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DYNAMIC MANUSCRIPT

Innovative needle-assisted technique for intracorporeal anastomosis: Simplifying closure of common enterotomy in laparoscopic gastrointestinal surgery

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Abstract

Background Intracorporeal anastomosis offers notable advantages over extracorporeal techniques, including reduced tissue manipulation leading to faster recovery and potentially lower risks of surgical site infections and complications. However, it also involves several challenges, such as increased operative time and the need for experienced assistants and multiple trocars. Our novel technique addresses these problems.

Methods We present a novel approach for closing common enterotomies during intracorporeal anastomosis by using a linear stapler. This technique involves the use of a 6-cm straight needle, which facilitates closure of the common enterotomy. The technique can be performed independently by a single surgeon without the need for additional trocars or assistants.

Results This technique was applied for 20 patients undergoing laparoscopic gastrointestinal surgery between June 2023 and February 2024. The median age of the enrolled patients was 65 years, with laparoscopic right hemicolectomy with intracorporeal ileocolostomy being the most common procedure (60% of cases). The median anastomosis time was 22.5 min. No occurrence of anastomotic leakage was reported, and only one patient (5%) developed temporary postoperative bowel obstruction, which was managed conservatively.

Conclusions Our technique enables efficient and safe closure of common enterotomies during intracorporeal anastomosis, minimizing reliance on additional trocars and experienced assistants. It simplifies the procedure and ensures fullthickness stapling, potentially reducing the likelihood of complications. Because of its broad applicability across various laparoscopic surgeries, this technique offers substantial benefits and is worth recommending for intracorporeal anastomosis.

Keywords Laparoscopic surgery · Intracorporeal anastomosis · Gastrointestinal surgery · Linear stapler · Minimally invasive technique · Postoperative outcomes

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Since its introduction in the 1980s, laparoscopic surgery has undergone continual advancements in terms of the surgical equipment, instrumentation, and surgical techniques used. Compared with traditional open surgery, laparoscopic surgery offers several advantages, including smaller incisions, reduced postoperative pain, reduced surgical stress response, reduced risk of infection and complications, faster recovery, and shorter hospital stays [1–3]. This approach also yields comparable oncological outcomes to those of traditional open surgery [3, 4].

Gastrointestinal surgery presents a unique challenge in laparoscopy. Restoration of gastrointestinal continuity is crucial following resection of the target organ. A meticulous anastomotic technique is required to achieve this that can be performed either extracorporeally using suturing techniques similar to traditional open surgery or intracorporeally, which would require the surgeon to be skilled in performing minimally invasive surgery [5].

Intracorporeal anastomosis in laparoscopic surgery often involves the use of linear staplers to create a common channel between bowel segments and subsequent closing of the common enterotomy using another staple cartridge. This technique typically necessitates an experienced assistant to manage the suspensory stitch at the apex; it also requires an increased number of trocars and has high surgical complexity [6, 7]. Additionally, potential sagging at the midpoint of the common enterotomy can further complicate the procedure.

This paper presents a novel yet straightforward technique that enables surgeons to perform closure of the common enterotomy independently during laparoscopic gastrointestinal surgery. This eliminates the need for additional trocars and an experienced assistant, offering wider applicability across laparoscopic procedures requiring anastomoses.

Materials and methods

Laparoscopic surgery was performed following standard protocols for anesthesia, patient positioning, and sterilization. The trocar placement and quantity were determined on the basis of individual surgical requirements. The operating surgeon performed resection in accordance with established surgical principles. For ascending colon tumors, this entailed complete mesocolic excision and central vascular ligation, followed by a laparoscopic right hemicolectomy. A linear stapler was used to respect the diseased bowel segment, leaving the ileum and transverse colon ends. In partial small bowel resection, following confirmation of resection lines and appropriate mesenteric excision, the linear stapler was used to transect the bowel, leaving two ends.

In intracorporeal anastomosis, the two bowel segments that were to be anastomosed were first approximated. The surgeon selected the anastomosis orientation, either peristaltic or antiperistaltic, on the basis of experience or existing evidence. Electrocautery or advanced energy

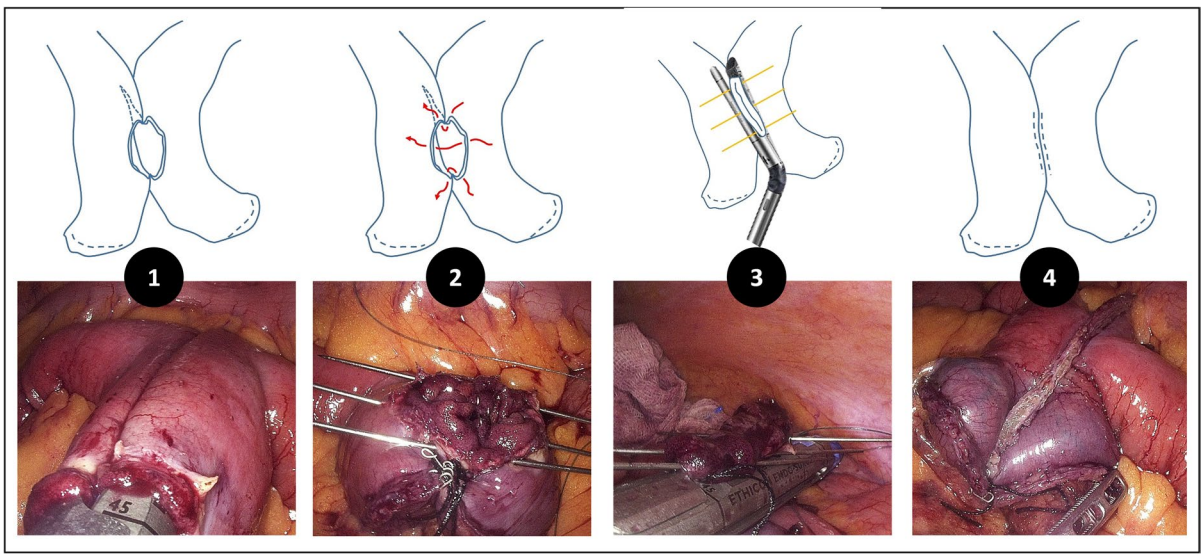

Fig. 1 Step 1: A linear stapler is employed to fire the first staple cartridge, establishing a common channel. Step 2: Three straight needles are strategically passed sequentially through both sides of the common enterotomy at the apex, midpoint, and opposite site, ensuring full-thickness penetration of the bowel wall. Step 3: The linear stapler is inserted beneath the three straight needles and carefully maneuvered along the bowel wall. Following appropriate adjustment of tissue within the stapler, the second staple cartridge is fired. Step 4: The common enterotomy is closed, completing the intracorporeal bowel anastomosis

devices were then used to create an enterotomy in each bowel end. Subsequently, a linear stapler of appropriate length and staple height was selected. The anvil and cartridge were inserted into either of the enterotomy sites and fired to create a common channel, resulting in a common enterotomy (Fig. 1, step 1).

Following this initial step, closure of the common enterotomy was required. To facilitate this closure, our innovative technique entailed the use of a simple tool: 6-cm-long straight needles with monofilament absorbable clear sutures pre-cut to approximately 8–10 cm in length (Maxon Suture, Medtronic Corp., USA). Three such needles were prepared for the closure process.

The common enterotomy was then positioned with its axis parallel to the surgeon's line of sight, aligning the bowel edges on either side. Subsequently, the straight needles were employed to achieve full-thickness piercing (penetrating serosa and mucosa) at three predetermined locations: the apex, midpoint, and opposite end of the enterotomy (Fig. 1, step 2).

Subsequently, a linear stapler was reintroduced, with staple height chosen on the basis of the tissue thickness. The linear stapler was carefully slid along the bowel wall beneath the three straight needles, positioned such that the opposing enterotomy site rested within the crotch of the stapler (Fig. 1, step 3). The linear stapler was then gently elevated, allowing the bowel to sag downward due to gravity and be suspended over the stapler by the three straight needles. This maneuver eliminates the need for additional trocars and assistant manipulation of suspensory sutures. Prior to stapler closure, meticulous adjustments were made to the bowel tissue entrapped between the anvil and cartridge to ensure minimal tissue resection, which mitigated the risk of postoperative stricture formation.

During preclamping, the sutures were pulled to remove the three straight needles. Subsequently, the linear stapler was fired to excise a small strip of the anterior bowel wall, completing the closure of the common enterotomy (Fig. 1, step 4). In most cases, a second layer of suturing was deemed unnecessary. A supplementary video has been provided that visualizes the practical application of this innovative technique.

Finally, the respected bowel specimen (if present) was placed in a specimen bag and removed from the peritoneal cavity. The specimen removal route can be through a slightly extended umbilical incision or repositioned to an off-midline incision, such as a Pfannenstiel incision. The decision to place a drain was made at the discretion of the lead surgeon on the basis of the clinical situation.

This innovative and straightforward technique draws inspiration from the design of the Shonan Monorail in Kanagawa Prefecture, Japan (https://kamakura-enoshima-monorail.jp/). On the monorail, the train cars are suspended below the elevated track, with the wheels located on the roof and running on a box-shaped track above. The relationship between the wheels and the track is similar to that between the straight needle and linear stapler in our technique, with the bowel suspended in a manner similar to that of the train cars.

We collected data, including sex, age, body mass index (BMI), disease diagnosis, surgical procedure performed, intracorporeal anastomosis type, number of trocars used, number of stapler cartridges fired for intracorporeal anastomosis, length of the incision for specimen extraction, time spent on intracorporeal anastomosis, incidence of anastomotic leakage, and incidence of postoperative bowel obstruction from patients who underwent this innovative surgical technique. The collected data were subjected to statistical analysis using JMP for Windows (version 17.0; SAS Institute, Cary, NC, USA). Continuous variables are presented as medians and their ranges, whereas dichotomous variables are presented as frequencies and percentages.

Results

This innovative technique for laparoscopic intracorporeal gastrointestinal anastomosis was implemented in a regional hospital from June 2023 to February 2024. The results from the initial 20 cases were analyzed.

The demographic characteristics, surgical details, and postoperative outcomes for the 20 patients who underwent this technique are summarized in Table 1. The median age of the patients was 65 years (range, 44–80 years), with a male predominance (55%; 11 men and 9 women). The median BMI was 24.6 (range, 19.4–29.4). Laparoscopic right hemicolectomy with intracorporeal ileocolostomy was the most frequently performed procedure using this new technique (n = 13, 65%). Gastrojejunostomy was the second most common anastomosis ($n = 5$, 25%).

The placement and number of trocars adhered to the established requirements of each surgical procedure, with no additional trocars required when the intracorporeal anastomosis technique was used. The median number of trocars used was 3 (range, 3–4), whereas the median number of staple cartridges required to complete the intracorporeal anastomosis (including the initial firing to create the common channel) was 3 (range, 2–3).

The median length of the extraction incision was 6.1 cm (range, 1.6–7.9 cm). The median time required for anastomosis was 22.5 min (range, 14–50 min). Notably, ileocolostomies exhibited a slightly longer median anastomosis time of 24.5 min (range, 18–50 min). However, a trend toward a decreasing anastomosis time as experience increased was observed (Fig. 2).

The incidence of surgical complications within 30 days postoperation was low. No cases of anastomotic leakage were

Table 1 The demographic characteristics, surgical details, and outcomes of 20 patients undergoing intracorporeal bowel anastomosis with closure of common enterotomy using the technique described in this study

Characteristics	
Age (years, median) (range)	65 (44–80)
Sex	
Male	11 (55%)
Female	9 (45%)
BMI (range)	24.6 (19.4–29.4)
Procedures	13 (65%)
Right hemicolectomy	3 (15%)
Gastrojejunostomy bypass	2 (10%)
Subtotal gastrectomy	2 (10%)
Segmental resection of small bowel	
Type of anastomosis	
Ileocolostomy	13 (65%)
Gastrojejunostomy	5 (25%)
Small bowel anastomosis	2 (10%)
Trocars (median) (range)	3 (3–4)
Cartridges (median) (range)	3 (2–3)
Specimen-extraction incision length (cm, median) (range)	6.1 (1.6–7.9)
Time of anastomosis (minutes, median) (range)	22.5 (14–50)
Anastomotic leakage	0
Postoperative ileus	1 (5%)

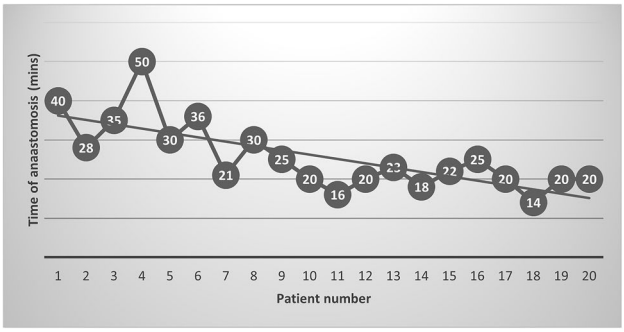

Fig. 2 As the number of cases increases, the time required to perform intracorporeal bowel anastomosis with closure of common enterotomy using this innovative technique as an adjunct procedure in laparoscopic surgery decreases

reported among the 20 cases. One patient (5%) who underwent laparoscopic right hemicolectomy with intracorporeal ileocolostomy developed postoperative bowel obstruction. However, this patient responded well to conservative management and was discharged successfully. Long-term follow-up is necessary to assess long-term surgical outcomes.

Discussion

Intracorporeal gastrointestinal anastomosis has distinct advantages and disadvantages compared with the extracorporeal approach. In laparoscopic right hemicolectomy, intracorporeal anastomosis minimizes bowel manipulation, potentially leading to faster recovery of gastrointestinal function and shorter hospital stays [8–12]. Furthermore, studies have demonstrated that intracorporeal anastomosis after right hemicolectomy reduced the risk of surgical site infections and postoperative bowel obstruction [13–15]. However, the greatest benefit of this approach may be related to the size and location of the incisions.

Extracorporeal gastrointestinal anastomosis necessitates externalization of the ileum and transverse colon for suturing, which can lead to considerable tension in patients with obesity or those with a shorter transverse colon mesentery. This often necessitates extending the umbilical incision, which can increase the risk of incisional hernia and other wound-related complications [11]. Intracorporeal gastrointestinal anastomosis effectively overcomes these challenges, particularly in patients with overweight. Surgeons require only a small incision for specimen extraction (or just trocar incisions in the case of bypass surgery) and can even reposition the extraction site away from the midline to, for example, a suprapubic location, to minimize the risk of incisional hernia [11, 12, 14–18]. Additionally, intracorporeal gastrointestinal anastomosis reduces the risks of mesenteric bleeding, serosal injuries, and bowel devascularization [11, 13].

However, intracorporeal anastomosis has several drawbacks such as an increased operative time, potential intracavitary gastrointestinal contamination, and a loss of tactile assessment of tumors and bowel quality [1, 8, 11, 13, 14]. In addition, surgeons cannot confirm that margins are adequate for oncologic resection through palpation.

Linear staplers are commonly used in intracorporeal gastrointestinal anastomosis to create a common channel. This typically involves creating small enterotomy openings at the bowel segment ends, followed by inserting the linear stapler's anvil and cartridge along the bowel axis and device firing. This step results in a larger common enterotomy. Closure of this common enterotomy can be achieved using laparoscopic suturing [1, 11, 12, 19], which requires advanced laparoscopic suturing skills and experience, with the suture line ideally being made within 45° of the surgeon's line of sight for optimal maneuverability. Alternatively, surgeons may opt for a second linear stapler firing to close the common enterotomy, often requiring a suspensory stitch at the apex to facilitate stapling [6, 7, 12, 20]. This approach typically requires additional trocars and an experienced assistant to manage the suspensory stitch. Moreover, larger common enterotomies can lead to sagging in the middle, further complicating stapling and potentially creating a need for additional sutures [6].

The innovative surgical technique presented in this paper addresses these challenges by employing three straight needles to achieve natural suspension of the common enterotomy on the linear stapler, eliminating the need for suspensory stitches. This enables anastomosis to be performed by a single surgeon without an assistant and avoids the need for additional trocars. Full-thickness stapling minimizes the risk of anastomotic leakage, as long as the needles penetrate the entire bowel wall thickness. Before stapler closure, the surgeon can easily adjust the bowel tissue entrapped between the anvil and cartridge to prevent excessive tissue entrapment and excision, thereby reducing stricture risk. Finally, this technique has broad applicability; it can be used in, for example, ileocolostomy, gastrojejunostomy, and small bowel-to-small bowel anastomoses, facilitating smoother surgical procedures.

This technique can serve as an adjunct for closing common enterotomies during laparoscopic intracorporeal bowel anastomosis with a linear stapler. Following an initial evaluation of its safety and effectiveness, we promptly adopted this method and reported early outcomes. Further experience, case accumulation, and long-term follow-up are necessary to assess the sustained impact and outcomes of this procedure.

Supplementary Information The online version contains supplementary material available at https://doi.org/10.1007/s00464-024-11292-x.

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Declarations

Conflict of interest All the authors including Drs. Tzu-Chieh Yin, Yen-Cheng Chen, Wei-Chih Su, Tsung-Kun Chang, Po-Jung Chen, Ching-Chun Li, Hsiang-Lin Tsai, Ching-Wen Huang and Jaw-Yuan Wang have no conflicts of interest or financial ties to disclose.

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