

The effect of different grades of laryngeal function on arterial blood gases during exercise

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Summary

The effect of grade of idiopathic laryngeal hemiplegia (ILH) in 149 horses (Thoroughbred and Standardbred) was assessed using treadmill exercise tests. Horses with abnormalities other than ILH observed at rest were excluded from the study and laryngeal function was graded according to an established system, with grade 1 being normal and grade 5 indicating complete paralysis. Minimum PaO₂ ($p < 0.001$) was lower, and maximum PaCO₂ ($p < 0.001$) higher in horses with grade 4 and 5 laryngeal function than in other grades.

The results of this study indicate that endoscopic assessment at rest using a simple grading system can provide an indication of the effects on blood gases during exercise for some grades of laryngeal function. From the data we suggest that horses that have some movement of the left arytenoid cartilage but are unable to achieve full abduction (grade 4) tend to have similar blood gas responses during maximal exercise to those with complete paralysis (grade 5). However, some horses with grade 1–3 laryngeal function had blood gas results similar to those of horses with grade 4 and 5 laryngeal function indicating that discrepancies may occur between the resting assessment and laryngeal function during strenuous exercise in some cases.

Keywords: Hypoxemia, hypercapnia, exercise testing, endoscopy, rhinolaryngoscopy

Der Einfluß verschiedener Grade der Kehlkopffunktion auf arterielle Blutgase während Belastung

Mittels Belastungstests auf dem Laufband wurde der Effekt des Grades der idiopathischen laryngealen Hemiplegie (ILH) an 149 Pferden (Galopp- und Trabrennpferden) bestimmt. Pferde, die in Ruhe außer ILH weitere abnorme Befunde zeigten, wurden von der Studie ausgeschlossen. Die Kehlkopffunktion wurde mittels einer eigens entwickelten Gradskala beurteilt, wobei der erste Grad eine normale Funktion und Grad 5 eine komplette Lähmung darstellten. Bei Pferden mit Funktionsbeeinträchtigungen der Grade 4 und 5 waren der minimale arterielle Sauerstoff-Partialdruck (PaO₂) niedriger ($p < 0,001$) und der maximale arterielle Kohlendioxid-Partialdruck (PaCO₂) höher ($p < 0,001$) als bei Tieren mit Kehlkopffunktionen der Grade 1 bis 3.

Die Ergebnisse der Studie zeigen, daß eine endoskopische Beurteilung in Ruhe anhand einer einfachen Beurteilungsskala für einige Grade der Kehlkopffunktion Hinweise auf die Beeinflussung der Blutgase bei Belastung geben kann. Anhand der Daten können wir sagen, daß Pferde, deren linker Aryknorpel noch etwas beweglich ist, bei denen jedoch keine vollständige Abduktion mehr stattfindet (Grad 4), ein ähnliches Verhalten der Blutgase bei maximaler Belastung zeigen, wie Pferde mit einer vollständigen Lähmung (Grad 5). Auch einige Pferde mit Kehlkopffunktionen der Grade 1 bis 3 zeigten ähnliche Blutgas-Resultate wie die Pferde mit Kehlkopffunktionen der Grade 4 und 5. Dies deutet darauf hin, daß in einigen Fällen Diskrepanzen zwischen der Beurteilung in Ruhe und der Kehlkopffunktion bei anstrengender Belastung auftreten können.

Schlüsselwörter: Hypoxämie, Hyperkapnie, Belastungstest, Endoskopie, Rhinolaryngoskopie

Introduction

Up to 53% of large breed horses may have some degree of laryngeal asynchrony and asymmetry at rest (Haynes 1984). However, the effect of such changes, particularly when a degree of laryngeal movement is retained, is a matter of speculation (Hackett et al. 1991). It has been suggested that laryngeal asynchrony and paresis precede total paralysis (Duncan et al. 1977), whilst others have suggested that paretic abductor muscles may fatigue during exercise resulting in increased airway compromise (Marks et al. 1970). Asynchronous laryngeal abduction has been considered as a normal variation (Baker 1982; Haynes 1984) or as proof of some degree of recurrent laryngeal neuropathy (Johnson and Merriam 1975).

Despite the increased use of endoscopy in equine practice and advances in the evaluation of respiratory function in the horse, interpretation of the effects of alterations in laryngeal function, particularly in cases of subtle asynchrony or paresis, varies widely between practitioners. More recently, the use of treadmill endoscopy has revealed that the degree of dysfunction evident at rest may differ from that observed during exercise (Kannegieter and Dore,

1995), and this technique has been used to aid the determination of the significance of upper airway obstruction. However, treadmill endoscopy requires expensive and elaborate equipment that is not usually readily available to the practitioner. The objective of this study was to evaluate the relationship between a grading system for laryngeal function, as observed at rest, and measurements of arterial blood gases during treadmill exercise tests.

Materials and methods

The effect of grade of idiopathic laryngeal hemiplegia in 103 Thoroughbreds and 46 Standardbreds (total number, 149 horses) was assessed using treadmill exercise tests. All horses had either raced or commenced pre-race training. The age of the horses was 3.9 ± 1.2 (mean \pm sd). All horses were presented for performance evaluation. Some had a history of reduction in performance. A standard clinical examination, including careful cardiac and pulmonary auscultation, electrocardiogram, rhinolaryngoscopy and

bronchoalveolar lavage was performed on each horse. Horses with abnormalities other than ILH were excluded from the study. Upper airway endoscopy was performed via the right nare. During endoscopic examination the horse was restrained in stocks, with a nose twitch applied. Horses were not sedated during endoscopic examination. Observation of laryngeal movement was made at rest, following swallowing (induced injecting by small amounts of water through the endoscope into the pharynx) and whilst partially occluding the nares (Marks et al. 1970; Hackett et al. 1991). Laryngeal function at rest was graded and recorded as follows (from Lane 1993):

- Grade 1 normal synchronous movement and full abduction of left and right arytenoid cartilages (no abnormalities observed)
- Grade 2 asynchronous abduction of the left and right arytenoid cartilages, but all major movements were symmetrical and full abduction could be achieved
- Grade 3 asymmetry at rest, although full abduction could be achieved by the left arytenoid cartilage
- Grade 4 asymmetry at rest, unable to fully abduct left arytenoid cartilage, but some movement still present
- Grade 5 No movement of left arytenoid cartilage, left arytenoid resting on or near the midline (true hemiplegia).

All horses were acclimated to treadmill exercise. Acclimation usually involved three 10 to 15 minute sessions, although this was varied according to the individual horse. King et al. (1995) reported that three periods of exercise on the treadmill was generally sufficient for physiological and behavioural acclimation.

The exercise tests were performed on a 10 % slope. The horses were trotted at 4 m/s for three minutes, followed by 2 minutes at 6 m/s and 1 minute at 8, 10, 11 and 12 m/s, or until fatigue. Fatigue was assessed as occurring when the horses were no longer able to keep pace with the treadmill despite encouragement. Samples of arterial blood were obtained during the last 10 seconds of each speed increment. Central venous temperature was also recorded at this time and this temperature used for correction of the arterial blood gas values.

Arterial blood samples for blood gas determination were collected from a 20 GA, 32 mm catheter (Angiocath, Becton Dickinson, USA) inserted in the transverse facial artery (Rose and Hodgson, 1994) via a J loop connector (80 mm long, 0.5 ml capacity J loop connector, Becton Dickson, USA) and extension tubing (150 mm long, 2.5 ml capacity Minimum Volume Extension Tubing, Tuta Laboratories, Australia). Samples of arterial blood were collected, after drawing off and discarding 4 to 5 ml of blood, into 2 ml syringes in which the dead space had been filled with heparin (Heparin Injection BP, 1000IU/ml, CSL, Australia). All air was immediately expelled from the syringe before it was capped and placed on crushed ice. All blood gas measurements were made within one hour using a blood gas analysis machine (ABL 505, Radiometer, Copenhagen, Denmark). Quality control of the blood gas analyser involved the twice weekly use of four solutions with predetermined values of pH, PO₂ and PCO₂ over the ranges encountered during experimentation levels 1–4, (QualiCHECK 4, Radiometer, Copenhagen, Denmark).

The effect of laryngeal function score on arterial partial pressure of oxygen and carbon dioxide during the exercise test was assessed using one way analysis of variance with significance set at p<0.05.

Results

The horses used in this study were drawn from those presented for examination to the Sydney University Equine Performance Laboratory. Complete hemiplegia (grade 5) was noted in 5/149 (3.4%) of

cases (Thoroughbreds, 5/103 or 4.9%; Standardbreds 0/46), whilst 10/149 (6.7%) of cases (Thoroughbreds, 9/103 or 8.7%; Standardbreds 1/46 or 2.1%) were unable to achieve full abduction of the left arytenoid cartilage (grade 4). Some degree of alteration in laryngeal function (grade 2–5) occurred in 41/149 (27.5%) of horses.

Significant alterations in blood gases occurred in horses with grade 4 or greater laryngeal function. Minimum PaO₂ was lower (p<0.001) in horses with grade 4 and 5 laryngeal function than other grades (Fig. 1). However, there was overlap between the minimum PaO₂ values for different grades, with 31/108, 1/9 and 6/17 horses with grade 1, 2 and 3 laryngeal function, respectively, having minimum PaO₂ values within the 95% confidence interval for grade 4 horses. Maximum PaCO₂ was greater for horses with grade 4 (p<0.01) and grade 5 (p<0.001) laryngeal function than for horses with other grades.

Discussion

Some degree of laryngeal asynchrony or asymmetry may occur in up to 53% of Thoroughbreds (Baker, 1982). In the current study, 27.5% of horses had at least some degree of laryngeal asynchrony or asymmetry (Grade 2–5). This difference may have occurred because many horses with marked laryngeal dysfunction, as determined by referring veterinarians, may have been referred directly for surgery, rather than to the Performance Laboratory for further evaluation.

Left laryngeal dysfunction which resulted in an inability to fully abduct the left arytenoid cartilage (grade 4 and 5) resulted in a gra-

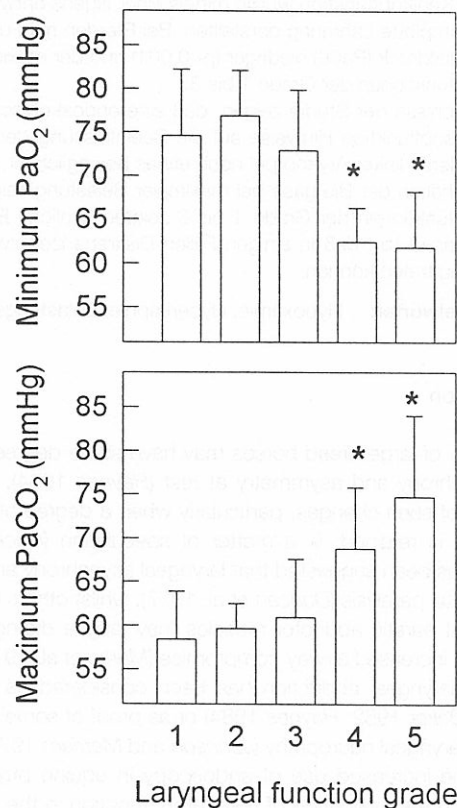


Fig. 1: Minimum PaO₂ and maximum PaCO₂ for different grades of laryngeal function achieved during a standardised exercise test to fatigue. (* indicates mean values for minimum PaO₂ and maximum PaCO₂ for grades 4 and 5 are significantly different to grades 1–3).

ter degree of hypoxemia and hypercapnoea during exercise than grades in which full abduction did occur. Bayly et al. (1984) and Tate et al. (1993) reported a greater degree of hypoxemia and hypercapnoea in horses with ILH compared to normal horses during track exercise. King et al. (1994) reported an increase in PaCO₂, but no significant difference in PaO₂ at 10 m/s in horses with ILH compared to normal horses during treadmill. The lack of significant decrease in PaO₂ associated with upper airway obstruction reported by King et al. (1994) may be because values achieved at 10 m/s were compared, rather than at maximal speeds. We have noticed in our laboratory that many horses with grade 4 and 5 laryngeal function may not show significant alterations in blood gas variables until exercising at or near maximum speed. In such cases laryngeal function may sufficiently abduct the left arytenoid at lower exercise intensities. However, increases in ventilation, causing the inspiratory upper airway pressure to become more subatmospheric, and fatigue of the hypotrophic cricoarytenoideus dorsalis muscle during exercise may contribute to airway narrowing (Marks et al. 1970), resulting in a vicious cycle of further collapse of the upper airway and flow limitation (Derksen et al. 1986).

Reports using treadmill endoscopy have documented substantial changes in laryngeal appearance in some horses during strenuous exercise when compared to rest (Kannegieter and Dore, 1995). Similar alterations in upper airway dynamics are suggested by the results of the current study, as there is overlap between the minimum PaO₂ values for different grades of laryngeal function. Therefore, whilst there is a trend towards decreasing minimum PaO₂ and increasing PaCO₂ during exercise in horses with greater degrees of laryngeal dysfunction it is not possible to accurately determine the likely effect in an individual horse.

Arterial hypoxemia has been reported during strenuous exercise in normal horses (Bayly et al, 1983; Thornton et al, 1983; Wagner et al, 1989) and minimum PaO₂ decreases in association with increases in VO₂max with training (Christley, unpublished data). Hence, some variation in minimum PaO₂ may have been associated with physiological mechanisms, particularly differences in VO₂max between horses. Because of these mechanisms, a horse with a normal airway and large VO₂max may have a similar degree of hypoxemia as one with a degree of ILH, but a lower VO₂max.

We suggest that horses which have some movement of the left arytenoid cartilage but are unable to achieve full abduction (grade 4) often have similar ventilatory effects and blood gas responses during maximal exercise to those with complete paralysis (grade 5). Horses with laryngeal asynchrony, but in which laryngeal movement is symmetrical and full abduction can occur (grade 2) tend to have similar changes in blood gases to those horses in which no abnormality was observed (grade 1). However, laryngeal function at rest must be interpreted with caution as horses with grades 1, 2 and particularly 3 laryngeal function may have blood gas results similar to those of horses with grade 4 and 5 laryngeal function, indicating that discrepancies may sometimes occur between the laryngeal function suggested by resting assessment and that which occurs during strenuous exercise. Therefore, treadmill endoscopy or investigation of changes in arterial blood gases during exercise may be needed to assess the significance of alteration in laryngeal function in any case in which the effects on performance are equivocal.

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