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CASE REPORT

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Caecal dysfunction following standing surgical procedures

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Abstract

The aim of this study is to report cases of caecal dysfunction following surgical procedures in the standing horse. The study design is retrospective. Six client-owned horses developed caecal dysfunction following a variety of surgical procedures undertaken in the standing sedated horse. Medical records were reviewed for caecal dysfunctions that had occurred in horses within 2 weeks of standing surgical procedures. Signalment, details of the original standing surgery and medications administered were recorded. Short-term outcome was obtained from clinical records. Long-term outcome was obtained by telephone questionnaire with the owner. Six horses were identified to have developed caecal dysfunction following standing surgery for tooth extraction, laparoscopic ovariectomy, laparoscopic cryptorchidectomy, fracture repair, melanoma removal and castration. Three horses were euthanised with caecal perforation at the time of diagnosis. Three underwent surgical treatment (typhlotomy, decompression and caecal bypass by ileocolostomy). All three horses were alive post-operatively (follow-up at 2, 12 and 24 months). Caecal dysfunction may develop following surgical procedures performed under standing sedation. Careful post-operative monitoring and early identification of caecal dysfunction, and consequent potential need for surgical intervention, are important to optimise outcomes and minimise the risk of fatal caecal perforation occurring.

KEYWORDS
Caecal dysfunction, Colic, Complication, Standing surgery

1 | INTRODUCTION

Caecal disease in the horse is uncommon; it has been shown to account for less than 4% of horses admitted to surgical referral centres with acute abdominal pain. (Dart et al., 1999) Caecal dysfunction (CD) causes a fluid-filled, amotile and massively distended caecum. The large colon is commonly empty (Sherlock & Eggleston, 2013; Dabareiner & White, 1997; Roberts & Slone, 2000). Horses with CD typically present with mild abdominal pain, depression, inappetence and reduced faecal output. These nonspecific clinical signs may be present for several days (Ross, 1989). Transrectal abdominal palpation is the mainstay of diagnosis (Plummer et al., 2007); CD is palpated as a caecum tightly distended with fluid (Sherlock & Eggleston, 2013; Plummer et al., 2007; Campbell et al., 1984). The differentiation of caecal impaction (type 1) and dysfunction (type 2) is usually based on palpation of firm dry ingesta (impaction) or liquid contents (dysfunction). However, this division is somewhat arbitrary and not necessarily easily defined. Some horses may present with a caecal impaction, but following treatment with oral and parenteral fluids can progress on to true caecal dysfunction cases, with the caecum massively distended on palpation. However, critically, caecal dysfunction can progress to fatal caecal perforation relatively quickly, without severe signs of colic, unlike visceral rupture in other locations such as the stomach. For a detailed discussion on the diagnosis, management and prognosis of the condition, the

reader is directed to a recent review article (Velloso Alvarez et al., 2021).<COMP: Please set reference citations as per the journal style, that is, in alphabetical order.>

The causes of CD are unknown and likely multifactorial (Velloso Alvarez et al., 2021). General anaesthesia (GA) is one of the most important risk factors; (Aitken et al., 2015) in one study 75% of horses with CD had undergone surgery up to 5 days previously (Smith et al., 2010) all of which were performed under GA (Smith, pers. Comm., 2021). No association is currently reported with standing surgery.

2 | MATERIALS AND METHODS

Electronic clinical records (March 2007 to September 2021) were searched for documents containing 'caecal dysfunction', 'caecal impaction', 'caecal rupture' or 'caecal perforation' at one equine hospital. The diagnosis was made on the basis of surgical exploration by board-certified clinicians or necropsy. Identified cases were examined for horses which had undergone standing surgery under sedation and local anaesthesia in the preceding week. Horses that had undergone GA during this time, horses in which another painful condition was considered a potential cause or horses in which there was caecal perforation that was secondary to a disorder not associated with primary caecal disease were excluded from the study.

3 | RESULTS

Thirty-nine horses were identified with caecal disease. Thirty-three were excluded for the following reasons: seven had undergone general anaesthesia in the preceding 2 weeks. Two horses were undergoing treatment for painful conditions (a nail penetration to the foot and a traumatic ocular injury) and one horse had undergone magnetic resonance imaging under standing sedation in the preceding 2 weeks. Two cases of caecal perforation were considered secondary, to strangulation of the ileum by a pedunculated lipoma and to a caeco-caecal intussusception and 21 cases had a diagnosis of primary CD (i.e. with no obvious premonitory cause).

Six horses were identified with CD or perforation following standing surgery under sedation. Details of the horse (age, breed and sex) and of the surgical procedure and medications administered were recorded. The details of the diagnosis and subsequent surgery for CD were also recorded. Finally, follow-up information was obtained from the clinical records (in cases of euthanasia) or by telephone contact with the owner.

3.1 | Case presentation

The details of the case history and initiating surgery are summarised in Table 1. The details of the clinical features prior to the subsequent exploratory laparotomy are summarised in Table 2.

3.1.1 | Case 1

Approximately 12 h after tooth extraction the horse developed intermittent and mild colic signs that became progressively more severe over the next 24 h.

The following day the horse was referred to the authors' clinic for further evaluation and management of the colic. Following assessment (Table 2) the horse was placed under GA and a ventral midline laparotomy performed. The peritoneal fluid was contaminated with feed material and the caecum was grossly enlarged with fluid contents. A perforation was identified at the medial aspect of the caecal base. The large colon was empty. The horse was euthanised under GA.

3.1.2 | Case 2

Following laparoscopy, the horse underwent continued antimicrobial treatment and analgesia at the previously stated doses (Table 1). Seventy-two hours after surgery the horse developed pyrexia (39.5°C), congested mucous membranes and signs of systemic inflammatory response syndrome. Metronidazole (brand unknown) 20 mg/kg PO three times a day (TID) was added to the antimicrobial regime, polymixin-B (brand unknown) 4500 iu/kg IV TID was administered and phenylbutazone was replaced with flunixin meglumine (Flunixin; Norbrook Laboratories Ltd, Newry, Northern Ireland, UK) 1.1 mg/kg IV twice daily for analgesia.

The mare developed severe colic signs 4 days following the standing surgery. In addition to the flunixin meglumine already being administered, a continuous infusion of ketamine, morphine and detomidine was administered to control the pain. The dose and duration of this infusion was unclear from the clinical records.

Repeat abdominocentesis 72 h following the initial sample (6 days after surgery) demonstrated an increasing total nucleated cell count (290×10^9/L). Procaine penicillin and gentamicin were discontinued and treatment with enrofloxacin (Lanflox; Nimrod, Gloucestershire, UK) 7 mg/kg PO once daily was initiated. This case was 13 years ago, when hospital policy did not require the support of culture and sensitivity prior to the use of a protected antimicrobial; if this case was more recent it is likely that an alternative agent would have been selected.

After a total of 14 days of unsuccessful medical management, the horse was placed under GA and a ventral midline laparotomy performed. This revealed a perforation on the medial wall of the caecum with adhesions to the large colon and medial border of the spleen. Euthanasia was performed under GA.

3.1.3 | Case 3

Following fracture repair the horse was sound at walk and discharged 12 h after surgery. Five days after this procedure, the horse displayed colic signs and was diagnosed with CD based on abdominal palpation per rectum. Conservative management was unsuc-

TABLE 1 Details of case history and initial surgery

Case	Age	Sex	Standing surgical procedure	Pre-operative drugs	Local anaesthesia	Sedation protocol	Surgery duration
1	16	Male	Extraction of tooth 409, initially orally and subsequently by mandibular repulsion	Sodium penicillin 10 mg/kg IV Gentamicin 6 mg/kg IV Flunixin 8 mg/kg IV Omeprazole 4 mg/kg PO	Mandibular nerve block Mepivacaine 0.3 mg/kg	Acepromazine 0.03 mg/kg IV Romifidine CRI totalling 0.3 mg/kg IV	3 h 30 min
2	8	Female	Unilateral ovariectomy, laparoscopic dissection followed by flank laparotomy for extraction	Procaine penicillin 28 mg/kg IM Gentamicin 6 mg/kg IV Phenylbutazone 4 mg/kg IV	Direct injection of surgical site with lidocaine 0.4 mg/kg	Detomidine and butorphanol combined CRI totalling 0.02 mg/kg IV of each	1 h 15 min
3	2	Female	Lag screw fixation of a sagittal fracture of P1 using two AO 4.5 mm screws	Trimethoprim/sulphadiazine 30 mg/kg PO Phenylbutazone 4.4 mg/kg IV	'Four point' nerve block with mepivacine 0.7 mg/kg	Acepromazine 0.03 mg/kg IV Detomidine intermittent boluses totalling 0.04 mg/kg IV Methadone 0.2 mg/kg IV	1 h 40 min
4	2	Male	Left laparoscopic cryptorchidectomy and right conventional standing open castration	Trimethoprim/sulphadiaz 30 mg/kg PO Phenylbutazone 4.4 mg/kg IV	Direct injection of surgical site with lidocaine 0.4 mg/kg	Acepromazine 0.03 mg/kg IV Detomidine intermittent boluses totalling 0.02 mg/kg IV Butorphanol intermittent boluses totalling 0.01 mg/kg IV Morphine 0.14 mg/kg IV	1 h 30 min
5	8	Female	Laser surgery for removal of perianal and axillary melanoma	Procaine penicillin 25 mg/kg IM Phenylbutazone 4.4 mg/kg IV Oncept® melanoma vaccine	Direct injection of surgical site with prilocaine 0.2 mg/kg	Acepromazine 0.03 mg/kg IV Detomidine intermittent boluses totalling 0.02 mg/kg IV Morphine 0.1 mg/kg IV	1 h
6	0.6	Male	Open standing castration	Procaine penicillin 20 mg/kg IM Phenylbutazone 4.8 mg/kg IV Dexamethasone 0.03 mg/kg IV	Intra-testicular lidocaine 1.2 mg/kg	Detomidine 0.01 mg/kg IV Butorphanol 0.01 mg/kg IV	30 min

cessful; 36 h later, the horse was referred back to the authors' clinic for further treatment. Persistent colic signs prompted surgical exploration.

The horse was placed under GA and a ventral midline laparotomy performed. A grossly enlarged, fluid-filled caecum was identified. The large colon was empty. A caecal bypass surgery was performed as described by Quinteros et al. (2010). Briefly, the caecum was exteriorised and evacuated via apical typhlotomy. The ileum was aligned between the medial and lateral free bands of the right ventral colon and an ILA 100 stapling device (United States Surgical Corporation, Norwalk, CT, USA) was used to create a side to side anastomosis between the ileum and right ventral colon. The stab incisions were closed with 2 metric poliglecaprone 25 (Monocryl; Johnson & Johnson International, New Brunswick, New Jersey, USA) monofilament suture in a continuous Lembert pattern. The lumen of the ileum, immediately aboral to the ileocolostomy, was occluded using a row of TA 90 staples (United States Surgical Corporation) applied perpendicular to the antimesenteric border (Figure 1). Mesenteric closure was performed by suturing the ileo-caecal fold to the caeco-colic fold using a continuous suture pattern.

The horse recovered well from GA. The horse developed pyrexia 4 days after surgery. Based on abdominal ultrasound this was suspected to be an intra-abdominal abscess at the caecal base. The horse remained stable and was discharged 3 weeks later for continued antimicrobial treatment. Insufficient time had elapsed post-discharge for follow-up beyond 4 months.

3.1.4 | Case 4

Twelve hours after laparoscopic cryptorchidectomy the horse was in lateral recumbency. A single dose of flunixin meglumine (Norbrook Laboratories Ltd) 1.1 mg/kg IV was administered and the horse received enteral fluids 10 ml/kg on three occasions over the next 12 h.

TABLE 2 Details of the clinical features prior to diagnosis of caecal dysfunction at surgery or post-mortem examination

Case			Blood analysis					Abdominocentesis		
	Heart rate (bpm)	Temperature (°C)	PCV (%)	TP (g/L)	WBC ($\times 10^9$/L)	Lactate (mmol/L)	Abdominal palpation per rectum	Appearance	Lactate (mmol/L)	WBC ($\times 10^9$/L)
1	60		35.6	76		8.4	Grossly enlarged, fluid-distended caecum	Serosanguinous	8.6	
2	Elevated	39.5	Unknown	Not performed	Turbid		150			
3	44	38.3	45.6	60	8.9	<0.8	Fluid distended caecum	Not performed		
4	32	37.7	32.6	62	7.8	<0.8	Fluid distended caecum	Not performed		
5	52	38	34.6	70	9.7	<0.8	Grossly enlarged caecum	Not performed		
6	88	39.9	57	52	1.3	>23	Not performed	Turbid, brown	>23	

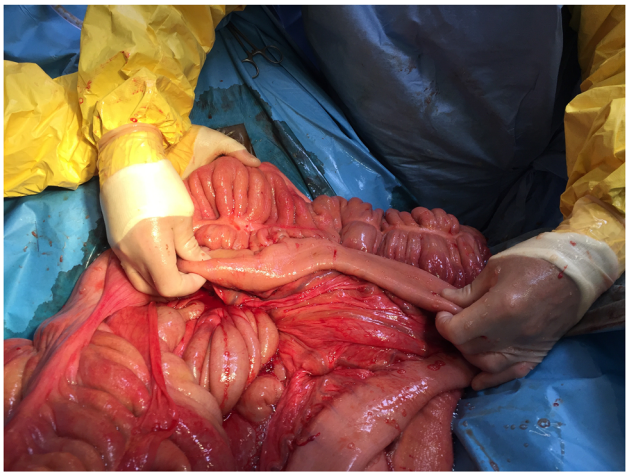

FIGURE 1 Surgical image of the ileocolostomy site

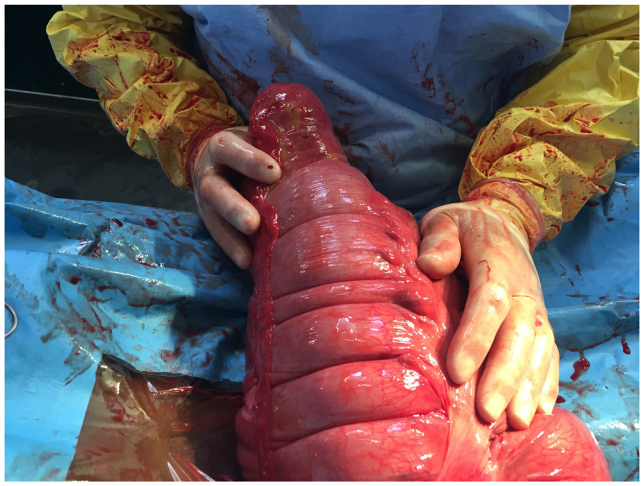

FIGURE 2 Surgical image of an enlarged, fluid distended caecum

The severity of abdominal pain increased over the next 12 h. Further abdominal palpation indicated that the caecum was massively enlarged with fluid distension.

The horse was placed under GA and a grossly enlarged, fluid distended caecum was identified. A caecal bypass was performed as described in Case 3. The large colon was full and was decompressed via a pelvic flexure enterotomy.

The horse recovered well from GA and was discharged 11 days later without complication. The horse returned to racing and was alive 24 months after surgery with no colic signs.

3.1.5 | Case 5

The horse was discharged from the clinic the same day as melanoma removal. Twelve hours after surgery mild colic signs and inappetence were displayed. The horse was treated with phenylbutazone 4.4 mg/kg IV and feed restriction. Six hours later colic signs recurred. Abdominal palpation per rectum identified distension of the caecum. The horse was referred to the authors' clinic (Table 2). Over the next 12 h, the horse continued to display worsening colic signs and abdominal palpation per rectum demonstrated a massively distended caecum.

The horse was placed under GA and a ventral midline laparotomy performed routinely. A grossly enlarged, fluid distended caecum was identified (Figure 2). A caecal bypass was performed as described in Case 3.

The horse recovered well from GA and was discharged 11 days later without complication. The horse returned to ridden exercise and was alive with no colic episodes at 1 year following surgery. The owner reported that prior to caecal bypass surgery, the horse was prone to weight gain; however, since surgery the horse has maintained an ideal body weight despite less restrictive feeding.

3.1.6 | Case 6

Following castration, due to poor owner compliance, the prescribed post-operative medications (antimicrobials and NSAIDs) were incompletely administered. The foal was reported to have a dull demeanour and was inappetent approximately 24 h after the procedure; the importance of post-operative medications was stressed to the owner. Approximately 12 h later (36 h after the procedure), the foal began demonstrating signs of mild colic. Abdominal palpation per rectum was not possible due to size. The foal was treated with flunixin (Finadyne; Norbrook Laboratories Ltd) 0.6 mg/kg IV and oxytetracycline (Engemycin; Norbrook Laboratories Ltd) 4 mg/kg IV. Turnout for gentle exercise was advised. Approximately 1 h after the initial examination the foal deteriorated markedly, demonstrating more severe colic signs, a dull demeanour, tachycardia (54 beats per minute) and tachypnoea. The horse was treated with enteral fluids (10 ml/kg) and referred to authors' clinic (Table 2). Euthanasia was performed following diagnosis of visceral rupture.

A post-mortem examination demonstrated extensive contamination of the abdomen with intestinal contents. A perforation was identified on the medial aspect of the caecum. The large colon was empty.

4 | DISCUSSION

Patients in this case series ranged from 7 months to 16 years (Table 1). It has previously been reported that the risk of CD is increased in horses >15 years and reduced in horses <1 year (Dart et al., 1997).

Caecal dysfunction has not previously been described in association with standing surgical procedures. However, many aspects of standing procedures including feed restriction, sedation and pain may affect caecal motility (Velloso Alvarez et al., 2021; Schusser et al., 2000; Ross et al., 1989). Sedation has been associated with reduced caecal motility; xylazine has been shown to reduce caecal emptying rates (Lester et al., 1998) and can abolish caecal myoelectrical events for up to 90 min (Rutkowski et al., 1989). Detomidine abolishes caecal electrical activity for up to 15 min (Roger & Ruckebusch, 1987) and has been shown to delay the passage of faeces following standing surgical procedures (Thibault et al., 2019). Butorphanol prolongs alpha 2 agonist effect on motility (Rutkowski et al., 1989). Morphine reduces gastrointestinal motility, with effects lasting 6 h documented after a single injection (Boscan et al., 2006) although the specific effects on caecal motility have not been studied.

Reduced feed intake has been shown to cause a significant decrease in progressive motility from the caecum to the right ventral colon (Ross, 1989). This may result in alterations in caecal contents and function. The details of feed restriction in these cases are not always known. At the authors' clinic, horses are not routinely withheld feed prior to standing surgery, with the exception of laparoscopy (Case 4), where horses are withheld feed for 48 h (now reduced to 12 h). Horses are refed as soon as possible. However, only two of these horses underwent the initial standing procedure at the authors' clinic [fracture repair (Case 3) and cryptorchidectomy (Case 4)].

The severity and duration of pain in the horses are difficult to evaluate. All cases had different procedures, some performed in differing clinics, and there was no consistent objective pain scoring used. Caecal dysfunctions have previously been associated with hospitalisation for other painful conditions, particularly ocular or orthopaedic disease (Campbell et al., 1984; Aitken et al., 2015; Patipa et al., 2012). Only Case 2 displayed pain sufficient for additional analgesia prior to colic signs although Case 6 may have been expected to be experiencing a degree of pain as limited analgesia was administered by the owner following castration. Administration of NSAIDs has been associated with caecal dysfunction (Dart et al., 1999; Dart et al., 1997) although it is not clear whether there is a causative role or whether it is the painful condition that the NSAID is being used to treat that is key. Additionally, it should be considered that NSAID use may mask signs of mild colic.

Caecal dysfunction following GA is well recognised, with a recent history of GA in up to 75% of cases (Smith et al., 2010). In the authors' clinic between March 2007 and September 2021, only 19% (7/37) of caecal dysfunctions had a history of GA in the past 2 weeks. This represents a far lower proportion of the CD cases than is reported (Smith et al., 2010) and represents a similar proportion to that with a history of a standing surgery, 16% (6/37). During this period at the authors' clinic, approximately 2000 horses underwent surgery under GA and approximately 1000 underwent standing surgery with sedation. However, most of the horses in this series underwent the standing procedure at other clinics and were referred for management of CD. Furthermore, there were obviously other procedures that involved sedation, not just surgery.

4.1 | Limitations

A limitation of this case series is the terminology and classification of CD, which is impossible to prove definitively. In this case series, accumulation and distension of largely fluid intestinal contents in the caecum, without evidence of propulsion, were clear from the records of cases classified as CD so the authors believe that these cases are genuinely CD and not impactions.

In 4/6 cases, the standing procedure was performed at other premises such that there was no standardisation of the sedation protocols or post-procedural management between cases. Different alpha 2-adrenergic agonists, and different preparations of the same agent, were used at different doses as intermittent boluses or continuous infusions. In 3/6 cases, the horses were under owner supervision between the initial procedure and the diagnosis of CD. It is therefore possible that early signs were missed or that reports are otherwise inaccurate.

No assumptions can be made from this series regarding the frequency of occurrence of caecal dysfunction following standing sedation protocols. Therefore, just six cases of caecal dysfunction in a 14-year period, from internal and referral cases, would suggest that this is a rare complication. Further investigation is required to ascertain the frequency of CD following standing surgical procedures.

5 | CONCLUSION

This case series reports CD following standing surgical procedures, which has not been reported previously. At the authors' clinic, such cases (6/37) represented a similar proportion to those that developed CD following GA (7/37). In 3/6 (50%) cases in this series, fatal perforation had occurred at the point of diagnosis. In the cases where perforation had not occurred (3/6), all cases survived to discharge and were alive at follow-up (though this was only a 4-month period for one case). This highlights the importance of careful monitoring, after standing procedures as well as GA. Early diagnosis is crucial; abdominal palpation per rectum is the mainstay of diagnosis and should therefore be performed wherever possible and persistent abdominal pain despite analgesia should always raise concerns about CD as a potential differential diagnosis.

CONFLICT OF INTEREST

Some of the cases were presented at the Colic Symposium, Lexington, Kentucky, USA 2017.

AUTHOR CONTRIBUTIONS

R Gough performed data collection and prepared the manuscript. L Carmichael contributed to data collection. B Bladon and K McGovern were responsible for study design and manuscript preparation.

DATA AVAILABILITY STATEMENT

Data are available on request from the authors.

PEER REVIEW

The peer review history for this article is available at https://publons.com/publon/10.1002/vms3.882.

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