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General Articles

Long-term survival of equine surgical colic cases. Part 1: Patterns of mortality and morbidity

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Summary

Postoperative complications and mortality can occur many weeks or months after colic surgery. We are interested in the long-term outcome of these cases. This study documents patterns of mortality and morbidity among 341 horses that recovered from colic surgery March 1998–August 2000. The progress of each horse was rigorously followed by periodic telephone and postal questionnaires. Event time data were recorded for each animal and a total of 321 horse years of survival, together with death from all causes, colic-related death and various postoperative complications.

Postoperative survival (of all horses excluding grass sickness cases) was triphasic over the first 600 days and there was marked mortality in the first 10 days postoperatively. The probability of survival postoperatively decreased to 0.87 by 10 days, 0.82 by 100 days and declined slowly to 0.75 at 600 days. Horses suffering from epiploic foramen entrapment had a significantly reduced probability of postoperative survival (RR = 2.1, P = 0.033). The causes of death for 104 horses that died postoperatively and the prevalence of postoperative complications are recorded for the study population. Postoperative colic was the most prevalent complication with 100 horses (29%) suffering one or more episodes. However, only 16 horses (4.6%) suffered 3 or more episodes. The incidence of postoperative colic was 0.55 episodes/horse year at risk. This study provides data that will inform the prognosis for postoperative colic cases and identifies epiploic foramen entrapment as carrying a worse prognosis for survival than other strangulating lesions.

Introduction

Colic is a major cause of morbidity and mortality in managed horse populations (Kaneene *et al.* 1997; Tinker *et al.* 1997). Many colic episodes resolve spontaneously or with medical management but 7–10% are fatal unless treated surgically (Hillyer *et al.* 2001). During the past 30 years, the prognosis for surgical treatment of equine colic has improved considerably and the success of colic surgery has been reviewed by Freeman *et al.* (2000). However, most reports are of short-term survival (i.e. survival to discharge from the hospital) or to a defined period postoperatively. As far as we are aware, only MacDonald *et al.* (1989) and Freeman *et al.* (2000) have conducted formal survival analysis of their postoperative colic cases. Survival analysis is the standard approach to evaluating the prognosis following medical or surgical intervention in the medical literature (Peto *et al.* 1976).

There is increasing pressure on veterinary surgeons to practise 'evidence based medicine', (Rossdale 2000). Veterinary surgeons need objective survival data in order to advise their clients of the likely outcomes of medical or surgical intervention and to establish their own selection of treatment options. Furthermore, veterinary surgeons must address the issue of medical/surgical audit and ensure that appropriate methods of monitoring postoperative outcomes and complication prevalence are being used.

The present report evaluates the long-term survival of postoperative colic cases. The study focuses on all events occurring after recovery from general anaesthesia including those that occur after discharge from the hospital. Specific objectives reported in this paper are the documentation and comparison of mortality rates between horses with different colic diagnoses, documentation of patterns of postoperative survival and the calculation of prevalence of postoperative complications.

TABLE 1: Proportion of cases in common (>10 cases) diagnostic categories

Diagnosis	No.	%
Small intestinal 216 cases		
Pedunculated lipoma strangulation	57	26
Grass sickness	30	14
Epiploic foramen entrapment (L-R)	20	9
Jejunal strangulation	20	9
Volvulus	15	7
Ileal impaction	13	6
Anterior enteritis	11	5
Large intestinal 97 cases		
Colon torsion <360°	27	28
Colon torsion >360°	20	21
Nephrosplenic entrapment	13	13

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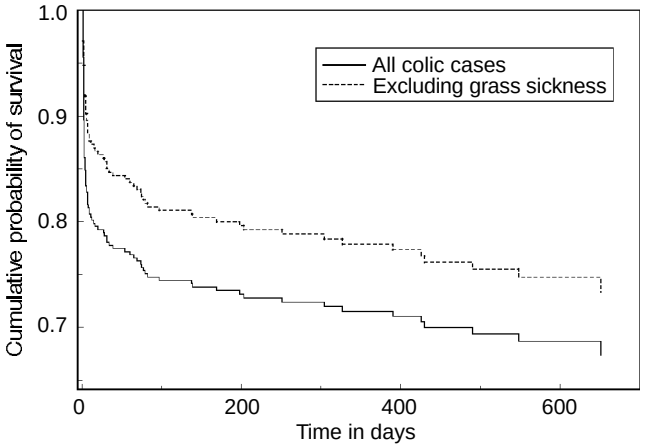

Fig 1: Kaplan-Meier plot of survival of all horses and for the study population excluding grass sickness cases.

Materials and methods

Case definition

Horses were recruited onto this study between March 1998 and August 2000. All horses recovering from exploratory laparotomy for acute, chronic or recurrent colic during this period were eligible for inclusion in the study. Recovery from general anaesthesia was defined as the horse walking out of the anaesthetic recovery box postoperatively. Details of horses that died or that were subjected to euthanasia during surgery or recovery from anaesthesia were recorded for comparison with the study population. On discharge from the hospital the study was discussed with horse owners and they received an information leaflet requesting their help with reporting of events.

Anaesthetic and surgical management

Twelve anaesthetists and 8 surgeons were involved in cases recorded by this study. Some variation in clinical practice was evident between individuals. Generally, anaesthesia was induced with either diazepam and ketamine or guiacol glycerine ether (GGE) and sodium thiopentone. The anaesthetic maintenance agent used was either halothane (218 cases) or isofluorane (123 cases).

All primary laparotomies were midline, *linea alba* incisions. Once the peritoneal cavity was open the contents were explored in a systematic manner until the obstruction or site of disease was identified (White 1990). Ischaemic lesions of small intestine necessitating resection of bowel were dealt with according to standard techniques. Distended intestine proximal to the lesion was decompressed via the ischaemic bowel prior to resection. Intestinal continuity was restored by means of an end-to-end jejuno-jejunal anastomosis. Jejuno-caecal anastomoses were performed in a side-to-side fashion, some were hand-sewn, others performed with a 75 or 100 mm stapling device. Large intestinal obstruction and displacement, including torsions of the large colon, were managed by standard procedures (White 1990). Closure of the *linea alba* was performed in a simple continuous pattern, usually in 2 or 3 sections depending upon surgeon. Absorbable polyglactin 910 (Vicryl)[1] was invariably the suture material used. Surgery time was recorded as the time from the first incision to the last suture being placed.

Horses were left to make an unassisted recovery from anaesthesia. Postoperative management regimens varied between clinicians and depending upon the nature of the colic problem. Most horses received postoperative nonsteroidal anti-inflammatory drugs for 2 days and antibiotics for at least 5 days. Fluid therapy was administered i.v. as necessary. Generally, horses were discharged from the hospital between 7 and 10 days postoperatively unless postoperative complications required a longer period of hospitalisation.

Data recording

Customised case history and clinical data recording forms were completed by the attending veterinary surgeon on admission to the hospital. Anaesthetic record charts were maintained throughout each surgical procedure and a comprehensive surgical report completed by the surgeon. Postoperative progress and complications occurring during hospitalisation were documented in the hospital records. Data from these paper records were coded and transferred to a computerised database after the horse was discharged from the hospital.

On discharge from the hospital, owners and referring veterinary surgeons were asked to inform the study team of any of the following events: death (any cause), death (colic-related),

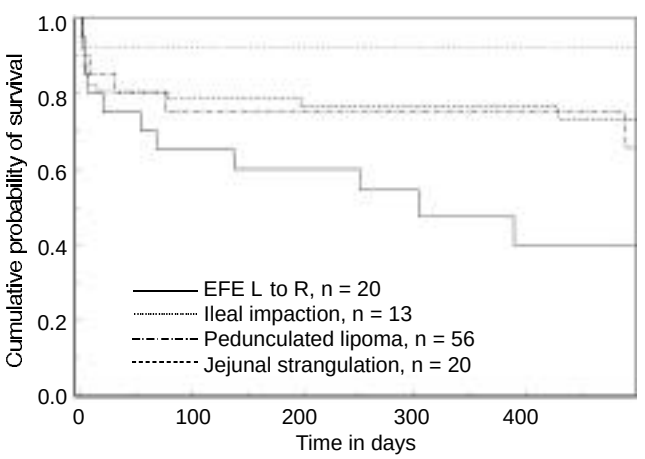

Fig 2a: Kaplan-Meier plot of survival probability for the 4 most commonly recorded small intestinal disease. EFE = epiploic foramen entrapment.

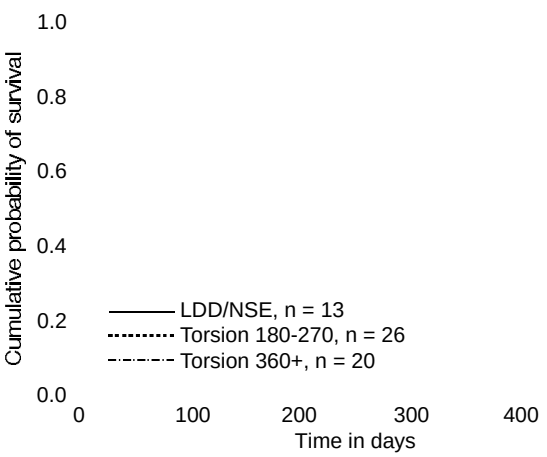

Fig 2b: Kaplan-Meier plot of survival probability for the 3 most commonly recorded large intestinal diseases. LDD = left dorsal displacement; NSE = nephrosplenic entrapment.

TABLE 2: Causes of death in 104 horses recovering from colic surgery

Cause of death	No.	Percentage of all deaths
Grass sickness	29	28
Colic related (no PME)	20	18
Peritonitis	12	12
Postoperative ileus	9	9
Gastric rupture	8	8
Unknown	8	8
Miscellaneous	18	17

PME = *postmortem* examination. Misc. category includes: small intestinal infarction (2), anastomosis obstruction (2), salmonellosis (2), small intestinal volvulus (1), adhesions (1), large colon torsion (1), large colon infarction (1), rectal perforation (1).

colic, diarrhoea, weight loss, wound suppuration, incisional hernia formation, return to ridden exercise and change of ownership. A dedicated telephone/fax line with a message recording facility was used for the study. In addition to owner-initiated reporting, periodic telephone and postal questionnaires were conducted. In the first year postoperatively, telephone questionnaires were conducted at 3 and 9 months postoperatively. A postal questionnaire was administered at 6 and 12 months postoperatively. Failure of an owner to respond to a postal questionnaire resulted in a telephone reminder 21 days later. Beyond 12 months postoperatively, owners were contacted by telephone every 6 months and the same questionnaire administered.

The questionnaires requested exact dates of events of interest. Where imprecise information was offered, owners were pressed for a more accurate date of an event. The date of weight loss was taken as the date of veterinary intervention. The date of wound suppuration and incisional hernia formation was taken as the date first noticed by the owner.

Censoring

Observations were censored if the owner could not be traced or if, following sale of the horse, a new owner was unwilling to participate in the study. The return of unreliable or inexact information from owners also resulted in censoring of observations on that horse. Observations on all surviving horses on the study were censored at the end of November 2000, 2 years and 9 months after commencement of the study.

Data analysis

Life table methods were used to construct Kaplan-Meier plots of cumulative probability of survival and of specific postoperative complications (Kaplan and Meier 1958). Univariable and multivariable relationships were explored using Cox proportional-hazards models (S-plus 6)[2]. Prevalence of the different recorded complications was calculated as was the incidence of postoperative colic (with 95% confidence intervals).

Grass sickness cases were excluded from the data set after preliminary analysis. These cases undergo exploratory laparotomy for confirmation of diagnosis by ileal biopsy and, if confirmed, were subjected to euthanasia (29/30 cases) within 48 h of surgery. Re-laparotomy (a second surgery within 7 days) was treated as an outcome variable. Horses were not re-recruited at the time of second surgery.

TABLE 3: Prevalence of postoperative complications amongst 311 horses (excluding grass sickness cases) recovering from colic surgery

	No. horses affected	Prevalence (% of horses recovered from surgery)
Colic	100 (177 episodes)	32.0
Wound suppuration	50	16.0
Jugular thrombosis	31	10.0
Ileus	30	9.6
Re-laparotomy	30	9.6
Incisional hernia formation	26	8.4
Diarrhoea	12	3.8
Laminitis	3	1.0
Salmonellosis	2	0.6

Results

A total of 341 horses were recruited into the study and 321 horse years of survival documented. During the study period, 32 colic cases failed to recover from surgery and were therefore ineligible for the study. The breed distribution of the study population reflected the hospital's referral population. Thoroughbreds and Thoroughbred crosses comprised 45% and ponies 19% of the population. Table 1 shows the number and proportion of cases in the most commonly encountered diagnostic categories. A total of 30 confirmed cases of grass sickness were excluded after the initial analysis.

A total of 769 telephone questionnaires and 213 postal questionnaires were administered. Response rates of 98% and 96% respectively were achieved. Of the 8 nonresponders to postal questionnaires, 7 responded to telephone administration of the same questionnaire. Five surviving cases were censored before the end of the study, one due to the unreliability of questionnaire responses, the other 4 due to change of ownership.

Patterns of survival

Figure 1 illustrates the pattern of survival for the whole cohort, and for the cohort excluding grass sickness cases. The difference between these 2 curves can be explained by the 96% mortality (29/30 cases) of grass sickness cases. For both curves a triphasic survival curve is apparent. For the cohort excluding grass sickness cases, there is marked mortality in the days immediately following surgery leading to a cumulative probability of survival of 0.87 by 10 days postoperatively. This is followed by a period of lower mortality up to approximately 100 days postoperatively. Beyond 100 days postoperatively the curve has a less steep gradient, possibly representing a similar mortality to the general equine population.

Survival of the most commonly encountered small intestinal cases is illustrated in Figure 2a. This demonstrates a probability of survival of 0.97 for ileal impaction cases, a nonstrangulating lesion of small intestine. This probability did not decline with time. Pedunculated lipoma strangulation and jejunal strangulation cases had a probability of survival of 0.8 by 100 days postoperatively and there is little decline in this probability with time. In contrast to these patterns of survival, epiploic foramen entrapment cases demonstrated a steady decline in the probability of survival throughout the observation period. By 100 days postoperatively the probability of survival was 0.7. Median survival time was 390 days. The gradient of the survival curve for epiploic foramen entrapment cases was significantly different to that of ileal impaction cases and

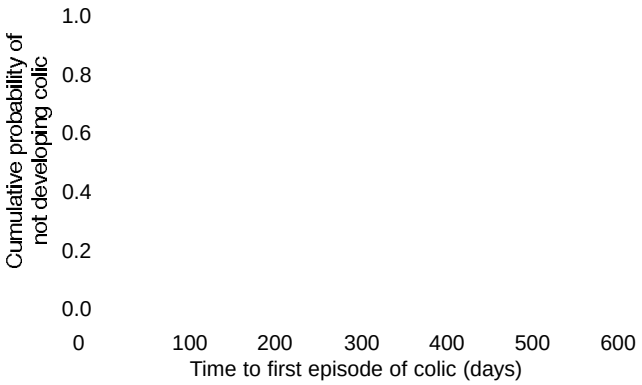

Fig 3: Kaplan-Meier plot of the probability of not developing colic postoperatively.

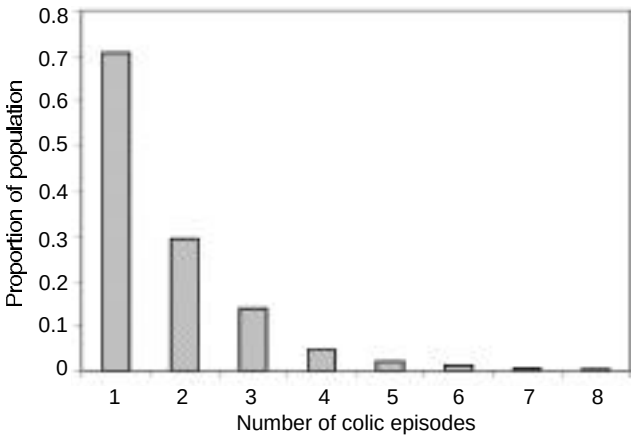

Fig 4: Histogram illustrating the proportion of horses suffering postoperative colic.

strangulating small intestinal lesions in a Cox proportional hazards model (relative rate = 2.11, 95% C.I. 1.42, 2.79, P = 0.033). Two of the epiploic foramen entrapment cases were nonstangulating, the other 18 had a mean resection length of 13.9 feet (compared to 14 feet for pedunculated lipoma strangulations).

The survival of common large intestinal cases is represented in Figure 2b. Nonstrangulating lesions (nephrosplenic entrapment and colon torsions of <270°) had a long-term probability of survival in excess of 0.9 which changed little with time. The probability of survival for strangulating colon torsions (>360°) declined to 0.8 by 100 days postoperatively but then remains constant with time.

Causes of mortality

Of the 104 horse deaths that were recorded during the study, 72 (69%) occurred prior to discharge from the hospital and 32 (31%) died after discharge. The most frequently reported causes of death are listed in Table 2. All 'colic related deaths' occurred after discharge from the hospital. This category includes all animals that died or were subjected to euthanasia on request by the owner due to recurrence of colic that required further surgical intervention, or following recurrent colic episodes.

Postoperative complications

The prevalence of postoperative complications in this population of horses is reported in Table 3. Postoperative ileus was recorded in 30 (9.6%) surgical survivors. Of these 30 horses, 29 (96%) were small intestinal cases, and 9 (30%) died or were subjected to euthanasia because of this complication. All cases of postoperative ileus occurred in hospitalised horses within a few days of surgery.

Thirty horses underwent re-laparotomy within a few days of their first surgical procedure. This represents 9.6% of all horses at risk. Of these 30 horses, 16 (53%) died or were subjected to euthanasia within the study period. Among horses that died, median time to death following re-laparotomy was 11 days. Median survival time following re-laparotomy was 77 days. The incidence of postoperative colic in horses undergoing re-laparotomy was 0.65 (0.35, 1.12) episodes/horse year at risk.

Twelve horses (3.8%) suffered diarrhoea postoperatively. Four of these 12 horses (33%) were subjected to euthanasia, 2 due to salmonellosis and 2 to peritonitis. All 4 fatalities occurred within 11 days of surgery. The 8 nonfatal diarrhoea episodes were transient only and none required veterinary intervention. Only 2 of the 8 episodes occurred in horses following large colon disease.

Postoperative colic

A total of 177 postoperative colic episodes reported were attended by veterinary surgeons. A further 66 episodes were reported which the owner considered to be colic but which were so mild that they did not warrant veterinary intervention. The time interval between surgery and the first postoperative colic episode is illustrated in Figure 3. The highest risk period for first colic is up to 100 days postoperatively. Beyond this time period, the gradient of the curve is less steep, although first postoperative colic was recorded up to a year after surgery. Figure 4 illustrates the frequency of postoperative colic amongst the surviving cohort. Although 100 horses (32% of postoperative survivors) suffered at least one postoperative colic episode, only 16 (5%) suffered 3 or more episodes. The 177 colic episodes recorded occurred during 321 horse years of monitored survival time giving an incidence of postoperative colic of 0.55 (0.47, 0.64) episodes/horse year at risk.

Discussion

The pattern of postoperative survival observed in the present study is similar in pattern to that described previously by MacDonald *et al.* (1989) and Freeman *et al.* (2000). These latter 2 studies focused on small intestinal surgery only whereas the present study documented survival after all colic surgery. The common pattern of postoperative mortality is a high mortality rate in the first few days postoperatively, continuing mortality at a lower rate up to 100–120 days, followed by a low level of mortality. Mortality for the postoperative colic population that survives beyond 100 days is 0.044 deaths/horse year at risk. This is higher than the figure of 0.025 deaths/horse year at risk for all-cause mortality reported by Tinker *et al.* (1997). This later phase of mortality is only observed in studies following horses after discharge from the hospital. Short term survival i.e. survival to discharge from the hospital, gives an incomplete picture of postoperative survival.

The high probability of survival observed in horses suffering from ileal impaction colic (0.97) is consistent with previous reports. Freeman *et al.* (2000) categorised small intestinal lesions

as strangulating (excluding horses undergoing jejunocaecostomy) or nonstrangulating and found no difference in survival between the groups. In the present study, small intestinal colic cases were categorised by diagnosis and differences in survival are apparent. Of particular interest is the higher mortality rate of epiploic foramen entrapment cases. Engelbert *et al.* (1993) reported 75% (12/16) survivors to at least 3 months, Vachon and Fischer (1995) 70% (31/44) to at least one year postoperatively. In the present study, cumulative probability of survival is 0.70 at 100 days and has fallen to 0.55 by one year. The higher mortality rate of epiploic foramen entrapment cases is an important factor to communicate to owners postoperatively. It may also inform decisions concerning re-laparotomy and intensive care. The reasons for the relatively worse survival of these cases, compared to other types of small intestinal strangulation, are unclear. The involvement of major blood vessels close to the foramen and the slow on set of strangulation in a foramen of fixed diameter may influence prognosis. This finding is worthy of further investigation.

Nonstrangulating diseases of the large colon had a long-term probability of survival in excess of 0.9. Although strangulating lesions (large colon torsions of >360°) had a high mortality rate in the first 100 days postoperatively, probability of survival then remained constant at 0.8 up to 500 days. This suggests that horses recovering from strangulating large colon torsion, which survive beyond 100 days have a good long-term prognosis.

Mortality within the first 100 days postoperatively is a feature common to horses recovering from strangulating lesions of both small and large intestine. The majority of cases (69%) that died during this period did so before discharge from the hospital and underwent *postmortem* examination. No single cause of death predominated. The 31% of cases that died after discharge rarely underwent *postmortem* examination, but most deaths were classified as 'colic related'. We speculate that adhesion formation, stricture at the site of anastomosis, incarceration through a mesenteric defect and re-strangulation are all possible causes of death in this group. It is significant that mortality in the first 100 days is observed specifically in horses with strangulating lesions. Is this a long-term effect of endotoxaemia resulting from bowel ischaemia or a consequence of bowel resection? This issue is explored further in Proudman *et al.* (2002).

The causes of death recorded for those horses initially recovering from surgery (Table 2) indicate the large number of grass sickness cases (with 96% mortality) in this study. Exclusion of these cases from further analyses is justified by the large number of cases, their high mortality rate and their early mortality which stops them from being at risk of suffering postoperative complications.

The most frequently reported postoperative complication was colic. In order to standardise case definition, only the 177 colic episodes attended by a veterinary surgeon were subjected to detailed analysis. The temporal pattern of postoperative colic was unexpected. It indicates that whereas the majority of first postoperative colic episodes occur within 100 days of surgery, they can occur up to one year postoperatively. The frequency graph of postoperative colic demonstrates that, although many horses suffered at least one colic episode, only 5% suffered 3 or more episodes. This information can be used to reassure the owners of horses that colic for the first time after surgery that this risk of persistent colic episodes is not high.

The incidence of colic in horses surviving colic surgery, 0.55 episodes/horse year at risk, is higher than that reported for normal horse populations. Tinker *et al.* (1997) reported a crude incidence of 0.1 episodes/horse year at risk; Uhlinger (1992) an incidence of 0.19 episodes/horse year at risk; Hillyer *et al.* (2001) an incidence of 0.072 episodes/horse year at risk in Thoroughbred racehorses. These data suggest that the incidence of colic is 2.8–7.6 times higher in horses that have undergone colic surgery. This finding is consistent with the report of Cohen and Peloso (1996) who identified previous abdominal surgery as a risk factor for colic (OR = 3.1, $P<0.0001$) and for chronic, recurrent colic (OR = 270, $P<0.0001$).

Wound suppuration was a major postoperative complication in this study with 16% of horses reported as suffering from it postoperatively. Previous reports vary widely in the prevalence of postoperative wound suppuration. Phillips and Walmsley (1993) reported 37% of 149 colic cases affected, MacDonald *et al.* (1989) reported wound complications (of all types) in 23% of 140 cases, and Kobluk *et al.* (1989) reported wound infection in 8.5% of 70 horses although 25.7% had drainage of some sort. This particular postoperative complication is clearly a major cause of postoperative morbidity. Risk factors for postoperative complications are the subject of further analysis of this dataset and will be reported separately (French *et al.* 2002).

The prevalence of postoperative ileus in the present study was 9.6% of horses surviving surgery. Comparison with other studies is difficult because of differences in the study population (small intestinal colic cases only vs. all cases), and in case definition. However, this figure is broadly similar to that of 10% reported by Freeman *et al.* (2000) for small intestinal colic cases. Hunt *et al.* (1986) reported a prevalence of 14% and MacDonald *et al.* (1989) reported a prevalence of 16%. Re-laparotomy, is now widely accepted as a treatment option in the management of ileus and postoperative colic (Huskamp and Bonfig 1985). The prevalence of re-laparotomy in this study (9.6%) is lower than that reported elsewhere (Vachon and Fischer 1995; Freeman *et al.* 2000). This probably reflects the policy towards re-laparotomy adopted by individual surgeons and institutions. Median survival time is low following re-laparotomy (77 days), a fact which should be considered when deciding whether to perform a second laparotomy. The incidence of colic in horses recovering from re-laparotomy is slightly higher than after a single surgery but many horses are likely to die before having chance to suffer from colic, an example of competing risks.

This study describes the long-term survival of postoperative colic cases that have been rigorously followed after discharge from the hospital. Patterns of survival are described for common diagnostic categories and the incidence of postoperative colic is reported. Horses suffering from epiploic foramen entrapment have a significantly lower probability of survival than those suffering from other strangulating obstructions. Data from this group of horses will be used in studies to model postoperative survival and to determine risk factors for postoperative complications.

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[2]Insightful Corporation, Seattle, USA.

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