



Surgery

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The Adhesive Small Bowel Obstruction Water-Soluble Contrast Guideline

A clinical practice guideline developed by the
University of Toronto's *Best Practice in Surgery* group

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Contents:

Section 1: Background information

Section 2: Guideline recommendations

Section 3: Guidelines recommendations with supporting evidence

Section 4: Implementation strategies

Section 5: External review

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Section 1: General Information

Aim

To develop and implement an evidence-based guideline for the management of patients with presumed adhesive small bowel obstruction (ASBO) using orally-administered water-soluble contrast (WSC).

Outcomes of interest

Hospital length of stay, need for surgery, in-hospital complications, and hospital re-admissions associated with ASBO.

Target population

Clinically stable patients with ASBO and no clinical or radiological "red flags" concerning for bowel ischemia/compromise. Due to the lack of evidence, the WSC guidelines is not validated in patients with hernia-related obstructions, virgin abdomens, pregnant patients, and pediatric patients. It is also not recommended to be used in the setting of malignant obstructions or inflammatory abdominal processes.

Intended users

General Surgery residents, fellows, and staff.

Rationale

Adhesions following abdominal surgery are the most common cause of small bowel obstruction (SBO).^{1,2,3} Surgical intervention for ASBO is sometimes necessary, and delays in treatment can lead to morbidity and mortality. Determining which ASBOs will resolve non-operatively is not standardized and relies on clinical acumen. Variability arises in the management of stable adhesive SBO patients with no signs of bowel ischemia.⁴

Traditional non-operative SBO management involves NG tube decompression, fluid resuscitation, and serial clinical monitoring until the obstruction resolves or the clinician determines that the patient needs an operation. This could take several days of monitoring, with no universal algorithm for surgeons to follow.⁶

Hyperosmolar water-soluble radiographic contrast (WSC) such as Gastrografin (diatrizoate meglumine and diatrizoate sodium solution; Bracco Diagnostics Inc., Monroe Township, NJ) has been successfully used in ASBO both diagnostically and therapeutically by administration through a nasogastric (NG) tube.⁴⁰

Diagnostically, WSC can be used to track the transit time of the contrast to the cecum using abdominal radiographs in stable SBO patients. The general approach is to give WSC via the NG tube and take serial abdominal X-rays, looking for the contrast to reach the cecum. Protocols and time intervals for X-rays following WSC administration vary, but most studies suggest allowing anywhere from 2 to 36 hours for the contrast to reach the colon, after which the obstruction is very unlikely to resolve on its own.⁴⁰ Several observational studies, randomized controlled trials, and systematic reviews have investigated this method and demonstrated it to have high sensitivity and specificity in predicting SBO resolution based on whether the WSC reaches the cecum. This should expedite the decision to operate or not, and can reduce overall hospital length of stay (LOS).

NG tube administered WSC also has a theoretical therapeutic role in SBO proposed by some studies.^{40,41} The high osmolarity of WSC such as Gastrografin can promote shifting of intestinal wall edema at the obstruction point. This can increase the pressure gradient across the obstruction as well as bowel motility to help the obstruction resolve.⁴⁰ However, the main role of WSC is in diagnosis, as there is limited evidence available for WSC as a therapeutic tool.

The purpose of this document is to provide evidence-based recommendations for the management of stable ASBO using a unified WSC protocol developed for the University of Toronto Division of General Surgery as part of the Best Practice in Surgery initiative.

Overview of process

A literature review was performed to evaluate recent literature and outcomes data in the use of WSC for ASBO. An electronic search of Medline using the following Medical Subject Headings:

- "small bowel obstruction" OR "intestinal obstruction" OR "mechanical obstruction" OR "adhesive obstruction"

AND

- "water soluble contrast" OR "water-soluble contrast" OR "Gastrografin"

AND

- "management"

The search included articles published between 1990 and 2018. The results were limited to English-language papers. Articles with a focus on ileus or pseudo-obstruction were excluded.

The initial search revealed over 230 articles, which was reduced to 42 after applying the search limit criteria listed above. These studies were identified and reviewed, and from this process another 20 were excluded for various reasons (not directly assessing WSC, general review papers, inability to acquire full text or English-language version, or other reasons). Evidence-based recommendations were identified in the remaining 22 studies, and for each recommendation the primary supporting evidence was reviewed by a panel of experts from several of the University of Toronto's affiliated academic hospitals. This panel then drafted a guideline based on best current evidence and expert opinion which they tailored to the University of Toronto hospital system.

The quality of evidence was assessed in adherence to the Scottish Intercollegiate Guidelines Network (SIGN) recommendations (<https://www.sign.ac.uk>).⁵

Section 2: Guideline recommendations

1. SBO diagnosis and initial management

- 1.1. A diagnosis of SBO should be made clinically and/or radiographically using cross-sectional imaging.
 - 1.1.1. Any suspicion of non-adhesive etiologies should be appropriately investigated.
- 1.2. Clinical stability must initially be ensured and appropriately reassessed.
 - 1.2.1. Signs of clinical instability due to suspected bowel ischemia or perforation may warrant urgent surgical exploration, based on the surgeon's judgment.
- 1.3. IV access and relevant bloodwork should be obtained. Fluid resuscitation should be initiated, correcting for any electrolyte abnormalities or acute kidney injury.
- 1.4. The patient should be made NPO and a nasogastric (NG) tube should be inserted. Gastric decompression with low-intermittent or continuous suction should be started.
- 1.5. Computed tomography (CT) with IV contrast (if no contraindications) may be performed to aid in diagnosis. Findings concerning for ischemia, such as free fluid, heterogeneous bowel wall enhancement, or closed loop configuration, may warrant urgent surgical exploration, based on the surgeon's judgment.

2. Initiating the water-soluble radiographic contrast (WSC) pathway

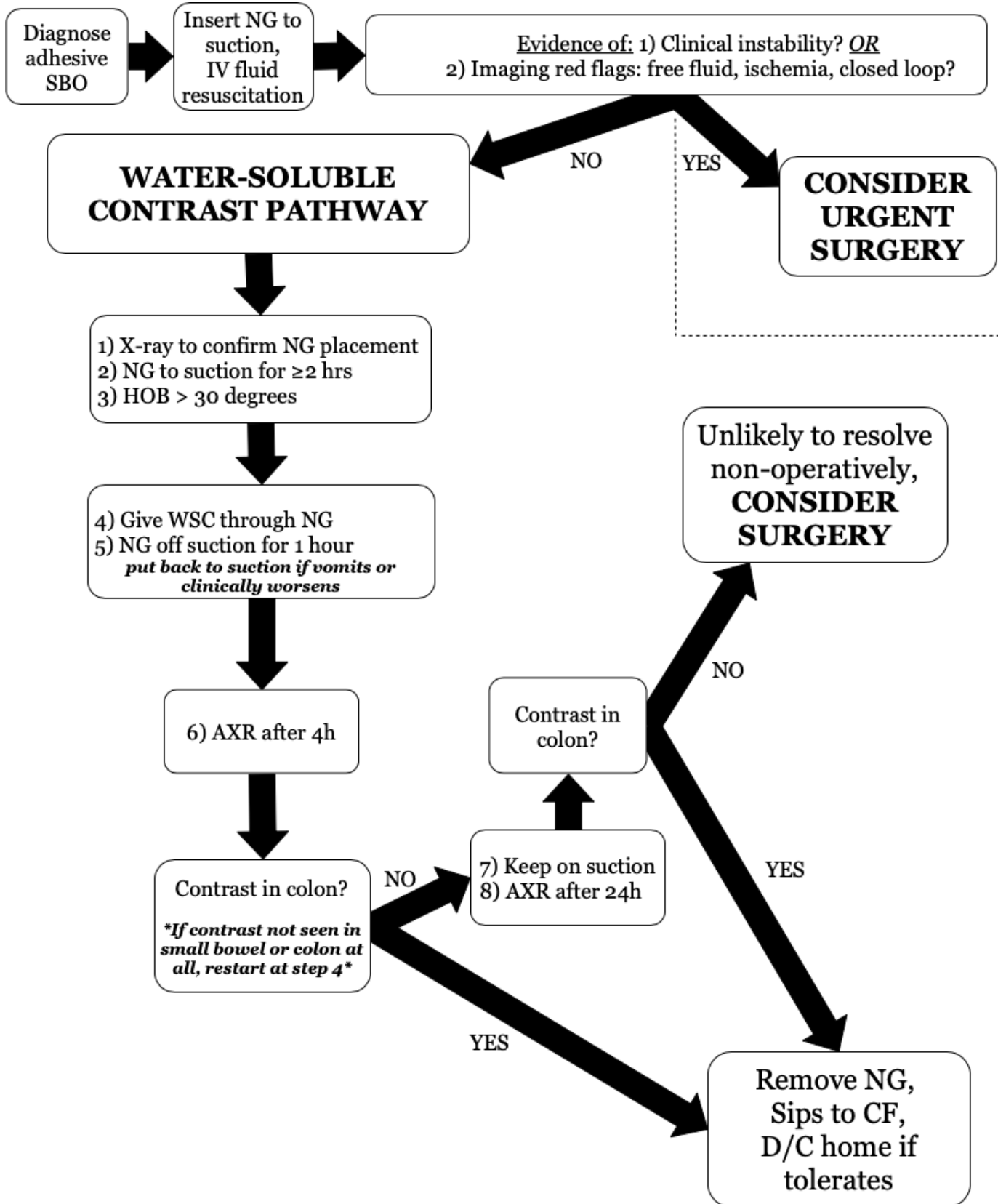
- 2.1. A nasogastric tube should be inserted, and placement should be confirmed with an X-ray. Reposition NG tube and repeat X-ray as necessary to confirm appropriate NG placement.
- 2.2. Once the NG tube placement is confirmed, it should be put to low-intermittent or continuous suction for at least 2 hours prior to administering WSC.
- 2.3. The head of the bed should be elevated to $>30^\circ$ at all times.
- 2.4. After 2 hours of NG tube decompression, 90mL of undiluted Gastrografin or similar WSC should be administered through the NG tube.
 - 2.4.1. Note: Some centers may consider using other WSC agents depending on local policies and procedures. Substitute as necessary.
 - 2.4.2. Document the time of WSC administration.
- 2.5. The NG tube should be clamped or placed to gravity for 1 hour to allow antegrade contrast passage.
 - 2.5.1. If at any point the patient feels nauseous, vomits, has worsening abdominal pain or distension, the NG tube should be placed back to suction. Continuation of non-operative management is at the discretion of the surgeon.

3. Using the WSC pathway

- 3.1. Obtain early (suggested at 4 hours) abdominal radiographs (upright + supine) after WSC administration.
 - 3.1.1. Note: Some centers may perform a low dose, non-contrast computed tomogram instead of X-rays for this step depending on individual center policy and procedures.
 - 3.1.2. If the contrast is in the cecum or any part of the colon, the patient has passed the protocol and the SBO will likely fully resolve non-operatively.
 - 3.1.2.1. Remove NG tube.
 - 3.1.2.2. Start sips of clear fluids and monitor serially.
 - 3.1.2.3. If patient tolerates clear fluid diet and is otherwise stable, he/she can be discharged home at surgeon's discretion.
 - 3.1.3. If the contrast on the early radiograph is not in the cecum but still seen in small bowel, keep NG tube in and on suction.
 - 3.1.4. If no contrast is seen in the small intestine or colon on the early radiograph (ie. no contrast present or contrast present only in bladder), then contrast should be re-administered as above and the pathway restarted as the contrast may not have been administered properly.
- 3.2. Repeat abdominal radiographs (upright + supine) 24 hours after WSC administration.

- 3.2.1. If the contrast is in the cecum or any part of the colon, the patient has passed the protocol and the SBO will likely fully resolve non-operatively.
 - 3.2.1.1. Remove NG tube.
 - 3.2.1.2. Start sips of clear fluids and monitor serially.
 - 3.2.1.3. If the patient tolerates clear fluid diet and is otherwise stable, he/she can be discharged home at surgeon's discretion
- 3.2.2. If the contrast on the delayed radiograph is not in the cecum but still seen in small bowel, the patient has failed the protocol.
 - 3.2.2.1. The obstruction is unlikely to resolve non-operatively. Surgical intervention should be considered.

WSC Pathway Diagram



Section 3: Guideline recommendations with supporting evidence

1. SBO diagnosis and initial management

1.1. A diagnosis of SBO should be made clinically and/or radiographically using cross-sectional imaging.

1.1.1. Any suspicion of non-adhesive etiologies should be appropriately investigated.

Small bowel obstruction occurs when there is mechanical blockage of the passage of intestinal contents, and if ischemia or strangulation of the intestine occurs this becomes a surgical emergency.¹⁸ Post-operative adhesions account for 65-70% of SBO.¹⁻³ Initial clinical history and physical examination are the first steps in differentiating adhesive from non-adhesive causes.²

Non-adhesive etiologies include hernias, volvulus, malignancy, or inflammatory bowel disease. The studies from our literature search did not validate the WSC pathway in any of these populations. A recent Cochrane review investigating the role of WSC in inoperable malignant obstructions found limited evidence supporting its use.¹⁹ Inflammatory abdominal processes, such as Crohn's disease, can cause small bowel obstructions. There is a paucity of literature on the use of WSC in this scenario, and only one case series was found in our search that addressed Crohn's patients with obstructions.²⁰ No studies were found investigating the use of WSC in hernia-related SBO. Bowel obstruction in patients who have not previously had abdominal surgery have historically mandated surgical exploration to rule out malignancy, but more recent data suggest that the vast majority of these obstructions are due to adhesions and therefore may be managed as such.^{21,22} Despite this, there is currently very limited literature on using WSC to manage SBO in virgin abdomens. Only one observational study supported this.²² In summary, the current literature does have enough evidence supporting the use of the WSC pathway for the above-listed presentations, and as such they will currently remain outside the scope of these guidelines.

Pregnant patients are also excluded from our protocol due to lack of supporting evidence. SBO during pregnancy is relatively rare but potentially serious. A recent review found only case reports on the subject, risk of fetal loss was as high as 17%, and failure rate of non-operative treatment in these patients was higher than that in non-pregnant patients.²³

There is also not enough supporting evidence in the pediatric population. The risk of postoperative adhesive SBO in children ranges from 1-9%, compared to approximately 25% in adults.^{24,25} One systematic review found that there is limited evidence investigating SBO management in children, and most available data are from observational studies which support traditional non-operative therapy.²⁶ Very few studies have specifically investigated WSC use in children. One case series of 8 patients who received WSC after failure of 48 hours of traditional non-operative management found a decreased LOS.²⁷ Another retrospective study included both adults and children with SBO, with subjects as young as 11 months old.²⁸ Given concerns of fluid shifts resulting from the hyperosmolarity of WSC such as Gastrografin causing complications in small children, and the lack of strong evidence supporting its use, our panel recommends excluding children from routine WSC pathway use until stronger evidence is available.

1.2. Clinical stability must initially be ensured and appropriately reassessed.

1.2.1. Signs of clinical instability due to suspected bowel ischemia or perforation may warrant urgent surgical exploration, based on the surgeon's judgment.

The key step in determining operative versus non-operative treatment of SBO is the degree of concern for bowel ischemia. While physical findings of fever and peritoneal signs may suggest bowel ischemia, the sensitivity of clinical examination alone is overall low, estimated at 48%,⁸ so imaging is recommended in the hemodynamically stable patient (see rationale under bullet 1.4 below).

Note: Approach to surgical intervention, including the choice of laparoscopy versus laparotomy, is beyond the scope of these guidelines.

1.3. IV access and relevant bloodwork should be obtained. Fluid resuscitation should be initiated, correcting for any electrolyte abnormalities or acute kidney injury.

SBO patients often present with high volume emesis and dehydration that can precipitate electrolyte shifts and acute kidney injury secondary to pre-renal losses.^{1,2} While elevated white blood cell and lactate levels may occur secondary to dehydration, they may also be a sign of bowel ischemia and should be incorporated into clinical decision making regarding operative versus non-operative treatment.¹²

1.4. The patient should be made NPO and a nasogastric (NG) tube should be inserted. Gastric decompression with low-intermittent or continuous suction should be started.

NG decompression is a key component of non-operative management of SBO. Some studies advocated for the use of long intestinal tubes such as nasojejunal (NJ) tubes, but there is no significant difference in the failure rate of non-operative management between the two tubes.¹¹ The other significant benefit of NG decompression is prevention of aspiration and associated respiratory complications.^{1,2} No studies in the literature were found to investigate any potential difference in clinical outcomes between low-intermittent or continuous suction.

1.5. Computed tomography (CT) with IV contrast (if no contraindications) may be performed to aid in diagnosis. Findings concerning for ischemia, such as free fluid, heterogeneous bowel wall enhancement, or closed loop configuration, may warrant urgent surgical exploration, based on the surgeon's judgment.

Plain abdominal X-rays can detect large volume pneumoperitoneum from perforation and mandate urgent surgical exploration in an unstable patient, but outside of this context more advanced imaging is necessary to further characterize the obstruction if the patient is stable.^{9,10} Ultrasound can detect small bowel distension, as well as free fluid, but provides limited assessment of overall anatomy or of signs of bowel compromise.¹⁶ CT is useful in diagnosing SBO, and although it cannot directly visualize adhesions, it can be used to identify non-adhesive causes of SBO. CT scans can also assess for bowel ischemia and help facilitate the decision of urgent surgery or a trial of non-operative management.^{1,2} Signs of current or impending bowel ischemia on CT include heterogeneous bowel wall enhancement, free mesenteric fluid, and closed loop configuration.^{13,14} Pneumatosis intestinalis and portal venous gas are later signs that suggest bowel necrosis and warrant urgent surgical exploration.¹⁵

2. Initiating the water-soluble radiographic contrast (WSC) pathway

- 2.1. A nasogastric tube should be inserted, and placement should be confirmed with an X-ray. Reposition NG tube and repeat X-ray as necessary to confirm appropriate NG placement.**
- 2.2. Once the NG tube placement is confirmed, it should be put to low-intermittent or continuous suction for at least 2 hours prior to administering WSC.**
- 2.3. The head of bed should be elevated to >30° at all times.**

The purpose of these above recommendations is to minimize the risk of aspiration. Confirming NG placement will allow for better decompression of the GI tract and will minimize risks of aspiration of the NG-administered WSC.²⁹ Elevating the head of the bed reduces gastroesophageal reflux and risk of aspiration.³¹ A study measuring endobronchial levels of a radioactive-labeled solution instilled into the stomach via NG tube demonstrated that supine patients flat in bed have higher sputum levels of radioactive solution compared to patients in the semi-recumbent (30-45°) or reverse Trendelenburg position.³⁰

- 2.4. **After 2 hours of NG tube decompression, 90mL of undiluted Gastrografin or similar WSC should be administered through the NG tube.**
 - 2.4.1. **Note:** Some centers may consider using other WSC agents depending on local policies and procedures. Substitute as necessary.
 - 2.4.2. **Document the time of WSC administration.**
- 2.5. **The NG tube should be clamped or placed to gravity for 1 hour to allow antegrade contrast passage.**
 - 2.5.1. **If at any point the patient feels nauseous, vomits, has worsening abdominal pain or distension, the NG tube should be placed back to suction. Continuation of non-operative management is at the discretion of the surgeon.**

Very few complications from the use of WSC agents such as Gastrografin have been described, and they appear to be relatively safe. There have been reports of hypersensitivity to the contrast agent itself,^{32,33} and of serious pneumonitis and pneumonia following accidental aspiration of the contrast.³⁴ Hence, it is important to monitor the patient after administering the contrast, and to take the steps listed above to minimize the risk of aspiration. Other reported concerns with Gastrografin use include large volume fluid shifts worsening hypovolemia, as well as one reported case of severe hemorrhagic gastritis in a patient with chronic peptic ulcer disease.³⁵

3. Using the WSC pathway

- 3.1. **Obtain early (suggested at 4 hours) abdominal radiographs (upright + supine) after WSC administration.**
 - 3.1.1. **Note:** Some centers may perform a low dose, non-contrast computed tomogram instead of X-rays for this step depending on individual center policy and procedures.
 - 3.1.2. **If the contrast is in the cecum or any part of the colon, the patient has passed the protocol and the SBO will likely fully resolve non-operatively.**
 - 3.1.2.1. **Remove NG tube.**
 - 3.1.2.2. **Start sips of clear fluids and monitor serially.**
 - 3.1.2.3. **If patient tolerates clear fluid diet and is otherwise stable, can be discharged home at surgeon's discretion.**
 - 3.1.3. **If the contrast on the early radiograph is not in the cecum but still seen in small bowel, keep NG tube in and on suction.**
 - 3.1.4. **If no contrast is seen in the small intestine or colon on the early radiograph (ie. no contrast present or contrast present only in bladder), then contrast should be re-administered as above and the pathway restarted as the contrast may not have been administered properly.**
- 3.2. **Repeat abdominal radiographs (upright + supine) 24 hours after WSC administration.**
 - 3.2.1. **If the contrast is in the cecum or any part of the colon, the patient has passed the protocol and the SBO will likely fully resolve non-operatively.**
 - 3.2.1.1. **Remove NG tube.**
 - 3.2.1.2. **Start sips of clear fluids and monitor serially.**
 - 3.2.1.3. **If the patient tolerates clear fluid diet and is otherwise stable, he/she can be discharged home at surgeon's discretion**
 - 3.2.2. **If the contrast on the delayed radiograph is not in the cecum but still seen in small bowel, the patient has failed the protocol.**
 - 3.2.2.1. **The obstruction is unlikely to resolve non-operatively. Surgical intervention should be considered.**

Various protocols for administration of WSC in SBO have been described. Our group reviewed the available literature and developed the above pathway. Our own literature search yielded a total of 22 relevant studies that met our inclusion criteria (see "Overview of Process" in Section 1 for details). The majority of studies were randomized controlled trials (9) or observational studies (10), but the best evidence we found came

from 3 systematic reviews and meta-analyses that had similar outcomes and recommendations.^{40,41,42} One of the RCTs included a systematic review in addition to their own study, which was considered for these guidelines as well.⁴⁸

The most recent and largest systematic review and meta-analysis on the subject is by Ceresoli et al.⁴⁰ The group reviewed a total of 21 studies (11 RCTs, 10 observational studies) which evaluated the WSC's diagnostic and therapeutic roles in SBO. This review assessed the following outcomes: diagnostic accuracy and prediction of non-operative resolution of the SBO if WSC reaches the colon, time to resolution, need for surgery, hospital LOS, and overall complications and mortality. In the 947 patients assessed for diagnostic accuracy, presence of WSC in the colon 2 to 36 hours post administration had an overall sensitivity of 92% (95% CI 0.90-0.94) and specificity of 93% (95% CI 0.88-0.96) in predicting SBO resolution. Time to resolution of the SBO was also found to be decreased by 28 hours in a subset of 253 patients ($P < 0.00001$). Need for surgery in over 650 patients treated with WSC was reduced compared to those managed non-operatively without it [OR 0.6 (95% CI 0.39-0.91, $P = 0.002$)]. Hospital LOS was reduced by 2.18 days in the WSC group ($N = 588$, $P < 0.00001$). Overall there was no significant difference in complications (OR 1.3, $P = 0.47$) or in mortality (OR 1.26, $P = 0.68$) with WSC.⁴⁰

Timing of X-rays post WSC administration was also reviewed by Ceresoli et al. as their included studies had varying protocols. With their meta-analysis, they compared accuracy in predicting SBO resolution at 3 discrete time intervals post WSC administration: 2-6 hours ($N = 355$), 8-12 hours ($N = 163$), and 24-36 hours ($N = 429$). Sensitivity and specificity were as follows: 82% (95% CI 0.77-0.86) and 95% (95% CI 0.89-0.99) in the 2-6 hour group, 97% (95% CI 0.95-1.00) and 89% (95% CI 0.78-0.98) in the 8-12 hour group, and 99% (95% CI 0.98-1.00) and 93% (95% CI 0.88-0.99) in the 24-36 hour group, respectively.⁴⁰

Two other reviews were conducted by Branco et al.⁴¹ and Abbas et al.⁴² They included many of the same studies in their analysis as Ceresoli et al. did, and therefore they had similar outcomes with minor differences only.

Branco et al. reviewed 14 studies (10 RCTs, 4 observational studies) for various outcomes, similar to Ceresoli et al. WSC predicted SBO resolution in 508 patients with a sensitivity of 96% (95% CI 0.95-0.97) and specificity of 98% (95% CI 0.94-0.99). Of the 765 patients assessed for need for surgery, 20.9% of patients receiving WSC required surgery, compared to 29.6% of those managed non-operatively without WSC, pooled OR 0.62 ($P = 0.007$). Time to resolution of the SBO also appeared to improve with WSC, but there was significant heterogeneity in the included studies for this outcome. Overall hospital LOS, however, was less with WSC, with a pooled analysis demonstrating a reduction of 1.87 days in the WSC group (95% CI -2.21 to -1.52, $P < 0.001$). The complication and mortality rates were similar in WSC and non-WSC groups, pooled OR 1.15 (95% CI 0.63 to 2.10, $P = 0.65$) and 1.37 (95% CI 0.43 to 4.38, $P = 0.59$), respectively.⁴¹

Abbas et al. reviewed 6 RCTs. With regards to predicting SBO resolution, pooled analysis of 538 patients demonstrated that WSC had a sensitivity of 97% and specificity of 96%. Resolution of SBO without surgery was not significantly higher in the WSC group with an odds ratio of 0.81 (95% CI 0.54-1.21, $P = 0.30$). Hospital stay was 1.83 days shorter in the WSC group (95% CI -2.21 to -1.45). With regards to time to SBO resolution, there was significant heterogeneity in the reviewed studies such that no meaningful analysis could be made. Complication and mortality rates were similar in WSC and non-WSC groups; pooled OR 1.18 (95% CI 0.61 to 2.29, $P = 0.625$) and 1.37 (95% CI 0.43 to 4.38, $P = 0.59$), respectively.⁴²

All 3 meta-analyses supported the diagnostic role of WSC in SBO and demonstrated similar calculations of sensitivity and specificity with regards to prediction of SBO resolution. They also had similar outcomes with regards to decreased hospital stay with the use of WSC, and all 3 suggested no differences in complication and mortality rates. Only Ceresoli et al. and Branco et al. demonstrated significant differences in the reduction of the need for surgery with WSC, as Abbas et al. found no significant difference with this outcome. Ceresoli et al. suggested a decrease in the time to resolution of SBO with WSC, while both Branco et al. and Abbas et al. had heterogeneous data on this outcome.

Of note, an RCT by Scotté et al. also included a systematic review of 10 other RCTs. No analysis was done assessing the sensitivity or specificity of WSC in predicting SBO resolution. Mean hospital LOS from a pooled sample of 279 patients was not significantly different between the WSC and non-WSC groups (3.51 vs. 3.53 days 95% CI 0.18 to 0.13, P=0.77).⁴⁸

The RCTs found in the literature search were variable in number of participants (range 35 to 242) and in outcomes. Most studies found that WSC was associated with decreased LOS⁴³⁻⁴⁶ and need for surgery.⁴⁷ 3 RCTs found no benefit from WSC,⁴⁸⁻⁵⁰ although in Scotté et al. the non-WSC arm received placebo saline solution rather than traditional treatment. Fevang et al. used a combination of barium and Gastrografin in their WSC solution,⁴⁹ which no other study had investigated. Choi et al.'s RCT was unique in that it assessed the benefit of WSC after failure of 48 hours of traditional non-operative management in 35 patients. They found a reduction of the need for surgery by 74% (P<0.001) compared to continuation of traditional non-operative management after the initial 48 hours.³⁶

Overall, the reviewed RCTs had relatively small sample sizes and conflicting information. The three meta-analyses described earlier included all these RCTs with the exception of Scotté et al., which was published more recently in 2017, and Choi et al., presumably for their unique methodology of starting the WSC 48 hours after traditional non-operative therapy only.⁴⁰⁻⁴²

All 10 of the observational studies reviewed supported the use of WSC. They ranged in sample sizes from 37 to 317 patients. Many of them lacked a control group which made drawing any meaningful conclusions challenging.^{36,51-56} One study that identified older age and history of prior open surgery were significantly associated with failure of non-operative management despite WSC.⁵³ The remaining three studies had both a WSC group and a non-WSC group. Two studies had outcomes suggesting lower LOS and rates of surgery.^{37,38} One study suggested that patients needing surgery were operated on faster in the WSC group than in the non-WSC group.³⁹ While only some of the included observational studies were also included in the meta-analyses described earlier,^{38,54} overall these studies had small samples and the lack of comparator group in many of them limited their ability to provide meaningful assessments of outcomes.

Table 1. Summary of supporting evidence

#	Study + Year	Journal	N	Supports WSC Use	SIGN Grade	Notes
Systematic Reviews/Meta-Analyses (3)						
11	Ceresoli et al 2016	Amer J of Surg	21 studies, 947 diagnostic role high sens/spec. + various info on therapeutic role	YES	1+	Provides information on optimal timing of AXRs
21	Branco et al 2010	BJS	14 studies (10 RCT + 4 observational), 508 diagnostic, 765 therapeutic	YES	1+	Predicted need for surgery, reduced need for surgery (?therapeutic benefit), reduced LOS
26	Abbas et al 2007	Cochrane	10 studies (6 RCT, 4 cohort)	YES	1+	No reduction in need for surgery. Reduced LOS. No evidence of therapeutic effect or faster resolution of SBO
RCTs (9)						
6	Scotté et al 2017	Surgery	242 (121 v 121)	NO	1-	No difference in LOS or need for surgery
22	Farid et al 2010	J Surg Res	110 (55 vs 55)	YES	1-	Reduces surgery rate (14% vs 35% in GG vs. non GG) and time to resolution
23	Kumar et al 2009	Singapore Med J	41 (21 GG 20 non GG)	YES	1-	Decreased time to resolution with GG (7 vs 35hrs), reduced LOS (4 vs days). No difference in need for surgery
24	Di Saverio et al 2008	WJS	76 (38 vs 38)	YES	1-	Reduces OR rate (19% vs 45% in GG vs. non GG) and LOS (4 vs 7 days all pts, 3 vs 5 convs mgt pts)
30	Burge et al 2005	ANZ J Surg	35 (18 GG vs 17no GG)	YES	1-	Decreased LOS (3 vs 4 days)
36	Biondo et al 2003	BJS	90 (44 GG vs 46 no GG)	YES	1-	Decreased LOS (8 vs 4 days), decreased readmission, no difference in OR rate
37	Choi et al 2002	Annals of Surg	139 initial patients managed non-operatively or OR, those who did not open up after 48hrs got GG (19) or OR (16).	YES	1-	14/19 getting GG improved, 5 did not pass so assumed complete obstruction. GG to determine complete vs incomplete obstruction + possible therapeutic effect

39	Fevang et al 2000	Eur J S	98 (48 GG vs 50 no GG)	NO	1-	Used barium + GG. No effect on LOS, OR rate, complications, mortality
41	Feigin et al 1996	Amer J S	50 (25 GG vs 25 no GG)	NO	1-	No effect on LOS, OR rate, complications, mortality
Observational Studies (10)						
2	Miquel et al 2017	Int J CR Dis	174 (all GG, no control)	YES	2-	Gastrografin® showed a sensitivity of 75%, specificity of 99%, positive predictive value (PPV) 92%, negative predictive value (NPV) 98%.
3	Kuehn et al 2017	JGIS	105 (all GG)	YES	2-	The Gastrografin® challenge had a specificity of 96% and a sensitivity of 100%; accuracy to predict the need for exploration was 96%.
7	Zielinski et al 2017	JACS	316 (173 GG 143 non GG)	YES	2+	Lower rate of OR, shorter LOS with GG
9	Bueno-Lledo et al 2016	Digestive Surgery	235 (all GG)	YES	2-	Older age + prior laparotomy for SBO associated with failure of convs. mgmt
17	Galardi et al 2013	American Surgeon	103 (72 GG vs 31 no GG)	YES	2+	Shorter time to OR (1 vs. 3.7 days)
20	Atahan et al 2010	J of Int Med Res	37 (all GG)	YES	2-	64% improved with GG. 24% of those who failed still improved non-operatively
28	Kapoor et al 2006	J Surg Res	62 initial, but all convs mgmt. 48hrs, then 24 GG (38 improved within 48hrs)	YES	2-	reduce OR rate but no comparator (all pts got GG)
29	Yagci et al 2005	J Inv Surg	317 (199 GG vs 118 no GG)	YES	2+	Urografin instead of GG. Reduced OR rate (11% vs 24%). LOS?
31	Aulin et al 2005	Gastroenterol Clin Biol	126 (all GG)	YES	2+	No control group, but 89% GG pts managed non-op.
32	Choi et al 2005	W J Gastroenterol	245 (GG only after 48hrs)	YES	2-	Used GG in patients who did not pass 48h of non-operative treatment. Reduced need for OR. No real control group

Section 4: Implementation Strategies

The WSC pathway was formally implemented at Sunnybrook Health Sciences Centre for management of all stable patients presenting with adhesive bowel obstruction admitted under the ACCESS Acute Care Surgery team. Initial review of the impact of the intervention is still in progress at the time of publication of these guidelines. Outcomes being evaluated include hospital readmission rate, rates of failure of non-operative therapy, hospital length of stay, in hospital complications, and mortality. The complete review and implementation analysis from Sunnybrook will be presented and published elsewhere.

Several other Acute Care Surgery teams across several University of Toronto hospitals have informally used varying versions of the WSC pathway. With the standardized pathway presented in these guidelines, there will be more uniformity in the protocols followed by different surgeons at different hospitals. These guidelines are based on best available evidence at the time of writing.

The following implementation strategies are suggested for implementing the WSC pathway:

- Make the recommendations part of a dedicated electronic/standardized patient order set. Go to <http://bestpracticeinsurgery.ca/implementation-tools/> for examples of standardized order sets
- Provide education to nursing staff, specifically in the ER and on surgical wards, on the protocol and their roles in NG tube management, administration of contrast, and timing of X-rays Go to <http://bestpracticeinsurgery.ca/implementation-tools/> for a slide deck that you can use to provide education to nurses.
- Create a local implementation team. Ensure the engagement of members of the Department of Radiology along with their staff and imaging technicians. As well, invite nurses from the ER and wards to assist with implementation. Lastly, having a local resident on the implementation team is strongly recommended.
- Download the Best Practice in Surgery to use the pathway in real time when caring patients.
- If not already available, institute system of rapid outpatient follow-up following discharge to ensure complete resolution of the SBO and no further concerns. The Acute Care Surgery model at many hospitals already has this clinic space and follow-up in place. If rapid follow up (< 2 weeks) not available, then ensure clear discharge instructions for when to contact surgeon or return to ER if recurrent symptoms

Section 5: External review

1. Reviewer comment: I know it is picky, but can you change "conservatively" to non-operatively? Often the 'conservative' approach is to operate.

Authors' response: Yes, agree. This has been changed

2. Reviewer comment: This looks very good overall. My only suggestion is to replace the term "conservative" with "non-operative" throughout.

Authors' response: Agree. This has been changed

3. Reviewer comment: Thank you for sharing the document. The document was already shared with and discussed by my colleague with our Abdominal Division Members in Medical Imaging a few months ago. I was also informed that these studies are being performed at TWH since last October. As I had expressed at our Medical Imaging Abdominal Divisional meeting, my main concern for not fully embracing this new imaging study is the fact that the Surgical resident staff would resort to this imaging study (instead of performing bedside assessment) on the patient if the 'clinical bowel obstruction has resolved or not. Case in point this week we had a case of a young Pt with (post ileocolic resection) Crohns and admitted with SBO (on first had Low dose Abd Tomogram and then Conventional IV contrast CT on same day) - and we were asked to repeat the Abd Tomogram next day (Radiation dose Less than Plain Film) to see if contrast reached the colon (Pt was not seen or examined by the resident staff when I asked them) -because they informed us that if contrast had the colon (which it did) she would be a medical and not surgical patient. The CT Tomogram still showed short chronic stricture and proximal bowel dilatation - Pt received 3 CT scans within 48 hrs
Though this one anecdotal case may not be sufficient - it is the lack of clinical judgement, being practiced more often than before, that makes me uncomfortable in embracing this new technique. From what I understand, my Abdominal Division has agreed to perform these studies

Authors' response: Thank you for sharing your concern. That is an unfortunate case. By no means is the imaging supposed to replace clinical assessment and judgement; Regular clinical follow-up of all patients is required. It is a guideline only, and the imaging is meant to be an adjunct to clinical decision-making, not a replacement for it. We have added a caveat to that effect. In addition, we are proposing this pathway specifically for adhesive bowel obstructions, and not inflammatory processes such as Crohn's as in the case described.

4. Reviewer comment: The guideline looks great to me! I would just suggest putting an easy-to-read summary near the beginning. To ease translation into practice, I think readers should be able to get the main message quickly, and read the full guideline for detail.

Perhaps you can add one-liners for

Problem:

Question:

Recommendation:

Authors' response: Thank you for the suggestion. Section 1 provides this information.

5. Reviewer comment: The general surgery group met to discuss the guideline at our divisional meeting and there were some concerns voiced about implementation:

- 1) Concerns that 2 hrs of suction was not long enough to ensure the patient wasn't at risk of aspiration

Authors' response: We don't know the exact time required for suction. Two hours has been used in other studies. The goal is to empty the stomach prior to administering contrast to reduce the risk of aspiration. This may take more or less time depending on the individual patient. We have added a caveat that if there is still a high volume draining from the NG after 2 hours, that longer drainage time should be considered.

2) They were concerned about the lack of strong evidence to support the use of WSC, namely the most recent RCT that did not demonstrate a benefit to its use. They suggested maybe participating in a trial?

Authors' response: The most recent RCT used a longer time frame for imaging assessment (48 hours) than most of the studies. The use of contrast and imaging has been shown to have a high predictive value up to 36 hours. I suspect that is why we see no difference in the most recent RCT. We have had good outcomes in the last year at Sunnybrook with the protocol, so I think the lack of a local trial does not prohibit the guideline from going forward.

3) They also felt that implementation would be an issue, given that the juniors may not feel comfortable (especially off service juniors) administering the contrast.

Authors' response: The nurses at Sunnybrook administer the contrast, but that may not be feasible at all institutions. Contrast administration should be done by experienced residents or with supervision.

4) The other issue is follow-up; we are one of the only hospitals without an ACS service and don't have a rapid assessment clinic; most patients discharged have to wait for a clinic appointment which can be weeks later.

Authors' response: Short-term follow-up is suggested but not required. We realize that not every institution has that capacity. We will change the guideline to allow for a longer follow-up interval. Patients should be informed to return to the ER if concerns prior to follow-up.

Although there was not broad buy-in, I believe if we inform of them of the experiences of Sunnybrook (?write up of the preliminary results) that we may convince the group that this is safe and feasible.

6. Reviewer comment: A couple of questions re: the literature/evidence.

1) Were the studies that calculated the diagnostic sensitivity and specificity of WSC blinded? (i.e. was the surgeon who was making a decision to operate blinded to the findings of the WSC study?)

Authors' response: The studies were not blinded.

2) Did the MA by Scotte include any assessment about the risk of surgery? Or time to resolution of SBO? If so, I think it should be included in the discussion given it's the most comprehensive MA on the topic?

Authors' response: The meta-analysis by Scotté et al does not comment on risks of surgery directly, although they do discuss risk factors for failure of non-operative management. Only age was identified as a significant potential risk factor for this. The study also does not comment directly on time to resolution of SBO. Like other studies, it calculates hospital length of stay as a surrogate for time to resolution of SBO, which in this paper was not significantly different between the 2 arms. The other time variables in the paper are time from CT to operative intervention, as well as time from oral refeeding to hospital discharge.

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