Clinical Report

Resolution of Distal Tracheal Obstruction Using Endoscopic-Guided Holmium:Yttrium-Aluminium-Garnet Laser Ablation in a Blue and Gold Macaw (*Ara ararauna*)

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Abstract: A 2-year-old, female, blue and gold macaw (*Ara ararauna*) presented with respiratory distress following a 1-week history of altered vocalization. The bird was anesthetized for a computed tomography scan, air sac cannulation, and tracheoscopy. The bird was diagnosed with a distal tracheal obstruction, occupying more than 80% of the tracheal lumen. Initial attempts at biopsy and resection were unsuccessful because of limited access to the obstruction. The bird was managed medically for 1 week with a combination of an oral antifungal medication, antibiotic drugs, a nonsteroidal anti-inflammatory agent, and daily intratracheal antifungal therapy. Tracheal endoscopic-guided Holmium:yttrium-aluminium-garnet laser ablation of the tracheal lesion allowed for complete removal of the mass, and the bird could vocalize within a few days of the procedure. On repeat tracheoscopy and computed tomographic examination 6 weeks postlaser ablation, there was no evidence of inflammation, recurrence of the mass, or stricture formation. Holmium:yttrium-aluminium-garnet laser ablation may be a valuable and minimally invasive tool for managing tracheal obstructions such as tracheal granulomas and strictures in birds.

Key words: tracheal obstruction, Ho:YAG, laser ablation, aspergilloma, blue and gold macaw, psittacine, *Ara ararauna*, avian

CLINICAL REPORT

A 2-year-old, female, blue and gold macaw (*Ara ararauna*) weighing 855 g was presented to a referral hospital in respiratory distress following a 1-week history of reduced and abnormal vocalization and deterioration despite medical management with doxycycline (dose not available) and meloxicam (dose not available) for 4 days at the referring veterinary clinic.

There was no known exposure to airway irritants immediately before presentation. The bird was historically housed in an outdoor aviary with mulch substrate, wooden perches, and native foliage. The aviary was shared with an adult male Amazon parrot (*Amazona* sp) and was adjacent to aviaries with breeding pairs of other parrots. All these other birds were reported to be healthy by the owner.

On presentation, the bird was quiet, alert, and responsive with marked inspiratory effort, intermittent open-mouth breathing, raspy vocalization, wheezing, and

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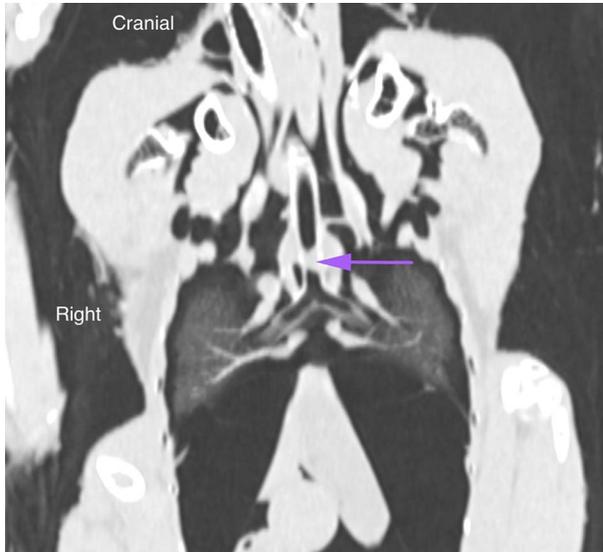Corresponding Author: Orr Cohen, ocohen@sashvets.com

harsh sounds in all air sacs on auscultation. Subcutaneous fluids (20 mL/kg; Compound Sodium Lactate, Baxter Healthcare Pty Ltd, Toongabbie, NSW, Australia) were administered once and the bird was placed in a heated enclosure that consisted of supplementary oxygen (40% humidified oxygen at 25°C [77°F]); there was mild improvement of the aforementioned clinical signs.

Diagnostic testing and air sac cannulation were performed under general anesthesia. The bird was premedicated with butorphanol (3 mg/kg IM; Ilium Butorgesic Injection, Troy Laboratories Pty Ltd, Glendenning, NSW, Australia). Anesthesia was induced using a mask with isoflurane (Isothesia NXT Inhalation Anesthetic, Piramal Enterprises Limited, Kohir Mandal, Medak District, Andhra Pradesh, India), incrementally increasing to 5% in a 1.5 L/min flow of oxygen. The macaw was then intubated intratracheally with an uncuffed 3.5 mm Cole silicone endotracheal tube (Jorgenson Laboratories, Loveland, CO, USA) and maintained on 2% isoflurane in a 1.5L/min flow of oxygen. A 24-G intravenous catheter was placed in the right ulnar vein for hand injection of iohexol (2 mL/kg IV; Omnipaque 300 mg iodine/mL, GE Healthcare Australia Pty Limited, Mascot, NSW,

Figure 1. Precontrast high-frequency lung reconstruction algorithm computed tomography scan of a 2-year-old female blue and gold macaw (*Ara ararauna*) in the dorsal plane showing the intratracheal lesion (purple arrow).

Australia). Blood was collected from the intravenous catheter immediately after placement and submitted for complete blood count (CBC) and plasma biochemistry panel.

A pre- and postcontrast computed tomographic (CT) study of the whole body was acquired in dorsal recumbency and reconstructed in lung and soft tissue algorithms (GE Revolution EVO 64m, GE Healthcare Japan Corporation, Hino-shi, Tokyo, Japan; 100 kVp; 53.8 mAs; collimation, 20 × 0.625 mm; gantry rotation speed, 0.5 seconds; field of view, 320 mm; matrix, 512 × 512 pixels; slice thickness, 0.625 mm [0.625-mm increment]; and collimator pitch, 0.531). A board-certified radiologist interpreted the images. The CT images revealed a focal, smoothly marginated, minimally enhancing, fluid attenuating, intraluminal distal tracheal/syringeal lesion (Figs 1 and 2) occupying 80% of the cross-sectional diameter on the transverse plane. Nasal cavities, paranasal sinuses, air sacs, and lungs were unremarkable. Given the slight contrast enhancement, the intratracheal structure was most likely mural in origin. Differential considerations included cyst, abscess, granuloma, and neoplasia.

After the CT scan, a 3.5-mm uncuffed endotracheal tube was placed in the right caudal thoracic air sac and secured to the skin with 4-0 absorbable monofilament suture (Monosyn, B. Braun, Rubi, Spain) in a finger-trap pattern. Anesthesia was maintained at 2% isoflurane in a 1.5L/min flow of oxygen via the air sac cannula and ventilation was adequate. A 2.7-mm
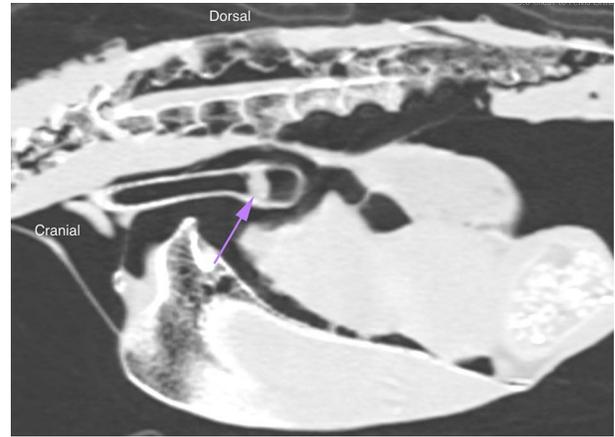

Figure 2. Pre-contrast high-frequency lung reconstruction algorithm computed tomography scan of a 2-year-old female blue and gold macaw (*Ara ararauna*) in the sagittal plane showing the intratracheal lesion (purple arrow).

rigid endoscope (HOPKINS Universal Endoscope 30°, Karl Storz SE & Co KG, Tuttlingen, Germany) and sheath (Avian Operating Sheath, 14.5Fr, Karl Storz SE & Co) were introduced via the oral cavity to examine the tracheal lumen and syrinx. A firm, smooth, white, rounded mass occupied most of the distal tracheal lumen, obscuring visualization of the syrinx. There was a translucent, fibrinous circumferential band proximal to the obstructive mass (Fig 3). Owing to tracheal narrowing in this location, the
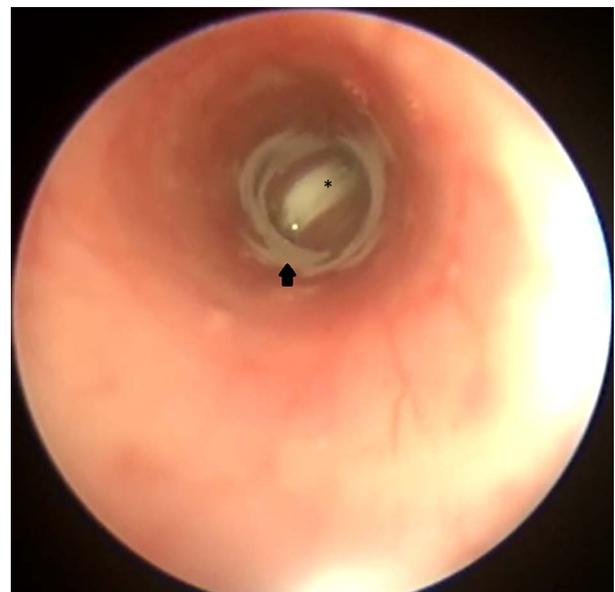

Figure 3. Endoscopic image capture of a distal tracheal granuloma (*) occluding more than 80% of the tracheal lumen and a fibrinous circumferential band (black arrow) in a 2-year-old female blue and gold macaw (*Ara ararauna*).

lesion could not be accessed for biopsy, and the patient recovered uneventfully. The patient's dyspneic condition resolved following recovery with the air sac cannula in situ.

The results of the CBC included a marked leukocytosis (51.6×10^9/L, reference interval $8.0–16.0 \times 10^9$/L) characterized by a heterophilia (46.4×10^9/L, reference interval $6.3–9.1 \times 10^9$/L) with a left shift (banded heterophils 1.0×10^9/L) and mild monocytosis (2.1×10^9/L, reference interval $0–0.25 \times 10^9$/L[1]) on a blood smear estimate.[1] The plasma biochemistry was submitted to an external laboratory (IDEXX, Sydney, NSW, Australia) with results indicating a mildly elevated creatine kinase (1827 U/L, reference interval 92–380 U/L) and aspartate aminotransferase (351 U/L, reference interval 64–168 U/L), consistent with muscle damage, and a marginally elevated glutamate dehydrogenase (4 IU/L, reference interval <1 IU/L), which was considered equivocal.[1]

An aspergilloma causing tracheal obstruction was suspected based on the age of the patient, environment, species, appearance of the lesion, and hematologic results. The bird was started on a treatment regimen of oral and intratracheal medications in the hospital with an Elizabethan collar to help maintain a patent air sac cannula after the patient started to show interest in the cannula site. Oral medications consisted of itraconazole (5 mg/kg PO q24h × 13 days; SPORANOX, JANSSEN-CILAG Ltd, Macquarie Park, NSW, Australia) while awaiting a compounded suspension of voriconazole, meloxicam (1.5 mg/kg PO q12h × 22 days; Dechra Veterinary Products Pty Ltd, Somersby, NSW, Australia), and amoxicillin and clavulanic acid (125 mg/kg PO q12h until resolved; Curam Duo 400/57, Sandoz Pty Ltd, Macquarie Park, NSW, Australia). The patient was gently restrained with a towel and anesthetized once daily for 7 days via the air sac cannula using sevoflurane (Sevorane, AbbVie Pty Ltd, Mascot, Australia) and oxygen, as previously described, for air sac cannula maintenance and intratracheal medications. Air sac cannula maintenance involved cleaning the stoma of the air sac cannula with diluted chlorhexidine once daily. Inhalant anesthesia was well tolerated and used to minimize stress, reduce repeated intramuscular injections, and allowed for rapid procedure time and recovery. Amphotericin B (1 mg/kg diluted to 1 mL with saline; Fungizone, CHEPLAPHARM Arzneimittel GmbH, Ziegelhof, Germany) and maropitant (1 mg/kg; Cerenia Injectable Solution, Zoetis, Rhodes, NSW, Australia) were administered intratracheally by gently inserting the syringe tip into the lumen of the glottis once daily.[2]

Purulent discharge was noted within the air sac cannula 3 days after placement. A bacterial culture and sensitivity isolated *Klebsiella pneumoniae,* which was sensitive to amoxicillin and clavulanic acid, so the patient was maintained on the antibiotic and monitored to assess treatment response.

After 7 days of intratracheal treatments with minimal response, the bird was anesthetized for a repeat tracheoscopy procedure to debride and remove the tracheal obstruction and address the purulent discharge by replacing the air sac cannula. The bird was premedicated with midazolam (0.5 mg/kg IM; Hypnovel Midazolam Injection, Pharmaco [Australia] Ltd, Chatswood, Australia) and butorphanol (4 mg/kg IM) approximately 20 minutes before induction. Anesthesia induction via the air sac cannula was unachievable due to the accumulation of purulent material and fibrin around the stoma and cannula. Therefore, anesthesia was induced with a face mask using sevoflurane and oxygen as previously described. The patient was then orotracheally intubated with a 3.5-mm silicone Cole endotracheal tube. Gentle suction with an 8-Fr suction catheter and suction pump was used to partially unblock the air sac cannula to allow manual ventilation for the procedure.

A 24-G intravenous catheter was placed in the left ulnar vein, and intravenous fluid therapy with Compound Sodium Lactate (Hartmann's Solution) was administered at 5 mL/kg/hr. Partial intravenous anesthesia with propofol (0.3 mg/kg/min; PROPOFOL-LIPURO, B Braun Australia Pty Ltd, Bella Vista, NSW, Australia) was used concurrently with sevoflurane to ensure an adequate depth of anesthesia for the procedure. Manual intermittent positive pressure ventilation was maintained throughout, alternating between the endotracheal tube and air sac cannula depending on access and depth of anesthesia. During laser ablation, inspired oxygen was reduced to FiO_2 21% to 40% using medical air to avoid airway fire and increased to 100% once the procedure was completed.

The patient was positioned in sternal recumbency with the head and neck held at extension. A flexible uretero-renoscope (9 Fr/3.5 Fr × 70 cm Video-Uretero-Renoscope FLEX-XC1, Karl Storz SE & Co) was introduced via the oral cavity into the endotracheal tube and advanced to visualize the mass. The mass was smaller than initially visualized 1 week prior and was occluding approximately 60% of the tracheal lumen. A 365-μm laser fiber (1.7 Fr O.D. × 3 m, 365-μm core fiber with SMA extension sleeve; Optical Integrity, Panama City Beach, FL, USA) was passed through the working channel of the flexible uretero-renoscope and directed onto the lesion. The

Table 1. The holmium:yttrium-aluminium-garnet laser settings for endoscopic tracheal granuloma ablation in a 2-year-old blue and gold macaw (*Ara ararauna*).

Frequency	8 Hz
Energy	0.8 J
Pulse count	67
Laser active	0.08 s
Total energy	53 J

holmium:yttrium-aluminium-garnet laser (Ho:YAG; Sphinx Jr Holmium Laser, LISA Laser Products GmbH, Katlenburg-Lindau, Germany) delivered 0.8 J of energy at 8 Hz with a total pulse count of 67 over 0.08 seconds via the laser fiber (Table 1), separating the mass from the mucosa. Biopsy forceps were introduced via the working channel of the scope to grasp and remove the mass in toto. Tracheoscopy was repeated immediately after retrieval of the lesion. There was a small amount of localized sanguineous fluid and irregularity of the mucosa at the site of the lesion (Fig 4). The procedural time from commencing endotracheal endoscopy to extubation was approximately 15 minutes.

The air sac cannula was removed with a marked amount of purulent and caseous material occluding the lumen. The stomal edge was markedly thickened with caseous exudate, which was debrided and cleaned thoroughly using chlorhexidine surgical preparation. A sterile-size 3.5-mm uncuffed endotracheal tube was introduced into the stoma aseptically and secured to the skin with 4-0 absorbable monofilament suture in a finger-trap pattern. Ventilation via the air sac cannula appeared adequate after the new cannula was replaced. The bird recovered from anesthesia uneventfully.

The bird demonstrated adequate ventilation and respiratory effort the following day with occlusion of the air sac cannula. The cannula was removed under general anesthesia using the sevoflurane protocol described previously; however, the bird was induced and maintained using a face mask and not intubated. The stoma edges were debrided with a size 15 scalpel blade, and caseous material was removed using sterile cotton tip applicators. A final intratracheal treatment of amphotericin B and maropitant was administered before recovery.

The bird was maintained in the hospital for observation for 6 days postendoscopic laser ablation. Based on continued improvement to vocalization and no signs of respiratory distress, the bird was discharged with compounded oral suspensions of terbinafine (20 mg/kg PO q12h until resolved; Compounding 4 Vets, Kingsgrove, NSW, Australia), voriconazole (10 mg/kg PO q12h until resolved; BOVA Aus, Caringbah, NSW, Australia), amoxicillin and clavulanic acid (125 mg/kg PO q12h until resolved), and meloxicam (1.5 mg/kg PO q12h × 22 days). Itraconazole was discontinued upon discharge.

Histopathology of the mass was consistent with focal, suppurative tracheitis. No microbial agents were seen. Bacterial culture of the mass grew *Klebsiella pneumoniae* as per the air sac cannula swab, and on final fungal culture at 4 weeks, *Aspergillus fumigatus* was isolated.

Six weeks after the endoscopic laser ablation procedure, the bird had normal vocalization. Respiratory effort was normal, and air sac auscultation was unremarkable. The bird was bright and alert, had maintained weight, and the owners reported the macaw's energy levels were normal.

At this 6-week reexamination, a tracheoscopy and CT scan were repeated under general anesthesia as previously described. The CT scan revealed the resolution of the previously visualized tracheal lesion. Similarly, repeat tracheoscopy demonstrated complete resolution
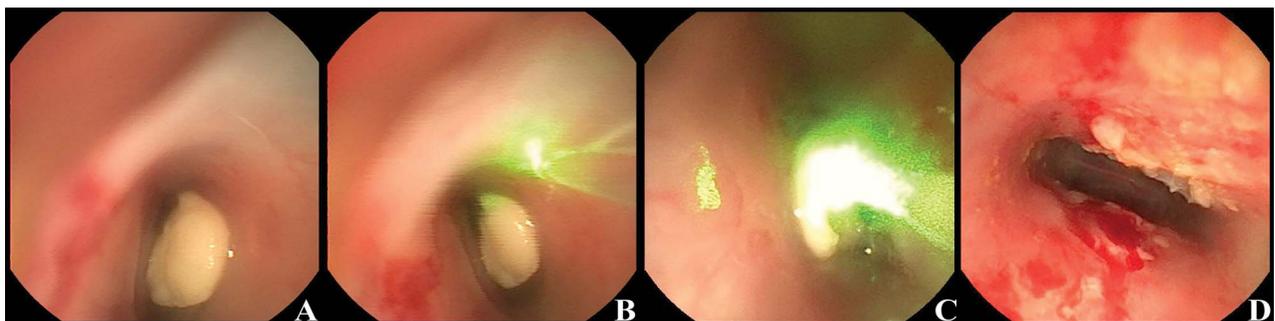

Figure 4. Tracheoscopy and laser ablation of a syringeal mass in a 2-year-old female blue and gold macaw (*Ara ararauna*). (A) Endoscopic identification of a white syringeal mass occupying approximately 60% of the tracheal lumen. (B) Directing the holmium:yttrium-aluminium-garnet laser fiber toward the syringeal mass with the aid of video endoscopy, (C) laser ablation of the syringeal mass, and (D) visualization of the distal trachea and syrinx following laser ablation and extraction of the syringeal mass.

Figure 5. Endoscopic image capture of the distal trachea 6 weeks after endoscopic holmium:yttrium-aluminium-garnet laser ablation demonstrating complete resolution of the lesion in the 2-year-old female blue and gold macaw (*Ara ararauna*).

of the distal tracheal lesion, with good visualization of the tracheal lumen and syrinx. The site of the distal tracheal mass had healed with no evidence of stenosis or recurrence of granulomatous or proliferative tissue (Fig 5).

Unfortunately, while the tracheal lesion had been resolved, on CT examination, there was evidence of diffuse thickening of the right cranial and caudal thoracic air sacs. Additionally, a repeat CBC demonstrated a florid, heterophilic leukocytosis consistent with ongoing active disease. The owner elected not to pursue further medical intervention, and the macaw was lost to follow-up.

DISCUSSION

Tracheal and syringeal obstructions are sporadically encountered in avian clinical practice. They are most frequently associated with granulomas, neoplasia, foreign body inhalation, and strictures secondary to inflammatory processes or trauma.[3] Clinical signs vary depending on the chronicity and severity of the obstruction, ranging from exercise intolerance and altered vocalization to severe dyspnea, collapse, loss of vocalization, open-mouth breathing, and neck extension.[3] There are significant challenges to the management and treatment of distal tracheal and syringeal obstructions due to the difficulty of access, intricacy of anatomy, and reduced ability to resect affected segments. We presented a case report of the successful resolution of a distal tracheal granuloma in a 2-year-old female blue and gold macaw using intratracheal endoscopic-guided Ho:YAG laser ablation.

Treatment for tracheal obstructions in avian patients has yielded various success rates in the published literature, with complications including recurrence of obstruction, inability to remove the obstruction, and death.[3–8]

Reported treatments include surgery, such as tracheotomies and tracheal resection and anastomosis,[3,4,7–12] endoscopic retrieval or debridement,[10,13] and retrieval by suction.[6] There are few reports of the use of laser ablation.[10,14] Stricture formation is a reported complication associated with tracheotomy and tracheal resection and anastomosis.[4,9,10] In a study reviewing postintubation tracheal strictures and treatment modalities, approximately 50% of birds were restricted following tracheal resection and anastomosis.[4] A retrospective study on the use of suction reported a 42% mortality rate.[6] Success of each therapy is, in part, associated with the underlying pathology and cause for obstruction.

Light amplification by stimulated emission of radiation is frequently used in human and veterinary medicine.[15,16] Various types of lasers have been used in the treatment and management of airway obstruction in humans, ranging from carbon dioxide laser (CO_2), diode laser, neodynium:YAG, to Ho:YAG.[15] The tissue interaction, depth of penetration, coagulation, and cutting effect of each laser type are dependent on the wavelength, characteristic of the tissue, power, and duration of exposure.[15] Endoscopic-guided laser ablation allows for minimally invasive approaches to the distal airway and has shown promising results in relieving airway obstructions in humans.[15–17]

The wavelength of the Ho:YAG laser is 2100 nm with good cutting and coagulation capabilities. The tissue depth penetration is approximately 0.5 mm.[15] There are a few published reports on the use of laser ablation therapy for avian respiratory diseases.[10,14,18] One case series used an endoscopic-guided diode laser in the treatment of air sac and lung granulomas in psittacine birds.[18] The case series did not address tracheal obstructions. Another case reported using an intratracheal endoscopic-guided CO_2 laser for debridement of tracheal strictures that had formed after a tracheal resection and anastomosis in a yellow-billed stork (*Mycteria ibis*).[10] While the CO_2 laser procedure provided temporary relief for the stork, the bird was ultimately euthanized due to the recurrence of the stricture. The major disadvantage of CO_2 lasers is their incompatibility with fiber-optic endoscopy.[17] Flexible fiberoptic endoscopy allows for superior visualization and access. Additionally, the CO_2 laser has poorer coagulative properties due to a shallower depth of penetration compared with other laser types.[15,19] Contact neodymium:YAG is also reportedly superior to CO_2 lasers with improved rates of healing.[17] Diode and Ho:YAG lasers are comparable in coagulation and cutting ability.[15] The

decision to use a Ho:YAG laser was based on availability in the authors' clinic.

Some risks associated with the use of Ho:YAG laser include airway fires. This is typically avoided with lowered power settings and reducing inspired oxygen to 40% during use.[15] Additional risk factors for consideration include perforation of tracheal tissue and hemorrhage if there is inadequate visualization before "firing" the laser. Additionally, damage to the tracheal wall can result in tracheal stricture formation.[10,15] Tracheal stricture formation or granuloma recurrence was not observed in this case at the 6-week postprocedure tracheoscopy. The average time of stricture formation after tracheal insult in avian species is reported at approximately 16 days.[4] Therefore, it is unlikely that a stricture would recur; however, further reexamination of this case was not possible.

Prolonged anesthetic procedures are linked to increased anesthesia-related death in avian patients.[20] A key advantage of endoscopic-guided Ho:YAG laser ablation in this patient was the speed at which the procedure was performed, totaling approximately 35 minutes from induction to recovery. While it has previously been reported that endoscopic laser ablation increases anesthetic time,[18] we found the procedure to be significantly faster than surgical interventions such as tracheotomy or tracheal resection and anastomosis. The contrast may be due to location; previous reports of granulomas were intracoelomic, endoscopically debrided, and only then treated with laser ablation.[18] It is also hypothesized that intratracheal amphotericin B treatments before endoscopic-guided Ho:YAG laser ablation assisted in the success of the procedure. When comparing tracheoscopy findings on initial presentation with those at the time of procedure 1 week later, the granuloma was subjectively reduced in size. This likely contributed to decreasing the procedure time.

The success of laser ablation will depend on the underlying pathology.[16] In patients with large or multiple lesions, laser ablation may be prolonged, thereby increasing anesthetic risk.[16] Laser ablation may be considered for chronic foreign body obstructions that adhere to the tracheal lumen. This may reduce bleeding and assist in dislodging the foreign body for ease of endoscopic retrieval. Limitations include availability in clinical practice and patient size. The ureterorenoscope used in this case report was 9-Fr (3mm) outer diameter with a 3.5-Fr working channel, limiting patient size to birds with greater tracheal diameters.

Air sac cannula secondary infections are a reported complication in the literature despite prophylactic antibiotic use.[21] It is difficult to determine whether the air sacculitis in this case was secondary to cannulation or a contributing pathogen to the initial presentation. The air sac cannula likely perpetuated infection by creating a biofilm, thereby reducing the efficacy of systemic antimicrobial therapy. Bacterial culture of the tracheal granuloma grew the same organism, *Klebsiella pneumoniae*, with the same sensitivity panel that was cultured from the air sac cannula 4 days earlier. Owing to logistical constraints, endoscopic laser ablation could not be performed sooner, resulting in the delay of air sac cannula removal. Sensitivity panels were supportive of the use of amoxicillin and clavulanic acid; however, there are no pharmacokinetic studies in blue and gold macaws, and the dosage may not have reached or sustained appropriate therapeutic plasma concentrations. Escalating antimicrobial therapy may have aided in reducing the progression of the disease.

In this case, the use of an intratracheally administered maropitant, a neurokinin-1 receptor antagonist, was extrapolated from the intranasal use for rhinitis in cats. Substance P is present in the respiratory tract and plays a role in airway inflammation.[22,23] The support for its use on the respiratory mucosa has not been substantiated with clinical trials and was used off label.[22] While no adverse effects were noted in this case, there is no current evidence for its direct use on the respiratory mucosa of avian patients.

This case report demonstrates successful local resolution of a distal tracheal lesion using Ho:YAG laser therapy. Endoscopic Ho:YAG laser ablation should be considered as a minimally invasive intervention for tracheal obstructive lesions such as granulomas and strictures in avian patients.

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