



ORIGINAL ARTICLE

# Prospective evaluation of intestinal decompression in treatment of acute bowel obstruction from Crohn's disease

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## Abstract

**Background:** Conservative therapy for Crohn's disease (CD)-related acute bowel obstruction is essential to avoid emergent surgery. The present study aimed to evaluate the efficacy of using a long intestinal decompression tube (LT) in treatment of CD with acute intestinal obstruction.

**Methods:** This is a prospective observational study. Comparative analysis was performed in CD patients treated with LT (the LT group) and nasogastric tube (the GT group). The primary outcome was the avoidance of emergent surgery. Additionally, predictive factors for failure of decompression and subsequent surgery were investigated.

**Results:** There were 27 and 42 CD patients treated with LT and GT, respectively, in emergent situations. Twelve (44.4%) patients using LT were managed conservatively without laparotomy, while only nine (21.4%) patients in the GT group were spared from emergent surgery ( $P < 0.05$ ). Both in surgery-free and in surgery patients, the time to alleviation of symptoms was significantly shorter in the LT groups than in the GT groups (both  $P < 0.01$ ). C-reactive protein decrease after intubation and 48-hour drainage volume  $> 500$  mL were predictors of unavoidable surgery (both  $P < 0.05$ ). The rate of temporary stoma and incidence of incision infection in the LT surgery group were significantly lower than those in the GT group (both  $P < 0.05$ ). No significant differences were observed in the frequency of medical and surgical recurrences between the LT and GT groups (all  $P > 0.05$ ).

**Conclusions:** Endoscopic placement of LT could improve the emergent status in CD patients with acute bowel obstruction. The drainage output and changes in C-reactive protein after intubation could serve as practical predictive indices for subsequent surgery. Compared to traditional GT decompression, LT decompression was associated with fewer short-term complications and did not appear to affect long-term recurrence.

**Key words:** Intestinal decompression; acute bowel obstruction; Crohn's disease; emergent surgery

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## Introduction

Crohn's disease (CD) is a chronic idiopathic intestinal disorder with a broad spectrum of clinical manifestations. CD is characterized by inflammation extending throughout the entire bowel wall; nearly 50% of patients diagnosed with CD experience complications such as stricturing or penetrating disease [1]. The majority of CD patients require surgery as part of the therapeutic regimen, despite great advancements in the use of immunomodulators and biological agents. A large proportion of these surgical interventions are conducted for intestinal stenosis [2], with 39.9%–48.2% of patients developing symptomatic strictures beyond 20 years of diagnosis [3].

Acute bowel obstruction (ABO) is the most common surgical emergency in inflammatory bowel disease, occurring more often in patients with CD [4, 5]. Although surgical approaches and post-operative prophylaxis have been sufficiently identified in the multidisciplinary management of intestinal obstruction related to CD [6, 7], the timing of surgical intervention remains to be established, especially in emergent conditions. Given that emergent surgery entails a higher risk of morbidity and complications [8], GI surgeons choose to avoid emergent surgery in virtually all CD patients with ABO and rely on non-operative optimization.

Conservative management for emergent admission of CD with intestinal obstruction includes fasting, intravenous hydration and gastrointestinal decompression and can be adapted according to the individual patient's situation, thus constituting an essential part of pre-operative optimization [9]. Nasogastric tubes have been widely recommended for early conservative management of acute small-bowel obstruction (ASBO); however, such treatments are only successful in approximately 40% of patients, and 60% of these patients proceed to surgery [10]. Recently, the refined decompression tube was used to aspirate intestinal contents to alleviate symptoms of intestinal obstruction, achieving favorable results [11–13]. For challenging ASBO cases, endoscopic placement of a long intestinal decompression tube (LT) is more advisable [14].

In the present study, we reported our experience using endoscopic methods to place LTs into the small bowel and compared outcomes of LTs and traditional nasogastric tubes (GTs) in the treatment of CD complicated by ABO.

## Patients and methods

### Patients

This was a single-center prospective cohort study that was approved by the Institutional Review Board of Jinling Hospital. All patients gave informed consent. The specific inclusion criteria were as follows: (i) patients with accurate diagnosis of ABO characterized by abdominal radiography, including X-ray and computed tomography on admission; (ii) patients with diagnosis of CD based on multidisciplinary evidence; and (iii) patients admitted to the wards within 12 hours after ABO onset. The exclusion criteria were as follows: (i) patients with suspicion of strangulation and bowel perforation on admission, requiring immediate surgery; and (ii) patients declining to participate or who were lost to follow-up.

On admission, CD patients with ABO were treated with LT or GT based on the surgeon's judgment, in the absence of a specific protocol. Nasogastric tubes (Terumo Medic, Hangzhou, China) and long decompression tubes (Create Medic, Tokyo, Japan)

were inserted within 12 hours after admission. Depending on the decompression tube used, patients were divided into the LT group or the GT group.

### Instrument and procedures

The long decompression tube was a 14-F, 300-cm tube with three channels (suction, injection and balloon channels) and one balloon. Under gastroscopic monitoring, the tube embedded with a guide wire was guided from the nasal cavity into the stomach. Endoscopic biopsy forceps grasped the tube at the tip and directed it through the pylorus (Figure 1A), until the catheter had advanced as far as approximately 10 cm from the jejunum, when the gastroscope was slowly withdrawn. After removal of the guide wire, the balloon was inflated with 10–15 mL distilled water, facilitating the catheter's movement towards the obstruction site.

Once the LT was immobile, 20–100 mL diatrizoate meglumine (Gastrografin; 9 Bracco Diagnostics, Princeton, NJ) and 50–200 mL air were injected for identification of the tube's progress and stricture locations on an abdominal plain film (Figure 1B). Every 24 hours, we verified the tube position and observed improvements in radiographic signs, including gas–liquid levels within the luminal cavity and segments of intestinal stenosis.

### Assessment of decompression effect

The decompression effect was classified as ABO alleviation and ABO resolution according to the simple scoring system used in our institution (Table 1). The alleviation of symptoms was measured every 8 hours according to the patients' complaints and doctors' physical examinations. We retrospectively collected these data from daily records. Radiographic alleviation referred to reduced visible gas and free fluid on CT (Computed Tomography) or X-ray. The resolution of ABO was classified as follows: complete resolution of symptoms, disappearance of air–fluid levels in radiographic findings and no discomfort on enteral feeding.

At 48 hours after the disappearance of abdominal symptoms and signs, if patients did not have complications requiring surgery, we immediately initiated enteral nutrition. The amount of enteral nutrition was gradually increased until patients could tolerate the target doses. On the fourth day after successful intubation, if the patients did not reach the ABO resolution, surgery was considered. In addition, intestinal strangulation, necrosis and perforation were indications for emergent surgery. All groups were managed similarly in terms of medical management and treatment decisions.

### Data collection

Patient data, including demographics, disease onset and evolution, disease classifications and endoscopic intubation course, concomitant medications and surgery-related data were collected. Specialized software (Haitai Software, Nanjing Haitai Medical Information System Company, Nanjing, China) was used to monitor the integrity of the dataset. To explore the long-term outcomes of the two intubation groups, outpatient clinic surveys and telephone interviews were conducted to acquire endpoint outcome data.

For patients undergoing surgery, overall complications were defined as those occurring within 30 days after surgery or before discharge. Intra-abdominal septic complications included abdominopelvic abscesses and anastomotic leaks

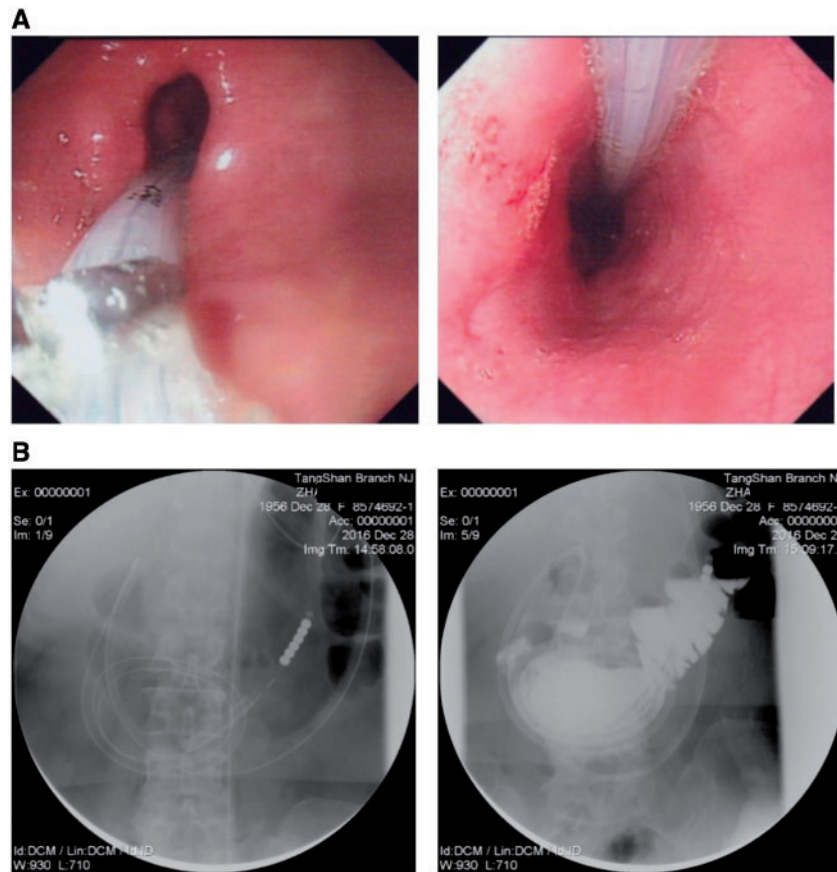


Figure 1. The long tube was endoscopically advanced into the jejunum (A) and the tube location was identified on an abdominal plain film (B).

Table 1. Parameters used for assessing severity of acute bowel obstruction (ABO)

Variable		Severity score		
		0	1	2
Clinical manifestation	Fever	No	Mild	Severe
	Abdominal pain	No	Mild	Severe
	Vomiting	No	Mild	Severe
	No bowel movement	No	Yes	-
	No flatus	No	Yes	-
Radiographic findings	Discomfort on enteral feeding	No	Yes	-
	Air-fluid levels	No	Mild	Severe
	Visible gas	No	Mild	Severe

ABO onset: 8–13, ABO alleviation: 3–7, ABO resolution: 0–2.

confirmed by imaging or laparotomy. Symptom recurrence was defined as the presence of symptoms, including flares of CD (e.g. increased bowel frequency and abdominal pain). If the symptom recurrence was sufficiently severe to require medical escalation, medical recurrence would be recorded. Patients were considered to have radiographic recurrence when radiographic examination revealed bowel stricture, marked mucosal enhancement, fistula and comb sign. Surgical recurrence referred to a second surgery at least 3 months after the primary surgery.

## Statistical analysis

Data were analysed using GraphPad Prism Software (version 5.01; GraphPad, San Diego, CA, USA) and SPSS Software (version 22.0; SPSS, Inc, Chicago, IL, USA). Descriptive statistics for discrete variables were listed as frequencies and percentages. The chi-square test was used to compare differences in categorical variables. Continuous variables were presented as the mean  $\pm$  standard deviation and were compared between groups using the one-way analysis of variance (ANOVA). Risk factors of unavoidable laparotomy were identified using a logistic regression model. Cumulative survival curves were constructed by the Kaplan–Meier method, and the log-rank test was used to assess surgical or medical recurrence-free survival. A P-value less than 0.05 was considered statistically significant.

## Results

### Patient characteristics

Between January 2014 and January 2017, a total of 799 consecutive CD patients attended the clinic, and 102 of these were identified as having CD with ABO. According to the inclusion and exclusion criteria, 69 patients were eligible and were analysed in the present study (Figure 2).

Of the 69 patients, 27 (39.1%) were treated with LT and 42 were treated with GT. Patients in the LT and GT groups were categorized into two subgroups on the basis of the need for emergent surgery. Twelve (44.4%) patients in the LT group were managed successfully with conservative therapy, while only

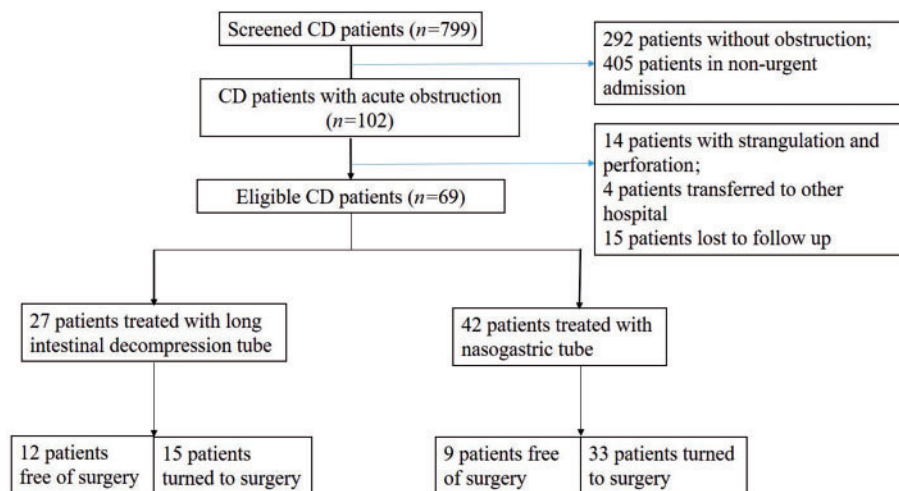


Figure 2. Flowchart of the current study and outcomes of patients identified.

Table 2. Characteristics of Crohn's disease patients with acute bowel obstruction

Characteristics	Surgery-free (n = 21)			Surgery (n = 48)			P-value <sup>a</sup>	P-value <sup>b</sup>
	LT group (n = 12)	GT group (n = 9)	P-value	LT group (n = 15)	GT group (n = 33)	P-value		
Gender (male)	5 (41.7)	6 (66.7)	0.39	9 (60.0)	23 (69.7)	0.49	0.45	1.00
Age at diagnosis, years	44.4 ± 11.8	32.1 ± 8.6	0.02	43.8 ± 17.1	36.6 ± 13.2	0.12	0.88	0.35
Disease duration, years	6.16 ± 4.07	5.89 ± 4.46	0.89	4.23 ± 2.40	5.60 ± 3.97	0.37	0.21	0.85
Obstructive symptoms duration, years	4.23 ± 3.96	4.76 ± 5.16	0.79	4.47 ± 3.59	5.32 ± 3.97	0.51	0.83	0.72
Smoker	1 (8.3)	1 (11.1)	1.00	3 (20.0)	2 (6.1)	0.34	0.60	0.52
Disease location								
L1 (ileal)	6 (50.0)	3 (33.3)	0.43	6 (40.0)	12 (36.4)	0.96	0.617	0.87
L2 (colonic)	0 (0.0)	1 (11.1)		1 (6.7)	2 (6.1)			
L3 (ileocolonic)	6 (50.0)	5 (55.6)		8 (53.3)	19 (57.6)			
L4 (upper GI)	3 (25.0)	1 (11.1)	0.60	1 (6.7)	2 (6.1)	1.00	0.29	0.53
Disease behavior								
B2 (stricturing)	7 (58.3)	6 (66.7)	1.00	8 (53.3)	21 (63.6)	0.50	1.00	1.00
B3 (fistulizing)	5 (41.7)	3 (33.3)		7 (46.7)	12 (36.4)			
Perianal disease	3 (25.0)	2 (22.2)	1.00	4 (26.7)	11 (33.3)	0.90	1.00	0.82
Body mass index, kg/m <sup>2</sup>	17.89 ± 2.15	18.86 ± 2.07	0.31	17.15 ± 2.15	17.3 ± 3.21	0.88	0.37	0.17
Steroid usage	1 (8.3)	1 (11.1)	1.00	4 (26.7)	2 (6.1)	0.13	0.34	0.52
Infliximab usage	1 (8.3)	2 (22.2)	0.55	1 (6.7)	8 (24.2)	0.29	1.00	1.00
No. of previous intestinal surgery	0.75 ± 0.97	0.89 ± 0.78	0.73	0.53 ± 0.64	0.97 ± 0.98	0.12	0.49	0.82
Lab parameters on admission								
C-reactive protein, mg/L	112.4 ± 80.5	41.4 ± 35.9	0.03	34.0 ± 36.2	18.4 ± 25.1	0.09	0.002	0.03
Albumin, g/L	33.1 ± 5.7	34.1 ± 5.8	0.70	32.6 ± 7.8	34.3 ± 7.5	0.47	0.84	0.95
White blood cell count, ×10 <sup>9</sup> /L	8.28 ± 3.83	8.18 ± 3.79	0.95	6.72 ± 3.19	5.52 ± 3.57	0.87	0.26	0.06
Platelet count, ×10 <sup>9</sup> /L	262.1 ± 72.0	229.7 ± 62.5	0.29	187.0 ± 58.9	260.9 ± 86.9	0.22	0.006	0.32
Hemoglobin, g/L	106.7 ± 16.8	99.0 ± 13.41	0.28	108.6 ± 23.9	101.5 ± 21.5	0.80	0.81	0.74

Data are presented as number (%) or mean ± standard deviation.

LT, long intestinal decompression tube; GT, nasogastric tube.

<sup>a</sup>Comparison between LT surgery-free group and LT surgery group.

<sup>b</sup>Comparison between GT surgery-free group and GT surgery group.

nine (21.4%) patients in the GT group were spared emergent surgical management ( $P = 0.043$ ).

Among the patients with or without emergent surgery, there was no significant difference between the LT and GT groups with respect to clinical data collected on admission, including sex, disease duration, medication history, smoking habits and Montreal classification (all  $P > 0.05$ , Table 2). However, the age at CD diagnosis and C-reactive protein (CRP) level on admission were

significantly higher in LT patients who required surgery than those in GT patients who required surgery (both  $P < 0.05$ , Table 2).

### Efficacy of tube-decompression therapy

The details and outcomes of long tube placement are shown in Table 3. The mean time to alleviation of abdominal pain was significantly shorter in the LT group, including the LT surgery

**Table 3.** Outcomes of tube-decompression therapy for Crohn's disease patients with acute bowel obstruction

Outcome	Surgery-free (n = 21)			Surgery (n = 48)			P-value <sup>a</sup>	P-value <sup>b</sup>
	LT group (n = 12)	GT group (n = 9)	P-value	LT group (n = 15)	GT group (n = 33)	P-value		
Abdominal-pain alleviation time, hours	7.49 ± 4.99	20.78 ± 12.2	0.003	14.20 ± 10.02	23.61 ± 9.31	0.002	0.047	0.46
Bowel-sound alleviation time, hours	11.83 ± 7.41	26.56 ± 14.28	0.006	26.27 ± 12.41	25.64 ± 8.63	0.83	0.001	0.81
Radiographic alleviation, n (%)	10 (83.3)	8 (88.9)	1.00	3 (20.0)	1 (3.0)	0.16	0.002	<0.001
Symptom resolution time, days	2.20 ± 1.37	3.70 ± 1.54	0.01	–	–	–	–	–
Concomitant medication								
Steroid	1 (8.3)	0 (0.0)	1.00	0 (0.0)	1 (3.0)	1.00	0.46	1.00
Somatostatin	9 (75.0)	6 (66.7)	0.52	14 (93.3)	29 (87.9)	1.00	0.29	0.31
Enteral nutrition	11 (91.7)	8 (88.9)	1.00	3 (20.0)	2 (6.1)	0.34	0.001	<0.001
Lab parameters change								
C-reactive protein decrease	12 (100.0)	7 (77.7)	0.37	4 (26.7)	14 (42.4)	0.30	<0.001	0.17
Albumin increase	9 (75.0)	5 (55.6)	0.40	10 (66.7)	24 (72.7)	0.93	0.70	0.42
Drainage volumes, mL								
24 hours	837 ± 689	344 ± 243	0.055	1000 ± 498	381 ± 306	<0.001	0.48	0.70
48 hours	560 ± 301	264 ± 127	0.01	826 ± 406	493 ± 155	<0.001	0.04	<0.001
72 hours	314 ± 167	220 ± 135	0.18	566 ± 291	319 ± 243	0.004	0.013	0.25

Data are presented as number (%) or mean ± standard deviation.

LT, long intestinal decompression tube; GT, nasogastric tube.

<sup>a</sup>Comparison between LT surgery-free group and LT surgery group.

<sup>b</sup>Comparison between GT surgery-free group and GT surgery group.

group and the LT surgery-free group (7.49 ± 4.99 and 14.20 ± 10.02 hours, respectively), than those in the corresponding GT groups (20.78 ± 12.20 and 23.61 ± 9.31 hours, respectively; both  $P < 0.01$ ). The mean bowel-sound alleviation time and symptom resolution time were shorter in the LT surgery-free group than those in the GT surgery-free group. The drainage volumes after LT decompression were generally higher than those after GT decompression.

### Predictors for emergent surgery

Comparing surgery and surgery-free groups, CRP levels on admission were significantly higher in both the LT and GT patients who avoided emergent surgery than in those who required surgery (both  $P < 0.05$ , Table 2). Patients who responded to long tube decompression had shorter abdominal-pain and bowel-sound appearance times (Table 3). The alleviation rate according to radiographic findings in patients who avoided emergent surgery was apparently higher than that in patients who required surgery (Table 3). More patients in the surgery-free groups tolerated enteral nutrition through the tube within 48 hours after intubation (Table 3).

We further assessed the variation in CRP and ALB (Albumin) before and after tube placement with the formula: CRP/ALB level 1 day after intubation – CRP/ALB level 1 day before intubation. As the data in Table 3 show, all LT surgery-free patients had a decrease in CRP, while only four (26.7%) patients in the LT surgery group experienced such a decrease ( $P < 0.001$ ). Only the LT surgery-free group showed a downward trend in CRP after intestinal decompression (Figure 3). However, the variation of ALB in both groups showed no difference (both  $P > 0.05$ ). At 48 hours after intubation, the difference in drainage outputs became most significant between surgery and surgery-free patients in both groups.

Multiple logistic regression analysis showed CRP decrease after intubation and 48-hour drainage volume >500 mL were independent risk factors for unavoidable surgery (Table 4).

### Emergent surgery and outcomes

Surgery-related data are presented in Table 5. The mean length of decompression before surgery in the LT surgery group was 4.58 ± 1.37 days—longer than that of the GT surgery group, at 2.86 ± 1.45 days ( $P < 0.05$ ). Pre-operative total parental nutrition support and ASA (American Society of Anesthesiologists) scoring did not differ between the groups. Of note, the rate of temporary stoma was significantly lower in the LT group than in the GT group (20.0% vs. 54.5%,  $P < 0.05$ ). For details of the intra-operative findings, there were no differences in stricture type, fistulae, abscess and inflammatory masses. Only the patients with severe intestinal edema in the GT surgery group were significantly more numerous than those of the LT surgery group (33.3% vs. 69.7%,  $P < 0.05$ ), indicating that a decreased stoma rate in the LT surgery group was mainly attributed to intestinal edema alleviation.

No deaths were reported among the surgically treated patients during the 30 days following the index hospital stay. There were significant differences in the mean time to flatus (18.75 ± 5.62 vs. 23.94 ± 5.74 hours,  $P < 0.01$ ) and bowel movement (17.53 ± 6.10 vs. 23.32 ± 6.32 hours,  $P < 0.01$ ) between the LT surgery group and the GT surgery group (Table 5). Patients in the LT group had a lower incidence of incision infection than patients in the GT group (2.3% vs. 17.9%,  $P < 0.05$ ). Only 1 (6.7%) patient in the LT surgery group and 11 (33.3%) patients in the GT surgery group developed early post-operative obstruction, although the difference did not reach statistical significance ( $P = 0.073$ , Table 5).

### Relationship of recurrence and decompression methods

For surgery-free patients with endoscopic placement of long tubes, five (41.7%) and two (16.7%) experienced medical and surgical recurrence, respectively, throughout a mean follow-up of 33.5 months. No significant differences were observed in the frequency of medical and surgical recurrences between the LT groups and the GT groups (all log-rank  $P > 0.05$ , Figure 4). The

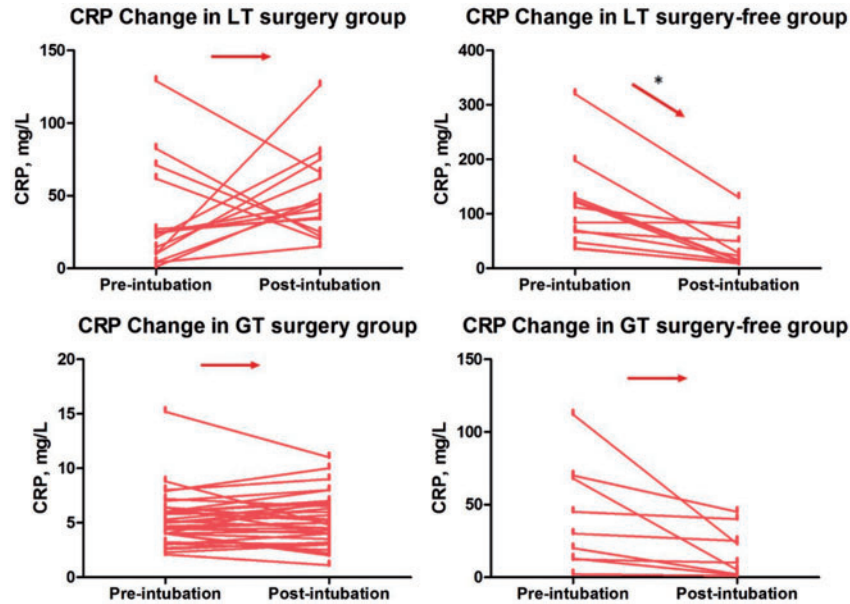


Figure 3. Changes in C-reactive protein (CRP) from pre-intubation 1 day to post-intubation 1 day.

Table 4. Risk factors of unavoidable emergent surgery in Crohn's disease patients with acute bowel obstruction

Variable	Odds ratio	95% confidence interval	P-value
C-reactive protein on admission	0.99	0.97–1.01	0.25
C-reactive protein decrease after intubation	0.08	0.01–0.14	0.01
48-hour drainage volume >500 mL	12.11	5.21–286.70	0.03
Abdominal-pain alleviation time	0.98	0.50–1.82	0.94
Bowel-sound alleviation time	0.84	0.15–3.26	0.82

median surgery-free survival intervals between successful decompression and re-surgery in the GT group and the LT group were 32 months (range 12–58 months) and 48 months (range 24–60 months), respectively, but the difference was not statistically significant.

During the first year of follow-up, five of nine patients (55.5%) in the GT surgery-free group experienced recurrent obstruction with symptomatic and radiographic evidence, while only one of 12 patients (8.3%) in the LT surgery-free group had recurrent obstruction, which reached significance ( $P = 0.046$ ).

## Discussion

This study was designed to evaluate the efficacy of LT in the treatment of ABO secondary to CD. We primarily analysed the relative effectiveness of LT versus GT for avoidance of surgery and then determined the indicators for urgent surgery for ABO. The impacts of decompression methods on long-term outcomes were subsequently investigated.

Management of CD patients with ABO in emergency settings remains a controversial subject [9]. Decades ago, some surgeons believed that early operative intervention was imperative, especially with clinical signs of peritonitis, both because of the difficulty in diagnosing strangulated obstruction and because of the high mortality rate associated with delayed surgical intervention [15–17]. However, Singh et al. reported that post-operative mortality was high after emergent surgery for CD patients [18]. In addition, CD is likely to recur, leading to

repeated or extensive small-bowel resections, and a frequent outcome of such procedures is short bowel syndrome [19, 20]. Therefore, pre-operative optimization of conservative management and more effective treatments are necessary to avoid emergent surgeries.

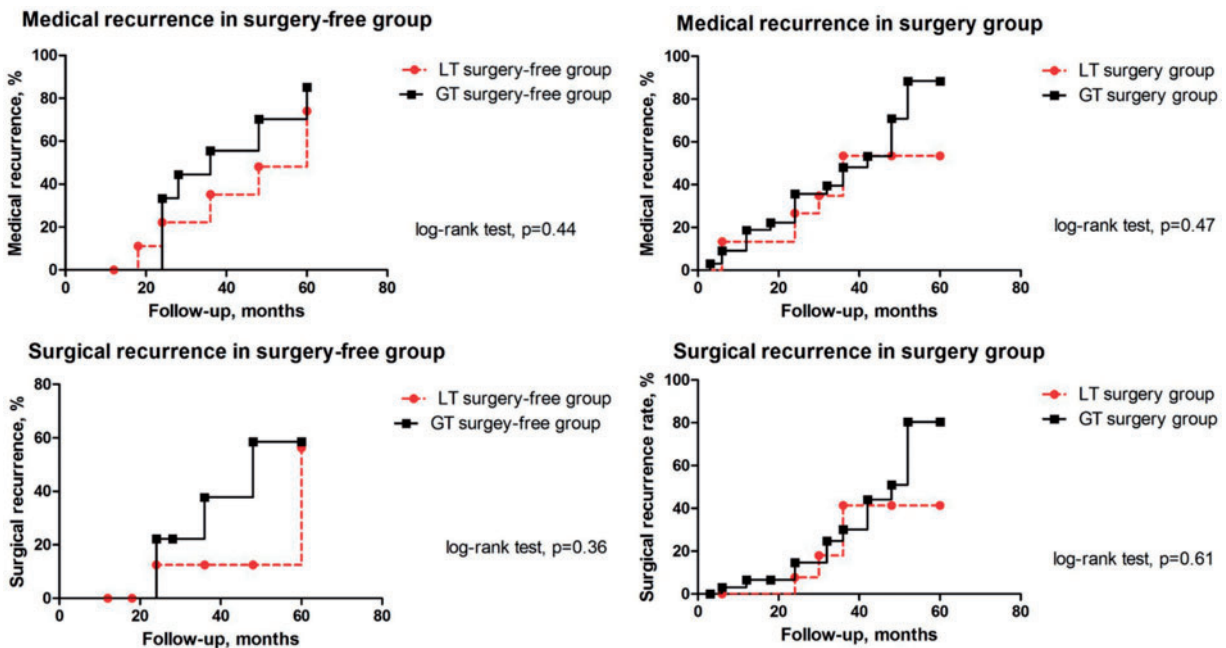
Since 1980, three studies have reported a 73%–75% success rate with LT decompression [21–23]. Phillip et al., in the Mount Sinai School of Medicine, conducted a prospective, randomized trial of short versus long tubes in adhesive small-bowel obstruction (SBO) and demonstrated no significant differences with regard to the decompression achievement [23]. In 2012, Chen et al. [24] and Guo et al. [10] also investigated LT decompression for adhesive SBO and claimed that endoscopic placement of the ileus tube is convenient and worthy to be promoted despite the potential risks. However, most of these studies focused on adhesive SBO and the evidence of its efficacy in acute obstruction of CD remained not completely convinced. Indeed, due to their inflammatory nature, inflamed components of stenosis in CD are likely to respond to medical treatment, enabling conservative therapy before surgery [25]. Moreover, the techniques of LT decompression have developed in the past two decades. The long intestinal decompression tube, in the present study, was a newly designed LT that was first introduced and used in Japan [26]. LT with three channels and two balloons was specifically designed for endoscopic placement and has developed several functions such as suction, enteroclysis and enteral nutrition [27, 28]. Therefore, evidence on the decompression efficacy of this new LT in CD patients with ABO needs to be established.

**Table 5.** Surgical approaches and outcomes

Item	LT surgery group (n = 15)	GT surgery group (n = 33)	P-value
Decompression time before surgery, days	4.58 ± 1.37	2.86 ± 1.45	0.030
Pre-operative total parental nutrition	15 (100.0)	31 (93.9)	1.00
ASA score, n (%)			1.00
≥3	4 (26.7)	10 (30.3)	
<3	11 (73.3)	23 (69.7)	
Surgical procedure			0.31
Small-bowel resection	11 (73.3)	17 (51.5)	
Ileocolic resection	3 (20.0)	9 (27.3)	
Partial colectomy	1 (6.7)	7 (21.2)	
Temporary stoma	3 (20.0)	18 (54.5)	0.032
<b>Intra-operative findings</b>			
No. of strictures			0.31
1	3 (20.0)	14 (42.4)	
2	7 (46.7)	12 (36.4)	
>2	5 (33.3)	7 (21.2)	
Stricture type			0.16
Chronic stricture	12 (80.0)	17 (51.5)	
Acute inflammation	2 (13.3)	8 (24.4)	
Mix stricture	1 (6.7)	8 (24.4)	
Severe intestinal edema	5 (33.3)	23 (69.7)	0.027
Inflammatory masses	1 (6.7)	7 (21.2)	0.41
Fistula/abscess	7 (46.7)	12 (36.4)	0.54
<b>Post-operative outcomes</b>			
Time to flatus, hours	18.75 ± 5.62	23.94 ± 5.74	0.005
Time to bowel movement, hours	17.53 ± 6.10	23.32 ± 6.32	0.005
Time to tolerate enteral nutrition, days	45.67 ± 8.6	50.42 ± 10.81	0.14
Post-operative length of stay, days	8.13 ± 4.49	11.59 ± 5.22	0.024
Post-operative complications			
Infection of incision	1 (6.7)	12 (36.4)	0.040
Intra-abdominal septic complications	1 (6.7)	5 (15.2)	0.65
Anastomotic leakage	0 (0)	2 (6.1)	1.00
Abscess/mass	1 (6.7)	3 (9.1)	1.00
Early post-operative obstruction	1 (6.7)	11 (33.3)	0.073

Data are presented as number (%) or mean ± standard deviation.

LT, long intestinal decompression tube; GT, nasogastric tube; ASA, American Society of Anesthesiologists.



**Figure 4.** Comparison of the cumulative medical and surgical recurrence rates between long intestinal decompression tube (LT) and nasogastric tube (GT) groups, together with the P-value from the log-rank test.

As our results showed, 12 (44.4%) patients treated with LT were spared emergent surgery, indicating a virtual advantage over conventional GT decompression. However, the CRP appeared to be significantly higher on admission in both the LT and GT patients who avoided surgery than in those who required surgery, implying that patients with obstruction caused by an 'inflammatory stricture' were more likely to avoid surgery than those whose obstruction was caused by a 'fibro-stenotic stricture'. The emergent surgery rate of patients with tube decompression is higher (55.6% in the LT group, 78.6% in the GT group, and 65.2% in the whole population) compared to previously published data [9]. The first reason is that more than half of patients in this study were complicated with penetrating disease, which means the patients' situation was more complex and emergent laparotomy was required. The second is that most of these patients had exhausted the drug therapy, so the surgery was the first-line treatment at this situation to improve the patients' status.

Consistently with the favorable outcomes of LT, patients in the LT group were relieved from obstruction in less time, and their drainage volumes were larger than those of the GT group. From a theoretical perspective, the advantages of LT originated from its natural properties. Specifically, the sufficiently LT lends itself to the inherent capability of being properly positioned at the point of obstruction, as opposed to the positioning of a nasogastric tube. In addition, the majority of CD-related obstructions are proximal SBO [29]; thus, the efficacy of GT decompression is substantially reduced when there is considerable distance from obstruction sites and the barrier function of pylorus [30]. The properly placed LT could exert its function of aspirating the intestinal content, relieving dilatation of the proximal bowel, alleviating edema of the bowel wall and improving blood supply to the intestines [24]. We also attempted to use steroid as concomitant medical therapy in selected cases, whereas there was no difference between patients with or without emergent surgery, implying that the steroid did not help to avoid emergent surgery. Besides, for patients with long-term steroid usage, the steroid burst could not eliminate the symptoms.

Although some ABOs can be resolved with tube decompression alone, surgical intervention may still be required for patients who show no clinical improvement [23]. By comparing the surgery group and the surgery-free group, we attempted to identify indications for avoidable surgery in patients treated with tube decompression. The CRP level in our study appeared to be a potential parameter indicating surgery by the fact that more surgical patients had an increase in CRP than did surgery-free patients. In the context of the conclusion that CRP was a disease activity marker for CD, this phenomenon was consistent with the finding reported in our previous study [31]. Apart from CRP, the drainage volume was another predictor to which we should pay attention. As expected, liquid volumes drained by LT were generally higher than those drained by GT. The cut-off value of the drainage volume was obscured because the decompression methods differed, although volumes over 500 mL at 48 hours could serve as an indication for subsequent surgery, as a previous study recommended [14]. In addition, 10 (83.3%) surgery-free patients in the LT group and 8 (88.9%) in the GT group exhibited radiographic alleviation, while almost none of surgery-requiring patients achieved this goal. This result agrees with other studies reporting that enterographic findings could serve as indicators for surgery [12, 23, 24].

In the present study, we observed that patients with LT were operated on later than patients with GT (4.58 vs. 2.86 days,  $P < 0.05$ ). The longer pre-operative period enabled

comprehensive preparation, including inflammation control and nutrition support, hence turning an emergent surgery into a semi-urgent surgery. We found that incision infection, temporary stoma creation and post-operative ileus were less frequent in the LT surgery group than in the GT surgery group. We attributed these favorable effects to the technical advantages of the LT in terms of diagnosis and treatment. Previous studies reported that contrast small intestine imaging through the LT had accuracy of nearly 100% in determining the obstruction site [28], allowing surgeons to assess the therapeutic effect of treatments, to locate the obstruction site and to design valid strategies for surgery. As LT possesses triple lumens, water-soluble contrast medium and enteral nutrition could be delivered through the tube, thus alleviating luminal inflammation and optimizing the nutrition status of the patients [32, 33]. Pre-operative enteral nutrition not only allowed withdrawal of immunosuppressive agents [16, 34], but also relieved inflammatory bowel strictures [35].

For patients in both the LT and GT groups who avoided laparotomy, the surgical recurrence rates were 16.7% and 44.4%, respectively, with follow-up of approximately 3 years, comparable to recurrence rates reported previously [36]. The LT group seemingly had a slightly lower cumulative surgical recurrence rate, although this did not reach significant difference. To compare 1-year recurrent rates, patients who successfully treated with LT developed fewer recurrent obstructions than those with GT (8.3% vs. 55.5%,  $P = 0.046$ ). The result suggests that LT may allow patients to maintain remission for a longer period without obstruction.

This study has several limitations. First, this was not a randomized trial and was restricted by the small sample size. Second, the determination of management strategies depended on our local experience, without a specific protocol. Therefore, the effects of personal preference could not be fully excluded. Nevertheless, the baseline characteristics of patients were comparable in both LT and GT groups, eliminating the heterogeneity of a selected population to some extent. A multicenter prospective randomized study should be considered to verify the conclusions of the present study. For clinicians, several factors should be considered when using LT decompression. The patients should be informed with the cost as well as the discomfort of LT treatment. Besides, the interventional endoscopy and experienced operators are also required when choosing LT decompression.

In conclusion, LT decompression is an appropriate initial treatment for CD patients with ABO. LT was superior to GT in the fast alleviation of bowel obstruction and prevention of subsequent laparotomy. Patients failing to respond to decompression therapy were identified with risk factors, including increased CRP and drainage volume at 48 hours. For patients who required emergent surgery, their post-operative recovery could benefit from LT treatment.

## Authors' contributions

R.Q.L. and S.H.Q. were involved in the study design, as well as in the planning, interpretation of data for this study and in drafting the manuscript. S.H.Q. and K.H.W. collected data and performed dataset analysis. C.L. and J.F.G. interpreted the data and edited the manuscript. Z.M.W. and L.Y. conducted the interview and recurrence evaluation. W.M.Z. supervised the whole project. All authors read and approved the final manuscript.

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## Conflict of interest

None declared.

## References

- Peyrin-Biroulet L, Loftus EV, Colombel JF et al. The natural history of adult Crohn's disease in population-based cohorts. *Am J Gastroenterol* 2010;**105**:289–97.
- Yamamoto T, Watanabe T. Surgery for luminal Crohn's disease. *World J Gastroenterol* 2014;**20**:78–90.
- Rieder F, Zimmermann EM, Remzi FH et al. Crohn's disease complicated by strictures: a systematic review. *Gut* 2013;**62**:1072–84.
- Marakis G, Pavlidis TE, Ballas K et al. Surgical emergency for inflammatory bowel disease. *Int J Colorectal Dis* 2007;**22**:93–4.
- Berg DF, Bahadursingh AM, Kaminski DL et al. Acute surgical emergencies in inflammatory bowel disease. *Am J Surg* 2002;**184**:45–51.
- Bellolio F, Cohen Z, MacRae HM et al. Strictureplasty in selected Crohn's disease patients results in acceptable long-term outcome. *Dis Colon Rectum* 2012;**55**:864–9.
- Fazi M, Giudici F, Luceri C et al. Long-term results and recurrence-related risk factors for Crohn disease in patients undergoing side-to-side isoperistaltic strictureplasty. *JAMA Surg* 2016;**151**:452–60.
- Arsoniadis EG, Ho YY, Melton GB et al. African Americans and short-term outcomes after surgery for Crohn's disease: an ACS-NSQIP analysis. *J Crohns Colitis* 2017;**11**:468–73.
- Pallone F, Boirivant M, Torsoli A et al. Conservative management of acute intestinal obstruction in Crohn's disease. *Lancet* 1984;**1**:518.
- Guo SB, Duan ZJ. Decompression of the small bowel by endoscopic long-tube placement. *World J Gastroenterol* 2012;**18**:1822–6.
- Gowen GF, DeLaurentis DA, Stefan MM. Immediate endoscopic placement of long intestinal tube in partial obstruction of the small intestine. *Surg Gynecol Obstet* 1987;**165**:456–8.
- Gowen GF. Long tube decompression is successful in 90% of patients with adhesive small bowel obstruction. *Am J Surg* 2003;**185**:512–5.
- Li D, Du H, Shao G et al. Application of small intestine decompression combined with oral feeding in middle and late period of malignant small bowel obstruction. *Oncol Lett* 2017;**14**:180–4.
- Di Saverio S, Coccolini F, Galati M et al. Bologna guidelines for diagnosis and management of adhesive small bowel obstruction (ASBO): 2013 update of the evidence-based guidelines from the world society of emergency surgery ASBO working group. *World J Emerg Surg* 2013;**8**:42.
- Govani SM, Stidham RW, Higgins PD. How early to take arms against a sea of troubles? The case for aggressive early therapy in Crohn's disease to prevent fibrotic intestinal strictures. *J Crohns Colitis* 2013;**7**:923–7.
- Sarr MG, Bulkley GB, Zuidema GD. Preoperative recognition of intestinal strangulation obstruction: prospective evaluation of diagnostic capability. *Am J Surg* 1983;**145**:176–82.
- Kirchmann HM, Bender SW. Intestinal obstruction in Crohn's disease in childhood. *J Pediatr Gastroenterol Nutr* 1987;**6**:79–83.
- Singh S, Al-Darmaki A, Frolkis AD et al. Postoperative mortality among patients with inflammatory bowel diseases: a systematic review and meta-analysis of population-based studies. *Gastroenterology* 2015;**149**:928–37.
- Schluskel AT, Steele SR, Alavi K. Current challenges in the surgical management of Crohn's disease: a systematic review. *Am J Surg* 2016;**212**:345–51.
- Bharadwaj S, Narula N, Tandon P et al. Role of endoscopy in inflammatory bowel disease. *Gastroenterol Rep (Oxf)* 2018;**6**:75–82.
- Quatromoni JC, Rosoff L, Halls JM et al. Early post-op small bowel obstruction. *Ann Surg* 1980;**191**:72–4.
- Wolfson P, Bauer J, Gelernt JM et al. Use of long tubes in the management of patients with small bowel obstruction due to adhesions. *Arch Surg* 1985;**120**:1001–6.
- Fleshner PR, Siegman MG, Slater GI et al. A prospective, randomized trial of short versus long tubes in adhesive small-bowel obstruction. *Am J Surg* 1995;**170**:366–70.
- Chen XL, Ji F, Lin Q et al. A prospective randomized trial of transnasal ileus tube vs nasogastric tube for adhesive small bowel obstruction. *WJG* 2012;**18**:1968–74.
- Malgras B, Pautrat K, Dray X et al. Multidisciplinary management of gastrointestinal fibrotic stenosis in Crohn's disease. *Dig Dis Sci* 2015;**60**:1152–68.
- Tanaka S, Yamamoto T, Kubota D et al. Predictive factors for surgical indication in adhesive small bowel obstruction. *Am J Surg* 2008;**196**:23–7.
- Gowen GF. Rapid resolution of small-bowel obstruction with the long tube, endoscopically advanced into the jejunum. *Am J Surg* 2007;**193**:184–9.
- Li D, Li R, Wu P et al. Clinical and diagnostic significance of enteroclysis through nasointestinal decompression intubation. *Cell Biochem Biophys* 2014;**70**:349–53.
- Whelan G, Farmer RG, Fazio VW et al. Recurrence after surgery in Crohn's disease: relationship to location of disease (clinical pattern) and surgical indication. *Gastroenterology* 1985;**88**:1826–33.
- Maglinte DD, Kelvin FM, Rowe MG et al. Small-bowel obstruction: optimizing radiologic investigation and nonsurgical management. *Radiology* 2001;**218**:39–46.
- Zuo L, Li Y, Wang H et al. A practical predictive index for intra-abdominal septic complications after primary anastomosis for Crohn's disease: change in C-reactive protein level before surgery. *Dis Colon Rectum* 2015;**58**:775–81.
- Li Y, Zuo L, Zhu W et al. Role of exclusive enteral nutrition in the preoperative optimization of patients with Crohn's disease following immunosuppressive therapy. *Medicine (Baltimore)* 2015;**94**:e478.
- Di Saverio S, Catena F, Ansaloni L et al. Water-soluble contrast medium (gastrografin) value in adhesive small intestine obstruction (ASOP): a prospective, randomized, controlled, clinical trial. *World J Surg* 2008;**32**:2293–304.
- Scarpa M, Martinato M, Bertin E et al. Intestinal surgery for Crohn's disease: role of preoperative therapy in postoperative outcome. *Dig Surg* 2015;**32**:243–50.
- Hu D, Ren J, Wang G et al. Exclusive enteral nutritional therapy can relieve inflammatory bowel stricture in Crohn's disease. *J Clin Gastroenterol* 2014;**48**:790–5.
- Domènech E, Garcia V, Iborra M et al. Incidence and management of recurrence in patients with Crohn's disease who have undergone intestinal resection: the Practicrohn Study. *Inflamm Bowel Dis* 2017;**23**:1840–6.