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A new technique to perform a semi-closed single-layer handsewn jejuno-caecal side-to-side anastomosis in the horse

Introduction

Intestinal resection and anastomosis are often performed in surgical colic cases. A wide range of method of anastomosis have been described both hand sewn and stapled, end to end, side to side and end to side[1]. Methods are selected by surgeon's preference depending on intestinal tract involved, time of surgery, cost, possible complications. Manipulation is considered a risk factor for the development of bowel inflammation, adhesion formation and postoperative ileus[2,3]; time of surgery is considered an important factor to determine post-operative survival [2].

Both handsewn and stapled jejunocaecostomy have been described and evaluated[3] to perform incomplete caecal bypass or jejuno- or ileo-caecal anastomosis and until recent times considered the best option to re-establish intestinal continuity after partial ileal resection.

Hand sewn techniques have been described for side-to-side and end-to-side anastomosis[1], while intestinal staplers may be used to perform a side-to-side jejuno- (or ileo-) caecostomy[1]

Stapled techniques are considered advantageous reducing bowel manipulation and contamination but in some cases carry an higher risk of complications[1]. Their use can also significantly reduce surgical time if the staples lines are not oversewn[1].

The aim of this study is to describe a new technique of jejuno-caecal side to side anastomosis with minimal mucosal exposure, bowel manipulation and reduced surgical time.

We compared functional characteristics of this technique with those of a hand-sewn 2-layer jejuno-caecal anastomosis. To test this we constructed jejuno-caecal anastomosis in fresh intestinal segments and measured construction time, bursting pressure and evaluated failure mode.

We also applied this technique in ten clinical cases and report complications and follow up.

Material and Methods

Part 1- Ex vivo study

Intestinal segments were collected from 24 slaughtered horses. Intestinal segments were harvested conserving the distal jejunum, ileum, ileocecal valve and caecum. They were washed, stored and transported at room temperature in Lactade Ringer Solution[4,5]. Twelve segments were used to create two-layers inverting jejuno-caecal anastomoses and twelve to create semi-closed one-layer inverting jejuno-caecal anastomoses. All anastomoses were created within four hours from the death of the horse and then stored in LRS until testing for a maximum time of an hour.

Surgical technique

Semi-closed one layer anastomosis. The jejunum was transected at least about 1 meter proximally to the ileum and the edges of the proximal stump inverted with a Parker-Kerr suture over a crushing intestinal clamp.

The jejunal stump was then apposed with four stay sutures placed aside of its antimesenteric border onto the body of the caecum between the dorsal and medial teniae approximately 2 thirds of length from the apex (FIG 1). The distance between the two proximal stay sutures and the distal ones was standardized with a ruler at 14 cm. The assistant surgeon then placed tension on two of the stay sutures so to align the two segments of bowel. A Lembert suture pattern with 2-0 Polyglactin 910 comprising serosa, muscularis and submucosa of the two bowel segments was then started from one of the proximal stay suture and continued distally down to the distad stay suture on the same side (Fig.2). At this level the suture was tied and continued to the distal stay suture on the opposite site of the jejunal stump were it was tied again. The jejunal stump was reversed and another Lembert suture performed on the opposite site . This suture was then tied reaching the proximal stay suture.

48 The two proximal stay sutures were then used to lift the two bowel segments up to the level where
49 the jejunal stump was nearly straight and pending. To enter the intestinal lumen a 25-30 mm full
50 thickness incision with a n° 10 scalpel blade was performed on the two segments (Fig.3).
51 Two crushing enterostats were then placed into the enterotomies about 1 –1,5 cm apart, taking care
52 not crossing the suture lines.
53 A pair of Lister's scissors were then introduced between the two enterostats and the two adjacent
54 bowel walls cut, paying particular attention not to cross the distal suture line (Fig 4). To avoid
55 cutting of this end of the stoma this part of the suture was held between the surgeon's fingers. Once
56 the stoma creation was completed the anastomosis was completed as well approaching the free parts
57 of the intestinal walls by continuing the previously interrupted Lembert suture (Fig 5-5a).
58 **Two-layers anastomosis.** The jejunal stump was isolated with a crushing bowel clamp, resected
59 and inverted with a Parker-Kerr suture. The stump was the apposed on the caecal body and a
60 serosubmucosal continuous suture (polyclactin 910, 2-0) was placed to connect the two segments
61 for a standardized (by means of a ruler) length of 14 cm. The suture thread was tied at the end of the
62 suture but not cut. The serosa and muscularis of the jejunal stump and of the caecal body were cut
63 for a length of 13 cm, leaving the mucosa intact. A continuous suture (polyglactin 910, 2-0)
64 comprising mucosa and submucosa of both intestinal segments was placed aside of the first one and
65 tied at the end of the incision. The mucosa of the two segments was then incised creating the stoma.
66 The mucosal suture was then completed on the other side of the stoma. The seromuscular suture
67 was completed as well with the suture left-over from the first one[1].
68
69 After completion each anastomosis was tested for leakage of intestinal content. A hundred
70 milliliters of water were inserted in the proximal jejunum and gently milked through the
71 anastomosis to mimic transit of intestinal content.
72 In each bowel segment, after completion of the anastomosis, the jejunum was transected and ligated
73 approximately 30 cm proximal to the anastomosis and the caecum tied over the ileocaecal valve

and 30 cm distad to the anstomosis with plastic tie bands and then kept at room temperature submerged in LRS until mechanical tests were performed for a maximum of one hour.

Construction Time

Time (minutes) of anastomosis construction was defined as the time between positioning of the crushing clamp on the jejuna stump and completion of the suture.

Mean and SEM were than calculated and compared for each type of anastomosis with an unpaired t test Welch corrected.

Bursting pressure

All anastomosis were tested for leakage by air filling and subsequent submersion in a water tank to test for bursting strength with a gas inflation tank test[4,5].

A metal cannula connected to a compressed air tank was inserted into the jejunal lumen and a similar cannula inserted in the caecum distal to the anastomosis and connected to a calibrated mercury sphygmomanometer. Air-tight sealing of the cannula insertion was assured by placement of plastic tie-band over the intestinal wall. Each specimen was submerged in water and inflated with air at 1L/min until gas leaked from the bowel[4,5].

Luminal pressures were continuously measured and recorded by digital camera. Review the recordings allowed evaluation of the exact peak pressure at specimen failure.

Failure was confirmed by visualization of gas bubbles leaking from the submerged intestine and by observing a decline in the luminal pressure, and in some by complete bursting of the anastomosis or intestinal wall with sudden dropping of measured pressure.

Statistical analysis

Construction time was compared using a paired Student's t-Test. Bursting pressure was compared between techniques using a Wilcoxon matched pair test.

97 All statistical analyses were performed with commercially available software (Graphpad InStat®
98 version 3.05 for Windows 95/NT, GraphPad Software, San Diego, Calif. USA,
99 www.graphpad.com) with significance set at $p \leq 0.05$. Results are reported as mean ±SEM.

100 **Part 2: Clinical cases:**

101 On ten horses, aged 9-23 years, weight 400-560 kgs the same technique has been applied to resolve
102 ileal or ileocaecal valve obstruction. All horses have been referred for colic syndrome and following
103 exploratory laparotomy were diagnosed intestinal pathologies involving jejunum or ileum requiring
104 a jejuno-caecal side-to-side anastomosis for complete (4 cases) or incomplete (6 cases) ileocaecal
105 bypass. Horses that had a complete ileocaecal bypass were selected to have this technique applied
106 because the pathological involvement of the ileum and/or jejunum was so extensive to preclude the
107 use an end-to-end ileo-ileal or jejuno-ileal anastomosis, that was otherwise selected as first surgical
108 option.
109 Surgical technique was the same described for the *ex vivo* study, except for incomplete ileocaecal
110 bypass were the jejunum wasn't transected and closed with the Parker-Kerr suture, but simply
111 apposed on the caecal body wall (Fig 6-6a). Furthermore, in all cases a stay suture was applied
112 proximally to the anastomotic site between the caecum and the jejunum to avoid kinking of the
113 anastomosis to prevent obstruction (Fig 7a).
114 At the end of the procedure each anastomosis was tested for leakage and function by milking of
115 intestinal content from the jejunum . The intestine was then repositioned in the abdomen that was
116 then closed in a routine manner.
117 Horses received lidocaine infusion for 24 hours postoperatively, Ringer Lactade Solution IV for 36-
118 72 hours depending on the duration of post-operative ileus, flunixin meglumine at decreasing dose
119 (1.1, 0.5, 0.25 mg/kg IV tid) for three days, systemic antibiotics (penicillin+ dihydrostreptomycin)
120 for 5 days.
121 Complications and follow up were recorded.

Results

Part 1- Ex vivo study

Both anastomosis types had similar external appearance. None of the anastomosis performed with either technique leaked water after completion.

In all cases anastomoses were brought to failure by excessive intraluminal pressure during the inflation tank test. When the anastomotic site failed an air leak was detected associated with an initially mild decrease in measured pressure. Only in five cases the anastomosis bursted causing a sudden decrease in intraluminal pressure, and this was always associated with 2 layers anastomoses. Failure occurred always at the anastomtic sites.

Mean (±SEM) construction time were 29.23±0.68 minutes for the HS and 12.327±0.35 minutes for the SC. The difference between values is significant ($p<0,001$).

Mean (±SEM) bursting pressure was 164,58±3,45 mmHg for HS and 119,43±10,22 mmHg for the SC and the difference resulted statistically significant ($p<0,0008$).

Part 2: Clinical cases

During surgery no leakage from anastomotic site was detected after completion. Two cases (one complete and one incomplete bypass) developed postoperative ileus that resolved within 72 hours postoperatively. A further third case (complete bypass) developed ileus 8 days postoperatively and was re-operated on the 9th postoperative day. At re-laparotomy kinking of the anastomosis due to failure of the proximal stay suture was detected and repaired. The anastomosis itself looked patent and functional. (Fig 8) .The horse recovered well thereafter.

Four horses developed mild wound infection that resolved before discharge from the hospital.

All horses were discharged from the hospital between 10 and 23 days postoperatively.

Follow up of at least six months duration revealed that all horses recovered well from surgery and none developed signs of colic thereafter.

Discussion

We found that a side-to-side jejunocaecal anastomosis could be created using a semi closed technique more rapidly than a two-layer hand-sewn anastomosis, but with lower bursting strength. However, the recorded bursting pressures for both anastomosis types were higher than intraluminal pressures recorded in in horses with bowel distention. Failure occurred always at the anastomotic site.

Jejunocaecostomy, a common anastomotic procedure in equine surgery, carries a higher risk of complications than jejunojejunostomy[6,7]. In addition, hand sewn techniques are technically demanding in terms of skills and time[1].

Although an effective and time-saving method in equine jejunocaecal anastomosis, having been associated with less manipulation, less contamination and less operative time, the use of intestinal staplers is costly and carries a higher risk of complications than hand sewn techniques if not oversewn[1].

The cutting thread technique, either with suture wire[8] or by diathermy[9], has been reported to reduce contamination in side-to-side anastomoses but also to be quite time-consuming[1].

The technique hereby described associate advantages of the stapled with the low cost of the hand-sewn techniques, adding the advantages of little manipulation and mucosal exposure.

We found that time of construction resulted significantly reduced when compared to the two layer handsewn techniques. This can be attributed to the reduced suturing time but also to the simplicity of the new technique that doesn't request double incision of the stoma and forced caution given by working with open lumens.

Manipulation is reduced comparing to the two-layer technique also by the fact that there is no need to place enterostats on the caecum wall. This is allowed by the fact that the two little openings done

170 to insert scissors, are made lifting the two segments, thus keeping them away from the body of the
171 caecum, reducing the risk of intestinal content spillage.
172 None of the anastomoses leaked soon after completion neither in the *ex vivo* or *in vivo* part of the
173 study and all the anastomoses resisted pressures of over 80 mm Hg. Bursting pressure is often used
174 to compare different anastomotic techniques both in the acute and chronic phase[4,5,10-16,18] , although
175 in this particular case could be not completely accurate. In our experience caecal distension is rarely
176 a complication of jejuno-jejunostomy and so would be a rare occurrence that such an anastomosis
177 would be stressed by intraluminal pressure. In our study failure usually resulted from distortion of
178 the suture line caused by considerable compliance and distention of the caecum body wall. Thus we
179 believe that by inflating the caecum until disruption of the anastomosis or bursting of the intestinal
180 wall, we tested the two sutures with forces with various directions relative to the stoma achieving an
181 accurate method to test the techniques.
182 All the anastomoses resisted pressures well over those reported for side-to-side jejuno-jejunal
183 anastomosis performed with intestinal staplers[10] . Although comparison of bursting pressure could
184 not be completely accurate within different studies, furthermore if involving different intestinal
185 segments, this can nevertheless furnish the surgeon parameters of the strength of this technique in
186 relation to other well-known methods of anastomosis.
187 The bursting pressure of the anastomosis performed with this technique is significantly lower than
188 for the two layer one, although effectiveness of the one-layer method has already been proven by
189 studies performed on end to end anastomosis [17,18] in the horse. Particular care must be taken to place
190 suture bites into the submucosa, and failure to do so has been the primary cause of anastomosis
191 failure in the *ex-vivo* study. Nevertheless the one layer technique resulted safe and efficient in the
192 clinical cases, assuring fluid- and water-proof closure of the anastomosis.
193 The characteristics of the semi-closed technique here described, allowing manipulation of the two
194 bowel segments with little exposure of the mucosa, could prove useful and fast to perform. Special

care should be taken when inserting the Lister scissors and cutting the two body wall in order not to cross the suture lines.

Haemorrhage from the anastomotic site could be an issue[19]. Although we couldn't test properly for hemorrhage of the stoma edges, placing the two crushing enterostats before creating the stoma should prevent haemorrhage from the anastomosis and possibly help in the healing of the intestinal layers. In fact there are multiple methods to achieve anastomosis of two intestinal segments only by compression of adjacent intestinal wall[20].

With our technique the alignment of the intestinal layers is the same achieved with other methods like staplers or Compression Anastomotic Devices (Nitinol Rings) that have been demonstrated to provide a fully functional anastomosis[20].

In clinical cases the technique proved efficient and easy to perform. No haemorrhage from the anastomosis was suspected in the cases reported and the only anastomosis-related complications was caused by disruption of the proximal stay suture. Follow up at minimum six months revealed all horses were alive and didn't show any colic sign after discharge.

Although such few cases are not sufficient to determine complication rates of this technique they are, altogether with other studies on one-layer anastomosis, a starting point from which beginning the development of faster and less contaminating techniques. There is still obvious need for in vivo study to determine evolving of the stoma in term of fibrosis, long-term dimensions, caeco-jejunal reflux and possible complications of this technique, that rarely occur in the acute phase.

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Figure Legend:

Fig 1: apposition of the four stay suture

Fig 2: continuous Lembert suture

Fig 3: incision of the wall of the two segments

Fig 4: insertion of the two crushing enterostat and creation of the stoma

Fig 5: closure of the fourth side of the anastomosis

Fig 5 a: completion of the anastomosis

Fig 6: disposition of the bowel segments in incomplete bypass

Fig 6 a: in vivo image of incomplete bypass

Fig 7 : Proximal suture to avoid kinking of the anastomosis

Fig 8: one layer anstomosis on day 9 post-op