (Figure 2).
The proportion of test types stratified by the reason for the test submission are shown in Table 1. In animals that were identified as clinically ill, the proportion of samples tested using bacterial culture only (41.6%) and PCR only (46.7%) were similar, and a smaller proportion of samples was tested by a combination of the 2 tests (11.7%). Some samples that were submitted for screening purposes were tested by PCR only (56.6%), whereas 37.3% were tested using a combination of both and only 6.1% were tested by bacterial culture only. Most samples with no clinical history were tested using PCR only (90.3%).

**Reason for sample submission**

Over the years 2008 to 2018, 28.6% of all submitted samples originated from a horse that was identified as clinically ill or suspected to be infected with *S. equi*. Approximately 6% of samples were submitted to follow up on horses that had recovered from clinical illness. A variety of screening measures accounted for 39% of samples submitted. Disappointingly, 25.8% of samples was submitted without a clinical history. For samples that tested positive for *S. equi*, most samples (66.8%) were recovered from horses that were clinically ill, whereas a small proportion (2.8%) of samples represented confirmed positivity in animals that had clinically recovered from infection (Table 2). Approximately 12% of positive samples were recovered from horses being sampled for various screening measures and > 18% of positive samples resulted from submissions with no clinical history.

**Trends in testing**

Overall, there was a decreasing trend in testing between 2008 and 2018. The number of samples submitted for all test types for *S. equi* ranged from 83 in 2013 to 519 in 2009 (Figure 3). The number of samples submitted from animals that were identified as clinically ill showed trends that were similar to the overall trend for all animals regardless of clinical status. The yearly trend in the number of samples submitted for animals that were not considered clinically ill was similar to the overall trend in testing, with the number of tests being highest in 2009 and decreasing over the following years (Figure 3).

Seasonal trends in the number of tests between 2008 and 2018 were not observed when based on either month or quarter in all samples tested or in samples recovered from clinically ill animals. However, there was an effect of year for all tested animals (OR = 0.96, 95% CI: 0.92 to 0.99; P = 0.04) and tests for clinically ill animals only (OR = 0.88, 95% CI: 0.85 to 0.91; P < 0.01).

**S. equi test positivity by year**

Data for test positivity by year are shown in Figure 4. The yearly proportion of those that were positive for *S. equi* ranged from 5.4% [95% confidence interval (CI): 2.9 to 9.7 in 2016] to 14.9% (95% CI: 9.8 to 22.0 in 2012), but there was no significant trend in the proportion positive over the 11-year period (P = 0.5). The proportion of clinically ill animals tested that were positive for *S. equi* varied from 13.6% (95% CI: 6.2 to 27.2) to 34.4% (95% CI: 23.6 to 47.1) and, again, there was no significant trend in the proportion positive over the 11 y (P = 0.8). The proportion of samples recovered from well animals and those with no clinical history that were positive ranged from 0 to 14.3% (95% CI: 6.1 to 30.1, P = 0.2 for trend) and 0 to 13.3% (95% CI: 7.5 to 22.4, P = 0.1 for trend), respectively.

The mean number of tests submitted was associated with the overall proportion testing positive. Years with a test positivity of ≥ 14% had a mean of 108.7 (± 25.5) submitted tests and those with a test positivity < 14% had 309.1 (± 41.0) submitted tests (P = 0.01).

**S. equi test positivity by month**

Combining all years, the proportion of all samples that were positive ranged from 7.0% (95% CI: 4.1 to 11.6) in September to 14.9% (95% CI: 9.8 to 22.0) in February (Figure 5). The proportion of samples submitted from clinically ill animals that were positive ranged from 14.1% (95% CI: 7.5 to 24.9) in September to 38.2% (95% CI: 26.4 to 51.6) in January.

Seasonal effects in test positivity were not significant when assessed by month in all animals tested (P = 0.1) or by clinical status (clinically ill P = 0.1; not clinically ill P = 0.8; no clinical history P = 0.3). However, when assessed by quarter, a significant seasonal effect was noted for clinically ill animals, with a greater proportion positive in the winter months of January to March (P = 0.04). There was no seasonal effect for all animals tested when seasonality was assessed by quarter (P = 0.367). Average *S. equi* test positivity in clinically ill animals was 31.6% in January to March, 24.0% between April and June, 16.8% between July and September, and 24.6% between October and December.

**Table 1.** Proportion of equine samples submitted to the Animal Health Laboratory (AHL) for *S. equi* testing stratified by test type and reason for test, 2008 to 2018.

<table>
<thead>
<tr>
<th>Reason for sample submission</th>
<th>All samples (N = 2899)</th>
<th>Positive samples (N = 289)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clinical illness</td>
<td>801 (28.6%)</td>
<td>193 (66.8%)</td>
</tr>
<tr>
<td>General screening</td>
<td>365 (13.0%)</td>
<td>11 (3.8%)</td>
</tr>
<tr>
<td>Biosecurity/move to a new barn/conditioning</td>
<td>221 (7.9%)</td>
<td>1 (0.4%)</td>
</tr>
<tr>
<td>Post-infection follow-up</td>
<td>170 (6.1%)</td>
<td>8 (2.8%)</td>
</tr>
<tr>
<td>Hend problem</td>
<td>443 (15.8%)</td>
<td>16 (5.5%)</td>
</tr>
<tr>
<td>Post-exposure testing</td>
<td>71 (2.5%)</td>
<td>7 (2.4%)</td>
</tr>
<tr>
<td>Other</td>
<td>5 (0.2%)</td>
<td>—</td>
</tr>
<tr>
<td>No history</td>
<td>723 (25.8%)</td>
<td>53 (18.3%)</td>
</tr>
</tbody>
</table>

**Table 2.** Proportion of all equine samples submitted to the Animal Health Laboratory (AHL) for *S. equi* testing and positive *S. equi* samples stratified by reason for test, 2008 to 2018.

<table>
<thead>
<tr>
<th>Reason for sample submission</th>
<th>No (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clinical illness</td>
<td>4 (11.7%)</td>
</tr>
<tr>
<td>PCR only</td>
<td>74 (46.7%)</td>
</tr>
<tr>
<td>Culture only</td>
<td>76 (37.3%)</td>
</tr>
<tr>
<td>Culture + PCR</td>
<td>24 (3.3%)</td>
</tr>
</tbody>
</table>
Discussion

To the authors’ knowledge, this is the first descriptive analysis of S. equi testing conducted in Canada. The proportion of samples submitted for PCR testing increased between 2008 and 2018, now accounting for most tests for S. equi. Several reasons may account for this observation. Bacterial culture takes a minimum of 1 to 2 d but PCR testing can be completed in as little as 1 to 2 h, allowing for the rapid isolation of affected horses and mitigation of transmission to others (3). Accumulating evidence of the inferior sensitivity of culture compared to PCR has resulted in bacterial culture no longer being considered the gold standard for the detection of S. equi (6,13–16). This evidence has been incorporated into clinical practice guidelines for the management of S. equi (3) and it is likely that veterinarians have increasingly adopted these guidelines, resulting in most samples being submitted for PCR testing rather than bacterial culture.

There was a general downward trend in the number of tests for S. equi from 2008 to 2018. The odds of a test decreased by 4% with each increasing year for all samples and 12% for clinically ill animals only. These findings may indicate that veterinarians are increasingly making diagnoses based on clinical picture rather than on laboratory test results. The cost of testing may act as a disincentive to wider testing, and it is possible that owners have become less inclined to pay for testing and are more likely to ask their veterinarian to treat suspected cases empirically rather than in response to a positive test. It is also possible that, with the introduction of the more sensitive PCR test, owners have become more reluctant to test clinically well animals that may be identified as silent carriers. These animals may require unanticipated biosecurity measures; however, the data presented here do not support a reduction in testing solely due to screening clinically well animals.

Similar patterns were seen in testing for clinically ill compared to screened animals by year leading to the interpretation that testing for sick animals drives testing for well animals to determine carrier status or to determine where transmission is happening in a herd. This theory is consistent with past research focusing on the swine industry which determined that higher diagnostic laboratory submissions were associated with disease outbreaks (17).

It is possible that owners are increasingly vaccinating their horses against S. equi thereby reducing the need to test for the illness. Although 2 vaccines are available for S. equi in Canada, there are few studies in the literature examining vaccine uptake and there was no evidence to document vaccine uptake over time. One study describing equine networks reported a vaccine uptake of 60% in participants at an Ontario equestrian event in the year 2014 (18). A study describing horse movement patterns in Ontario, Canada reported that 20.5% of participating horses had received a vaccine for S. equi in the year before the study (19). This disparity may reflect the current vaccine guidelines recommending S. equi vaccination based on the risk management practices of individual owners which may vary year to year (9).

There was no significant yearly trend in test positivity over the 11-year period. Test positivity in all samples varied between 5 and 15%, similar to reports from the United Kingdom of test positivity ranging from 5 to 10% in 2018 (20–23). The lack of trend in proportion testing positive over the years along with the reduction in number of samples submitted for testing may imply that disease burden is not changing year to year or that more owners/veterinarians are diagnosing animals based on clinical picture rather than testing.

In the current analysis, the 3 y with the highest test positivity overall (in the 14 to 15% range) occurred during years with the fewest samples submitted (2008, 2012, and 2013). This is consistent with past research which has demonstrated that during outbreaks, when testing for a pathogen is likely to be high, the probability of a positive test decreased (24). Conversely, it may
be the case that lower testing frequency corresponds to a higher test positivity. It would follow that, with a lower frequency of testing, samples were mainly submitted for clinically ill animals as a greater frequency of screening tests would dilute test positivity. Indeed, the years 2008, 2012, and 2013 had few samples submitted for screening purposes.

Regarding the seasonal trend of test positivity, the proportion of samples testing positive was highest in samples from clinically ill animals in the winter months. This finding is consistent with past research demonstrating that positive cases occurred mainly in winter months (25). The authors postulated that this might reflect a higher density of animals kept indoors during the winter, thereby increasing transmission among animals. In addition, the bacteria causing strangles can survive for up to 9 d on surfaces in the summer but up to 34 d in the winter (26), allowing for more opportunities for indirect transmission in the winter.

In contrast to our results, in surveillance reports from the United Kingdom in the year 2018, test positivity was reasonably consistent among seasons, varying from 7 to 9% from January to March (20), 5 to 10% from April to June (21), 6 to
There are several limitations associated with this study. The tests and results in this analysis represent only owners seeking veterinary care and therefore, do not necessarily represent the entire picture of \textit{S. equi} in the province. The AHL is a large veterinary diagnostic laboratory in Ontario; however, a large proportion of samples in Ontario is tested at private laboratories. Respiratory infection panels are available for the equine population at some private laboratories in Ontario but not at the AHL. Accordingly, veterinarians might choose one of these private laboratories if they are trying to diagnose non-specific respiratory signs such as nasal discharge. There may be a geographical bias towards the private laboratories outside of the Guelph area because sample pick-up by these laboratories may be more convenient for the veterinarian. Therefore, not having access to the data from private laboratories may have affected the findings in such a way that they are not representative of Ontario’s equine population. A more comprehensive analysis should include data from multiple diagnostic laboratories, ensuring validation of testing trends among laboratories.

The analysis relied solely on diagnostic submission data from the AHL at the University of Guelph. Such administrative data were not collected for the purposes of research or surveillance and therefore, lack the detail and rigor of data collected for active disease surveillance. The incomplete clinical history of hundreds of samples in this dataset made it impossible to distinguish among sick animals, screened animals, or testing to distinguish between the vaccine strain versus the circulating strain of \textit{S. equi} for many of the submitted samples; therefore, records may have been unintentionally misclassified.

Finally, although sampling techniques (e.g., nasal swab, guttural pouch lavage) can strongly influence detection of \textit{S. equi} (15), the data for sample technique in this dataset were entered in a free-text format distributed across multiple variables and were therefore impossible to extract without examining each submission individually. These issues highlighted limitations of using administrative data for disease surveillance purposes. Mandatory standardized data field requirements on laboratory submission forms would improve the classification of samples, thereby improving our ability to pursue better surveillance options for \textit{S. equi}.

In conclusion, there is limited research assessing the epidemiology of \textit{S. equi} infections. The current analysis provides an important foundation on which to build in order to support infection control measures for diseases in the horse industry. As testing has moved toward the rapid and more sensitive PCR method, there have been overall reductions in testing. This might reflect a move toward diagnosis based on clinical picture, a reduced willingness to pay for testing, a higher rate of vaccination, or concern about detecting clinically healthy carriers of \textit{S. equi}, necessitating implementation of unanticipated biosecurity measures. Seasonal variation in test positivity might relate to climate or other unknown factors. These hypotheses can only be assessed with more standardized and complete data on test submissions. For example, the reason for testing could be a required element that is chosen from a drop-down list or checklist, ensuring the completeness of data.

Given the considerable animal health and financial implications of outbreaks of \textit{S. equi}, including the cancellation of equestrian events, there is a need for the equine industry in Ontario to develop and maintain more complete surveillance data for \textit{S. equi}. This study highlighted the limitations of using diagnostic laboratory data for such surveillance and underscored the need for standardization of diagnostic submission data to better inform detection and refine prevention and management strategies for \textit{S. equi}.

Acknowledgment

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### Answers to Quiz Corner

Les réponses du test éclair

1. A) A left shift with neutropenia suggests aggressive inflammation with severe consumption of neutrophils.
   
   A) Un virage à gauche accompagné de neutropénie suggère une inflammation agressive avec consommation sévère de neutrophiles.

2. C) Loss in skin turgor is first detectable when there is 5% to 10% dehydration.
   
   C) Une perte du signe du pli cutané est d’abord décelable lorsqu’il y a de 5 % à 10 % de déshydratation.

3. B) Lymphoma is the most common gastric neoplasm in cats. Adenocarcinoma is the most common gastric neoplasm in dogs.
   
   B) Le lymphome est le néoplasme gastrique le plus commun chez le chat. L’adénocarcinome est le néoplasme gastrique le plus commun chez le chien.

4. B) Crooked calf disease is a well-documented disorder that is seen in calves whose dams ingest plants containing the quinolizidine alkaloid during the early part of gestation.

   B) La maladie du veau crochu est un problème bien démontré qui est observé chez les veaux dont les mères ingèrent des plantes contenant des alcaloïdes quinolizidiniques au début de la gestation.

5. D) Of the viruses listed, BRSV is the only one that has been associated with interstitial pneumonia.

   D) De tous les virus énumérés, le virus respiratoire syncytial bovin est le seul associé à la pneumonie interstitielle.
Conjunctival dacryops in a domestic shorthair cat

Emily A. Van Bommel

Abstract — A 1-year-old spayed female domestic shorthair cat with a 1-week history of a conjunctival mass located in the dorsolateral quadrant of the right eye was presented to a referral hospital. Ophthalmic examination revealed a pink, fluctuant, and non-painful cystic swelling of the upper right palpebral conjunctiva. An ocular ultrasound confirmed the presence of a fluid-filled cystic structure that extended into the temporal orbit. The histopathology of the excisional biopsy revealed multiple cysts lined by ductal epithelium along with dilated lacrimal gland ducts and lymphocytic nodules adjacent to the dorsal lacrimal gland; consistent with a diagnosis of dacryops.

Résumé — Dacryops conjonctivale chez un chat domestique à poil court. Une chatte domestique stérilisée de 1 an à poils courts avec une histoire d’une semaine d’une masse conjonctivale située dans le quadrant dorsolatéral de l’œil droit a été présentée à un hôpital de référence. L’examen ophtalmologique a révélé une tuméfaction kystique rose, fluctuante et non douloureuse de la conjonctive palpébrale supérieure droite. Une échographie oculaire a confirmé la présence d’une structure kystique remplie de liquide qui s’est étendue dans l’orbite temporale. L’histopathologie de la biopsie excisée a révélé de multiples kystes bordés d’épithélium canalaire ainsi que des canaux glandulaires lacrymaux dilatés et des nodules lymphocytaires adjacents à la glande lacrymale dorsale; compatible avec un diagnostic de dacryops.


A 1-year-old spayed female domestic shorthair cat was evaluated by the family veterinarian for a 1-week history of a cystic swelling of the conjunctival tissue in the dorsolateral quadrant of the right eye after a 3-day treatment of tobramycin and dexamethasone ophthalmic solution (Tobradex, 0.3%/0.1%; Alcon Canada, Mississauga, Ontario) failed to resolve the cystic swelling. This medication had been prescribed 5 mo earlier for bilateral conjunctivitis and was applied to the right eye q12h before consultation. A smooth cystic swelling under the right dorsolateral palpebral margin was present on physical examination. A complete blood cell count and serum biochemistry were carried out, and all parameters were determined to be within normal limits. Referral to the Ophthalmology Service at the Ontario Veterinary College Health Science Center (OVC-HSC) for further evaluation and possible surgical therapy by a Board-certified veterinary ophthalmologist was recommended.

Ocular examination on referral presentation revealed a pink, fluctuant cystic swelling with translucent walls that appeared to extend from the dorsotemporal fornix of the right eye (Figure 1). No other anomalies were detected in the right eye and none were seen on ocular examination of the left eye. The neuro-ophthalmic examination; including the dazzle reflex, menace response, palpebral reflex, and direct and consensual pupillary light reflexes, in both eyes was normal. Intraocular pressures using the Tonovet Tonometer (Jorgensen Labs, Loveland, Colorado, USA) were normal [right eye: 22 mmHg, left eye: 17 mmHg; Normal: 18 ± 5.07 mmHg (1)]. A Schirmer Tear Test (Merck Animal Health, Madison, New Jersey, USA) was normal [right eye: 18 mm/min, left eye: 17 mm/min; Normal: 16.24 ± 6.20 mm/min (1)]. Fluorescein staining was negative in both eyes.

Based on the findings at this stage, a presumptive diagnosis of dacryops was made. An ocular ultrasound of the cystic structure was recommended to evaluate its extent into the orbit. As surgery was likely to follow imaging, the cat was anesthetized. A drop of topical anesthetic [proparacaine hydrochloride solution (Alcaine, 0.5%; Alcon Canada, Mississauga, Ontario)] was applied to the right eye before the ocular ultrasound. Ocular ultrasound confirmed the presence of a cystic structure (dacryops) that extended into the temporal orbit with anechoic fluid-like content (Figure 2). Using aseptic technique, the cat was prepared for an excisional biopsy of the cystic structure. Intravenous cefazolin (93 mg) (ceFAZolin for Injection Mfr. Std. 1g; SteriMax, Oakville, Ontario) and subcutaneous robencoxib (8 mg) (Onsior; Elanco, Greenfield, Indiana, USA) were administered.

An operating microscope was used to allow better visualization of the surgical field during the procedure. A lateral canthotomy was performed using tenotomy scissors to gain better access to the cystic structure.
exposure to the dorsal conjunctival tissues and the fluid-filled structure. Using blunt and sharp dissection with tenotomy scissors, the 30-mm fluid-filled fluctuant mass was isolated, excised, and fully removed (Figure 3). The tissue was placed in 10% formalin and submitted for histological evaluation. Surgical closure of the conjunctival incision was with 6-0 polyglactin 910 (Coated Vicryl; Ethicon, Somerville, New Jersey, USA) using an inverting Cushing pattern to close the dead space. However, the suture was still exposed following closure and posed the potential for corneal irritation and ulceration. The suture was removed and 7-0 polyglactin 910 (Coated Vicryl; Ethicon, Somerville, New Jersey, USA) was used in an inverting Cushing pattern on the bulbar and palpebral conjunctiva to close the dead space. Closure of the skin at the lateral canthus was done with 5-0 polypropylene (Prolene; Ethicon, Somerville, New Jersey, USA) using a simple interrupted pattern, braiding the suture ends to prevent them from contacting the cornea and causing irritation and/or ulceration.

Post-operative management included topical tobramycin (Tobrex, 0.3%; Alcon Canada, Mississauga, Ontario), in the right eye, q8h and topical tear gel (Tear-GEL; Bausch & Lomb, Rochester, New York, USA) in both eyes, q6h for 14 d until recheck by the family veterinarian. Pain management included robenacoxib (Onsior; Elanco, Greenfield, Indiana, USA), 6 mg, PO, q24h for 3 d and gabapentin (100 mg/mL suspension; Chiron Compounding Pharmacy, Guelph, Ontario), 40 mg, PO, q8 to 12h for 5 d. An Elizabethan collar was provided to prevent self-trauma.

At the recheck appointment 14 d after surgery, the skin incision had healed well and the skin sutures were removed. A Schirmer Tear Test was 7 mm/min and 17 mm/min in the right and left eyes, respectively. There was very mild fluorescein stain uptake ventrally in the right eye. Secondary keratoconjunctivitis sicca (KCS) and mild corneal erosion were diagnosed in the right eye; this resulted from surgical excision of the dorsal lacrimal gland. Administration of topical tobramycin (Tobrex, Alcon Canada), q8h and tear gel (Tear-GEL, Bausch & Lomb) q6h was continued in the right eye until the next recheck appointment. At the subsequent recheck appointment 4 wk after the initial recheck appointment, the right eye did not take up fluorescein stain. A Schirmer Tear Test was 4 mm/min and 14 mm/min in the right and left eyes, respectively. The topical tobramycin was discontinued, and tear gel (Tear-GEL, Bausch & Lomb), administered q6h to the right eye was to be continued indefinitely.

**Histopathology**

The excised mass was placed in 10% buffered formalin for fixation, embedded in paraffin, and stained with hematoxylin and eosin (H&E). Histopathology revealed that the tissue was composed of multiple cysts lined by cuboidal epithelium that ranged from 1 to 3 layers thick. There was a moderate amount of eosinophilic cytoplasm in the epithelial cells. Lobular glandular tissue was present (lacrimal gland), and within the glandular tissue normal ducts were diluted. Surrounding the glandular tissue, there were scattered nodules of lymphocytes forming secondary lymphoid follicles (Figure 4). The histopathological diagnosis was multiple epithelial cysts (dacryops) along with diluted lacrimal ducts and lymphocytic nodules surrounding the dorsal lacrimal gland.

**Discussion**

Given the age of the cat and ocular findings in the reported case, dacryops was the primary differential diagnosis. This was based on the dorsolateral temporal location of the fluctuant conjunctival swelling, its translucent wall, and the lack of pain or irritation. The histopathological features described in this case confirmed a diagnosis of dacryops. In veterinary medicine, dacryops is a rare clinical finding that is infrequently reported in literature (2). Cysts associated with lacrimal tissue have been reported in dogs (2–4), cats (5,6), a horse (7), a red-eared slider (8), and humans (9–11). Dacryops may form in any location where lacrimal tissue is present (2,4).
Lacrimal cysts in dogs have been reported to originate from the orbital and nictitans lacrimal glands (3,4), be associated with dilation of the nasolacrimal system (12), or originate from ectopic (choristomatous) lacrimal tissue (4).

The term dacryops was first described by Schmidt in 1803 (4,11) and refers to an ectasia of lacrimal gland tissue containing apocrine secretions of tear gland origin (3,5,6). In human medical literature in 1974, Duke-Elder (13) proposed a classification of lacrimal ductal cysts based on anatomic location, and this classification was later modified in 1986 to describe palpebral lobe cysts (also called simple dacryops); orbital lobe cysts; cysts of the accessory lacrimal glands of Wolfring and Krause; and cysts of ectopic (choristomatous) lacrimal gland tissue (14). Histologically, all reported cases of dacryops in veterinary and human literature share similar features: single or double layer of cuboidal or flat epithelial lining, occasional fibrosis of the walls of the cyst, and adjacent lacrimal glandular tissue that often contains inflammatory infiltrates (lymphocytes and neutrophils) (2–7,9,10). Occasionally, there is atrophy of lacrimal glandular tissue due to secretory stasis (5).

It is unclear as to the exact etiopathogenesis involved in dacryops formation. In 1992 Weatherhead (11) proposed that the formation of dacryops requires 2 sequential and related events: the first is occlusion of a ductule and the second is an ongoing secretory process. It has been hypothesized that chronic inflammation or trauma of the conjunctival tissue leads to fibrosis in the ductal orifice and an occlusion of lacrimal ductal openings (11). Previously it was thought that this occlusion resulted in mechanical ectasia due to a build-up of secretions. However, this theory has been contradicted due to experimental studies showing that blockage of lacrimal duct openings causes atrophy of the gland (5,10). Another hypothesis describes an osmotic gradient caused by an increased concentration of IgA protein in the lumen of lacrimal ductules following an immune challenge (11). A proposed theory by Jakobiec et al (15) involves a combination of periductular inflammation and dysfunction of the neural plexus around the ductules. Of note, patients without any previous history of trauma and inflammation have been diagnosed with dacryops, suggesting a congenital anomaly or that an imbalance in secretory composition may be at play (9). The mechanism of dacryops formation is likely multifactorial (4,5,9). The histopathological findings in the reported case demonstrating lymphocytic infiltrates forming secondary
lymphoid nodules is suggestive of an ongoing inflammatory process, with a suspected underlying etiology being feline herpesvirus type-1 (FHV-1).

Cases of periorcular cystic lesions in cats have been previously reported in the literature. Zemljič et al (16) described a case of an 18-month-old European Shorthair with an orbital-nasal cyst of unknown etiology and origin. It was proposed that the anomaly originated from the lower lacrimal canaliculus or nasolacrimal duct. Another report by Sritrakoon et al (6) described a 9-month-old domestic shorthair with dacryops of the third eyelid; previous inflammation of the third eyelid was hypothesized as the mechanism of development of the cyst. In these 2 aforementioned case reports, a suggested infectious etiology from FHV-1 was thought to contribute to the formation of the cysts. The latest report in 2020 by Maggio (5) described bilateral temporal lacrimal gland dacryops in a 1-year-old Maine Coon cat. In this latter report, severe inflammatory infiltrates in the lacrimal gland tissue were seen on histology, suggesting an immune-mediated process. The immune-mediated process may have followed chronic inflammation and infection with FHV-1; however, the patient had no previous ocular or respiratory disorders. In addition, the rarity of dacryops in cats is in strong contrast to the frequency of FHV-1 diagnosis in cats (5).

Suggested etiologies in the reported case include a congenital anomaly and/or chronic inflammation and infection with FHV-1, given the young age of the cat and reported history of bilateral conjunctivitis 5 mo earlier. A common feature in all 4 cases, including the reported case, is the young age of all cats (ranging from 9 to 18 mo), suggesting a possible underlying congenital anomaly resulting in cyst formation. A congenital anomaly has also been reported in 2 young basset hounds (17), 3 young Labrador retrievers (2), an 8-month-old Neapolitan Mastiff (3), and two 5-month-old golden retrievers (4).

Historically, untreated dacryops demonstrate progressive enlargement and are unlikely to undergo spontaneous regression (4). Occasionally, they can become complicated by inflammatory disorders. In addition, the rarity of dacryops in cats is in strong contrast to the frequency of FHV-1 diagnosis in cats (5).

In conclusion, a diagnosis of dacryops (lacrimal gland cyst) should be considered as part of the differential diagnosis list in young cats presenting with a fluctuant cystic swelling of conjunctival tissue. In cases in which surgical excision is performed, long-term follow-up care should be considered for secondary problems such as KCS.

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References

One Health Une santé

Launching a One Health column

Carlton Gyles
Former Editor-in-Chief
The Canadian Veterinary Journal

The suggestion that The Canadian Veterinary Journal (The CVJ) should establish a One Health column was made at a CVMA Strategic Planning workshop in March 2019 and later that year, independently, in a survey of The CVJ readers. The CVMA Editorial Committee discussed and endorsed this initiative in the spring of 2020. Karin Orsel, the CVMA representative on the Editorial Committee, noted that Herman Barkema at the University of Calgary would be an excellent choice to lead the effort. The Committee agreed and Herman was asked.

My high school principal in Jamaica used to say, “If you want something done, ask a busy person.” We are delighted that, despite an extremely busy schedule, Herman was enthusiastic in his response to our invitation. He observed that “We have a great One Health team here and very good contacts with the other Canadian teams.”

What is One Health?

Michele Anholt, Herman Barkema

Vulnerable groups are being vaccinated against SARS-CoV-2. The swift development of a vaccine is an astonishing accomplishment achieved by the global cooperation of many highly skilled scientists. Society also has much of the knowledge to have prevented the emergence of SARS-CoV-2 but this is a more difficult problem to solve. Disease emergence is a complex, or “wicked,” problem. It arises at the intersection of people, animals, and the environment; the science explaining disease emergence crosses disciplinary lines; there is incomplete and contradictory knowledge; it is interconnected with other problems; and disease emergence, as well as its possible solutions, imposes a large economic burden. Investment in reductionist science has led to the development of vaccines, but it is time to also invest in systems science. There are various names applied to systems science at the human — animal — environment interface, each with a slightly different focus, but the label One Health has been gaining favor (1).

The veterinary profession in Canada has taken a leadership role in promoting improved understanding of the interrelationships among animal health, human health, and ecosystem health. The CVMA has been very supportive of the One Health concept and approach and currently has an active role, with programs on antimicrobial stewardship, tick awareness and Lyme disease, importation of dogs, and adaptation to climate change. The CVJ has been a part of the CVMA’s initiatives and has published numerous articles on various aspects of One Health in recent years. This column is an important addition to the range of writings on One Health and we are grateful to the experts who have agreed to make this a regular feature in the The CVJ.
security and safety, biodiversity loss, maintenance of healthy water ecosystems, and the consequences of climate change. One Health examines interacting systems, each embedded in natural, economic, social, and political environments (Figure 1).

In public health, the economic, social, and political factors that can either constrain or promote wellness are known as the determinants of health. Although not commonly applied to the health and resilience of animals, animals are also affected by characteristics of their physical environment and the anthropogenic imposition of social, cultural, and economic expectations. For example, intensification of animal production systems has occurred to increase efficiency, meet global demands for animal protein, and improve profitability. However, there is evidence that increased animal density can be detrimental to animal health (2).

One Health uses a transdisciplinary approach with investigators from various branches of knowledge and diverse backgrounds and perspectives collaborating to solve a common issue. Ciesielski et al (3) define a transdisciplinary approach as “the generation and utilization of research frameworks and admixed ideas that could not come from, or fit into, any one field.” The blending of disciplines in a transdisciplinary approach is greater than what is observed in interdisciplinary (“integration, adaptation, and harmonization of ideas that come from distinct fields”), or multidisciplinary (“the aggregation of fully formed ideas that come from distinct fields”) approaches (3). The fruit smoothie, fruit salad, and bowl of fruit have all been commonly used as a metaphor to illustrate degrees of disciplinary integration (4).

Another approach to understanding transdisciplinarity has been described by Max-Neef (5), who described the degree of coordination of the disciplines as levels of a pyramid. The base of the pyramid asks, “What exists?” These are the specialized disciplines in biology, mathematics, physics, chemistry, ecology, geology, sociology, economics, etc. At this empirical level, reductionist science is used to explain natural phenomena in terms of their underlying molecular, biochemical, or physical processes (6).

The second level is composed of the technical disciplines that explore the question, “What are we capable of doing?” At this level, knowledge attained by researchers at the empirical level is used by practitioners (physicians, veterinarians, engineers, architects, agrologists, industry, etc.) to heal, build, and grow. This is a pragmatic level that develops vaccines, builds bridges, and produces enough food to feed billions with enormous benefit to mankind. The question not asked at this level is whether we always should, just because we can.

The third level aims to answer the question, “What is it we want to do?” Inquiry at this normative level integrates the researchers and practitioners from the empirical and technical levels throughout the research process. There should be meaningful inclusion of all perspectives when developing the research questions, throughout planning and conducting the study, and during communication of the results. Collectively, the research team seeks the best ways to achieve their shared aims, goals, and purposes of the study.

Citizens also have a voice at this level because it is society that ultimately determines what is acceptable. In democratic societies in which authority lies with the general population, how this question is answered is decided through environmental impact assessments, policy debates, plebiscites, or elections. Through these platforms, stakeholders have access to accurate information and are given fair and meaningful opportunities to comment on and influence decisions (5). Decision-makers (government or citizens) make their respective decisions with the expectation that information will be shared without manipulation; this is fundamental to liberal democracies (7). Therefore, care must be taken not to influence the outcome by providing biased information (8).

The question at the fourth level contemplates the wider implication of decisions made and asks, “How should we do what we want to do?” At this value level, coordination between scientists, practitioners, and decision makers at all levels of the pyramid work together to move society from knowledge towards wisdom. The goal is to better address these important questions: i) how can we meet the needs of the present and future generations in Canada and around the world; ii) could our actions and the chaotic nature of systems result in unintended and unwelcome consequences; iii) does our response address social injustices; and iv) do our actions respect nature and environmental limits? The aspiration behind these questions is sustainability of the response(s).

It has been tiring and sorrowful living during this pandemic; can we prevent another? How could a One Health approach mitigate the risk of future zoonotic disease emergencies? Collaborations of scientists at the empirical level of the pyramid (virologists, ecologists, and molecular scientists) and the pragmatic level (epidemiologists, pathologists, veterinari-
ians, and physicians) have concluded that SARS-CoV-2 likely emerged at the intersection of horseshoe bats, pangolins, and people at a traditional wet market in Wuhan, China (9,10).

What can we do to reduce the future potential of pathogen transmission between wildlife and people? And how do we want to do that? How should we address the challenges of habitat loss and exploitation of wildlife populations that has increased animal-human-environment interactions? One suggestion has been to close wet markets across Asia (11). However, this will impose excessive restrictions on cultural expectations and compromise food security for a very large population; not a sustainable solution (12). A better approach would be a transdisciplinary collaboration that includes biological scientists as well as sociologists, economists, and decision-makers who can collectively address the questions from all levels of the pyramid for an ethical and sustainable solution that will reduce the risk of zoonotic disease transmission.

Investment in One Health is growing. In just the past 2 years, Canada has seen the creation of One Health at UCalgary (https://research.ucalgary.ca/one-health) and the One Health Institute at the University of Guelph (https://onehealth.uoguelph.ca/). Increasingly, funding opportunities require a One Health approach, such as a recent Emerging Infectious Diseases Modelling Initiative that encourages applicants “to establish multi-disciplinary collaboration that demonstrate integration of the One Health approach” (https://www.nserc-crsng.gc.ca/Professors-Professeurs/Grants-Subs/EIDM-EIDM_eng.asp). A quick Google search of “One Health” will result in many examples of programs and projects across the globe that advocate a One Health approach. These investments and collective action are the hope for a better future for all.

**One Health in action**

A complex blend of economic, social, and bio-physical factors has led microbes to develop resistance to drugs that have enabled intensive animal production, made invasive medical procedures such as surgery and dialysis possible, and minimized the outcome of many infectious diseases. Antimicrobial resistance (AMR) poses a global threat to human and animal health (https://www.oie.int/fileadmin/Home/eng/Media_Center/docs/PortailAMR/EN_OIE-AMRstrategy.pdf). The AMR — One Health Consortium (https://research.ucalgary.ca/amr) is a pan-Alberta initiative with 67 researchers from 11 institutions working across 30 projects. Funding was provided by Alberta’s Minister of Jobs, Economy and Innovation ($6.315M) plus $9.254M in matching funds from many other revenue sources. To realize its vision of a future in which AMR is contained, the Consortium’s projects collectively address multiple mitigation strategies and the 4 levels of Max-Neef’s (5) transdisciplinary pyramid (Figure 2).
References

The participation of advertisers in the CVJ is an indication of their commitment to the advancement of veterinary medicine in Canada. We encourage our readers to give their products and services appropriate consideration. — Ed.

Le support des annonceurs démontre leur engagement pour l’avancement de la médecine vétérinaire au Canada. Nous vous encourageons à prendre connaissance de leurs services et produits. — NDLR
Whether a reality of a pandemic-changed society or merely certain groups or individuals within it, the veterinarians in Dr. Schneider’s practice have noticed a shift in communication emphasis in some of their clients. This primarily takes two forms. Some clients have become far more problem-oriented; they want to focus strictly on their animals’ problems and treatments. Meanwhile, others have become more concerned about the veterinarian addressing the context in which their animals’ problems and any treatments occur.

In both situations, the cause of these clients’ orientations to their animals’ problems and treatments remains the same. These are not new orientations for these people. These simply have become more pronounced as both groups seek certainty and control in a contemporary world that, as their personal experiences have proven, may be difficult to come by.

For example, Dr. Schneider and his associates know that food animal clients like Mr. Cardigan want to focus solely on any sick animals’ problems and their treatments. When Mr. Cardigan’s prize cow goes off feed and develops diarrhea, he makes caring for her his and his employees’ top responsibility. Not only do they provide only minimal care to the rest of the farm’s animals, the client’s concern about the animal also causes him to ignore the short- and long-term financial and other responsibilities of running a farm that sells products for human consumption. When he experiences reductions in his workforce due to COVID-related illnesses or family caregiving responsibilities, he chooses to ignore these. Instead, he chooses to focus on the survival of that one animal problem as usual.

Among the companion animal clients in Dr. Schneider’s practice are those like Ms. Ormandy and her overweight golden retriever, Calvin. Of all the changes the veterinarians asked the client to consider as part of a comprehensive approach to canine weight loss over the years, all Ms. Ormandy chooses to hear is “exercise.”

“It’s so lovely this time of year and Calvin loves to explore the neighborhood,” she inevitably says happily regardless of the weather. “I’m sure we’ll both enjoy taking at least one brisk walk twice a day. And maybe even more.”

Although this may sound like an ideal client response, it fills Dr. Schneider and his staff with dread.

“What is that woman thinking?” “She and Calvin are both borderline obese!” “Calvin’s an untrained oaf.” These and other comments fill the air as the magnitude of the disconnect between what the client is willing to do to help her animal and the complexity of the problem hits them yet again.

These realities were challenging enough for the veterinarian and his staff to address if they wanted to create a comprehensive program to help Calvin lose weight. To attempt to do this using the only solution the client is willing to embrace seemed like a mission impossible. And although the client thus far had not experienced any pandemic-related fallout, her unrealistic view regarding her proposed canine weight-reduction program suggests she might take a more carefree view of her own health too.

In both these situations, the clients’ strictly problem-oriented focus functions like a set of blinders when it comes to quality communication with the practitioner.

What about those food animal and companion animal clients who opt for a more comprehensive, contextual approach?

Dr. Schneider and his veterinary staff recognize the value of food animal clients who want to understand the context in which their animals’ problems occur. If they did not appreciate the value of this when they entered practice, they soon learned this from their successful food animal clients. Those whose animals supply meat or other products for human consumption cannot afford to focus strictly on one animal’s problem — or even one problem in multiple animals — for many reasons. Heading the list is whether the sick animal’s condition poses a threat to other animals or humans. Second is whether the time necessary to properly treat the ill animal is available, or if doing so would compromise the care of the other animals in the herd.
or flock. In the pandemic era, this also includes any ill animals adding to the burden of an already reduced workforce due to COVID-related illnesses or family caregiving responsibilities.

However, it also takes a certain amount of knowledge, skill, and experience to address all the relevant variables effectively and in a timely manner. Because Mary Cassotis and her partner, Lucy, have worked hard for years learning this as it relates to their land and what to grow on it, their successful organic farm can offer the public an ever-expanding array of fresh chicken and duck eggs, poultry, cheese, honey, and other animal-based products from their flocks, herds, and hives. However, Mary's daughter and son-in-law have not fared so well in their attempts to duplicate Mary's and Lucy's broad-spectrum success. When the pandemic further reduces their small customer base, the fledgling entrepreneurs became even more disheartened. Nonetheless, and much as Mary and Lucy want to help them, they adhere to their promise not to interfere with the younger generation's new endeavor unless asked.

"My daughter and her husband have a lot more formal education regarding organic farming than Lucy and I did and we're very proud of their academic achievements," admits Mary. "But they didn't have the practical knowledge and experience that comes with raising and environmentally sustaining a particular combination of plant and animal species on a particular piece of land. They didn't understand their land's micro- and macro-environmental idiosyncrasies."

However, in this case Dr. Schneider and his staff developed sufficient, nonjudgmental rapport with the young couple that they could function as a local resource for them. They introduced the newbies to other novices attempting to establish working farms so they could learn from each other's experiences in a more relaxed environment. Dr. Schneider also provided the names of experienced locals he knew enjoyed sharing their knowledge with newcomers and his associates shared a list of resources they had compiled.

In the companion animal realm, those who always opt for a contextual approach are often book- (or, increasingly) Internet-smart.

The Mazukes are among this population. When one of their cats develops a cough and Dr. Schneider begins discussing possible causes after getting a history and conducting a comprehensive physical, they repeatedly nod their heads knowingly. They then tell the veterinarian all about the disease, its treatment, and anything else they learned during their extensive web-surfing. But they also have made up their minds regarding their animal's problem and the best way to treat it.

Although some practitioners may argue that the Mazukes' orientation is a problem-oriented rather than contextual approach, it is not. Their goal is not to diagnose and treat their animals themselves. They simply want to demonstrate how much they know about their animal's problem and its treatment. That is the larger context in which they interact with the veterinarian.

These clients pose difficult communication challenges for practitioners. Some veterinarians may ache to ask, "Why are you here if you already know everything about Scruffy's problem?" However, the fact remains that the client did seek the veterinarian's help. Although some of them may want to impress the veterinarians, others sincerely may desire to communicate with their practitioners in the practitioners' own language to facilitate the examination and their animals. Unfortunately, it can be difficult to differentiate the two. However, it is better to assume that these clients seek to help rather than humiliate the practitioner and do their best to help the animal.

As Dr. Schneider told an inexperienced younger colleague, "Over the years I've learned that some of those clients conduct their extensive fact-finding processes prior to interacting with all professional and trades people. It's just something they apparently do because they want to be informed consumers."

In all these situations, the clients' tendency to take a problem-oriented or contextual approach to their animals' problems preceded any changes related to the pandemic. However, in some cases pandemic-related changes and stressors may have caused them to adopt these orientations more often or exaggerate these approaches for some reason.

Perhaps these people routinely opt for one or the other approach because it somehow helps them understand the situation. Perhaps doing this helps them to feel more comfortable in the veterinary setting. Maybe they see it as a way to enhance their understanding of their animals' problems and their treatment. It is even possible that their approach has nothing to do with the animal — they just want to feel in control when they do not.

Although it is possible that some clients deliberately assume their orientations to intimidate or irritate the practitioner, these most likely represent the minority. Even if they do want to intimidate or otherwise irk the veterinarian, in the long run it is better for practitioners to summon the self-control to harness their own emotions at these times and focus on helping the animal instead.
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