Idiopathic Laryngeal Hemiplegia

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ABSTRACT: Idiopathic laryngeal hemiplegia (ILH) is the most common cause of upper respiratory unsoundness in horses. Classified as a distal axonopathy, ILH primarily affects the intrinsic laryngeal muscles on the left side. The adductor muscles are more severely affected at an earlier stage than is the primary abductor muscle. Endoscopic evaluation in standing or exercising horses can result in a definitive diagnosis of ILH. Quantitative methods to further evaluate laryngeal function include morphometric evaluation of laryngeal images, airflow mechanics, and tidal breathing flow–volume loop analysis. Four potential treatment options for ILH are currently available: prosthetic laryngoplasty, ventriculectomy/cordectomy, arytenoidectomy, and laryngeal reinnervation.

Idiopathic laryngeal hemiplegia (ILH; Figure 1), a common upper airway condition, occurs in approximately 8% of large sport horses. Affected animals have upper airway obstruction and produce a characteristic respiratory noise during exercise, p. 85. Horses affected with subclinical and clinical ILH show evidence of neurogenic atrophy of the intrinsic laryngeal muscles, p. 89.

The exact reason for the differential involvement of abductor and adductor muscle atrophy in ILH is unknown, but alterations in axonal transport appear to be the most likely explanation, p. 89.

Dynamic collapse of the paralyzed arytenoid cartilage increases inspiratory pressure, decreases inspiratory airflow, and ultimately increases inspiratory resistance, p. 90.

Prosthetic laryngoplasty is the preferred treatment for selected grade III and all grade IV cases of ILH, p. 90.
The epiglottis is the second unpaired cartilage; it fuses with the two cuneiform cartilages rostral to the thyroid cartilage. The aryepiglottic folds extend from the lateral borders of the epiglottis to the arytenoid cartilage on the ipsilateral side. The thyroepiglottic ligament courses from the base of the epiglottis to the medial surface of the thyroid laminae.

The cricoid cartilage, the third unpaired cartilage, lies between the thyroid laminae and the first cartilaginous tracheal ring. The dorsal surface of the lamina is divided by a median ridge. The rostral border of the lamina articulates with the arytenoid cartilage and the lateral border with the caudal cornu of the thyroid cartilage. Caudally, the cricoid cartilage is attached to the first tracheal ring by the cricotracheal membrane.

The paired arytenoid cartilages have three significant projections: The corniculate process originates from the rostral arytenoid border, and the rostral and caudal borders converge ventrally to form the vocal process. The muscular process projects from the dorsal part of the lateral surface, and its medial surface articulates with the cricoid lamina. The cricoarytenoid ligament supports the ventromedial aspect of the cricoarytenoid joint. The transverse arytenoid ligament connects the dorsomedial angles of the opposing arytenoid cartilages.

The other paired cartilage is the cuneiform cartilage, which articulates with the lateral border of the epiglottic base and projects caudodorsad. The vestibular ligament attaches to the free extremity of the cuneiform cartilage.

**Musculature**

The larynx has three extrinsic muscles (Figure 3). The thyrohyoideus muscle runs rostrally from the thyroid lamina to the basihyoid and thyrohyoid bones. If the hyoid bone is fixed, the muscle draws the larynx rostrad; if the hyoid bone is not fixed, the muscle acts in conjunction with the sternothyroideus, omohy-
Figure 3—(A through F) Left lateral images of the equine laryngeal musculature and associated structures, starting superficially (A) and proceeding deep (F). ($m =$ musculus)
Several studies have con-
Most studies indicate that males are affected 
Respiratory noise 
Left-sided paresis 
The earlier detection of ILH in Thor-
RECURRENT LARYNGEAL NERVE 
whereas horses shorter than 15 hands are rarely 
11
Compendium 
In addition, 50% of horses with respiratory noise 
VOCAL FOLD 
January 2001 
6–8 
RESPIRATORY NOISE 
88 Equine 
(RRLN) branches from the vagus nerve at the level of 
the right subclavian or costocervical artery, and comes 
to lie on the lateral tracheal wall. It passes cranially with 
the trachea and becomes adjacent to the dorsolateral 
tracheal surface in the midcervical region. The left re-
current laryngeal nerve (LRLN) branches from the va-
gus nerve at the level of the heart base, 25 to 30 mm 
caudal to the RRLN branching point. It divides into 
two branches that curve medially around the aorta and 
ligamentum arteriosum to lie on the trachea. A small 
branch lies in close association with the sympathetic 
nerve for a short distance before rejoining the larger 
main branch. The LRLN then travels a course similar 
to that of the RRLN.4
The cranial laryngeal nerve arises from the vagus 
nerve and passes rostroventrally medial to the origin 
of the internal carotid and occipital arteries. It supplies 
a motor branch to the cricothyroid muscle and is sensory 
to the mucous membrane of the larynx.4
IDIOPATHIC LARYNGEAL HEMIPLEGIA 
Incidence
Approximately 14% of horses with exercise intolerance 
have an upper airway disorder. With an incidence 
of approximately 2% to 8%, ILH is a common cause of 
respiratory unsoundness in horses.1 Respiratory noise 
during exercise is a common finding in horses with 
ILH, occurring in approximately 80% of affected ani-
mals.3 In addition, 50% of horses with respiratory noise 
during exercise are diagnosed with ILH.5
The incidence of ILH appears to correlate with adult 
body size, gender, and side of the larynx affected.6–8 
Heavy cross-bred horses have an increased incidence of 
ILH, whereas horses shorter than 15 hands are rarely 
affected.6,8 Most studies indicate that males are affected 
more commonly than are females.6,8 Left-sided paresis is 
more common (95%).6 Several studies have con-
firmed a hereditary predisposition.9,10
Approximately 80% of affected horses show clinical 
signs by 6 years of age. The majority of Thoroughbreds 
with ILH exhibit clinical signs between 3 and 5 years of 
age, whereas coldbloods are affected later in life (4 to 7 
years of age).11 The earlier detection of ILH in Thor-
oughbreds may be related to the age at which intensive 
exercise begins.
Idiopathic laryngeal hemiplegia appears to have a 
slightly different clinical presentation in draft horses, in 
which the mean age for diagnosis of ILH is 6.9 years; 
clinical signs are first recognized at 5.6 years of age. 
Respiratory noise alone is detected in 48% of affected 
draft horses, exercise intolerance and respiratory noise 
are seen in 30%, and exercise intolerance alone is ob-
served in 19%. The dissimilar clinical presentation in 
draft horses most likely reflects the age at which they
begin work and the type of work they perform (non-speed work).³

Pathophysiology

Horses affected with subclinical and clinical ILH show evidence of neurogenic atrophy of the intrinsic laryngeal muscles. The disease is classified as a distal axonopathy (i.e., dying-back neuropathy), in which axonal degeneration accompanied by a slow proximal spread of nerve fiber breakdown occurs over time.¹² The muscles affected in horses with ILH include all of the intrinsic laryngeal muscles supplied by the recurrent laryngeal nerve.¹³ There is preferential denervation of the LRLN, with most changes occurring in the branch supplying the adductor muscles.¹² The adductor muscles (i.e., the cricoarytenoideus lateralis and arytenoideus transversus) are more severely affected at an earlier stage than is the primary abductor (i.e., the cricoarytenoideus dorsalis).¹³ The muscles on the left side of the larynx are primarily affected, although denervation of the adductors on the right side has also been documented.¹⁴

The exact reason for the differential involvement of the abductor and adductor muscle atrophy seen in horses with ILH is unknown, but several hypotheses have been proposed. They include differences in fiber diameter,¹⁵ length,¹⁶ or position¹⁷; alterations in axonal transport;¹⁷ focal areas of compression;¹⁸ thiamine deficiency;¹⁸ and destruction by Streptococcus equi.¹⁸ Based on the scientific data accumulated to date, altered axonal transport appears to be the most likely explanation for the differential involvement of the two muscle groups. However, there may be more than one explanation for differential involvement.

ASSESSMENT OF UPPER AIRWAY FUNCTION

Endoscopic Evaluation

Laryngeal cartilage movement at rest has been categorized (see Grades of Resting Laryngeal Cartilage Movement¹⁹). At rest, the paired arytenoid cartilages are in a median position between abduction and adduction. Arytenoid abduction occurs during exercise. When the nostrils are occluded and inhalation occurs, the upper airway remains patent and full abduction of the arytenoid cartilages occurs.

The slap test is used to assess arytenoid cartilage function. In normal horses, a slap on one side of the withers produces a flickering axial movement of the contralateral arytenoid cartilage. In tense or excited horses, the arytenoid cartilages become fixed in an abducted position, thereby abolishing the response. In horses with ILH, the test is insensitive and may produce false-negative results, possibly because of muscle fiber reinnervation in the face of persistent denervation.²⁰

The effects of xylazine hydrochloride on laryngeal function have been evaluated. In one study,²¹ xylazine did not appear to alter the adduction response of the arytenoid cartilages to tactile stimulation; at rest and following nasal occlusion, it decreased the area of the rima glottidis and degree of abduction without changing the amount of asynchrony or trembling. Other investigators report that xylazine administration results in more synchronous arytenoid cartilage movement.²²

The degree of abduction present after swallowing is a more accurate assessment of laryngeal cartilage movement than is the degree of abduction after nasal occlusion. Many horses that are unable to symmetrically abduct the arytenoid cartilages after nasal occlusion are able to fully abduct after swallowing or exercise. In addition, horses that cannot symmetrically abduct after swallowing show evidence of dynamic collapse during exercise.²³

Horses with grade III laryngeal function should be assessed using videendoscopy during exercise on a high-speed treadmill. Horses that do not develop dynamic collapse during exercise would not benefit from laryngeal surgery.

Calculation of the left:right (L:R) cross-sectional area of the rima glottidis at rest is a quantitative endoscopic method to assess laryngeal cartilage function. Because the left and right surface areas are equally affected by varying distances and obliquity in the dorsoventral plane, the L:R ratio is a more reliable parameter than is absolute area. However, L:R ratios do not compensate for obliquity in the transverse plane. Morphometric evaluation of laryngeal images can be used as an adjunct to visual assessment of laryngeal cartilage movement. However, L:R ratios cannot distinguish grade III movement from grade I or II.²⁴ Because grade IV ILH can be definitively diagnosed via endoscopy in resting horses and because L:R ratios cannot distinguish among grades I to III, the clinical usefulness of this technique is limited.

Airflow Mechanics

Idiopathic laryngeal hemiplegia is characterized as a variable extrathoracic airway obstruction. The flow-volume loop is abnormal in horses with grade III laryngeal function. Horses with grade III laryngeal function should be assessed using videendoscopy during exercise on a high-speed treadmill. Horses that do not develop dynamic collapse during exercise would not benefit from laryngeal surgery.

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obstruction. In affected horses, dynamic collapse of the paralyzed arytenoid cartilage impedes inspiratory airflow. To maintain airflow, the inspiratory pressure differential across the larynx (driving pressure) increases; despite this increased driving pressure, however, airflow cannot be maintained and thus inspiratory impedance (resistance) increases.

**Tidal Breathing Flow–Volume Loops**

In uncooperative patients (e.g., human infants, horses), tidal breathing flow–volume loops (TBFVLs) are used to detect airway obstruction. In horses with upper airway obstruction secondary to dynamic collapse of unsupported soft tissue structures, the respiratory cycle is unchanged in the expiratory limb but decreases in the inspiratory limb. In exercising horses with experimentally induced laryngeal hemiplegia (LH), TBFVLs are characterized by marked inspiratory airflow limitations and normal expiratory airflow curves (Figure 4).

**TREATMENT**

One of the most important aspects of equine laryngeal disease is understanding the available treatment options and the anticipated prognosis for future athletic performance. The choice of treatment varies depending on the type of horse and the problem (noise and/or obstruction) being addressed. Surgeons must have a working knowledge of all options to advise clients as to which treatment is likely to yield the most satisfactory results.

**Prosthetic Laryngoplasty**

The prosthetic laryngoplasty procedure is preferred for treating selected grade III and all grade IV cases of ILH. The goal of the procedure is to produce abduction and stabilization of the paralyzed arytenoid cartilage and tense the vocal fold. This prevents dynamic collapse of laryngeal soft tissue structures, thereby alleviating exercise intolerance and inspiratory noise in horses with ILH. Some investigators believe that 60% to 70% of maximum abduction is optimal. Stabilization appears to be more important than is the degree of abduction; the latter apparently has little effect on outcome except when the arytenoid cartilage is abduct ed in such a manner that it depresses into the pharyngeal wall. Excessive abduction increases the prevalence of complications.

Clinical failure of laryngoplasty can occur because of infection, improper prosthetic placement, pull-out from the muscular process, and possibly patient age (younger horses have softer cartilage, which increases the risk of suture pull-through). In an in vitro model, pull-through (through the muscular process) was the primary cause of prosthetic failure. Cyclic movement of the cartilage may occur in horses with grade III ILH, thereby increasing the risk for pull-through. Transection of the adductor branch of the recurrent laryngeal nerve may decrease cyclic loading and cartilage pull-through; however, this has not been proven. Placing two prostheses may slow or eliminate cutting through the cartilage of the cricoid or muscular process of the arytenoid.

Several postoperative complications have been associated with laryngoplasty. These include failure to maintain abduction, ossification of the laryngeal cartilages, choke, reaction to the prosthesis, wound infection and dehiscence, seroma formation, tracheitis, suture sinus formation associated with contamination of the prosthesis, pneumonia, intralaryngeal granulomatous polyps, right-sided laryngospasm during exercise, laryngeal edema, chondritis, regurgitation, coughing, and death due to asphyxia. The frequency of postoperative complications is 9% to 47%. Coughing is considered the primary complication following prosthesis insertion. Up to 40% of horses may cough immediately after surgery, and 5% to 10% become chronic coughers. Cutting or removing the prosthesis has alleviated chronic coughing in some patients. The second most common postoperative complication is nasal discharge of food and water. This likely occurs because of excessive abduction leading to...
interference with the palatopharyngeal arch and entrance of food and water into the esophagus.\textsuperscript{32}

The effect of prosthetic laryngoplasty on respiratory sounds has not been studied to date. The success of prosthetic laryngoplasty in reversing exercise intolerance ranges from 5\% to 95\%\textsuperscript{30,32,33} and tends to be better in non-racehorses.\textsuperscript{30} The success rate is reportedly lower when a ventriculectomy procedure is not performed in conjunction with the prosthetic laryngoplasty.\textsuperscript{32} When horses were exercised at a maximum level on a treadmill in an experimentally induced LH model, however, no significant difference in airflow parameters was noted between horses that received prosthetic laryngoplasty alone and those that received prosthetic laryngoplasty combined with a bilateral ventriculectomy.\textsuperscript{29} A large retrospective study evaluating racing performance found no significant difference in performance in horses treated with laryngoplasty alone and those treated with laryngoplasty and ventriculectomy.\textsuperscript{34} No apparent difference in success rate was noted among draft horses receiving unilateral ventriculectomy, bilateral ventriculectomy, or prosthetic laryngoplasty plus bilateral ventriculectomy.\textsuperscript{34} Unlike horses that must perform at high speeds, draft horses with grade IV LH may indeed benefit from ventriculectomy/cordectomy.

**Ventriculectomy/Cordectomy**

The objective of ventriculectomy is to produce abduction of the arytenoid cartilage via the formation of adhesions between the arytenoid and thyroid cartilages and to reduce filling of the ventricle with air during inspiration. Partial resection of the vocal fold (cordectomy) performed in conjunction with ventriculectomy has been proposed to improve adhesion of the arytenoid cartilage to the wing of the thyroid cartilage.

Indications for ventriculectomy/cordectomy include partial LH resulting in decreased abductor ability and/or asynchronous motion of the arytenoid cartilages, the presence of respiratory noise without significant exercise intolerance, and animals not meriting the cost of laryngoplasty.\textsuperscript{35} The success rate for improvement in exercise tolerance after ventriculectomy/cordectomy ranges from 5\% to 100\%; greater success is seen in pleasure and draft horses.\textsuperscript{3,32} Ventriculectomy/cordectomy has been used with variable success (10\% to 80\%) to decrease noise production in horses with ILH,\textsuperscript{22,36} but no objective studies have investigated the value of this procedure in minimizing airway sounds in horses.

A quantitative analysis of the effects of ventriculectomy as a treatment for experimentally induced left LH found that ventriculectomy alone failed to improve upper airway function in horses exercising at a submaximal level. The technique fails to adequately stabilize the arytenoid cartilage in the abducted position, which results in airflow turbulence and inspiratory noise.\textsuperscript{37}

**Arytenoidectomy**

The purpose of arytenoidectomy is to increase the cross-sectional area of the rima glottidis, thereby decreasing the resistance to airflow. The goal is to remove all unsupported structures to prevent dynamic collapse during exercise.\textsuperscript{38} Currently, arytenoidectomy is the treatment of choice for laryngoplasties that have failed as a result of inadequate abductions or release of the arytenoid cartilage, abnormalities of the laryngeal cartilages that preclude laryngoplasty (e.g., chondritis, chondroma, laryngeal ossification, focal lesions of the arytenoid cartilages), and laryngoplasties that have resulted in chronic coughing because of piriform recess obstruction with resultant contamination of the larynx with ingesta.\textsuperscript{39}

Three arytenoidectomy procedures have been described. Subtotal arytenoidectomy involves removal of the arytenoid body only, and thus dysphagia and aspiration are uncommon sequelae. However, airflow mechanics and blood gas measurements obtained from horses with experimentally induced LH are not improved in animals treated with subtotal arytenoidectomy and unilateral ventriculectomy.\textsuperscript{40} The corniculate process and vocal fold are drawn into the airway during exercise, resulting in continued dynamic collapse and interference with airflow.\textsuperscript{40}

Partial arytenoidectomy involves removal of both the arytenoid body and corniculate process. Dysphagia or coughing and aspiration pneumonia may result if excessive mucosa near the piriform recess is inadvertently removed.\textsuperscript{38} In a retrospective study of partial arytenoidectomies, 36\% of patients nasally discharged food and/or water, but only 9\% had performance limitations.\textsuperscript{31} Quantitative evaluation (using TBFVL) of partial arytenoidectomy combined with bilateral ventriculectomy in horses with experimentally induced LH revealed that some flow limitation remains at near-maximal airflow rates.\textsuperscript{42}

Total arytenoidectomy involves removal of the arytenoid body, muscular process, and corniculate process. Dysphagia with secondary aspiration pneumonia has been described as a common and sometimes life-threatening complication.\textsuperscript{39} Dysphagia presumably results from removal of excess tissue from the dorsal aspect of the rima glottidis. To date, this procedure has not been quantitatively evaluated.

**Laryngeal Reinnervation**

In theory, laryngeal muscle reinnervation is the best
treatment option for horses with ILH. Three techniques have been described: nerve–pedicle transfer, nerve implantation, and nerve anastomosis.\(^5\)\(^-\)\(^6\) Nerve implantation and nerve anastomosis have been shown to be unsatisfactory for resolving the airway obstruction produced by ILH.\(^7\)\(^-\)\(^10\) However, these techniques have been evaluated only in standing horses. Because the first and second cervical nerves are accessory nerves of respiration and may fire only with increasing respiratory efforts, evaluation of the efficacy of these techniques should be performed during exercise. The nerve–muscle pedicle graft (using an omohyoid pedicle innervated by the first and second cervical nerves) has been shown to effectively restore airway function in horses exercising at submaximal levels. However, reinnervation does not occur for 6 to 12 months after transplantation.\(^11\)

CONCLUSION

Despite the high incidence of ILH in large sport horses, the pathophysiology of the disease is poorly understood. Several surgical procedures have been developed to treat ILH, but no one procedure has been proven to consistently allow full return to athletic function. Prosthetic laryngoplasty is the treatment of choice for select grade III and all grade IV cases of ILH. The major problems associated with this surgery include failure because of suture pull-through or complications associated with permanent fixation of the laryngeal cartilage. Laryngeal reinnervation is the only procedure that maintains normal laryngeal architecture and dynamics. However, because of the length of time required for reinnervation, further advancements in the technique must be developed to hasten reinnervation and thus make the technique more attractive to horse owners.

REFERENCES

The article you have read qualifies for 1.5 contact hours of Continuing Education Credit from the Auburn University College of Veterinary Medicine. Choose only the one best answer to each of the following questions; then mark your answers on the test form inserted in Compendium.

1. Which of the following laryngeal cartilages is paired?
   a. thyroid  
   b. arytenoid  
   c. epiglottic  
   d. cricoid

2. All of the following laryngeal muscles are extrinsic except the
   a. omohyoideus.  
   b. thyrohyoideus.  
   c. hyoepiglotticus.  
   d. sternothyroideus.

3. The ________ muscle is involved in abduction of the arytenoid cartilage.
   a. cricoarytenoideus lateralis  
   b. arytenoideus transversus  
   c. thyroarytenoid  
   d. cricoarytenoideus dorsalis  
   e. ventricularis

4. Except for the cricothyroid muscle, all of the intrinsic muscles of the larynx are innervated by the ________ nerve.
   a. recurrent laryngeal  
   b. cranial laryngeal  
   c. first cervical  
   d. 12th cranial

5. Based on scientific data accumulated to date, the most likely explanation for the differential involvement of the laryngeal adductor and abductor muscles in horses with ILH is
   a. differences in fiber diameter.  
   b. focal areas of nerve compression.  
   c. destruction of nerve fibers by neurotoxins.  
   d. thiamine deficiency.  
   e. alterations in axonal transport.

6. Measurements of airflow mechanics from horses with LH demonstrate
   a. increased inspiratory airflow.  
   b. decreased expiratory driving pressure.  
   c. increased inspiratory impedance.  
   d. decreased expiratory impedance.

7. The best diagnostic method to determine the treatment of choice for a horse with grade III laryngeal cartilage movements is to perform
   a. TBFVLs during maximal exercise on a high-speed treadmill.  
   b. endoscopic examination during maximal exercise on a high-speed treadmill.  
   c. quantitative endoscopic examination with calcula-

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tion of the L:R cross-sectional area of the rima glottidis.
d. airflow mechanics and calculate and compare inspira-
atory impedance values at rest and during maximal
exercise.
e. nasal occlusion and induce swallowing during rest-
ing endoscopic examination.

8. ___________ is the primary complication reported
to develop following prosthetic laryngoplasty.
a. Seroma formation at the surgery site
b. Regurgitation of feed material
c. Suture sinus formation
d. Coughing
e. Wound infection

9. ___________ is the treatment of choice for a horse
with grade II laryngeal cartilage movement.
a. Prosthetic laryngoplasty
b. Laryngeal reinnervation
c. Ventriculectomy
d. Arytenoidectomy
e. none of the above

10. Clinical failure of the prosthetic laryngoplasty pro-
dure is reportedly associated with
a. infection at the surgical site.
b. improper prosthesis placement.
c. pull-through from the muscular process.
d. age of the animal.
e. all of the above