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Evaluation of techniques to prevent colorectal anastomotic leakage

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ABSTRACT

Background: Anastomotic leakage is a major complication after anterior resection for rectal cancer. The double-stapling technique (DST) is the main method for creating a colorectal anastomosis. However, the rate of anastomotic leakage after DST remains high, and the technical risk factors have not been well established.

Materials and methods: Five methods of colorectal anastomosis were performed on the porcine rectum and colon: single-stapled double-purse-string (SSDP), DST, side-to-side with a linear stapler (SS-L), side-to-side with a circular stapler (SS-C), and SS-C with hand-sewn reinforcement ($n = 6$ for each method). In each group, burst pressures were tested, paying special attention to the locations of the first disruptions. The anastomosis line, including staples, was embedded in polyester resin, and polished sections were examined histologically.

Results: Burst pressures were significantly higher in the SS-L and SS-C than those in the SSDP and DST groups ($P < 0.001$) and were higher in the SS-C with hand-sewn reinforcement than those in the SS-L and SS-C groups ($P < 0.001$). Remarkably, in the SSDP, DST, and SS-C groups, the first disruptions occurred on the staple line created by the circular stapler.

Conclusions: The experimentally strongest colorectal anastomosis created with instruments currently in use was a SS-C. This anastomosis does not overlap staple lines and does not require a purse-string suture. Hand-sewn reinforcement was effective in increasing the anastomotic strength.

1. Introduction

The double-stapling technique (DST) is the most frequently performed method for colorectal anastomosis and is the only intracorporeal method possible for lower rectal anastomosis. However, the risk of anastomosis leakage (AL) after DST remains high, and the technical risk factors have not been well established [1–6].

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In a preliminary endoscopic evaluation of anastomosis lesions after DST, we noted three characteristics of AL [1]. First, all ALs occurred on the circular anastomosis line. Second, half the ALs occurred on the overlapping stapler points, and the other half occurred between the overlapping points. Third, neither necrotic changes nor ischemic injury occurred in other locations, including the residual rectal stump. Furthermore, investigation of the technical factors related to the development of AL after DST anastomosis revealed that the anastomosis method itself may be closely associated with the development of AL. However, our endoscopic evaluation of DST assessed relatively few patients, and analyzing larger patient populations within a short period is difficult. Therefore, we chose to evaluate the technical factors of colorectal anastomosis in this animal study.

Some animal experiments on colorectal anastomosis strength have been reported. However, all preliminary experiments used the colon or small intestines [2,5]. The present study was performed using porcine rectum, which lacks serosa and has thick muscle layers. The purpose of this experiment was to investigate the technical factors of colorectal anastomosis with stapling and to identify the most reliable method. Hand-sewn reinforcement was also examined to determine whether it was effective in increasing the anastomotic strength.

2. Materials and methods

2.1. Animal care

Fifteen healthy female Japanese domestic pigs, 3–4 mo-old and weighing 30–42 kg, were used in this study, which was conducted in full accordance with the principles and authorization of the local Helsinki Institutional Review Board for animal studies (approval code A23-189-0, obtained from the corresponding ethical committee of Kyushu University).

2.2. Operative technique

Through a midline laparotomy, the distal rectum was transected at as low a level as possible and the proximal rectum divided at the transition between rectum and sigmoid colon. The rectum was removed from each pig, and a 30-cm long segment of the colon was removed from the >30-cm length proximal to the divided part of the rectum after ligation of the appropriate mesentery. The mesorectum was removed from the resected rectum, and only the anal side of the peritoneal reflection of the rectum was used for anastomosis. The size of each sample was measured with a digital vernier micrometer, with the following results: the mean length of removed rectum was 177.3 ± 12.8 mm, the mean width of the anal-side rectal stamp was 37.1 ± 2.9 mm, the mean width of the oral-side rectal stamp was 29.6 ± 3.8 mm, the mean thickness of the anal side of the rectal wall was 2.4 ± 0.3 mm, the mean thickness of the oral side of the rectal wall was 2.5 ± 0.4 mm, and the mean thickness of the colon wall was 1.2 ± 0.2 mm. Two different types of colorectal anastomoses were performed on the proximal and distal ends of each removed rectum. The same number of each type of anastomosis was performed on either the proximal or the distal side of the rectum. The anastomosis experiments were started immediately after the organs were excised and were completed in less than an hour.

Five different methods were evaluated ($n = 6$ for each method) as follows: single-stapled double-purse-string anastomosis (SSDP) (Fig. 2), DST (Fig. 3), side-to-side anastomosis with a linear stapler (SS-L) (Fig. 4), and side-to-side anastomosis with a circular stapler (SS-C) (Fig. 5) and SS-C with hand-sewn reinforcement (SS-C + HR) (Fig. 6).

2.3. Anastomosis with SSDP

The rectum and colon were fitted with a manually placed double-armed 3-0 Prolene purse-string suture around each open stump. A 29-mm intraluminal stapler (ILS; Ethicon Endo-Surgery, Tokyo, Japan) was selected, and the anvil was placed

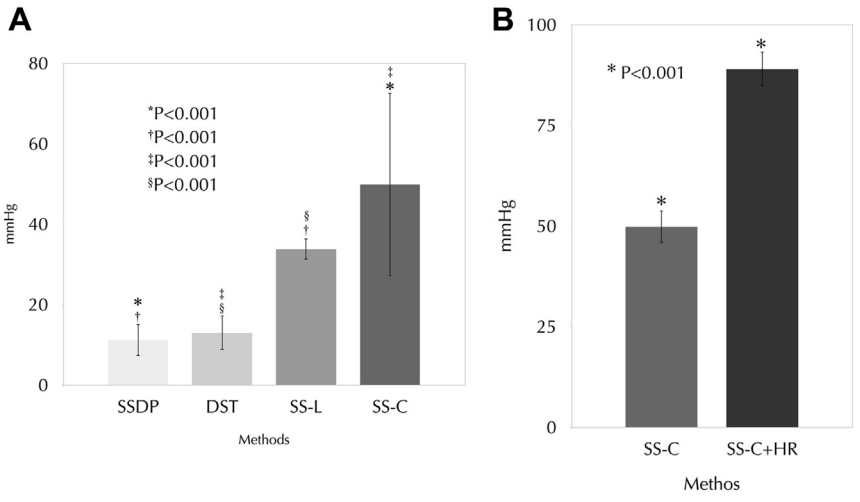

Fig. 1 – (A) First burst pressures (mean ± standard deviation, mm Hg) for each anastomosis method. (B) First burst pressures (mean ± standard deviation, mm Hg) for SS-C and SS-C + HR anastomosis methods.