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Survival and complication rates in 300 horses undergoing surgical treatment of colic. Part 1: Short-term survival following a single laparotomy

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Summary

***Reasons for performing study*: A minority of equine colic cases prove fatal unless treated surgically; however, few studies have considered long-term survival and complication rates, and few have attempted to identify factors that might affect outcomes. Such information is required for owners and veterinary surgeons to make informed decisions about the most appropriate treatment for individual cases.**

***Objectives*: To document short-term survival rates of 300 horses undergoing colic surgery and analyse factors that might have predisposed to short-term death.**

***Methods*: History, clinical and surgical findings, treatments and outcomes of 300 surgical colic cases (1994–2001) were reviewed. Comparisons among groups of discrete data were made using chi-squared or Student's *t* tests as appropriate. Significance was set at P<0.05, and 95% confidence intervals were calculated for percentages.**

***Results*: The short-term survival rate (to discharge) was 70.3% for all horses and 83.1% for those recovering from anaesthesia; for horses that had a single laparotomy it was 87.2%. The most common reasons for death/euthanasia in the post operative period after a single laparotomy were persistent pain/colic, post operative ileus and grass sickness. Horses with lesions involving the small intestine and caecum had lower survival rates (75.2 and 66.7%, respectively) than those with large colon or small colon lesions (89.9 and 100%, respectively). The survival rate for ischaemic/strangulating lesions (68.9%) was lower than for simple obstructions (90.5%).**

***Conclusions*: Short-term survival of horses undergoing exploratory laparotomy for acute colic is dependent on many factors, including the nature of the underlying disease, cardiovascular status and post operative complications.**

***Potential relevance*: These retrospective studies may be used as a basis for prospective studies assessing treatments that could ultimately improve survival and decrease complication rates.**

Introduction

Although the majority of cases of colic resolve either spontaneously or with simple medical treatment, a minority (up to 10%) prove fatal unless treated surgically (Hillyer *et al*. 2001). The surgical treatment of equine colic is expensive, and information about outcomes of surgical treatment is required for owners and veterinary surgeons to make informed decisions about the most appropriate treatment for individual cases (Mair 2002; Proudman *et al.* 2002a). Although there have been a number of previously published studies of survival rates of horses undergoing colic surgery (Tennant *et al.* 1972; Tennant 1975; Pearson *et al.* 1975; Huskamp 1982; Ducharme *et al.* 1983; Parry *et al.* 1983a; Pascoe *et al.* 1983; Reeves *et al.* 1986; Shires *et al.* 1986; White and Lessard 1986; Phillips and Walmsley 1993; Santschi *et al.* 2000), the majority of these originate from the 1970s and 1980s, and there are relatively few more recent studies. Few of these studies have considered long-term survival and complication rates, and few have attempted to identify factors that might affect the outcomes.

The short-term survival rates (i.e. rates of survival to discharge from the hospital) of 300 horses undergoing colic surgery at a private practice based in the southeast of England are documented in this report. Factors that might have predisposed to short-term death were also analysed. Further reports that document short-term complication rates and long-term survival and complication rates are described elsewhere (Mair and Smith 2005a,b). It is hoped that these retrospective studies provide data that can be used to plan prospective studies assessing treatments that could ultimately improve survival and decrease complication rates.

Materials and methods

Case records

The case records of 300 horses that underwent exploratory laparotomy at the Bell Equine Veterinary Clinic for acute colic between 1994 and 2001 were reviewed. Horses that died or were subjected to euthanasia without surgery (n = 48) were excluded. In all cases, T.S.M. was the primary surgeon. Information retrieved from the case records included subject details, use, previous medical history, details of current episode of colic, results of preoperative clinical and routine laboratory examinations, preoperative treatments, anaesthetic protocol, surgical findings and procedures, post operative treatments and complications.

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All first surgeries were midline *linea alba* incisions. The abdominal cavity was explored in a systematic fashion as described by White (1990). Following completion of surgery, horses were allowed to recover from anaesthesia unassisted.

The duration (to the nearest hour) of colic prior to examination was recorded if known, or estimated duration if the precise time of onset was not known. The severity of behavioural signs of pain at admission was recorded using a simple scoring system as follows: *grade 1* = no or mild pain (e.g. pawing, turning the head to the flank, lying down without rolling or sweating); *grade 2* = moderate pain (more severe pain with restlessness, crouching, kicking at the abdomen and rolling); and *grade 3* = severe pain (severe pain with sweating, violent rolling, extreme restlessness, and distress or depression). Faecal production in the 6 h prior to examination was classified as normal, reduced or absent based on history supplied by the owner. Short-term survival was defined as survival to discharge from the hospital.

Statistics

Data were entered into a statistics programme (Minitab for Windows Release 13)[1]. Descriptive statistics (mean ± s.d., median and range) were generated for continuous data. The evaluation of differences between survivors and nonsurvivors was undertaken using a Student's *t* test for continuous variables and a chi-squared test for categorical variables. The hypothesis was that pre- and intraoperative factors would affect the short-term survival following colic surgery. Significance was set at $P<0.05$, and odds ratios (OR) and 95% confidence intervals (95% CI) were calculated for categorical data. Results are stated in text as mean ± s.d.

Results

Case details

Subject details and management: Mean and median ages of the 300 horses were 11.3 ± 6.7 years and 10.0 years, respectively (range 1–32 years). The horses included 122 (40.7%) females, 162 (54.0%) geldings and 16 (5.3%) intact males. Eight of the mares were pregnant. Horses used for general riding activities were the most common type encountered.

History and clinical features: A history of previous episodes of colic was recorded in 109 horses (36.3%) and previous abdominal surgery in 6 horses (2.0%).

The mean and median duration of colic prior to admission to the hospital were 13.5 ± 12.4 h and 10.00 h (range 2.0–72.0 h), respectively. The severity score of pain at the time of admission was *grade 1* in 72 horses (24.0%), *grade 2* in 140 horses (46.7%) and *grade 3* in 88 horses (29.3%).

The nature of the colic was continuous in 169 horses (56.3%) and intermittent in 131 (43.7%). Attitude at admission was normal in 68 horses (22.7%), painful in 121 (40.3%) and depressed in 111 (37.0%). Faecal output prior to admission was normal in 4 horses (1.3%), reduced in 110 (36.7%) and absent in 186 (62.0%). Spontaneous gastric reflux was present in 3 horses (1.0%) at admission. Abdominal distension was recorded in 79 cases (26.3%). Heart rate at admission had mean and median values of 56 ± 16 and 55 beats/min, respectively. The capillary refill time at admission was <2 secs in 150 horses (50.0%), 2–3 secs in 121 horses (40.3%) and >3 secs in 29 horses (9.7%).

TABLE 1: Primary surgical procedures performed in 257 horses

Surgical procedure	No.	%	95% CI
Abdominal exploration and lavage only	1	0.4	0.00–0.02
Intestinal manipulation only	87	33.8	0.28–0.40
Small intestinal decompression only	29	11.3	0.08–0.16
Enterotomy only*	5	1.9	0.01–0.04
Large colon evacuation and lavage	18	7.0	0.04–0.11
Caecal decompression/evacuation	9	3.5	0.01–0.06
Small intestine resection and end-to-end jejunojejunostomy	30	11.7	0.08–0.16
Small intestine resection and side-to-side jejunojejunostomy	13	5.1	0.03–0.08
Small intestine resection and end-to-end jejunoileostomy	12	4.7	0.02–0.08
Side-to-side jejunocaecostomy (hand-sewed)	3	1.2	0.00–0.03
Side-to-side jejunocaecostomy (stapled)	33	12.8	0.09–0.17
Side-to-side ileocolostomy	2	0.8	0.00–0.03
Large colon resection and side-to-side anastomosis	4	1.6	0.00–0.04
Caecal apical resection	2	0.8	0.00–0.03
Small colon resection and end-to-end anastomosis	1	0.4	0.00–0.02
Small colon lavage	5	1.9	0.01–0.04
Small colon colotomy	3	1.2	0.00–0.03

*E.g. faecalith or foreign body removal.

Mucous membrane colour was normal (n = 79; 26.3%), pale (n = 84; 28.0%), congested (n = 112; 37.3%), toxic (n = 16; 5.3%), cyanotic (n = 8; 2.7%) or jaundiced (n = 1; 0.3%). Gut sounds at admission were normal (n = 46; 15.3%), reduced (n = 130; 43.3%) or absent (n = 124; 41.3%).

Mean and median packed cell volume (PCV) and total plasma protein (TPP) at admission were 38.3 ± 9.0 and 37.0% (n = 286), and 73.0 ± 11.3 and 70.0 g/l (n = 284), respectively. Abdominal paracentesis was attempted in 241 horses, and failure to obtain any fluid was recorded in 26 of these (10.8%). The fluid was normal in appearance (n = 122; 50.6%), sanguinous (n = 82; 34.0%) or frankly haemorrhagic (n = 1; 0.4%). Ten horses (4.1%) had peritonitis (total nucleated cell count >10.0 x 10^9/l with >90% neutrophils; TPP concentration >25 g/l).

General anaesthesia and surgery: Mean and median duration of surgery were 104 ± 40 mins and 100 mins (range 12–240 mins), respectively.

Of the 300 horses, 257 (85.7%) recovered from anaesthesia. Of these 257, resection of bowel was performed in 81 (31.5%); this included resection of small intestine (n = 74), caecum (n = 2), large colon (n = 4) and small colon (n = 1). Length of intestine resected was 5 cm–8 m (small intestine), 10–50 cm (caecum), 6–75 cm (large colon) and 8–30 cm (small colon). The different primary surgical procedures performed in the 257 horses are summarised in Table 1. Large colon evacuation and lavage via a colotomy at or close to the pelvic flexure was performed in a total of 173 horses. Ischaemic bowel was left in the abdomen at the completion of surgery in 18 horses (7.0%). This involved the ileal stump (n = 11), duodenum/proximal jejunum (n = 2), caecum (n = 2) or large colon (n = 3). Routine surgical procedures performed in these horses included peritoneal lavage with saline solution (sodium chloride 0.9% for irrigation)[2] prior to closure of the abdomen (n = 245; 95.3%) and intraperitoneal administration of heparin (Multiparin 1000 iu/ml)[3] (20,000 u) (n = 140; 54.5%). A sodium hyaluronate/modified carboxymethylcellulose/glycerol absorbable

TABLE 2: Lesions and short-term survival rates identified at initial surgery in 300 horses

Lesion	No.	%	STSR%
Small intestine			
Strangulation by pedunculated lipoma	39	13.0	64.1
Simple obstruction by mesenteric lipoma	2	0.7	100
Volvulus	12	4.0	83.3
Incarceration in mesenteric rent/band	8	2.7	37.5
Incarceration in epiploic foramen	15	5.0	20.0
Incarceration in inguinal hernia/rupture	5	1.7	80.0
Incarceration in umbilical hernia	1	0.3	100
Incarceration in diaphragmatic hernia	1	0.3	0
Incarceration in gastrosplenic ligament rent	1	0.3	100
Incarceration in ventral hernia	1	0.3	0
Obstruction by omental adhesions	5	1.7	80.0
Obstruction by mesenteric adhesions	6	2.0	83.3
Jejunal intussusception	1	0.3	0
Ileocaecal intussusception	4	1.3	100
Other ileocaecal obstructions	9	3.0	77.8
Ileal hypertrophy	1	0.3	0
Ileal impaction	6	2.0	100
Jejunal impaction	5	1.7	80.0
Obstruction by mesenteric abscess	2	0.7	50.0
Anterior enteritis	7	2.3	100
Diffuse enteritis	2	0.7	0
Perforated jejunal ulcer	1	0.3	0
Focal obstruction by inflammatory bowel disease	5	1.7	80.0
Focal obstruction by lymphoma	1	0.3	100
Ileus without discrete/physical obstruction*	7	2.3	28.6
Caecum			
Acute dysfunction	7	2.3	85.7
Torsion†	1	0.3	0
Caecocaecal intussusception	2	0.7	100
Caecocolic intussusception	4	1.3	0
Large colon			
Right dorsal displacement	42	14.0	93.0
Volvulus	51	17.0	64.7
Left dorsal displacement	8	2.7	75.0
Colonic impaction†	3	1.0	66.7
Colonic sand impaction	5	1.7	100
Retroflexion on pelvic flexure†	7	2.3	85.7
Nonstrangulating intestinal infarction	3	1.0	33.3
Faecalith obstruction	2	0.7	100
Colitis	3	1.0	66.7
Obstruction by omental adhesions	1	0.3	100
Focal obstruction by eosinophilic colitis	1	0.3	100
Small colon			
Impaction	4	1.3	100
Foreign body obstruction	1	0.3	0
Faecalith obstruction	3	1.0	66.7
Strangulation by pedunculated lipoma	1	0.3	100
Obstruction by ovarian pedicle	1	0.3	100
Obstruction by omental adhesions	1	0.3	100
Peritoneal cavity			
Peritonitis (no gastrointestinal lesion identified)	2	0.7	100

*Includes 4 cases of grass sickness; †includes one case of grass sickness; STSR = short-term survival rate.

adhesion barrier film (Seprafilm II)[4] was used in 23 horses (8.9%). Intraperitoneal antibiotics were administered at the time of surgery in 13 horses (5.1%) (sodium benzylpenicillin [Crystapen 5 Mega Injection][5] [n = 2] and metronidazole [Torgyl Solution][6] [n = 11]). An abdominal drain (Folec Latex Foley Catheter, 20–22 fg)[7] was placed in 15 cases (5.8%). Omentectomy was performed in 20 cases (7.8%).

Closure of the laparotomy wound was performed in a standard fashion in all horses. The *linea alba* was closed using a simple continuous suture of double-stranded 5 metric polyglactin 910 (Vicryl)[8]. Lavage of the wound with sterile saline after closure of the *linea alba* and before closure of the subcutaneous tissues was performed in 239 horses (93.0%). Crystalline benzyl penicillin[5] was applied topically to the wound prior to closure of the subcutaneous tissues in 212 cases (82.5%). The subcutaneous tissues were closed with 3 or 3.5 metric polyglactin 910[8] as a simple continuous suture in all horses. Dissection of the fascia from the edge of the *linea alba* was performed in 23 horses (8.9%). The wound was protected for recovery by a stent (n = 24; 9.3%) or an antimicrobial incise drape (Ioban 2)[9] (n = 104; 40.5%).

Post operative treatment: Post operative therapy in the 254 horses that recovered from anaesthesia (excluding 3 horses that died in the recovery period) included i.v. administration of Hartmann's solution (n = 252; 99.6%) and i.v. flunixin meglumine (Finadyne Solution)[5] (0.25 mg/kg bwt q. 8 h) (n = 251; 98.8%). Additional analgesia (flunixin meglumine[5] or phenylbutazone [Equipalazone injection][10]) was provided to horses demonstrating overt signs of pain as necessary. All horses received i.v. sodium benzylpenicillin[5] and gentamicin (Genta 100)[11]; the duration of i.v. antibiotic therapy varied from 3–14 days. Prokinetic drugs were administered in 36 cases (14.2%), including: lignocaine hydrochloride (Lidocain 2%)[12] (1.3 mg/kg bwt i.v. as a bolus followed by 0.05 m/kg bwt/min as an infusion) (n = 27); erythromycin lactobionate[13] (2.2 mg/kg bwt in 1 l saline i.v. over 60 mins q. 6 h) (n = 6); cisapride (Prepulsid)[14] (0.8 mg/kg bwt *per os* or *per rectum* q. 8 h) (n = 2); or metoclopramide hydrochloride (Metoclopramide)[15] (0.04 mg/kg bwt/h diluted in sterile Hartmann's solution administered as a constant rate infusion) (n = 1). The duration of prokinetic treatment was 4 h–6 days. Passage of a nasogastric tube post operatively was performed as deemed necessary, based on clinical parameters. Nasogastric intubation was performed in 140 horses (55.1%); this involved intermittent passage of a nasogastric tube (n = 136) or placement of an indwelling nasogastric tube (n = 4). Mean and median duration of hospitalisation were 7.2 ± 2.5 and 7.0 days (range 0–21 days), respectively.

Surgical findings, intraoperative complications and fatalities

The individual diagnoses are shown in Table 2. Death during anaesthesia (believed to be caused by endotoxic and hypovolaemic shock) occurred in 4 horses (1.3%), all of which had ischaemic intestine. Euthanasia was performed during surgery in 39 cases (13.0%). The reasons for euthanasia included rupture/perforation of a viscus in 10 horses (5 had pre-existing intestinal perforation, while rupture of intestine occurred during surgical manipulation in the other 5). In 29 horses (25 of which had ischaemic intestine), euthanasia was performed after discussion with the owner about the poor prognosis. The most common lesions identified in these 29 horses included large colon volvulus and small intestine strangulation by a pedunculated lipoma. The lesions identified in horses that died or were subjected to euthanasia during surgery are listed in Table 3.

Intraoperative complications were recorded in 7/257 horses (2.7%) that recovered from anaesthesia; haemorrhage from mesenteric vessels (n = 6) and sand contamination of the peritoneum (n = 1). Of the 257 horses, 3 (1.2%) had fatal complications during the recovery phase; unexplained death (n = 1), long bone fracture (tibia) (n = 1) and severe pulmonary oedema (n = 1).

TABLE 3: Lesions identified in 43 horses that died or were subjected to euthanasia under anaesthesia

Lesion	No.
Anaesthetic deaths	
Small intestine strangulation in epiploic foramen	2
Small intestine strangulation in mesenteric rent	1
Large colon volvulus	1
Euthanasia due to intestinal rupture/perforation	
Small intestine strangulation by pedunculated lipoma	1
Ileal hypertrophy	1
Small intestine obstruction by inflammatory bowel disease	1
Perforated jejunal ulcer	1
Caecocolic intussusception	1
Large colon volvulus	2
Left dorsal displacement of large colon	1
Right dorsal displacement of large colon	1
Small colon foreign body	1
Euthanasia due to poor prognosis	
Small intestine strangulation by pedunculated lipoma	6
Small intestine strangulation in mesenteric rent/band	2
Small intestine strangulation in epiploic foramen	2
Small intestine strangulation in diaphragmatic hernia	1
Small intestine obstruction by mesenteric abscess	1
Diffuse enteritis	2
Ileus	1
Caecocolic intussusception	1
Large colon volvulus	9
Left dorsal displacement of large colon	1
Nonstrangulating intestinal infarction of large colon	2
Small colon faecalith	1

Rate of post operative deaths after single exploratory laparotomy

The short-term survival rate (to discharge) was 70.3% for all 300 horses and 83.1% for 254 horses recovering from anaesthesia (excludes 3 horses that died during the recovery stage). A second laparotomy was performed before discharge from the hospital in 27/254 horses (10.6%). These cases are described elsewhere (Mair and Smith 2005c). Of 227 horses that recovered after a single surgery, 198 were discharged from the hospital, giving a short-term recovery rate of 87.2%. The reasons for death in 29 horses in the post operative period included persistent colic (n = 13), post operative ileus (n = 8), grass sickness (n = 5), severe shock (n = 1), colitis (n = 1) and myopathy (n = 1). The pathological findings in 27 of these horses where *post mortem* examination was performed included necrotic bowel and peritonitis (n = 12), ileus (n = 7), grass sickness (n = 5), gastric rupture (n = 2) and colon volvulus (n = 1).

Short-term survival rates and associations with pre- and intraoperative features

Overall short-term survival rates: The prevalence of lesions identified at the first surgery and their short-term survival rates (i.e. survival to discharge from the hospital) for all 300 horses are shown in Table 2. The lesions describe the surgical diagnoses made at the initial laparotomy.

Preoperative findings and short-term survival: There was no significant association between age, breed, sex or use and survival. There was no significant association between duration of colic and survival. Statistically significant differences in short-term survival were found for the following preoperative features: severity of pain, faecal production, heart rate, capillary refill time and gut sounds (Table 4). The recovery rate was lower for horses with normal faecal production compared to those with reduced faecal production.

TABLE 4: Association between severity of pain, faecal production, heart rate, capillary refill time and gut sounds at admission with short-term survival

	Total no.	No. (%) surviving	95% CI
Severity of pain score			
1 (mild)	72	53 (73.6%)	0.62–0.83
2 (moderate)	140	109 (77.9%)	0.70–0.84
3 (severe)	88	49 (55.7%)	0.45–0.66
Faecal production			
Normal	4	3 (75.0%)	0.19–0.99
Reduced	110	92 (83.6%)	0.75–0.90
Absent	186	116 (62.4%)	0.55–0.69
Heart rate (beats/min)			
30–39	24	22 (91.7%)	0.73–0.99
40–49	91	76 (83.5%)	0.74–0.90
50–59	57	44 (77.2%)	0.64–0.87
60–69	60	40 (66.7%)	0.53–0.78
70–79	29	13 (44.8%)	0.26–0.64
80–89	27	14 (51.8%)	0.32–0.71
>90	12	2 (16.7%)	0.02–0.48
Capillary refill time (secs)			
<2	150	121 (80.7%)	0.73–0.87
2–3	121	78 (64.5%)	0.55–0.73
>3	29	12 (41.4%)	0.23–0.61
Nature of gut sounds			
Normal	46	34 (73.9%)	0.59–0.86
Reduced	130	105 (80.8%)	0.73–0.87
Absent	124	72 (58.1%)	0.49–0.67

TABLE 5: Association between the site and pathological nature of the intestinal lesion and short-term survival

	Total no.	No. (%) surviving	95% CI
Site			
Small intestine	125	94 (75.2%)	0.67–0.82
Caecum	12	8 (66.7%)	0.35–0.90
Large colon	109	98 (89.9%)	0.83–0.95
Small colon	9	9 (100%)	0.72–1.00
Pathological lesion			
Simple obstruction	148	134 (90.5%)	0.85–0.95
Strangulating obstruction/ nonstrangulating infarction	103	71 (68.9%)	0.59–0.78

Intraoperative features and short-term survival: Period of surgery was not related significantly to survival rate. Excluding 2 horses with primary peritonitis and horses that died under anaesthesia, statistically significant differences in short-term survival were detected with respect to location and pathological nature of the lesion (excluding enteritis/colitis cases) (Table 5).

Of 257 horses that had surgery completed (including 3 horses that died during recovery), the short-term survival rate was significantly lower in those that had resection of bowel (56/81, 69.1%) compared with no resection (155/176, 88.1%; OR 0.3; 95% CI 0.15–0.62; P = 0.0002).

Survival rate among 298 horses that underwent surgery (excludes 2 horses with peritonitis and no identifiable intestinal lesion) was significantly higher for simple obstructions of small bowel (43/54, 79.6%) than for ischaemic obstructions of small bowel (51/93, 54.8%; OR 3.22; 95% CI 1.40–7.75; P = 0.003). The short-term survival rate was significantly higher for simple obstructions of large bowel (95/104, 91.3%) than for ischaemic obstructions of large bowel (20/47, 42.6%; OR 14.25; 95% CI 5.39–39.17; P<0.0001).

Survival rates for the different primary surgical procedures performed in 257 horses are shown in Table 6. Horses that had

TABLE 6: Association between short-term survival rates and primary surgical techniques in 257 horses

Surgical procedure	No.	Short-term survival rate (%)	95% CI
Abdominal exploration and lavage only	1	100	0.00–0.02
Intestinal manipulation only	87	94.2	0.28–0.40
Small intestinal decompression only	29	82.7	0.08–0.16
Enterotomy only	5	60.0	0.01–0.04
Large colon evacuation and lavage	18	83.3	0.04–0.11
Caecal decompression/evacuation	9	77.8	0.02–0.06
Small intestine resection and end-to-end jejunojejunostomy	30	76.7	0.08–0.16
Small intestine resection and side-to-side jejunojejunostomy	13	69.2	0.03–0.08
Small intestine resection and end-to-end jejunoileostomy	12	75.0	0.02–0.08
Side-to-side jejunocaecostomy (hand-sewed)	3	66.7	0.01–0.03
Side-to-side jejunocaecostomy (stapled)	33	69.7	0.09–0.17
Side-to-side ileocolostomy	2	0	0.00–0.03
Large colon resection and side-to-side anastomosis	4	50.0	0.01–0.04
Caecal apical resection	2	100	0.00–0.03
Small colon resection and end-to-end anastomosis	1	100	0.00–0.02
Small colon lavage	5	100	0.01–0.04
Small colon colotomy	3	100	0.01–0.03

ischaemic bowel left in the abdomen at the completion of surgery had a significantly lower survival rate (6/18; 33.4%) than those that did not (205/239; 85.8%; OR 0.08; 95% CI 0.02–0.26; P<0.0002).

Discussion

Since the 1970s there have been major advances in knowledge about the pathophysiological mechanisms involved with various forms of colic, in surgical and anaesthetic techniques, and in critical care of the pre- and post operative colic patient; these have been partly responsible for improvements in survival rates. Earlier referral is also likely to have had a positive influence on survival rates. However, as survival rates have increased, so the complications of colic surgery have become more apparent (Freeman *et al.* 2000; French *et al.* 2002). The nature of the complications of colic surgery may also have changed as success rates have increased. Surgery is notoriously difficult to evaluate objectively, and many studies are anecdotal and based on case series (Horton 1996). Although prospective studies are likely to generate more useful and scientifically robust data about survival and post operative complications (Proudman *et al.* 2002a,b), retrospective studies such as this are also helpful and provide valuable information on which future prospective studies can be based.

Previous studies have indicated that old age is both a risk factor for the development of colic and associated with a poorer prognosis for survival compared with younger horses (Pascoe *et al.* 1983; Reeves *et al.* 1989). It was surprising, therefore, that there was no significant association between age and survival in our study. This might suggest that old horses heal and survive colic surgery as well as young horses. However, it must be recognised that only univariable analysis of the data was undertaken in this study, and this takes no account of possible confounding effects between variables. This limitation of the study must be considered when evaluating the other results. For example, the short-term survival was significantly affected by the degree of faecal production prior to admission. However, the recovery rate was lower for horses with reduced faecal production compared to horses with normal faecal production. Such results are difficult to explain and may be erroneous; in this case, they may be related to large differences in the number of horses in the different categories.

This study assessed only surgeries performed by one primary surgeon. Although some studies have suggested that experience of the primary surgeon has no influence on outcome (Proudman *et al.* 2002b), others have shown that different surgeons have a major effect on outcome (Shires *et al.* 1986; Freeman *et al.* 2000). The potential influence of the surgeon on outcome and complication rates was excluded in the present study. There was a trend for decreasing survival rates with increasing surgery time identified in this study and that of Phillips and Walmsley (1993), and Proudman *et al.* (2002b) suggests that speed of surgery (which may be influenced by surgical experience) is an important issue. However, the nature of the lesion and the surgical techniques required will also have major effects on the duration of surgery. These variables are therefore likely to have been confounding factors in the present study, and may explain why the association between duration of surgery and outcome was not significant.

Direct comparison of the results of different studies of survival after colic surgery is difficult because of variations in the inclusion criteria and categorisation of cases. In addition, differences in decisions about whether to progress to exploratory laparotomy or euthanasia in horses presenting with signs of advanced endotoxaemia are likely to have marked effects on the short-term success rates. In one previous retrospective study of exploratory laparotomies undertaken in an equine practice in the south of England (Phillips and Walmsley 1993), 107 of 149 horses were discharged home, giving a short-term survival rate of 71.8%, which is comparable to a short-term survival rate in the present study of 70.3%. Interestingly, there are substantial differences in the relative prevalence of different lesions identified in the 2 studies, which potentially make direct comparisons misleading.

The pattern of post operative survival has recently been documented in detail by Proudman *et al.* (2002a,b). These show a high mortality rate in the first few days post operatively, continuing mortality at a lower rate up to 100–120 days, followed by a low level of mortality. Short-term survival rates (i.e. survival to discharge from the hospital) therefore give an incomplete and possibly unrealistic picture of post operative survival. However, the high mortality rates in the immediate post operative periods and the incidence of the different complications recorded in these periods provide valuable information on which future efforts to improve survival rates should be based. The most common post operative complications in this group of horses were post operative ileus (18.2%), persistent pain (32.1%) and endotoxaemic shock (13.9%) (Mair and Smith 2005a), and all appeared to have a significant effect on survival/death rates. The prevalence of these complications is, in turn, related to the nature of the original lesion and the duration of disease prior to surgery.

The survival rates were poorest in horses showing the most severe pain and the poorest cardiovascular status, which is in agreement with many previous studies (Greatorex 1972; Eikmeier 1973; Kalsbeek 1975; Berggren and Reinertson 1977; Parry *et al.* 1983a,b; Pascoe *et al.* 1983; Puotunen-Reinert 1986; Reeves *et al.* 1986; Orsini *et al.* 1988; Furr *et al.* 1995; Thoefner *et al.* 2000; Proudman *et al.* 2002b). The significant association between heart rate at admission and survival (Table 4) demonstrates the importance of cardiovascular status in affecting survival. This association is clear, despite the fact that many horses had received α_2 adrenergic agonist drugs, which are likely to have 'artificially'

lowered the recorded heart rates. Even though no significant association was shown between the duration of colic and outcome for all horses undergoing surgery, the importance of cardiovascular status implies that the speed of referral and the decision to undertake surgery are likely to have a major effect on the outcome in those horses with strangulating obstructions that rapidly develop cardiovascular compromise. No significant association between preoperative haematological and serum biochemical results and outcome were found in this study.

The survival rates were poorer for small intestinal obstructions compared to large intestinal obstructions, which also agrees with previous studies (Ducharme *et al.* 1983; Pascoe *et al.* 1983; White and Lessard 1986; Phillips and Walmsley 1993). The results of the present study demonstrated a higher short-term survival rate for horses with simple obstructions of small intestine (79.6%) compared with strangulating obstructions of small intestine (54.8%). These findings agree with those of Pascoe *et al.* (1983), but differ from several other studies (Ducharme *et al.* 1983; Phillips and Walmsley 1993; Freeman *et al.* 2000).

Short-term survival rates for small intestinal surgery (excluding horses that died under anaesthesia) reported over the past 15 years range from about 50% to about 85% (Engelbert *et al.* 1993; Phillips and Walmsley 1993; van der Welden and Klein 1993; Vachon and Fischer 1995; Singer and Livesey 1997; Freeman *et al.* 2000; Fugaro and Cote 2001; van den Boom and van der Velden 2001; Semevolos *et al.* 2002) and the rates found in the present study are clearly at the lower end of this range. Numerous factors may influence these recovery rates, making it difficult directly to compare the results between different studies. The presence of other underlying diseases (such as grass sickness) also influences the apparent recovery rates following small intestinal surgery. Recovery rates for horses with strangulating small intestinal lesions and horses that require resection of small intestine are lower than for all small intestinal surgery cases. Multiple pre-, intra- and post operative factors affect the short-term survival of horses with small intestinal disease, but a recent study (Morton and Blikslager 2002) identified the following factors to be most influential on survival; post operative ileus, necessity for repeat laparotomy, and elevated heart rate and low TPP concentration in the initial 24 h post operative period. Post operative ileus was the factor that placed horses at the greatest risk of nonsurvival in that study, and a similar association between the development of post operative ileus and reduced survival rates was also demonstrated in the present group of horses (Mair and Smith 2005a). The short-term survival rate for horses with small intestinal obstructions that developed post operative ileus was 50% compared with 90% in horses that did not develop ileus (Mair and Smith 2005a). In the study of Morton and Blikslager (2002), horses that developed post operative ileus were 29.7 times less likely to survive than horses that did not.

The importance of different surgical techniques in influencing short-term survival has been assessed by a number of workers. In the present study, strangulating obstructions of small intestine (which required surgical resection) were shown to be associated with a reduced short-term survival compared with simple obstructions of small intestine (which required no resection). Jejunocaecostomy has been associated with a reduced survival rate and higher complication rates (compared with horses having other forms of small intestinal surgery) in previous studies (MacDonald *et al.* 1989; Freeman *et al.* 2000). Reduced survival rates associated with this procedure have been attributed to the inability to resect all of the ileum, necessitating leaving devitalised bowel in some horses, and an increased rate of post operative ileus following jejunocaecostomy (Freeman *et al.* 2000). The jejunocaecostomy has also been associated with a tendency to mechanical complications that require early repeat laparotomy (Pankowski 1987). Potential reasons why the jejunocaecostomy may be prone to short-term complications include the possibility that horses requiring this procedure may have more severe forms of intestinal disease than others (Freeman *et al.* 2000). Also, the jejunocaecostomy results in the creation of a sharp transition between intestinal segments of dissimilar function. In addition, the jejunum must overcome intracaecal pressure to empty (Huskamp 1973) without the coordinating mechanism of the ileum and the ileocaecal valve (Roger and Malbert 1989; Ross *et al.* 1990; Freeman *et al.* 2000). In the present study, jejunocaecostomy was associated with a poorer survival rate than most other surgical procedures performed on the small intestine, but this association was not significant due to low numbers. However, there was a significantly lower survival rate for horses where ischaemic intestine was left in the abdomen at the completion of surgery compared with those where no ischaemic intestine was left; 4 of 11 horses that had a jejunocaecostomy and an ischaemic ileal stump left in the abdomen died.

In conclusion, the results of this study have identified a number of factors, both pre- and intra-operative, that appeared to affect the short-term outcome of horses undergoing surgical treatment of colic. Only univariable analyses of the data were undertaken in this study. Such analyses take no account of possible confounding between variables, and this fact must be taken into consideration in the assessment of the results. Although it may not be possible to amend the preoperative factors, greater emphasis on preoperative interventions (such as stabilising and improving the cardiovascular status) might improve the overall survival rates. There was no significant association between duration of colic and survival in this study, which was surprising. However, it must be recognised that the duration of colic was estimated in many cases, and the influence of duration of colic on survival is likely to vary depending on the nature of the disease (for example, the chances of survival will be much higher for a horse with a displacement of the large colon of several hours duration, compared with a horse with a large colon volvulus). These variables were not taken into account in this study, and the speed of diagnosis and referral are important factors that can directly influence short-term survival rates (Freeman *et al.* 2000). Improvements and changes in surgical techniques may, in the future, allow modification of some of the intraoperative factors that influenced short-term survival, but prospective studies assessing the effect of such interventions on short-term survival will be needed.

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Manufacturers' addresses

[1]Minitab Inc., State College, Pennsylvania, USA.
[2]Ivex Pharmaceuticals, Larne, Co. Antrim, UK.
[3]CP Pharmaceuticals Ltd, Wrexham, Denbighshire, UK.
[4]Genzyme Corporation, Cambridge, Massachusetts, USA.
[5]Schering-Plough Animal Health, Uxbridge, Middlesex, UK.

[6]Merial Animal Health Ltd, Harlow, Essex, UK.
[7]SIMS Portex Ltd, Hythe, Kent, UK.
[8]Ethicon Ltd, Edinburgh, Midlothian, UK.
[9]3M Healthcare, Borken, Germany.
[10]Arnold's Veterinary Products Ltd, Shrewsbury, Shropshire, UK.
[11]CP-Pharma, Burgdorf, Germany.
[12]A. Albrecht, Aulendorf, Germany.
[13]David Bull Laboratories, Warwick, Warwickshire, UK.
[14]Janssen-Cilag, Boulogne, France.
[15]Berk Pharmaceuticals Ltd, Bradford, Yorkshire, UK.

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