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Equine Upper Respiratory Surgery

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Introduction

The purpose of this chapter is to review the veterinary literature for various surgeries of the equine upper respiratory tract in an effort to evaluate the evidence supporting various therapies. The list of conditions to be covered is not, and need not be, all inclusive. Indeed, the treatment of many conditions should be intuitive and the benefit of intervention self evident, such as drainage of pulmonary abscesses or excision of a neoplastic mass. Therapeutic benefit from such procedures is obvious, and need not necessarily be supported by randomized, controlled trials. This chapter will instead focus on the therapeutic benefit from more widely occurring conditions such as laryngeal hemiplegia (LH), dorsal displacement of the soft palate (DDSP), arytenoid chondritis (AC), and epiglottic entrapment (EE).

An evidence-based approach to surgery can be challenging, and equine practice itself presents its own unique challenges. Some conditions do not necessarily lend themselves to experimental models. For example, some intermittent conditions, such as DDSP and EE, are only present during exercise, and the circumstances that induce the abnormality are not easily reproducible at rest. The diagnosis in such instances is often speculative, based on a compatible history, and often leads to differing inclusion criteria. As a result, such studies may not be directly comparable. In addition, the effect of treatment and the prognosis for future performance can be difficult to determine because horses often have multiple problems.

There are also variables between groups of horses to consider, as well. Athletic horses perform widely varying tasks for a living and the demands placed on the horses can dramatically affect the surgical outcome. For example, hunters and jumpers that exercise for short durations at submaximal intensity can be expected to have a lower requirement for airflow than a racehorse galloping at speeds in excess of 14 m/s. Studies comparing results in these different disciplines confirm this.

Many of the surgeries for the upper respiratory tract are technically demanding. There can be tremendous variation in results between surgeons depending on training, level of expertise, and the frequency with which the surgeon performs the procedure. Many of the surgical procedures are exceedingly difficult to perform and it is unreasonable to expect that an untrained individual would achieve results similar to a specialist that performs the surgeries on a regular basis. As a result, retrospective studies that compile results from many surgeons tend to have more pessimistic results than studies where one or a small number of surgeons performs all of the procedures. Many conditions do not occur with enough frequency to perform clinical trials on par with the large studies that are commonplace in human medicine. Owners keep these animals to perform in their chosen equestrian discipline; the goal is to win. This presents its own set of problems for clinical research in equine respiratory surgery. Owners may be unwilling to accept a sham treatment if they recognize a performance limiting problem with their horse. Thus, placebo controlled trials are non-existent in equine surgery. Similarly, studies that compare a new treatment to the previous standard therapy are infrequent because clients may be reluctant to participate in them. Clients are astute enough to recognize that the new treatment is being investigated because of shortcomings in the standard therapy; there is always the impression that newer equates to better. Unfortunately, such obstacles to collection of evidence are accompanied by even less

noble reasons exist for the active promotion of unvalidated new procedures, including a disregard of scientific methodology, vanity, and financial incentive.

The result has been a succession of studies of new procedures that differ in horse populations, inclusion criteria, measure of success, and control population. The appearance of these procedures generally precedes their appearance in the peer reviewed literature. Nevertheless, these therapies may be actively promoted in web pages, lay publications, and non peer-reviewed publications. This makes it difficult for the practitioner to assess the importance of many new procedures by any method other than to see how the technique fares with the passage of time.

The evidence-based medicine approach is relatively new in human and veterinary medicine. Most of the studies cited in this paper were written long before the practice of evidence based medicine was established. All of the studies cited here were written by established researchers and clinicians doing what they were supposed to be doing; engaging in state of the art practice, developing and testing new techniques, and reporting their findings in peer reviewed literature. It is easy in light of present knowledge to retrospectively critique their methodology; however one must remember that many of these studies were in fact “landmark” papers that shaped the direction of future study. There has been a noticeable improvement in the quality of the studies over time as newer studies strive to avoid the weaknesses of prior publications.

This review is intended solely to evaluate the evidence in the literature; it is not intended to be a critique of the authors. The author took the liberty of mining the various papers for results and performed calculations that may not have been presented in the original studies. This was done to provide meaningful comparisons between studies and was performed without favoritism to any of the studies. Original technique descriptions, small case series, or reports that use methodologies dramatically different from current practice were ignored in favor of larger retrospective or prospective studies in order to present the best current evidence

Laryngeal Hemiplegia

Laryngeal hemiplegia is caused by paralysis of the recurrent laryngeal nerve, the effect of which can be mimicked by transaction of the nerve. This is significant because there is a research model for this condition that closely replicates the naturally occurring disease and allows investigation of the various surgeries to treat LH under controlled conditions.

The goals of treatment of laryngeal hemiplegia are to restore airflow and eliminate respiratory noise, although these two outcomes are somewhat interrelated. The prosthetic laryngoplasty as described by Marks, et. al, in 1970¹ has been the mainstay for restoring the normal airway mechanics via abduction and stabilization of the arytenoid cartilage. Two other procedures are occasionally used to restore normal airway mechanics; arytenoidectomy to remove the paralyzed cartilage and laryngeal reinnervation. Noise reduction may be accomplished by a ventriculectomy, performed through a ventral laryngotomy, transendoscopically with a laser, or via a ventriculocordecotomy.

Prosthetic Laryngoplasty

Four experimental studies on LH induced by transection of the recurrent laryngeal nerve have evaluated the effects of LH on respiratory and blood gas variables in instrumented horses prior to neurectomy, after neurectomy, and after a prosthetic laryngoplasty.²⁻⁵ Laryngeal hemiplegia caused decreases in respiratory frequency, minute ventilation, PaO₂, and pH, and increases in upper airway impedance, negative inspiratory pressure and PaCO₂. In all cases, prosthetic laryngoplasty either restored the variables to pre-neurectomy values, or significantly improved the variables compared to pre-surgical values.²⁻⁵ Obviously not all studies measured the same variables but there was complete agreement between the studies that looked at the same variables. Furthermore, there have been no subsequent studies to contradict these findings. Taken together, these studies provide strong evidence that a prosthetic laryngoplasty can be successful in eliminating or attenuating the effects of induced laryngeal hemiplegia on respiratory and blood gas variables. Unfortunately, the clinical relevance of these studies is diminished by the fact that the effects of a prosthetic laryngoplasty were measured at treadmill speeds of 4.3², 7.2³, 8.3⁴, and 10 m/s⁵; all of which are substantially below the speed achieved by racehorses.

The outcome for clinical cases undergoing a prosthetic laryngoplasty is much less clear. Interpretation of results is confounded by all of the customary factors that plague retrospective studies. Differences in surgeons, techniques, case selection, breed and use of horse, follow-up interval, and criteria for success make it difficult to compare between studies. Analysis is also complicated because horses often have more than one respiratory condition. Racing data is especially difficult to analyze because there is a high loss of horses to follow-up. In addition, grouping of horses into the four permutations of raced and unraced, pre and post surgery, leaves small groups and unconvincing statistical analysis. For these reasons, all of the authors in clinical studies have used subjective owner satisfaction as the criteria for success. The more recent literature strives to use more objective outcome criteria by using racing data. Results from five retrospective studies are tabulated in **table 1**. These results are based on owner assessment of outcome and do not account for horses lost to follow-up.

From this data, a number of generalizations can be made. The prognosis for successful racing performance, based on subjective owner or trainer assessment ranges from 48%-81%⁶⁻⁸ and 77%⁶, 80%⁸, and 94%⁹ of racehorses made at least one start after surgery. There is not enough evidence to determine if the prognosis is better for racing Standardbreds or Thoroughbreds, and there is conflicting evidence on whether the prognosis for racing is better for younger or older horses. There appears to be trend for horses to drop in class post surgery.^{8,9} Differing methodologies between the studies make further inferences difficult.

Horses engaging in non-racing sports have a much better prognosis. A number of studies have reported a successful outcome, 86%¹⁰, 90%⁷, 92%¹¹, and 93%⁸ of horses following a laryngoplasty. For both racehorses and non-racing horses, exercise intolerance, respiratory noise, and coughing seem to be major complications of the procedure. Unquestionably, prosthetic laryngoplasty is a difficult procedure to perform and results can vary widely. However, the fact remains that the procedure has now been

performed for 36 years without any serious rival for replacement. This is at least some evidence that the procedure is efficacious to some degree.

Laryngeal reinnervation

The first report on laryngeal reinnervation in ponies appeared in 1989 and demonstrated that the technique was possible.^{12, 13} A subsequent experimental study using horses with LH induced by transaction of the recurrent laryngeal nerve demonstrated that a nerve muscle pedicle graft from the first cervical nerve was capable of improving or restoring respiratory variables to baseline values; however horses were only exercised at 7 m/s.¹⁴ There is only one clinical report of this procedure utilizing 129 Thoroughbreds, of which, results were available for 113 horses.¹⁵ Ninety five percent of horses that raced prior to surgery started in at least one race post surgery, but only 60% of unraced horses were able to race after surgery. Six of 10 operated Standardbreds raced postoperatively and 5 of 7 Warmbloods were improved.

This study principally used race records to assess results, so comparison with a laryngoplasty in which owner satisfaction was used is impossible. It is tempting to compare race records for laryngeal reinnervation with the prosthetic laryngoplasty race records, but methods utilized in the various studies were so disparate that meaningful comparisons are impossible. It is also unclear how widely this procedure is performed. In the 16 years since the initial report in experimental horses, there is only one clinical study and two surgeons accounted for all of the cases. That study clearly shows that laryngeal reinnervation can be successful; however a prosthetic laryngoplasty still appears to be the choice of the majority of surgeons.

Arytenoidectomy

It is more difficult to assess a prognosis for return to function following arytenoidectomy than for a prosthetic laryngoplasty because an arytenoidectomy is performed to treat several conditions, including arytenoid chondritis, laryngeal hemiplegia, as well as to treat horses in which a prosthetic laryngoplasty has failed. Two arytenoidectomy techniques are described that differ in the amount of the arytenoid cartilage that is removed.

Subtotal arytenoidectomy was reported to result in 90% of 20 racehorses returning to racing. Racing performance was reported as excellent or fair in these horses; however no information of the longevity or success of the racing careers was presented.¹⁶ In 1990, an experimental study in treadmill horses demonstrated that upper airway mechanics did not improve following a subtotal arytenoidectomy to correct laryngeal hemiplegia induced by recurrent laryngeal nerve neurectomy.¹⁷ It is noteworthy that the subtotal arytenoidectomy did not result in improvement in these horses even at a treadmill speed of 7 m/s. Based on the failure of this technique to improve airway mechanics under experimental conditions and the lack of follow-up reports to verify the initial results, this technique has been abandoned.

The initial report on partial arytenoidectomy in 1980 described successful return to function in 3/4 non-racehorses.¹⁸ A subsequent report of 75 cases revealed that 75% of non-racehorses were able to return to their intended use, but only 45% of Thoroughbreds

and 20% of Standardbreds were able to return to racing.¹⁹ This report may be overly pessimistic on racehorse performance because approximately 30% of the racehorses underwent *bilateral* arytenoidectomy. A later report demonstrated that 61% percent of horses that had not previously raced, and 78% of horses that had raced, were able to race after a partial arytenoidectomy.²⁰ Research evidence confirms that a partial arytenoidectomy is able to attenuate the detrimental effects on airway mechanics in horses with induced laryngeal hemiplegia at speeds that correlated to 100% of HR_{max}.²¹
²²All of the clinical studies contained horses operated for both arytenoid chondritis and laryngeal hemiplegia. The authors attempted to separate the results so that the reader could determine if the prognosis was different between the two conditions; however group size was too small to allow any inferences to be drawn.

A recent study in treadmill horses with induced laryngeal hemiplegia attempted to determine whether a prosthetic laryngoplasty or a partial arytenoidectomy was superior. Both procedures nearly restored respiratory variables to normal values when horses were exercised at speeds corresponding to maximal heart rate and there was a slight advantage to a prosthetic laryngoplasty. This would appear to indicate that the procedures are comparable for horses exercising at sub maximal intensity. The speed corresponding to maximal heart rate is still well below racing speed so it can not be determined from the available evidence whether arytenoidectomy and laryngoplasty are equivalent in racehorses.²²

Respiratory noise

The persistence of respiratory noise is a major complication following all treatments for arytenoid chondritis and laryngeal hemiplegia. The initial description of the prosthetic laryngoplasty combined that procedure with a ventriculectomy.¹ However, in 1980's the necessity of the ventriculectomy was questioned. One research study demonstrated that a ventriculectomy alone did not reverse the detrimental effects of induced laryngeal hemiplegia on upper airway mechanics, even when horses only exercised at 7.2 m/s.³ Subsequent research using microphone recordings of respiratory noise have convincingly demonstrated that a ventriculocordectomy alone is superior to a prosthetic laryngoplasty alone at reducing airway noise.²³ A unilateral laser ventriculectomy was not successful in reducing airway noise using the same methodology.²⁴ Based on these objective studies using a realistic model it is reasonable to conclude that the ventriculocordectomy is the most efficacious procedure at eliminating respiratory noise secondary to laryngeal hemiplegia.

Curiously, the academic debate on the necessity of a ventriculectomy was largely ignored by surgeons because all retrospective studies on prosthetic laryngoplasty and arytenoidectomy performed between 1970 and 2003 combined those procedures with either a ventriculectomy or ventriculocordectomy. This, is in spite of the fact that clinical studies have been unable to document any improvement in performance with the addition of either a ventriculectomy or ventriculocordectomy.^{6,7} Clearly, surgeons perceive a benefit even if it is unsubstantiated by the available evidence. A treadmill study in exercising horses with induced LH demonstrated that a ventriculocordectomy improves upper airway mechanics but is vastly inferior to a prosthetic laryngoplasty.²³ In another study, a ventriculocordectomy did not result in any additional improvement in airway

mechanics above that provided by a prosthetic laryngoplasty.⁵ Recently, a ventriculocordectomy has been reported as the sole treatment for 92 horses with incomplete laryngeal paralysis. Owners or trainers subjectively judged that performance was improved in 59% of horses and the surgery was considered worthwhile by 86% of owners. Twenty-two percent of the horses coughed after surgery and noise during exercise remained in 21% of horses; which is comparable to studies of a prosthetic laryngoplasty. This study shows that respiratory noise may be decreased and performance improved following a ventriculocordectomy; however, further comparisons to other surgical procedures for LH are not possible because this report principally consists of horses with incomplete laryngeal paralysis.²⁵

Dorsal Displacement of the Soft Palate (DDSP)

Very little is clear when it comes to analyzing the literature to determine the best treatment for DDSP. The condition is prevalent in racing Standardbreds and Thoroughbreds, and although the incidence is unknown; one prominent authority has estimated the incidence at 10-20%.²⁶ The most accurate method of diagnosis is debated and diagnostic methods and inclusion criteria vary between studies. Careful reading will reveal that many horses in these studies were operated without a clear diagnosis, or for lack of other options. Also, many of the horses in those studies had more than one upper airway condition.

Outcome assessment is difficult for racehorses and selection of the comparison group can greatly influence results. Use of the horse as its own control is ideal, but there are many reasons why a horse may not race well, and horses are often retired (and lost to follow-up) for unrelated reasons. Statistical comparison can be problematic when horses do not race before or after surgery. Further complicating interpretation of results is that the use of random controls can skew results in favor of the study population if that population is an elite one that is not comparable to the average horse.

In addition to these previously acknowledged limitations, there are others that are never mentioned. It is uncommon to be called upon to treat a horse at a referral center that has not had some prior medical or surgical treatment performed. Several studies of surgical interventions report the incidence of other known prior surgical interventions in the study population to be 9%²⁷, 29%²⁸, 68%²⁹, and 93%³⁰; and this probably underestimates the actual incidence because many horses are presented with no history. The history of prior surgery is a confounding variable that is not addressed in any of the papers. In addition, there is an inherent bias in comparing populations from different referral centers, due in large part to the quality of the horses, but this fact is widely ignored when comparing studies. This author believes that the bias introduced by the study population is significant and may account for the majority of the differences between studies.

In light of these problems is it possible to determine what is the best surgical procedure for DDSP? Actually, there is not even a consensus that the best option *is* surgery: even amongst surgeons.³¹ Advocates of non-surgical therapy cite results similar to the surgical procedures; however this argument is weakened by the fact that there are few surgical cases in which some form of medical therapy has not been attempted.

In interpreting the success of therapy, objective race data is increasingly being used to determine the success of procedures as opposed to owner satisfaction. However, interpretation of this data presents its own challenges. Most of the studies report the percentage of racehorses in which racing performance was improved post surgery. The reader of these studies is cautioned to read the fine print, because this figure includes analysis of horses that were able to race a specified number of races, typically 1-3 races, both before and after surgery. In many studies, this results in exclusion from the analysis of greater than 50% of the horses. For example, a study of 209 horses reported a 59% and 60% success rate for the procedures being studied; however this percentage was based on racing data from only 89 horses of the 209 reported.³² Similar attrition is present in many reports in which the take home message of percent success is derived from 42%³², 45%²⁷, 49%^{28, 33}, and 80%³⁴, } of the operated cases. Reports differ significantly in how well the remainder of the cases is accounted for.

It has almost become axiomatic that 60% success rate for DDSP treatment can be expected regardless of what one does. This sentiment has been now repeated so often that it is difficult to attribute the original quote. Complex data from years of surgery is distilled to a single number, the “percent success;” this is then compared to the other surgical options. The reader is cautioned that there is no uniformity in how this number is derived. (Table 2)

Surgical Techniques for DDSP

In brief, DDSP has been proposed to result from either caudal retraction of the larynx or an inability of the upper airway to resist the dynamic collapsing forces. Surgical procedures have developed that address each of these mechanisms. The caudal retraction theory gave rise to several variations of the sternothyro-hyoid myectomy.^{27, 34-36} These are probably the most widely performed procedures and have proven to be safe and efficacious (approximately 60%) when performed by a many individuals. They are also the basis for combination procedures.

Several procedures have been developed to decrease upper airway compliance and resist dynamic collapse. These include: staphylectomy, palatoplasty, thermal cauterization techniques, and epiglottic augmentation. A pitfall of most of the aforementioned techniques is that that research studies designed to validate the basic premise for these procedures have been uniformly unsuccessful. The three different thermal cauterization techniques reported also include various permutations of a sternothyroideus tenectomy and staphylectomy so their results can not be attributed solely to the thermal cauterization as the authors suggest.^{27, 34, 37}

A newer procedure, the tie-forward, does have credible research that supports the procedure as well as a thorough, prospective, clinical evaluation.²⁹ One notable caveat for the tie-forward is that the proposed etiology that this procedure addresses has not been demonstrated to cause DDSP. Results of the tie-forward have not been confirmed by others owing to the newness of the technique.

For all procedres it remains to be seen if the proposed etiology of DDSP is: 1) correct, 2) incorrect, and the procedures are beneficial for other reasons, or 3) if the favorable responses are a result of the study population. It is very likely that the results

obtained from all of surgical treatments are more reflective of the hospital population than any differences in the procedures. It is almost unquestionable that the debate will continue for some time.

Epiglottic Entrapment (EE)

Epiglottic entrapment (EE) occurs much less frequently than LH or DDSP. Epiglottic entrapment may be persistent or intermittent. The persistent form of epiglottic entrapment is readily and accurately diagnosed with upper airway endoscopy leaving little reason to question the accuracy of the diagnosis in the studies reviewed here. The intermittent condition is easily diagnosed during endoscopy on a high speed treadmill. It would seem intuitive that the prognosis for surgical correction would be the same for the intermittent and persistent forms of epiglottic entrapment; however studies on EE preceded widespread use of high speed treadmill use for diagnostic purposes, and only 4 of 179 cases examined here were reported to be intermittent.³⁸⁻⁴¹ Surgical approach to the aryepiglottic fold is either through a laryngotomy and resection of the aryepiglottic fold³⁸; or transnasal⁴² or transoral³⁹ axial division of the aryepiglottic fold. A laryngotomy has subjectively been demonstrated to have a greatly reduced prognosis for racing (27%) when compared to transoral axial transection in a small number of cases.³⁸

Two studies have evaluated transendoscopic Nd:YAG transaction of the aryepiglottic fold. Tate found that 10/11 horses with EE were performing in their intended activity post surgery.⁴⁰ Tulleners 1990 reported in 57 Standardbreds and 44 Thoroughbreds that 66%-80% had no change, 10%-17% improved, and 5%-17% decreased in racing class after surgery.⁴¹ Transoral transaction of the aryepiglottic fold has resulted in 20 /20 racehorses returning to racing at their prior level.³⁹ Transoral division of the aryepiglottic was shown by Lumsden to result in 82% owner satisfaction and 75% of these horses demonstrated no change in racing performance. Transnasal transaction of the aryepiglottic fold resulted in 16/17 racehorses returning to successful competition.⁴²

All methods evaluated were effective in correcting the entrapment. Fewer horses had a satisfactory outcome when treated via a laryngotomy approach. The transnasal, transoral, and transendoscopic approaches achieve comparable results. It appears that the preoperative performance is the best predictor of postoperative performance with EE and that the literature does not suggest that one method is superior to another.

CONCLUSIONS

In spite of the difficulties posed in evaluating surgical techniques of the equine respiratory system, it should be possible to critically assess procedures and practice using evidence-based assessments. The emphasis for future research in equine respiratory surgery needs to be on prospective rather than retrospective studies, on trials instead of case series, and on systematic reviews, rather than unsystematic ones. Strategies to improve the quality of the evidence available would include education of surgeons in clinical research methodology, improved funding for research, and compulsory evaluation of new techniques before their general adoption. In addition, if randomized,

controlled trials are not feasible, alternative designs, such as prospective matched-pair trials, may need to be better developed and utilized.

Table 1. Postoperative Performance and complications following a prosthetic laryngoplasty

Number of operated horses	Number of horses with followup	Percent satisfaction	Exercise Intolerance Post-op	Respiratory Noise Post-op	Coughing Post-op	Reference
70	55	60%	425	47%	33%	8
80	69	70%	255	9%		7
230	176	81%		255	26%	6
104	79	92%	6%	21%	9%	11
200	198	86%	13%	27%		10

Table 2. Results of procedures used to treat Dorsal Displacement of the Soft Palate

Procedure	n	% success	Criteria for success	% of horses included in % success	reference	Year
mid-cervical sternothyrohyoideus myectomy	17	58%	subjective assesment		³⁵	1988
staphylectomy	69	59%	total earnings- 3 races before and after	42%	³²	1995
mid-cervical sternothyrohyoideus myectomy	80	60%	total earnings- 3 races before and after		³²	1995
sternothyrohyoideus and partial omohyoideus myectomy	50	70%	earnings per start	100%	⁴³	1997
sternothyroideus tenectomy	41	70%	Race times	10%	³⁶	1997
variety of sx and medical	92	64%	earnings per start	49%	²⁸	2002
sternothyroideus tenectomy and transnasal laser cauteriztion	52	92%	subjective assesment		³⁷	2002
sternothyroideus tenectomy, staphylectomy, thermoplasty	96	62%	Total earnings	80%	³⁴	2005
sternothyroideus tenectomy, staphylectomy, oral thermoplasty	102	63%	earnings per start	45%	²⁷	2005
Sternothyrohyoideus myectomy, staphylectomy, ventriculectomy	53	60%	earnings per start	49%	³³	2004
tie-forward	116	87%	subjective assesment		²⁹	2005

epiglottic augmentation	59	66%	performance index		³⁰	1997
conservative	31	61%	earnings per start		⁴⁴	2005

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