Transendoscopic Laser Surgery of the Upper Respiratory Tract: What Is Possible?

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Transendoscopic laser surgery provides a minimally invasive and highly effective method of resolving a number of upper airway obstructions. The initial investment in equipment can be amortized over a sufficient time span to make the use of the laser cost effective and profitable in a large-volume equine practice. Author’s address: Dept. of Clinical Studies, New Bolton Center, University of Pennsylvania, 382 W. Street Rd., Kennett Square, PA 19348-1692. © 1998 AAEP.

1. Introduction, Instrumentation, and Restraint

During the past 12 years, transendoscopic laser surgery has become a well accepted, routine method of treating a variety of upper respiratory tract obstructions. The specific techniques, postoperative care, possible complications, and long-term outcomes have been amply defined.1–7

A 1-m long, 8.5- to 9.8-mm outer diameter videendoscope (Olympus®) coupled with a 20-in. (~51 cm) color monitor (Sony) provide an optimal high-detail image. Alternatively, a fiber-optic endoscope with an adapter that fits on the eyepiece and a camera used for arthroscopy can be used, but the image clarity is not ideal. A standard VCR and a printer (Sony®) are useful for making hard copies for the medical record, and the images are a powerful educational and marketing tool when provided to owners, trainers, and veterinarians.

The only other instrument that is necessary for certain procedures in which traction or retrieval of tissue is needed is a 600-mm-long bronchoesophagoscopy grasping forceps.6 This instrument functions much like an arthroscopic or laparoscopic grasping instrument and can be custom bent by hand to assume the shape necessary for manipulations in the pharynx, larynx, and proximal trachea.

Laser energy is delivered through a long flexible, small diameter (0.6–2.2 mm) optical fiber, which can usually be used for multiple procedures. The Nd:YAG laser has been used most extensively for equine upper respiratory tract surgery. Currently, this type of laser can be purchased for approximately $15,000–20,000.4 The Nd:YAG laser is durable and requires minimal maintenance. It has been used in over 1100 procedures at the University of Pennsylvania without a single mechanical failure. During recent years, smaller, lightweight (approximately 12 kg) portable diode lasers that operate on 110-V power have become available. They reportedly are durable and create essentially the same gross and histologic footprint as the Nd:YAG laser when used in contact fashion.7 A 25-W diode laser costs approximately $35,000.5 The carbon dioxide laser with a flexible waveguide has also been used to a lesser extent. The holmium:YAG and KTP (potassium titanyl phosphate) lasers use other wavelengths that transmit light to tissue through flexible fibers, but
they have been used much less frequently in the equine upper respiratory tract. Most procedures can be performed on an outpatient basis on the standing horse. After being sedated with xylazine, xylazine and butorphanol, or detomidine, the horse is loosely cross tied in stocks. For most procedures, small doses of xylazine (initially 0.44 mg/kg IV, followed by increments of 0.22 mg/kg IV as needed) provide adequate restraint. The surgical site is topically anesthetized with Cetacaine® under direct vision through polyethylene tubing introduced through the biopsy channel of the videendoscope. Ideally, one assistant maintains the position of the endoscope in the nasal passage and another assistant helps with the restraint and manipulation of grasping forceps, if necessary.

Some procedures can be more accurately or safely performed with the horse under general anesthesia. Nasotracheal intubation with an 18- to 20-mm cuffed endotracheal tube in adults is preferable to allow improved access to the oral pharynx, nasal pharynx, larynx, and proximal trachea. When general anesthesia and 100% oxygen are used, extreme caution must be taken so that the laser beam does not impact and penetrate the endotracheal tube, which could potentially cause an airway fire. In addition to the surgeon's not hitting the tube with the laser beam, the horse can simply be allowed to breathe room air with the oxygen source disconnected from the nasotracheal tube during the actual procedure. Alternatively, a helium–oxygen mixture, which delivers less than 40% inspired oxygen and is significantly less flammable, can be used.

2. Postoperative Care

The upper respiratory tract is subject to extensive movement and continuous exposure to saliva, feed, hay, bacteria, dust, dirt, coughing, chewing, and swallowing. In spite of these formidable obstacles, healing usually progresses eventfully. Postoperative anti-inflammatory therapy and restricted exercise are important adjuncts to laser surgery. Ideally, performance horses should not be allowed to resume training until an endoscopic examination has confirmed that there is minimal inflammation at the surgical site and mucosal healing is progressing in a routine fashion.

As would be expected, the peak of inflammation is typically seen during the first 3–5 days after surgery, with a gradual diminution in swelling and edema after this time. Usually, the horse can resume work in approximately 7–14 days, if healing is uncomplicated. During the convalescence period, the horse should be restricted to a box stall with only handwalking exercise or small paddock turnout allowed if it is quiet. Immediately after surgery all horses are given a single intravenous injection of phenylbutazone (2.2 mg/kg) and dexamethasone (0.044 mg/kg). The horse is discharged from the hospital with detailed typed instructions, which vary depending on the procedure performed. Typically, horses are

given phenylbutazone 2.2 mg/kg PO q 12 h for approximately 7 days. They also receive prednisone 0.9 mg/kg PO q 24 h for 1 week, followed by the same dose given every other day for three treatments. Finally they are given a reduced dose of 0.45 mg/kg, which is also given every other day for three treatments. Often, a pharyngeal spray that contains a mixture of 750 ml of furacin, 1000 ml of glycerin, 250 ml of dimethyl sulfoxide, and 2 g of prednisone is dispensed with instructions that approximately 10–15 ml be sprayed into the pharynx slowly twice daily, while swallowing movements are watched for, through a #10 French catheter introduced through the nasal passage to the level of the nasal pharynx. Any modifications in treatment recommendations and duration of convalescence are made by the referring veterinarian at the time of the first endoscopic re-examination.

3. Surgical Technique

Laser surgery is done by using what is termed a noncontact or contact technique. In the noncontact technique, as the name implies, the fiber is placed very close to, but not in contact with, tissue (usually 3–10 mm from tissue), with the beam spot size tightly focused. With a Nd:YAG laser, the noncontact technique is typically used with high powers of between approximately 40 and 100 W to photovaporize and coagulate relatively large volumes of tissue. This technique is advantageous if a large amount of tissue has to be removed. The disadvantage of the noncontact technique is that possible immediate, indiscriminate injury to normal adjacent structures can occur, and there is also the potential for latent thermal injury caused by the forward and lateral tumbling of the laser light into normal tissue.

As a way to prevent these possible complications, the contact technique is used. It allows for a more precise incision or excision of soft tissue. In the contact technique, typically, an 800-µm outer diameter sculpted fiber with a conically shaped tip or a 2.2-mm outer diameter fiber with a synthetic sapphire tip attached is used with the tip directly in light contact with tissue at powers of between approximately 15 and 18 W. An incision can be made and blood vessels are coagulated by lightly dragging the fiber across the tissue. With the use of the contact technique, there is much less risk of damage to normal adjacent tissue because of the substantial reduction in the lateral and forward scatter of laser energy. Laser surgery is a cost-effective option because a single disposable 800-µm sculpted fiber can usually be used over and over, dozens of times. Since surgery is generally being performed in a nonsterile environment, this can be done without resterilizing the fiber. Alternatively, the fiber can be gas autoclaved for sterile delivery, if necessary.

A high power, noncontact technique is most often used for the nondiscriminating bulk removal of tissue, such as progressive ethmoid hematomas or solitary pharyngeal polyps, for example. In loca-
tions where the precise incision or excision of tissue with minimal thermal transfer and scarring is critical, the 800-µm sculpted fiber and the contact technique, and either Nd:YAG or diode laser energy, are perfect for the job. Examples of procedures that can be performed by using the contact technique include axial division of aryepiglottic fold entrapments, excision of the membranous portions of the aryepiglottic folds for the treatment of axial deviation of the aryepiglottic folds, subepiglottic and dorsal pharyngeal cyst excision, excision of intralaryngeal and intratracheal granulation tissue, ventriculofoldectomy, median septum fenestration for the management of unilateral guttural pouch tympany, and correction of choanal atresia. Brief descriptions of specific contact techniques follow.

4. Axial Division of Epiglottic Entrapment

Virtually all entrapments can be corrected transendoscopically in the standing horse, on an outpatient basis (Fig. 1). The incision is made directly on midline, beginning at the caudal free margin of the entrapment and dragging the 800-µm sculpted fiber forward to the tip of the entrapped epiglottis. As the incision deepens, the tissue spreads, and the mucosal defect becomes wider, because this tissue is under a little bit of tension. The inner reflection of the mucous membrane is carefully cut, avoiding contact with the dorsal epiglottic surface. After the correction is complete, swallowing is induced by touching incompletely anesthetized areas on the caudal lateral aspect of the epiglottis by using the fiber. If a small rim of entrapping membranes persists, additional cutting is done until the correction is complete. Also, if the entrapping membranes are very bulky or badly ulcerated and fibrotic and do not retract into a normal lingual epiglottic position after the midline incision is completed, portions of the offending membrane can be judiciously excised by placing traction on this tissue with the forceps and then removing it with the laser. Correction of epiglottic entrapment by using the laser has significant advantages to performing the correction by using a curved bistoury with the horse under general anesthesia. When the horse is watched to see if it swallows repeatedly immediately after surgery, a dynamic appreciation of the quality and completeness of the correction can be achieved, and additional cutting can be performed if needed.

Intermittent epiglottic entrapment, in which the horse is not entrapped during examination or after sedation and application of topical anesthesia, can be corrected by placing traction on the entrapping membranes on the lingual epiglottic surface by using the forceps. In effect, the entrapment is re-created or continued and maintained in position by using the forceps while the midline incision is made.

Routine anti-inflammatory therapy as previously described is recommended, and most horses can resume training after 7–14 days of handwalking. With the laser used in over 500 cases, the re-entrapment rate has been ~4%.

5. Excision of the Membranous Portions of the Aryepiglottic Folds

A diagnosis for the excision of the membranous portions of the aryepiglottic folds for the treatment of axial deviation of the aryepiglottic folds can only be made during a high-speed treadmill evaluation [Fig. 2(a)]. The tissue involved is grasped at its free margin midway between the lateral aspect of the epiglottis and the corniculate process of the arytenoid. When the forceps are rotated clockwise or counterclockwise, this tissue is placed under tension, and the horizontal cut is made with an 800-µm sculpted fiber, beginning immediately adjacent to the rostral lateral aspect of the epiglottic margin, working caudally toward the corniculate. When the forceps are manipulated to establish traction, a clear plane can be distinguished, and the vertical cut can be made adjacent to the corniculate process of the arytenoid. In this manner, an ~2 cm x 2 cm isosceles right triangle piece of mucous membrane is removed from the affected side(s) [Fig. 2(b)].

Horses are treated with anti-inflammatory medication and usually resume training after 14 days of walking. This technique has produced an improvement in approximately 75% of the horses affected with this particular problem. Complications have

Fig. 1. Epiglottis: (a) typical ulcerated entrapment in a Thoroughbred racehorse; (b) appearance immediately after axial division with a Nd:YAG laser and an 800-µm sculpted fiber.
not been observed in approximately 30 consecutive procedures.

6. **Excision of Subepiglottic and Dorsal Pharyngeal Cysts**

The mucous membrane over the most prominent portion of the cyst is grasped with the forceps and placed under traction. A horizontally oriented fusiform mucosal incision is made with one limb of the incision above the forceps and one immediately below, removing as much mucosa as deemed necessary. It is important not to remove an excessive amount of mucosa in order to avoid problems with scarring and intermittent dorsal displacement of the soft palate. When progressively more traction is placed on the overlying mucosa, the cyst lining becomes apparent and can be dissected out in its entirety with an 800-µm sculpted fiber (Fig. 3). Hemorrhage is negligible, except for the most caudal aspect of the cyst attachment adjacent to the epiglot-
tic base. The more unusual dorsal pharyngeal cysts are grasped with the forceps and excised at the base. Anti-inflammatory therapy and rest are provided and healing is generally complete in ~14 days.

7. Intralaryngeal Arytenoid Granulation Tissue
Intralaryngeal arytenoid granulation tissue growths are not uncommon, particularly in racing Thoroughbreds (Fig. 4). Conservative therapy consisting of rest and antimicrobial and anti-inflammatory medication often fails to cause regression of these growths. These growths are removed to eliminate their space-occupying effect and to prevent potential injury to the opposing arytenoid during strenuous exercise. Excision of the growth involves principles much like those governing arthroscopic chip fracture removal. The granulation tissue growth is freed up from the attachment to the underlying cartilage by using an 800-µm sculpted fiber until the tissue is hanging by a small remnant of tissue. The granulation tissue mass is then grasped with the forceps and removed by advancing the forceps forward into the trachea to disrupt the remaining attachments. Any additional small fragments of loose tissue can then be excised with the laser and forceps until a concave defect with smooth, firmly attached mucosal margins is present. In approximately 60–70% of horses, this defect heals with only a small, slightly raised, whitish bump without excessive granulation tissue regrowth. In the other 30–40% of horses, variable-sized granulation tissue masses regrow, which can be removed with a second procedure.

8. Ventriculectomy and Ventriculofoldectomy
Ventriculectomy and ventriculofoldectomy can be performed transendoscopically in the standing horse by using a noncontact technique. For more precise excision, however, preferably this technique is done with the horse in right lateral recumbency, either as the sole intervention or in conjunction and immediately prior to performing a left laryngoplasty. Typically, as seen on high-speed treadmill examination, the vocal fold and ventricle are the tissues that collapse into the airway; hence both are removed. Through an oral approach to the operation, the forceps are introduced into the depth of the ventricle, and the ventricle mucosa is grasped and everted. When the forceps are rotated clockwise, this the ventricle and vocal fold are moved axially in toward the midline. The 800-µm sculpted fiber is then used to excise as much of the ventricle and vocal cord as desired, beginning dorsally and cutting in a shallow curve toward the ventral midline and then incising from rostral to caudal. The defect created heals extremely well in ~30 days. The epithelialized tissue looks pink and healthy and typically blends in with the lateral wall (Fig. 5). Exuberant granulation tissue is extremely unusual.

9. Median Septum Fenestration
The procedure of median septum fenestration for the management of unilateral guttural pouch tympany is most easily performed with the foal anesthetized in lateral recumbency. If pneumonia is present, surgery can also be done by using sedation and topical anesthesia. A Chamber’s catheter is introduced into the downside guttural pouch under direct vision. The endoscope is then introduced into the upside guttural pouch, and the fenestration is created by using an 800-µm sculpted fiber. The Chamber’s catheter is rotated until the ball tip tenses the median septum into the pathway of the laser fiber and as large a hole as desired (ideally, 2 cm in diameter) can be made. Extreme caution should be exercised to avoid the caudal and ventral aspect of the pouch to avoid inadvertent nerve damage. An immediate, permanent correction of unilateral tympanites can be expected in approximately 70% of foals.1,2,5

10. Choanal Atresia
Choanal atresia in horses is typically membranous, and the membrane can be excised by using an 800-µm sculpted fiber.1,2 Suction is necessary to evacuate smoke and secretions that accumulate while the foal is anesthetized and, in this case, orally intubated. Routine anti-inflammatory therapy is provided. If a cicatricial membrane develops, reoperation is possible.

11. Staphylectomy
A staphylectomy can be performed transendoscopically in the orally intubated, anesthetized horse. The free margin of the soft palate is tensed by using the 600-mm grasping forceps, and as much tissue as desired is excised by using an 800-µm sculpted fiber. I typically do not perform this technique with the laser because I usually perform a bilateral sternothyroideus tenectomy in conjunction with the staphylectomy. In our practice, it is simply easier to do the tenectomy with the horse in dorsal recumbency and then enter the larynx to do the staphylectomy by using conventional techniques.

12. Incision or Excision of Miscellaneous Lumps and Bumps
Use your imagination and be creative. Using the previous brief descriptions and exercising due precaution and respect for the regional anatomy, you can deal with miscellaneous indications that develop in a similar fashion.

References and Footnotes
4. Tulleners EP. Evaluation of peroral transendoscopic contact


aOlympus Inc., GIF Type 100, 6925J, Oakland Mills Rd., Columbia, MD 21045.

bSony Corp. Registration Service Center, 123 W. Tyron Ave., Teaneck, NJ 07666-0000.
cUniversal broncho-esophagoscopic grasping forceps, 600 mm length, 8280.62, Richard Wolfe Medical Instrument Corp., Rosemont, IL 60018.
dSurgical Laser Technologies, 147 Keystone Dr., Montgomeryville, PA 18936-9920.