

# Early gastrografin administration after ileus tube insertion does not improve the clinical outcomes in patients with adhesive small bowel obstruction

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## Research article

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# Abstract

**Background** Gastrointestinal decompression through ileus tube is useful for the treatment of adhesive small bowel obstruction (ASBO). Gastrografin administration through the ileus tube is performed if decompression therapy fails to relieve obstruction. However, the appropriate timing of gastrografin administration is unclear. The present study aimed to evaluate the efficacy of gastrografin administration within 48 h after admission. **Methods** This retrospective study used the data of patients with ASBO admitted to our hospital between January 2014 and August 2018. The study included those who underwent ileus tube intubation but did not achieve obstruction relief for over 24 h after admission. The patients were classified into the following two groups: those treated with gastrografin administration within 48 h after admission (EGA group) and those treated without gastrografin administration within 48 h after admission (non-EGA [NEGA] group). Propensity-score matching was performed to compensate for confounding differences between the groups. The short-term outcomes of therapeutic effectiveness such as the rate of surgery avoidance, the period until the first stool, period of ileus tube intubation, and total period of hospital admission were evaluated and compared between the two groups. **Results** This study included 152 patients: 67 in the EGA group and 85 in the NEGA group. Fifty-five pairs were matched with similar background characteristics. After matching, the rates of surgery avoidance were 89.1% (49/55) and 94.5% (52/55) in the matched EGA and NEGA groups, respectively ( $P = 0.49$ ). Although the median insertion days of ileus tube in the NEGA group were significantly lesser than those in the EGA group (7 [5–9] vs. 5 [4.5–7],  $P = 0.017$ ), other therapeutic outcomes were not significantly different between the two groups. In the non-EGA group, 5.5% (3/55) achieved obstruction relief without gastrografin administration. **Conclusions** Early gastrografin administration might not be superior to non-early gastrografin administration in clinical outcomes of patients with ASBO. Follow-up by decompression with ileus tube for at least 48 h after admission is required in patients with ASBO, which may avoid unnecessary gastrografin administration and consequently reduce the total cost of treatment.

## Background

Acute small bowel obstruction is usually associated with postoperative adhesion. Patients with clinical evidence of adhesive small bowel obstruction (ASBO), except those with suspected strangulation, have been treated conservatively [1]. Gastrointestinal decompression using an ileus tube or a nasogastric tube is considered to be an effective treatment in such patients [2]. A previous randomized controlled trial showed that the relief of clinical symptoms and improvement in the findings of abdominal radiography were quicker with an ileus tube than with a nasogastric tube [3]. Recently, a new insertion method using an ultrathin endoscope, which reduces the procedure time and radiation exposure time, has been reported [4]. Therefore, gastrointestinal decompression using an ileus tube is the first treatment choice in patients with acute bowel obstruction at our hospital. Ileus tube insertion is usually performed on the first day of hospital admission in these patients.

However, we sometimes experience failure in relieving obstruction with only gastrointestinal decompression using an ileus tube. Surgery is considered in these patients, but this approach might have

high burden among patients. If gastrointestinal decompression fails to relieve obstruction, gastrografin is often administered through the ileus tube [5]. Gastrografin is a hyperosmolar water-soluble contrast medium; therefore, the status of small bowel obstruction can be evaluated with gastrografin administration. The ileus tube can be inserted deeper because gastrografin administration is usually performed under continuous radiography. Furthermore, gastrografin administration has been suggested to have a therapeutic effect, which was reported to reduce the need for surgery [5, 6]. In addition to gastrointestinal decompression using an ileus tube, gastrografin administration could be effective for treatment when conservative therapy fails [5]. Therefore, we usually administer gastrografin via the ileus tube if the obstruction does not improve over 12–24 h after ileus tube intubation. However, the appropriate timing of gastrografin administration after ileus tube intubation is unclear. Gastrografin administration at an early stage might be associated with earlier improvement compared with insufflation at a later stage or no insufflation. In contrast, gastrografin administration at an early stage might be considered as excessive treatment because some patients might show relief of obstruction with only ileus tube intubation. Therefore, the present study aimed to evaluate the efficacy and therapeutic outcomes of gastrografin administration at an early stage within 48 h after admission, with a propensity-score matching analysis to compensate for the confounding bias [7, 8].

## Methods

### Patients and study approval

This retrospective study used the data of patients older than 18 years with acute small bowel obstruction admitted to the Division of Gastroenterology, Department of Internal Medicine, Nihon University School of Medicine between January 2014 and August 2018. The inclusion criteria were as follows: (1) presence of clinical symptoms and physical signs associated with acute small bowel obstruction such as abdominal pain, distention, nausea, and vomiting without stool production; (2) diagnosis of ASBO on radiography with computed tomography (CT), which was confirmed by no less than two clinicians or radiologists (Figure 1); and (3) admission to the Department of Gastroenterology at our hospital within one day after symptom onset. The exclusion criteria were as follows: (1) emergency surgery for suspected strangulation; (2) large bowel obstruction, cancer peritonitis, obstructed abdominal wall, groin hernia, active inflammatory bowel disease including suspected Crohn's disease; (3) early postoperative small bowel obstruction within 4 weeks after surgery; (4) successful treatment without any decompression therapy; (5) successful treatment using a nasogastric tube; and (6) successful treatment using an ileus tube without gastrografin administration within 24 h after admission. If patients had two or more admissions during the study period, the first admission was considered. Patients were classified into the following two groups: (1) those treated with gastrografin administration within 48 h after admission (early gastrografin administration group; EGA group) and (2) those treated without gastrografin administration within 48 h after admission (non-early gastrografin administration group; NEGA group). Some patients were treated with gastrografin administration after 48 h following admission and others were treated without gastrografin administration during the entire hospital stay.

## **Ileus tube insertion and gastrografin administration**

All enrolled patients underwent gastrointestinal decompression within 24 h after admission. The CLYNY single or double-balloon type tube (Create Medic, Tokyo, Japan) was used as an ileus tube for decompression of the gastrointestinal tract. The length and outer diameter were 300 cm and 5.3 mm (16 Fr), respectively. The ileus tube was inserted using endoscopy and/or continuous radiography with a guidewire (500 cm in length and 1.32 mm in diameter). In the endoscopic insertion method, the guidewire was inserted into the duodenum through the main channel of a trans-nasal ultrathin endoscope (GIF-XP260N; Olympus, Tokyo, Japan). After removal of the endoscope, the ileus tube was inserted through the guidewire, reaching at least the upper jejunum (Figure 2). A small amount of gastrografin was used to obtain contrast images of the small intestinal tract during ileus tube intubation. Patients who failed to insert ileus tube were switched to the treatment with nasogastric tube. Such patients were excluded from this study. After insertion, gastrointestinal decompression was performed via the ileus tube, without any oral intake. Gastrografin was administered when there was no clinical remission of the small bowel obstruction, which was considered as symptom remission with stool. Administration was performed through the ileus tube (Figure 3). The amount of gastrografin at one administration was 150 ml. If possible, the ileus tube was advanced to the anal side. It was then clamped for 1–2 h after gastrografin administration. Gastrografin administration was sometimes repeated when improvement was not achieved over 24 h after the previous administration. In the EGA group, the first gastrografin administration was performed within 24–48 h after hospital admission. In the NEGA group, decompression was continued using an ileus tube without gastrografin administration for at least 48 h after admission. If clinical improvement was not achieved for over 48 h, gastrografin administration was considered, as in the EGA group.

## **Outcome measures**

Clinical variables, including age, sex, height, weight, body mass index (BMI), type and number of prior surgeries, and laboratory test indexes on admission, were compared between the EGA and NEGA groups. The aim of decompression therapy or gastrografin administration was clinical improvement and surgery avoidance because of ASBO. Therefore, the study outcomes were the rate of surgery avoidance, the period until the first stool, period of ileus tube intubation, and total period of hospital admission. Clinical improvement was defined as remission of abdominal symptom with stool production. After confirming clinical improvement, the ileus tube was clamped and then drinking or liquid food was started. Thereafter, the ileus tube was removed after confirming the absence of symptom recurrence over 24 h. Discharge criterion was the achievement of remaining clinical improvement with taking soft or normal food over 48 h after tube removal. In contrast, patients eventually underwent surgery if clinical improvement was not achieved with decompression therapy and gastrografin administration during admission. Patients who showed no clinical improvement in the initial 48 h after admission were consulted by surgeons. Surgery was finally performed if the clinical symptoms worsened or strangulation was suspected.

## **Statistical analysis**

There were confounding biases between the two study groups, as this was a non-randomized study. Thus, propensity-score matching analysis, which has been used to compensate for confounding factors, was adopted in this study [9-11]. Logistic regression of factors, including background characteristics, and propensity score were calculated. Age (<70 years vs.  $\geq 70$  years), sex (male vs. female), number of surgeries (multiple vs. others), type of surgery (gastrointestinal vs. others), height (<160 cm vs.  $\geq 160$  cm), weight (<50 kg vs.  $\geq 50$  kg), BMI (<21 kg/m<sup>2</sup> vs.  $\geq 21$  kg/m<sup>2</sup>), white blood cell count (<10000/ $\mu$ l vs.  $\geq 10000$ / $\mu$ l), C-reactive protein level (<0.5 mg/dl vs.  $\geq 0.5$  mg/dl), and method of ileus tube insertion (endoscopy with radiography vs. radiography) were included in covariate analysis. Nearest-neighbor matching in a 1:1 ratio from the EGA and NEGA groups was performed in calipers (0.11) with a width equal to 0.25 of the standard deviation of the logit of the propensity score. Results are expressed as median (interquartile range [IQR]) for continuous data distributed abnormally. Fisher's exact test and the Mann-Whitney test were used to identify differences in categorical data and continuous data distributed abnormally, respectively. All statistical analyses were performed using JMP Pro 13.0 software (SAS Institute, Cary, NC, USA). A P-value <0.05 was considered statistically significant. The sample size could not be calculated owing to the retrospective nature of this study.

## Results

### Background characteristics before matching

A total of 169 patients were treated using ileus tube insertion as first-line therapy in this study. Of these, 17 patients immediately achieved relief of obstruction within 24 h after admission. Therefore, 152 patients were included in this study. Flowchart of patient enrollment is shown in Figure 4. The background characteristics of the enrolled patients are presented in Table 1. Then, 67 were included in the EGA group and 85 were included in the NEGA group. Among all patients, the median age was 69 (IQR, 56.8–79) years, and 44.7% (68/152) of the patients were male. The most common previous surgical type was gastrointestinal surgery (35.5%, 54/152). The median height, weight, and BMI were 158.0 (IQR, 152–164) cm, 51.5 (IQR, 44–60) kg, and 20.5 (18.3–22.7) kg/m<sup>2</sup>, respectively. In first-line treatment, endoscopy with radiography was used for ileus tube insertion in 31.6% (48/152) of the patients. The insertion time was evaluated in 82 patients (35 patients from the EGA group and 47 patients from the NEGA group). The median insertion time was 37 (IQR, 29.4–46.5) min. There were no significant differences in the factors between the two groups.

### Study outcomes before propensity-score matching

Therapeutic outcomes before propensity-score matching are presented in Table 2. A total of 11 patients underwent surgery because conservative therapy did not achieve clinical remission. The rates of surgery were 10.4% (7/67) in the EGA group and 4.7% (4/85) in the NEGA group, and there was no significant difference between the groups (P = 0.22). In the NEGA group, 5.9% (5/85) of patients were successfully

treated without gastrografin administration. The median period until the first stool and median period of hospital admission were not significantly different between the EGA and NEGA groups (median period until the first stool: 3 [IQR, 2–4] vs. 3 [IQR, 2–3] days,  $P = 0.51$ ; median period of hospital admission: 12.5 [IQR, 9.25–14] vs. 11 [IQR, 9–15] days,  $P = 0.14$ ). However, the median period of ileus tube intubation was significantly shorter in the NEGA group than in the EGA group (7 [IQR, 5–8] vs. 5 [IQR, 4–7] days,  $P = 0.007$ ).

### **Propensity-score matching and matching factors between the study groups**

Propensity-score matching was performed, and 55 pairs were obtained in this study. The C-statistic was estimated to be 0.64, indicating good predictive power. The matching factors after propensity-score matching are shown in Table 3. No factor was significantly different between the two groups. In addition, all absolute standardized difference ranges were within  $1.96\sqrt{2/n}$ , which indicated that the characteristics were well balanced.

### **Study outcomes after propensity-score matching**

Therapeutic outcomes after propensity-score matching are presented in Table 4. The rates of surgery were 10.9% (6/55) in the matched EGA group and 5.5% (3/55) in the matched NEGA group, and there was no significant difference between the groups ( $P = 0.49$ ). In the matched NEGA group, 5.5% (3/55) of patients were successfully treated without gastrografin administration. The median period until the first stool and median period of hospital admission were not significantly different between the matched EGA and NEGA groups (median period until the first stool: 3 [IQR, 2–4] vs. 3 [IQR, 2–3] days,  $P = 0.27$ ; median period of hospital admission: 12 [IQR, 9.5–14.5] vs. 11 [IQR, 8.5–14.5] days,  $P = 0.20$ ). However, the median period of ileus tube intubation was significantly shorter in the matched NEGA group than in the matched EGA group (7 [IQR, 5–9] vs. 5 [IQR, 4.5–7] days,  $P = 0.017$ ).

## **Discussion**

This was the first study to evaluate the efficacy of early gastrografin administration after ileus tube insertion. The present study found that early gastrografin administration was not superior to non-early gastrografin administration with regard to the improvement in clinical outcomes among patients with ASBO.

With regard to the treatment of acute small bowel obstruction, the most important factor is the exclusion of bowel strangulation, which requires immediate surgery [5], and the mortality rate in such patients has been reported to be over 30% when the period from onset to surgery is over 36 h. Thus, overlooking strangulation can result in a very serious situation. Enhanced CT is useful to assess the blood flow in the ileum. Emergency surgery was performed in 37 patients with acute small bowel obstruction at our

hospital; 33 patients were suspected of strangulation and 4 patients were at the discretion of the surgeons. Strangulation was observed in 16 patients during surgery. Finally, 21 patients required partial bowel resection.

Conservative therapy should be selected only in patients with obstruction who do not have bowel strangulation. It is usually performed in patients not suspected with bowel strangulation to avoid surgery. The ileus tube is frequently selected for gastrointestinal decompression. However, there have been clinical concerns with regard to the technical difficulty associated with the insertion of a long intestinal tube under radiography, which requires a long time and involves a high radiation dose. Recently, many types of useful tube insertion methods have been reported, and they allow easy insertion of an ileus tube in patients with small bowel obstruction [12-16]. Treatment using an ileus tube should be selected in patients with small bowel obstruction owing to its usefulness and high effectiveness. An ileus tube might not be selected in some patients at the discretion of the doctor because of a poor general condition or a history of clinical remission without an ileus tube. With regard to the use of ileus tube insertion as first-line therapy in this study, 10.1% (17/169) of all identified patients treated using the ileus tube immediately achieved relief of obstruction for only one day.

The efficacy of gastrografin administration was noted in patients with small bowel obstruction resistant to gastrointestinal decompression using an ileus tube, and it contributed to a reduction in the period of hospital admission. Gastrografin reduces the edema of the gastrointestinal wall through absorption of water owing to its high osmotic pressure. The addition of gastrografin administration to decompression using an ileus tube relieved obstruction in 80.5% (136/169) of all identified patients. Although 11 patients finally underwent surgery because of the failure of conservative therapy using an ileus tube, the overall effectiveness rate was 93.5% (158/169) among all identified patients who received an ileus tube with or without gastrografin administration, and they did not require surgery. Previous studies reported that the success rate with conservative therapy using an ileus tube was 74%–81.1% [15, 17]. The success rate in the present study was higher than that in these previous studies, and this might be because of the increased efficacy with the addition of gastrografin administration.

We hypothesized that gastrografin administration at an early stage might contribute to better outcomes of conservative therapy for small bowel obstruction. However, in this study, the final surgical rate did not differ between the EGA and NEGA groups. The period until the first stool and total period of hospital admission were not significantly different between the two groups. In contrast, the period of ileus tube intubation was significantly longer in the EGA group than in the NEGA group. Furthermore, 5.5% (3/55) of patients in the NEGA group after matching (5.9%, 5/85 before matching) were successfully treated without gastrografin administration. Therefore, we could not confirm the superiority of early gastrografin administration within 48 h after admission. On the contrary, early gastrografin administration, the opportunity to relieve ileus without gastrografin administration might be missed. The results suggest that gastrografin administration might not be as important as gastrointestinal decompression in the early stage of small bowel obstruction. Gastrografin has a high osmolarity (1900 mOsm/l), and it induces water movement from the gastrointestinal wall to the lumen. Although gastrografin administration

reduces edema, it increases the amount of fluid in the lumen, which might reduce the efficacy of decompression by an ileus tube. Gastrografin administration might be performed after sufficient decompression by an ileus tube, which might contribute to a reduction in the total cost, including the cost of materials and staff for gastrografin administration.

During the study period, overall, 48 patients underwent surgery, and 37 of these patients underwent surgery without conservative therapy mainly because strangulation was suspected at the initial diagnosis. The remaining 11 patients underwent surgery because consecutive treatment using ileus tube did not achieve clinical remission. Of these 11 patients, 9 only required adhesion dissection and 2 required not only adhesion dissection but also partial small intestine resection owing to strangulation. The average (median) period of conservative therapy was 5 (8.9) days. Only one patient showed relapse of acute small bowel obstruction, and the obstruction was relieved with conservative therapy. Other patients were followed-up without recurrence of small bowel obstruction. Surgical treatment should be considered in patients who do not achieve clinical remission with only conservative therapy, including gastrointestinal decompression by an ileus tube and gastrografin administration.

The present study has some limitations. First, this was a retrospective study without randomization. Therefore, there might have been bias with regard to the selection of the treatment strategy. There was a possibility that early gastrografin administration was conducted for patients with severe condition. To reduce this bias, propensity-score matching was performed, and it was found that the treatment outcomes did not differ between before and after matching. Second, two types of ileus tubes were used in this study. One has only one balloon attached to the edge to the tube sheath, whereas the other has two balloons. Thus, the efficacy of gastrointestinal decompression might differ between the two types of tubes, and such a difference might affect the treatment outcomes. Third, the length of insertion and the amount of output from ileus tube were not evaluated in this study. These factors might affect the treatment outcomes. Therefore, a prospective randomized controlled trial should be performed in the future to clarify the efficacy and the most appropriate timing of gastrografin administration after ileus tube insertion.

## **Conclusions**

Conservative approaches, including gastrointestinal decompression using an ileus tube and reduction of edema of the gastrointestinal wall through gastrografin administration, can help relieve acute small bowel obstruction without strangulation, which might contribute to surgery avoidance. However, early gastrografin administration might not be superior to non-early gastrografin administration. Moreover, some patients with small bowel obstruction were successfully treated without gastrografin administration. Therefore, follow-up for at least 48 h without gastrografin administration after admission might be appropriate in the treatment of acute small bowel obstruction.

## **List Of Abbreviations**

ASBO = adhesive small bowel obstruction

BMI = body mass index

CT = computed tomography

IQR = interquartile range

## Declarations

**Ethics approval and consent to participate:** This study and the opt-out form of informed consent were approved by the Institutional Review Board at Nihon University School of Medicine (RK-180911-17). Informed consent was obtained in the form of opt-out on the web-site. Those who rejected were excluded.

**Consent for publication:** Not applicable

**Availability of data and materials:** The datasets used and analyzed during the current study are available from the corresponding author on reasonable request.

**Competing interests:** The authors declare that they have no competing interests.

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**Authors' contributions:** Y.T and M.E: conception and design, drafting of the article, critical revision of the article for important intellectual content.

R.I, S.S, M.I, M.M and T.G: study supervision

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## Tables

**Table 1.** Background characteristics of the enrolled patients

	All n = 152	EGA group n = 67	NEGA group n = 85	P- value
Median (year) [IQR]	69 [56.8-79]	70 [56.5-79]	68 [59-77]	0.82
Male, n (%)	68 (44.7)	30 (44.8)	38 (44.7)	1
Primary site type, n (%)				0.65
Colon	54 (35.5)	29 (43.3)	25 (29.4)	
Rectum	8 (5.3)	3 (4.5)	5 (5.9)	
Cecum and splenic	2 (1.3)	1 (1.5)	1 (1.2)	
Unknown	25 (16.4)	9 (13.4)	16 (18.8)	
Metastatic	3 (2.0)	1 (1.5)	2 (2.4)	
None	34 (22.4)	12 (17.9)	22 (25.9)	
Unknown	26 (17.1)	12 (17.9)	14 (16.5)	
Surgery	26 (17.1)	12 (17.9)	14 (16.5)	0.83
Tumor size, median (cm) [IQR]	158.0 [152-164]	158 [153-163.5]	158 [152-166]	0.89
Weight, median (kg) [IQR]	51.5 [44-60]	51 [46.5-58]	52 [54-61]	0.82
BMI, median (kg/m <sup>2</sup> ) [IQR]	20.5 [18.3-22.7]	20.2 [18.6-22.7]	20.7 [18.0-22.9]	0.86
Hemoglobin, median (g/dl)	9850 [7675-12225]	10500 [7950-12550]	9600 [2100-11900]	0.51
Albumin, median (mg/dl)	0.33 [0.1-1.45]	0.5 [0.1-1.58]	0.3 [0.1-1.0]	0.43
Site of insertion				0.86
Copy with	48 (31.6%)	22 (32.8%)	26 (30.6%)	
Lymph				

raphy	104 (68.4%)	45 (67.2%)	59 (69.4%)	
on time, median (min)	(n = 82)	(n = 35)	(n = 47)	
	37 [29.3-46.5]	34 [36-42.5]	39 [31-52]	0.083

EGA, early gastrografin administration; NEGI, non-early gastrografin administration; IQR, interquartile range; WBC, while blood cell; CRP, C-reactive protein

The P-value is calculated using Fisher's exact test for categorical data.

The P-value is calculated using the Mann-Whitney *U* test for continuous data distributed abnormally.

**Table 2.** Clinical outcomes in the study groups before matching

	All n = 152	EGA group n = 67	NEGA group n = 85	P- value
gastrografin administration, n (%)	147 (96.7%)	67 (100%)	80 (94.1%)	0.067
leakage, n (%)	11 (7.2%)	7 (10.4%)	4 (4.7%)	0.22
Time until the first stool, median (days)	3 [2-4]	3 [2-4]	3 [2-3]	0.51
Time of ileus tube intubation, median [IQR]	6 [5-8]	7 [5-8]	5 [4-7]	0.007
Time of hospital admission, median (days)	11 [9-14]	12.5 [9.25-14]	11 [9-15]	0.14

EGA, early gastrografin administration; NEGA, non-early gastrografin administration; IQR, interquartile range

The P-value is calculated using Fisher's exact test for categorical data.

The P-value is calculated using the Mann-Whitney *U* test for continuous data distributed abnormally.

**Table 3.** Matching factors between the two study groups after propensity-score matching

	EGA group n = 55	NEGA group n = 55	P- value	ASD
Age matching between the groups				
Age, years; <70/≥70	25/30	29/26	0.57	0.15
Sex; male/female	23/32	24/31	1	0
Primary diagnosis; multiple/others	44/11	44/11	1	0
Primary site; gastrointestinal/others	22/33	24/31	0.85	0.074
Height, cm; <160/≥160	22/33	24/31	0.85	0.074
Weight, kg; <50/≥50	31/24	31/24	1	0
Body mass index, kg/m <sup>2</sup> ; <21/≥21	23/32	22/33	1	0.037
White blood cell count, µl; <10000/≥10000	30/25	28/27	0.85	0.073
C-reactive protein level, mg/dl; <0.5/≥0.5	28/27	26/29	0.85	0.073
Site of insertion; endoscopy with fluorography/radiography	19/36	19/36	1	0

EGA, early gastrografin administration; NEGA, non-early gastrografin administration;

WBC, white blood cell; CRP, C-reactive protein; ASD, absolute standardized difference

The P-value is calculated using Fisher's exact test for categorical data.

The P-value is calculated using the Mann-Whitney *U* test for continuous data distributed abnormally.

**Table 4.** Clinical outcomes in the study groups after matching

	EGA group n = 55	NEGA group n = 55	P-value
astrografin administration, n (%)	55 (100)	52 (94.5)	0.24
urgery, n (%)	6 (10.9)	3 (5.5)	0.49
eriod until the first stool, median (days) [IQR]	3 [2-4]	3 [2-3]	0.27
eriod of ileus tube intubation, median (days) [IQR]	7 [5-9]	5 [4.5-7]	0.017
eriod of hospital admission, median (days) [IQR]	12 [9.5-14.5]	11 [8.5-14.5]	0.20

EGA, early gastrografin administration; NEGA, non-early gastrografin administration; IQR, interquartile range

The P-value is calculated using Fisher's exact test for categorical data.

The P-value is calculated using the Mann-Whitney *U* test for continuous data distributed abnormally.

## Figures



**Figure 1**

Radiography and computed tomography images of patients with acute small bowel obstruction



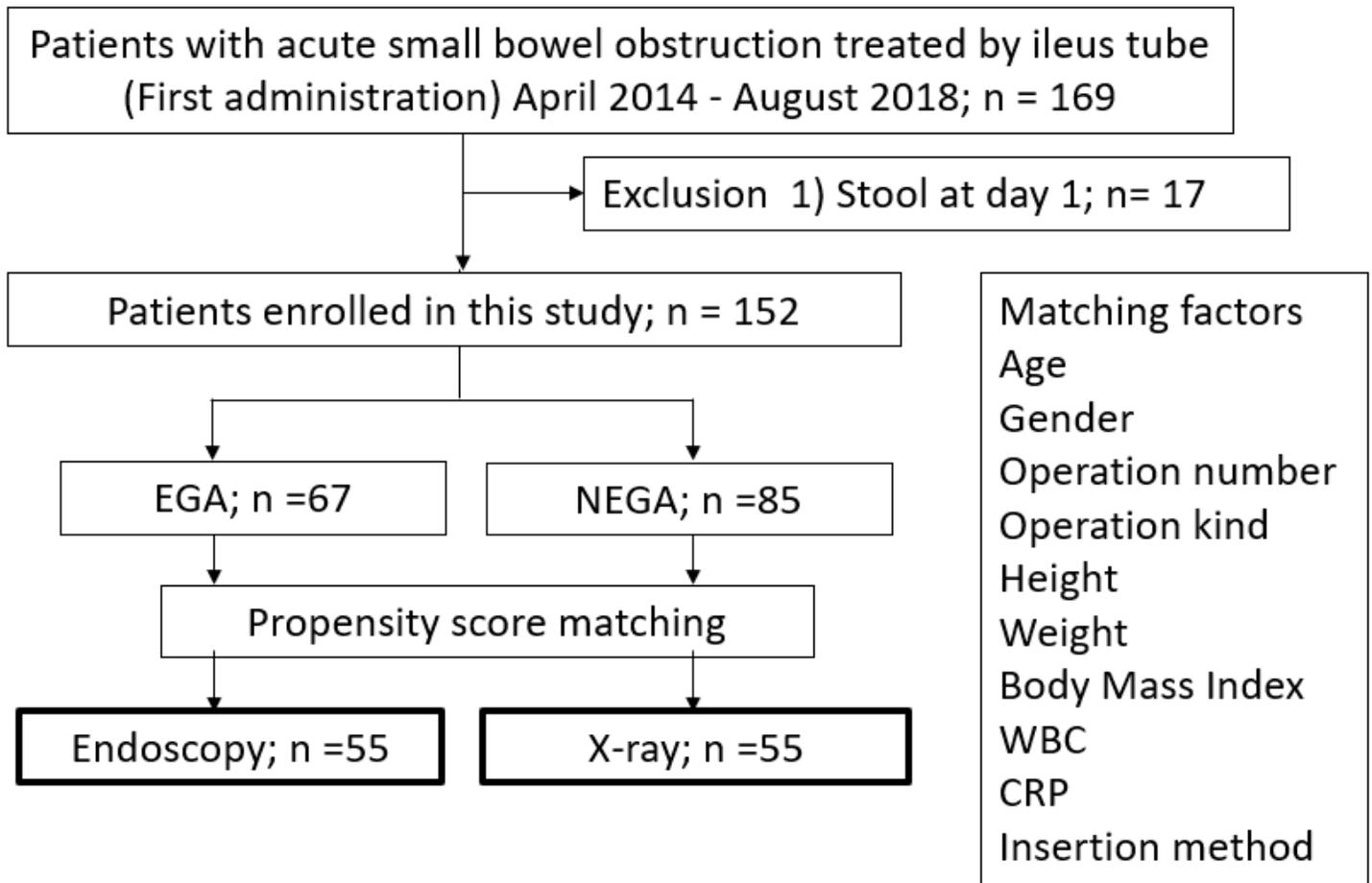
**Figure 2**

Radiograph after insertion of an ileus tube into the jejunum



**Figure 3**

Radiograph of gastrografin administration through the ileus tube



**Figure 4**

Flowchart of patient enrollment in this study