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Treadmill and Overground Diagnosis of Upper Respiratory Tract Disorders

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What is dynamic airway collapse and why does it occur?

Obstructive disorders of the upper respiratory tract (URT) have been recognised as important causes of poor performance in the equine athlete for many years. Collapse of structures within the upper airways results in a reduction in the diameter of airway and causes increased resistance to airflow, an increase in the work of breathing and a reduction in ventilation, thereby reducing the oxygen supply to the exercising muscles. It is now acknowledged that resting endoscopic findings alone are not necessarily representative of the situation occurring during strenuous exercise and that exercising endoscopy is necessary in order to make a definitive diagnosis in many cases (Kannegieter et al., 1995; Tan et al., 2005; Lane et al., 2006b). This is perhaps not surprising when we consider the changes that occur within the respiratory system between rest and fast exercise. Breathing and stride frequency are matched at canter and gallop. The breathing frequency increases from 8-12 breaths per minute at rest to approximately 120 breaths per minute during strenuous exercise. Tidal volume also increases (approximately threefold) resulting in the minute ventilation increasing from 50l/min at rest to over 2000 l/min when galloping (Lekeux and Art, 1994). In order to drive ventilation, the pressures within the airway increase dramatically during exercise (Ducharme et al., 1994). Any weakness (either pathological or physiological) of the upper airway musculature may result in an inability to resist the increased negative airway pressures associated with exercise and hence will result in dynamic airway collapse.

Diagnosis of dynamic airway collapse:

Treadmill endoscopy:
The use of treadmill endoscopy was first described by Morris and Seeherman (1990) and over the past 20 years has enabled clinicians to visualise the upper airways during exercise. This has greatly aided our understanding of the different forms of dynamic collapse affecting the exercising horse and to date
has been considered to be the “gold standard” for diagnosis of dynamic airway collapse. This technique has the advantage that testing protocols may be standardised and other measurements may also be made concurrently, such as measurement of airflow and gas exchange. However, treadmill endoscopy requires the horse to be examined at a specialist facility. The procedure is labour intensive and time consuming and considered by many to be too expensive. In addition there are frequently concerns over the potential risk of injury. This has meant that historically, relatively few horses have undergone exercising endoscopy in order to achieve a definitive diagnosis and in many cases the decision for surgery has been based on clinical history and resting endoscopic findings alone.

**Overground endoscopy:**
During the past few years, advances in technology have enabled the development of portable endoscopes that may be used during ridden exercise in the field (Franklin et al 2008, Tamzali et al 2009, Pollock et al, 2009). A number of systems are now becoming available commercially and will doubtless have an important impact on the ability to diagnose dynamic airway collapse in the exercising horse. The advantages of this technique include the ability to exercise the horse in its natural environment with a rider onboard and without the need for referral to a specialist centre. Presently these systems are most useful for diagnosing URT collapse in horses that make abnormal respiratory noise during training. However, care must be taken in interpreting negative findings in horses that only make abnormal respiratory noise during competition (eg. racing) or that are presented with poor performance without reported respiratory noise. In such cases it is necessary to recreate the work effort encountered during competition as opposed to during training.

**Types of URT collapse**
A range of different forms of dynamic airway collapse have been identified (Franklin 2008). These may affect the nasal passages, nasopharynx, larynx or trachea and in many cases (30 – 50%) may be multifactorial (Tan et al., 2005; Lane et al., 2006a).

**Dynamic collapse affecting the nasal passages and nasopharynx:**
Palatal dysfunction is the most common form of URT collapse affecting racehorses and has also been observed in eventers and other horses performing less strenuous exercise. Palatal instability (PI) is manifest as progressive dorso-ventral billowing movements of the caudal portion of the soft palate, with flattening of the ventral surface of the epiglottis against the dorsal surface of the
soft palate. In many cases this ultimately leads to dorsal displacement of the soft palate (DDSP) whereby the caudal border of the soft palate becomes displaced to a position above the epiglottis resulting in obstruction of the rima glottidis. However, in some cases PI does not lead to DDSP during exercise testing. It is unclear whether these horses would experience DDSP under different conditions.

Pharyngeal wall collapse may involve either the lateral pharyngeal walls or the dorsal pharyngeal wall which makes up the roof of the nasopharynx. In some horses, a combination of dorsal and lateral pharyngeal collapse together with upward movements of the soft palate may result in pronounced circumferential pharyngeal collapse. This condition occurs much less commonly than palatal dysfunction and appears to be more common in Standardbreds and sport horses than Thoroughbreds. Excessive neck flexion has been proposed to be an important contributing factor in these horses.

Less common conditions affecting the nasopharyngeal airway include alar fold collapse and rostral soft palate instability.

**Dynamic collapse affecting the laryngeal airway**

Left sided arytenoid cartilage collapse (ACC) as a result of recurrent laryngeal neuropathy is the most common disorder affecting the laryngeal airway. During exercise, the corniculate process of the arytenoid cartilage, together with the ipsilateral vocal fold, moves towards the midline of the rima glottidis during inspiration. In some cases bilateral vocal fold collapse may be observed. Vocal cord collapse (VCC), affecting one or both vocal cords, may also occur in the absence of ACC. The degree of airway obstruction is less than with ACC and exercise tolerance may not be compromised, particularly if horses are exercising at submaximal intensities.

Axial deviation of the aryepiglottal folds (ADAF) results in medial displacement of the vertical margins of one or both aryepiglottal folds during inspiration. This frequently occurs in combination with other forms of dynamic airway collapse. Some authors have suggested a possible association with palatal dysfunction. However, the condition may also occur as an isolated entity. The clinical significance will depend on the degree of obstruction of the rima glottidis and whether other forms of dynamic airway collapse are present concurrently.

Intermittent epiglottal entrapment (EE) occurs when the epiglottis becomes enveloped by the subepiglottic mucosa and aryepiglottal folds. In the majority of cases, EE may be diagnosed during a resting endoscopic examination. However, occasionally cases only become apparent during strenuous exercise.
Some horses with intermittent EE also experience intermittent or persistent dorsal displacement of the soft palate (DDSP) during exercise.

Less common causes of laryngeal collapse include:
*Right sided arytenoid cartilage collapse*, which is most commonly associated with fourth branchial arch defects (4BAD).
*Dynamic bilateral arytenoid and vocal fold collapse* which has been associated with head flexion, in Norwegian Trotters.
*Epiglottal retroversion* whereby the apex of the epiglottis retroverts and covers the rima glottidis during inspiration.
*Collapse of the apex of the corniculate process* may occur, without concurrent collapse of the ventral aspect of the corniculate process. Other forms of dynamic collapse, such as VCC or ADAF usually occur concurrently. This condition has also been diagnosed in Clydesdale horses during a resting examination.

**Dynamic collapse affecting the trachea:**
Collapse of the crico-tracheal membrane and dynamic tracheal collapse have both been reported in the literature but appear to be rare.

**Conclusions:**
Collapse of the structures within the equine upper airway are an important cause of poor performance. A variety of conditions are recognised and may often be multifactorial in nature. New field-based endoscopy systems should enable more horses to undergo exercising endoscopy and receive a definitive diagnosis prior to surgical treatment. In addition, their use should aid further research into the causes and most appropriate treatments for different forms of dynamic airway collapse.

**References**


