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Intermittent Dorsal Displacement of the Soft Palate and Laryngeal Hemiplegia in the Horse: New Insights into Treatment Options

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Upper airway abnormalities are a major cause of poor performance in the equine athlete.¹ The most common abnormalities are dorsal displacement of the soft palate (DDSP) and left laryngeal hemiplegia (LLH).^{1,2} The diagnosis of these afflictions is based on a thorough history, a complete physical exam, and a resting endoscopy of the upper respiratory tract. In addition, videoendoscopy during a high-speed treadmill examination may be required for horses that exhibit abnormalities only at performance speeds. A wide variety of conservative and surgical treatments for DDSP have been advocated. The success rate associated with most DDSP treatment options has traditionally been mediocre, fueling continued exploration for new therapies, including the “laryngeal tie-forward” technique. Unlike DDSP, left laryngeal hemiplegia has been treated primarily with lateralization of the arytenoid cartilage (tie-back) for the past 30 years. Adjunctive procedures for horses undergoing a tie-back procedure include removal of the vocal cords (cordectomy), laryngeal sacculotomy, or a combination of the procedures (ventriculocordectomy). Recently published studies suggest that the intended use of the horse is important when considering surgical treatment alternatives. This issue of *Large Animal Veterinary Rounds* reviews the recent literature on treatment options for DDSP and LLH in the horse, with a particular focus on surgical techniques.

Clinical anatomy

The pharynx is a musculomembranous tube that is the conduit for airflow to and from the lungs.³ Dilation is important for airflow and constriction is important for swallowing; both functions are achieved by the coordinated action of the nasopharyngeal muscles. Contraction of the pharyngeal muscles also alters the size and configuration of the hyoid apparatus that directly increases nasopharyngeal size and stability. The muscles of the tongue (genioglossus and genioid) pull the hyoid apparatus rostrally, while the “strap muscles” (sternohyoid and sternothyroid) pull the hyoid apparatus caudally. The combination of these opposing forces leads to the cranioventral displacement of the basihyoid bone, which is vital for upper airway stability during exercise. The soft palate is a mucous membrane-covered muscular shelf that separates the pharynx into nasal and oral compartments. The horse is an obligate nasal breather; therefore, it is imperative that the soft palate remains ventral to the epiglottis during exercise to provide unimpeded nasal airflow. The soft palate muscles, which are important for maintaining this position, are the levator veli palatini, tensor veli palatini, palatinus, and palatopharyngeus muscles. In the exercising horse, the tensor veli palatini muscle is responsible for maintaining stability of the rostral aspect of the soft palate, while the palatinus and palatopharyngeus muscles are responsible for maintaining the ventral position of the caudal aspect of the palate. The muscles of the palate are all innervated by the pharyngeal branch of the vagus nerve, except for the tensor veli palatini that receives innervation from the mandibular branch of the trigeminal nerve.



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The larynx is the channel between the pharynx and the trachea; its main functions are to act as a low-resistance conduit for airflow, protect the airway during deglutition, and aid in vocalization. The larynx is composed of multiple cartilages/muscles and is lined by respiratory mucosa. In combination with the epiglottis, the paired arytenoids are responsible for the diameter of the rima glottis. The arytenoids, positioned at the craniodorsal aspect of the larynx, are abducted in response to the muscular pull of the cricoarytenoid dorsalis muscle (CAD) that is situated between the muscular process of the arytenoid and the dorsolateral aspect of the cricoid cartilage. The CAD muscles, as well as the other laryngeal muscles (except the thyroarytenoid muscle), are innervated by the recurrent laryngeal branch of the vagus nerve. Within the lumen of the larynx are the paired vocal folds that connect the ventral aspect of the arytenoids to the thyroid cartilage. Abaxial to the vocal folds are the laryngeal saccules, which on average, are 2.5 cm deep and hold a volume of 5 to 6 mL.

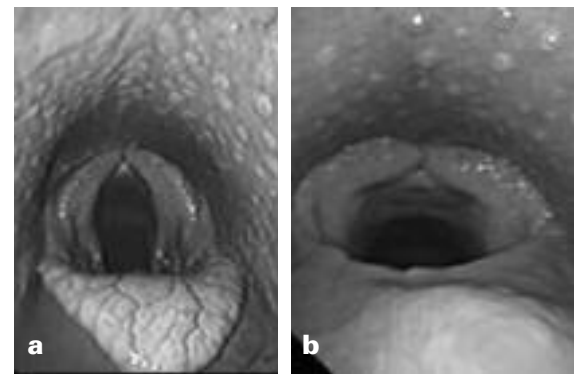
Dorsal displacement of the soft palate (DDSP)

DDSP is a performance-limiting upper airway disorder. It is reported to occur in 1.3% of horses that have been endoscopically evaluated at rest,⁴ and in up to 17% of horses evaluated for poor performance using videoendoscopy during high-speed treadmill examinations.¹ The prevalence of the disease is probably higher, considering its dynamic nature. A recent study revealed that only 62% of horses (being evaluated for poor performance) displacing their palates during a high-speed treadmill examination had a history of abnormal upper respiratory noise.⁵ When displaced, the caudal free margin of the soft palate is located dorsal to the epiglottis, allowing it to billow across the laryngeal opening during expiration (Figure 1). This produces the classic “gurgling” sound during performance and the increased resistance to airflow is responsible for exercise intolerance. The obstructive nature of this disease results in increased expiratory impedance, decreased minute ventilation, hypoxia, and hypercarbia.^{6,7} Recent literature suggests that the most likely etiology of intermittent DDSP is a neuromuscular dysfunction of the muscles of the soft palate (palatinus and palatopharyngeus)⁶ or the thyrohyoideus muscle⁸ (responsible for the rostral and dorsal movement of the laryngeal cartilages with respect to the basihyoid bone). The location of the pharyngeal branch of the vagus nerve in the medial compartment of the guttural pouch and its importance in soft palate function, makes every horse diagnosed with DDSP a candidate for guttural pouch endoscopy.

Non-surgical treatment

Horses with recent or active upper airway inflammation should be given anti-inflammatory therapy and rested for 60 to 90 days. Methods for providing anti-inflammatory therapy in the horse include systemic corticosteroids, systemic nonsteroidal anti-inflammatory drugs (NSAIDs), topical throat sprays, immune-modifying drugs, and guttural

Figure 1: Endoscopic evaluation of a horse with the soft palate in a normal position ventral to the epiglottis (a) and a horse with DDSP (b).



pouch lavage. If bacterial infection is suspected, the horse should be treated with an appropriate course of antibiotics.

Other conservative therapies include improvement of fitness, tack changes (figure-8 nose band), and tongue-ties. Such measures have been shown to improve earnings in 61% of racehorses diagnosed with intermittent DDSP.⁹ Controversy still exists regarding the use of tongue-ties for the treatment of DDSP. Research on clinically normal horses has revealed that application of a tongue-tie alone^{10,11} or in combination with a sternothyrohyoid myectomy¹² does not aid in maintaining stability and patency of the nasopharyngeal airways. Research suggests that the application of tongue-ties in normal horses is not performance-enhancing. Opponents of the use of tongue-ties suggest that retraction and depression of the tongue (coordinated by muscles of the hyoid apparatus) are necessary for nasopharynx stabilization and cannot be achieved by simple forceful extraction of the tongue.³ In one study of horses afflicted with DDSP, tongue-ties were found to be effective in 33% of cases.¹³

Surgical treatment

In the past, numerous surgical procedures have been utilized to treat horses with DDSP. Roughly 60% surgical success was reported for the following techniques: staphylectomy,¹⁴ sternothyrohyoid myectomy,^{14,15} sternothyroid tenectomy, epiglottic augmentation,¹⁶ thermocautery,¹⁷ and combinations of the listed procedures.^{5,18} A more recent report describes a combination treatment protocol using staphylectomy, sternothyrohyoid myectomy, and ventriculectomy, with a 60% success rate.¹⁹ When critically evaluated, the results of these surgical procedures are very disappointing because up to 61% of horses with DDSP will respond to conservative therapy.⁹

“Laryngeal tie-forward” procedure

The “laryngeal tie-forward” procedure is a promising, recently described surgical procedure for the treatment of DDSP. This technique stems from work performed at

Cornell University revealing that prior to displacement of the palate, some horses have decreased electromyographic activity of the thyrohyoid muscle.⁸ The role of the thyrohyoid muscle is to move the larynx rostrally and dorsally. Ducharme and co-workers⁸ were able to create DDSP in 7 of 10 normal horses by transection of the thyrohyoid muscles. They were then able to reverse DDSP in the majority of horses by mimicking thyrohyoid function with a prosthetic suture between the basihyoid bone and the thyroid cartilage. Subsequently, the same group performed the “laryngeal tie-forward” procedure on 116 horses clinically affected with intermittent DDSP.²⁰ Overall, 82% of the horses improved following surgery and 80% of the horses diagnosed by videoendoscopy no longer displaced their palates at exercise.

Surgical technique

The horse is placed under general anesthesia, dorsally recumbent, with the head and neck extended.²¹ A 15-cm ventral midline incision is made, extending from the rostral aspect of the basihyoid bone to 1-cm caudal to the cricoid cartilage. The paired sternohyoid muscles are bluntly separated, exposing the ventral aspect of the laryngeal cartilages. The basihyoid bone is exposed and a small hole is drilled through the bone at the midline. Two non-absorbable sutures are passed through the hole in the basihyoid bone and each suture is passed through the lateral wing of the thyroid cartilage near the tendonous insertion of the sternothyroid muscle on either side of the larynx. The horse’s head is then flexed to 90° and the sutures tied. Typically, the tied sutures place the rostral aspect of the thyroid cartilage slightly rostral (0.5 cm) to the caudal aspect of the basihyoid bone. The end result is that the larynx moves 4-cm rostrally and 2-cm dorsally. The head is then released to its normal position and the incision is closed. Postoperatively, the horse is fed from a hay net and water is available at shoulder level (not on the floor). The skin staples/sutures are removed in 2 weeks and the horse can resume training.

Since the initial publication,²⁰ the authors have performed the procedure in an additional 70 horses with continued high success rates.²¹ A 6% recurrence rate of DDSP was seen in horses evaluated 4 to 12 months postoperatively. Variations to the procedure include the choice of nonabsorbable suture, the passage of the prosthetic suture around the basihyoid bone rather than through a drill hole, and performance of a sternothyroid tenectomy during the procedure.

Left laryngeal hemiplegia (LLH)

Laryngeal hemiplegia (LH) is a dysfunction in the movement of the arytenoid cartilages and can involve cartilages on either side, although the left is most often affected. LH is a progressive neurogenic atrophy of intrinsic laryngeal muscles secondary to the progressive loss of large myelinated nerve fibers in the left recurrent laryngeal nerve. LH may occur more frequently in large horses, with as many as 50% of horses over 17 hands affected.²² The reported incidence of LH in thoroughbred yearling sales has

Table 1: Subjective laryngeal movement grades for resting horses²⁵

Grade	Movement
1	Symmetrical, synchronous abduction and adduction of the left and right arytenoid cartilages.
2	Some asynchronous movement of the left arytenoid cartilage during any phase of respiration; full abduction of the left arytenoid cartilage <i>can</i> be maintained by swallowing or nasal occlusion.
3	Asynchronous movement of the left arytenoid cartilage during any phase of respiration; full abduction of the left arytenoid cartilage <i>cannot</i> be induced and maintained by swallowing or nasal occlusion.
4	No substantial movement of the left arytenoid cartilage during any phase of respiration.

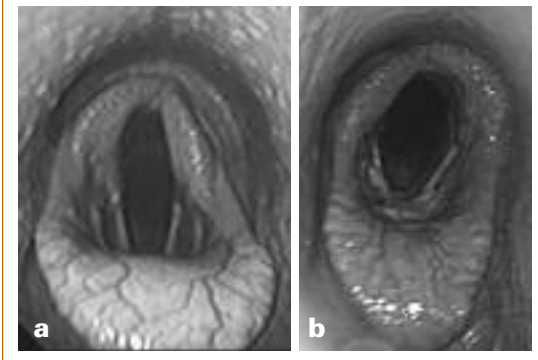
ranged from 2.75% to 25%.^{23,24} In addition, a study examining poor performance in racehorses revealed that the prevalence of LLH was 23.6%.¹ In North America, a grading scale has been devised to describe the variable arytenoid function in horses undergoing upper airway endoscopy (Table 1).²⁵ Further research into horses with grade III LLH demonstrated that 77% have severe dynamic laryngeal collapse during exercise.²⁶ Progression from grade III to IV has long been accepted but, until recently, deterioration in grades I and II was considered unlikely. However, a new study reveals that 15% of horses with LLH deteriorate clinically over a 12-month period, including those with initial grade I or II.²⁷ Horses with grade III or IV hemiplegia make respiratory noise and are exercise-intolerant (Figure 2a).

Treatment

Treatment of LLH varies, depending on the intended use of the horse. In racehorses, the primary objective is to perform a procedure that minimizes the resistance of airflow past the dysfunctional arytenoid and improves exercise tolerance. In show horses, it is more common to focus on eliminating the respiratory noise associated with LLH. Surgical techniques have centered on lateralizing the arytenoid (tie-back or re-innervation), partial removal of the arytenoid, and surgical alteration of the laryngeal saccules and/or vocal cords. The three most common procedures are briefly discussed below.

- *Prosthetic laryngoplasty* (tie-back): Laryngoplasty is the placement of a prosthetic non-absorbable suture that mimics the function of the CAD muscle. The suture is placed between the caudal dorsal aspect of the cricoid cartilage and the muscular process of the arytenoid cartilage, and tied so that the arytenoid is in a permanently abducted position. When performing the technique, the surgeon should attempt to abduct the arytenoid sufficiently to minimize resistance to airflow without compromising airway protection during deglutition (Figure 2b). Abducting

Figure 2: Endoscopic view of a horse with grade IV LLH preoperatively (a) and following prosthetic laryngoplasty (b).



the arytenoid just beyond the intermediate position appears to be ideal. Over-abduction not only predisposes the animal to aspiration, but also to increased abnormal respiratory noise.²⁸ It is imperative to practice good surgical technique and achieve proper placement of the prosthesis to minimize postoperative abduction loss, which is reported to be as high as 40% and to occur primarily during the first 6 weeks after surgery.²⁹ Improved performance following laryngoplasty is found in 50% to 70% of racehorses and in up to 92% of non-racing performance horses.^{30,31} Horses with residual poor performance after laryngoplasty should be re-examined on a high-speed treadmill, since dynamic collapse of the lateralized arytenoid, vocal folds, aryepiglottic folds, left corniculate process, and intermittent DDSP, have been observed.³² The addition of a ventriculectomy (described below) in the clinical setting,³⁰ or a ventriculocordectomy in the experimental setting,³³ offers no further improvements for upper airway function in horses undergoing prosthetic laryngoplasty. Respiratory noise following laryngoplasty alone will be dramatically improved within 30 days of surgery, but typically does not return to normal.²⁸

• **Sacculotomy (ventriculectomy) or ventriculocordectomy:** These procedures are usually performed through a laryngotomy, but can be completed in the standing patient with the aid of a surgical laser.^{34,35} The premise behind these techniques is to evert the laryngeal sacculi and resect them, with or without removal of the vocal cords, to create an adhesion between the arytenoid and thyroid cartilages. Theoretically, this should limit the dynamic axial collapse of the arytenoid cartilage during exercise. Although the author has had good success with eliminating respiratory noise in horses with LLH following laryngoplasty alone, ventriculectomy and ventriculocordectomy are often advocated as well to reduce noise during the postoperative period.^{30,31} Research into the reduction of abnormal respiratory noise following surgery has revealed the benefits of bilateral³⁶ and unilateral ventriculocordectomy,³⁷

but not of unilateral cordectomy.³⁸ Bilateral ventriculocordectomy is more effective in reducing respiratory noise in horses with LLH than laryngoplasty, but it takes roughly 90 days for the full effect, whereas with laryngoplasty, results are evident after only 30 days.^{28,36} In experimental studies, effective reductions in postoperative noise have been achieved via laser-assisted unilateral ventriculocordectomy, considered a novel approach, which appears to improve airway function to a similar degree as prosthetic laryngoplasty.³⁷ Additional clinical trials on horses with LLH are required to substantiate these recent findings because previous studies demonstrated that bilateral ventriculocordectomy did not improve airway function to the same degree as laryngoplasty.³⁶

• The author's approach to the treatment of horses with LLH varies according to the intended activity of the patient. In racehorses or non-racing performance horses requiring improved airway function and whose respiratory noise is *not* a concern, a laryngoplasty is performed. In non-racing performance horses whose airway function and abnormal respiratory noise *is* a concern, a ventriculocordectomy is performed in addition to a laryngoplasty. Should further studies confirm the results of recent research on ventriculocordectomy and its ability to improve airway function, a ventriculocordectomy alone may be sufficient for non-racing performance horses whose airway function \pm abnormal respiratory noise is a concern. The potential benefits of this approach would be decreased operative and postoperative risks.

Summary

Upper airway disorders are a major cause of poor performance in a wide range of equine athletes, including horses used for flat racing, dressage, show-jumping, show hitch, and western performance. Initial evaluation of a horse suspected of having airway dysfunction should include an accurate history, a complete physical exam, and adjunctive diagnostics (eg, upper airway endoscopy). DDSP is likely more prevalent than once thought and continued research into this disease should help practitioners formulate a reasonable treatment strategy. Effective treatments for LLH exist and surgical procedures should be undertaken with the intended use of the individual horse in mind. A thorough understanding of upper airway function in the horse will benefit all of our patients.

Dr. Ryan Shoemaker is an Assistant Professor of Large Animal Surgery in the Department of Large Animal Clinical Sciences at the Western College of Veterinary Medicine. His research interests revolve around treatment of osteoarthritis in the equine athlete, intestinal injury following strangulation, and upper airway dysfunction in the horse.

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Abstracts of Interest

Can an external device prevent dorsal displacement of the soft palate during strenuous exercise?

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REASONS FOR PERFORMING STUDY: Dorsal displacement of the soft palate (DDSP) is a common condition in racehorses for which various surgical treatments are often performed. In light of recent findings that suggested the position of the larynx may influence the occurrence of DDSP, we investigated whether a noninvasive mean of affecting the position of the larynx could be effective in the management of DDSP.

HYPOTHESIS: An external device (laryngo-hyoid support; LHS) positioning the larynx in a more rostral and dorsal location and preventing caudal displacement of the basihyoid bone would be effective in preventing DDSP during strenuous exercise.

METHODS: Ten horses were exercised on a high-speed treadmill under 4 different treatment conditions: control

(n = 10); control with external device (n = 10); after bilateral resection of thyrohyoid (TH) muscles (n = 7); and after bilateral resection of TH muscles with external device (n = 7). Two trials were performed randomly for each of the 4 conditions. In Trial 1, videoscopic images of the upper airway, pharyngeal and tracheal static pressures, and arterial blood gases were collected. In Trial 2, airflow measurement combined with mask and tracheal static pressure was obtained, and upper airway impedance calculated. The trials allowed calculation of airway impedance and respiratory frequency, and assessment of ventilation using arterial PO₂ and PCO₂.

RESULTS: Under control conditions, none of the 10 horses developed DDSP. There was no statistically significant effect from the LHS on airway impedance or respiratory frequency, nor on arterial PO₂ and PCO₂. Seven of the 10 horses developed DDSP during exercise after resection of the TH muscles. None of these 7 horses continued to experience DDSP during exercise with the external device. In the latter group and condition, the LHS significantly improved inspiratory and expiratory flow and impedance.

CONCLUSIONS: The LHS helped prevent experimentally induced DDSP at exercise, probably by statically positioning the larynx in a more rostral and dorsal position.

POTENTIAL RELEVANCE: Field studies are required to investigate whether the LHS can successfully prevent DDSP in horses with naturally occurring disease.

Equine Vet J 2005;37(5):425-9.

Career racing performance in Thoroughbreds treated with prosthetic laryngoplasty for laryngeal neuropathy: 52 cases (1981-1989).

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OBJECTIVE: To compare racing performance before and after prosthetic laryngoplasty for treatment of laryngeal neuropathy in inexperienced and experienced Thoroughbred racehorses.

DESIGN: Retrospective study.

ANIMALS: 52 Thoroughbred racehorses treated with prosthetic laryngoplasty for laryngeal neuropathy.

PROCEDURE: Lifetime race records were analyzed by use of a verified regression model. Individual race records and hospital records were also reviewed.

RESULTS: Experienced horses had a decline in performance, as measured by performance index, earnings percentage, and mean prediction error, during the 6-month period before prosthetic laryngoplasty. Performance improved after surgery, relative to performance in 1 to 4 races immediately before surgery, but did not attain previous baseline values for performance index and earnings percentage, although racing speed was restored to baseline values. Factors associated with failure to attain baseline levels of performance included other racing-related injuries and disorders, major complications of surgery, and age. Individually, however, many horses had long and successful careers after surgery. Performance of inexperienced horses after surgery was at least equal to that of experienced horses.

CONCLUSIONS AND CLINICAL RELEVANCE: In addition to warning clients of the complications associated with prosthetic laryngoplasty, it may be prudent to provide a guarded prognosis for full restoration of racing performance in older horses, unless they are especially talented and are free of other racing-related problems.

J Am Vet Med Assoc 2000;217(11):1689-96.

Upcoming Meetings

31 May – 3 June 2006

2006 American College of Veterinary Internal Medicine (ACVIM) Forum

Louisville, KY

Contact: Tel.: 800 245-9081; 303 231-9933

Fax: 303-231-0880

Email: ACVIM@ACVIM.org

Web site: www.acvim.org

16 – 19 July 2006

International Pig Veterinary Society Congress

Copenhagen, Denmark

Contact: ipvs.de

22 – 26 August 2006

Society for Theriogenology (SFT)/ American College of Theriogenologists (ACT) Conference and Symposium

St. Paul, Minnesota

Contact: therio.org

17 – 21 September 2006

International Veterinary Emergency and Critical Care Symposium

San Antonio, Texas

Contact: www.veccs.org

15 – 19 October 2006

24th World Buiatrics Conference

Nice, France

Contact: Service Gestion des congrès

Tel: 00 33 (0)4 93 92 81 61/58

Fax: 00 33 (0)4 93 92 83 38

E-mail : wbc2006@nice-acropolis.com

Website: www.wbc2006.com

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