Ex vivo model for a new bilateral antimesenteric V-modified side-to-side isoperistaltic anastomosis to prevent recurrence in ileocolic Crohn's disease

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ABSTRACT

INTRODUCTION The high rate of recurrence following ileocaecal resection for Crohn's disease may lead to repeat surgery in 20–30% of patients at five years after surgery. Recurrence usually occurs at the anastomosis and the neoterminal ileum and the association of a strictureplasty to widen the bowel lumen in the regions immediately proximal ('anastomotic inlet') and distal ('anastomotic outlet') to the anastomosis may delay or reduce the risk of surgical recurrence.

MATERIALS AND METHODS A side to side isoperistaltic anastomosis, with an associated V-modified strictureplasty on the anti-mesenteric border at the level of the anastomosis inlet and outlet has been designed. We produced a wet lab ex vivo model of the anastomosis and, to evaluate the different calibre of the anastomotic segments, we compared it with ex vivo models of three anastomotic configurations currently used in surgery for Crohn's disease: i) side to side isoperistaltic anastomosis; ii) modified side-to-side isoperistaltic anastomosis with double Heineke–Mikulicz procedure (Sasaki anastomosis); iii) anti-mesenteric functional end-to-end handsewn anastomosis (Kono-S anastomosis).

RESULTS Differences were recorded at the level of the anastomosis inlet and outlet, with a larger volume estimated in the Sasaki anastomosis and in the V-modified anastomosis. The V-modified anastomosis had a larger volume compared with the Sasaki anastomosis for a longer segment of small bowel.

CONCLUSIONS We have developed an experimental animal model for a new anastomotic technique which could be applied in surgery for Crohn's disease following small-bowel or ileocolic resection.

KEYWORDS

Crohn's disease – Colorectal surgery – ileocaecal resection – Anastomotic recurrence – V-modified antimesenteric anastomosis

Accepted 28 December 2018

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Introduction

The high rate of recurrence following ileocaecal resection for Crohn's disease may lead to reoperation in 20–30% of patients at five years after surgery,¹ with approximately 40–50% of patients who underwent surgery likely to need further operations within 10–15 years.² Recurrence usually occurs on the anastomosis and the neoterminal ileum³ and different anastomotic techniques have been evaluated with the belief that a wide-calibre anastomosis, such as side-to-side configuration, can result in lower recurrence rates.⁴ A more radical surgical approach, extending the margins of resection proximally and distally to the diseased segment, does not reduce the risk of recurrence, but contributes to the occurrence of short bowel syndrome and must be avoided.⁵ Redo surgery can be technically demanding due

to adhesions and the potential for abscesses and fistulae⁶ and carries a significant risk of septic complications.⁷ Surgery for anastomotic recurrence of Crohn's disease often requires resection of a shorter segment of small bowel compared with primary surgery,⁸ and the association of a strictureplasty to widen the bowel lumen in the bowel regions immediately proximal ('anastomotic inlet') and distal ('anastomotic outlet') to the anastomosis may delay or reduce the risk of surgical recurrence.⁹ In this study we present a model for a modified side-to-side isoperistaltic anastomosis, in which a strictureplasty technique has been applied to the inlet and the outlet of the anastomosis, to widen the lumen of the bowel in these two critical areas with the aim of minimising the risk of clinical and surgical anastomotic recurrence.

Figure 1 Schematic view of bilateral V-modified side to side isoperistaltic anastomosis. A) Afferent small bowel ‘anastomotic inlet; B) efferent small bowel/colon ‘Anastomotic outlet’; C) staple line; D) side-to-side isoperistaltic anastomosis; E) Y-to-V anti-mesenteric incision; α to β incision is 1.5–2 cm; β to γ and β to γ' incision is 2–2.5 cm and can be extended to widen the bowel lumen for a longer segment after closing in a transverse fashion; δ angle is 120–140 degrees; F) mesenteric edge. The antimesenteric V-flap is sutured from β to α .

Materials and methods

A side-to-side isoperistaltic anastomosis, with an associated V-modified strictureplasty on the anti-mesenteric border at the level of the anastomosis inlet and outlet has been designed: a Y-shaped enterotomy is made on the antimesenteric margin of the bowel immediately proximal and distal to the anastomosis, the defect is then sutured in a V-shaped fashion, with resulting widening of the lumen of the bowel (Fig 1).¹⁰

To describe the technical steps of the newly designed ‘bilateral anti-mesenteric V-modified side-to-side isoperistaltic anastomosis’, we produced a wet-lab ex vivo model of the anastomosis (Fig 2) and to evaluate the different calibre of the anastomotic segments we compared it with ex vivo models of three anastomotic configurations currently used in Crohn’s disease surgery: i) side-to-side isoperistaltic anastomosis; ii) modified side-to-side isoperistaltic anastomosis with double Heineke–Mikulicz procedure (Sasaki *et al*);⁹ iii) antimesenteric functional end-to-end handsewn anastomosis (Kono-S).¹¹ The ex vivo specimens consisted of porcine small bowel with attached mesentery obtained from an approved supplier of animal tissue for prosection.

The time needed for anastomosis completion was recorded and the volume of the anastomosis was estimated in the different segments of the anastomosis using a 14 French gauge (Fr) Foley catheter inflated at different volumes, and by measuring the two maximum diameters of the different anastomotic segments after sectioning the bowel at 0.8–1.2 cm intervals, applying the formula $V = 4/3$

Figure 2 Ex vivo model of V-modified antimesenteric isoperistaltic side to side anastomosis. 2a) The two small bowel segments are approximated in a iso-peristaltic fashion. 2b) The site for a Heineke–Mikulicz strictureplasty is marked on the left, while the site for a V-modified plasty is marked on the right. 2c) A Kono-S anastomosis is prepared after approximating the supporting column. 2d) The V-plasty is advanced. 2e) A Foley catheter is used to estimate the volume of the different segments of the anastomosis. 2f) The anastomotic segment is sectioned every 0.8–1.2 cm and the volume of every segment is calculated applying the formula.

$\times \pi \times a \times b \times c$, where V is the volume of the ellipsoid (small bowel segment) in cm^3 , π is 3.14 and a b and c are the three maximum radius of the specific small-bowel segment. Each anastomosis was fashioned three times to minimise the risk of confounders due to technical imprecision of the measurements of time and volume of the different anastomoses configurations. Volume is expressed in cubic centimetres as mean and standard deviation.

Continuous variables are presented as means (plus or minus standard deviation) and were compared with the use of Student's t test. The Mann-Whitney U test was used for continuous, not normally distributed, outcomes. A P -value of less than 0.05 was considered statistically significant.

Results

Twelve anastomoses were fashioned in total. The 14 Fr Foley catheter with the balloon inflated with 6 ml saline solution easily passed within the lumen of the anastomosis of all the four different anastomoses configurations, probably because of the elasticity of the porcine intestine. Differences were recorded for the different anastomoses at the level of the anastomosis inlet and outlet, with a wider calibre estimated in the Sasaki anastomosis and in the V-modified anastomosis (Fig 3 and Table 1).

A trend towards a wider calibre in the V-modified anastomosis compared with the Sasaki anastomoses was noted in segments -3, -2, +2 and +3, suggesting that the increase in calibre of the V-modified anastomosis could affect a

Table 1 Volume estimation of the different segments of the small bowel anastomoses as schematically represented in Figure 3. Volume was calculated by measuring the maximum diameter of each segment of the anastomosis after sectioning the bowel at 0.8–1.2 cm intervals and by applying the formula $V \frac{4}{3} \times \pi \times a \times b \times c$, where V is the volume of the ellipsoid (small bowel segment) in cm^3 , π is 3.14 and a b and c are the three maximum radii of the specific small-bowel segment. Data are expressed as mean and standard deviations.								
Anastomosis	-3	-2	-1	SS	SS	+1	+2	+3
V-modified	4.75 ± 1.21	5.01 ± 0.78	5.12 ± 1.12	6.32 ± 1.38	6.46 ± 1.17	4.92 ± 1.32	5.15 ± 1.1	4.7 ± 1.09
Side to side	4.33 ± 0.8	4.02 ± 1.9	4.26 ± 1	6.5 ± 0.99	6.02 ± 1.18	4.4 ± 1.3	4.04 ± 0.81	4.66 ± 1.02
Sasaki	4.21 ± 0.94	4.57 ± 0.94	6.02 ± 1.32	6.25 ± 1.1	6.42 ± 1.18	5.98 ± 1.7	4.51 ± 0.94	4.32 ± 0.9
Kono-S	4.41 ± 0.62	3.98 ± 1.4	4.6 ± 1.05	6.83 ± 1.42	6.59 ± 0.86	4.72 ± 0.94	4.12 ± 1.2	4.32 ± 0.96
SS, lumen of the side-to-side anastomosis.								

longer segment of small bowel, despite being less evident in segments -1 and +1 where the Sasaki anastomosis has a wider calibre (Table 1). All the anastomosis models had similar anastomotic lumen, except from the Kono-S anastomoses with a wider anastomotic calibre.

The time needed for completion of the anastomoses was longer for the Kono-S (14.7 ± 4.3 minutes) compared with the side-to-side isoperistaltic (10.3 ± 5.2) but not statistically different with the Sasaki (13.7 ± 6.1) and V-modified (14.5 ± 3.5) anastomoses.

Discussion

We have developed an animal model for a new anastomotic technique which could be applied in Crohn's disease surgery following small-bowel or ileocolic resection. The anastomosis has been developed applying at the level of the anastomotic inlet and outlet of an isoperistaltic side-to-side anastomosis, the previously described Moskel-Walske-Neumayer technique.¹² This strictureplasty was suggested in Crohn's disease for short strictures with a proximally dilated small bowel, conferring a gentle transition from dilated to non-dilated bowel.¹⁵ Even if our model does not present any proximal small-bowel dilatation, this may not uncommonly be the case in real-life scenarios, as stricturing disease represents the most common indication for surgery in ileocolic Crohn's disease,¹⁴ and therefore the resulting bowel lumen at the anastomotic inlet maybe wider following in vivo application of the newly proposed anastomotic technique.

A strictureplasty technique to the inlet and outlet of a side-to-side anastomosis was previously applied by Sasaki *et al*,⁹ who added a Heineke-Mikulicz strictureplasty immediately proximally and distally to the anastomosis. Our model suggests that even if the Sasaki anastomosis confers a wider lumen immediately in proximity of the anastomosis, this is for a very short bowel segment and may not prevent a clinical anastomotic recurrence, while our newly designed V-modified anastomosis may confer a less marked, but still wider lumen, for a longer segment of small bowel at the anastomotic inlet and outlet, compared with the traditional side-to-side anastomosis.

Strictureplasty techniques have been used increasingly over the past 30 years in the management of obstructing Crohn's disease with conventional techniques such as Heineke-Mikulicz strictureplasty and Finney strictureplasty being the most widely reported methods.¹⁵ Some authors have shown that fewer recurrences of disease occur at strictureplasty sites than resection sites,¹⁶ with site-specific recurrences as low as 4%.¹⁷ Complications from strictureplasties in Crohn's disease have been documented, with 4% of patients suffering from complications such as anastomotic leaks, fistula and abscess formation in a meta-analysis of 1112 patients.¹⁸ The safety of the proposed technique of a V-modified anti-mesenteric isoperistaltic anastomosis needs to be evaluated in an in vivo feasibility study, with assessment of the rate of postoperative complications and of the long-term clinical and endoscopic follow-up findings.

Longer operating time also represents a concern, even if the technique could require shorter time compared with the Kono-S anastomosis, particularly in view of the possibility of applying a stapler to fashion the side-to-side anastomosis. Moreover, our V-plasty modification could be easily applied to the inlet of other anastomotic configurations, such as end to side, end to end and anti-peristaltic side to side. Even if a wider calibre of the inlet and outlet of the V-modified anastomosis is confirmed, it has to be demonstrated whether this will translate in lower anastomotic recurrence rates as recurrence of Crohn's disease is multifactorial and it is too simplistic to believe that making the bowel around the anastomosis wider would linearly reflect on recurrence. Moreover, the lumen provided in vivo by the V-plasty anastomosis may not be wide enough to delay a clinical presentation of Crohn's disease recurrence, as the recurrence may also affect the bowel proximal to the V-plasty. Current discussion on Crohn's disease recurrence revolves around the role of the mesentery, with Coffey *et al* demonstrating a significantly reduced surgical recurrence rate when including a substantial part of mesentery in the specimen.¹⁹ While the mesentery is likely to play a pathogenic role in Crohn's disease, it is also crucial for intestinal vascularisation, and extensive removal may compromise bowel tissue with concerns regarding haemorrhagic dangers associated with division of the mesentery in patients with Crohn's disease and potential need for increased length of resected bowel if larger mesenteric segments are removed.²⁰ The Kono-S anastomosis also differs for the approach on the mesentery, which is divided close to the intestinal wall to preserve vascularisation and innervation,^{11,21} with the theoretical advantage of the complete exclusion of the mesentery, the initial site of Crohn's disease recurrence.²² For now, it still remains unclear how much mesentery should be resected in primary and recurrent Crohn's disease surgery. A feasibility study is currently being designed at Portsmouth Hospitals NHS Trust to evaluate the feasibility and safety of the proposed new anastomotic technique that, at this stage, only represents an experimental model needing to be tested in-vivo with prolonged follow-up data.

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