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Original Article

A retrospective single-center study evaluating early postoperative complications of hand-sewn modified double-layer intestinal anastomosis following the reversal of stoma (either ileostomy or colostomy) in children

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Abstract

Background: Stoma reversal, which involves restoring intestinal continuity, is a complex but commonly performed elective procedure in pediatric surgery. However, it carries significant risks, including postoperative complications and even mortality. This study aimed to evaluate early postoperative complications associated with hand-sewn modified double-layer intestinal anastomosis following stoma reversal in children who had previously undergone definitive bowel surgery.

Methods:
This retrospective study was conducted in the Department of Pediatric Surgery at Chattogram Maa-O-Shishu Hospital Medical College over a period of eleven years, from January 2014 to December 2024. A total of 673 children who underwent stoma closure were included in this study. We analyzed the indications for stoma formation, the duration from creation to closure of the stoma, operative time, and length of hospital stay. Early postoperative complications were assessed using the Clavien-Dindo classification within the first 30 days after surgery. Patients were followed up at two and four weeks after the procedure.

Results:
The median age of the participants was 2.17 ± 0.8 years (IQR: 1.4 - 4.5 years), with a male-to-female ratio of 2.17:1. The primary indications for the initial surgery, which involved stoma formation, included anorectal malformation (231 cases), Hirschsprung's disease (183 cases), intussusception (110 cases), jejunoileal atresia (53 cases), meconium ileus (22 cases), pelvic or blunt abdominal trauma (22 cases), postoperative bands and adhesions (18 cases), ileocecal tuberculosis (12 cases), lymphoma (7 cases), Meckel's diverticulum with bands (11 cases), and typhoid ulcer perforation (4 cases). The median interval between the primary procedure and stoma closure was 62 weeks (IQR: 48–76 weeks). The median operative time was 108 minutes. A total of 219 patients (32.5%) experienced postoperative complications, which included surgical site infection (SSI) (37.8%), anastomotic leak (15.1%), small bowel obstruction or paralytic ileus (9.6%), post-operative diarrhea (8.2%), enterocutaneous fistula (4.2%), gastrointestinal bleeding (3.2%), and postoperative intra-abdominal abscess (2.3%). Medical complications accounted for 19.7% of all complications, with pneumonia (12.3%) being the most common. Reoperations were required due to intestinal obstruction, anastomotic leak, and post-operative intra-abdominal abscess. Additionally, 57 associated procedures were performed, including 13 appendectomies, seven inguinal herniotomies, and 37 circumcisions. Twenty-three patients required a stay in the Pediatric Intensive Care Unit (PICU) following reversal surgery, and seventeen of these patients survived successfully. The median length of hospital stay for these patients was 8.4 days, ranging from 7.3 to 12.1 days.

Conclusions:
There were several indications for stoma formation in children. Surgical site infections (SSIs) were the most common complication following stoma reversal. While most complications could be managed conservatively, cases of anastomotic leak and intestinal obstruction necessitated reoperation.

Keywords: Ileostomy, colostomy, reversal of stoma, hand-sewn, double-layer intestinal anastomosis, surgical site infection, anastomotic leak

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Introduction:

A stoma is a surgically formed exteriorization of the ileum or colon to the anterior surface of the abdominal wall [1]. The most common stomas include the distal small intestine (ileostomy) and the large intestine (colostomy) [1]. This procedure is often performed in pediatric surgery. The main reasons for performing a stoma are to divert the faecal stream, decompress the bowel, protect the gut anastomosis, or a combination of these indications [2]. While stomas can provide significant benefits, they may also lead to considerable complications [3]. Early reversal of the intestinal stoma has been recommended in many studies and may be associated with favorable clinical outcomes [4, 5].

Stoma closure is a critical aspect of gastrointestinal surgery, aimed at restoring the natural continuity of the digestive tract after a temporary diversion [6]. Restoring intestinal continuity can be a challenging procedure influenced by various factors. Stoma reversal is performed when the disease condition for which it was created has resolved, and the patient has healthy bowel ends with no distal obstruction [7]. Stoma closure complications are reported at up to 55%, and mortality at up to 4% [8]. These complications may include surgical site infections, anastomotic leaks, bleeding, anastomotic strictures, and, in severe cases, death [9]. Postoperative complications can lengthen hospital stays and cause heavy financial burdens, while severe complications can even result in fatal outcomes [10]. Anticipating and identifying complications are essential and could lead to better outcomes.

There are various ways for intestinal anastomosis, including hand-sewn sutures, staplers, compression rings, metal wire, and magnetic techniques [11,12]. The following techniques are applied for intestinal anastomoses: (1) interrupted or continuous; (2) single or two layers; (3) end-to-end or end-to-side or side-to-side (or any combination); (4) different suture materials; (5) extra mucosal or full-thickness sutures; (6) size and spacing between each suture [13]. Among these techniques, hand-sewn suturing remains the mainstay for intestinal anastomosis owing to the availability and affordability of suture material and familiarity with the procedure [14]. Historically, two-layer anastomosis has been the most conventional method [14]. However, healing of the anastomosis depends on several factors, including tension at the suture line, adequate apposition, alignment, and blood supply at both ends of the intestine, clean gut at the time of operation, meticulous surgical technique, and overall nutritional status [11,12].

Despite this, the ideal anastomotic technique and the choice of suture material remain areas of conflict in intestinal anastomosis. This study aimed to evaluate early postoperative complications of hand-sewn modified double-layer intestinal anastomosis following stoma reversal in children who had undergone definitive bowel surgery.

Methodology:

This retrospective study was conducted in the Department of Pediatric Surgery at Chattogram Maa-O-Shishu Hospital Medical College over a period of eleven years, from January 2014 to December 2024. A total of 673 children who underwent stoma closure were included in this study. All patients had healthy bowel ends without distal obstruction, demonstrated good anal sphincter control, and were generally in good health to undergo surgery. Before stoma closure, anastomotic integrity and distal gut patency were assessed by digital rectal examination, followed by a bananagram and, in some cases, a distal loopogram. All patients were admitted one day prior to the stoma closure and received prophylactic parenteral antibiotics, along with mechanical bowel preparation.

Surgical technique: The closures were performed under general anesthesia using a hand-sewn modified double-layer intestinal anastomosis. Here, we used continuous 4-0 polyglactin sutures for the transmural inner layer and interrupted 4-0 polyglactin sutures for the outer seromuscular layer. Stitch advancement was approximately 5 mm. Only sufficient pressure was applied to the suture during bowel approximation to ensure a watertight anastomosis without causing ischemia. All stomas were closed intraperitoneally through a formal laparotomy performed by senior medical professionals, specifically assistant professors or higher.

Postoperative Considerations: Patients were not allowed to take orally till 5th day after surgery. Drain tube collection was measured daily and was usually removed on the 6th or 7th postoperative day (POD) after full establishment of oral feeding. The total length of hospital stay (in days) was calculated from the day of operation.

The following data were analyzed: indications for stoma formation, duration from stoma creation to closure, operative time, length of hospital stay, and early postoperative complications, assessed using the Clavien-Dindo classification within the first 30 days after surgery. Post-operative complications occurring within 30 days after stoma reversal and their management were also analyzed. Patients were followed up postoperatively at two weeks and four weeks after the procedure.

Operational definitions: Anastomotic leak was defined as radiographic demonstration of a fistula or non-absorbable material draining from a wound after oral administration, or visible disruption of the suture line during re-exploration [14].

Intra-abdominal abscess without visible discharge was seen in patients as fever, persistent abdominal pain, tachycardia, and raised leucocyte count, and was confirmed on ultrasound of the abdomen [14].

Prolonged postoperative ileus: The inability to tolerate oral intake for a minimum of five days postoperatively in the absence of other symptoms of bowel obstruction [8].

Wound infection: Infection necessitating drainage or antibiotic treatment [8].

Results:

A total of 673 patients who underwent stoma reversal were enrolled in this study. The median age of the participants was 2.17 ± 0.8 years (IQR: 1.4 - 4.5 years), with male predominance (male-to-female ratio of 2.17:1) (Table I). The median interval between the primary procedure and stoma closure was 62 weeks (IQR: 48–76 weeks). The median preoperative hemoglobin level was 11.8 gm/dl (IQR: 10.30-13.30). Blood transfusion was necessary for eighty-five patients postoperatively (Table I). The median operative time was 108 minutes (Table I). The median time to achieve bowel movement after the reversal surgery was 3.2 days (IQR: 2.2-3.8 days) (Table I).

Table I: Clinical characteristics of the patients

Variables	
Median Age, in months	26 ± 10 months
Male-to-Female ratio	2.17:1
The median operative time (minutes)	108 minutes
Postoperative blood transfusion	85 patients
The median time to achieve bowel movement	3.2 days (IQR: 2.2-3.8 days)
The median length of hospital stays (days)	8.4 days (IQR: 7.3-12.1 days)

The primary indications for the initial surgery (stoma formation) included anorectal malformation (231 cases), Hirschsprung's disease (183 cases), intussusception (110 cases), jejunoileal atresia (53 cases), meconium ileus (22 cases), Meckel's diverticulum with bands (11 cases), postoperative bands and adhesions (18 cases), typhoid ulcer perforation (4 cases), ileocecal tuberculosis (12 cases), lymphoma (7 cases), and pelvic or blunt abdominal trauma (22 cases) as shown in Figure 1.

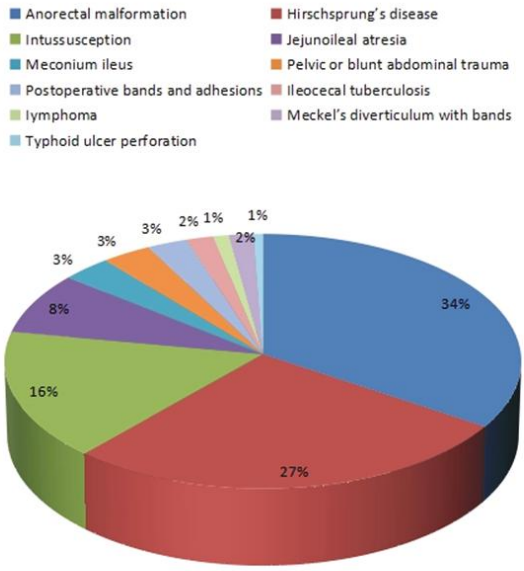

Figure 1: Indications of stoma formation

In our study, colostomy (58.11%) was the most common type of stoma. Among these colostomies, the loop sigmoid colostomy (34.33%) was the most prevalent, followed by a loop transverse colostomy (23.78%) (Table II). The next most common stoma created in our study was an ileostomy (41.89%). Within the ileostomy, the double-barrel ileostomy was the most frequently performed, representing 21.39%, followed by the loop ileostomy at 11.88% and the Bishop-Koop or Santulli procedure at 8.62% (Table II). Postoperative complications were most frequently associated with loop ileostomy (13.8%), followed by loop transverse colostomy, both of which necessitated subsequent surgical intervention. A comprehensive summary of these complications is provided in Table II.

Table II: Distribution of patients according to the stoma type

Stoma type	Total number	Developed Complications required surgical management	Percentage
Sigmoid colostomy	231	11	4.8%
Transverse Colostomy	160	21	13.1%
Double-barrel ileostomy	144	15	10.4%
Loop ileostomy	80	11	13.8%
Bishop-Koop or Santulli Procedure	58	7	12.1%

In this study, 34.33% of patients (365 cases) experienced various complications before stoma closure. The most frequently occurring complications associated with the stoma included skin excoriations (124 cases), meta

bolic alkalosis accompanied by hyponatremia and hypokalemia (116 cases), colostomy diarrhea (40 cases), intestinal prolapse (48 cases), retraction (11 cases), and parastomal hernia (8 cases), as shown in Figure 2. Dehydration and electrolyte imbalances were effectively corrected prior to stoma closure.

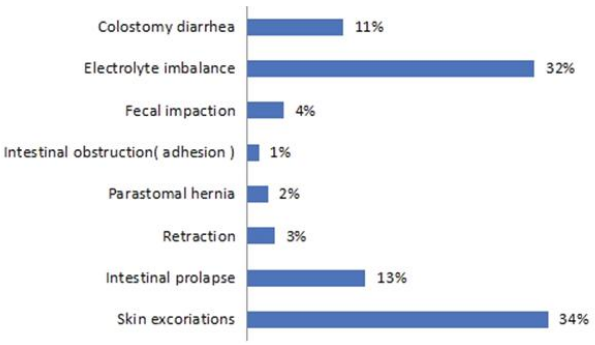

Figure 2: Complications of the stoma

Regarding stoma closure, 57.8% of patients had simple closure, while 42.2% underwent bowel resection and anastomosis (Table III). In most cases, an end-to-end intestinal anastomosis was performed. Along with the reversal of this stoma, fifty-seven associated procedures were performed, including 13 appendectomies, 7 herniotomies, and 37 circumcisions (Table IV).

Table III: Different surgical techniques for stoma closure

Technique of stoma closure		Patients of the study group (n=673)
Simple closure		389 (57.8%)
Resection & anastomosis		284 (42.2%)
Methods of anastomosis	End-to-end anastomosis	586 (87.1%)
	End-to-side anastomosis	87 (12.9%)

Table IV: Associated procedures

Name of the Procedures	n (%)
Appendectomy	13 (22.8%)
Inguinal herniotomy	07 (12.3%)
Circumcision	37 (64.9%)
Total	57

Two hundred nineteen patients (32.5%) developed postoperative complications, which included surgical site infection (SSI) (37.8%), small bowel obstruction/paralytic ileus (9.6%), enterocutaneous fistula (4.2%), anastomotic leak (15.1%), gastrointestinal bleeding (3.2%), postoperative diarrhea (8.2%), and postoperative intra-abdominal abscess (2.3%) (Figure 3). Medical complications comprised 19.6% of all complications, with the most common being pneumonia (12.3%), as detailed in Figure 3. All postoperative complications were recorded and classified according to the Clavien-Dindo classification. The majority of complications (70.3%) were minor (Clavien-Dindo I-II) and managed conservatively, as shown in Table V and Table VI. Only 29.7% were considered major complications necessitating surgical intervention (Clavien-Dindo III-V), as shown in Table V and Table VI. The patients with SSI, postoperative paralytic ileus, gastrointestinal bleeding, and postoperative diarrhea were managed conservatively. Reoperations were required due to intestinal obstruction, anastomotic leak, and postoperative intra-abdominal abscess. Twenty-three patients required a stay in the Pediatric Intensive Care Unit (PICU) after a reversal, with seventeen of them successfully surviving. The median length of stay for these patients was 8.4 days, with a range of 7.3 to 12.1 days (Table I).

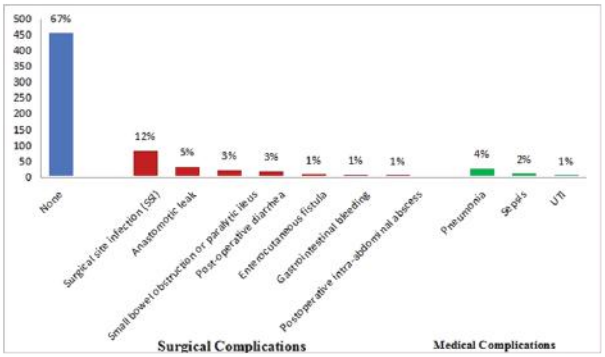

Figure 3: Postoperative complications occurring within 30 days of stoma reversal

Table V: Postoperative complications according to Clavien-Dindo classification after stoma closure

Clavien-Dindo classification	Number	Percentage
Grade I	106	48.4%
Grade II	48	21.9%
Grade III	42	19.2%
Grade IV	17	7.8%
Grade V	6	2.7%

Table VI: Management of postoperative complications after stoma closure

Management of complications	Total number	Percentage
Conservative management	154	70.3%
Surgical management	65	29.7%

Discussion:

Stomas in children are usually temporary due to various underlying conditions, and several techniques have been developed in recent decades to restore intestinal continuity [1,11]. Stoma reversal is a frequent surgical technique with little mortality and considerable morbidity [8]. The hand-sewing technique for bowel anastomosis is the most widely used, as it is cost-effective, well-established, and utilizes readily available materials [13]. In most cases, the traditional sutured anastomosis can be performed in a double-layer fashion [14]. This study evaluates the efficacy and safety of a modified double-layered technique for intestinal anastomosis during stoma reversal.

Congenital anomalies of the gastrointestinal tract were the main indication for intestinal stomas, accounting for 500 (74.3%) patients, while 173 (25.7%) patients had acquired diseases. The most prevalent causes for intestinal stomas in our study included anorectal malformations (34%), followed by Hirschsprung's disease (27%) and jejunoileal atresia (8%). Among the various anatomical sites and types of stoma, the loop sigmoid colostomy was the most commonly performed procedure. Similarly, in our study, anorectal malformation was the most frequent indication for stoma formation, as reported by Massenga et al. and Shalaby et al., in which loop sigmoid colostomy was the most frequently performed intestinal stoma [15,16]. Millar et al. from South Africa reported that more than 90% of neonatal colostomies were performed due to large bowel obstruction caused by Hirschsprung's disease or anorectal anomalies [17].

Each type of stoma is associated with a particular spectrum of complications [18]. The complications associated with ileostomy and colostomy differ [18]. Colostomies typically have a higher incidence of parastomal hernias, while ileostomies are more commonly associated with skin-related complications [19]. In our study, 34.33% of patients experienced stoma-related complications. Among these, skin excoriation was the most prevalent at 34.1%, followed by electrolyte abnormalities at 31.8%. A study conducted by A.M. Redha et al. reported a similar incidence of peristomal skin excoriations and skin maceration at 45.3% in patients who had undergone ileostomy [18]. Due to bypassing of the colon's absorptive capacity, patients with ileostomies often experience a watery output that is highly alkaline and has active enzymatic content that can be extremely toxic and irritant to the skin [18,21]. Babakhanlou et al. noted that patients with ileostomy are at high risk for dehydration, acute kidney injury, and electrolyte imbalances such as hyponatremia, hypokalemia, and hypomagnesemia with resultant secondary complications [21]. A stoma prolapse occurs when a proximal segment of bowel intussuscepts and protrudes through the stomal orifice [21]. In our study, stoma prolapse was observed in 13.2% of patients. The incidence is typically around 3% for ileostomies and between 10% to 30% for colostomies [19,21]. Risk factors for the development of a stomal prolapse include obesity, conditions associated with increased abdominal pressure, or poor surgical technique [21]. Parastomal hernias are defined as incisional hernias related to an abdominal wall stoma [21]. The incidence rates of parastomal hernias vary across studies, ranging from 3 to 50%; however, our research found an incidence of only 2%. [20,21]. Risk factors for parastomal hernias include obesity, malnutrition, steroid use, chronic obstructive pulmonary disease, and the presence of ascites [20]. While stenosis of the stoma can occur, it was not observed in our study. Stenosis can result from a small colostomy opening or ischemia of the stoma margins [19]. Most of these complications can be effectively managed through early definitive surgery and stoma revision [22]. Preoperative counseling for parents and caregivers, along with education on proper stoma care, hygiene, diet, and skin care techniques, leads to successful outcomes. Additionally, performing early stoma closure can also yield satisfactory results [22].

In 1887, Halsted outlined the key principles for creating a safe anastomosis, which include gentle handling of tissues, meticulous hemostasis, preservation of the blood supply, strict aseptic technique, minimal tissue tension, accurate tissue apposition, and obliteration of dead space [23]. Since then, the principles of a successful bowel anastomosis have remained unchanged; techniques have sometimes been modified

based on individual surgical experience and personal preference [23]. The most commonly used technique for bowel anastomosis is hand-sewing, which is cost-effective, widely recognized, and allows easy access to materials [13]. Hand-sewn anastomosis had greater mechanical strength, reduced tendency to stricture, protected the anastomosis from leakage, and improved histological healing [23]. The double-layered intestinal anastomosis was formulated in the early 19th century by Travers [14]. Traditionally, this technique employs a two-layer suturing method, featuring an inner layer of continuous absorbable sutures and an outer layer of either continuous or interrupted non-absorbable sutures [14]. Ross AR et al. recommend absorbable sutures to minimize tissue reaction, promoting rapid healing and reducing scarring [24]. In our research, we utilized continuous absorbable sutures for the inner transmural layer and interrupted absorbable sutures for the outer seromuscular layer of the bowel anastomosis. This approach resulted in minimal anastomotic leaks and also reduced luminal narrowing.

In our study, the most common postoperative complication following stoma reversal was surgical site infection (SSI), which occurred in 37.8% of cases. This was followed by anastomotic leaks at 15.1% and pulmonary infections at 12.3%. Similar postoperative complications have been reported by Alaa El-Hussuna et al. and Fei Liu et al. [25,26]. However, the complication rate in our study was lower than that found in other research [25,26,27]. Additionally, our findings indicated that small-bowel resection and anastomosis were associated with a higher risk of complications compared to simple closure. This aligns with previous studies, which noted that small-bowel resection was typically necessary when simple closure was not technically feasible due to adhesions, often in more complex cases [25,26]. This may help explain the increased risk of complications.

In our study, we found that the overall surgical site infection rate was 12.1%. Research by Pokorny et al. and Rullier et al. indicated that wound infection was the most common complication, with reported rates of 9.0% and 13.9%, respectively—findings consistent with our results [26]. Although wound infection following stoma closure was generally not life-threatening, it increased the risk of wound dehiscence, incisional hernia, the pain of patients, length of stay, and health-care costs [26]. Surgical site infections were mainly attributed to bacterial dysbiosis and bacterial collagenase [27]. Our findings suggest that earlier stoma reversals are associated with a lower risk of wound infections. Prolonged fecal stream diversion has been proposed to contribute to a shift in gut microbiota toward dysbiosis [28]. Lee et al. noted that late stoma reversals (beyond 12 months) were associated with an increase in harmful bacteria and a decrease in beneficial bacteria, further increasing the risk of wound sepsis [28]. Moreover, Saha et al. and Soeters et al. reported that low serum albumin levels can impair wound healing by diminishing collagen synthesis and function, as well as reducing the ability to engulf pathogenic microorganisms. This can lead to wound infections and an increased risk of anastomotic leaks and entero-cutaneous fistulas [28,29].

Anastomotic leakage following stoma closure was a serious complication with significant morbidity [29]. In our study, the incidence of anastomotic leakage was 5.2%, which aligns with other studies reporting rates of 3.3% to 7.7% [27]. Modified double-layer intestinal anastomosis offers several advantages, including effective apposition of the serosal surfaces, no luminal narrowing, and less damage to the submucosal vascular plexus [27]. Karam et al. identified several risk factors associated with anastomotic leakage in their study, the strongest of which were male gender and obesity [29]. They also noted that anastomotic leakage occurred more frequently in benign conditions because it was associated with an inflammatory state that interfered with anastomotic healing [30]. The consequences of anastomotic leakage can include generalized peritonitis or pelvic abscess, extended hospital stays, decreased quality of life, and increased mortality rates. To mitigate these complications, laparotomy combined with fecal diversion is often employed [30].

Medical complications should also be considered after the reversal of the stoma. In our study, the frequency of medical complications was pneumonia (4.1%), sepsis (2.3%), and urinary tract infections (1.1%). Vergara-Fernández et al. also. documented a similar type of postoperative medical complications following stoma reversal [31].

The Clavien-Dindo scoring tool has been utilized in both the USA and Europe to assess the severity of complications following stoma closure, making its applicability crucial in evaluating outcomes [28]. Stoma closure is associated with a low rate of serious complications, specifically major grade III and IV complications, which occur in approximately 9.7% of cases.

Research by Mansfield et al. and Rubio-Perez et al. reported major complication rates of 7.3% and 18%, respectively, with these complications necessitating reoperation or other invasive interventions [30, 32]. The interval from ostomy to reversal was the most common risk factor for postoperative complications, although this issue is still debated. In our study, the median time from the primary procedure to stoma closure was 14.5 months, and 32.5% of patients experienced postoperative complications. Notably, there was a seemingly "safer" period around 7 to 11 months, which might be considered optimal [32]. After 12 months, the complication rate exceeded 30% [32]. Various methods to reduce the rate of postoperative complications after stoma reversal were also offered, e.g., distal limb irrigation techniques and purse-string skin closure to minimize wound-related complications [31].

Conclusions:

There are numerous indications that need stoma formation. Surgical technique was a key risk factor for postoperative complications. A modified double-layer hand-sewn intestinal anastomosis has been demonstrated to be a safe, effective, and feasible method for the reversal of stomas. Surgical site infection (SSI) is the most frequently encountered complication following stoma reversal. While the majority of complications can be managed conservatively, certain cases involving anastomotic leaks and intestinal obstruction may necessitate reoperation.

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