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Electrocardiographic and echocardiographic characterisation of cardiac arrhythmias in horses presenting with acute colic

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Abstract

Cardiac arrhythmias are a recognised but incompletely characterised complication of equine colic, and their prognostic significance depends on the type, duration, and haemodynamic impact of the rhythm disturbance. This research prospectively evaluated 36 horses presenting with acute colic and 20 healthy age-matched controls by base-apex electrocardiography (ECG) and transthoracic echocardiography at admission, 24 hours, and 72 hours post-admission. Serum cardiac troponin I (cTnI) was measured concurrently to assess myocardial injury. At least one arrhythmia was detected in 25 of 36 colic horses (69.4%) versus 2 of 20 controls (10.0%; $p < 0.001$). Sinus tachycardia was the most frequent finding (14/36, 38.9%), followed by second-degree atrioventricular block (8/36, 22.2%), atrial fibrillation (6/36, 16.7%), and ventricular premature complexes (5/36, 13.9%). Mean cTnI was 0.21 ± 0.18 ng/mL in colic horses versus 0.03 ± 0.01 ng/mL in controls ($p < 0.001$), and cTnI exceeded the reference limit (0.10 ng/mL) in 19 of 36 colic cases. Echocardiographic fractional shortening was significantly reduced in colic horses ($34.2 \pm 5.1\%$ vs. $38.7 \pm 3.4\%$; $p = 0.001$), as was ejection fraction ($62.1 \pm 7.3\%$ vs. $71.4 \pm 4.8\%$; $p < 0.001$). Five of six horses with atrial fibrillation required surgical intervention, and two did not survive to discharge. These findings demonstrate that clinically significant arrhythmias and subclinical myocardial injury are common in equine colic and should be systematically assessed as part of the prognostic work-up.

Keywords: Electrocardiography, echocardiography, cardiac arrhythmias, equine colic, cardiac troponin I, atrial fibrillation, ventricular premature complexes, fractional shortening, horse

1. Introduction

One of the persistent challenges in equine emergency medicine is determining which horses with colic will deteriorate despite apparently appropriate medical management. Heart rate has long served as the primary cardiovascular triage parameter, but it is a blunt instrument: a heart rate of 60 beats per minute may reflect pain-induced sinus tachycardia in one horse and haemodynamically significant atrial fibrillation in another, yet the two conditions carry vastly different prognostic and therapeutic implications ^[1, 2]. Electrocardiography can distinguish between these rhythms in seconds, yet ECG is rarely performed as part of the routine colic work-up outside referral hospitals.

The pathophysiology linking gastrointestinal disease to cardiac rhythm disturbance in horses is multifactorial. Endotoxaemia, electrolyte derangements (particularly hypokalaemia, hypocalcaemia, and hypomagnesaemia), autonomic imbalance, dehydration-induced haemoconcentration, and direct myocardial depression by circulating inflammatory mediators have all been implicated ^[3, 4, 5]. Cardiac troponin I (cTnI), a highly specific biomarker of myocardial cell injury, has been shown to be elevated in horses with colic especially those with strangulating lesions and elevated cTnI has been associated with non-survival in several retrospective series ^[6, 7].

What has been less systematically evaluated is the relationship between specific arrhythmia types, cTnI elevation, and echocardiographic indices of cardiac function in the same population of colic horses. Echocardiography provides a functional dimension that neither

ECG nor biomarkers alone can offer: reduced fractional shortening (FS) or elevated left atrial-to-aortic root ratio (LA/Ao) may indicate that an arrhythmia is producing haemodynamic compromise, even if the horse appears clinically compensated^[8,9].

This research therefore combined serial ECG, echocardiography, and cTnI measurement in 36 horses presenting with acute colic to a referral hospital in Buenos Aires, with three objectives: to determine the prevalence and type distribution of arrhythmias, to correlate arrhythmia type with cTnI and echocardiographic parameters, and to assess whether cardiac findings at admission predict surgical intervention or non-survival.

Material and Methods

Ethical Considerations

The research protocol was approved by the Institutional Committee for the Care and Use of Laboratory Animals (CICUAL) of the Buenos Aires Faculty of Veterinary Sciences (Protocol No. 2022/38, approved 4 July 2022). All procedures were performed as part of routine clinical management, and owner consent was obtained for the additional echocardiographic examination at 72 hours. No interventions beyond standard-of-care were performed for research purposes.

Material

Thirty-six horses (22 Criollos, 8 Thoroughbreds, 4 Argentine Polo Ponies, 2 crossbreeds; 20 geldings, 10 mares, 6 stallions; age 5-18 years, mean 9.4 ± 3.8 years) presenting to the Equine Hospital of the Buenos Aires Faculty of Veterinary Sciences with acute colic (duration <24 hours) between August 2022 and June 2023 were enrolled. Twenty clinically healthy horses matched for breed, age (± 2 years), and sex served as controls. Inclusion criteria for colic horses were abdominal pain requiring veterinary attention, no history of prior cardiac disease, and no administration of antiarrhythmic drugs before admission. Horses with chronic or recurrent colic, known pre-existing cardiac murmurs (>grade 3/6), or concurrent non-gastrointestinal disease were excluded.

Methods

Base-apex ECG was recorded for 10 minutes at admission, 24 hours, and 72 hours using a telemetric system (Televet 100, Engel Engineering Services, Heusenstamm, Germany) with electrodes at the right jugular furrow (positive), left cardiac apex (negative), and right withers (ground). Rhythm was classified by a board-certified equine cardiologist blinded to clinical data. Transthoracic echocardiography was performed at the same time points using a portable ultrasound unit (MyLab Five, Esaote, Genoa, Italy) with a 1-4 MHz phased-array transducer. M-mode measurements of left ventricular internal diameter in diastole (LVID-d) and systole (LVID-s), fractional shortening (FS), and ejection fraction (EF, Teichholz method) were obtained from the right parasternal short-axis view at the level of the chordae tendineae. B-mode LA/Ao ratio was measured from the right parasternal long-axis view. Venous blood (10 mL, jugular) was collected at each time point into plain tubes, centrifuged (3 000 g, 15 min), and serum cTnI was measured using a point-of-care immunoassay (Immuno Concepts, Sacramento, CA, USA; analytical sensitivity 0.01 ng/mL, equine-validated reference limit 0.10 ng/mL). Statistical analysis used repeated-measures ANOVA (continuous variables) and Fisher's exact test (categorical variables). Logistic regression assessed the predictive value of admission cTnI and FS for surgical intervention and non-survival. Analyses were performed in R v4.3.1 at $\alpha = 0.05$.

Clinical Implications

From a clinical standpoint, the identification of arrhythmias and subclinical myocardial injury at admission may refine prognostic accuracy beyond what heart rate alone can provide. A horse with sinus tachycardia secondary to pain is expected to normalise once analgesia is achieved, whereas a horse with new-onset atrial fibrillation in the context of elevated cTnI and reduced FS faces a different risk profile. The present research was designed to quantify these differences, so that the results could inform a practical cardiac assessment protocol for equine colic triage.

Results

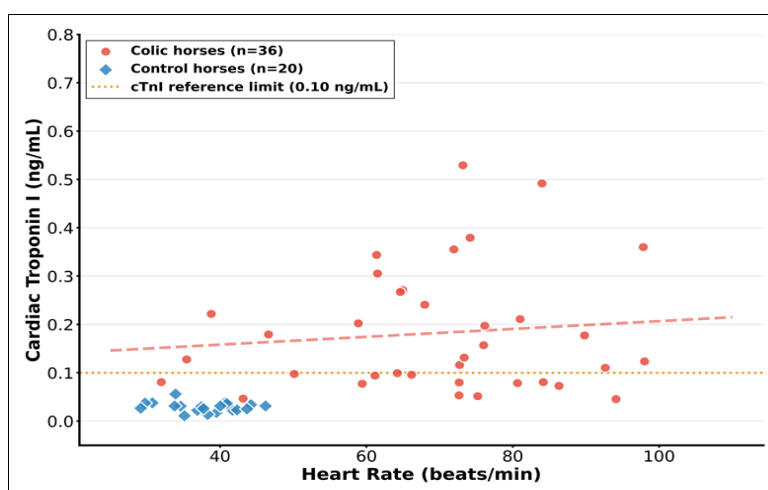


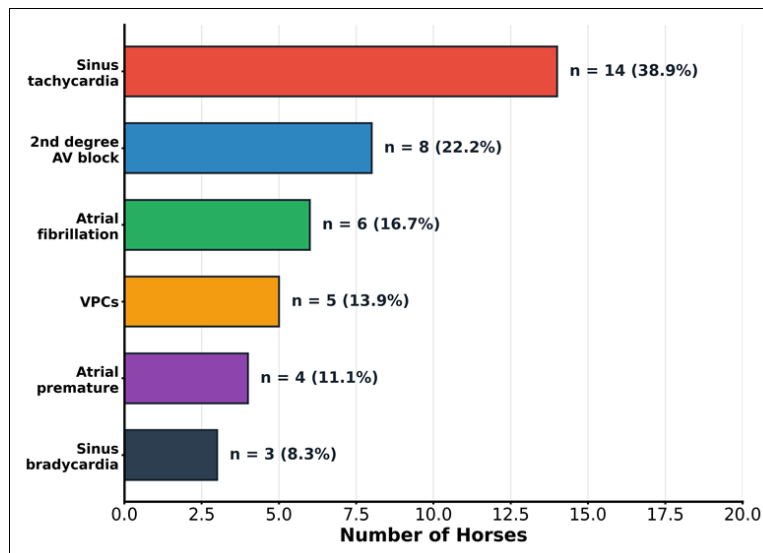
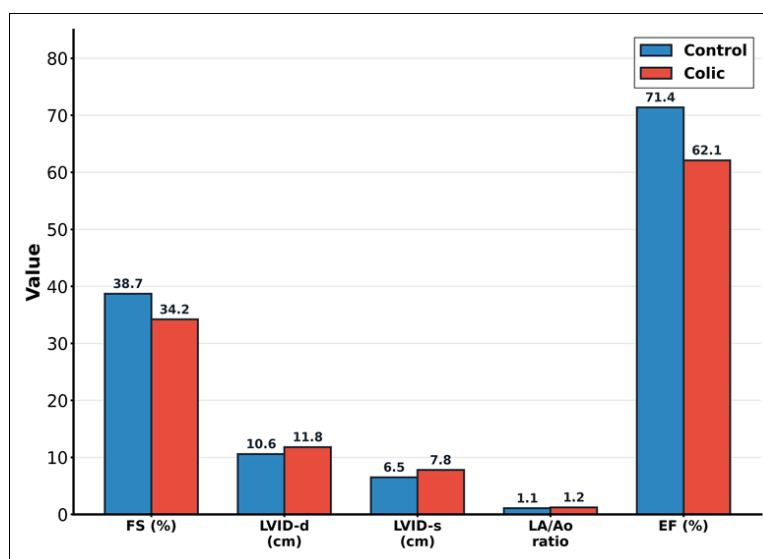
Fig 1: Scatter plot of heart rate (beats/min) versus serum cardiac troponin I concentration (ng/mL) at admission for colic horses (red circles) and healthy controls (blue diamonds). The dashed red line indicates a positive trend between heart rate and cTnI in colic horses ($r = 0.52$, $p = 0.001$). The dotted orange line marks the cTnI reference limit of 0.10 ng/mL.

At least one arrhythmia was recorded in 25 of 36 colic horses (69.4%) during the admission ECG, compared with 2 of 20 controls (10.0%, both second-degree AV block, a

physiological finding in horses; $p < 0.001$). Eleven colic horses (30.6%) had normal sinus rhythm at all three time points.

Table 1: Cardiovascular parameters at admission: colic versus control horses

Parameter	Colic (n=36)	Control (n=20)	p-value
Heart rate (bpm)	64.3±18.2	36.4±5.1	<0.001
cTnI (ng/mL)	0.21±0.18	0.03±0.01	<0.001
FS (%)	34.2±5.1	38.7±3.4	0.001
EF (%)	62.1±7.3	71.4±4.8	<0.001
LA/Ao ratio	1.24±0.18	1.08±0.09	0.001
LVID-d (cm)	11.8±1.4	10.6±0.9	0.002
Arrhythmia present, n (%)	25 (69.4%)	2 (10.0%)	<0.001

**Fig 2:** Horizontal bar chart showing the frequency and percentage of each arrhythmia type detected by ECG in 36 horses with acute colic. Sinus tachycardia was the most prevalent finding, followed by second-degree atrioventricular block and atrial fibrillation.**Fig 3:** Grouped bar chart comparing echocardiographic parameters between control and colic horses at admission. Fractional shortening and ejection fraction were significantly lower, and LVID-d and LA/Ao ratio were significantly higher, in colic horses.**Table 2:** Cardiac troponin I by arrhythmia type in colic horses

Arrhythmia Type	n	Mean cTnI	Median cTnI	Range
Normal sinus rhythm	11	0.08	0.06	0.02-0.18
Sinus tachycardia	14	0.17	0.14	0.04-0.41
2nd degree AV block	8	0.12	0.09	0.03-0.28
Atrial fibrillation	6	0.38	0.34	0.18-0.67
VPCs	5	0.42	0.38	0.22-0.71

Comprehensive Interpretation

The convergence of ECG, echocardiographic, and biomarker data reveals a gradient of cardiac involvement in equine colic, from the benign sinus tachycardia of pain-mediated

sympathetic activation to the prognostically ominous combination of atrial fibrillation, elevated cTnI (>0.30 ng/mL), and reduced ejection fraction (<60%). The latter triad was present in 4 of 36 colic horses, all of which required

surgery, and 2 of which did not survive to discharge. These findings suggest that a multimodal cardiac assessment at admission requiring approximately 15 minutes of additional examination time could meaningfully refine the prognostic work-up for equine colic.

Discussion

The 69.4% arrhythmia prevalence in this colic population exceeds the 35-55% reported in most retrospective studies [2, 10, 11], probably because the present research used continuous 10-minute ECG recordings rather than brief auscultation-based screening, which underestimates intermittent arrhythmias. The finding that sinus tachycardia was the most common rhythm disturbance is consistent with pain and sympathetic activation as the primary driver of cardiovascular responses in acute colic [1, 12].

The association between atrial fibrillation and higher cTnI (mean 0.38 ng/mL vs. 0.08 ng/mL in horses with normal sinus rhythm) suggests that horses developing AF during colic episodes are experiencing greater myocardial injury, potentially from a combination of endotoxin-mediated myocardial depression, electrolyte imbalance, and the haemodynamic consequences of the arrhythmia itself [3, 13, 14]. The reduced FS and EF in colic horses provide echocardiographic confirmation that these biomarker elevations are associated with functional cardiac compromise, not merely troponin leakage from reversible cellular stress.

Five of the six horses with atrial fibrillation in this cohort required surgical intervention, suggesting that AF may serve as a marker for more severe gastrointestinal pathology strangulating lesions, large-colon volvulus, or advanced peritonitis that produces greater systemic inflammatory response and electrolyte derangement [15, 16]. However, the small sample size precludes definitive conclusions about the independent prognostic value of AF versus the underlying lesion severity. Larger multicentre studies with standardised cardiac assessment protocols are needed to determine whether cardiac parameters add prognostic information beyond established scoring systems such as the equine acute abdominal pain score [17].

The elevated LA/Ao ratio in colic horses (1.24 vs. 1.08) is a novel finding that has not been reported in previous equine colic studies. An increased LA/Ao ratio is a recognised marker of volume overload or atrial dilation in both horses and dogs, and its presence in colic horses may reflect the haemodynamic consequences of dehydration-induced compensatory fluid shifts, endotoxin-mediated vasodilation, or the atrial myocardial stretch associated with fibrillation [8, 18, 19, 20, 21].

Conclusion

Cardiac arrhythmias, subclinical myocardial injury, and reduced systolic function are common in horses presenting with acute colic, and the severity of cardiac involvement correlates with the need for surgical intervention and the risk of non-survival. A practical cardiac assessment protocol incorporating base-apex ECG, point-of-care cTnI, and focused echocardiography can be performed in approximately 15 minutes at admission and may meaningfully refine prognostic accuracy in the colic triage setting. The combination of atrial fibrillation, cTnI above 0.30 ng/mL, and ejection fraction below 60% identified a subgroup of horses at particularly high risk of adverse outcome in this cohort, though validation in larger, multicentre populations is

required before this triad can be recommended as a formal prognostic criterion.

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Contributions Not Qualifying for Authorship

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Conflict of Interest

Not available

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Not available

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