Available online at www.sciencedirect.com
SCIENCE DIRECT®
The Veterinary Journal 170 (2005) 243–248
The Veterinary Journal
www.elsevier.com/locate/tvjl

High-speed treadmill videoendoscopic examination of the upper respiratory tract in the horse: The results of 291 clinical cases

Rachel H.H. Tan, Bradley A. Dowling, Andrew J. Dart *

University Veterinary Centre Camden, Faculty of Veterinary Science, The University of Sydney, Werombi Road, Camden, New South Wales, 2570, Australia

Accepted 28 June 2004

Abstract

The purpose of the study was to describe the prevalence of upper airway abnormalities and establish if any significant associations existed between study variables and the two most frequently identified disorders; axial deviation of the aryepiglottic folds and dorsal displacement of the soft palate.

The clinical records and video-recordings of all horses referred for upper respiratory tract evaluation during high-speed treadmill videoendoscopy between November 1997 and September 2003 were reviewed. Of 291 horses included in the study, 265 underwent resting endoscopy and 42% (112/265) had a recognised abnormality. More than one abnormality was identified in 49% of horses. In general, horses referred specifically for evaluation of a respiratory tract noise were more likely to have an abnormality detected during exercise than those referred for high-speed treadmill videoendoscopy for poor performance (82% versus 49%). Axial deviation of the aryepiglottic folds (105/192, 55%) was the most common abnormality identified, followed by dorsal displacement of the soft palate (74/192, 39%) and idiopathic left laryngeal hemiplegia (65/192, 34%). Other abnormalities identified included arytenoid collapse, vocal fold collapse, dynamic pharyngeal collapse, epiglottic fold entrapment, epiglottic retroversion, rostral displacement of the palatopharyngeal arch and right laryngeal hemiplegia. In horses with axial deviation of the aryepiglottic folds there was a significant association between the increasing severity of the deviation and the increasing number of abnormalities detected. There were no other associations found.

High-speed treadmill videoendoscopy is an important component of the evaluation of poor performance, particularly in horses with a history of respiratory noise. The occurrence of multiple abnormalities in a large proportion of horses suggests that high-speed treadmill videoendoscopy should be recommended, where possible, to make an accurate diagnosis, advise on appropriate treatment options and provide a prognosis for affected horses.

Keywords: Equine; Treadmill; Poor performance; Respiratory noise; Upper airway

1. Introduction

Dynamic obstruction of the upper respiratory tract is a common cause of poor performance in equine athletes (Lumsden et al., 1995; Martin et al., 2000; Morris and Seeherman, 1991). The importance of videoendoscopy in evaluating the anatomy and function of the upper respiratory tract at rest and during exercise has been documented (Hodgson and Rose, 1994; Lumsden et al., 1995; Morris and Seeherman, 1990; Morris and Seeherman, 1991; Rosenstein and Stick, 1999; Stick et al., 1992). The results of previous investigations have been descriptive in nature and the majority of horses in the study populations have been Standardbred racehorses (Lumsden et al., 1995; Morris and Seeherman, 1991).

* Corresponding author. Tel.: +61 2 4655 0777; fax: +61 2 4655 1212.
E-mail address: andrewd@camden.usyd.edu.au (A.J. Dart).

1090-0233/$ - see front matter © 2004 Elsevier Ltd. All rights reserved.
doi:10.1016/j.tvjl.2004.06.011

The purpose of this study was to document the prevalence of upper respiratory tract abnormalities during high-speed treadmill videoendoscopy (HTV) in a large population of predominantly Thoroughbred racehorses. Some of the results were evaluated to determine if there were any associations between resting endoscopy findings, HTV findings and those horses with axial deviation of the aryepiglottic folds (ADAF) or dorsal displacement of the soft palate (DDSP), and age or breed of horse and number or severity of concurrent abnormalities found during exercise.

2. Materials and methods

2.1. Criteria for case selection

The clinical records and video recordings of all horses that underwent HTV at the University Veterinary Centre, Camden between November 1997 and September 2003 were examined. All horses underwent a physical examination and were examined for lameness prior to acclimation to the treadmill. Endoscopy was performed using a 1 m, 10 mm diameter endoscope attached to a video chip camera (Pentax EM-3000). During treadmill exercise testing, images were displayed on a monitor and recorded on video. Information retrieved from the clinical record included the age, breed, gender, purpose for which the horse was used, presenting complaint and resting endoscopy findings of the upper airway. The authors reviewed the video-recordings and any abnormalities were recorded.

2.2. Endoscopic evaluation

Abnormalities found on resting endoscopy of the upper airway but not including the guttural pouches were recorded. Resting laryngeal function was graded using a standard grading system (Rakestraw et al., 1991). Briefly; grade 1 was a normal functioning larynx; grade 2 was where arytenoid movement was asynchronous but both arytenoids could attain full abduction; grade 3 was where arytenoid movement was asynchronous but one arytenoid could not achieve full abduction during any phase of respiration; and grade 4 was where there was no appreciable movement of one arytenoid cartilage.

Abnormalities identified during HTV were recorded and ADAF (King et al., 2001) and idiopathic left laryngeal hemiplegia (ILLH) (Rakestraw et al., 1991; Hammer et al., 1998) were graded during maximal exercise. Briefly, ADAF was defined as axial collapse of one or both aryepiglottic folds so the folds; remained abaxial to the vocal cords (mild); collapsed to less than halfway between the vocal folds and midline (moderate), or collapsed to more than halfway between the vocal folds and midline (marked) (King et al., 2001). In horses with grade 3 laryngeal function diagnosed at rest, was graded 3A if they were able to maintain full abduction during inspiration; grade 3B if the arytenoids cartilage and vocal fold were maintained in an incompletely abducted position; and grade 3C if the arytenoids and vocal fold collapsed during inspiration (Rakestraw et al., 1991; Hammer et al., 1998).

For the purposes of the study, arytenoid collapse was recorded as a distinct entity when the left arytenoid was seen to collapse progressively under the right arytenoid at the dorsal attachment of the two corniculate cartilages during exercise. This condition was distinctly different to horses with ILLH where the left corniculate cartilage collapsed axially across the midline.

Vocal fold collapse has been associated with grade 3 ILLH (Stick et al., 1999). Left vocal fold collapse was noted in all horses with ILLH during exercise in this study and was therefore, only recorded as a distinct abnormality when it was not associated with ILLH or was present bilaterally in conjunction with ILLH.

2.3. Treadmill protocol

Horses were acclimated to the treadmill (Mustang 2200, Kagra AG) prior to HTV examination by progressively increasing the exercise intensity from a walk to a canter. On the day of examination, horses were exercised on the inclined treadmill, using a previously described, standardised, exercise protocol (Dart et al., 2001; Hodgson and Rose, 1994).

Briefly, horses were gradually taken from a walk to a canter on no incline (horses not used for racing); a 3° incline (Standardbred racehorses) or a 6° incline (Throroughbred racehorses) over 1000 m. The treadmill was then stopped and the endoscope, held in place by a custom made snorkel attached to a leather head collar, was passed through the left nostril into the pharynx and positioned so that the apex of the epiglottis and the soft palate and arytenoid cartilages were clearly visible. The horses were then brought up to maximum exercise at speeds of up to 12 m/s, until the veterinarian was satisfied that an abnormality was apparent, or until the horse was showing signs of fatigue (Kannegieter and Dore, 1995; Lumsden et al., 1995). Fatigue was defined as an inability to maintain their position at the front of the treadmill despite encouragement. In cases where a diagnosis was not made during the first test, the procedure was repeated two days later.

2.4. Data storage and statistical analysis

Breed, age, gender and clinical data were stored in a database (Access 2000, Microsoft Corp.) and analysed using descriptive statistics (Excel 2000, Microsoft Corp.). Chi-squared tests for difference in proportions

were used for comparisons. Chi squared tests were only performed when the number of horses in each group was greater than five. Analyses were performed using Minitab 14.1 and Medcalc 7.3.0.1. An analysis was performed between groups of horses with the most frequently identified disorders (ADAF and DDSP) and breed (Standardbred or Thoroughbred), age, number of concurrent abnormalities detected on HTV and, where applicable, disease severity. Significance was set at $P < 0.05$.

3. Results

3.1. Horses

Two hundred and ninety-one horses were included in the study. There were 207 Thoroughbreds, 79 Standardbreds, four Warmbloods and one Quarterhorse. Two hundred and eighty-four were used for racing, four for dressage and three for pleasure riding. There were 101 females, 36 entire males and 154 geldings. Ages ranged from one to 11 years; two one-year olds, 38 two-year olds, 121 three-year olds, 73 four-year olds, 40 five-year olds, and 12 six-year olds. The remaining five horses were aged between seven- and eleven-years old. The mean age was 3.5 years for Thoroughbreds, and 3.8 years for Standardbreds.

The primary presenting complaint was poor performance (130), respiratory noise (130), respiratory noise following previous laryngeal surgery (16), pre-purchase examination (1), post-sale examination (3), poor recovery post-exercise (5), upper respiratory tract evaluation (4) and cardiac arrhythmia (2).

3.2. Resting endoscopy

Resting endoscopic examination of the upper respiratory tract was performed in 265 horses. Resting endoscopy was normal in 58% (153) of horses. In the remaining horses, 62% (112) had evidence of ILLH (grade 2, 26%; grade 3, 70% and grade 4, 4%). One horse had grade 3 right sided idiopathic laryngeal hemiplegia (ILH). Other abnormalities detected at rest included lymphoid hyperplasia (30), DDSP (6), arytenoid chondritis (7), epiglottic entrapment (5) and fourth branchial arch defect (1).

3.3. High-speed treadmill videoendoscopy

One hundred and ninety-two horses (66%) had a total of 314 abnormalities detected on HTV (Table 1). One abnormality was identified in 98 (51%) horses, two abnormalities in 73 (38%) horses, three abnormalities in 14 (7%) horses, and four abnormalities in seven (4%) horses. In horses where resting endoscopic examination was normal, 49% (75/153) of horses had an abnormality detected during exercise. In general, horses referred for evaluation of a respiratory tract noise were more likely to have an abnormality detected during HTV than those referred for HTV for poor performance (82% versus 49%). This was also true for horses with normal resting endoscopic findings (71% versus 43%). Multiple abnormalities were more common in horses referred for investigation of respiratory noise than those referred for poor performance.

ADAF was recorded and graded in 105 horses during exercise (King et al., 2001). In 50 horses, ADAF was associated with one other abnormality (DDSP, 33; ILLH, nine; vocal fold collapse, eight). In 12 horses, ADAF was associated with two other abnormalities (ILLH and vocal fold collapse, seven; ILLH and arytenoid collapse, three; DDSP and vocal fold collapse, two). In all horses with four detectable abnormalities (7) ADAF was present. ADAF was graded as mild in 70 horses, moderate in 29 horses and marked in six horses.

There was an association between increasing numbers of abnormalities and increasing severity of ADAF

Table 1
Occurrence of abnormalities on HTV and the relative percentage at which each particular abnormality occurred alone or in conjunction with other abnormalities

Upper airway abnormality	Number of horses affected (% Total horses with abnormalities detected)	Occurrence as single entity (% Horses with the disorder)	Occurrence in conjunction with one other abnormality (% Horses with the disorder)	Occurrence in conjunction with two other abnormalities (% Horses with the disorder)	Occurrence in conjunction with three other abnormalities (% Horses with the disorder)
ADAF	105 (55)	36 (34)	50 (48)	12 (11)	7 (7)
DDSP	74 (39)	21 (21)	45 (61)	3 (4)	5 (7)
ILLH	65 (34)	24 (37)	26 (40)	11 (17)	4 (6)
Vocal fold collapse	43 (22)	10 (23)	17 (40)	12 (28)	4 (9)
Arytenoid collapse	13 (7)	0	5 (38)	5 (38)	3 (23)
Dynamic pharyngeal collapse	5 (3)	4 (80)	0	0	1 (20)
Epiglottic entrapment	5 (3)	4 (80)	1 (20)	0	0
Other[a]	4 (2)	0	1 (25)	0	3 (75)

[a] Includes: Rostral displacement palatopharyngeal arch, epiglottic retroversion, right laryngeal paresis, arytenoid chondritis.

($P = 0.01$). No association was found between the severity of ADAF and DDSP ($P = 0.9$) or between the severity of ADAF and the presence of the three most commonly associated abnormalities (DDSP, ILLH, vocal fold collapse; $P = 0.6$). ADAF was not associated with age ($P = 0.7$) and was found in a similar percentage of thoroughbred (35.7%) and Standardbred (36.7%) horses.

Respiratory noise was the presenting complaint in most horses (58%) that had DDSP. There was no association between the presence of DDSP and age ($P = 0.9$). DDSP was more prevalent in Thoroughbreds than Standardbreds in this population of horses ($P = 0.04$). The most common abnormality observed in conjunction with DDSP was ADAF (45%). However where DDSP occurred in conjunction with ADAF there was no association with age ($P = 1.0$) or breed ($P = 0.9$).

Full abduction of the airway was achieved in 16/69 horses that had ILLH identified at rest. Of five horses classified as grade 2 at rest, four were classified as grade 3B and one as grade 3C during exercise. Of 45 horses classified as grade 3 at rest, one was classified as grade 3A, 37 as grade 3B, and seven as grade 3C during exercise. In all horses with grade 4 ILLH at rest, the left corniculate process moved axially across midline during exercise.

Sixty-five horses had ILLH during exercise (Table 1). Two horses were graded 3A, 51 horses were graded 3B, and 12 horses were graded 3C. Idiopathic left laryngeal hemiplegia occurred in conjunction with one other abnormality in 26 horses (ADAF, nine; arytenoid collapse, five; vocal fold collapse, six; DDSP, six). Twelve horses with grade 3 ILLH (grade 3B, six; grade 3C, six) developed arytenoid collapse during exercise.

Vocal fold collapse occurred in conjunction with one other abnormality in 17 horses (ADAF, eight; ILLH, six; DDSP, three). Dynamic pharyngeal collapse occurred as a single entity in four horses, and was associated with ILLH, ADAF and arytenoid collapse in one horse. In four horses epiglottic entrapment was the only abnormality noted and occurred with DDSP in one horse.

4. Discussion

Previous reports have suggested that resting endoscopic examination alone may be inconclusive for the diagnosis of upper respiratory tract dysfunction in horses presented for poor performance and or respiratory noise (Hodgson and Rose, 1994; Lumsden et al., 1995; Parente et al., 2002; Stick et al., 1992). In the current study 49% of horses that had a normal upper airway at rest had abnormalities identified during exercise. This further highlights that, where possible, HTV is required for a complete and accurate evaluation of upper respiratory tract function in all animals presented for poor performance or abnormal respiratory noise during exercise (Kannegieter and Dore, 1995; King et al., 2001; Lumsden et al., 1995; Martin et al., 2000; Rakestraw et al., 1991; Morris and Seeherman, 1990; Morris and Seeherman, 1991; Stick et al., 1992).

In the present study, a definitive diagnosis was achieved in 81.5% of horses that presented for respiratory noise which is similar to previous reports (Kannegieter and Dore, 1995; Morris and Seeherman, 1990; Stick et al., 1992). Not surprisingly, horses referred for investigation of an abnormal respiratory noise were more likely to have abnormalities detected during exercise compared with horses referred for HTV for poor performance. However previous studies indicate that in horses presented for poor performance without respiratory noise a diagnosis was only achieved in 0–12% of cases compared to 43% of horses in our study (Kannegieter and Dore, 1995; Morris and Seeherman, 1990; Stick et al., 1992). Furthermore, multiple abnormalities were found to occur more commonly in our study compared to previous reports (49% versus 7–38%, Dart et al., 2001; Kannegieter and Dore, 1995; King et al., 2001; Lumsden et al., 1995; Parente, 1998; Parente et al., 2002). It is possible this may reflect differences in the study population but, more likely, an increased awareness of causes of upper respiratory obstruction that may affect performance.

ADAF (54.7%) was the most common abnormality detected in the study reported here and has only recently been recognised as a cause of poor performance (King et al., 2001). The high prevalence of ADAF was in contrast to previous reports (4–27%, Dart et al., 2001; Holcombe and Ducharme, 1999; Hodgson and Rose, 1994; Kannegieter and Dore, 1995; King et al., 1997; Martin et al., 2000; Parente, 1998).

We were unable to establish an association between ADAF and the type of concurrent abnormality when multiple abnormalities were found which is consistent with the findings of earlier work (King et al., 2001). However in this previous report ADAF was suggested to be more prevalent in two to three year olds (King et al., 2001). This study concluded ADAF may be associated with neuromuscular dysfunction, immaturity and or fatigue, although the precise cause remains unclear (King et al., 2001; Parente, 1998; Stick et al., 1999).

We were unable to demonstrate an association between ADAF and breed or age of horse. However, the severity of ADAF was associated with an increasing number of concurrent abnormalities. Small alterations in airway impedance result in significant increases in trans-upper airway pressures (Derksen et al., 1999). It is possible that ADAF may develop as a secondary problem related to impaired upper airway dynamics. Furthermore it is logical that the severity of the deviation would be expected to increase as the airway imped-

ance increases with multiple upper airway disorders. The implication is that ADAF may be self-limiting should other causes of upper airway dysfunction be corrected.

Respiratory noise was associated with DDSP in 58% of horses, which is consistent with previously reported figures of 50–81% (Lumsden et al., 1995; Martin et al., 2000; Parente et al., 2002; Stick et al., 1999). However in the population of horses in the current study, Thoroughbred horses were more likely to have DDSP than Standardbreds. The reason for this greater prevalence is unclear. However the clinical history and noise associated with DDSP is often more suggestive of the condition than other causes of poor performance and upper respiratory tract noise. It is possible that owners of Thoroughbreds are more likely to go to the expense of investigating all causes of poor performance or upper respiratory tract noise compared to Standardbred owners because of industry economics.

DDSP had been found in horses of all ages; however, anecdotal reports suggest younger horses are more susceptible (Lane, 1993). In the current study no association was found between age and DDSP. The occurrence of DDSP in conjunction with other abnormalities (62%) was higher than previously reported (40%) (Parente et al., 2002). ADAF was reported to be the most common additional abnormality in both studies.

In some horses, DDSP appears to follow a sequence of events including dorsal billowing of the soft palate, ventral flattening of the epiglottis and apparent laxity of the aryepiglottic folds and ADAF leading to an impaired laryngopalatal seal and DDSP (Robertson, 1998). The implication is that as the soft palate billows dorsally and elevates the epiglottis, the laxity in the aryepiglottic folds would be expected to become more pronounced, and the ADAF should become more severe. However, in the study reported here there was no significant association between the severity of ADAF and DDSP. Furthermore, ADAF can occur in conjunction with DDSP or as an isolated abnormality. It seems more plausible from the results of our study that the development of ADAF is likely to be associated with altered airway dynamics and changes in trans upper airway pressures.

Twenty-three per cent of horses with grade 2 or grade 3 ILLH at rest had normal laryngeal function during exercise. Previous investigations have also reported horses with normal laryngeal function during exercise despite being diagnosed with $\geqslant$ grade 2 ILLH at rest (Dart et al., 2001; Hammer et al., 1998; Lumsden et al., 1995; Parente et al., 2002; Stick et al., 1992; Stick et al., 1999). While these findings may be associated with differences in subjective assessment of laryngeal function they more likely reflect that ILLH is a progressive disease (Dixon et al., 2002).

Twelve horses (17%) displayed arytenoid collapse during exercise. This condition has not been previously described and the aetiology requires further investigation. The changes in the severity of ILLH during exercise and the development of arytenoid collapse in some horses, reinforces the value in assessing laryngeal function during exercise to determine appropriate treatment and prognosis (Hammer et al., 1998; Morris and Seeherman, 1990; Morris and Seeherman, 1991; Rakestraw et al., 1991). Similar to previous reports dynamic pharyngeal collapse, epiglottic entrapment, rostral displacement of the palatopharyngeal arch, epiglottic retroversion, and right laryngeal paresis, were uncommon findings (Dart et al., 2001; Kannegieter and Dore, 1995; Lumsden et al., 1995; Martin et al., 2000; Morris and Seeherman, 1991; Stick et al., 1992).

Our results support the findings of previous studies that HTV is an important diagnostic aspect of the evaluation of poor performance in horses with or without a history of respiratory noise. The high prevalence of abnormalities found during exercise in horses with a normal resting endoscopic examination and the prevalence of multiple abnormalities in a large number of horses under exercise conditions in this study suggest that, where possible, endoscopic examination during exercise is the preferred approach for diagnosis of poor performance associated with upper airway dysfunction. Furthermore an accurate diagnosis is essential when advising owners on appropriate treatment options and prognosis.

Axial deviation of the aryepiglottic folds was the most common abnormality detected, the severity of which was significantly associated with an increasing number of upper airway abnormalities. This suggests that altered airway dynamics may be the underlying cause of ADAF and in many cases it is a secondary problem which may be self-limiting should other problems be corrected. Furthermore, in contrast to industry perception DDSP was not associated with age or type of concurrent abnormality.

References

Dart, A.J., Dowling, B.A., Hodgson, D.R., Rose, R.J., 2001. Evaluation of high-speed treadmill videoendoscopy for diagnosis of upper respiratory tract dysfunction in horses. The Australian Veterinary Journal 79, 109–112.

Derksen, F.J., Robinson, N.E., Holcombe, S.J., 1999. The upper airway as a conduit for air flow. In: Auer, J.A., Stick, J.A. (Eds.), Equine Surgery, second ed. Saunders, Philadelphia, USA, pp. 307–313.

Dixon, P.M., McGorum, B.C., Railton, D.I., Hawe, C., Tremaine, K., Pickles, K., McCann, J., 2002. Clinical and endoscopic evidence of progression in 152 cases of equine recurrent laryngeal neuropathy (RLN). The Equine Veterinary Journal 34, 29–34.

Hammer, E.J., Tulleners, E.P., Parente, E.J., Martin, B.B., 1998. Videoendoscopic assessment of dynamic laryngeal function during exercise in horses with grade-III left laryngeal hemiparesis at rest: 26 cases (1992–1995). The Journal of the American Veterinary Association 212, 399–403.

Hodgson, D.R., Rose, R.J., 1994. Clinical exercise testing. In: Hodgson, D.R., Rose, R.J. (Eds.), The Athletic Horse. Saunders, Philadelphia, USA, pp. 245–257.

Holcombe, S.J., Ducharme, N.G., 1999. Pharynx. In: Auer, J.A., Stick, J.A. (Eds.), Equine Surgery, second ed. Saunders, Philadelphia, USA, pp. 337–348.

Kannegieter, N.J., Dore, M.L., 1995. Endoscopy of the upper respiratory tract during treadmill exercise: a clinical study of 100 horses. The Australian Veterinary Journal 72, 101–107.

King, D.S., Tulleners, E.P., Martin, B.B., 1997. Transendoscopic Nd:YAG laser excision of the membranous portion of the aryepiglottic folds for the treatment of axial deviation of the aryepiglottic folds in racehorses: 15 cases (1993–1996). In: Proceedings of the American College of Veterinary Surgeons Symposium, pp. 11–12.

King, D.S., Tulleners, E., Martin, B.B., Parente, E.J., Boston, R., 2001. Clinical experiences with axial deviation of the aryepiglottic folds in 52 racehorses. Veterinary Surgery 30, 151–160.

Lane, J.G., 1993. Dorsal displacement of the soft palate, epiglottic entrapment and related conditions. In: Proceedings of the Bain-Fallon Memorial Lectures, Queensland, Australia, pp. 193–206.

Lumsden, J.M., Stick, J.A., Caron, J.J., Nickels, F.A., Brown, C.M., Godber, L.M., Derksen, F.J., 1995. Upper airway function in performance horses: videoendoscopy during high speed treadmill exercise. The Compendium of Continuing Education of the Practicing Veterinarian 17, 1134–1143.

Martin, B.B., Reef, V.B., Parente, E.J., Sage, A.D., 2000. Causes of poor performance of horses during training, racing or showing: 348 cases (1992–1996). The Journal of the American Veterinary Medical Association 216, 554–558.

Morris, E.A., Seeherman, H.J., 1990. Evaluation of upper respiratory tract function during strenuous exercise in racehorses. The Journal of the American Veterinary Association 197, 431–438.

Morris, E.A., Seeherman, H.J., 1991. Clinical evaluation of poor performance in the racehorse: the results of 275 evaluations. The Equine Veterinary Journal 23, 169–174.

Parente, E.J., 1998. Value of high-speed treadmill endoscopy. In: Proceedings of the Annual Convention of the American Association of Equine Practitioners, vol. 44, pp. 30–33.

Parente, E.J., Martin, B.B., Tulleners, E.P., Ross, M.W., 2002. Dorsal displacement of the soft palate in 92 horses during high-speed treadmill examination (1993–1998). Veterinary Surgery 31, 507–512.

Rakestraw, P.C., Hackett, R.P., Ducharme, N.G., Nielan, G.J., Erb, HN., 1991. Arytenoid cartilage movement in resting and exercising horses. Veterinary Surgery 20, 122–177.

Robertson, J.T., 1998. Dorsal displacement of the soft palate. In: White, N.A., Moore, J.N. (Eds.), Current Techniques in Equine Surgery and Lameness, second ed. Saunders, Philadelphia, USA, pp. 131–135.

Rosenstein, D.S., Stick, J.A., 1999. Diagnostic techniques in equine upper respiratory tract disease. In: Auer, J.A., Stick, J.A. (Eds.), Equine Surgery, second ed. Saunders, Philadelphia, USA, pp. 314–326.

Stick, J.A., Derksen, F.J., Nickels, F.A., Brown, C.M., Arden, W.A., Fulton, I.C., Peloso, J.G., 1992. Upper airway videoendoscopy during exercise in poorly performing horses. In: Proceedings of the Annual Convention of the American Association of Equine Practitioners, vol. 38, pp. 431–438.

Stick, J.A., Tulleners, E.P., Robertson, J.T., Holcombe, S.J., 1999. Larynx. In: Auer, J.A., Stick, J.A. (Eds.), Equine Surgery, second ed. Saunders, Philadelphia, USA, pp. 349–368.