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Tracheobronchoscopic Assessment of Exercise-Induced Pulmonary Hemorrhage and Airway Inflammation in Barrel Racing Horses

R. Léguillette, M. Steinmann, S.L. Bond, and B. Stanton

Background: Poor performance is often suspected to be associated with EIPH in barrel racing horses; however, there are no published reports of EIPH for this discipline. The prevalence of EIPH in barrel racing horses is also unknown.

Objectives: This study was performed to determine the prevalence of EIPH and signs of airway inflammation in barrel racing horses under normal racing conditions in Alberta.

Animals: About 170 barrel racing horses.

Methods: Observational cross-sectional study. Tracheobronchoscopic examinations were performed at least 30 minutes postrace. Video recordings were scored off-site independently by two observers for EIPH and tracheal mucus accumulation (TMA). Horses with an EIPH score ≥2 were not assessed for TMA. Interobserver agreement was calculated by weighted κ statistics. Run times, environmental variables, and clinical information were also recorded for analysis.

Results: 77/170 (45.3%) of horses examined showed evidence of EIPH (grade ≥ 1). Interobserver agreement was 0.94. 140/141 (99.3%) of horses assessed for TMA showed evidence of tracheal mucus accumulation (grade ≥ 1) with 104/141 (73.8%) having a TMA score ≥ 2. Interobserver agreement was 0.73. A weak positive association was found between EIPH scores and average run speed, the presence of cough at rest reported by the riders, increased recovery time, exercise intolerance, and outdoor pattern.

Conclusions and clinical importance: The high prevalence of EIPH observed in the sampled population indicates that barrel racing induces substantial stress on the lungs. The presence of EIPH did not impact negatively on performance. Factors such as environmental dust and frequent traveling might have contributed to the high prevalence of TMA observed.

Key words: Endoscopy; Tracheal blood; Tracheal mucus; Western performance.

Exercise-induced pulmonary hemorrhage (EIPH) is the presence of blood in the airways after exercise in horses. It is most commonly detected by tracheobronchoscopic assessment, by the presence of red blood cells in bronchoalveolar lavage (BAL) fluid[1] or both modalities. It has a high prevalence in sampled populations of both Thoroughbred and Standardbred racehorses,[2–5] and has a negative impact on racing performance in Thoroughbreds.[5,6] Poor performance is often suspected to be associated with EIPH in barrel racing horses; however, there are no published reports of EIPH for this discipline. Barrel racing is a highly demanding timed event where a rider guides the horse around 3 barrels in a cloverleaf pattern.[7] Arena and pattern sizes might vary but horses typically run very consistent times on patterns of the same length, so changes in performance are quickly noticed by riders. Decreased performance in barrel racing horses is the presenting complaint to equine practitioners in up to 40% of cases.[8]

Abbreviations:

OR	odds ratio
CI	confidence interval
EIPH	exercise-induced pulmonary hemorrhage
BAL	bronchoalveolar lavage
TMA	tracheal mucus accumulation

Risk factors that have been associated with an increased incidence of EIPH in racehorses are low ambient temperatures (1.9 × more likely to have EIPH grade ≥1 at <20°C)[4] and bar shoes.[9] It has been reported that EIPH is associated with experimentally induced airway inflammation with acetic acid[10], but no association was found in field studies between EIPH and cytological or endoscopic evidence of airway inflammation.[11,12] Prophylactic treatment with furosemide is currently the only proven method of decreasing EIPH severity and frequency in Thoroughbred racehorses; the use of nasal strips might help to decrease severity of clinical signs.[13–16]

Tracheal mucus accumulation (TMA) has been significantly correlated with BAL indicators of pulmonary inflammation[17,18] and has also been associated with poor performance when high grades (≥2) are present in Thoroughbred racehorses.[19]

This paper reports the prevalence of EIPH and TMA as an indicator of airway inflammation in a sample population of barrel racing horses under normal racing conditions in Alberta.

From the Faculty of Veterinary Medicine, Department of Veterinary Clinical and Diagnostic Services, University of Calgary, Calgary, AB T2N 4N1, Canada (Léguillette, Steinmann, Bond, Stanton); Moore Equine Veterinary Centre, 260048A Writing Creek Cres, Rocky View County, AB T4A 0M9, Canada(Léguillette, Stanton).

The data were not presented to any conference.

The work was performed at barrel racing events across southern Alberta, Canada.

Corresponding author: R. Léguillette, Faculty of Veterinary Medicine, Department of Veterinary Clinical and Diagnostic Services, University of Calgary, Calgary, T2N 4N1 AB, Canada; e-mail: rleguill@ucalgary.ca

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Materials and Methods

In this descriptive field study, observers traveled to 12 barrel racing jackpots and performed tracheobronchoscopic examinations on a convenience sample of 170 horses after racing. TMA and evidence of EIPH were scored using previously validated grading scales.[17,18,20]

Horses (n = 170)

Recruitment methods for this study utilized social media, event organizers, and clients of local veterinarians. Inclusion criteria involved completion of at least one run on the day of assessment; horses were excluded from participating in the study more than once. No other exclusion criteria were applied in order to enroll as many participants as possible. Horses were allowed to compete on their typical medical regime, which in some cases included the use of furosemide and nasal strips. Risks and benefits of participation were explained to all owners and consent forms signed before the endoscopy being performed. The study was approved by the University of Calgary Veterinary Sciences Animal Care Committee.

Endoscopic Procedure and Scoring

Using a similar method described in previous large-scale studies,[4,5,20] tracheobronchoscopic examinations were performed with the use of a 1.4-m-long, high-definition video-endoscope.[a] Examinations were performed within 2 hours of racing and no earlier than 30 minutes after racing.[21] Two observers blinded to race results independently reviewed video recordings. One observer was previously untrained in the evaluation of airway endoscopy (MS); the other was an experienced observer (RL; Dip. ACVIM, Dip. ACVSMR (Equine)). Scores were assigned to each video for the presence of blood (Fig 1)[20] and the presence of tracheal mucus as an indicator of lower airway inflammation. The scoring assigned assessing tracheal mucus was modified from previously validated grading scales.[17,18] TMA was scored from 0 to 5, with no partial scores being used (Fig 2).

Descriptive Data Collected

Data collected at each event were used to evaluate variables within four variables: environmental information,[b] race information, event outcomes, and individual medical history. Data requested from participants were based on a risk screening questionnaire developed to investigate recurrent airway obstruction.[22]

Statistical Analysis

Weighted kappa statistics were calculated to assess interobserver agreement on all EIPH and TMA scores. Where observers

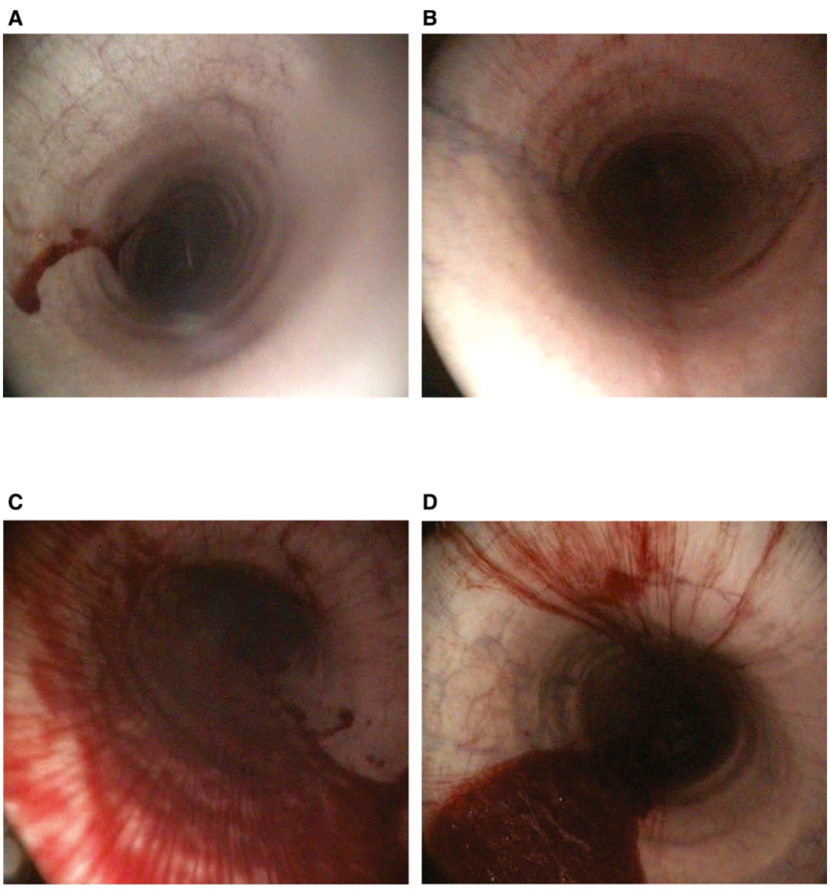

Fig 1. Grading scales for exercise-induced pulmonary hemorrhage (EIPH). A: Grade 1, B: Grade 2, C: Grade 3, D: Grade 4, according to Hinchcliff et al.[20]: Grade 1 = 1 or more flecks of blood or 2 or fewer short, narrow streams of blood in the trachea or mainstem bronchi visible from the tracheal bifurcation; Grade 2 = 1 long stream of blood or more than 2 short streams of blood occupying less than a third of the tracheal circumference; Grade 3 = multiple, distinct streams of blood covering more than a third of the tracheal circumference, with no blood pooling at the thoracic inlet; Grade 4 = multiple, coalescing streams of blood covering more than 90% of the tracheal surface, with blood pooling at the thoracic inlet.

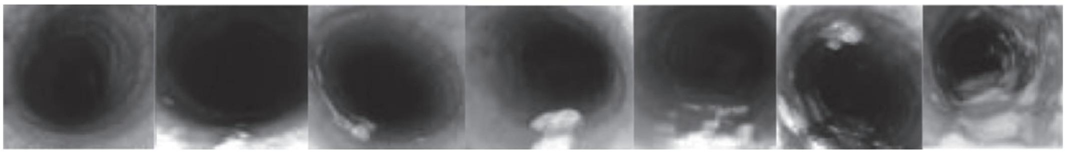

Fig 2. Grading scale for tracheal mucus accumulation (TMA). Modified from Gerber et al.[18]: TMA was scored from 0 to 5, with no partial scores being used.

disagreed, scores from the more senior observer were used for correlation statistics to avoid using half scores. The average speed over the pattern (total distance of pattern divided by running time) was calculated. Analyses of correlations were performed by a Spearman rank test between all the descriptive variables collected (environmental variables, individual history variables, and average speed) and the scores of both EIPH and TMA. A parametric 2-sample t-test was performed to compare the descriptive data (individual history variables and average speed) for the horses with an EIPH score of 4, to those with an EIPH score of 0, 1, 2, or 3, and to compare the TMA score between indoor and outdoor runs. Mean values ± SD were given for all results; a P-value of <.05 was considered statistically significant for all results.

Results

Of the 170 horses examined, 78 were geldings and 91 were mares (1 sex not recorded). 151 of the horses were Quarter Horses, 7 Appendix, 6 American Paint Horses, 3 Quarter Horse crosses, 1 Thoroughbred, and 2 were of unknown breeding. The age of the horses was 9.8 ± 3.9 years (Range 3–23 years).

At least 1 run was completed the previous day to assessment by 87 horses examined, and 9 horses had completed 2 runs before assessment on the day examined. All other horses only completed 1 run on the day of assessment before being examined. No difference in EIPH score (P = .61) was found between the horses having completed several runs on the day before or on the day of the assessment and those that only ran once on the day of the assessment.

Of the 12 jackpots attended, 1 event utilized a short distance pattern (230 feet), 3 events utilized a medium distance pattern (260 feet and 287 feet), and 8 events utilized a long distance pattern (330 feet, 335 feet, and 360 feet). The events were held in an indoor arena on 6 occasions; 6 jackpots were held outdoors. Ninety horses ran indoor and 80 horses ran on outdoor patterns. Five horses were examined at the first event; 9 horses at the second event; 4 horses at the third event; 31 horses at the fourth event; 10 horses at the fifth event; 41 horses at the sixth event; 15 horses at the seventh event; 15 horses at the eighth event; 5 horses at the ninth event; 11 horses at the tenth event; 14 horses at the eleventh event; and 12 horses at the twelfth event.

Horses with an EIPH grade ≥2 were not scored for mucus, as the blood could have obscured the amount of mucus present and scoring EIPH was the main focus of this study.

The prevalence of EIPH was 77/170 sampled horses (45.3%) (Fig 3). EIPH grade 1 was detected by the less experienced observer in 1 horse that the more experienced observer scored as EIPH grade 0; it was not included in the prevalence calculation. Weighted kappa statistics for interobserver agreement of EIPH scores were 0.94. Epistaxis on the day of assessment was reported in 5 horses.

Varying doses (between 125 and 250 mg) of furosemide had been administered to 10 of the 170 horses between 2 and 3 hours before their run; of these, 8 had EIPH.

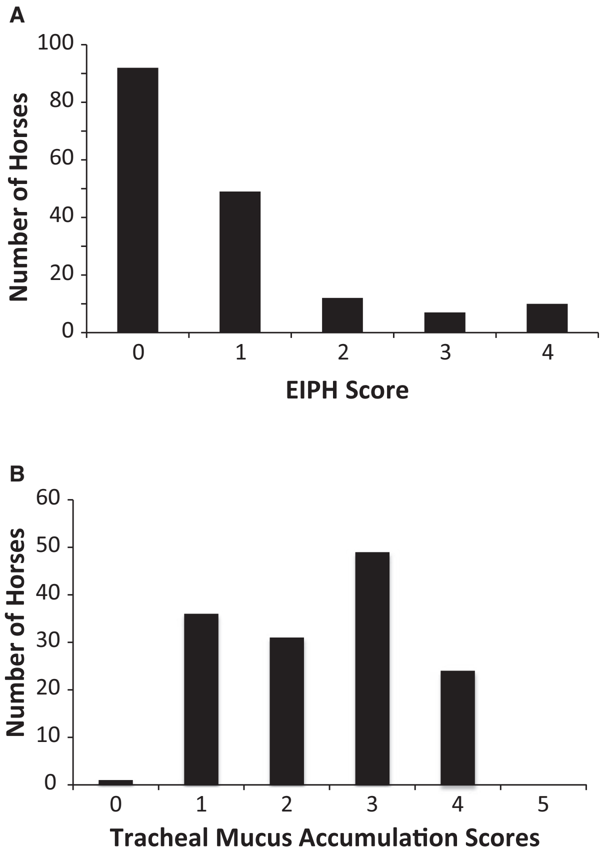

Fig 3. Histograms showing the distribution of exercise-induced pulmonary hemorrhage (EIPH) scores (**A**) and tracheal mucus accumulation (TMA) scores (**B**) of 170 tracheobronchoscopically assessed horses.

Analysis of the 10 horses with a grade 4 EIPH score showed they were overall significantly faster than those with a score of 0, 1, 2, or 3; these horses competed in races over short (1 horse), medium (1 horse), and long (8 horses) course lengths ($P = .04$; mean speed of horses with a grade 4 EIPH score= 19.15 ± 1.23 ft/s versus 17.99 ± 2.05 ft/s for horses with EIPH score <4). However, comparing horses that competed only on a long pattern showed no significant difference in speed between the 8 horses with a grade 4 EIPH score and those with a score of 0, 1, 2, or 3 (mean speed of horses with a grade 4 EIPH score on long pattern only= 19.09 ± 1.42 ft/s versus 18.68 ± 1.39 ft/s for horses with EIPH score <4).

Linear correlation was studied between EIPH and each environmental variables (humidity, temperature, barometric pressure), run conditions or performance (indoor/outdoor, pattern length, average run speed), and information on the respiratory condition (the presence of cough at rest, during exercise, intolerance to exercise, increased recovery time) collected (Table 1). We found that EIPH score was weakly associated with average run speed ($r = 0.22$, $P = .008$, n = 140), the presence of cough at rest before exercise reported by the riders ($r = 0.20$, $P = .008$, n = 169), increased recovery time and exercise intolerance ($r = 0.20$, $P = .01$, n = 169 for each), and outdoor pattern ($r = 0.15$, $P = .05$, n = 169).

Only one horse had no tracheal mucus (TMA prevalence was 99.3%), based on the observations of the more experienced observer (Fig 3). There was no disagreement between observers for TMA grade 0 and 1. The prevalence of TMA (grade ≥2) was 104/141 (73.8%). Weighted kappa statistics for interobserver agreement for TMA scores were 0.73.

Coughing was reported in 88/169 horses (52%) (individual history data were missing for 1 horse).

Of all tested variables (Table 1) for a linear correlation with TMA, the TMA score was only weakly associated with the presence of cough during work reported by the riders ($r = 0.19$, $P = .02$, n = 141).

We found a moderate correlation between the presence of cough at rest and the presence of cough during exercise ($r = 0.34$, $P < .001$, n = 170), exercise intolerance ($r = 0.33$, $P < .001$, n = 170), increased recovery time ($r = 0.23$, $P = .003$, n = 170), the pattern length ($r = 0.23$, $P = .003$, n = 170), and the average run speed ($r = 0.25$, $P = .002$, n = 141). We found a moderate correlation between the presence of cough during exercise and exercise intolerance ($r = 0.31$, $P < .001$, n = 170). A history of exercise intolerance reported by the owners was also moderately correlated with increased recovery time, pattern length, and average run speed ($r = 0.26$, $P < .001$, n = 170; $r = 0.28$, $P < .001$, n = 170, and $r = 0.21$, $P = .01$, n = 141, respectively).

As expected, speed, pattern length, and indoor versus outdoor variables on one hand and environmental variables on the other hand (temperature humidity, barometric pressure) (Table 1) were moderately to strongly correlated (specific correlation data not shown).

Table 1. Descriptive data and clinical information collected (individual history data missing for 1 horse) and shown by endoscopic score for exercise-induced pulmonary hemorrhage (EIPH) and for tracheal mucus accumulation (TMA).

	Variables	High	Low	Mean
Environmental Information	Ambient temperature (°C)	26	2	13
	Barometric pressure (hPa)	1032	910	1011
	Humidity (%)	95	14	54

	Clinical Questions	Yes	No
Individual History	Labored breathing at rest?	20	149
	EIPH history	44	125
	Cough at rest?	43	126
	Cough at work?	77	92
	Exercise intolerance?	51	118
	Increased recovery time?	33	136

		Bleeder?	Cough at Rest?	Cough at Work?	Exercise Intolerance?	Increased Recovery Time?
EIPH score (n = 172)	0	11/92	13/92	40/92	20/92	12/92
	1	12/49	21/49	23/49	18/49	11/49
	2	7/12	4/12	5/12	6/12	5/12
	3	5/7	1/7	2/7	3/7	0/7
	4	10/12	3/12	7/12	4/12	5/12
TMA score (n = 142)	0	0/1	0/1	0/1	0/1	0/1
	1	2/37	10/37	11/27	10/37	5/37
	2	7/31	3/31	9/31	6/31	6/31
	3	11/49	19/49	32/49	13/49	6/49
	4	3/24	3/24	10/24	9/24	5/24

Discussion

This study describes the prevalence of EIPH (45.3%) and TMA (99.3%) in a sample population of barrel racing horses under normal racing conditions in Alberta. The prevalence of EIPH detected in this study is high; however, it was lower than the reported prevalence of EIPH (68 and 55%) in large-scale Thoroughbred racehorse studies.[4,5] The physiological adaptations of barrel racing horses are likely similar to those of racehorses, so it is not surprising that there is also a high prevalence of EIPH among barrel racers. The explosive nature of barrel racing induces a rapid acceleration of heart rate and pulmonary vessel pressure.[23] Among the factors thought to contribute to EIPH are high pulmonary vascular pressure exacerbated by a negative pleural pressure as respiratory effort and rate increase during intense exercise.[24,25] This high transmural pressure could lead to stress failure of the pulmonary capillaries causing blood to enter the airways and be seen endoscopically.[26]

There was a weak positive correlation between the average speed and the presence of EIPH in this study; performance at higher speed has an effect on the likelihood of exhibiting EIPH in barrel racing horses. We also found that, over the long pattern, horses with an EIPH score = 4 had no significant difference in average run time than the horses with no or lower EIPH grades; when all course distances were included, horses with an EIPH score = 4 were significantly faster than those with a score of 0, 1, 2, or 3. That the presence of EIPH in the sampled population did not impact negatively on performance could be unique to barrel racing due to the extremely short distance covered, as there is moderate evidence in Thoroughbred racehorses, which indicates a higher EIPH score is related to decreased performance.[1] Similar correlation between EIPH score and speed was found ($r = 0.20$) when horses that received furosemide were removed from analysis (furosemide has been shown to improve racing outcomes in racehorses[27]), to eliminate performance bias.

We found a high prevalence (99.3%) of TMA in the present study. As horses with an EIPH score ≥2 were not scored for TMA, the prevalence reported in this study may be an overestimation of the true prevalence. Some barrel racing events are held indoors, where the amount of dust in the environment is typically much higher than observed at an outdoor event. However, we did not find any difference in TMA score between the indoor (n = 90) and outdoor runs (n = 80). Transportation has also been shown to increase the amount of mucopurulent secretions in the lower respiratory tract in horses[28]; given that barrel racing horses often travel to several different events over a weekend, the accumulative effect of transportation may also have affected the observed prevalence of TMA. Although we did not record this information, it may have contributed to the high level of TMA observed here as compared to some Thoroughbred racehorse studies (41.2%, 60%).[19,29–31] TMA scores ≥2 have been associated with reduced performance in Thoroughbred racehorses[19]; the prevalence of TMA score ≥2 in the sampled population of barrel racing horses was high (104/141; 73.8%) and further studies are required to determine whether this has a performance-limiting effect in this sport.

Coughing either at rest or during exercise was reported in 52% of horses examined, which is higher than previous reports of coughing in less than 16–50% of racehorses[32,33] but similar to a previous study reporting 44.9% of horses coughing at the beginning of exercise.[34] The current study agrees with other published reports that coughing is more likely (6.6 × greater occurrence) to occur in nonracing sport horses than racehorses;[35] however, it is difficult to compare prevalence as many studies use cough as an inclusion criterion. Interestingly, a weak association was found between the EIPH score and the presence of cough at rest reported by the riders. The fact that some horses with EIPH but no apparent epistaxis are reported to cough could have contributed to this finding.

An enrollment bias could have affected the reported prevalence of both EIPH and TMA, as owners with horses that showed signs of respiratory issues might have been more likely to enroll in the study. Conversely, we also observed that some owners had detected epistaxis in their horse on one or more previous occasions, and were not interested in enrolling in this study. A limitation of this study is that tracheobronchoscopic assessments were only conducted once per horse at a single event.

Another factor that must be considered is that this study relied upon information disclosure from owners relating to the medical regime the horse was competing on, particularly furosemide administration. However, the majority of the horses reported to be on furosemide still bled (8/10). Further study is required to determine whether furosemide is effective at preventing EIPH in barrel racing horses, as published literature relating to the efficacy of furosemide all pertains to Thoroughbred racehorses.[13–15]

Low ambient temperatures have previously been identified as a risk factor for increased incidence of EIPH (1.9 × more likely to have EIPH grade ≥1 at <20°C).[4] However, the range of temperatures that Thoroughbred racehorses were exposed to during this study was relatively small (mean 17.9°C, 95% range 12.9–22.9°C),[4] and a very high prevalence of EIPH was observed (55% horses examined had an EIPH grade ≥1). Strenuous exercise at cold temperatures (−5°C) has been shown to induce airway inflammation in horses.[36] The range of temperatures that horses were exposed to in the present study was moderate (mean 12.8 ± 8.2°C), and a high prevalence of EIPH was observed (45.3% horses examined had an EIPH grade ≥1).

In this study, there were a high prevalence of EIPH and a very high prevalence of TMA in barrel racing horses performing under normal racing conditions in southern Alberta. The majority of horses that raced on furosemide (8/10) had an EIPH score ≥1. Furthermore, it is currently unknown whether EIPH or TMA has a performance-limiting effect on barrel racing horses, and future studies should investigate whether any risk factors can be identified for EIPH or TMA in barrel racing horses.

Footnotes

[a] Karl Storz Endoskope

[b] Environmental information gathered from The Weather Channel (www.weather.com)

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Conflict of Interest Declaration: Authors declare no conflict of interest.

Off-label Antimicrobial Declaration: Authors declare no off-label use of antimicrobials.

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