Evolution of laryngeal surgery in the last 20 years

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Historical aspect on “roaring”

The term “roaring” was already known in the eighteenth century as the respiratory noise produced during strenuous exercise that was associated diminished work tolerance. More over the relationship between left laryngeal paralysis and “roaring” was confirmed by transection of the left laryngeal nerve. Science could, however not convince the law in England, which still stated in 1882 that “roaring was caused by thick mucus adhering the walls of the larynx. The idea that “roaring” could be an inherited trait came up as early as 1764, when a group of Danish stallions was brought to the Normandy, which resulted in a significant increase incidence of left laryngeal hemiplegia in the following years. The Royal College of Veterinary Surgeons disqualified affected Thoroughbred stallions form breeding in 1890, further underlining the close relationship between the disorder and breeding practices. Most commonly large breeds of horses were affected by the disorder, such as draught- and saddle horses.

At that time it was not possible to visualize the larynx during exercise; therefore the veterinarians had to rely on its digital palpation. It was soon recognized that the laryngeal muscles atrophied on the left side. In 1911 Williams described his findings in detail.

Surgical Procedures on the larynx

It is very interesting to note that most surgical procedures applied today in laryngeal surgery were developed 150 years ago by Günther Junior from Hannover. These procedures: vocal corpectomies, ventriculectomies as well as partial and total arytenoidectomies. With time additional procedures were developed.

Ventriculectomies
The basic idea involved to create a fibrous band between the thyroid cartilage, the vocal fold and the arytenoids cartilage by obliteration of the ventricle. Several techniques were described involving simple removal with or without suture closure of the opening of the
ventricle after removal of its lining, additional removal of the vocal cord, and cautery of the ventricle.

Williams developed a simple technique for ventriculectomy in 1907 but Hobday was subsequently the one who really made this technique popular and it became to be known as the “Hobday Operation”. In the early days a laryngotomy approach through the cricothyroid membrane was selected, however with the introduction of lasers and modern electrocautery, the technique was modified to be performed in the tranquilized standing horse through an approach via the ventral nasal meatus. In some cases the laryngotomy was partially or completely closed.

Today, ventriculectomy is rarely applied as the sole procedure to treat laryngeal hemiplegia, except in the rare sow horse, which does not have to perform at a high intensity. Frequently however, the procedure is performed as an adjunct therapy in addition to a laryngoplasty procedure. The thought here is to induce some scarring between the thyroid- and the arytenoid cartilage, which adds some resistance to the region and in doing so impedes the adduction occurring during intense inspiration during high velocity exercise.

In selected cases, still today, ventriculocordectomy is performed, where in addition to the ventricle also the vocal cord is excised, either uni- or bilaterally. These procedures are usually performed through a transnasal approach in the standing horse.

**Laryngoplasty**

The modern laryngoplasty was introduced by Marks and co-workers in 1970. These authors could achieve what Möller 1888 was unable to achieve, namely to produce and subsequently maintain a functional abduction of the arytenoid cartilage. The initial technique involved the application of an elastic suture material (Lycra) between the caudal rim of the cricoid cartilage and the muscular process of the arytenoid cartilage in association with a ventriculectomy. Since then multiple variations of the technique have been described including two and three separate prostheses, the use of non-elastic prosthesis material, absorbable prostheses, variations in the location where the prostheses were placed and omission of the ventriculectomy. An interesting approach was proposed by Schumacher et al. in 2000, where he proposed a cable system as the prosthetic material that is maintained in position by attaching a washer at both ends after abduction of the arytenoid cartilage. The idea behind this approach was to reduce the
complication rate through pulling out of the prosthesis of the muscular process, which has been reported repeatedly.\textsuperscript{14,17}

The fact that until today “new and improved” prostheses configurations are developed is underlined by the recent publication of Boening in 2007.\textsuperscript{18}

Arytenoidectomies

It was again Günther who established the first technique of arytenoidectomy to improve airflow by removing instead of abducting the arytenoid cartilage.\textsuperscript{3} However his attempts at total arytenoidectomy were accompanied by severe aspiration pneumonia and death of the patient. He then attempted to perform a partial or subtotal aryteoidectomy, but still his results were unsatisfactory. Up to 1900 the technique was modified by different authors until it definitely fell into disgrace because of the high complication rates. It is only during the last 20 years that the technique was “reinvented”. The refined surgical techniques, the significantly improved anesthesia techniques and protocols and the increased armamentarium in drugs, such as anti-inflammatories, allow the today’s surgeons to decrease the complication rate and in doing so offer a better prognosis to animals undergoing subtotal, partial or total arythenoidectomies.\textsuperscript{17,19-21} The nomenclature for the different techniques is somewhat confusing: in the subtotal arytenoidectomy the entire cartilage except the corniculate – and muscular processes is removed, whereas in the partial arytenoidectomy only the muscular process is retained.\textsuperscript{22} A study where both techniques were compared revealed that the partial arytenoidectomy improved upper airway function in exercising horses with surgically induced left laryngeal hemiplegia and was superior to subtotal arytenoidectomy as a treatment both for failed laryngoplasties and arytenoid chondropathy.\textsuperscript{20} The authors recommended combining a partial arytenoidectomy with a ventriculectomy and closing the entire incision in such a way that no excessive or loose tissue is left in the airway and all excised mucosal edged are apposed.

Neuromuscular pedicle graft

The first nerve grafting procedures were attempted by Smith in 1894\textsuperscript{23} and Tagg in 1935\textsuperscript{24} and were similar in concept as the techniques advocated today.\textsuperscript{22,25-28} From a physiological point of view this procedure is the most promising to restore normal function of the larynx under competitive conditions. The procedure involves harvesting muscle segments directly
innervated by the 1st cervical nerve and their implantation into the atrophied cricoarytenoideus dorsalis muscle. The benefit of using muscle pieces innervated by the 1st cervical nerve is that it depolarizes during inspiration and in doing so induces abduction of the cricoarytenoideus dorsalis muscle following re-innervation. Some encouraging results have been achieved, but the recovery time is much longer than with the previously described procedures – in most cases one year. Additionally, in must be recognized that even in a successful case the involved arytenoid looks motionless during standing endoscopy because the 1st cervical nerve is inactive at rest.

**Surgical procedures of the epiglottis**

**Epiglottic entrapment**

There are two surgical approaches described to correct the problem: the laryngotomy/pharyngotomy approach and the transnasal or transoral approach respectively. The latter are known as minimally invasive techniques. The first approaches to the epiglottis occurred through a laryngotomy and part of the aryepiglottic fold was resected under visual control. Initially the fold was resected from side to side, but this technique resulted in frequent dorsal displacement of the soft palate. Subsequently, tissue-sparing techniques were developed causing minimal damage to the mucosa and minimal scarring, because of the variable amount of underlying epiglottic hypoplasia found in many horses suffering from epiglottic entrapment. These technique split the entrapping aryepiglottic fold axially and allow it to retract and heal in the normal subepiglottic position. This axial splitting can be performed through application of a laser, electrocautery and “hook-bistoury”.

Performing the transnasal hook-bistoury procedure in the standing horse is discouraged because of serious complications including lacerations of the epiglottis, the soft palate, and pharynx. These complications can be avoided if the procedure is performed in the anesthetized horse through an oral approach. Horses with a deformed epiglottis, covered by the aryepiglottic fold must be given a poor prognosis for return to an athletic career.

**Subepiglottic cysts and granulomas**

Once diagnosed, subepiglottic cysts and masses should be surgically removed. Today the approach through a laryngotomy is discouraged because the cysts and masses are
frequently difficult to identify and subsequently remove, but it has been described in the literature.\textsuperscript{38} Therefore the transoral or transnasal approach is usually selected.\textsuperscript{39,40} It is important to remove the cystic lining. Simple aspiration of the cyst usually results in re-filling of the cyst. The most successful technique involves the use of an electrically or laser powered\textsuperscript{39} snare that resects the cyst or mass at its base. It is important to grasp the cyst before the snare is activated. Otherwise once loose and detached from its base, it is usually swallowed by the horse. Routine management is applied postoperatively.

**Epiglottic hypoplasia**

Epiglottic hypoplasia is frequent cause of dorsal displacement of the soft palate. Management of this congenital and possibly inherited trait is difficult. Up to now the only technique resulting in partial success is augmentation of the epiglottis through submucosal injection with polytetrafluoroethylene.\textsuperscript{41,42} The augmentation can be performed in the anesthetized horse transorally or through a laryngotomy incision. The advantage of the transoral incision is the fact that the epiglottis I can be straightened, preventing inadvertent exit of the needle through the mucosa as may occur in the retroflexed epiglottis, when a laryngotomy approach was selected. The use of the Arnold-Burning injection syringe worked well. Depending on the size of the epiglottis 4 to 5 linear longitudinal injection strands are deposited submucosally parallel to each other and equidistantly along the ventral aspect of the epiglottis. This type of treatment resulted in a 29-40\% increase in thickness of the epiglottis and allowed 66\% of the horses showing poor racing performance to improve their working ability.\textsuperscript{42}

**Axial deviation of the aryepiglottic folds**

Axial deviation of the aryepiglottic folds is mainly diagnosed in racehorses and is a rarely encountered problem. The only treatment described involves transendoscopic Nd:YAG laser resection.\textsuperscript{43}

**Tie forward**

The tie-forward procedure is performed on the larynx but is used to treat a pharyngeal problem - namely dorsal displacement of the soft palate. An investigative study showed that
resection of the thyrohyoid muscles resulted in dorsal displacement of the soft palate, which could be corrected by placing a suture to substitute the function of the resected muscles. As a followup to this study the surgical technique of tie-forward was developed and applied clinically. 87% of the 98 horses where follow-up data could be collected were classified as improved and in 80% of the 20 horses, which were available for a treadmill follow-up evaluation, an improved performance index could be established.

Summary

It is interesting to note that most of the procedures used today to improve laryngeal problems were established in the mid to late 1800. Since then more specific diagnostic techniques were developed and as a sequence of this, or in concert with these, the surgical techniques have been refined. The main trend is towards minimally invasive surgical techniques, which reduce morbidity and very often reduce the complications of surgical interventions. One new surgical laryngeal technique developed during the last 20 years is the tie-forward procedure for correction of dorsal displacement of the soft palate – nota bene a pharyngeal problem. Not all problems have been solved, actually very few are. One of the major problems still not satisfactorily solved is the laryngoplasty. There are still many instances where the suture is pulled out of muscular process. The ideal situation would be the implantation of magnet to muscular process that can be activated electronically at the beginning of a race and after the horse cooled of the activation can be reversed.

References


