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Readiness-Based Gastrografin Trial Protocol for Adhesive Small Bowel Obstruction: A Single-Center Retrospective Cohort Study of a Diagnostic Filter and Decision-Making Catalyst

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Abstract

Background

Gastrografin® is widely used in adhesive small bowel obstruction (ASBO) management. However, protocols advocate immediate administration without physiological readiness criteria—such as resolution of vomiting, reduced nasogastric output, and absence of gastric distension—which may increase procedural risks, particularly contrast aspiration in frail older patients. We implemented an institutional readiness-based Gastrografin trial protocol and retrospectively evaluated its clinical outcomes. We assessed clinical utility, safety, and diagnostic performance, including readiness as a diagnostic filter and prompt execution in relation to workflow and hospital stay.

Methods

This single-center retrospective cohort study included 151 patients with adhesive small bowel obstruction (ASBO) admitted to Sakai City Medical Center between January 2020 and April 2025. Nonoperative management was initiated, and the Gastrografin trial (30–60 mL) was performed upon verified physiological readiness. Outcomes were compared between Gastrografin (n = 117) and non-Gastrografin (n = 34) groups, and between early (≤ 1 day, n = 91) and delayed (> 1 day, n = 26) administration. Multivariable logistic and linear regression models identified predictors of surgical conversion and length of hospital stay.

Results

Overall, 117 patients (77.5%) underwent the trial, with an 86.3% contrast passage rate (101/117). The trial group had a lower operative rate (9.4% vs. 35.3%, $p = 0.001$) and shorter length of hospital stay (median 5 vs. 9 days, $p < 0.001$) than the non-trial group. Early vs. delayed trial timing showed comparable success (86.8% vs. 84.6%, $p = 0.752$) and surgical conversion rates (6.6% vs. 19.2%, $p = 0.065$). On multivariable logistic regression, long-tube placement predicted surgery conversion (aOR: 47.25, $p = 0.001$), whereas trial timing did not. Early administration was independently associated with shorter hospital stay (B = -4.65, p < 0.001), an adjusted difference of approximately 4.7 days. Aspiration occurred in 3 patients (2.5%), prompting safety guardrails (daytime-only timing, nursing surveillance, swallowing screening).

Conclusions

Mandating physiological readiness acts as a diagnostic filter to safely exclude refractory cases at high risk of conservative management failure. Once readiness is met, prompt trial execution serves as a

decision-making catalyst that eliminates clinical inertia, accelerating surgical workflow and significantly reducing length of hospital stay.

Background

Adhesive small bowel obstruction (ASBO) is a common postoperative complication and remains a major cause of emergency surgical admissions [1, 2]. Although nonoperative management (NOM) is successful in most patients, distinguishing between patients who will recover with conservative therapy and those who ultimately require surgical intervention remains challenging [3, 4]. This diagnostic uncertainty frequently leads to prolonged length of hospital stay (LOS) [1, 2, 4–6] and delays in identifying patients unlikely to respond to NOM; such delays carry substantial clinical consequences, as operative intervention deferred beyond 72 h is associated with significantly increased 30-day postoperative mortality [7]. Similarly, delayed surgical management (> 24 h) has been reported to carry a 3.5-fold increase in mortality [8]. Water-soluble contrast agents (WSCAs), such as Gastrografin®, have been widely integrated into ASBO algorithms [2, 9–15]. Contemporary practice increasingly recognizes WSCA administration not as a direct therapeutic agent, but as a real-time functional diagnostic assay that provides critical physiological insight into obstruction severity and resolution [9–15]. Despite its widespread adoption, the optimal timing, patient selection, and clinical integration of WSCA administration remain debated [13–16]. Crucially, whether a structured WSCA trial can be leveraged as an objective decision-making catalyst to accelerate clinical workflow remains an unresolved question. Most existing protocols, including the Bologna guidelines, advocate routine or immediate administration following initial gastric decompression [2, 3, 5]. However, these immediate-administration models seldom incorporate strict physiological readiness criteria—such as resolution of vomiting, absence of abdominal distension, and reduced nasogastric output—prior to contrast challenge. Premature administration in unready patients, particularly frail older individuals, substantially elevates procedural risks, most notably contrast aspiration [9, 17, 22]. To address these vulnerabilities, we implemented a readiness-based, criteria-driven Gastrografin trial protocol conceptually designed to prioritize patient safety and minimize procedural risks. In this study, we aimed to evaluate the overall clinical utility, safety, and diagnostic performance of this readiness-based approach in patients with ASBO. Specifically, we investigated how mandating physiological readiness serves as an initial diagnostic filter and how prompt trial execution upon readiness influences diagnostic stratification, decision-making timing, and acute surgical workflow.

Methods

Study design

This single-center retrospective cohort study included 151 patients with postoperative ASBO admitted to Sakai City Medical Center between January 2020 and April 2025. Inclusion criteria were a history of abdominal surgery and a confirmed diagnosis of ASBO based on clinical presentation and computed tomography (CT) findings. Exclusion criteria included ASBO suspected to be caused by ischemia,

strangulation, tumors, hernias, food obstruction, or inflammatory diseases. Cases presenting with peritonitis were also excluded.

Ethics approval

This study was approved by the Ethics Committee of our hospital in accordance with the Declaration of Helsinki (approval no.: 25–503). Patient anonymity was ensured in accordance with the Japanese Act on the Protection of Personal Information. The requirement for informed consent was waived owing to the retrospective nature of the study.

Treatment protocol

Figure 1 shows the treatment strategy and protocol for ASBO used at our institution. Initial NOM consisted of nil per os, intravenous fluid resuscitation, and gastrointestinal decompression when indicated.

The Gastrografin trial

The Gastrografin trial was initiated in strict adherence to the algorithm shown in Fig. 1 when the following physiological readiness criteria were met: resolution of vomiting, a decrease in gastric tube drainage volume (≤ 200 mL/d or ≤ 100 mL/8 h), and absence of gastric distension on abdominal radiography. Gastrografin (30–60 mL) was administered orally or through a nasogastric tube, with strict aspiration precautions.

To evaluate contrast passage, sequential abdominal radiographs were obtained after administration: at 3 h to confirm gastric emptying, and at 8 h and the following morning to evaluate transit beyond the obstruction point. If the 3-h radiograph showed residual contrast in the stomach and gastric distension, the risk of vomiting or aspiration was considered high, and gastric decompression was performed. Successful Gastrografin trial passage was defined as radiographic confirmation of contrast passing beyond the obstruction point into the distal bowel or colon. Trial failure was defined as non-passage of contrast beyond the obstruction on sequential radiographs up to the next morning. In such failure cases, NOM was continued; however, if conservative management failed to achieve adequate clinical resolution —defined by persistent obstruction for > 3 days, nasogastric/gastric drainage volume > 500 mL/d on Day 3, or failure of drainage to decrease (Fig. 1)—gastrointestinal decompression with a long tube was considered, and surgical intervention (laparoscopic surgery when feasible) was pursued if clinical resolution remained unachieved.

Grouping and comparative analyses

Among the 117 patients who participated in the Gastrografin trial, two predefined subgroup analyses were performed: early (≤ 1 d) vs. delayed (> 1 d) Gastrografin administration, and trial success vs. failure. Additionally, outcomes were compared between the Gastrografin (117 patients) and non-Gastrografin (34 patients) groups. Furthermore, to explore clinical management trajectories, patients were categorized into five distinct cohorts based on trial participation, timing, and outcome (Non-trial, Early-Success, Delayed-Success, Early-Failure, and Delayed-Failure), and their baseline and clinical characteristics were summarized. Furthermore, multivariable regression models were constructed among patients who underwent the Gastrografin trial (n = 117) to identify independent factors associated with length of hospital stay and surgical conversion, evaluating the independent impact of trial timing and trial success after adjusting for relevant clinical covariates.

Outcome measures

The primary outcome was LOS. Secondary outcomes included the rate of surgical conversion, time from admission to defecation, time from admission to initiation of oral intake, SBO recurrence during hospitalization, and procedural safety outcomes (including contrast aspiration). In addition, clinical factors and management variables associated with prolonged LOS and surgical conversion were evaluated.

Data collection

Patient data, extracted from medical records, included age, sex, surgical history, use of gastrointestinal decompression (nasogastric or long tube), whether a Gastrografin trial was performed and its timing, need for operative management, SBO recurrence during hospitalization, time from admission to defecation and initiation of oral intake, and length of hospital stay.

Statistical analysis

Categorical variables are presented as numbers and percentages and were compared using chi-square or Fisher's exact tests when more than 20% of the expected frequencies were < 5. Continuous variables are presented as medians with interquartile ranges and were compared using the Mann–Whitney U test. Multivariable logistic regression analysis was performed to identify independent predictors of surgical conversion, with adjusted odds ratios (aORs) and 95% confidence intervals (CIs) reported. Multivariable linear regression analysis was conducted to identify independent factors associated with LOS, reporting unstandardized coefficients (B), standard errors (SE), 95% CIs, and overall model fit (R^2 and adjusted R^2). Multicollinearity among independent variables was assessed using the Variance Inflation Factor (VIF), with values < 2.5 considered acceptable. Statistical significance was set at $p < 0.05$. All statistical analyses were performed using SPSS version 26 (Armonk, NY, USA).

Use of AI-assisted technologies

During the preparation of this manuscript, the authors used AI and AI-assisted technologies solely to improve readability, English grammar, and stylistic flow. The authors subsequently reviewed and edited the content and take full responsibility for the final manuscript.

Results

Patient characteristics

Table 1 shows relevant patient characteristics. Overall, 151 patients (52.3% male) with ASBO were included. The median age was 74 years. Overall, 88% of the patients previously had open abdominal surgery, and 62.9% had a prior SBO episode. The Gastrografin trial was performed in 117 patients (77.5%). Initial gastrointestinal decompression using a nasogastric tube was performed in 56.3% of patients, with 12.6% ultimately requiring long-tube placement for advanced decompression. Overall, operative management was required in 15.2% of patients, and the median LOS was 6 days.

Table 1
Baseline characteristics of all patients with adhesive small bowel obstruction

Variables	n = 151
Age (years)	74 [65–81]
Sex (male)	79 (52.3)
Details of previous abdominal surgery	123 (81.4)
Open surgery	10 (6.6)
Open and laparoscopic surgery	17 (11.2)
Laparoscopic surgery	1 (0.6)
Robot-assisted surgery	
History of open surgery (yes)	133 (88.1)
History of SBO (yes)	95 (62.9)
Gastrografin trial (yes)	117 (77.5)
Gastrointestinal decompression	85 (56.3)
Nasogastric tube	19 (12.6)
Long tube	
Operative management (yes)	23 (15.2)
In-hospital SBO recurrence	10 (6.6)
Period from admission to defecation (d)	2 [1–3]
Period from admission to start of meals (d)	2 [2–4]
Length of hospital stay (d)	6 [3–9]
Values are presented as numbers (%) or medians [interquartile ranges].	
SBO: small bowel obstruction	
All long-tube decompressions were performed after failure of the initial nasogastric decompression; therefore, patients who required long-tube placement are counted in both categories.	

Comparison between the Gastrografin and non-Gastrografin trial groups

Table 2 shows a comparison of baseline characteristics and clinical outcomes between the Gastrografin and non-Gastrografin groups. The Gastrografin trial group had a significantly lower proportion of patients undergoing operative management compared with the non-Gastrografin group (9.4% vs. 35.3%, *p* =

0.001). The Gastrografin group showed earlier oral intake (2 d vs. 4 d, $p < 0.001$), and length of hospital stay (5 d vs. 9 d, $p < 0.001$).

Table 2
Comparison of baseline characteristics and clinical outcomes between the Gastrografin and non-Gastrografin trial groups

Variables	**Gastrografin trial group n = 117**	**Non-Gastrografin trial group n = 34**	***p***
Age (years)	74 [65–81]	73 [65–85]	0.635
Sex (male)	60 (51.3)	19 (55.9)	0.699
Details of previous abdominal surgery	100 (85.4)	23 (67.6)	
Open surgery	6 (5.1)	4 (11.7)	
Open and laparoscopic surgery	11 (9.4)	6 (17.6)	
Laparoscopic surgery	0 (0)	1 (2.9)	
Robot-assisted surgery			
History of open surgery (yes)	106 (90.5)	27 (79.4)	0.128
History of SBO (yes)	72 (61.5)	23 (67.6)	0.552
Gastrografin trial (yes)	117 (100)	-	
Gastrografin trial success	101 (86.3)		
Period from admission to Gastrografin trial (d)	1 [1–1]		
Day 0	25 (21.4)		
Day 1	66 (56.4)		
Day 2	20 (17.1)		
Day 3	6 (5.1)		
≤ 1 d (early group)	91 (77.8)		
> 1 d (Delayed group)	26 (22.2)		
Vomit and aspiration after Gastrografin trial	3 (2.5)		
Gastrointestinal decompression	65 (55.6)	20 (58.8)	0.845

Values are presented as numbers (%) or medians [interquartile ranges]. P-values reflect comparisons between groups.

SBO: small bowel obstruction.

All long-tube decompressions were performed after failure of the initial nasogastric decompression; therefore, patients who required long-tube placement are counted in both categories.

Variables	Gastrografin trial group n = 117	Non-Gastrografin trial group n = 34	*p*
Nasogastric tube Long tube	9 (7.7)	10 (29.4)	0.002
Operative management (yes)	11 (9.4)	12 (35.3)	0.001
In-hospital SBO recurrence	6 (5.1)	4 (11.8)	0.233
Period from admission to defecation (d)	2 [1–2]	2 [1–7]	0.040
Period from admission to start of meals (d)	2 [1–3]	4 [2–6]	< 0.001
Length of hospital stay (d)	5 [3–8]	9 [6–16]	< 0.001
Values are presented as numbers (%) or medians [interquartile ranges]. P-values reflect comparisons between groups.			
SBO: small bowel obstruction.			
All long-tube decompressions were performed after failure of the initial nasogastric decompression; therefore, patients who required long-tube placement are counted in both categories.			

Gastrografin trial success vs. failure

Table 3 shows a comparison of baseline characteristics and clinical outcomes between the Gastrografin trial success and failure groups. Overall, 101/117 (86.3%) patients who underwent the trial achieved successful contrast passage; 16/117 (13.7%) were failures. The success group demonstrated better clinical outcomes concerning time to defecation (1 d vs. 6 d, $p < 0.001$), time to oral intake (2 d vs. 5 d, $p < 0.001$), and length of hospital stay (4 d vs. 12 d, $p < 0.001$). Operative management was required in only 3.0% of the success group, compared with 50.0% of the failure group ($p < 0.001$). In-hospital SBO recurrence was also significantly lower in the successful group than in the unsuccessful group (2.0% vs. 25%, $p = 0.003$).

Table 3
Baseline characteristics and clinical outcomes by Gastrografin trial success or failure

Variables	Success group n = 101	Failure group n = 16	*p*
Age (years)	74 [66–80]	74 [51–84]	0.868
Sex (male)	52 (51.5)	8 (50.0)	1.000
Details of Previous Abdominal Surgery	87 (86.1)	13 (81.2)	
Open surgery	3 (3.0)	3 (18.8)	
Open and laparoscopic surgery	11 (10.9)	0 (0)	
Laparoscopic surgery	0 (0)	0 (0)	
Robot-assisted surgery			
History of open surgery (yes)	90 (89.1)	16 (100)	0.357
History of SBO (yes)	64 (63.4)	8 (50.0)	0.408
Period from admission to Gastrografin trial (d)	1 [1–1]	1 [1–2]	0.164
Day 0	24 (23.8)	1 (6.3)	0.752
Day 1	55 (54.5)	11 (68.8)	
Day 2	19 (18.8)	1 (6.3)	
Day 3	3 (3.0)	3 (18.8)	
≤ 1 d (Early group)	79 (78.2)	12 (75.0)	
> 1 d (Delayed group)	22 (21.8)	4 (25.0)	
Gastrointestinal decompression	51 (50.5)	14 (87.5)	0.006
Nasogastric tube	3 (3.0)	6 (37.5)	< 0.001
Long tube			
Operative management (yes)	3 (3.0)	8 (50.0)	< 0.001
In-hospital SBO recurrence	2 (2.0)	4 (25.0)	0.003
Period from admission to defecation (d)	1 [1–1]	6 [2–8]	< 0.001

Values are presented as numbers (%) or medians [interquartile ranges]. P-values reflect comparisons between groups.

SBO: small bowel obstruction

All long-tube decompressions were performed after failure of the initial nasogastric decompression; therefore, patients who required long-tube placement are counted in both categories.

Variables	Success group n = 101	Failure group n = 16	*p*
Period from admission to start of meals (d)	2 [1–3]	5 [4–5]	< 0.001
Length of hospital stay (d)	4 [3–7]	12 [8–20]	< 0.001
Values are presented as numbers (%) or medians [interquartile ranges]. P-values reflect comparisons between groups.			
SBO: small bowel obstruction			
All long-tube decompressions were performed after failure of the initial nasogastric decompression; therefore, patients who required long-tube placement are counted in both categories.			

Early vs. delayed Gastrografin administration

Table 4 shows the comparison of baseline characteristics and clinical outcomes between early and delayed Gastrografin administration groups. Overall, 91 of 117 patients (77.8%) received early administration, and 26 patients (22.2%) received delayed administration. The trial success rate did not differ significantly between the two groups (86.8% vs. 84.6%, $p = 0.752$). However, the early group showed significantly shorter times to defecation (median 2 d vs. 3 d, $p < 0.001$), oral intake (2 d vs. 3 d, $p < 0.001$), and hospital stay (4 d vs. 9 d, $p < 0.001$). The rate of operative management tended to be lower in the early group, although the difference did not reach statistical significance (6.6% vs. 19.2%, $p = 0.065$).

Table 4
Comparison of baseline characteristics and clinical outcomes between early and delayed Gastrografin administration

Variables	**Early group**	**Delayed group**	***p***
	n = 91	**n = 26**	
Age (years)	73 [62–80]	76 [70–81]	0.140
Sex (male)	46 (50.5)	14 (53.8)	0.826
Details of Previous Abdominal Surgery	82 (90.1)	18 (69.2)	
Open surgery	4 (4.4)	2 (7.7)	
Open and laparoscopic surgery	5 (5.5)	6 (23.1)	
Laparoscopic surgery	0 (0)	0 (0)	
Robot-assisted surgery			
History of open surgery (yes)	86 (94.5)	20 (76.9)	0.015
History of SBO (yes)	58 (63.7)	14 (53.8)	0.552
Gastrografin trial (yes)	91 (100)	26 (100)	0.752
Gastrografin trial success	79 (86.8)	22 (84.6)	
Period from admission to Gastrografin trial (d)	1 [0–1]	2 [2–2]	< 0.001
Day 0	25 (27.5)	-	
Day 1	66 (72.5)	-	
Day 2	-	20 (76.9)	
Day 3	-	6 (23.1)	
Gastrointestinal decompression	46 (50.5)	19 (73.1)	0.047
Nasogastric tube	6 (6.6)	3 (11.5)	0.414
Long tube			
Operative management (yes)	6 (6.6)	5 (19.2)	0.065
In-hospital SBO recurrence	5 (5.5)	1 (3.8)	1.000

Values are presented as numbers (%) or medians [interquartile ranges]. P-values reflect comparisons between groups.

SBO: small bowel obstruction

All long-tube decompressions were performed after failure of the initial nasogastric decompression; therefore, patients who required long-tube placement are counted in both categories.

Variables	Early group n = 91	Delayed group n = 26	*p*
Period from admission to defecation (d)	2 [1–2]	3 [2–4]	< 0.001
Period from admission to start of meals (d)	2 [1–3]	3 [3–5]	< 0.001
Length of hospital stay (d)	4 [3–7]	9 [6–12]	< 0.001
Values are presented as numbers (%) or medians [interquartile ranges]. P-values reflect comparisons between groups.			
SBO: small bowel obstruction			
All long-tube decompressions were performed after failure of the initial nasogastric decompression; therefore, patients who required long-tube placement are counted in both categories.			

Overall Clinical Trajectories Across Five Subgroups

To further characterize clinical trajectories according to trial participation, timing, and outcome, patients were categorized into five distinct clinical trajectory cohorts (Table 5). Baseline demographics, including age and previous surgical history, appeared generally similar across the five cohorts. Among trial participants, the Early-Success cohort (n = 79) had the shortest hospital stay, with a median LOS of 4.0 days and low rates of long-tube placement (1.3%), surgical conversion (1.3%), and in-hospital SBO recurrence (1.3%). In the Delayed-Success cohort (n = 22), achieving contrast passage was associated with a median LOS of 8.0 days. In contrast, contrast passage failure was followed by higher rates of intervention: the Early-Failure cohort (n = 12) and Delayed-Failure cohort (n = 4) required long-tube decompression in 41.7% and 25.0% of cases, and surgical conversion in 41.7% and 75.0% of cases, respectively, resulting in longer hospitalizations (median LOS: 9.5 and 13.0 days).

Table 5
Baseline characteristics and clinical trajectories across the five clinical patient cohorts

Variables	Non-Gastrografin trial group n = 34	Early-Success group n = 79	Delayed-Success Group n = 22	Early-Failure group n = 12	Delayed-Failure group n = 4
Age (years)	73 [67–84]	73 [65–88]	74 [69–81]	70 [50–80]	81 [79–84]
Sex (male)	19 (55.9)	39 (49.4)	13 (59.1)	7 (58.3)	1 (25.0)
History of open surgery (yes)	27 (79.4)	74 (93.7)	16 (72.7)	12 (100.0)	4 (100.0)
History of SBO (yes)	23 (67.6)	52 (65.8)	12 (54.5)	6 (50.0)	2 (50.0)
Period from admission to Gastrografin trial (d)		1 [0–1]	2 [2–2]	1 [1–1]	3 [3–3]
Nasogastric tube	20 (58.8)	36 (45.6)	15 (68.2)	10 (83.3)	4 (100.0)
Long tube	10 (29.4)	1 (1.3)	2 (9.1)	5 (41.7)	1 (25.0)
Operative management (yes)	12 (35.3)	1 (1.3)	2 (9.1)	5 (41.7)	3 (75.0)
In-hospital SBO recurrence	4 (11.8)	1 (1.3)	1 (4.5)	4 (33.3)	0 (0.0)
Length of hospital stay (d)	9 [6–15]	4 [2–6]	8 [6–12]	9.5 [7–18]	13 [12–17]

SBO: small bowel obstruction

Multivariable Analyses for Surgical Conversion and Length of Hospital Stay

To identify independent predictors of surgical conversion, a multivariable logistic regression model was constructed (Table 6). Long-tube placement was independently associated with surgical conversion (aOR: 47.25, 95% CI: 4.51 to 494.73, $p = 0.001$). Older age was also significantly associated with an increased likelihood of surgery (aOR: 1.10 per year, 95% CI: 1.01 to 1.19, $p = 0.025$). Importantly, early Gastrografin administration (≤ 1 d) was not independently associated with surgical conversion (aOR: 0.34, 95% CI: 0.07 to 1.64, $p = 0.178$), consistent with univariable comparisons showing no significant difference in operative rates between early and delayed groups (6.6% vs. 19.2%, $p = 0.065$) (Table 4). To evaluate the independent determinants of LOS, a multivariable linear regression analysis was performed (Table 7; Model $R^2 = 0.510$, Adjusted $R^2 = 0.485$). Surgical conversion was the strongest independent

factor associated with prolonged hospitalization (B = 10.41, 95% CI: 6.29 to 14.53, $p < 0.001$). After controlling for surgical conversion and other relevant clinical covariates, early Gastrografin administration remained independently associated with shorter LOS (B = -4.65, 95% CI: -7.05 to -2.26, $p < 0.001$), corresponding to an adjusted difference in LOS of approximately 4.7 days.

Table 6
Multivariable logistic regression analysis for surgical conversion among patients undergoing the Gastrografin trial

Variables	Adjusted Odds Ratio	95% Confidence Interval	*p*
Age (per 1-year increase)	1.10	1.01 to 1.19	0.025
History of open surgery (vs. No)	0.45	0.05 to 3.63	0.450
History of SBO (vs. No)	2.54	0.42 to 15.51	0.313
Early timing of Gastrografin trial (vs. Delayed)	0.34	0.07 to 1.64	0.178
Long tube placement (vs. No)	47.25	4.51 to 494.73	0.001
SBO: small bowel obstruction, CI: confidence interval.			

Table 7
Multivariable linear regression analysis for factors associated with length of hospital stay among patients undergoing the Gastrografin trial

Variables	Unstandardized B	Standard Error	95% Confidence Interval	*p*
Age (per 1-year increase)	0.03	0.03	-0.02 to 0.09	0.207
History of open surgery (vs. No)	0.03	1.73	-3.39 to 3.44	0.988
History of SBO (vs. No)	-3.06	1.01	-5.06 to -1.06	0.003
Long tube placement (vs. No)	1.92	2.08	-2.19 to 6.03	0.357
Early timing of Gastrografin trial (vs. Delayed)	-4.65	1.21	-7.05 to -2.26 -5.95 to 1.21	< 0.001
Gastrografin trial Success (vs. Failure)	-2.37	1.81	6.29 to 14.53	0.193
Surgical conversion (vs. No)	10.41	2.08		< 0.001
Model summary: $R^2 = 0.510$, Adjusted $R^2 = 0.485$.				
SBO: small bowel obstruction, CI: confidence interval.				

Safety and complications

Regarding adverse events, vomiting and contrast aspiration after Gastrografin administration occurred in 3 of 117 patients (2.5%) (Table 2). A review of their clinical courses revealed that 2 of these 3 patients developed aspiration-induced respiratory failure requiring temporary endotracheal intubation and mechanical ventilation. However, all patients who required mechanical ventilation were successfully extubated, and no trial-related mortality was observed.

Discussion

We evaluated the clinical utility of a structured, readiness-based Gastrografin trial protocol for patients with adhesive small bowel obstruction (ASBO). Our principal findings indicate that the trial functions primarily as a diagnostic filter and workflow-optimizing catalyst rather than a purely therapeutic intervention. Specifically, while early Gastrografin administration (≤ 1 day) did not alter trial success rates (86.8% vs. 84.6%, $p = 0.752$) or surgical conversion rates (6.6% vs. 19.2%, $p = 0.065$) compared with delayed administration, remained independently associated with shorter hospitalization, corresponding to an adjusted difference in LOS of approximately 4.7 days (B = -4.65, $p < 0.001$), despite a median timing difference of only 1 day between the cohorts.

Clinical implications of the readiness-based filter

Although our readiness-based protocol was conceptually designed with safety in mind to prevent contrast-related complications such as aspiration, our secondary analyses revealed a clinically relevant insight: the protocol functions primarily as a diagnostic filter and workflow catalyst rather than a purely therapeutic maneuver. By providing a rapid, binary diagnostic determination once clinical readiness criteria are met, the protocol enables immediate oral intake upon success or prompt escalation (long-tube placement or surgery) upon failure, thereby potentially facilitating resource optimization and shorter hospital stays.

Unlike conventional strategies—such as the Bologna guidelines—that advocate immediate water-soluble contrast agent (WSCA) administration following initial gastric decompression [2, 3, 5], our protocol deliberately mandates verified physiological readiness (resolution of vomiting, absence of abdominal distension, and reduced nasogastric output) prior to contrast challenge. While initially aimed at risk mitigation, this requirement also serves as a clinical stratification filter by identifying patients who are not yet physiologically suitable for the contrast challenge. In our cohort, patients who did not undergo the trial—primarily due to unachieved readiness (persistent gastric distension or high drainage) or attending physician discretion—experienced substantially worse clinical outcomes, including higher operative rates (35.3% vs. 9.4%) and prolonged hospitalization (9 d vs. 5 d). Rather than indicating an intrinsic therapeutic superiority of Gastrografin, this marked divergence illustrates that mandating readiness functions in clinical practice as a functional filter, effectively separating physiologically stable candidates suited for prompt non-operative evaluation from refractory or complex cases requiring alternative management trajectories. In clinical practice, non-trial individuals often present with persistent high output or severe bowel distension—established clinical indicators associated with a high

rate of NOM failure [4, 5, 18]. In these unready, high-risk patients, contrast loading is unlikely to yield success and risks unnecessary observational delay; thus, recognizing these hallmarks should serve as an immediate trigger for care escalation—such as long-tube decompression or prompt surgical intervention—rather than trial initiation [2, 5, 18].Although requiring documented readiness inherently delays trial initiation compared to immediate-administration models, the overall trial-initiated cohort achieved a median length of stay (5 days) comparable to outcomes reported in immediate-trial literature (median/mean 4 to 5 days) [5, 9, 11]. These findings suggest that the potential clinical utility of identifying high-risk refractory cases may offset the initial delay associated with waiting for physiological readiness.

Decision-making catalysis and timely trial execution

Within the filtered trial cohort, contrast passage provided a highly responsive secondary filter that defined distinct clinical trajectories. Successful passage was associated with rapid symptom resolution and extremely low operative rates (3.0%), whereas passage failure was associated with a prolonged course and surgical intervention (50.0%). Crucially, early administration (≤ 1 day) did not alter trial success rates (86.8% vs. 84.6%, $p = 0.752$) or overall surgical conversion rates (6.6% vs. 19.2%, $p = 0.065$) in our multivariable model (Table 6). These findings support the interpretation that the trial acts as a real-time functional assay rather than a direct therapeutic agent, aligning with contemporary evidence that WSCAs facilitate diagnostic stratification rather than altering intrinsic disease severity [3, 9, 10, 13–15, 18, 19].

Crucially, our multivariate analyses provide some adjustment for measured differences that could influence the association between trial timing and outcomes. Although early administration could preferentially identify patients with a less severe clinical course, the comparable trial success rates between the early and delayed groups suggest that timing was not simply synonymous with successful contrast passage. In multivariate regression for surgical conversion (Table 6), long-tube placement and older age were independently associated with operative intervention, whereas trial timing itself was not independently associated with surgical conversion. Conversely, in the multivariable model for length of stay (Table 7), while surgical intervention predictably prolonged hospitalization, neither trial success/failure nor long-tube requirement independently dictated total stay duration. Instead, early trial administration remained independently associated with shorter length of stay, with an adjusted difference of approximately 4.7 days (B = -4.65, $p < 0.001$) even after adjustment for trial outcome, long-tube utilization, and surgical intervention. Importantly, these findings suggest that the primary benefit of the Gastrografin trial lies not merely in the speed of administration per se, but in its role as an objective decision-making catalyst that may reduce "clinical inertia"—the common practice of repetitive, nonbeneficial "watchful waiting" ("let's wait one more day") [3, 6, 16]. Although the actual difference in the timing of trial initiation between the early and delayed groups was a matter of only one day (median 1 vs. 2 days), this difference was associated with an adjusted difference in hospital stay of approximately 4.7 days. Once physiological readiness is confirmed, conducting the trial without delay provides a clear, binary diagnostic trajectory: successful contrast passage warrants immediate initiation

of oral intake, whereas failure prompts decisive escalation to long-tube decompression or timely surgical intervention [3, 16, 21]. By providing an objective milestone at each management phase, the protocol may reduce observational delay and thereby contribute to shorter hospitalization.

Safety concerns, clinical adverse events, and protocol enhancements

Although our readiness-based protocol was designed to minimize procedural risks, patient safety—specifically preventing contrast aspiration—remains a critical concern [1, 5]. Indeed, our findings demonstrate that structured readiness criteria alone could not completely eliminate severe complications. Among trial participants (n = 117), vomiting and aspiration after Gastrografin trial occurred in three patients (2.5%), two of whom subsequently required endotracheal intubation and mechanical ventilation. Given that hyperosmolar contrast aspiration can precipitate catastrophic pulmonary injury or fatal respiratory failure in frail or older individuals [9, 22], these adverse events underscore that water-soluble contrast administration carries non-negligible risks that must not be understated [3]. Retrospective evaluation of these incidents revealed potential vulnerabilities that may warrant additional attention in older or otherwise high-risk patients. Recognizing these limitations, we do not claim that our current protocol inherently guarantees absolute safety. Instead, these events have prompted consideration of additional, stringent safety measures:

- Timing restrictions: Restricting Gastrografin trials exclusively to daytime working hours when full nursing staff and clinical manpower are available for continuous monitoring.
- Enhanced clinical surveillance: Mandating direct, post-administration observation by nursing staff to detect subtle signs of distress or silent regurgitation, particularly in older patients who may not verbally report nausea.
- Pre-administration swallowing evaluation: Performing a formal swallowing assessment or screening prior to oral contrast administration in frail elderly individuals.

By acknowledging the inherent risks of WSCA administration in older populations [2, 8, 17] and continually refining our clinical guardrails, we emphasize that early trial execution must be strictly balanced with rigorous, real-time safety monitoring.

Limitations

This study has several limitations that should be recognized when interpreting our findings. Most importantly, its retrospective, single-center design and relatively small sample size inherently introduce selection bias and potential unmeasured confounding. Because Gastrografin was administered only after patients met readiness criteria, the non-trial cohort inherently contained patients with more severe obstruction, persistent distension, or high output, as well as cases managed according to individual attending physician discretion. Although we performed multivariable regression analyses (Tables 6 and 7) to adjust for key clinical parameters—including trial timing, long-tube utilization, and surgical

intervention—these models could not fully account for all unmeasured baseline variables, such as granular inflammatory dynamics or objective frailty status. Finally, while our protocol incorporates physiological guardrails, structured criteria alone cannot entirely eliminate procedural risks such as contrast aspiration, as demonstrated by our clinical experience. Therefore, large-scale, prospective randomized controlled trials are essential to validate our findings, refine physiological readiness parameters, and evaluate the reproducibility and generalizability of this workflow-oriented strategy.

Conclusions

In conclusion, a readiness-based Gastrografin trial protocol provides a highly efficient, safety-oriented framework for ASBO management. Mandating physiological readiness acts as an initial diagnostic filter to safely exclude high-risk refractory cases. Once readiness is confirmed, prompt trial execution serves as a robust workflow catalyst that eliminates "clinical inertia," providing clear binary decision-making milestones at each management phase. Ultimately, this strategy accelerates definitive clinical resolution and significantly reduces total hospital stay, offering a practical model to complement current international guidelines and optimize acute surgical workflow.

Abbreviations

aOR
Adjusted odds ratio
ASBO
Adhesive small bowel obstruction
CI
Confidence interval
CT
Computed tomography
LOS
Length of hospital stay
NOM
Nonoperative management
SBO
Small bowel obstruction
SE
Standard error
VIF
Variance inflation factor
WSCA
Water-soluble contrast agent

Declarations

Ethics approval and consent to participate

This study was approved by the Ethics Committee of our hospital in accordance with the Declaration of Helsinki (approval no.: 25-503). Patient anonymity was ensured in accordance with the Japanese Act on the Protection of Personal Information. The requirement for informed consent was waived owing to the retrospective nature of the study.

Consent for publication

Not applicable.

Availability of data and materials

The datasets used and/or 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

Hiroyuki Kayata was responsible for the overall study concept, design, methodology, formal analysis, project administration, and writing the original draft. Akihiro Usui contributed to the study concept, methodology, investigation, and provided supervision. Takuya Matsui, Saori Nakano, Kazumi Ida, Mizuho Tsuji, Koki Terakawa, Koichi Inukai, Yu Hashimoto, Koji Amano, Fumitaka Kato, Naoki Shinyama, and Nobutaka Mukai collected the clinical data and contributed to the data investigation. Yasuki Nakata and Masanori Morita provided overall oversight, supervision, and critical revisions of the manuscript for important intellectual content. All authors contributed to the final manuscript, read, and approved the final version for submission.

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Figures

Figure. 1

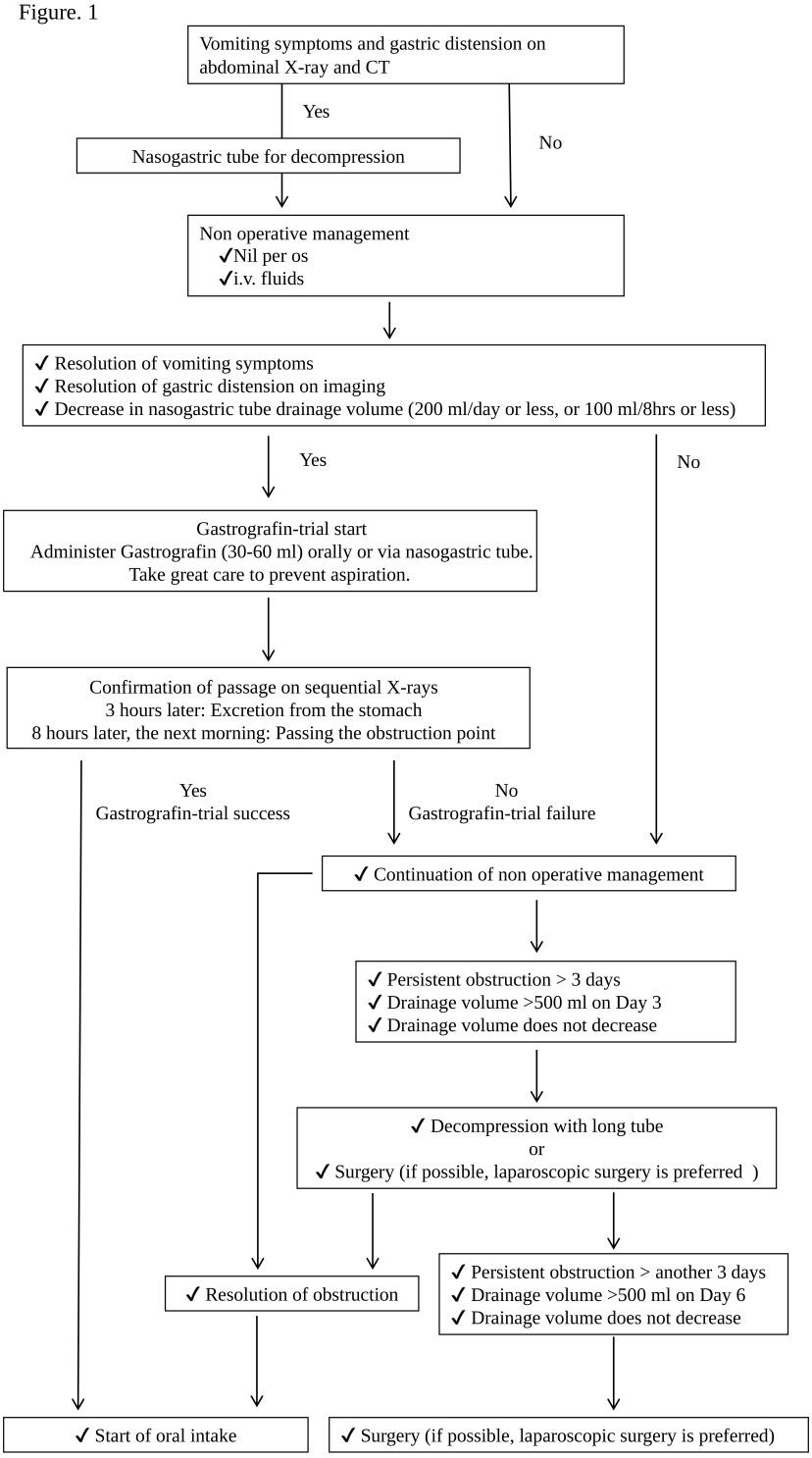


Figure 1

Readiness- and criteria-driven Gastrografin trial protocol flowchart for adhesive small bowel obstruction management