Perioperative plasma cortisol concentration in the horse

G F Stegmann[a*] and R S Jones[a]

ABSTRACT

The cortisol response to anaesthesia and surgery was studied in 2 groups of horses undergoing either abdominal or non-abdominal surgery. The preoperative mean plasma cortisol concentration (pcc) of 381.7 nmol/ℓ (s.d. 254.7) was markedly higher in the abdominal group than the early-morning mean pcc of 115.6 nmol/ℓ (s.d. 78.4) in the non-abdominal group. During halothane anaesthesia and surgery the mean pcc increased significantly ($p < 0.05$) from the preoperative mean of 119.2 to 215.9 nmol/ℓ (s.d. 79.8) after 30 min of surgery in the non-abdominal group. In the abdominal group a decrease occurred after induction of anaesthesia and surgical preparation, but increased during surgery to a mean pcc of 418.1 nmol/ℓ (s.d. 236.5). In the postoperative period a large decrease in the mean pcc occurred after 24 h in the abdominal group. It was only after 60 h that the pcc (153.2 nmol/ℓ) equalled the pcc of the non-abdominal group (171.4 nmol/ℓ) at 24 h . The slow decline over 60 h could be an indication of the prolonged recovery associated with abdominal surgery in the horse.

Key words: anaesthesia, cortisol, horse, surgery.

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INTRODUCTION

Anaesthesia and surgery are often required for treatment of various conditions in the horse, and the mortality rate for emergency abdominal surgery (colic) is reported to be 13 times higher compared with other surgical procedures[7]. The metabolic and hormonal response to anaesthesia and surgery in the horse have been documented[10,16]. Emergency abdominal surgery results in large increases in plasma cortisol concentrations compared to non-abdominal surgery[5]. The stress response may be influenced by anaesthesia and surgery. It is characterised by increased sympathetic nervous system activity, and the release of endocrine substances, of which cortisol is regarded as one of the important mediators. Of particular concern is the effect of a negative nitrogen balance and the net breakdown of protein during surgical recovery[20]. Perioperative factors that may alter plasma cortisol values during anaesthesia and surgery in the horse have not been fully investigated, and the clinical significance of high plasma cortisol concentrations during abdominal surgery is unknown. The purpose of this study was to investigate the perioperative plasma cortisol concentration (pcc) in clinical cases scheduled for either abdominal or non-abdominal surgery, and to elucidate the effects of anaesthetic induction, surgical incision, manipulation of the intestines and recovery from anaesthesia and surgery.

MATERIALS AND METHODS

The horses in this study were clinical cases referred for examination and possible treatment to the Equine Division, Department of Veterinary Clinical Science, University of Liverpool, and was performed under Home Office Project Licence PIL 40/02353. All cases requiring surgery during a 4-month period were included in the study. The age, sex, breed, body mass, type of surgery performed, surgical time and quality of recovery from anaesthesia are summarised in Table 2. The horses were divided into 2 groups depending on the type of surgery performed: non-abdominal (21 cases) and abdominal (15 cases). The former group involved either soft tissue or orthopaedic surgery. All cases were stabled at Leahurst, in the veterinary hospital. The non-abdominal cases were scheduled for surgery only after a complete diagnosis was made, and starved overnight for anaesthesia and surgery the following morning.

The abdominal group consisted of horses requiring surgery involving the abdominal cavity. The cases that required relief of intestinal obstruction involved extensive manipulation of the intestines, and could also include an enterectomy. These horses arrived after-hours and were operated on between 18:00 and 06:00. The other cases in the abdominal group required minimal or no handling of the gut, and were operated on during the day, similar to the non-abdominal group.

The horses scheduled for non-abdominal surgery were premedicated at 08:00 with acetylpromazine (ACP, C-Vet, Leyland) at a dose of 0.02 mg/kg administered by intramuscular injection, but this was omitted in horses scheduled for abdominal surgery. Anaesthesia was induced 60 min later at 09:00 by intravenous administration of guaiphenesin (Gujatal, Aesculaap) at 70–80 mg/kg, given until the horse became uncoordinated. This was followed by an intravenous bolus of thiopentone sodium (Intraval Sodium, Rhône-Poulenc) at a dose of 6 mg/kg. After endotracheal intubation, anaesthesia was maintained with halothane administered in oxygen from an out-of-circle precision vaporiser (Fluotec Mark 3, Ohmeda). A large animal circle anaesthetic machine with soda lime carbon dioxide absorption (Bowring Engineering) was used. The oxygen flow rate was set at 2ℓ/100 kg/min after induction and reduced to 1ℓ/100 kg/min for maintenance of anaesthesia. The vaporiser dial was set at 6–8 % after intravenous induction and subsequently reduced to 2 % for anaesthetic maintenance when a medium plane of surgical anaesthesia was reached, indicated by a sluggish anal reflex and the palpebral reflex just absent. Ventilation was spontaneous. The electrocardiogram, heart rate and arterial blood pressure (systolic, diastolic and mean) were recorded with a Tektronic 400 Recorder (Spacelabs, California). The arterial blood pressure was measured directly from a catheterised facial artery in dorsally recumbent horses or the transverse facial artery in laterally recumbent horses, and intraoperatively recorded at the time of blood-sample collections.

Animals with painful conditions, *e.g.*

[a]Department of Anaesthesia, University of Liverpool, Leahurst, Neston, South Wirral L64 7TE, United Kingdom.

*Present address: Department of Surgery, Faculty of Veterinary Science, University of Pretoria, Private Bag X04, Onderstepoort, 0110 South Africa.

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Table 1: **Perioperative mean and standard deviation of equine plasma cortisol concentration** (nmol/ℓ).

Collection time		Non-abdominal			Abdominal		
		Mean	s.d.[a]	*n*	Mean	s.d.	*n*
1.1	Arrival	–	–		381.7	±254.7	15
1.2	Early morning	115.6	±78.4	21	–	–	
1.3	Preinduction	122.3	±67.1	21	446.3	±332.9	15
1	Preoperative mean	119.2	±72.3	21	414.0	±298.1	15
2	Surgical preparation	124.8	±66.8	21	408.5	±232.1	15
3	Incision	145.5	±82.5	21	387.5	±210.9	15
4	30 min surgery	215.9*	±79.8	10	402.4	±173.9	12
5	60 min surgery	202.6	±91.9	4	418.1	±236.5	8
6	90 min surgery	188.3	–	1	391.6	±239.3	5
7	120 min surgery	138.6	–	1	368.7	–	1
8	Completion[b]	187.4	±94.7	21	395.0	±171.9	15
9	Standing[c]	220.8	±106.0	21	439.1	±215.3	15
10	24 h postoperative	171.4	±89.2	21	328.4	±112.1	15
11	36 h postoperative	138.3	±101.8	21	348.6	±229.1	15
12	48 h postoperative	121.2	±87.2	21	321.5	±316.6	15
13	60 h postoperative	88.6	±27.9		153.2	±24.3	15

[a]s.d. = standard deviation.
[b]Completion = sample taken at the end of surgical procedure irrespective of surgical time.
[c]Standing = standing after recovery from anaesthesia.
*Indicates a significant increase ($p < 0.05$) from the early-morning plasma cortisol concentration.

the emergency abdominal cases or the fracture cases, may have received analgesic treatment from the referring veterinarian. Analgesics such as the non-steroidal, anti-inflammatory agents *e.g.* flunixin meglumine, or the alpha$_2$-agonists such as xylazine hydrochloride were commonly used. The intravenous administration of a balanced polyionic fluid was initiated during clinical examination in the abdominal cases and continued after induction of anaesthesia to maintain arterial blood pressure at a minimum of 8 kPa. The volume of fluid administered during this period was determined by the hydration status (as judged from the preoperative haematocrit and skin fold elasticity) and the intra-operative mean arterial blood pressure. The volume administered varied between 5 and 20 ℓ. If maintenance of this pressure was not possible with fluid alone during surgery, dobutamine (Dobutrex, Eli Lilly) was administered additionally as an intravenous infusion at a dose of 2–5 μg/kg/min. The dobutamine was diluted (50 mg in 200 mℓ normal saline) and the infusion rate adjusted individually to maintain arterial blood pressure above 8 kPa.

The quality of recovery was scored on a scale of 1 to 3. A score of 1 was awarded if the horse stood at the 1st attempt, 2 if more than one attempt was required to stand, and 3 if the horse became excited and the recovery violent.

During the postoperative period, intravenous fluid therapy was continued in the abdominal group for 2–3 d, depending on the period that water and food was withheld to allow for surgical recovery of the gut, especially after an enterectomy. In both groups either flunixin meglumine (Finadyne, Schering Plough, Welwyn Garden City) at 1 mg/kg or butorphanol (Torbugesic, Willows Francis, Crawley) at 0.1 mg/kg was administered when required for pain relief during this period.

A 14-gauge teflon catheter was placed in both jugular veins under local anaesthesia. One was used to administer drugs and fluids, and the other to withdraw blood samples. Blood samples were collected preoperatively at predetermined intervals (Table 1), every 30 min during anaesthesia and surgery, and postoperatively at 12 h intervals. The samples were collected in fluorinated EDTA glass tubes and centrifuged within 30 min of collection. The plasma was decanted into plastic vials, stored at –20 °C, and subsequently analysed in batches for cortisol concentration by a radioimmunoassay technique as previously verified and characterised in this laboratory[1]. Blood samples for arterial blood-gas analysis were anaerobically collected at the time of surgical incision from the catheterised facial artery into heparinised syringes, stored in iced water and analysed within 30 min with a blood-gas analyser (Model 178, Corning Medical Scientific, Medfield, Massachusetts).

Statistical analysis

The variability of data was expressed by using standard deviation. Means and standard deviations (s.d.) were calculated using standard methods. Data were analysed with the Statistical Analysis Systems (SAS) software programme using a 1-way analysis of variance (ANOVA) for repeated measures. If significant differences were found, the Wilcoxon signed-rank test was applied to identify significant differences within the groups. Student's *t*-test was used for significant differences between groups. Differences were statistically significant if $p < 0.05$.

RESULTS

Thirty-six cases were included in this study, 15 of which involved abdominal surgery. In the non-abdominal group, 11 cases involved soft-tissue surgery and the other 10 cases were orthopaedic.

The mean pcc is listed in Table 1 and the changes over time plotted in Fig. 1. The mean pcc over the total sampling period for the abdominal group was 575.3 nmol/ℓ and significantly ($p < 0.05$) higher compared to 356.6 nmol/ℓ for the non-abdominal group. At arrival in the hospital the mean pcc of 381.7 nmol/ℓ (s.d. 254.7) in the abdominal group was markedly higher compared to the early morning sample of 115.6 nmol/ℓ (s.d. 78.4) in the non-abdominal group, *i.e.* before premedication. A further increase in the pcc occurred in the abdominal group to a mean of 446.3 nmol/ℓ (s.d. 332.9) after clinical examination and just before induction of anaesthesia. After induction and surgical preparation the concentration decreased to 387.5 nmol/ℓ (s.d. 210.9). During abdominal exploration and surgery the concentration increased to a mean of 418.1 nmol/ℓ (s.d. 236.5) with a maximum pcc of 1135.2 nmol/ℓ obtained from the 5-year-old gelding during enterectomy (Table 2). The mean at completion of surgery was 395 nmol/ℓ (s.d. 171.9). Recovery from anaesthesia resulted in a further increase in the concentration to 439.1 nmol/ℓ (s.d. 215.3). During the postoperative period the concentration decreased to a mean of 328.4 nmol/ℓ (s.d. 112.1) within 24 h and 153.2 nmol/ℓ (s.d. 24.3) after 60 h.

In the non-abdominal group, pcc was marginally increased after premedication, induction of anaesthesia and surgical preparation to 145.5 nmol/ℓ (s.d. 82.5). During the 1st 30 min of surgery the mean concentration increased significantly ($p < 0.05$; Table 1) from its preoperative mean of 119.2 to 215.9 nmol/ℓ (s.d. 79.8). Very little change in the mean concentration occurred thereafter until completion of surgery. Recovery from anaesthesia increased the concentration from a mean of 187.4 nmol/ℓ (s.d. 94.7) at completion of surgery to 220.8 (s.d. 106). Twenty-four hours postoperatively the concentration

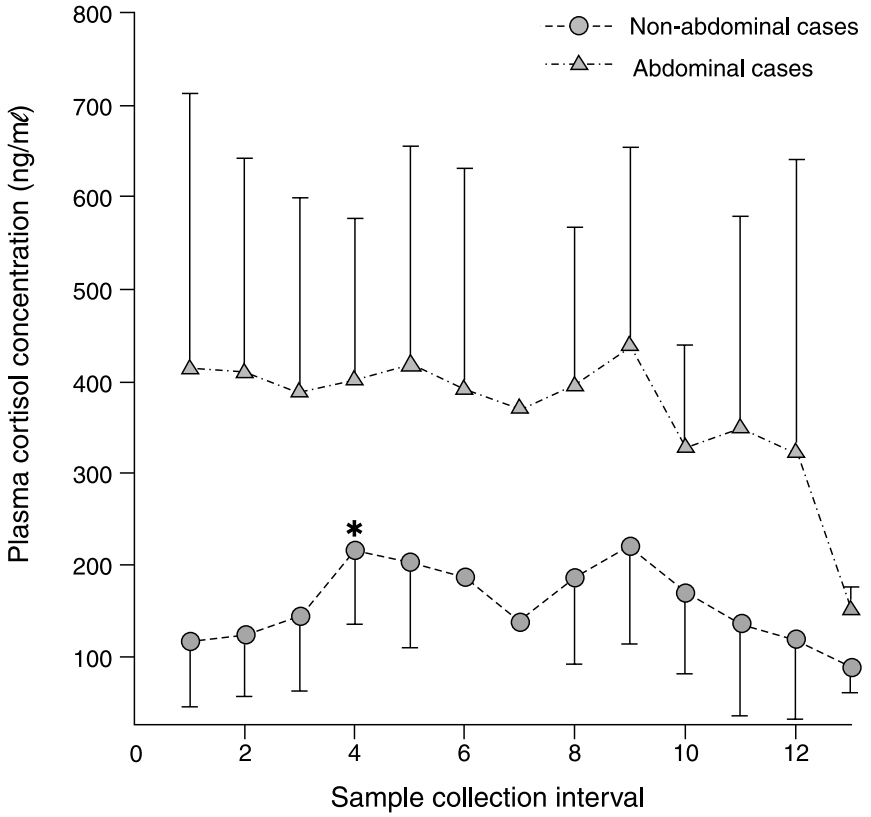

Fig. 1: **Perioperative plasma cortisol concentration in abdominal and non-abdominal cases.** Values represent mean ± s.d. Y-axis markings correspond with the blood sample collection intervals as numbered in Table 1. ✱ Indicates a significant increase in cortisol concentration from the preoperative value.

decreased to 171.4 nmol/ℓ (s.d. 89.2) and at 60 h postoperatively it declined to 88.6 nmol/ℓ (s.d. 27.9).

Results from the arterial blood gas analysis are listed in Table 3. The mean, minimum and maximum values for pH in the abdominal group was 7.2 (7.23–7.37) compared to the mean, minimum and maximum values for pH 7.3 (7.16–7.48) in the non-abdominal group. The partial pressure for CO_2 in the abdominal group varied between a minimum of 5.6 and a maximum of 12.5 kPa (mean 7.9) as compared to 6.2 and 9.4 kPa (mean 7.5) in the non-abdominal group. The partial pressure of O_2 varied between a minimum of 6.8 and a maximum of 50.2 (mean 27.9) in the abdominal group compared to 5.6 and 55.2 kPa (mean 28.3) in the non-abdominal group. The base excess in the abdominal group varied between –9.0 and +7.5 as compared to –2.8 and +5.4 in the non-abdominal group.

Arterial blood pressure and heart rate are demonstrated in Table 3. The mean heart rate in the abdominal group was 51 beats/min (s.d. 14) as compared to 39.6 beats/min (s.d. 14) in the non-abdominal group. The mean arterial blood pressure varied between a minimum of 4.3 and a maximum of 15.6 kPa (mean 8.5, s.d. 3.6) in the abdominal group in comparison to a minimum of 5.3 and a maximum of 15.3 kPa (mean 8.7, s.d. 2.4) in the non-abdominal group. The mean haematocrit in the abdominal group before fluid administration varied between 0.30 and 0.45 (mean 0.38, s.d. 0.05).

Surgical time is reported in Table 2. The mean time for both groups was similar: for the abdominal group it was 1.9 h, ranging from 15 min to 4.5 h. In the non-abdominal group mean surgical time was 1.75 h, ranging from 1 to 4 h.

In the abdominal group, 14 % of horses experienced a violent recovery, while 40 % scored 2 and 46 % 1. In the non-abdominal group, 10 % experienced a violent recovery while 47 % scored 2 and 43 % 1.

DISCUSSION

The pcc in the horse may be influenced by various factors that may include the circadian rhythm in cortisol secretion[4], transport[3], drugs administered[9], disease[5], and anaesthesia and surgery[11]. In this investigation the pcc in the abdominal group was more than 3 times higher compared with the non-abdominal group at induction of anaesthesia (Table 1). Both groups were affected by a variety of conditions that required treatment, and which varied between emergency abdominal surgery to elective removal of a skin neoplasm. They were subjected to different treatments during the perioperative period as dictated by their respective clinical condition.

The horses in the non-abdominal group were starved overnight and premedicated with acetylpromazine 1 h before induction of anaesthesia. No change in pcc was observed with the acetylpromazine at a dose of 0.02 mg/kg. An increase in cortisol concentration in the horse had been reported previously after the administration of acetylpromazine at a dose of 0.5 mg/kg[9], which is considerably higher than the dose used in this investigation, and commonly used for premedication. Starvation may also increase pcc[3]. The pcc of 122.3 nmol/ℓ from the non-abdominal group in this investigation was within the range of 51.4–160.0 nmol/ℓ previously reported for donkeys[3], and 53.2–88 for horses over a 24 h period with the peak occurring at 06:00 and the trough at 24:00[4]. The period of peak cortisol secretion occurs around 06:00 to 09:00, which coincided with anaesthesia and surgery in the non-abdominal cases. The pcc for horses scheduled for arthroscopic surgery was previously reported to be 141 nmol/ℓ, which is somewhat higher than the mean of 115.6 nmol/ℓ recorded in this investigation for non-abdominal cases. Following surgical incision the concentration increased to 215.9 nmol/ℓ compared to a mean of 232.9 nmol/ℓ recorded with arthroscopic surgery[10]. From this investigation, no indication was found that painful conditions, other than acute intestinal obstruction, resulted in the same magnitude of increase in pcc, although preoperative administration of analgesics may have influenced preoperative concentrations in both groups. For example, the pcc in the horse with a fracture of phalanx 1 (Table 2) was 78 nmol/ℓ at completion of surgery.

The horses that required emergency abdominal surgery were transported to the hospital for urgent treatment and possible surgery. Blood sample collection for cortisol assay occurred after arrival during clinical examination. Transport induces an increase in pcc in donkeys[3] and this may also apply to horses that are not subjected to road transport regularly[6]. Upsetting the normal management pattern of a horse with transportation, and subjecting it to unaccustomed practices at the veterinary hospital, may disturb the normal circadian rhythm of cortisol secretion. The abdominal pain experienced by many of these cases results in physical distress, and possibly the increase in plasma cortisol seen after clinical examination in this investigation may have been compounded by procedures such as placement of a stomach

Table 2: **Breed, age, sex, body mass, surgical procedure, surgical time and quality of recovery from anaesthesia.**

Breed[a]	Age[b] (years)	Sex[c]	Mass (kg)	Surgical procedure	S-time[d] (hr)	Recovery[e] (1–3)
Non-abdominal cases						
Pony	10	g	260	Mandibular fracture pinning	1.8	1
TBX	10	f	550	Tarsal arthrodesis	2	3
Hackney	6	g	500	Tibial crest sequestrum	2	2
TB	3	f	560	Fracture phalanx 1	4	3
TBX	4	f	500	Carpal fracture	3.5	2
Pony	3	f	360	Tooth extraction	2	2
Draught	8	g	660	Arthrodesis	4.5	1
TB	1	g	400	Arthrotomy	2.25	2
Pony	15	g	300	Biopsy preputium	0.25	2
TB	6	f	560	Sarcoid excision	0.25	1
TB	14	g	400	Penis amputation	1.25	2
TBX	19	m	400	Penis amputation	1	2
TB	17	g	430	Quittor	2	1
TB	3	g	450	Rhinotomy	2	2
TB	5	f	480	Tendon exploration	1.75	2
Hunter	9	g	460	Desmotomy	2	1
Hunter	12	g	650	Neurectomy	1.2	1
Dutch draft	7	g	750	Excision skin neoplasm	0.8	2
TB	2 w	f	70	Osteotomy	0.5	1
Pony	14	g	400	Laryngeal entrapment	2	1
Draught	7 w	f	150	Osteotomy	2.5	1
Abdominal cases						
TB	3	g	450	Enterectomy	1	2
TB	5	g	400	Enterectomy	2	1
Warmblood	4	f	650	Abdomen wound dehiscence	1	2
TBX	20	f	530	Enterectomy	4	3
TB	5	g	460	Enterectomy	1.5	2
Pony	6 w	f	75	Biopsy duodenum	1	1
Pony	2 m	m	90	Biopsy duodenum	2	2
Trotter	2	m	320	Cryptorchidectomy	1	1
TB	2	g	400	Scirrous cord	0.75	1
Anglo-Arab	4	g	450	Scirrous cord	1.5	2
TBX	14	f	420	Enterectomy	2.25	1
TB	6	g	500	Enterectomy	1.5	2
Hunter	11	g	600	Enterectomy	4.5	1
Welsh Pony	7	g	200	Bowel manipulation	1	1
Pony	1	m	400	Cryptorchidectomy	1.25	3

[a]TB = Thoroughbred; TBX = Thoroughbred cross.
[b]w = weeks; m = months.
[c]m = male; f = female; g = gelding.
[d]S-time = surgical time.
[e]Recovery = quality of recovery: 1 = stood at 1st attempt; 2 = >1 attempt to stand; 3 = excitement and recovery violent.

tube and rectal examination. Drugs such as the alpha$_2$-agonists, *e.g.* xylazine hydrochloride, are commonly administered by referring veterinarians to relieve pain before and during transportation. In goats the administration of xylazine during transportation suppresses the cortisol response[12], and may also influence the pcc in horses scheduled for emergency abdominal surgery.

Pcc may also be influenced by the hydration status of the horses. Some of these cases were moderately dehydrated upon arrival. The administration of intravenous fluid may cause haemodilution and a decrease in pcc. The clinical picture for both the abdominal and non-abdominal groups would favour some modification of the normal circadian rhythm of cortisol secretion before induction of anaesthesia. The concentration, however, continued to increase in the pre-operative period despite fluid administration, and only decreased during surgical preparation after induction of anaesthesia. Elimination of conscious perception of pain and discomfort by general anaesthesia may have been responsible for the moderate decrease in concentration observed in this investigation.

The mean pcc associated with colic has previously been reported to be 364 nmol/ℓ with a minimum and maximum of 188 and 828 nmol/ℓ[5]. The mean pcc of 446.3 nmol/ℓ in the present study is somewhat higher. The maximum concentration recorded that we recorded was 1135 nmol/ℓ obtained from the 400 kg gelding during enterectomy (Table 2). Colic in the equine is a condition that may be associated with various degrees of visceral pain, disturbances of gastrointestinal function, hypovolaemic shock, dehydration, acid-base and electrolyte abnormalities, and endotoxaemia. It often requires an urgent exploratory laparotomy to correct displaced intestines that cause obstruction and gas distension, or resection of ischaemic portions of the intestine. The higher $PaCO_2$ observed in the abdominal cases during surgery may have resulted from abdominal distension and dorsal recumbency during anaesthesia, resulting in a decreased minute ventilation.

Anaesthetic agents may influence pcc during anaesthesia. The use of intravenous agents for induction and maintenance of anaesthesia were not associated

Table 3: **Mean, minimum and maximum intraoperative arterial blood pressure and partial pressure of oxygen and carbon dioxide** (kPa), **pH, base excess and heart rate** (beats/min).

	Non-abdominal cases (n = 15)	**Abdominal cases** (n = 21)
pH	7.2	7.3
min–max	7.23–7.37	7.16–7.48
$PaCO_2$[a]	7.5	7.9
min–max[b]	6.2–9.4	5.6
PaO_2[c]	28.4	27.9
min–max	5.6–55.2	6.8–50.2
Be[d]	1.5	1.4
min–max	–2.8 – +5.4	–9 – +7.5
Hr[e]	39.6	50.6
min–max	25–60	36–74
Map[f]	8.7	8.5
min–max	5.3–15.3	4.3–15.6

[a]$PaCO_2$ = partial pressure of carbon dioxide in arterial blood.
[b]min = minimum; max = maximum.
[c]PaO_2 = partial pressure of oxygen in arterial blood.
[d]Be = base excess.
[e]Hr = heart rate.
[f]Map = mean arterial blood pressure.

with increased pcc even after major surgery[17,19]. The use of halothane in oxygen for maintenance of anaesthesia acts as a stressor, resulting in an increase in plasma cortisol concentration[18]. Halothane anaesthesia is associated with hypotension[15], which is a common complication during abdominal surgery as a result of release of vasoactive substances[13]. During this investigation an attempt was made to keep the mean arterial blood pressure within normal limits, and intravenous fluids and sympathomimetic agents were considered essential components in the maintenance of optimal cardiovascular function. The lower arterial blood pH, partial pressure for oxygen, and base excess observed in the abdominal group may be the result of inadequate cardiopulmonary function and tissue perfusion after induction of anaesthesia. The perioperative use of sedatives such as acetylpromazine and xylazine may reduce arterial blood pressure as a result of reduced peripheral vascular resistance. Hypotension during anaesthesia may also increase pcc in the horse[11]. Stimulation of the sympathetic nervous system is an important homeostatic mechanism to maintain arterial blood pressure, but it also stimulates release of cortisol. Positive inotropic agents such as dopamine and dobutamine may be administered during inhalation anaesthesia in equines to prevent intraoperative hypotension[14]. Infusion of dopamine in low concentrations during anaesthesia only increased pcc some time after termination of the infusion in one study[11], but the use of dobutamine to maintain blood pressure during halothane anaesthesia in ponies did not prevent an increase in plasma cortisol during anaesthesia[15]. In this investigation arterial blood pressure during surgery was maintained with dobutamine infusions in both groups if horses became hypotensive. Mean arterial blood pressures recorded were similar for both groups in this investigation. Acetylpromazine was omitted from the anaesthetic protocol in the abdominal cases to avoid increasing peripheral vasodilation and hypotension[8]. Endotoxaemia in the bovine stimulates the release of cortisol[2] and this may also occur in the equine. The mean pcc at incision (387.5 nmol/ℓ), and during abdominal surgery (418.1 nmol/ℓ) lasting as long as 240 min, changed very little during this period (387.5 to 395 nmol/ℓ). The 'expected' increase during surgery may have been masked by a decrease in noxious stimulation after relieving abdominal obstruction and distension.

Recovery from anaesthesia increased pcc (Table 1), and this may have resulted from falling about after multiple attempts to stand. Violent recoveries associated with excitement may increase pcc. In this investigation only 10–13 % of recoveries were violent and 40–47 % of the horses required more than one attempt to stand. The sharp decline in pcc after 24 h may have reflected the removal of the physical distress associated with colic. It was not before 60 h postoperatively that pcc approximated the concentration recorded for the non-abdominal cases 24 h postoperatively. The delayed return of pcc to normal may reflect the continued treatment required during the postoperative period after abdominal surgery until optimal gastrointestinal function is restored. Although the abdominal group consisted of horses subjected to surgery for emergency relief of acute abdominal obstruction, there were also cases that were elective and not subjected to preoperative pain, *e.g.* the intestinal biopsy in the foal. Indications are that the pcc in these cases was not as high as for horses subjected to emergency abdominal surgery, *e.g.* the pcc for the intestinal biopsy was 193.1 nmol/ℓ at completion of surgery.

A number of conclusions can be drawn from this study. In the non-abdominal group the preoperative pcc remained within the range previously reported for normal horses despite the presence of clinical abnormalities associated with pain. Starvation overnight and administration of acetylpromazine did not affect pcc; however, halothane anaesthesia and surgery significantly increased pcc. In the abdominal group the preoperative pcc was 3 times higher than the pcc recorded for the non-abdominal group, but the magnitude of the cortisol response to anaesthesia and surgery was less in the abdominal group compared with the non-abdominal group. The origin of the high pcc in the abdominal group may be multifactorial. Recovery from anaesthesia may result in an increase in pcc. Postoperatively the pcc in the non-abdominal group recovered within 48 h to preoperative concentrations, while the abdominal group required 60 h for pcc to approximate the non-abdominal pcc.

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