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ORIGINAL RESEARCH

Equine colic outcomes and prognostic factors at a South African academic hospital (2019–2021)

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Background: Colic is a common equine emergency requiring medical or surgical intervention. These interventions can be costly, making outcomes data and prognostic indicators essential for guiding referral and treatment decisions.

Objectives: To determine survival rates to hospital discharge and evaluate prognostic indicators in equine colic cases treated at a referral hospital (Onderstepoort Veterinary Academic Hospital [OVAH], South Africa).

Methods: This retrospective observational cohort study analysed records from horses with colic that were presented to the OVAH from January 2019 to August 2021. Data included signalment, admission heart rate (HR) and packed cell volume (PCV), treatment type (medical vs. surgical), surgical diagnosis, postoperative complications, and survival to discharge.

Results: Of 415 cases, 375 were treated (292 medically, 83 surgically). 91% of medically, 77% of surgically treated, and 88% overall survived. Compared to a previous study, overall survival to discharge improved by 5% ($p = 0.025$), mainly due to improved surgical outcomes. Survival was associated with treatment type and surgical lesion site (lower for small intestinal than large intestinal lesions). Medically treated cases with an increased HR and surgical cases with a high PCV had lower survival rates. Signalment showed no association with outcomes.

Conclusion: Survival rates to discharge were comparable to previously published international reports and showed significant improvement to previous results from the same institution, due to improved surgical outcomes. These findings can assist veterinarians in referral and treatment decisions. Further research on long-term survival and additional prognostic indicators is required to improve outcome predictions for equine colic treatment.

Keywords: colic, equine, survival, outcome, surgical complications

Introduction

Colic is the most common equine medical emergency, with an incidence of approximately 3.5–10.6 colic events per 100 horses per year (Freeman 2018). Veterinary intervention is often required, which may be entirely medical management or include surgical intervention. Internationally, advances in anaesthesia and surgery have markedly improved outcomes for equine colic surgery (Salem et al. 2016). However, financial costs, combined with uncertain prognoses, remain major barriers to owners consenting to surgical intervention, even in high-income countries (Averay et al. 2023). These challenges are likely to be more pronounced in South Africa, a middle-income country, where horse owners may face greater financial constraints.

To address these issues, recent data on survival rates for medical or surgical treatments, along with the identification of reliable and accessible preoperative prognostic indicators, are needed. A global effort to achieve these has been initiated through the International Colic Surgery (INCISE) Audit, funded by the University of Liverpool (UK). This platform provides an online database that has been collecting data from 63 participating veterinary clinics worldwide since 2020. Its goal is to provide benchmarking data to facilitate quality improvement programmes for the management of equine colic (Cullen et al. 2024). Clinics registered with this audit tool can download their own data for monitoring and evaluation. The Onderstepoort Veterinary Academic Hospital (OVAH) enrolled in this programme in 2020.

The OVAH has the only university-affiliated equine clinic in South Africa. As such, its standards of treatment should reflect best practices for the country. Survival rates from equine colic cases treated at the OVAH could serve as a benchmark for other South African equine clinics and provide valuable information to aid decision-making. The most recent study on equine colic survival rates at the OVAH examined cases treated between 1998 and 2007. Since then, advances in treatment protocols are likely to have improved survival rates, highlighting the need for updated outcomes data. Additionally, comparing current outcomes with historical data would help determine whether the management of these cases at the OVAH has improved and how it aligns with current international standards.

When determining prognostic indicators, it is preferable to study variables that are frequently recorded, of low cost and easily obtainable. These include signalment parameters, as older or heavier breed horses have been associated with lower survival rates following colic surgery (Proudman et al. 2006; Laurenza et al. 2020). In addition, type and site of surgical lesion have been shown to relate to outcome, with ischaemic lesions and small intestinal lesions having the worst outcomes (Gardner

et al. 2018). An increased heart rate (HR) or packed cell volume (PCV) have also been associated with poorer outcomes in horses presenting with colic in several studies (Hoaglund et al. 2018; Kos et al. 2022) but may not reliably identify colic treatment survivors (Farrell et al. 2021).

These studies on predictors of outcomes were performed in other countries and as the disease profile of equine colic cases may differ between countries, these parameters also need to be investigated to determine their value as prognostic outcomes indicators in a South African context. While attempts have been made to use these and other prognostic indicators to develop scoring systems to minimise errors from subjective decision-making, it has been acknowledged that these systems often have low sensitivity and have not been tested in diverse populations (Farrell et al. 2021).

The primary aim of this study was to determine treatment outcome rates for equine colic cases admitted to the OVAH between January 2019 to August 2021, up to discharge from hospital. The secondary aim of the study was to assess prognostic indicators for treatment.

Methods

This study was a retrospective observational cohort study. Electronic case records were reviewed for all horses older than five months of age that presented to the OVAH for gastrointestinal colic between January 2019 to August 2021. Foals younger than five months and pregnant mares were excluded due to their naturally higher heart rates, which could introduce bias into the results, as well as non-gastrointestinal causes of colic. Data from the case records were entered into the INCISE database, and an EXCEL spreadsheet was created for data analysis purposes.

The researchers selected variables of interest for this study based on their identification in scientific literature as prognostic indicators associated with outcomes in equine colic treatment. These variables were also likely to have been frequently recorded in the OVAH case records of equine colic cases. These selected variables included signalment (breed, sex, age), HR and PCV on admission, treatment type (surgical or medical), surgical diagnoses, postoperative complications, and outcome (survival to discharge). Multiple surgical diagnoses and complications could be reported for a single horse. For euthanised horses, the reason for euthanasia (welfare/poor prognosis or economic) were recorded. If performed, postmortem findings were reported. Not all data points were available for every horse, which required data analysis to be calculated according to each sample size. For horses treated for more than one episode of colic during the study period, signalment treatment details and outcomes were recorded for each episode, as treatment type for one horse could differ between admissions. Postoperative complications were classified according to the International Colic Audit criteria (Appendix 1a; INCISE 2022).

Statistical analysis of the data included a Z-test for two proportions to compare medical survival rates (SRMed) and surgical survival rates (SRSurg). The Kolmogorov-Smirnov test was used to assess data normality for age, HR and PCV. The Mann-Whitney U test was employed to evaluate associations between HR, PCV and survival.

For categorical data analysis, horses were classified based on the following criteria:

- Age: < 2 years old, then in 2-year intervals up to 28 years of age, and > 28 years old)
- HR on admission: Bradycardia (< 28 beats per minute [bpm]), Normal (28–48 bpm), Tachycardia (49–70 bpm), and Shock (>70 bpm).
- PCV on admission: Low (≤ 30%), Normal (31–50%), High (≥ 51%) (HR and PCV values according to Southwood 2013).

The chi-squared (χ^2) test for Independence was used to identify significant differences between categorical variables and survival. When sample sizes were ≤ 5, Fisher's exact test was applied. Logistic regression was conducted to analyse the combined effects of HR and PCV on outcomes, with median values used to replace missing data. Statistical significance was defined as $p < 0.050$. Analyses were performed using IBM SPSS Statistics Grad Pack 30.0.

Prior to the commencement of the study, approval was obtained from the University of Pretoria Research and Animal Ethics committees (REC 036-21).

Results

A total of 415 cases (362 horses) with the primary complaint of colic were presented to the OVAH during the 32-months study period. The data for all collected parameters was found to be non-parametric.

The most commonly represented breeds were Thoroughbreds and Warmbloods, followed by Friesians, Arabians, American Miniature Horses, Percherons, Boerperds and Irish Sport Horses. Details of horse demographics and treatment survival rates are provided in Table I. Of the 375 cases treated, 188 (50.1%) were geldings, 158 (42.1%) were mares and 29 (7.7%) were stallions. No significant associations were identified between breed or sex and survival rates for either surgical or medical treatment.

The median age of all cases was 10 years (IQR 6–14; range: 0.5–32 years). For the medically treated horses, the median age was also 10 years (IQR 7–14; range: 0.5–32 years), while for those that underwent surgery, it was nine years (IQR 5–13, range: 0.5–24 years). The two oldest horses having surgery were 21 years and 24 years old, and both survived to discharge. There were 23 horses over 20 years old treated medically of which two did not survive – however, all eight horses over 26 years survived. No statistically significant associations between age and survival were identified for surgical or medical treatment (Table I).

Fifty-three horses were presented with more than one colic episode during the study period. Forty horses were euthanised without treatment following their initial evaluation and were excluded from further analysis. Economic reasons were reported as a deciding factor for euthanasia in 36/40 cases (90.9%), while four horses were euthanised solely due to a poor prognosis. Of the 375 cases (322 horses) that received treatment, 330 survived

Table I: Demographics of cases treated and outcomes Age = Median (IQR [Interquartile Range]; Range); For Age, Gender and Breed: *n* = frequency relevant data recorded

	Surgical survivors	Surgical non-survivors	Surgical survivors vs. non-survivors: *p* value	Medical survivors	Medical non-survivors	Medical survivors vs. non-survivors: *p* value
AGE (years) (*n* = 371)	9 (5–13; 0.5–24)	10 (4.5–12.5; 1.75–18)	*p* = 0.880 (χ^2:5.9, df:11)	10 (7–14; 0.5–32)	10 (7–15; 1–24)	*p* = 0.22 (χ^2:17.72, df:14)
GENDER (*n* = 375)			*p* = 0.786 (χ^2:0.483, df:2)			*p* = 0.894 (χ^2:0.223, df:2)
Mare	19	7		120	12	
Gelding	36	9		131	12	
Stallion	9	3		15	2	
BREED (*n* = 374)			*p* = 0.817 (χ^2:4.43, df:8)			*p* = 0.769 (χ^2:9.91, df:14)
Thoroughbreds (*n* = 151)	24	6		108	13	
Warmbloods (*n* = 109)	24	7		74	4	
Friesian (*n* = 34)	6	4		21	3	
Arabian (*n* = 17)	3	1		11	2	
Miniature (*n* = 11)	2	0		9	0	
Percheron (*n* = 9)	2	0		7	0	
Boerperd (*n* = 6)	1	0		5	0	
Irish Sport (*n* = 6)	0	0		6	0	
Appaloosa (*n* = 5)	0	0		5	0	
Nooitgedacht (*n* = 4)	0	0		4	0	
Clydesdale (*n* = 3)	0	0		3	0	
Quarter Horse (*n* = 3)	0	0		2	1	
Welsh Pony (*n* = 2)	0	0		2	0	
Saddlebred (*n* = 2)	0	0		2	0	
Other (*n* = 12)	2	1		8	1	

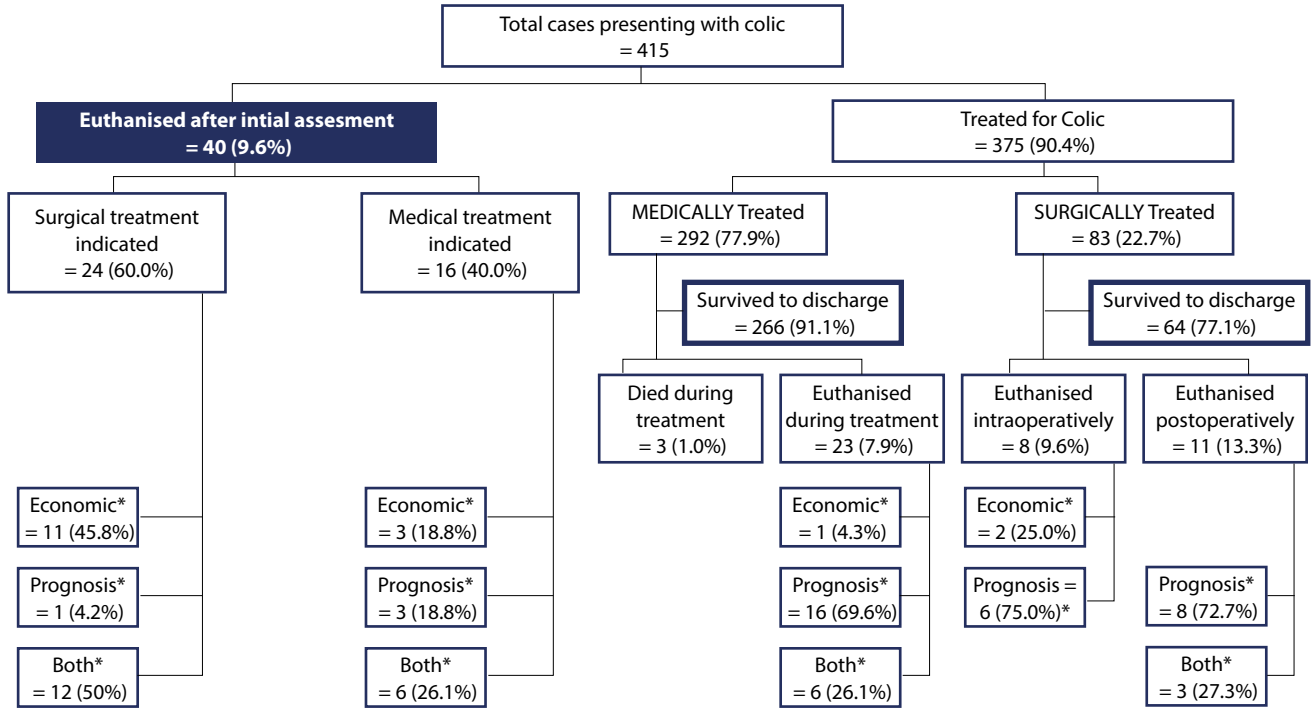

Figure 1: Consort flow diagram of outcomes of horses that presented to OVAH for colic
(* = reason for euthanasia: Economic = economic, Prognosis = poor prognosis, Both = both economic and poor prognosis)

to discharge, resulting in an overall survival rate (OSR) of 88% for cases that were treated (Figure 1).

Among the treated cases, 292 out of 375 (77.9%) received only medical therapy. The survival rate for medically treated cases was significantly higher than for surgical cases: 91.1% (266/292) compared to 77% (64/83) (p = 0.0005). The most common reason for euthanasia during treatment was poor prognosis, which accounted for 73.7% (14/19) of surgical cases and 69.6% (16/23) of medical cases (Figure 1).

Data from the previous study on colic survival rates at OVAH were extracted from the published results (Voigt et al. 2009). These results were as follows: during the period 1998–2007, 889 horses were treated for colic at OVAH of which 738 survived (83.0%). The success rate for medical treatment was 92.8% (518/558) and for surgical treatment was 66.5% (220/331).

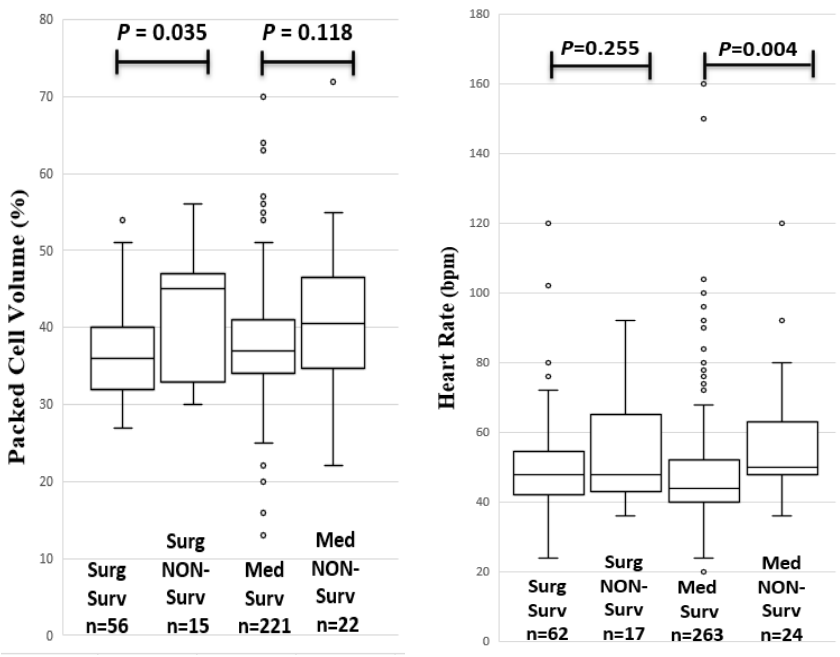

Figure 2: Heart rates and packed cell volumes at admission of surgically and medically treated survivors and non-survivors
(n = frequency relevant data recorded, Surg Surv = surgical survivors, Surg NON-Surv = surgical non-survivors, Med Surv = medical survivors, Med NON-Surv = medical non-survivors).

In comparison, in this study, 375 cases were treated for colic at OVAH of which 330 survived (88.0%). The medical survival rate was 91.1% (266/292) and the surgical survival rate was 77.1% (64/83). A chi-square test comparing the survival rates from the 1998–2007 study with those from this study showed a statistically significant 5.0% overall improvement in survival rates (p = 0.025). However, the 10.6% improvement in surgical survival rates and the 1.7% decline in medical survival rates were not significantly different (p = 0.062 and p = 0.369, respectively).

Heart rates on admission were recorded for 402 cases, with a median of 44 bpm (IQR 40–52; range 20–160). One hundred and fifty cases had an elevated HR (HR ≥ 49 bpm), including 43 whose heart rates were > 70 bpm. Following initial assessment, 23 horses (15.3%) with elevated heart rates were euthanised, of which 12 (27.9%) had heart rates > 70 bpm.

There was no statistically different difference in heart rates between surgical survivors and non-survivors (p = 0.255; 95% CI: 0.002–0.957). However, a significant difference between the heart rates was observed between medical survivors and non-survivors (p = 0.004; 95% CI 0.000006–0.244) (Figure 2).

Cases were grouped according to HR into Bradycardia (< 28 bpm), Normal (28–48 bpm), Tachycardia (49–70), Shock (> 70 bpm). Among cases in the Normal group, 20% (47/233) underwent surgery, compared to 21.9% (21/96) of those in the Tachycardia and 33% (10/31) of those in the Shock HR groups. Although this showed a tendency for horses with an elevated HR to receive surgery, these results were not statistically significant (p = 0.308).

Horses in the Shock HR group had lower survival rates following either surgical or medical treatment but this was only statistically significant for medically treated cases (p = 0.441 and p = 0.026, respectively). In contrast, all five horses in the Bradycardia group survived to discharge, including one treated surgically.

PCV was recorded on admission for 339 cases and for 314 cases that subsequently received treatment. The median PCV on admission for all cases was 37% (IQR 34–42; range 13–72). A high PCV (i.e. > 50%) on admission was recorded in 21 cases. Of these, 5/21 horses were euthanised without treatment, 5/21 underwent surgical treatment with 2/5 surviving to discharge and 11/21 were treated medically, 8/11 of whom survived to discharge.

A comparison of PCV values between surgical and medical survivors and non-survivors found that higher values were associated with non-survival after surgery (p = 0.035) but no significant difference between the PCV values of medical survivors or non-survivors was found (p = 0.118) (Figure 2).

Horses categorised as High PCV on admission were more likely to die following surgery than those in the Normal or Low PCV groups (Odds Ratio: 9.0, [95% CI: 1.47, 54.94], p = 0.0196). There was a non-statistically significant trend towards horses with a high PCV dying during medical treatment (Odds Ratio: 3.96 [95% CI: 0.97, 16.18], p = 0.074).

Compared to those treated medically, the proportion of horses receiving surgical treatment was higher in those with a PCV over 50% compared to those with lower PCV results, but this was not statistically significant (p = 0.317). Eleven horses treated surgically had a low PCV (< 30%) on admission and 10 survived to discharge following surgery, but this relatively high surgical success rate, was not statistically significant when compared to horses with PCV values ≥ 30% (p = 0.277).

Logistic regression analysis was used to explore further the predictive values of HR, PCV and their interaction, on survival rates (Table II). The only statistically significant result was for elevated PCV and death following surgery, where a PCV of 51%

Table II: Logistic regression analysis for HR, PCV and their interaction, in predicting survival after surgical or medical treatment

	Coefficient B	Standard Error	z	*P*	Odds Ratio	95% CI Lower	95% CI Upper
Surgical Cases							
Intercept	-14.83	6.62	–2.24	0.025	0	0	0.16
Heart Rate	0.19	0.12	1.65	0.1	1.21	0.96	1.52
Packed Cell Volume	0.33	0.16	2.05	0.041	1.39	1.01	1.9
Interaction	0	0	–1.61	0.106	1	0.99	1
Medical Cases							
Intercept	-2.29	4.07	–0.56	0.574	0.1	0	297.34
Heart Rate	-0.04	0.08	–0.51	0.613	0.96	0.83	1.12
Packed Cell Volume	-0.03	0.1	-0.3	0.761	0.97	0.79	1.19
Interaction	0	0	0.81	0.42	1	1	1.01

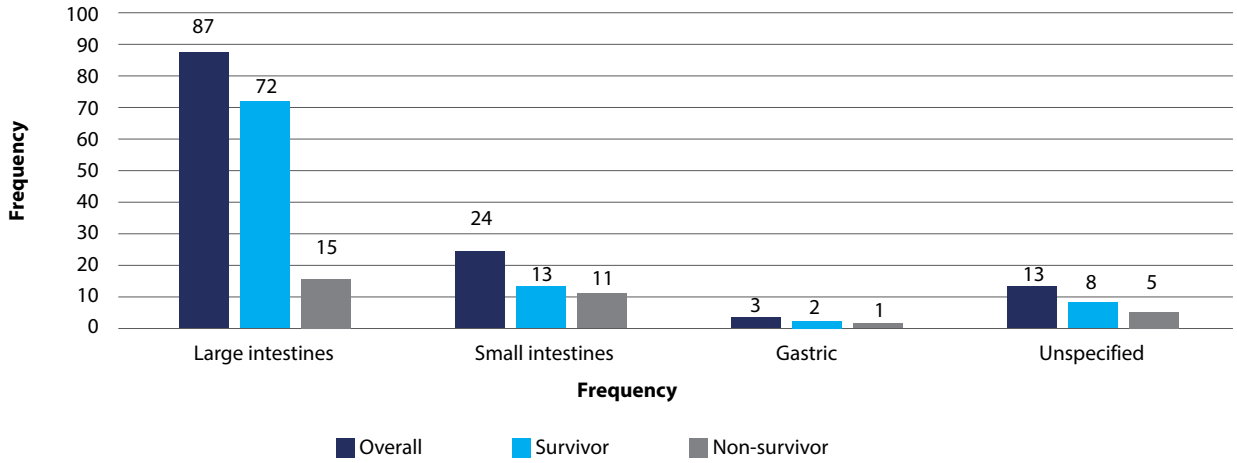

Figure 3: Frequency lesion identified at surgery according to gastrointestinal site and outcome (Note: A single horse could have lesions identified intraoperatively at more than one site)

was the critical threshold for probabilities greater than 50% (p = 0.035). However, only five horses were in this data group.

The most common pathology identified during surgery was impaction, occurring in 52 horses (62.7%), followed by colonic displacement, which was diagnosed in 31 horses (37.3%). The SRSurg for horses with impaction was 80.8% (42/52), and 87.1% (27/31) for horses with displacements. The majority of impactions occurred in the large intestine (LI), involving the large colon (n = 16), small colon (n = 15), or caecum (n = 1), with SRSurg values of 81.1%, 86.7% and 100%, respectively. The SRSurg for small intestinal impactions (n = 10) was lower at 60.0%. Two cases of gastric impactions occurred, both of which survived. However, there was no statistically significant association between the site of gastrointestinal impaction and death rate (p = 0.461).

There was a non-significant association for horses with intestinal ischaemic pathologies to have lower survival rates (n = 23, p = 0.151). Among these, torsion was the most common type, with an overall survival rate, of 61.5% (8/13). Caecal torsion (n = 2) was less frequent than colonic torsion (n = 11) and both cases survived.

The location of pathology in the gastrointestinal tract had a significant influence on outcome, with horses that had lesions in the small intestine (SI) being more likely to die following surgery compared to those who had lesions in the LI (OR:4.06, 95%CI: 1.53, 10.79: p = 0.0079) (Figure 3).

Of the 83 horses that underwent surgery, 19 were euthanised – 8 (42%) horses during surgery and 11 (58%) in the immediate postoperative period. Among the eight horses euthanised during surgery, colonic torsion was the most common pathology, occurring in four cases.

Seven horses underwent repeat laparotomies within seven days of their initial surgery. Five were euthanised either during or immediately after the procedure due to a poor prognosis, while two survived to discharge. The SRSurg for repeat laparotomy was 28.6%.

Postmortem examination reports were available for six horses. The findings included peritoneal adhesions between the gastrointestinal tract and the abdominal wall, intestinal necrosis, SI volvulus, idiopathic focal eosinophilic enteritis, and recurrence of the original lesion in two cases (right dorsal colon displacement and diaphragmatic hernia).

A total of 169 postoperative complications of various types and degrees of severity were recorded in 72/75 (96%) surgical cases. Seventy-one of these cases had two or more types of complications, with an average of 2.3 complications per horse. The most common complications were postoperative ileus

Table III: Types of postoperative complications and outcomes (Note: a single horse could have experienced more than one complication)

Complication	Frequency (Total)*	Frequency in Euthanised Cases**	Euthanasia Rate***
None	3 (4.0%)	0	0
Intra-abdominal complications			
Reflux – Postoperative ileus	38 (50.7%)	9	23.7%
Colic	32 (42.7%)	7	21.9%
Recurrence of impaction	2 (2.7%)	0	0
Recurrence of entrapment	1 (1.3%)	1	100%
Intestinal necrosis	1 (1.3%)	1	100%
Unresolved hernia causing deterioration	1 (1.3%)	1	100%
Incisional (wound) complications			
Incisional infection	19 (25.3%)	2	10.5%
Incisional dehiscence	4 (5.3%)	3	75.0%
Oedema (excessive) around incision without infection	2 (2.7%)	0	0
Herniation of intestines through incision	1 (1.3%)	1	100%
Other infective/inflammatory complications			
Pyrexia	21 (28.0%)	4	19.1%
Thrombophlebitis	15 (20.0%)	2	15.4%
Laminitis	4 (5.3%)	1	25%
Systemic inflammatory response syndrome (SIRS)	7 (9.3%)	2	28.6%
Diarrhoea *(cause unspecified)*	6 (8.0%)	0	0
Pneumonia	5 (6.7%)	0	0
Peritonitis	3 (4.0%)	1	33.3%
Salmonellosis	2 (2.7%)	0	0
Other complications			
Equine gastric ulceration syndrome	3 (4.0%)	0	0
Corneal ulcer	2 (2.7%)	0	0

*Frequency observed in the 75 surgical cases. **Frequency observed in the 11 cases euthanised postoperatively, ***Proportion of cases with this complication who were euthanised postoperatively

(POI) (38 cases) and colic (32 cases), with survival rates of 76.3% and 78.1%, respectively. Postoperative pyrexia was recorded in 21 cases and occurring more frequently in non-survivors (36.4%) compared to survivors (26.5%). Thrombophlebitis at the intravenous injection site was reported in 20% of cases. Laminitis contributed to mortality in one of the four affected horses, which was euthanised due to severe progression of the condition. Postoperative complications were observed in all non-survivors (Table III).

Discussion

In this study, outcome in horses that were presented to the OVAH for colic and in which treatment was pursued, was favourable with survival of 77% of horses undergoing surgery, 91% of medically treated cases and an OSR of 88%. While age, breed and gender were not associated with mortality after treatment, non-surviving horses had higher heart rates on admission, this was statistically significant for those receiving medical therapy only. In surgically treated cases, a high PCV on admission was associated with poorer outcomes. The location of the gastrointestinal lesion was the only surgical factor significantly associated with survival, with small intestinal lesions being associated with the poorest outcomes.

The improved OSR compared to previously published data from the same hospital between 1998 and 2007 (Voigt et al. 2009 is largely attributed to the increased SRSurg of 10.6%. Despite a decrease in SRMed of 2.0% compared to the previous results, the SRMed of 91.1% remained high. Both the changes in SRSurg and SRMed were not statistically significant, this is possibly due to a type II statistical error caused by the small sample size.

The survival rates for equine colic treatment in this study are similar to recent studies on equine colic survival from other studies, that reported OSRs of 76–83%, SRSurg of 42–68.5% and SRMed of 86–93% (Sutton et al. 2009; Christophersen et al. 2014; Boom & Sloet van Oldruitenborgh-Oosterbaan 2018; Dybkjær et al. 2022; Spadari et al. 2023; Archer et al. 2024) (Table IV). While direct comparisons are difficult due to differences in study designs, advances in the treatment of equine colic in recent years have largely been achieved in surgical technique, early referral of surgical cases and postoperative care (Freeman 2018).

Increasing awareness among horse owners about the improved outcomes associated with surgical treatment of equine colic may encourage more owners to elect surgery when a reasonable prognosis exists (Averay et al. 2023). Sharing these improved SRSurg outcomes with the equestrian community and horse owners could lead to an increase in equine colic cases being referred for further evaluation and a higher proportion of owners agreeing to surgery.

Table IV: Survival to discharge rates from various international studies (rates given as proportion, and ratio of number of survivors to non-survivors).

Country	First Author of Study	Period	Number of Centres	OSR for Treated Cases*	SRMed	SRSurg
South Africa	Voigt	1998–2007	1	83% (737/889)	93% (518/558)	67% (220/331)
Denmark	Christophersen	2000–2009	1	76% (1087/1429)	87% (946/1093)	42% (141/336)
Israel	Sutton	2003–2006	1	76% (158/208)	93% (67/72)	66% 90/136
Denmark	Dybkjær	2010–2018	1	83% (1160/1397)	90% (966/1077)	61% (194/320)
Netherlands	Boom	2012–2013	1	80% (218/274)	86% (178/207))	60% (40/67)
Italy	Spadari	2018–2021	3	N/A**	N/A**	69% (309/451)
Multi-continental	Archer	2019–2021	63	N/A**	N/A**	60% (2279/3785)

*Cases euthanised before treatment excluded
**Only surgical cases were reported

Nevertheless, this study found that, for most horses for which surgery was recommended after the initial assessment but were subsequently euthanised, the decision could possibly have been influenced more by their owners' financial constraints than by the surgical prognosis.

Furthermore, the study period coincided with the COVID-19 pandemic, which worsened financial difficulties across all economic levels. This context may partly explain why euthanasia was chosen more often for horses requiring surgery than those needing medical treatment, as medical treatment is generally a less expensive option. However, these financial and social factors were beyond the scope of this investigation.

Anaesthesia-related mortality remains a significant global challenge in equine surgery, with no improvement observed in recent years (Freeman 2018). This issue is particularly relevant in the context of emergency colic surgeries where horses face a higher risk from anaesthesia-related mortality compared to elective procedures (3% vs. 0.96%, respectively); most complications are neuromuscular or respiratory and occur during the recovery phase of anaesthesia (Laurenza et al. 2020).

In the previous study from this hospital, 1.2% (4/330) of horses died intraoperatively; however, it was not specified whether these deaths were due to surgical or anaesthetic factors (Voigt et al. 2009). Notably, the current study reported no anaesthesia-related deaths. This low anaesthesia-related mortality rate could be attributed to the smaller sample size in the current cohort or may reflect advances in anaesthetic practices and perioperative management at OVAH.

Factors contributing to anaesthesia-related mortality include older age and higher body weight (Proudman et al. 2006; Laurenza et al. 2020). It is unclear whether these factors were more favourable in this cohort of horses at OVAH, as the study population did not include horses of advanced age, with the oldest having surgery being 24 years compared to 35 years in the Laurenza study, and weight was not recorded.

Other studies have also suggested that heavier breeds, such as Draught horses, have worse surgical outcomes, because of their weight rather than an inherent susceptibility of the breed (Proudman et al. 2006). The increased weight of the horse is postulated to cause greater intraoperative pulmonary atelectasis leading to ventilation-perfusion mismatch and hypoxaemia, which can persist into the postoperative period to worsen survival (Proudman et al. 2006). In the current study, no breed-related differences in survival rates were observed, likely due to the study population's composition, which consisted predominantly of Thoroughbreds, Warmbloods, and Friesians, with only a small number of heavy horse breeds or small ponies undergoing surgery. Therefore, it is recommended that future studies of this type include the recording of the horses' weight.

Horses at OVAH undergoing surgery had significantly lower survival rates than those treated medically, consistent with evidence that surgical cases are typically more ill and prone to poorer outcomes. Surgery is indicated in horses with cardiovascular deterioration during medical treatment, suggesting intestinal ischaemia, further leading to increased illness severity in the population of surgically treated cases (Gardner et al. 2018).

Increased HR and PCV are indicators of increased illness severity in horses with colic. An increased HR is often associated with increased PCV, and although both have been identified as predictors of poor outcomes in surgical and medical treatments (Proudman et al. 2006; Kos et al. 2022), some studies have found that an increased PCV does not predict treatment outcomes (Farrell et al. 2021).

In this study, while trends were observed suggesting that horses with higher HR or PCV had worse outcomes, statistical significance was observed only in medically treated horses with elevated HR and surgically treated horses with high PCV. Logistic regression analysis of these two parameters and their interaction as predictors of mortality, found that only an increased PCV significantly influenced mortality after surgery. However, this finding should be interpreted with caution owing to the small sample size.

Tachycardia can result from various factors, including fear, pain, hypovolaemia, endotoxaemia or cardiac dysfunction, all

of which may be seen in colicking horses. While a high HR has been used to predict outcomes in colic cases (Farrell et al. 2021), tachycardia may also result from non-medical causes, such as fear or stress during transportation to OVAH. This presents a limitation in the study, as only the initial HR upon admission was recorded. Serial measurements would have provided a better understanding of this dynamic. This limitation might explain why HR did not significantly predict surgical outcomes, as the observed tachycardia may not have been directly related to the underlying illness.

An increased PCV typically indicates dehydration, stress or endotoxaemia, all of which negatively impact survival rates (Kos et al. 2022). In horses requiring colic surgery, a high PCV due to severe preoperative dehydration has been associated with worse postoperative outcomes, potentially due to challenges in achieving adequate rehydration in the perioperative period (Hoaglund et al. 2018). In addition, an increased PCV has been associated with SI surgical cases, which generally carry a poorer prognosis than LI cases; this correlation may be attributed to the increased incidence of strangulation in SI colics, where fluid sequestration into the intestinal lumen leads to reflux and rapid dehydration (Kos et al. 2022).

High PCV may also represent a physiological response to living at altitudes over 1 000 m (Jaramillo et al. 2020). This is particularly relevant as the OVAH is situated on South Africa's vast interior plateau, which covers approximately two-thirds of the country, and lies at an altitude exceeding 1 000 m. This region includes several economically important areas with active equestrian communities. Consequently, horses living in this high-altitude region may naturally exhibit higher PCV values compared to those living in coastal areas. Further research is needed to quantify the extent of this difference.

For the primary veterinarian, particularly one without equine specialisation, evaluating a colicking horse involves considering a range of factors beyond just a high HR, which could indicate severe illness. When advising the owner on treatment options – including the potential for specialist referral – other key considerations include the horse's age, overall condition (both current and prior to the illness), financial value, and insurance status. If referred to a specialist centre for further evaluation, an equine specialist will have access to additional diagnostic tests to help determine whether medical or surgical treatment is warranted, or if euthanasia should be considered. Other prognostic indicators that may inform this decision include time to referral, pain severity, respiratory rate, rectal examination findings, quality of borborygmi, abdominal ultrasound results, and serum levels of calcium and lactate, as well as a prolonged capillary refill time (Farrell et al. 2021; Mair & Smith 2005a). Should the horse require surgery, intraoperative factors that influence outcomes include the type and location of the gastrointestinal lesion (Freeman 2018; Long 2022) and the experience level of the surgeon (Spadari et al. 2023).

In this study, the only prognostic indicators with a clear relationship to outcomes were treatment type and lesion location. Signalment showed no influence on outcomes, and admission HR and PCV were not consistently predictive, with results varying with treatment type. This highlights the need for further studies to confirm the value of other prognostic indicators identified in the literature. All together, these can be used to develop a scoring system tailored to equine colic cases. Such an approach would align with methods used at other centres that have recently developed and validated scoring systems, such as the Colic Assessment Score (Farrell et al. 2021). This system was derived from retrospective identification of clinical parameters associated with survival, followed by prospective validation. Ultimately, however, clinicians should base their management decisions on a comprehensive evaluation of the horse's clinical condition, rather than relying solely on scoring system results.

Equine colic surgery is often termed as "exploratory laparotomy" because the pathology is diagnosed during the surgical exploration of the abdominal cavity. Intraoperative findings allow for a more accurate prognosis and may result in the recommendation for euthanasia during surgery. In this study, intraoperative euthanasia was performed in eight out of 83 cases (9.6%). This was a lower rate compared to the 17.2% observed in a Danish study, in which the authors also reported that intraoperative euthanasia rates at their institution had decreased from a rate of 40% a decade earlier (Dybkjær et al. 2022). This decrease was attributed to advances in surgery leading to surgeons being more likely to attempt procedures not formerly considered possible, such as intestinal resection. These factors may also have resulted in the low intraoperative euthanasia rate in this study, which had decreased from 19% (64/331), as recorded in the previous OVAH study.

The type of pathology causing colic significantly impacts the outcome, especially if it leads to the development of the systemic inflammatory response syndrome (SIRS) (Roy et al. 2017). Horses with ischaemic lesions, particularly if the presentation is delayed and bowel resection is required, tend to have a poorer prognosis (Gardner et al. 2018). This trend was evident in this study, as horses with intestinal strangulation had lower survival rates following surgery compared to those with uncomplicated obstructive lesions or intestinal displacements.

In this study, the site of pathology significantly influenced survival rates, with SI pathologies associated with lower survival rates compared to LI pathologies. This difference may be due to the higher prevalence of strangulating lesions in the SI and the increased prevalence of postoperative adhesions and obstructions following SI surgery (Freeman 2018).

While previous studies have reported poor outcomes for horses with caecal pathology (Mair & Smith 2005a), none of the four horses with caecal pathology in this study died, including two with ischaemic-type lesions. Additionally, although the incidences of torsions and displacements were similar to that reported in the previous OVAH study, the proportion of surgically treated impactions had markedly increased from 22.7% (75/331) to 41.3% (52/126) (Voigt et al. 2009). An interesting observation was an unexplained cluster of small colon impactions diagnosed at OVAH during the winter of 2021, which may have contributed to this finding.

Postoperative complications were prevalent in this study, affecting the majority of surgical cases. However, many of these

were relatively minor and non-life-threatening, such as corneal ulcers and thrombophlebitis, as well as conditions like gastric ulcer syndrome, which may have existed prior to surgery. The frequent co-occurrence of related complications, such as POI and colic in the same horse, also contributed to the high total number of complications reported.

POI, a common postoperative complication, is typically caused by surgical manipulation of the small intestines, which leads to inflammation of the myenteric neural plexus and the muscle layers of the intestines, disrupting intestinal motility (Little et al. 2010). In this study, POI was observed in 50.7% of surgical cases, which is at the higher end of the reported range in other studies, where incidence rates vary from 6.3% to 53% (Salem et al. 2016). These variations may be due to differences in diagnostic criteria (Salem et al. 2016). In future studies, adopting standardised definitions of postoperative complications, such as those outlined by the INCISE Audit criteria, may help address inconsistencies in diagnostic criteria across reports.

Thrombophlebitis of the jugular vein was reported in 20% of cases, which is higher than previously reported rates (1.3–18%) (Salem et al. 2016). This condition, often linked to the use of indwelling intravenous catheters, is a common complication during horse hospitalisation, particularly severely debilitated horses (Lankveld et al. 2001). Such horses are predisposed to thrombophlebitis due to factors including infection from prolonged cannulation, bacteraemia and a hypercoagulable state (Geraghty et al. 2009; Cesarini et al. 2010). Whilst these factors may have contributed to the relatively high incidence of thrombophlebitis observed in this study, specific hospital protocols may also have contributed, particularly those related to skin disinfection and hair clipping at the jugular vein catheterisation site (Geraghty et al. 2009). Further investigation is warranted to better understand and mitigate this complication.

Recurrent colic is often attributed to adhesions that form after surgery (Alonso et al. 2014). While numerous strategies have been proposed to prevent these adhesions, none have shown clear evidence of efficacy (Salem et al. 2016). In this study, persistent postoperative pain or recurrent colic was reported in 47.2% of cases, which is higher than rates reported in other studies (28.2–32.1%) (Mair & Smith 2005a; Mair & Smith 2005b). It is possible that postoperative pain in this study was overreported due to misinterpretation by less experienced evaluators (veterinary students) who may have mistakenly recorded behaviours such as food-seeking or restlessness as signs of colic.

Surgical site complications occurred in 30.7% of cases, consistent with previous studies reporting an incidence of 26.9% (Mair & Smith 2005b). The most serious outcome of these complications was complete incisional dehiscence with intestinal protrusion, observed in four horses. Of these, only one horse survived, following surgical repair under general anaesthesia. This severe complication is associated with factors such as pregnancy and prior incisional infection (Hann et al. 2021). When dehiscence is detected, the use of an abdominal belt applied promptly has been recommended to prevent full incision breakdown and evisceration (Kelmer 2023).

Postoperative pneumonia was observed in 6.7% of cases, consistent with previously reported rates of 0–8% (Tyma & Epstein 2023). This condition has been linked to factors such as intra- and postoperative aspiration of gastric reflux, poor overall health, prolonged antibiotic administration and extended hospitalisation. In this study, the specific cause of pneumonia (e.g. aspiration or blood-borne bacteria) was not documented. In cases of equine colic, pneumonia could also result from accidental introduction of liquid paraffin into the lungs due to a misplaced or dislodged nasogastric tube, during efforts to relieve intestinal impaction prior to referral (Metcalfe et al. 2010). Notably, all horses diagnosed with pneumonia in this study survived to discharge.

SIRS and endotoxaemia are terms with distinct clinical conditions, though veterinarians often mistakenly use these terms interchangeably when describing a severely ill, colicking horse. (Moore & Vandenplas 2014). Endotoxaemia refers specifically to the presence of endotoxins, such as lipopolysaccharides from microbial sources, circulating in the blood stream. In contrast, SIRS is a clinical diagnosis caused by the systemic effects of inflammatory mediators produced by the horse's own immune system in response to acute gastrointestinal inflammation or ischaemia, without necessarily involving endotoxins (Moore & Vandenplas 2014).

Efforts to predict outcome in horses with SIRS have included the development of scoring systems based on abnormalities in HR, respiratory rate, temperature, white cell count, blood lactate concentrations and mucous membrane appearance (Roy et al. 2017; Long 2022). One such model demonstrated an 84% case-fatality rate in horses with the highest scores. While this model could not be directly applied to the population in this study due to differences in study design, it is possible that a different number of horses in this study would have been categorised as SIRS if this model had been utilised.

Four horses presumed to have SIRS developed laminitis, including one non-survivor. Laminitis is recognised as a complication of SIRS. Previously thought to result from the inflammatory effects of endotoxins (Parsons et al. 2007), laminitis is now recognised as a form of remote organ dysfunction secondary to the systemic inflammatory effects of SIRS on the hoof lamellae (Leise & Fugler 2021). In this study, the incidence of laminitis among post-surgical survivors was 5.3%, which aligns with the 4.4% incidence reported in a similar population (De La Rebiére de Pouyade et al. 2009).

In this study, repeat laparotomy was performed in 9.3% of cases, which is comparable to previously reported rates (4.6%–6.3%) (Spadari et al. 2023; Findley et al. 2017). However, the surgical survival rate in this study was lower (28.6% compared to 44.8%–50%) (Spadari et al. 2023; Findley et al. 2017). The two horses that survived to discharge were large intestinal impactions with no infectious or ischaemic lesions found during the second surgery. Repeat surgeries are expensive and carry increased risks, including endotoxaemic shock, incisional hernias, POI and colitis (Dunkel et al. 2015; Mair & Smith 2005c). Additionally, incisional site infections can occur in over half of these cases (Mair & Smith

2005c). However, the small number of horses undergoing repeat laparotomy in this study (7 out of 83) limits conclusions.

Several limitations should be considered when interpreting these findings. As a retrospective study, the quality of the data recorded was reliant on the accuracy and completeness of hospital records maintained during the horses' admissions. In some cases, these records were incomplete, requiring adjustments to the data analysis to account for missing information. Improved record-keeping practices would have mitigated this issue, expanded the sample size of the study population and enhanced the overall quality and reliability of the results.

Horses were evaluated by different clinicians whose treatment decisions and recommendations may have varied. The decision to perform humane euthanasia is complex, with individual clinicians and owners having different criteria or attitudes towards euthanasia (Sutton et al. 2009; Christophersen et al. 2014). Additionally, this study did not include long-term survival or the horse's return to previous levels of activity in its protocol. These factors should be considered for inclusion in future studies of this nature.

Conclusion

This study ascertained the survival rates of equine colic cases treated at OVAH between 2019–2021. Survival rates were comparable to international standards and showed significant improvement compared to the previous study of equine colic admissions at the OVAH from 1998–2007. This improvement was attributed to better surgical outcomes.

Prognostic indicators associated with outcomes included the type of treatment given, with lower survival rates observed in horses receiving surgical intervention compared to those treated medically. Among surgical cases, the site of pathology significantly influenced outcomes, with small intestinal lesions associated with poorer survival compared to large intestinal lesions. Although overall survival rates were lower in horses presenting with elevated HR or PCV, particularly within certain treatment groups, a substantial proportion of horses with elevated or even markedly increased values survived to hospital discharge. This finding suggests that HR and PCV have limited value as independent prognostic indicators. None of the studied signalment parameters were found to be predictive of outcomes.

Further research is therefore required to identify consistently reliable prognostic indicators which could be used to develop a scoring system appropriate for this population. Veterinarians should base management plans for equine colic cases on a comprehensive evaluation of the full clinical picture rather than relying on individual parameters.

Conflict of interest

The authors declare they have no conflicts of interest that are directly or indirectly related to the research.

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Ethical approval

Prior to the commencement of the study, ethical approval was obtained from the following ethical review board: U*niversity of Pretoria Research and Animal Ethics committees (REC 036-21).*

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ORIGINAL RESEARCH

Equine colic outcomes and prognostic factors at a South African academic hospital (2019 2021)

APPENDIX: Definitions of postoperative complications (INCISE AUDIT 2022 Appendix 1a)

Surgical site infection: any purulent or serous discharge from the surgical site with a duration over 24 hours.

Postoperative colic: signs of abdominal discomfort which necessitates analgesia to manage.

Postoperative reflux: collection of over 2 litres of gastric content after passing a nasogastric tube.

Postoperative pyrexia: at least one incident of a rectal temperature over/equal to 38.6 ºC

Postoperative diarrhoea: production of loose faeces for over 24 hours or on more than two consecutive incidents.

Repeat laparotomy: repeat laparotomy/celiotomy before the horse is discharged from hospital.

Systemic inflammatory response syndrome: horse had 2 or more of the following: heart rate > 60 beats/min; respiratory rate > 30 breaths/min; rectal temperature > 38.6 °C; leukocyte count > 12 500 cells/µl or < 4500 cells/µl and 10% band neutrophils.

Incisional dehiscence – total (linea alba): complete dehiscence of all abdominal wall layers, either partially or along the entire length of the incision line.

Abdominal – septic peritonitis: degenerative or toxic changes in neutrophils and presence of extra- or intracellular bacteria in peritoneal fluid.

Catheter related – thrombophlebitis: focal heat over area; subcutaneous perivenous tissues and venous wall thickening; ultrasonographic evidence of a thrombus; pain on palpation of area.

Laminitis: SIRS related: digital pulses bounding, weight shifting; requiring additional laminitis treatment (e.g. digital cryotherapy, extra analgesia).

Ocular – corneal ulceration: cornea positive for fluorescein stain uptake, requirement for ophthalmic therapy.

Other: the researcher entered in manually other postoperative complications that were diagnosed by the OVAH clinicians and recorded in the medical record.