



ORIGINAL ARTICLE

Evaluation of postsale endoscopy as a predictor of future racing performance in an Australian thoroughbred yearling population

BJ Ahern,^{a*} A Sole,^a K de Klerk,^b LR Hogg,^c SA Vallance,^d FR Bertin^a and SH Franklin^e

Introduction Upper airway endoscopy of thoroughbred (TB) yearlings is commonly used in an attempt to predict laryngeal function (LF) and its impact on future race performance. The aim of this study was to determine if different grading systems and laryngeal grades were correlated with future performance.

Materials and Methods Postsale endoscopic recordings were obtained from an Australian TB yearling sale during a four-year period from 2008 to 2011. Horses were included if they had a diagnostic postsale video endoscopic recording and raced within Australia. Recordings were graded using the Havemeyer system and subsequently recategorised according to the Lane scale and two condensed scales. Performance data were sourced from Racing Australia and comparisons were made between groups.

Results A total of 1244 horses met the inclusion criteria. There were no significant differences in sex or sales price between groups. There were no significant differences in the number of starts or wins between groups for any grading system. For the condensed Havemeyer scale, horses with intermediate LF were separated into two groups. Significant differences in earnings were found between 'normal' and 'abnormal' ($P = 0.02$) and 'intermediate-low' and 'abnormal' grades ($P = 0.03$). There were no significant differences between horses with 'intermediate-high' and 'abnormal' grades ($P = 0.40$). No significant differences were found between the two intermediate grades ($P = 0.60$) or between horses with normal LF and either 'intermediate-low' or 'intermediate-high' grades ($P = 0.99$).

Discussion Resting LF in Australian yearling TBs assessed using a condensed Havemeyer grading scale had some predictive value for future racing performance. This information should be considered when performing yearling endoscopic examinations.

Keywords endoscopy; laryngeal; performance; racehorse; sales; upper airway

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*Corresponding author.

^aThe University of Queensland, School of Veterinary Science, Equine Specialist Hospital, Gatton, Queensland, 4343; b.ahern@uq.edu.au^bHawkesbury Equine Veterinary Centre, 226 Hawkesbury Valley Way, Clarendon, New South Wales, 2756, Australia^cKangaroo Island Veterinary Clinic, 252 Playford Highway, Kingscote, Kangaroo Island, South Australia, 5223, Australia^dAdvantage Equine, Ascot Vale, Victoria, 3032, Australia^eSchool of Animal and Veterinary Sciences, The University of Adelaide, Roseworthy Campus, Roseworthy, South Australia, 5371, Australia

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Upper airway abnormalities such as laryngeal and palatal dysfunction are common causes of poor performance in racehorses.^{1–6} These conditions result in dynamic airway obstruction, causing obstruction to airflow and reduced oxygen supply to the exercising muscles, ultimately leading to reduced athletic performance.^{7–12} The identification of potential upper airway abnormalities that may affect future performance is an important consideration for prospective purchasers of racehorses.

Any prediction of future athletic performance based on a single factor is challenging. At thoroughbred yearling sales when it is solely based on a single endoscopic examination, it can be difficult to determine conclusively. For an examination to be potentially useful there are many variables that need to be considered and standardised where possible to allow for a fair assessment. There are many potential sources of variation in an endoscopic examination and these need to be taken into account when trying to determine the future likelihood of athletic performance of an individual yearling.

Endoscopy of the upper respiratory tract (URT) in the horse at rest has been used as a means of predicting exercising upper airway function and future athletic performance for many years.^{13–20} Postsale endoscopic examinations of yearlings are commonly employed around the world in order to identify the presence or otherwise of a defined limited number of laryngopharyngeal disorders. The presence of these listed conditions constitutes a failed examination and affords the purchaser the opportunity to rescind the sale. Nevertheless, it is recognised that some horses that meet the conditions of sale may have URT findings of potential concern. As such, presale endoscopy has become commonplace to detect upper airway findings considered potentially negatively impacting future performance that is not captured in the conditions of sale constituting a fail.

A variety of grading systems have been described for the assessment of resting laryngeal function (LF). In Australia and the UK, the Lane system²¹ is currently used exclusively during postsale endoscopic examinations to classify arytenoid cartilage function. The Lane system utilises five grades and, at Australian sales, a laryngeal score of grade 3 or below qualifies as a pass, whereas a grade 4 or 5 is categorised as a fail. Elsewhere (in the USA and South Africa), Rakestraw's 4-point scale has been used,²² with grades 1 and 2 (able to obtain and maintain full abduction) considered normal and with grades 3 (unable to obtain and maintain full abduction) and 4 as

abnormal. A consensus statement of the 2003 International Havemeyer workshop on equine recurrent laryngeal neuropathy proposed that an alternative grading scale be adopted²³ and was used in our study. The Havemeyer grading system is a four-point grading scale with sub-grades for grades II and III. This system further classifies horses with arytenoid cartilage asymmetry and variable ability to maintain complete abduction, identified as grade 3 in the Lane system, into two groups: grade II.2 and grade III.1, and may be a more sensitive means of identifying laryngeal dysfunction and accurately predicting future racing performance as a result.

The aim of this study was to evaluate four consecutive years of post-sale endoscopic URT examinations performed at a single Australian yearling thoroughbred (TB) sale and determine if either the Lane, Havemeyer or one of two condensed grading systems were able to predict future racing performance.

It was hypothesised that: (1) laryngeal grading of yearlings would be predictive of future racing performance in an Australian TB racing population and (2) the Havemeyer or a condensed grading system would be most useful to distinguish between horses with variable arytenoid cartilage asymmetry and maintenance of abduction at rest and be better correlated with future race performance, hence improving predictability in relation to purchase recommendations.

Materials and methods

Inclusion criteria

Horses were included if they were sold at the Melbourne Premier Yearling Sale during the four-year period from 2008 to 2011, had a diagnostic post-sale video endoscopic recording in the opinion of the experienced reviewers, and had raced within Australia.

Table 1. Grading scales for assessment of laryngeal function

Havemeyer grade	Condensed Havemeyer grading scale	Lane grade	Condensed Lane grading scale
I	Normal	1	Normal
II.1		2	
II.2	Intermediate (low)	3	Intermediate
III.1	Intermediate (high)		
III.2	Abnormal	4	Abnormal
III.3			
IV		5	

Table 2. Grading systems in relation to earnings, starts and number of wins

Type	Grading	N	%	Earning (AUD)		Starts		Wins	
				Median	Range	Median	Range	Median	Range
Lane	I	386	33.3	17,459	0–591,642	16	0–86	1	0–11
	II	420	30.1	19,600	0–1,334,850	14	0–72	1	0–11
	III	419	35.1	20,823	0–706,250	15	0–76	1	0–10
	IV	19	13.3	1000	0–102,940	7	0–39	0	0–6
	V	1	0.08	1550	-	3	-	0	-
Condensed Lane	Normal	806	64.8	20,100	0–7,953,936	17	0–174	1	0–11
	Intermed	420	33.8	21,500	0–756,475	17	0–112	1	0–11
	Abnormal	18	1.4	1000	0–102,940	12	0–39	1	0–10
Havemeyer	I	386	33.3	17,458	0–591,642	16	0–86	1	0–11
	II.1	420	30.1	19,600	0–1,334,850	14	0–72	1	0–11
	II.2	324	27.3	21,620	0–706,250	15	0–76	1	0–10
	III.1	95	7.8	15,765	0–237,770	10.5	0–61	1	0–10
	III.2	16	0.9	5939	0–102,940	10	0–36	0	0–2
	III.3	3	0.4	500	0–35,085	4	0–39	0	0–5
	IV	1	0.08	1550	-	3	-	0	-
Condensed Havemeyer	Normal	806	64.8	20,100	0–7,953,936	17	0–174	1	0–11
	Intermed lo	324	26.1	23,611	0–756,475	17	0–76	1	0–11
	Intermed hi	96	7.7	13,380	0–298,615	12	0–112	1	0–10
	Abnormal	18	1.4	1000	0–102,940	12	0–39	0	0–6

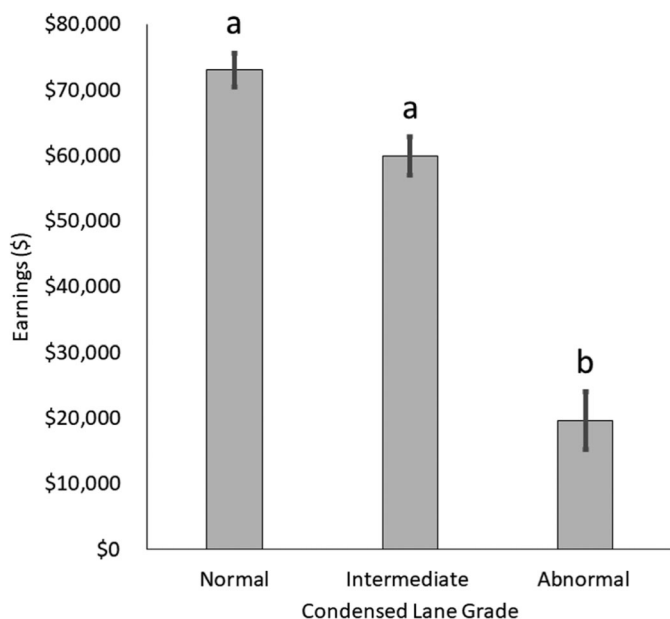


Figure 1. Mean \pm SD earnings for horses using the condensed Lane scale. Normal versus intermediate ($P = 0.99$), Normal versus abnormal ($P = 0.04$), intermediate versus abnormal ($P = 0.03$). Different letters denote statistically significant differences.

Sales and racing records

Sales data were retrieved from the sales company records, including lot number, sex and purchase price. Racing performance data were sourced from Racing Australia (<http://www.racingaustralia.horse/home.aspx>). Key performance variables included number of starts, number of wins and total earnings.

Video recording and endoscopic examinations

When requested by the purchaser, yearlings were presented for endoscopic evaluation by the sale company-approved veterinarian within 24 hours of purchase. A nose twitch was applied prior to passing the endoscope through the ventral meatus and a recording of the URT was obtained. At least one swallow resulting in maximal arytenoid abduction was required to be evident in the video recording to be considered diagnostic.

Laryngeal grading systems

All video recordings were independently graded by three veterinarians experienced in assessing URT function, using the Havemeyer system (Table A1). Agreement between two or three of the three assessors' grades was taken as the definitive grade.

Subsequently, data were recategorised according to the Lane scale (Table A2) and two condensed grading scales (based on the Havemeyer and Lane scales, respectively), which were developed in an effort to reflect clinically relevant groups (Table 1).

Statistical analysis

Horses were grouped by laryngeal grade for each of the grading systems. The Lane grade 5 and Havemeyer grade IV groups were excluded from statistical analysis due to extremely small population size ($n = 1$). Normality was assessed by a Shapiro-Wilk test. Data

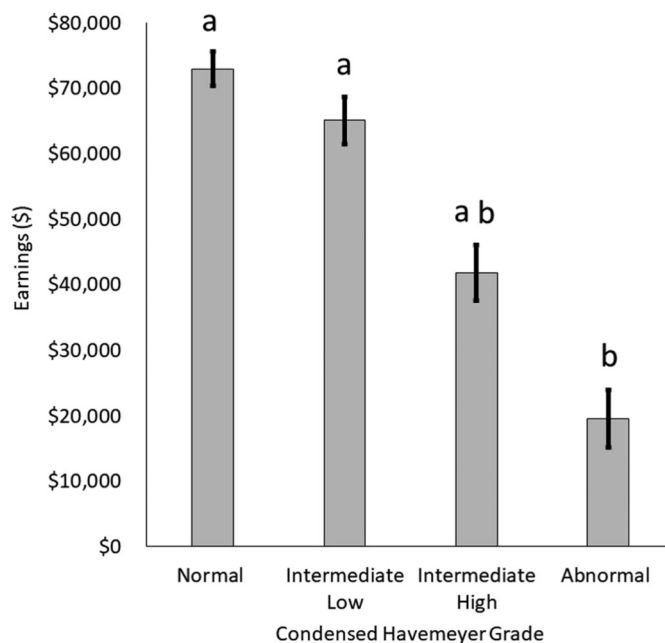


Figure 2. Mean \pm SD earnings for horses using the condensed Havemeyer scale. Normal versus intermediate-low ($P = 0.99$), Normal versus intermediate-high ($P = 0.99$), Normal versus abnormal ($P = 0.02$), intermediate-low versus intermediate-high ($P = 0.60$), intermediate-low versus abnormal ($P = 0.03$), intermediate-high versus abnormal ($P = 0.40$). Different letters denote statistically significant differences.

following a normal distribution was reported as mean \pm SD, whereas data not following a normal distribution was reported as median \pm range. Categorical data were reported as counts of horses and compared using either a chi-square test or a Fisher's exact test depending on expected counts. Statistically significant outliers detected by a robust regression and outlier removal (ROUT) method with $Q = 1\%$ were excluded from all analyses. Performance parameters were compared between groups using analysis of variance (ANOVA) with Dunn's multiple comparison post hoc test for normally distributed data and a Kruskal-Wallis test for nonnormally distributed data. Statistical analysis was performed using commercially available statistical software (GraphPad Prism v7.0 for Windows, GraphPad Software, La Jolla, CA 92108, USA) and statistical significance was set at $P < 0.05$.

Results

Study population

A total of 3047 horses were presented for endoscopic examination at the sales over the four-year period, of which a total of 1244 horses (690 males (55.5%) and 554 females (44.5%)) met the inclusion criteria. The number of horses in each grade according to the Havemeyer, Lane and condensed grading systems is summarised in Table 2. The median and range of sale prices across all horses were \$62,654 (\$3000–\$490,000). The median and range of earnings in each group are reported in Table 2. There were no significant differences in sex or sales price between laryngeal grade groups.

Laryngeal grade and race performance

There were no significant differences in the number of starts or number of wins between groups for any of the grading systems used (Table 2). However, there were differences in earnings evident using some grading systems. There was a trend for horses with both higher Lane and Havemeyer grades to earn less money during their racing career ($P = 0.08$ and $P = 0.09$, respectively), however, this did not reach statistical significance. When the condensed grading scales were used, horses with 'abnormal' grades had decreased career earnings compared to 'normal' and 'intermediate' grades ($P = 0.04$ and $P = 0.03$, respectively) for the condensed Lane scale. There was, however, no difference between 'normal' and 'intermediate' grades ($P = 0.99$) (Figure 1). For the condensed Havemeyer scale horses with intermediate LF were separated into 'intermediate-low' and 'intermediate-high' (Figure 2). Significant differences in earnings were found between 'normal' and 'abnormal' ($P = 0.02$) and 'intermediate-low' and 'abnormal' grades ($P = 0.03$) while there were no significant differences between horses with 'intermediate-high' and 'abnormal' grades ($P = 0.40$). However, no significant differences were found between the low and high 'intermediate' grades ($P = 0.60$) or between horses with normal LF and either 'intermediate-low' or 'intermediate-high' grades ($P = 0.99$).

Discussion

In this study, we reviewed postsale URT endoscopic recordings from a large population of TB yearlings. Four different grading scales were used to determine if there was any association with subsequent career performance. Higher Lane and Havemeyer grades were associated with a trend for reduced career earnings; however, this was not statistically significant. It is possible that with more horses included in the study, the trend may have reached significance; however, this requires further investigation. By condensing these two grading systems into groups that might more closely reflect the clinical situation, we were able to separate horses with respect to their future career earnings. Using the condensed Lane grading scale, horses with abnormal LF had significantly lower earnings than those with normal or intermediate LF. The condensed Havemeyer grading scale may be more useful for distinguishing between horses with intermediate LF/asymmetrical arytenoid abduction. However, larger numbers of horses are needed to confirm this. In addition, of note is that many decisions are currently made on presale endoscopy grading, which was not the focus of this study and the comparison of pre and postsale endoscopy grading has not been performed currently.

Prediction of LF and future performance of racehorses presented at yearling sales, based on resting endoscopic examinations, is commonplace throughout the world. Similar to the findings of this study, it has previously been shown that horses with obviously abnormal LF, that are unable to achieve full abduction of the arytenoid cartilage(s) at rest, have reduced athletic potential and future earnings compared with those with normal LF.^{15, 17} However, the effect of variable resting LF is more challenging to determine. Studies comparing resting versus exercising endoscopic examinations have confirmed that there are significant associations between the two assessments.^{16, 18, 22, 24}

A strength of the Havemeyer system is that it divides the scores into a seven-grade system, rather than four grades or five used previously. In particular, it attempts to separate out horses with asynchronous or asymmetric arytenoid movements and may be more useful to predict, which horses are more likely to develop dynamic laryngeal collapse during exercise. Barakzai and Dixon¹⁹ found a significant correlation between subgrades of III.1, III.2 and III.3 and the grade of LF during exercise. Others have used concurrent ultrasound examination of the laryngeal region to enhance the diagnostic capabilities of a resting endoscopic examination and better predict clinically relevant laryngeal dysfunction.^{25, 26}

Our findings support and build on those of the study by Garrett *et al.* that assessed 2954 TB yearlings in North America to investigate associations between their URT function at a presale inspection endoscopic examination and their future racing performance at 2–4 years of age.¹⁸ A modified Havemeyer scale was also used in that study to compare horses with grade I, II.1, II.2 and III LF. Subcategories of grade III were not included due to the low numbers of horses in those categories. Horses with grade III LF had fewer starts, decreased mean earnings and lower earnings per race at age 3 and 4, when compared with those of grades I, II.1. and II.2. Horses with a grade II.2 LF also had significantly less earnings at 4 years of age than horses with those with grades <II.2 although results were not significantly different at 2 and 3 years of age suggesting that some of those horses may experience deterioration of their LF over time. Our study found that there was no difference in total earnings between horses with normal LF and those with grade II.2 (which we classified as intermediate-low). However, we did not investigate differences between age groups.

In this study population, 20 horses were sold despite having a Lane grade of 4 or 5 classified as a failure at the sale. This may either reflect errors in grading and an erroneous pass being recorded on the postsale URT endoscopy and the sale having progressed. Or it may reflect that the purchasers still completed the sale despite a failing grade for another reason, such as breeding potential, regardless of the failing laryngeal grade. Failing laryngeal grades were associated with a reduction in the career earning of the yearlings in this study and this underlines the importance of accurate and diagnostic postsale URT examinations.

There are two main assumptions inherent in this study that are limitations. It is assumed that surgical correction was not undertaken on horses postsale, and that all horses were of the same racing potential in all other aspects aside from the LF. While the significance of the latter point can be minimised by the large sampling size, the former is an important consideration when evaluating career performance. It is reasonable to assume that some horses included in this study would have undergone surgical treatment for laryngeal hemiplegia, which may have impacted their subsequent performance and earnings. As such assuming that the surgical treatment was effective then the detrimental effect of the laryngeal dysfunction present as a yearling may be underappreciated in this study as a result.

A further limitation of this study is the fact that each endoscopic examination represents only a single point in time and there can be variation in appearance between different examinations on the same horse.²⁷ In addition, there can be inter and intraobserver variation. An effort was made to address study observer variation by having three

reviewers and requiring agreement of at least two observers. Another limitation of a retrospective-based study on yearlings presented to sales is that yearlings with higher grades (poorer) LF are selected out by vendors and are not presented. This has considerable effect on the ability to detect differences between groups when the numbers of horses in higher LF categories are markedly lower compared with other lower LF groups. As a result, the statistical power to detect a possible effect of higher LF grades on future performance is reduced. This is seen when power calculations are performed with an alpha error of 0.05 and a power of 0.8 for all grading systems. Depending on the grading system used, the number required to detect a statistically significant difference ranges from 62 to 26,485 horses required per group. Clearly, this is outside the scope of this study and as such, the results we present need to be interpreted with appropriate caution.

Interobserver variability was not assessed in this study. A previous study found inter and intraobserver reliability to be high when examinations were performed by experienced clinicians.²⁸ However, others found only moderate agreement.^{29, 30} This study also did not investigate the impact of other URT abnormalities. Other studies have reported conflicting results when attempting to investigate potential associations with pharyngeal disorders and future racing performance. Garrett *et al.* (2010) found horses with a flaccid or shortened epiglottis had decreased earnings.¹⁷ These horses may be more likely to experience dorsal displacement of the soft palate during exercise (DDSP), which would negatively affect their performance. Kelly *et al.* compared resting and exercising upper airway function in yearlings and found that the occurrence of intermittent DDSP at exercise was significantly associated with epiglottic structure > grade 2 and a recent history of respiratory tract infection.²⁰ However, a previous study did not find epiglottal or palatine abnormalities to be predictive of inferior racing performance although that study investigated a much smaller number of horses.¹⁵

Conclusion

Based on the results of this study, resting LF was useful as a predictor of future racing performance in yearling TB racehorses in an Australian population. Currently, in Australia, the commonly used Lane system does not separate horses with grade 3 (intermediate) LF in order to differentiate, which of those horses may have a high or low risk of reduced future performance. Potentially, the use of a condensed Havemeyer grading scale for yearling sales in Australia would be most reflective of potential future career earnings and boost buyer confidence as a result. However, a study with larger numbers of horses is needed to confirm this.

Conflict of interest and sources of funding

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Appendix

Table A1. Lane grading system²²

Grade	Description
I	All movements, both adductory and abductory are synchronised and symmetrical regardless of whether sedated or examined before or after exercise. A 'mirror' effect is achieved through a perspective artefact whereby the right arytenoid appears less abducted when the endoscopy is performed through the right nostril and the left is simply less abducted when the larynx is viewed via the left nasal chamber.
II	All major movements are symmetrical and a full range is achieved. Transient asynchrony, flutter or delayed opening may be seen.
III	Asymmetry of the <i>rima glottidis</i> at rest due to reduced motility by the left arytenoid cartilage and vocal fold. On occasions, typically after swallowing or during the nostril occlusion, full symmetrical abduction is achieved.
IV	There is consistent asymmetry of the <i>rima glottidis</i> but with some residual active motility by the left arytenoid cartilage and vocal fold. Full abduction is not achieved at any stage.
V	True hemiplegia. There is obvious and consistent asymmetry of the <i>rima glottidis</i> with no residual active motility by the left arytenoid cartilage and vocal fold. No response to the slap test is evoked.

Table A2. Havemeyer grading system²⁴

Grade	Description	Sub-grade
I	All arytenoid cartilage movements are synchronous and asymmetrical. Full arytenoid cartilage abduction can be achieved and maintained	
II	Arytenoid cartilage movements are asynchronous and/or larynx is asymmetrical at times, but full arytenoid cartilage abduction can be achieved and maintained	<ol style="list-style-type: none"> 1. Transient asynchrony, flutter or delayed movements seen. 2. There is asymmetry of the <i>rima glottidis</i> most of the time due to reduced mobility of the affected arytenoid and vocal fold, but there are occasions, typically after swallowing or nasal occlusion, when full symmetrical abduction is achieved and maintained.
III	Arytenoid cartilage movements are asynchronous and/or asymmetrical. Full arytenoid cartilage abduction cannot be achieved and maintained	<ol style="list-style-type: none"> 1. There is asymmetry of the <i>rima glottidis</i> much of the time due to reduced mobility of the arytenoid and vocal fold, but there are occasions, typically after swallowing or nasal occlusion, when full symmetrical abduction is achieved, but not maintained. 2. Obvious arytenoid abductor deficit and arytenoid asymmetry. Full abduction is never achieved. 3. Marked but not total arytenoid abductor deficit and arytenoid asymmetry with little arytenoid movement. Full abduction is never achieved.
IV	Complete immobility of the arytenoid cartilage and vocal fold	

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