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A multidisciplinary, minimally invasive approach combining lacrimoscopy and fluoroscopically guided stenting for management of nasolacrimal apparatus obstruction in dogs

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OBJECTIVE
To describe and evaluate outcomes of a multidisciplinary, minimally invasive approach combining lacrimoscopy and fluoroscopically guided stenting for management of nasolacrimal apparatus (NLA) obstruction in dogs.

DESIGN
Prospective, nonrandomized clinical trial.

ANIMALS
16 client-owned dogs with confirmed NLA obstruction.

PROCEDURES
Dogs underwent CT contrast dacryocystorhinography, rhinoscopy, and lacrimoscopy. Whenever possible, the NLA was stented, typically with fluoroscopic guidance.

RESULTS
Median duration of clinical signs prior to treatment was 3.2 months (range, 0.2 to 14 months). Causes of NLA obstruction were a foreign body (n = 5), dacryocystitis (4), stenosis secondary to fibrosis (3), granulation tissue (1), or granulation tissue in association with a small foreign body (1); a cause was not identified in 2 dogs. Stents were placed in 14 of 16 (88%) dogs for a median duration of 5.6 weeks (range, 1.3 to 9.4 weeks). Stenting was not possible in 2 dogs with stenosis of the NLA secondary to granulation tissue or fibrosis. Owners of all 16 dogs reported at least 60% clinical improvement with median improvement rated as 95%, and owners of 8 dogs reporting complete resolution of signs. Two dogs required antimicrobial administration because of dacryocystitis that persisted after stent removal; a foreign body was not found in either dog.

CONCLUSIONS AND CLINICAL RELEVANCE
Overall clinical response and owner-rated improvement for dogs with NLA obstruction that underwent lacrimoscopy and fluoroscopically guided stenting were high, especially given that these dogs had failed to respond to conventional treatment. (*J Am Vet Med Assoc* 2018;252:1527–1537)

The lacrimal system is responsible for generating and draining the preocular tear film and, in dogs, consists of the lacrimal and accessory lacrimal glands, gland of the third eyelid, meibomian glands, goblet cells, preocular tear film, and NLA.[1,2] The NLA consists of the paired lacrimal puncta and canaliculi, lacrimal sac, and NLD. The NLD runs through the lacrimal bone, passes through a soft tissue canal on the medial surface of the maxillary bone,[3] and ends in the nasal punctum typically about 4 to 5 mm caudal to the opening of the external nares.[4] Accessory openings in the wall of the NLD as it crosses over the root of the maxillary canine tooth have been reported in 30% to 90% of dogs of various breeds.[5-8]

Obstructions of the NLA can be intraluminal, intramural, or extraluminal and can result in various clinical signs. Current treatment options are limited[1] and, although medical management controls secondary infection, it is almost uniformly unsuccessful in permanently resolving the obstruction or associated signs. Therefore, identifying and treating the underlying cause of obstruction via cannulation, surgical FB removal, or surgical rerouting of the NLA are typically required.[1] Such surgical approaches are invasive and often involve entry through the nasal bone, prolonged recovery times, notable complications, and potential disfigurement.[6]

To the authors' knowledge, peer-reviewed reports documenting success rates following cannulation or

ABBREVIATIONS

CTCD	CT contrast dacryocystorhinography
FB	Foreign body
NLA	Nasolacrimal apparatus
NLD	Nasolacrimal duct
NPD	Neomycin–polymyxin B–dexamethasone
OD	Oculus dexter (right eye)
OS	Oculus sinister (left eye)
UCDVMTH	University of California-Davis Veterinary Medical Teaching Hospital

surgical correction of NLA obstruction in dogs are lacking; however, advancements in minimally invasive techniques and instrumentation combined with increased veterinary access to specialized equipment have contributed to enhanced outcomes following catheterization of other surgically challenging tubular tissues, such as ureters.[7] In addition, fluoroscopic and endoscopic visualization of internal structures have become more widely used within the veterinary profession and have further improved clinical outcomes in numerous veterinary settings.[8-13] However, endoscopy of the NLA has, to the authors' knowledge, been reported only in humans and horses.[14-16] Therefore, the authors hypothesized that endoscopic and minimally invasive stenting techniques could be used to diagnose and treat NLA obstruction in dogs. The study reported here was designed to develop a means of managing NLA obstruction in dogs through a combination of lacrimoscopy and fluoroscopically guided stenting, and to report outcomes of a minimally invasive, multidisciplinary approach.

Materials and Methods

Study design
This study was designed as a clinical trial and was approved by the University of California Institutional Animal Care and Use Committee (IACUC protocol number 19945).

Eligibility criteria
All client-owned dogs in which NLA obstruction was diagnosed at the UCDVMTH or that were referred to the UCDVMTH for treatment of NLA obstruction between February 12, 2013, and March 7, 2016, were eligible for inclusion in the study. Additional recruitment efforts for affected dogs included posting an advertisement about the study on the UCDVMTH Clinical Trials web page[17] and notifying local veterinary ophthalmologists at an annual regional meeting and via emails. Informed consent for inclusion in the study was obtained from owners of all dogs.

Procedures
All dogs underwent a complete ophthalmic examination, including—in sequential order—Schirmer tear test type I, periocular palpation, slit-lamp biomicroscopy, indirect ophthalmoscopy, and application of fluorescein to the ocular surface. Some dogs also underwent applanation or rebound tonometry. Obstruction of the NLA was confirmed in all dogs on the basis of negative results of the fluorescein passage test (Jones test I) and an inability to flush the NLA in an antegrade direction (Jones test II).[18,19] Nasal airflow was tested in some dogs by holding a small tuft of cotton in front of each nostril and watching for movement of the cotton with respiration. Following initial assessment, dogs were generally prescribed oral and ophthalmic anti-inflammatory and antimicrobial medications to control dacryocystitis prior to further diagnostic testing and treatment.

At a subsequent visit, each dog was anesthetized with a protocol selected by the attending anesthesiologist and appropriate to the dog's medical status. Each dog was maintained in sternal recumbency, and its eyes were kept moist with artificial tear solution or ophthalmic ointment as needed throughout the procedure. Following anesthetic induction, CTCD was performed with a multislice helical CT scanner[a] with 0.625-mm image collimation and soft tissue and edge-enhancing reconstruction algorithms. After the nonenhanced CT scan of the patient's head was performed, approximately 0.5 to 1.5 mL of iodinated contrast medium[b] was injected into the patient's superior or inferior lacrimal punctum. Sequential CTCD images were acquired for the affected and unaffected NLAs. All images generated throughout the study were assessed by 1 radiologist (ERW).

In some dogs, rostral rhinoscopy was performed with a rigid telescope[c] to identify the nasal puncta and assess for abnormalities. Intraluminal abnormalities of the NLA were assessed by lacrimoscopy with a miniature flexible telescope with a 0° direction of view, 70° angle of view, 100-cm working length, and 0.5-mm outer diameter.[d] To obtain better access to the canaliculus and aid scope manipulation, the lacrimoscope was, in some dogs, introduced through a stainless steel lacrimal cannula, 0.034-in ureteral dilator,[e] or 3.5F polytetrafluoroethylene urinary catheter.[f] Because the lacrimoscope was flexible but did not have cable-operated tip movement, it was inserted and directed manually through a series of gentle twisting movements. The lacrimoscope diameter did not permit an auxiliary channel for insufflation or irrigation; therefore, dilation of the NLA was achieved via continuous or pulsatile instillation of sterile saline (0.9% NaCl) solution through the lacrimal punctum not occupied by the lacrimoscope, with a 20- to 30-mL syringe connected to an IV extension line[g] attached to a 1.75-in, 20- to 24-gauge IV catheter[h] from which the stylet had been removed.

Following lacrimoscopy, each dog's NLA was flushed with hyaluronate[i] for its viscosity to dislodge FBs or with povidone-iodine solution diluted 1:50 with sterile saline solution for its antimicrobial activity. In all cases, sterile saline was used as a final flush solution. Antegrade flushing of the NLA often was done simultaneously with rostral rhinoscopy to better identify the nasal punctum or to assist with retrieval of foreign material from the NLA. When necessary, bleeding within the NLA was reduced by infusing 0.1 mL of 1:10,000 epinephrine through the lacrimal puncta. Alligator forceps[j] were used with lacrimoscopic, rhinoscopic, or fluoroscopic guidance in some dogs for FB retrieval from the lacrimal or nasal puncta, and when an FB was removed, the NLA was typically reevaluated endoscopically for additional foreign material or mural damage.

Following radiography and endoscopy, a 0.018-in × 50-cm or 0.025-in × 150-cm hydrophilic guidewire[k] was introduced, generally with fluoroscopic

guidance, either antegrade into the superior or inferior lacrimal punctum or retrograde through the nasal punctum **(Figure 1)**. When passed antegrade, the guidewire's exit point was used to identify the nasal punctum with fluoroscopy or endoscopy. In some instances, a 3.5F polytetrafluroethylene urinary catheter[f] with the tip cut off was passed retrograde over the guidewire and into the nasal punctum before the guidewire was removed and the NLA was flushed retrograde with the catheter, as described earlier for antegrade flushing. In some dogs, a 0.034-in ureteral dilator[f] or a 4F introducer sheath and dilator[l] combination was used to dilate the NLD prior to lacrimoscopy.

Following successful passage of a guidewire, the NLA was stented in an antegrade or retrograde direction with a 3.5F or 5F red rubber urethral catheter[m] with the tip cut off, or with a 2F or 2.5F urinary pigtail polyurethane catheter[n] placed over the guidewire (Figure 1). Stents were selected on the basis of availability in a size small enough to pass within the lumen of the patient's NLA but rigid enough to pass over the guidewire. For each patient, the largest stent that satisfied both criteria was chosen. Once the stent was appropriately positioned, the guidewire was removed, and the stent was sutured to the skin adjacent to the nares and medial canthus with 2-0 or 3-0 nylon or polypropylene in a finger-trap pattern and with tabs made from porous or duct tape. Postoperatively, the eyes of each patient were stained with fluorescein and reevaluated to confirm absence of corneal ulceration, and patients were then treated with topically applied NPD ophthalmic ointment or solution, or with artificial tears. All dogs were discharged with an Elizabethan collar, analgesics, sedatives (when needed), and oral and ophthalmic antimicrobial and anti-inflammatory medications.

Statistical analysis

Signalment, date of initial evaluation at the UCDVMTH, history, clinical findings, and treatment were consistently recorded in the electronic medical record for later retrieval. Initial follow-up was done by reexamination of the patient at the UCDVMTH, and long-term follow-up was done by telephone or email with the owner or referring veterinary ophthalmologist. Following treatment, all owners were asked to estimate the clinical improvement they had noted since the procedure. They were asked to do this using a scale from 0 to 10, where 0 = no improve-

Figure 1—Images of nasolacrimal stent placement in dogs with NLA obstruction. A—Fluoroscopic image obtained following placement of a hydrophilic guidewire along the NLA from lacrimal punctum to nasal punctum. B—Photograph of a dog in which a nasolacrimal stent has been placed by advancing a 2.5F pigtail polyurethane catheter over a guidewire in the NLD and then removing the guidewire. C—Diagram illustrating anchoring of a nasolacrimal stent to skin adjacent to the nares and medial canthus through the use of tape tabs and a finger-trap suture pattern.
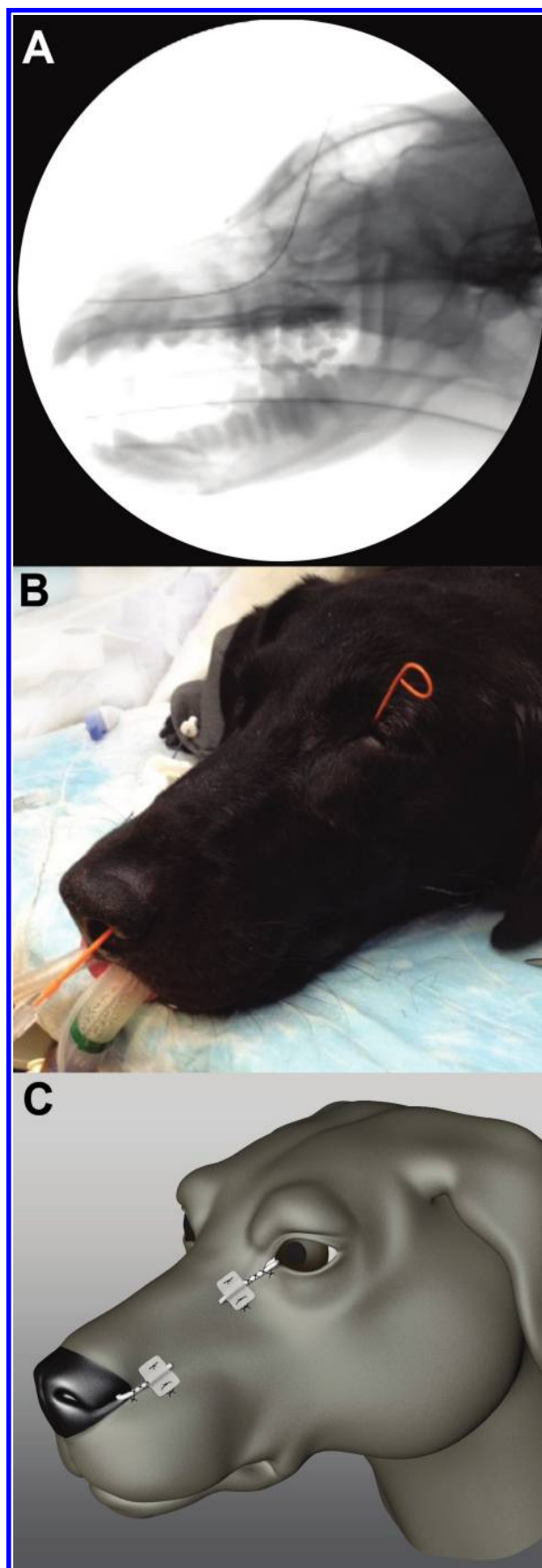
ment or worsening of ocular discharge and 10 = 100% improvement with complete absence of ocular discharge or no more ocular discharge than they expected in a healthy dog. Clinical improvement was reported as the percentage (or percentage range) provided by owners.

Dogs for which owners rated the clinical improvement as 100% (ie, overall clinical improvement score of 10) were compared with dogs in which improvement was rated as < 100% (ie, overall clinical improvement score of 0 to 9). The Mann-Whitney U test was used to compare the groups in regard to duration of stent placement, a 2-tailed Student t test was used to compare the groups in regard to duration of signs prior to referral, and the Fisher exact test was used to compare the groups in regard to proportion of dogs from which an FB was removed. For all analyses, values of $P < 0.05$ were considered significant.

Results

Population summary

Sixteen dogs met all inclusion criteria and were enrolled in the study **(Supplementary Table S1**, available at avmajournals.avma.org/doi/suppl/10. 2460/javma.252.12.1527). Median age was 4.3 years (range, 0.7 to 12.8 years), median body weight was 23.3 kg (51.3 lb; range, 6 to 43.7 kg [13.2 to 96.1 lb]), and median duration of clinical signs prior to assessment at the UCDVMTH was 3.2 months (range, 0.2 to 14 months). All dogs were referred by veterinary ophthalmologists and with a chief complaint of unilateral ocular discharge (OD, n = 7; OS, 9) that persisted following nasolacrimal flushing alone (13) or in combination with probing with an alligator forceps (1), probing and surgical enlargement of the superior lacrimal punctum (1), or exploratory surgery of the proximal portion of the NLA (1) by the referring ophthalmologist. All dogs had received a variety of medical treatments prior to referral. However, treatment of 2 dogs had been discontinued by the time of referral because of a perceived lack of response; 14 dogs were still being treated at the time of referral. On examination at the UCDVMTH, all dogs had unilateral seromucoid or mucopurulent ocular discharge. Concurrent or historical ocular abnormalities in affected dogs included cataracts (n = 2); pigmentary uveitis of Golden Retrievers, historical ocular hypertension, a conjunctival pedicle flap OD because of a descemetocele, and an eyelid mass (1); persistent pupillary membranes and previous surgery for entropion and prolapse of the gland of the third eyelid (1); and periocular dermatitis (1).

Nasal air flow was tested in 8 of the 16 dogs and found to be reduced on the affected side in only 1 dog. This dog was ultimately determined to have dacryocystitis. Nasal lesions were not seen on CTCD or rhinoscopy in this dog; however, marked asymmetry of the nasal punctum was noted rhinoscopically. On the affected side, the nasal punctum was slit-like and located dorsolaterally within the middle meatus, 3 cm caudal to the mucocutaneous junction. On the unaffected side, the nasal punctum was round to ovoid and located within the ventrolateral meatus, approximately 5 mm caudal to the mucocutaneous junction.

Bacterial culture and susceptibility testing of the ocular discharge was performed by the referring veterinarian prior to referral (n = 5) or at the UCDVMTH following stenting when signs persisted (2). Results included *Staphylococcus* (including multidrug resistant *S intermedius* and coagulase-negative *Staphylococcus* spp), *Pseudomonas*, *Corynebacterium*, *Fusobacterium*, *Bacteroides, Prevotella*, *Porphyromonas*, *Actinomyces*, *Micrococcus, Moraxella*, and β-hemolytic *Streptococcus* spp.

Following initial evaluations at the UCDVMTH, preoperative treatments were recommended for all dogs but declined by the owners of 2 dogs because of the owner's or referring veterinarian's perception of a lack of patient response to similar treatments previously. Treatments initiated included various combinations of orally administered antimicrobials (n = 11) and NSAIDs (10), topically applied ophthalmic antimicrobials (14), and topically applied ophthalmic corticosteroids (12) for a median period of 4 weeks (range, 1 to 6.5 weeks) prior to stenting. A typical protocol was amoxicillin-clavulanate (13.75 mg/kg [6.25 mg/lb], PO, q 12 h), carprofen (2.2 mg/kg [1.0 mg/lb], PO, q 12 h), and topically applied NPD ophthalmic suspension (1 drop in the affected eye, q 6 h) for 4 weeks prior to stenting.

CTCD

Computed tomographic contrast dacryocystorhinography was performed at the UCDVMTH in 15 of the 16 dogs. The remaining dog had CTCD performed at another hospital, but the reported findings were available for review. For dogs in which CTCD was performed during the study, transverse CT images of the affected and unaffected NLA were examined on a medical image-viewing workstation in a scrolling mode. Images were reformatted in other anatomic planes as necessary for complete evaluation. Except in brachycephalic dogs, the boney lacrimal canal was easily identified on nonenhanced images as a round or oval structure in cross-section, coursing along the medial aspect of the maxilla **(Figure 2)**. Following contrast medium administration, the lumen of the lacrimal canal was identified as a highly attenuating, but often discontinuous, contrast column. Contrast material that exited the lacrimal canal was typically diffusely distributed in the ventral aspect of the nasal cavity outlining the most dependent ectoturbinates **(Figure 3)**. Computed tomographic contrast dacryocystorhinography confirmed complete NLA obstruction in 6 dogs; in the remaining 10 dogs, the NLA was patent, although sometimes with partial mechanical obstruction. Evidence of osseous resorption resulting in enlargement of the lacrimal canal diameter was also seen in 6 dogs.

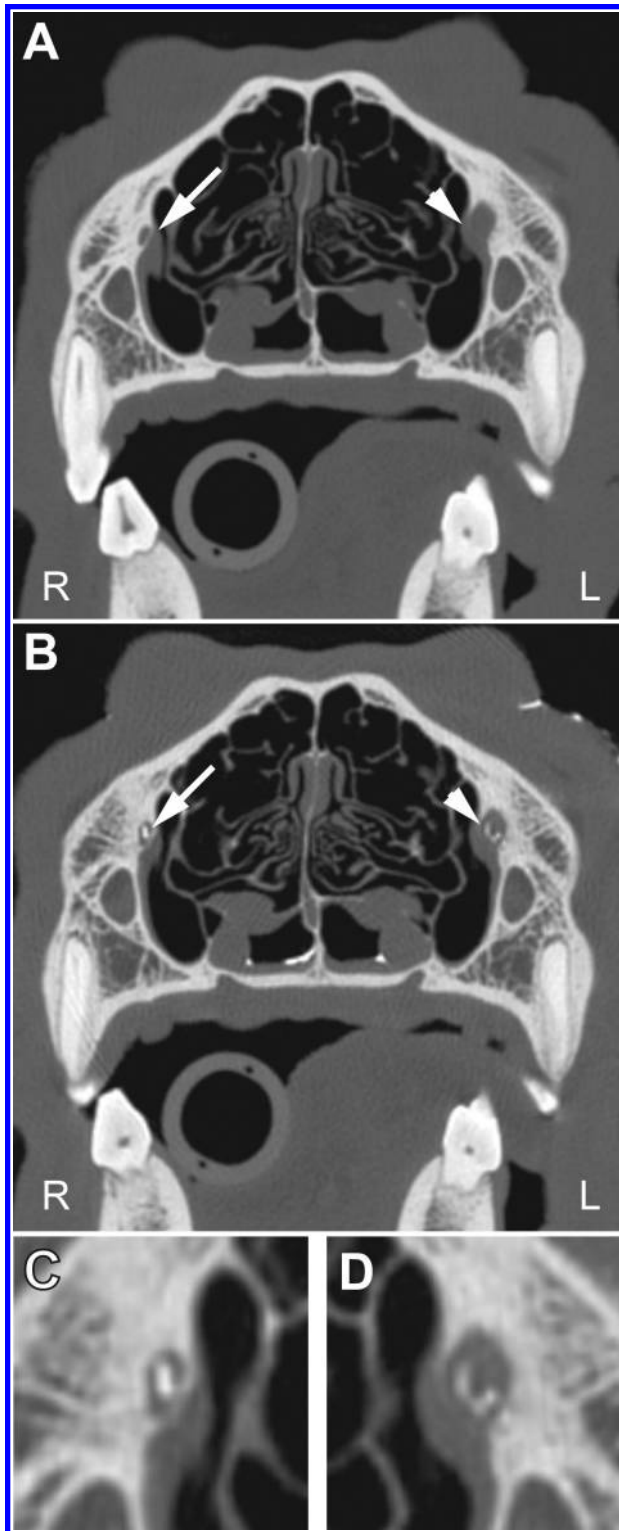Defects of contrast filling, indicative of a luminal FB, were observed (Figure 2) in 6 dogs. An FB

Figure 2—Computed tomographic images of an 8.5-year-old Greater Swiss Mountain Dog with partial obstruction of the left nasolacrimal duct caused by an intraluminal plant awn FB. A—Transverse image of the skull acquired at the level of the mid-nasal cavity prior to contrast medium administration. The right NLD appears normal (arrow). However, osteolysis surrounds the left NLD, resulting in an expansile appearance to its lumen (arrowhead). B—Transverse image acquired at the same anatomic level as the image in panel A, but following contrast medium administration into the right (arrow) and left (arrowhead) NLDs. C—Magnified image of the right NLD from panel B. Contrast medium uniformly enhances the normal-appearing NLD lumen which is surrounded by a thin rim of soft tissue attenuation representing the wall. D—Magnified image of the left NLD from panel B. The cross-sectional appearance of the intraluminal contrast material is indicative of an intraluminal FB or polypoid mural mass that results in a luminal filling defect causing partial duct obstruction. The duct wall is also markedly and unevenly thickened, suggestive of an inflammatory response.
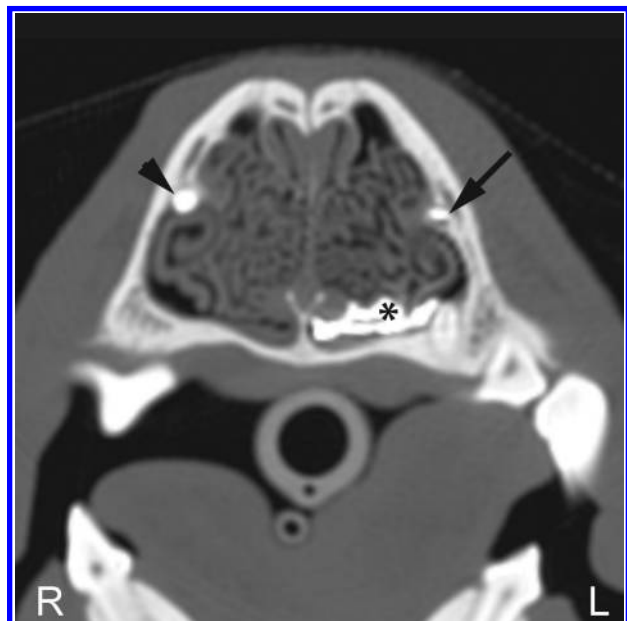

Figure 3—Transverse CT image through the rostral aspect of the nasal cavity in a 1.8-year-old castrated male Cairn Terrier referred for treatment of NLA obstruction. The image was obtained following contrast medium administration into both NLDs. The right nasolacrimal duct lumen (arrowhead) is dilated and there is no contrast medium pooling in the dependent region of the right nasal cavity. The left nasolacrimal duct (arrow) appears normal and is patent, as indicated by pooling of contrast medium in the dependent region of the left nasal cavity (asterisk). Therefore, complete obstruction of the right NLD was diagnosed.

was subsequently removed from 5 of these 6 dogs. The NLD was completely obstructed in only 1 of the 6 dogs with a defect of luminal filling. The proximal aspect of the duct was dilated in 2 dogs. In 3 dogs, a discontinuous contrast column was identified without evidence of obstruction. In these dogs, the affected and unaffected NLAs appeared similar

on CTCD images. For the dog that had CTCD performed elsewhere, the duct was reported to be patent, and no intraluminal contrast filling defects were identified.

Rhinoscopy

Following CTCD, rostral rhinoscopy was performed in 14 dogs and was useful in identifying the nasal punctum in 10 dogs and an NLA FB in 2 dogs (**Figure 4**; **Supplementary Video S1**, available at avmajournals.avma.org/doi/suppl/10.2460/
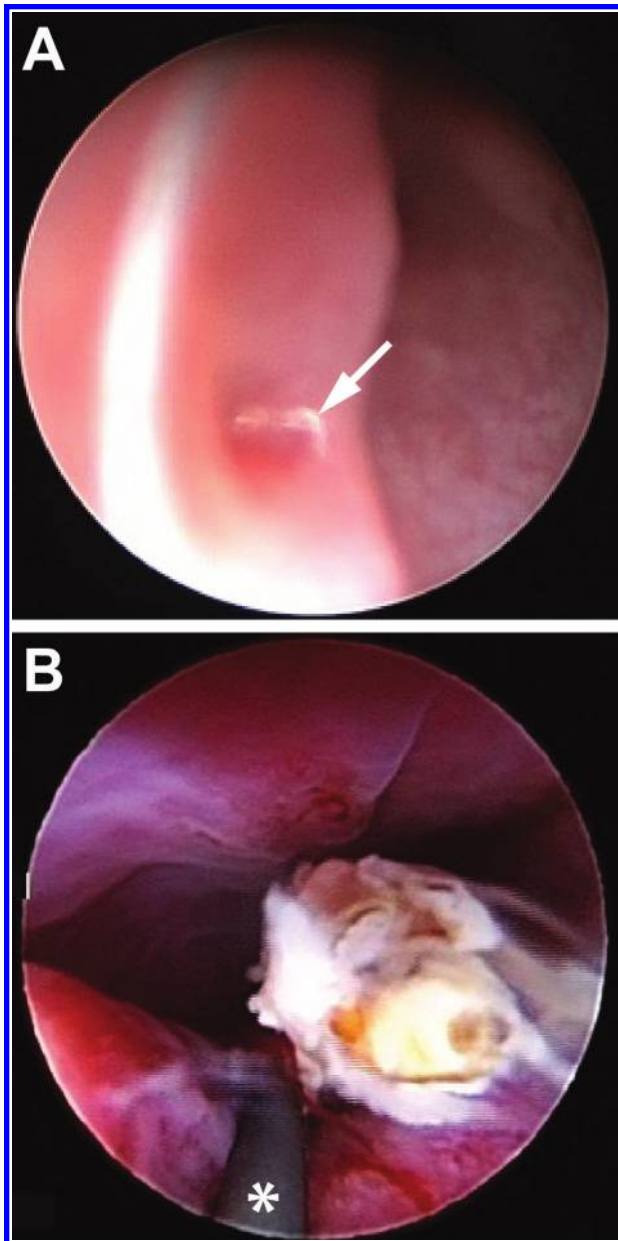
Figure 4—Rhinoscopic images of a 5-year-old castrated male Boston Terrier (A) and a 4.3-year-old sexually intact male Labrador Retriever (B) referred for treatment of NLA obstruction. A—Notice the nasal punctum of the right NLD (arrow). The punctum was approximately 0.5 cm from the external nares on the lateral aspect of the middle meatus. B—Notice the large plant FB protruding from and obscuring the nasal punctum of the NLD. A guidewire (asterisk) is also emerging from the nasal punctum.

javma.252.12.1527). In 7 dogs, the nasal punctum was located in the typical location in the ventrolateral nasal meatus, approximately 5 to 10 mm inside the external nares. In 3 dogs, the nasal punctum was located more caudally within the dorsolateral middle meatus (approx 3 to 4 cm from the naris). Eight dogs had mild to moderate mucosal hyperemia (n = 6), mucosal friability (4), or mucus accumulation (4) noted by rhinoscopy.

Lacrimoscopy

Lacrimoscopy was performed in 14 dogs. In most dogs, passage of the endoscope was possible through the canaliculus and into, but not beyond, the lacrimal sac. This provided adequate visualization of the NLA tissues in 12 dogs, but not in 1 that had complete obstruction of the inferior canaliculus and 1 that had stenosis of the duct. In the 12 dogs in which visualization of the NLA tissues was adequate, lacrimoscopy revealed mural or luminal abnormalities including hyperemia (n = 9), friable granulation tissue (7), fibrosis (6), an FB (3), or polyps alone or in various combinations (2; **Supplementary Video S2**, available at avmajournals.avma.org/doi/suppl/10.2460/javma.252.12.1527). An endoscopically guided biopsy of a mass within 1 dog's lacrimal sac was performed, and histologic evaluation revealed granulation tissue and a small piece of plant material. Lacrimoscopy was performed after stent placement in 12 of the 14 dogs. The lacrimoscope was passed antegrade or retrograde through the lumen of the stent, and observations were made as the stent and lacrimoscope were simultaneously withdrawn from the NLA. In 6 of 12 dogs, this technique permitted observation of the entire NLA. Mural hyperemia was noted in 2 dogs; however, it was unknown whether the hyperemia resulted from stent placement or was preexisting.

Foreign body removal

Alligator forceps[j] were used with lacrimoscopic, rhinoscopic, or fluoroscopic guidance for FB retrieval in the 6 dogs suspected to have an FB on the basis of CTCD results. When an FB was removed, the NLA was typically then reevaluated endoscopically for additional foreign material or mural damage.

Foreign bodies were located in the proximal part of the NLA (n = 2), the nasal part of the NLA (2), or in the section of the NLD surrounded by bone (1); however, no FB could be located in 1 of the dogs. All identified FBs were plant material and were removed through antegrade flushing, with the use of alligator forceps under rhinoscopic or fluoroscopic guidance, or during stenting of the NLA.

Stent placement

The NLAs of all dogs were flushed antegrade or retrograde with diluted povidone-iodine solution (n = 15) or, because of its higher viscosity, hyaluronate (1), and flushing was easier following FB removal. A 0.018-in (n = 14) or 0.025-in (1) hydrophilic guidewire was then placed antegrade (14) or retrograde (1) with (10) or without (5) fluoroscopic guidance. Fluoroscopy was especially useful in identifying when the guidewire reflected caudally into the nasal cavity after exiting the nasal punctum and better allowed for manipulation of the guidewire rostrally to exit through the naris. In 3 dogs, the guidewire exited through an accessory punctum approximately midway in the nasal cavity; therefore, retrograde in-

sertion of the guidewire through the nasal punctum, with or without a dilator, introducer sheath, or both, was attempted in these 3 dogs, but was successful in only 1. In 10 dogs, including 1 with an accessory nasal opening, retrograde insertion of a dilator (n = 9) or larger stent (1) was used to facilitate FB removal or stent placement. In 3 dogs, a 4F introducer sheath and dilator were passed in combination over the guidewire in a retrograde direction, and in 6 other dogs, a 0.036-in dilator was used.

A stent could not be placed in 2 dogs that had NLD stenosis and a history of surgery at the site by the referring veterinary ophthalmologist (n = 1) or granulation tissue in the lacrimal sac that completely obstructed the NLA (1). Although the latter was a hunting dog with known exposure to foxtails and grass awns, no FB was found. Stents were placed in the remaining 14 dogs. A 3.5F (n = 2) or 5F (2) red rubber urethral catheter with the tip cut off, or a 2.5F (9) or a 2F (1) urinary pigtail polyurethane catheter was placed retrograde over the guidewire in these dogs.

Median duration of anesthesia for imaging and stenting was 3.25 hours (range, 2.25 to 5.25 hours). There was no association between duration of anesthesia and experience with these techniques. On evaluation of data from all methods used, the causes of NLA obstruction were identified as an FB (n = 5), dacryocystitis (4), stenosis secondary to fibrosis (3), granulation tissue (1), or granulation tissue in association with a small FB (1); a cause was not identified in 2 dogs.

Postoperative treatment

Immediate postoperative evaluation of patients' eyes with fluorescein confirmed absence of corneal ulceration in all dogs, and NPD ophthalmic ointment (n = 14), petrolatum ophthalmic ointment (1), or NPD ophthalmic suspension followed by petrolatum ophthalmic ointment 5 minutes later (1) was applied. All dogs were discharged with an Elizabethan collar and various combinations of systemically administered analgesics, sedatives, and anti-inflammatory drugs as well as topically applied ophthalmic anti-inflammatory and antimicrobial medications. The typical postoperative treatment regimen was amoxicillin-clavulanate (13.75 mg/kg, PO, q 12 h) or another systemically administered antimicrobial selected on the basis of results of culture and susceptibility testing, carprofen (2.2 mg/kg, PO, q 12 h), and topically applied NPD ophthalmic suspension (1 drop in the affected eye, q 6 h).

Information on duration of treatment was available for topical treatments in 7 dogs and for systemic treatments in 12 dogs. For these dogs, median duration of postoperative topical and systemic treatment was 50 days (range, 34 to 84 days) and 46 days (range, 7 to 75 days), respectively. Information on duration of stent placement was available for all 14 dogs in which a stent was placed. The stent remained in place for a median of 39.5 days (range, 9 to 66 days). Planned removal occurred at a median postoperative interval of 42 days (range, 35 to 66 days) in 11 dogs. In 1 dog, the stent was removed by the referring ophthalmologist 9 days after placement because of skin irritation and reported intolerance by the dog. In a second dog, the stent was removed by the owner 38 days after placement because it had reportedly broken. In a third dog, the stent was removed by the referring ophthalmologist 12 days after placement because the client reportedly preferred not to drive a long distance back to the UCDVMTH and could no longer tolerate the dog wearing an Elizabethan collar. The dog in which the skin irritation was reported was the only dog for which duct tape was used to secure the stent.

Clinical outcomes

Twelve dogs were seen at the UCDVMTH for recheck evaluations. For these dogs, median time from procedure to final examination was 2.1 months (range, 0.6 to 7.6 months). One dog was reexamined because of hemolacria 1 month after stent removal. Bacterial culture of the dog's NLA discharge revealed a group EF4-like species, and the dog was treated for 42 days with clindamycin hydrochloride (11 mg/kg [5.0 mg/lb], PO, q 12 h) and 0.1% diclofenac (OD, q 8 h), 0.3% gentamicin (OD, q 6 h), and 0.25% hyaluronan° (OD, q 6 to 8 hours) ophthalmic solutions. According to the client, clinical signs improved approximately 80%, and no further recurrence of signs was noted 25 months following cessation of medication. A second dog developed persistent dacryocystitis within 3 to 4 months following stent breakage and premature removal by the owner. Results of bacterial culture and susceptibility testing performed on a swab sample taken from the inferior lacrimal punctum identified a *Micrococcus* sp, small numbers of a nonenteric *Moraxella* sp, a fastidious *Streptococcus viridans* isolate, and very small numbers of a coagulase-negative *Staphylococcus* sp. On the basis of culture and susceptibility testing, the dog was prescribed 0.3% gentamicin ophthalmic solution (OS, q 6 h for 9 weeks), doxycycline (6.8 mg/kg [3.1 mg/lb], PO, q 12 h for 14 weeks), and 1% prednisolone acetate ophthalmic solution (OS, q 8 to 12 hours for approximately 14 weeks). The owners failed to administer the doxycycline as prescribed, with the result that the dog received a lower dose than intended; however, the owners reported 90% improvement during a recheck examination 1 week following cessation of medical treatment.

At the final follow-up examination, 7 of the 12 dogs evaluated at the UCDVMTH did not have any ocular discharge. Two of 9 dogs tested had positive results of a Jones test I (1 with no ocular discharge and 1 with mild mucoid discharge); 3 of the 7 dogs with negative results of a Jones test I had no ocular discharge. One dog with no ocular discharge at the final follow-up examination had a positive result of a Jones test II.

Opinions regarding degree of clinical improvement were received from the dogs' owners (n = 15) or referring ophthalmologist (1) at a median time of 9.5

months (range, 2.1 to 40 months) after the procedure and 8 months (range, 0.3 to 36 months) after discontinuing medications. Median improvement in clinical signs was 95% (range, 60% to 100%), with 8 of the 16 owners rating clinical improvement as 100% (Supplementary Table S1). No significant (P = 0.203) difference was detected in duration of stent placement for dogs for which owners rated improvement as 100% (median, 38 days; range, 9 to 62 days) and those for which improvement was rated as < 100% (median, 43 days; range, 35 to 66 days). Likewise, no significant (P = 0.130) difference was detected in duration of signs prior to referral for dogs for which owners rated improvement as 100% (median, 2 months; range, 0.2 to 14 months), compared with those for which improvement was rated as < 100% (median, 4.5 months; range, 2 to 12 months). Finally, the proportion of dogs in which an FB was detected (clinically or histologically) was not significantly (P = 1.0) different between those for which owners rated improvement as 100% (3/8 dogs) and those for which owners rated improvement as < 100% (3/8 dogs).

Discussion

To the authors' knowledge, the present report represents the first description of successful management of NLA obstruction in dogs through a combination of CTCD, lacrimoscopy, rhinoscopy, and fluoroscopically guided stenting, and is the first report of lacrimoscopy in small animals, although it has been reported in horses.[14] Owner-rated clinical improvement for dogs treated with these methods was high (median, 95% improvement; range, 60% to 100% improvement), with clinical signs reported to be completely resolved in 8 of 16 dogs. This was especially notable considering that all dogs had been referred by board-certified veterinary ophthalmologists following a lack of response to standard treatment. To the authors' knowledge, this report also represents the first time that owner ratings of improvement have been reported following treatment of NLA obstruction in dogs. The authors believe that the high owner-rated clinical improvement scores were due to a number of factors, especially the combined use of complementary and sometimes novel imaging techniques, advanced stenting materials, the multidisciplinary and minimally invasive approach, and intensive perioperative medical management.

In the present study, we used a combination of CTCD, rhinoscopy, lacrimoscopy, and fluoroscopy to visualize the NLA. Computed tomographic contrast dacryocystorhinography was particularly helpful because it permitted confirmation of NLA obstruction; allowed nasal, orbital, and skull abnormalities likely to cause obstruction to be ruled out; and revealed bony lysis suggestive of osteomyelitis or pressure necrosis. An FB was considered likely on the basis of CTCD in 6 dogs, and one was subsequently found and removed in all but 1 of these dogs. The finding of osteolysis in many patients supported the long-term use

of antimicrobial and anti-inflammatory drugs prior to and after stenting. Rhinoscopy was critical in assisting with FB removal from the NLA, eliminating the possibility of additional FBs or comorbidities (such as rhinitis that could also obstruct the NLA), and locating the nasal puncta. This latter feature facilitated retrograde lacrimoscopy and guidewire placement and also confirmed data from previous studies[5-8] suggesting that 30% to 90% of dogs have accessory openings in the duct wall as it crosses over the root of the canine tooth. Three of 10 dogs assessed in the present study had a nasal punctum that was located more caudally within the dorsolateral aspect of the middle meatus, whereas the remaining 7 dogs had nasal puncta in the typical location.

Limitations of lacrimoscopy encountered in the present study included the technical difficulty of simultaneously irrigating saline solution through the unoccupied lacrimal punctum, difficulty advancing the endoscope in an antegrade direction without placing it inside a more rigid tube such as a dilator or urinary catheter, difficulty in rotating and changing orientation of the endoscope owing to its small diameter and high flexibility, and difficulty passing the endoscope beyond the lacrimal sac. In particular, the only method by which the authors viewed the entire NLA necessitated placement of a guidewire and then a stent, subsequent removal of the guidewire, and placement of the lacrimoscope through the stent with lacrimoscopy performed as the stent and scope were simultaneously removed. Therapeutic stenting then required replacement of the guidewire and stent following lacrimoscopy, and raised some concerns that the initial manipulations required for lacrimoscopy may have caused sufficient iatrogenic injury to the NLA to make therapeutic stent placement difficult or impossible. However, this was not the case in any of the dogs treated in the present study.

Development of endoscopes less susceptible to damage and with higher rigidity or flexion control could aid lacrimoscopy and reduce the need to pass a dilator or stent to guide the endoscope. However, with experience, most of the challenges associated with lacrimoscopy encountered in the present study were surmountable, and lacrimoscopy was particularly useful for identification and characterization of intraluminal abnormalities, including fibrosis, FBs, granulation tissue, dacryocystitis, and polyps. It also gave a better appreciation of the general types and magnitude of luminal and mural lesions possible with NLA obstruction. In addition, the ability to endoscopically visualize the NLA in dogs presents opportunities for new, minimally invasive treatment options, such as recanulation of regions of fibrosis in the NLA using laser. In 92 people undergoing endoscopic surgery with a holmium:yttrium-aluminum-garnet or contact neodymium:yttrium-aluminum-garnet laser to treat NLA obstruction secondary to scarring, 77% were symptom free and had positive Jones test results following the procedure.[20] Following revision in patients in which the initial procedure failed, treatment

was considered successful in 88 of the 92 (96%) patients.[20] Similarly, transcanalicular or endocanalicular diode laser dacryocystorhinostomy restored and maintained NLA patency for 36 months in 88% of selected human patients with primary obstruction of the NLA.[21] Given the initial success of lacrimoscopy in the present study, the feasibility and outcome of endoscopically guided laser treatment in dogs with complete NLA obstruction owing to cicatricial scarring should be investigated.

Interventional radiology techniques are increasingly reported for treatment of a variety of conditions in veterinary patients, including benign and malignant obstructive diseases. This discipline uses minimally invasive methods and advanced instrumentation to manage diseases for which there are few or no other treatment options. In the dogs of the present report, the use of small, specialized equipment, such as guidewires, dilators, introducers, and catheters, was essential for successful stent placement. Additionally, fluoroscopy allowed for these procedures to be performed in a minimally invasive manner and precluded the need for more aggressive surgical procedures. The authors believe that their experience with the use of similar minimally invasive techniques and devices for ureteral stenting and management of other benign obstructive diseases assisted in the successful guidewire and stent placement in the present study, and that the multidisciplinary team approach was integral to the high success rate in this study.

Outcome of dogs in the present study was also likely dependent, to at least some extent, on the perioperative medical treatments that were used. On the basis of our experience and the results of the present study, we believe that optimal preoperative treatment should include topically and systemically administered, broad-spectrum antimicrobial and anti-inflammatory agents for at least 1 to 2 weeks prior to the procedure to minimize tissue swelling and bacterial infection associated with dacryocystitis (often secondary to a primary obstructive process). Against our advice and because of owner preferences, 2 dogs in the study were not treated immediately prior to stenting. Although the owners of 1 of these dogs reported 100% improvement following treatment, owners of the second dog reported the lowest improvement recorded (60%). Lack of preoperative treatment may have contributed to the lower degree of improvement in this dog.

In addition, the authors believe that NLA stents should remain in place for at least 4 weeks and that dogs should be treated with topically and systemically administered broad-spectrum antimicrobial and anti-inflammatory drugs for at least 4 to 6 weeks following the procedure. In the present study, stents remained in place for at least the recommended minimum period in all but 2 dogs. Although owners of these 2 dogs reported 100% improvement of clinical signs, an important distinction was that neither dog had abnormalities observed during endoscopy and that no FBs

were identified in them. Therefore, a shorter stent duration may be possible in dogs without an FB, severe obstruction, or inflammation of the NLD. However, the authors hypothesize that stenting, particularly for a protracted period, may not only prevent narrowing of the NLD but may actually dilate the NLD to some degree, similar to what is seen when ureteral stents are placed in other species.[22] Assessment of this hypothesis will require preoperative and postoperative measurement of NLD diameter by means of CTCD. It is also likely that a submaximal degree of NLA narrowing permits forcible flushing and is not demonstrable on CTCD, but is sufficient to cause clinical signs. In such cases, the authors hypothesize that narrowing and relative or complete stasis can lead to an ongoing cycle of inflammation with worsening stasis, and that this can lead to permanent scarring, fibrosis, or stricture. The authors further hypothesize that a stent may break this stasis-inflammation-cicatrization cycle, thereby preventing some of these complications. Results of the present study supported this hypothesis; however, the authors acknowledge that owner-reported improvement was 80% and 100% in the 2 dogs for which stent placement was not possible, suggesting that a stent might not always be necessary. A prospective study in which dogs with similar NLA obstruction undergo stenting or no stenting in conjunction with otherwise identical medical management would be necessary to elucidate this further.

Although techniques described in the present study achieved what clients perceived as improvement in all dogs and complete resolution of signs in 8 of 16 dogs, it is important to critically assess the outcome in the 8 dogs for which clients reported < 100% improvement. The dog with the lowest (60%) owner-reported improvement had a 4-month history of seromucoid to serosanguineous ocular discharge. During the study, an FB was removed and a stent was placed for 49 days. The dog subsequently redeveloped epiphora, but the owner, who was a veterinarian, elected not to pursue further assessment or treatment. Therefore, the cause of the epiphora was unknown, but was attributed to chronic fibrotic changes in the NLA. In people, intracanalicular valves have been reported that potentially play a role in NLA drainage.[23] Further studies are warranted to assess whether similar valves are present in dogs and, if so, what role they play in lacrimal drainage and whether they become dysfunctional with fibrosis or following stenting.

The dog with the second lowest owner-reported improvement (60% to 70%) had a narrow NLA lumen that prevented lacrimoscopy and necessitated placement of a small-diameter stent. No FB was detected, and chronic stenosis of the NLA was suspected. Previous probing and surgery of the dog's NLA or the dog's concurrent allergic dermatitis may have contributed to clinical signs. The dog with the third lowest owner-reported improvement (70% to 80%) was determined to have an NLA stricture on the basis of CT images, but the stricture could not be endoscopically confirmed because complete obstruction of the

inferior lacrimal punctum precluded dilation of the NLD by simultaneous irrigation and thereby made lacrimoscopy impossible. The dog's concurrent pemphigus foliaceus and slit-like nasal punctum may have contributed to the persistence of clinical signs.

Owners of 2 dogs reported improvement of 80%. One of these dogs had complete cicatricial obstruction of the proximal portion of the NLA as a result of extensive granulation tissue that likely developed following a previous surgery to remove an FB. Another FB was removed from this dog during treatment at the UCDVMTH. The second of these dogs was re-examined because of hemolacria 1 month after stent removal and, on the basis of culture and susceptibility testing of the discharge, was treated systemically with clindamycin and via ophthalmic application of 0.1% diclofenac, 0.3% gentamicin, and 0.25% hyaluronan solutions. According to the client, clinical signs improved approximately 80%, and no further recurrence of signs was noted 25 months after cessation of medication.

A dog reported by its owners to have improved 80% to 90% had a 2-month history of ocular discharge, and CTCD revealed a non–contrast-enhancing defect in NLD filling combined with surrounding osseous remodeling, suggestive of intraluminal foreign material or a polypoid or cystic mass. Histologic examination of a lacrimoscopy-guided biopsy specimen confirmed the diagnosis of granulation tissue and the presence of plant material, despite the fact that an FB was not identified clinically in this dog. Because of the amount of granulation tissue, only a 2.5F stent could be placed despite this patient being a large dog. A dog rated by its owners as 90% improved had a small amount of discharge from both eyes a few times a week in the spring, which the owner associated with blooming of plants in their backyard. The authors suspected allergic conjunctivitis or blepharitis contributed to this dog's seasonal ocular discharge; however, the dog was not reassessed at the UCDVMTH. Another dog also rated by its owners as having 90% improvement had persistent dacryocystitis following stent removal. On the basis of culture and susceptibility testing results, doxycycline was prescribed. The owners initially failed to give the drug at the prescribed dosage, but this was later corrected, and doxycycline administration was discontinued 1 week prior to the final follow-up examination.

Overall, owner-rated improvement for dogs that underwent the novel, multidisciplinary, minimally invasive approach to NLA obstruction described in the present study was high, especially given that these dogs had failed to respond to conventional treatment offered by referring ophthalmologists. We believe that the very good clinical outcomes and correspondingly high owner-reported clinical improvement scores can be attributed to a number of factors, especially combining complementary and sometimes novel imaging techniques, the use of advanced stenting materials, a multidisciplinary and minimally invasive approach, and intensive perioperative medical management. Analysis of completely and partially successful patient responses in the study suggested that appropriate perioperative medical management combined with use of this approach early in the disease course and prior to surgical exploration may be a useful treatment option. Dogs with chronic NLA obstruction and dogs that have had exploratory surgery may have a lower success rate; however, this study did not permit statistical evaluation of these claims.

Acknowledgments

Footnotes

a. LightSpeed 16-slice helical CT scanner, General Electric Co, Waukesha, Wis.
b. Isovue-370, iopamidol injection 76%, Bracco Diagnostics Inc, Monroe, NJ.
c. 0°, 2.8-mm (17.5F) by 18.5-cm rigid telescope, Endoscopy Support Services Inc, Brewster, NY.
d. Miniature straight-forward flexible telescope, model number 11565, Karl Storz Veterinary Endoscopy Ltd, Goleta, Calif.
e. 0.034-inch ureteral dilator, Infiniti Medical LLC, Redwood City, Calif.
f. Slippery Sam tomcat urethral catheter, Smiths Medical PM Inc, Waukesha, Wis.
g. Medex 33-inch extension set, Smith Medical ASD Inc. Dublin, Ohio.
h. BD Vialon, Becton Dickinson Infusion Therapy System Inc, Sandy, Utah.
i. Hyvisc, Boehringer Ingelheim Vetmedica Inc, Duluth, Ga.
j. 1.1-mm (3F) by 28-cm flexible biopsy forceps with double action jaws, model 27071 ZJ biopsy forceps, Karl Storz Veterinary Endoscopy Ltd, Goleta, Calif.
k. Weasel Wire, Infiniti Medical LLC, Redwood City, Calif.
l. 4F introducer sheath and dilator, Infiniti Medical LLC, Redwood City, Calif.
m. Kendall feeding tube and urethral catheter, Covidien LLC, Mansfield Mass.
n. Pigtail catheter, Infiniti Medical LLC, Redwood City, Calif.
o. I-Drop-Vet-Plus, I-MED Pharma Inc, Dollard-des-Ormeaux, QC, Canada.

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From this month's *AJVR*

Comparison of ultrasound-guided and landmark-based techniques for central venous catheterization via the external jugular vein in healthy anesthetized dogs

Danielle M. Hundley et al

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OBJECTIVE
To compare time to achieve vascular access (TTVA) between an ultrasound-guided technique (UST) and landmark-based technique (LMT) for central venous catheter (CVC) placement in healthy anesthetized dogs.

ANIMALS
39 purpose-bred hounds.

PROCEDURES
Anesthetized dogs that were hemodynamically stable following completion of a terminal surgical exercise were enrolled in the study during 2 phases, with a 45-day intermission between phases. For each dog, a UST and LMT were used for CVC placement via each external jugular vein by 2 operators (criticalist and resident). The TTVA and number of venipuncture attempts and catheter redirections were recorded for each catheterization. Placement of the CVC was confirmed by contrast fluoroscopy. After euthanasia, a gross dissection was performed during which a hematoma score was assigned to the catheter insertion site. For each phase, nonlinear least squares estimation was used for learning curve analysis of the UST.

RESULTS
Median TTVA, number of venipuncture attempts and catheter redirections, and hematoma score did not differ significantly between the 2 operators for either technique. Median TTVA for the UST (45 seconds) was significantly longer than that for the LMT (7 seconds). Learning curve analysis indicated that 8 and 7 UST catheterizations were required to achieve performance stability in phases 1 and 2, respectively.

CONCLUSIONS AND CLINICAL RELEVANCE
Results indicated that the UST was comparable to the LMT for CVC placement in healthy dogs. The extra time required to perform the UST was not clinically relevant. Additional studies evaluating the UST for CVC placement in clinically ill dogs are warranted. (*Am J Vet Res* 2018;79:628–636)

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