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**Running head: Cecal cannulation in standing horses**

**Technical note: A two-stage cecal cannulation technique in standing horses<sup>1,2</sup>**

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**ABSTRACT:** Cecal cannulation is necessary for sampling of intestinal contents for a variety of nutritional or digestive physiology studies. This report describes a two-stage technique for permanent cecal cannulation in standing horses. For the first procedure, a right flank laparotomy is performed and a small pouch of the cecal base exteriorized and sutured to the body wall. The second procedure is performed approximately 1 wk later. During the second procedure, the exposed cecal pouch is removed and the cannula inserted. Ten horses were cannulated using this technique. Following the first procedure, 1 horse developed a cecal impaction unresponsive to medical therapy and ruptured its cecum while 2 other horses developed mild transient colic that responded to medical management. Insertion of the cecal cannula after creation of the stoma in the second procedure resulted in transient colic in 4 of 9 horses but they responded to analgesic therapy in less than 24 h in all instances. The time to complete healing of the cannula site was approximately 30 d. The technique described in this report decreases the risk of peritonitis because of intestinal leakage and is technically easier to perform than previously described techniques.

**Key words:** cannula, cecum, fistula, horses

## INTRODUCTION

Cecal cannulation is performed in horses for a variety of nutritional, physiologic, or pharmacologic studies that require sampling of cecal contents. Cecal cannulation is performed by exteriorizing a portion of the cecum through the flank musculature to form a permanent adhesion to the body wall. To complete the procedure, an opening into the cecal lumen is made, after which the cecal mucosa heals to the skin. This has been described in the standing (Teeter et al., 1968) or anesthetized horse (Alexander and Donald, 1949; Jasper and Cupps, 1950; Lowe et al., 1970) and as a one-stage (Horney et al., 1973; Simmons and Ford, 1988) or two-stage

(Alexander and Donald, 1949; Lowe et al., 1970) procedure. General anesthesia has disadvantages besides the added expense. Muscle planes shift in the anesthetized horse, and a difficult anesthetic recovery may result in dehiscence of the surgically created stoma. A one-stage procedure has the disadvantage that adhesion between the cecum and body wall must form in the presence of considerable fecal contamination. Any disruption or leakage at the stoma site is likely to result in fecal contamination of the flank musculature or peritoneal cavity with a fatal outcome expected. It is difficult to gauge the expected complications and their rate of occurrence from the existing literature because many of the reports are vaguely written and do not state the number of animals used in operation procedures.

Surgical techniques have improved during the 60 yr since the earliest reports and accumulated experience indicates that the earlier techniques contain unnecessary steps that add to the surgical difficulty. The drugs available today for standing chemical restraint have made standing surgery a more attractive option than it was when most of these procedures were originally described. The purpose of this report is to describe a simple, two-stage procedure for cecal cannulation in standing horses and to report our experiences with the technique.

## **MATERIALS AND METHODS**

All procedures were approved by the Kansas State University Institutional Animal Care and Use Committee. Ten healthy 4-year-old Quarter Horses (6 geldings and 4 mares) with a mean BW of 460 kg (range, 463 to 503 kg) were used in this study. Horses were housed individually in box stalls. Brome hay and water were available at all times and 2.3 kg of concentrate (Life Design Compete, Nutrena, Minneapolis, MN) was offered twice daily. Feed was withheld for 12 h prior to surgery. Horses were vaccinated with tetanus toxoid (SuperTet,

Intervet Inc., Millsboro, DE) intramuscularly on the morning of surgery. The 10 horses were operated on in 2 groups separated by an 8-wk interval.

### ***Medications***

Starting immediately before surgery and continuing for 12 d, horses were orally administered trimethoprim/sulfamethoxazole (Qualitest Pharmaceuticals, Huntsville, AL) twice daily at a dosage of 15 mg/kg. Phenylbutazone (Vedco Inc., St Joseph, MO) was administered orally at a dose of 2 g per day for 12 d. Flunixin meglumine (Banamine, Schering Plough Animal Health Corp., Union, NJ) was administered at a dose of 500 mg intravenously, immediately prior to surgery and once daily thereafter as needed for any horse exhibiting signs of colic postoperatively. Horses that required tranquilization for the surgical prep were administered 10 mg of acepromazine (Vedco Inc., St Joseph, MO) intravenously. The skin and the flank muscles at the surgical site were desensitized by a line block using 50 to 75 mL of 2% lidocaine (Hospira Inc, Lake Forest, IL) per horse. Immediately prior to surgery, horses were sedated with 5 mg of detomidine (Dormosedan, Pfizer Animal Health, Exton, PA) intravenously and 15 mg of butorphanol (Torbugesic, Fort Dodge Animal Health, Fort Dodge, IA) intravenously.

### ***Surgical Procedure***

***Stage 1.*** Horses were restrained in stocks, hair was clipped, and the right paralumbar fossa was aseptically prepared using povidone iodine surgical scrub (Betadine, Purdue Products, LP, Stamford, CT). Following draping, a laparotomy was performed in the right paralumbar fossa using a modified grid technique (Ross, 1991). A skin incision was made midway between the tuber coxae and the last rib, beginning at the ventral border of the tuber coxae and extending ventrally for 15 to 20 cm (Figure1). The external abdominal oblique muscle was sharply incised parallel with the skin incision. The internal abdominal oblique and transverse abdominal muscles

were each bluntly separated in the direction of their fibers. The peritoneum was bluntly perforated and the abdomen entered. The muscles were separated only enough to permit entry of a hand into the abdomen. The cecum was readily identified by palpation of the cecal base and the dorso-ventrally oriented tenia. A fold of cecum adjacent to the incision was grasped and exteriorized to make a pouch. The serosal surface of the cecum was sutured to the internal abdominal oblique muscle using a simple continuous pattern of 0 polyglactin 910 (Vicryl, Ethicon, Somerville, NJ) while taking care not to penetrate the cecal lumen. A second layer of closure was performed by suturing the serosal surface of the cecum to the edges of the incised external abdominal oblique muscle using 0 polyglactin 910 in a simple continuous pattern. The cecum was sutured to the skin with a simple interrupted pattern of 2-0 nylon (Surgilon, United States Surgical, Norwalk, CT). Nitrofurazone ointment (Furazone, Squire Laboratories Inc., Revere, MA) was applied to the exposed cecal surface twice daily. Horses were examined and vital signs recorded every 3 to 6 h for the first few days following each surgical procedure. Monitoring intervals were dictated by the presence of clinical signs such as colic and fever. The intervals between examinations were gradually extended as the horses stabilized after surgery until horses were being monitored at 12 h intervals for the first month after surgery.

**Stage 2.** Six to 8 d after the first surgical procedure, horses were sedated with 3 mg of detomidine intravenously. Scissors were used to enter the cecal lumen in the middle of the exposed cecal pouch (Figure 2). The scissors were used to cut circumferentially to excise the exposed cecum as close to the skin edges as possible. No effort was made to control the small amount of hemorrhage from the incised cecal mucosa. Flexible cannulas were then inserted according to the manufacturer's instructions (flexible rumen cannula, #7C; 3.8 cm center diameter and 8.9 cm wall thickness; Bar Diamond, Parma, ID).

## RESULTS

The surgical procedure was well-tolerated by all horses and was accomplished without the need for additional analgesia or restraint. Eight of 10 horses were febrile (temperature, > 38.3°C) for 24 h following the first surgery. Three horses had transient febrile episodes within the first 2 wk following surgery, which were attributed to inflammation at the surgical site. Three horses exhibited signs of colic following the first surgical procedure. In 2 of these horses, the colic was attributed to cecal impaction. One horse was successfully treated by withholding feed, administration of oral fluids and electrolytes, mineral oil administered via a nasogastric tube, and flunixin meglumine (500 mg, Intravenously) for analgesia. The other horse was treated by oral fluids, mineral oil administered via a nasogastric tube, flunixin meglumine, and attempted manual evacuation of the cecal impaction through the cecal fistula. This horse ruptured its cecum and died after less than 12 h of medical therapy 7 d after the first surgical procedure. The colic episode in the remaining horse was resolved by administration of a single dose of flunixin meglumine.

Cecal motility was visually evident by peristalsis in the exteriorized portion of the cecum for the first 2 to 3 d after the first surgery. The cecal wall of the exteriorized pouch became edematous and desiccated, assuming a leather-like appearance by d 3. In one horse the cecal wall underwent necrosis and perforated on d 4. Premature rupture of the cecum caused no problems in this horse and the cannula was inserted uneventfully. In the remaining horses the cecal wall remained intact until the second stage of the cannulation process on d 6 to 8.

Four of the 9 horses developed signs of colic immediately following insertion of the cannula during the second surgical procedure. Clinical signs included tachycardia, sweating, looking at their sides, pawing, recumbency, and rolling. In these horses the pain was not

responsive to flunixin meglumine (500 mg, intravenously) and required xylazine (200 mg, intravenously) or detomidine (5 mg, intramuscularly) for effective analgesia. Signs of colic abated and were absent in all horses by 24 h following the second surgery.

The cecal wall was excised as closely as possible to the skin during the second surgical procedure. In spite of this, approximately a 5-mm rim of cecum remained. The serosal surface of the exposed cecum underwent necrosis and sloughed over the following 10 to 14 d. During this time there was a purulent, foul smelling exudate present at the junction of the skin and cecum. The stoma was cleaned daily with soap and water, and petroleum jelly was applied to the skin to prevent scalding by the exudate. Complete healing of the cecal mucosa to the skin was evident between the second and third week after the second surgical procedure.

Horses are now 1 yr post surgery and there have been no further episodes of colic or complications related to the incisions. All horses have some leakage of cecal contents around the cecal cannula, resulting in fecal soiling of the skin. Leakage was most pronounced in the first months following cannulation and has decreased with time. Temporarily removing the cannula for 1 to 3 d resulted in rapid shrinking of stoma size of the cecal fistula. Subsequent reinsertion of the cannula produced a snugger fit, though leakage is not completely resolved. Five of the 9 horses have had periodic episodes, in which the cannulae have become dislodged from the cecal fistula. The first instance of a missing cannula occurred about 6 wk after surgery. In 4 of these horses the dislodgement is infrequent (1 to 5 episodes per horse over the past year), whereas the remaining horse removes its cannula at will, both by rubbing and by pulling the cannula out with its mouth. It cannot be ascertained whether the horse removes the cannula because of irritation or for entertainment. Attempts to prevent cannula dislodgement have been made by inserting plastic washers with a larger diameter than the cannula's internal flange inside the cecum, and



while this has resulted in some improvement, it has not completely resolved the problem of cannula loss.

## **DISCUSSION**

In this report, we have described a two-stage technique for cecal cannulation in standing horses. Our technique differs from previous reports in many ways. The majority of previously reported procedures utilize general anesthesia for the cannulation procedure in one (Horney et al., 1973; Jasper and Cupps, 1950; Simmons and Ford, 1988) or both stages (Alexander and Donald, 1949) of a two-stage technique. Although general anesthesia is regarded as safe when performed by qualified individuals, it has several disadvantages when used as part of a cannulation protocol (Freeman et al., 1992). General anesthesia increases the expense and limits the locations, in which the procedure can be safely performed due to requirements for equipment and recovery facilities. Muscle planes and viscera shift in the recumbent horse and make it possible that the stoma into the cecum may be improperly positioned. Lastly, a difficult anesthetic recovery may result in dehiscence of the surgical site.

The earliest reports of cecal cannulation described the technique as a two-stage procedure (Alexander and Donald, 1949; Jasper and Cupps, 1950; Teeter et al., 1968; Lowe et al., 1970). More recently a single-stage technique has been described (Horney et al., 1973; Simmons and Ford, 1988); however, there are decided advantages to the two-stage technique. Cecal cannulation requires that the cecum be exteriorized through 3 flank muscles (transverse abdominal muscle, internal abdominal oblique muscle, and external abdominal oblique muscle) and adhered to the body wall. Suturing the cecum to the body wall is technically difficult to perform because the cecum is sacculated and the fibers of the individual muscles are oriented in different directions. The seal obtained during the first stage is secure, as far as strength is

concerned, but not impervious to fecal contamination that is certain to occur once the cecal lumen is penetrated. Leakage of cecal contents into the muscular planes of the flank or peritoneal cavity is a serious complication at a minimum, and in most cases, is fatal. By performing the cannulation as a two-stage procedure, a firm adhesion is created between the cecum and body wall prior to opening the cecum and subjecting the incision line to fecal contamination. Consequently no horses in this study developed peritonitis or serious incisional complications.

Any surgery of the cecum has the potential to alter cecal motility, as evidenced by the 2 horses that developed cecal impactions. Cecal impactions typically have an insidious onset that develops secondary to alteration of cecal motility, which then interferes with cecal emptying. Signs of cecal impaction are generally mild and include decreased feed intake and fecal output, as well as mild, intermittent abdominal discomfort. Cecal impaction is readily diagnosed by rectal palpation and medical management is usually successful if initiated early. Cecal rupture, as occurred in 1 horse in this study, is a fatal outcome that may occur if the condition is not recognized and prompt treatment instituted. Rectal palpation should be performed to rule out cecal impaction following surgery in any horses showing signs of colic, decreased feed intake, and decreased fecal output. Medical management of a cecal impaction can be challenging and should be performed under the direction of a veterinarian. To better manage the horses post-operatively, surgeries were performed in 2 groups approximately 1 mo apart. Because 2 horses from the first group developed cecal impactions after the first surgical procedure, hay intake was restricted for 2 wk postoperatively in the second group to decrease the likelihood of further instances of cecal impaction. As a result of heightened awareness and the feeding changes, no further instances of cecal impaction were observed.

Four horses demonstrated signs of pain immediately following cannula insertion. It is presumed that the source of the pain was pressure on the body wall caused by the cannulae. Evidence for this belief is provided by the immediate onset, the fact that the horses repeatedly looked at the cannulae, and that flunixin meglumine, a non-steroidal anti-inflammatory drug that inhibits prostaglandin synthesis, was not effective in alleviating pain in these horses. Administration of xylazine and detomidine, which are both potent analgesics and sedatives in horses, were efficacious. Overt signs of pain were resolved in all 4 horses by 12 h.

The surgical technique described in this report is simpler than that described by others as it does not require excision of skin or peritoneum, transection of the abdominal muscles, ligation of arteries, or construction of a peritoneal ring. Comparison of our results with other techniques is not possible because previous reports have been incomplete and inconsistent in their reporting of results. The number of animals used in operation procedures, complications, and detailed descriptions of the postoperative course often have not been described. This report describes an easily reproducible technique for cecal cannulation in the standing horse, as well as the associated complications and expected outcomes.

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## Legend for Figures

**Figure 1.** Stage 1 of the cecal cannulation to exteriorize the cecum. A: Horse is restrained in stocks; the dotted square delineates the area that is clipped of hair and the dotted line indicates the 7.5 cm skin incision midway between the pelvis and the 18th rib beginning at the ventral border of the tuber coxae. B: Modified grid paralumbar laparotomy approach to the abdomen; the skin and subcutaneous tissue are sharply incised (a), the aponeurosis of the external abdominal oblique muscle (b) is sharply incised in the same direction as the skin, the interanal abdominal oblique muscle (d) is bluntly separated in the direction of its fibers to expose the transverse abdominal muscle (c), which is then incised parallel with the skin incision. C: Stage 1 of the cecal cannulation is completed with the exteriorized cecal pouch sutured to the skin with interrupted sutures, and the cecum is also sutured to the internal abdominal oblique muscle and external abdominal oblique muscle.

**Figure 2.** Stage 2 of the cecal cannulation to create the stoma. A: the exposed cecal pouch is incised with scissors on d 6 to 8, B: the cecal pouch is circumferentially excised as close to the skin as possible exposing the cecal lumen, C: the internal flange of the cecal cannula is deformed to facilitate insertion into the cecum, and the inset depicts the cannula prior to deformation, D: insertion of the cecal cannula into the cecal lumen, and once fully seated within the cecum, the internal flange is allowed to return the normal shape (C inset), and E: completed cecal cannulation.

Figure 1

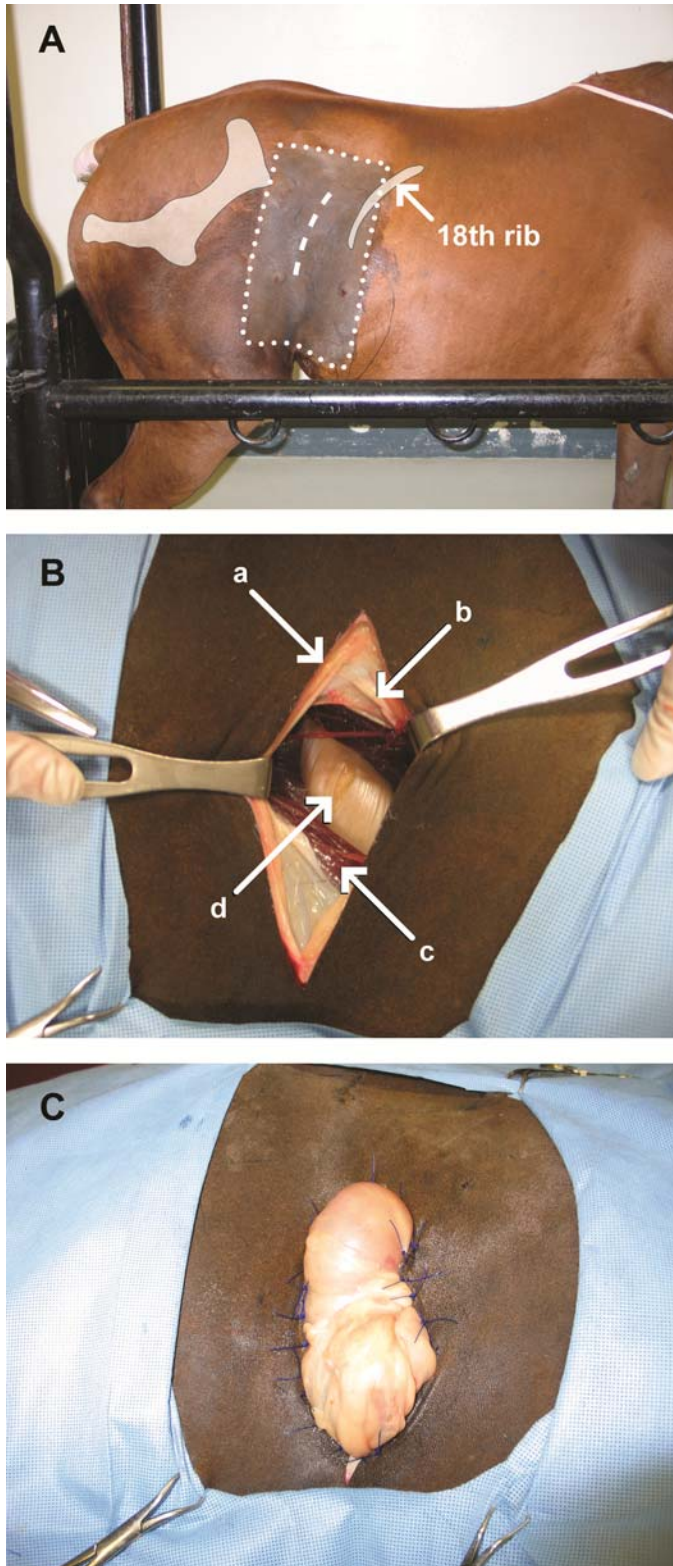




Figure 2

