







Prevention of acute adhesive intestinal obstruction in the postoperative period: A meta-analysis

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ABSTRACT

Background: Adhesive small bowel obstruction (ASBO) results from postoperative adhesions, causing prolonged hospital stays and surgeries.

Objective: To evaluate the effectiveness of ASBO prevention: surgical, adhesion prevention strategies, and conservative methods.

Methods: A meta-analysis evaluating interventions to prevent ASBO post-surgery used data from Web of Science, Scopus, Cochrane Library, ProQuest, PubMed, and Google Scholar (2020-2025). RevMan 5.4 and R Studio were used, including 25 relevant studies.

Results: Results highlighted differences in reoperation rates (1.4-20.7%), hospital stay lengths (4-23 days), and follow-up durations (≥ 2 years for 55% of studies). Surgical methods (odds ratio [OR] = 12.01) and the use of adhesion barriers (OR = 0.21) mitigated the risk of adhesive intestinal obstruction (AIO). Conservative management (OR = 4.58) was also effective.

Conclusions: Surgical methods, the use of barriers to adhesions, and other less invasive interventions help in the prevention of AIO, as well as in the recovery processes.

Keywords: acute adhesive small bowel obstruction, postoperative complication, adhesion barriers, surgical techniques, prevention strategies, non-operative interventions

INTRODUCTION

Adhesive small bowel obstruction (ASBO) is one of the most common and challenging causes of intestinal blockage, particularly in developed countries, accounting for a large proportion of postoperative complications after abdominal surgery [1, 2]. It arises primarily from intra-abdominal adhesions formed following surgical procedures, which contribute significantly to morbidity, prolonged hospital stays, and high readmission rates. ASBO is responsible for 12-16% of all emergency surgical admissions and nearly 20% of emergency surgical procedures, despite advancements in laparoscopic surgery [3, 4]. The economic burden is also considerable hospitalizations for ASBO exceed \$300,000 annually in the United States alone, reflecting its clinical and financial impact on healthcare systems [5].

Although the risk of ASBO recurrence after surgery has long been debated, recent evidence shows that appropriate surgical management may actually reduce recurrence risk compared to conservative care. However, diffuse adhesions still present a higher recurrence risk than single-band adhesions,

underscoring the importance of preventive interventions at the time of surgery rather than relying solely on later management [6]. During reoperations, adhesiolysis increases operative time and postoperative complications, highlighting the need for effective anti-adhesion measures. Currently available adhesion barriers have shown variable efficacy and limited translation from experimental to clinical settings [7].

Postoperative adhesions cause significant morbidity, prolonged hospital stays, and higher treatment costs, which frequently exceed reimbursements and negatively impact hospital profitability [8]. They may also lead to chronic pain, infertility, and recurrent bowel obstruction. Preventive measures such as meticulous surgical technique, minimally invasive procedures, and the intraoperative use of adhesion barriers can substantially lower these risks, thereby reduce healthcare costs and improve recovery outcomes [9]. Delayed diagnosis or inadequate prevention may result in severe complications such as bowel ischemia, sepsis, or even death, reinforcing the need for proactive preventive strategies rather than reactive treatment [10].

The pathophysiology of adhesion formation involves tissue disruption, inflammation, fibrin deposition, and angiogenesis,

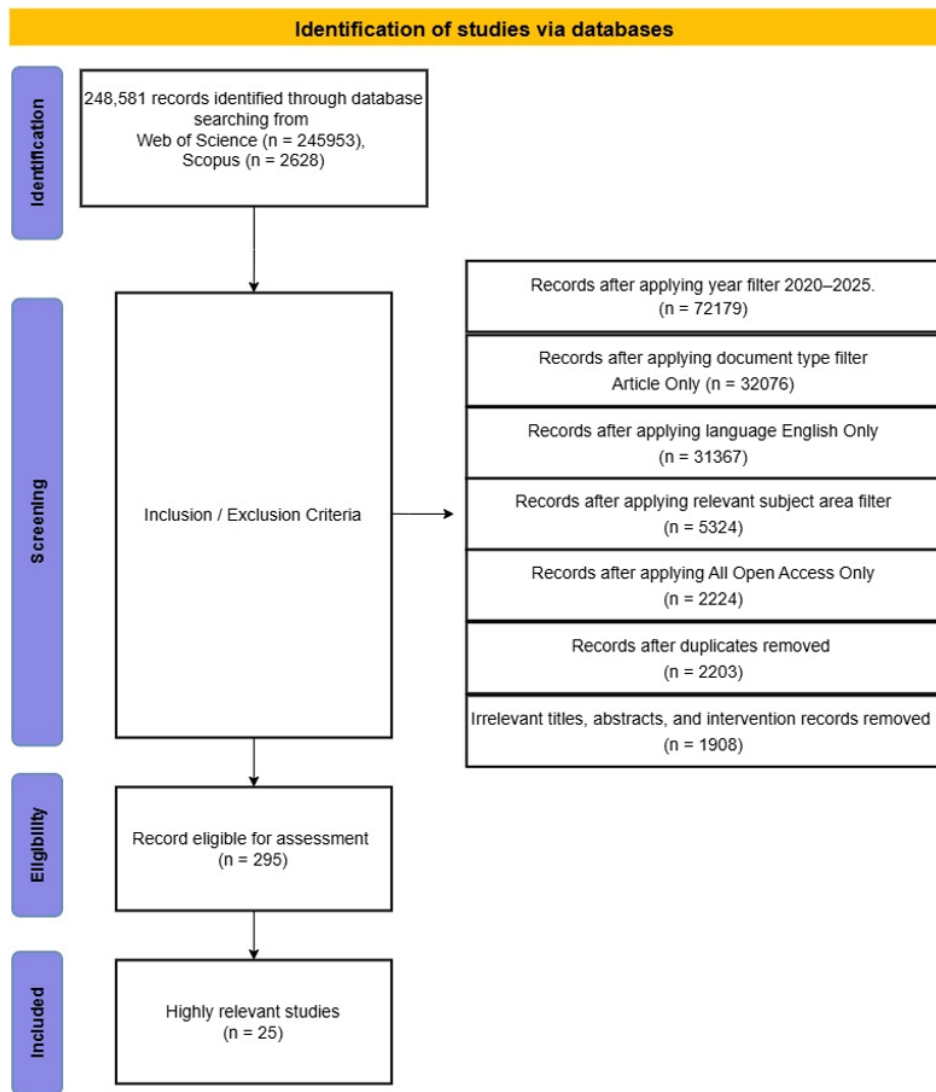


Figure 1. PRISMA flow diagram [17]

processes that are only partially controlled by existing preventive agents [11, 12]. Although nonoperative management remains suitable for uncomplicated cases, prevention through optimized surgical technique and anti-adhesion agents is crucial to avoid recurrence and long-term complications. Current evidence on preventive measures is fragmented, with few high-quality comparative studies on anti-adhesion barriers and pharmacological interventions [13, 14]. Additionally, the recurrence risk associated with laparoscopic versus open techniques remains insufficiently established, highlighting the need for comprehensive evaluation of preventive strategies [15]. Recent studies also emphasize individualized prevention protocols tailored to pre-existing adhesion risks, supporting the importance of a targeted approach [16]. Therefore, addressing these gaps through systematic synthesis is essential to determine the most effective preventive measures for ASBO. This meta-analysis aims to evaluate and compare various interventions that reduce the incidence of postoperative ASBO and guide evidence-based prevention strategies.

Objectives

To evaluate the effectiveness of preventive interventions (surgical and non-surgical) in reducing the risk of postoperative ASBO.

METHODS

This meta-analysis was conducted according to the guidelines set forth by the preferred reporting items for systematic reviews and meta-analyses (PRISMA) statement [17].

Search Strategy

A comprehensive literature search was conducted in six major databases Web of Science, Scopus, Cochrane Library, ProQuest, PubMed, and Google Scholar covering publications from 2020 to 2025. The initial search identified 338,924 records, which were progressively filtered by publication year, article type, language (English), subject relevance, and open access availability. After duplicate removal and screening, 25 eligible studies focusing on preventive interventions for ASBO were included in the final meta-analysis. The search and selection process is summarized in the PRISMA flow diagram (Figure 1).

In addition, a schematic summary illustrated in Figure 2 was developed to show the intervention types included:

- (1) surgical techniques,
- (2) adhesion barrier materials, and
- (3) conservative preventive approaches.

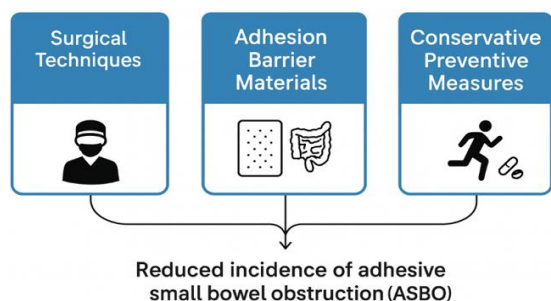


Figure 2. Summary of included preventive intervention categories (Source: Authors' own elaboration)

Study Eligibility Criteria

Predefined inclusion and exclusion criteria ensured methodological consistency and relevance.

Inclusion criteria

- Original studies published between 2020-2025
- Written in English and available as open access
- Directly evaluated preventive interventions for postoperative ASBO

Exclusion criteria

- Non-original research (reviews, editorials, and commentaries)
- Duplicate publications or studies not aligned with the research aim

Two independent reviewers screened all titles and abstracts for eligibility. Discrepancies were resolved through discussion, with a high inter-rater reliability (Cohen's kappa = 0.85), confirming consistent assessment.

Outcome Measures

The primary outcomes were defined as reoperation rates, hospital stay duration, and overall risk reduction of ASBO, measured through pooled odds ratios (OR) and 95% confidence intervals (CI). Secondary outcomes included follow-up duration and safety indicators such as complication or recurrence rates. Efficacy data were independently extracted by two reviewers, and any inconsistencies were resolved through consensus.

Risk of Bias Assessment

Risk of bias was evaluated using the Cochrane risk of bias tool for randomized controlled trials (RCTs) [18] and the Newcastle-Ottawa scale [19] for cohort, observational, and case-control studies. All included studies demonstrated low risk of bias, as summarized in **Table 1**.

Statistical Analysis

All statistical analyses were performed using RevMan 5.4 and R Studio (v4.0.3). A random-effects model was applied to calculate pooled OR with 95% CIs, and heterogeneity was assessed using I^2 statistics. Subgroup and sensitivity analyses were performed based on intervention type and study design. Forest plots illustrated pooled estimates, and publication bias was visually evaluated through funnel plots. A p-value < 0.05 was considered statistically significant.

Table 1. Risk of bias assessment for included studies

Author's/year	Study design	Bias
Aaen et al. (2021) [20]	RCT	Low
Behman et al. (2020) [21]	Cohort	Low
Beukel et al. (2023) [22]	Cohort	Low
Fan et al. (2024) [23]	Cohort	Low
Gu et al. (2021) [24]	Cohort	Low
Håkanson et al. (2020) [25]	Cohort	Low
Iwata et al. (2024) [26]	Cohort	Low
Li et al. (2023) [27]	Observational	Low
Maemoto et al. (2021) [28]	Observational	Low
Medvecz et al. (2020) [29]	Cohort	Low
Nakamura et al. (2021) [30]	Cohort	Low
Patwardhan et al. (2024) [31]	Cohort	Low
Qi et al. (2022) [32]	Cohort	Low
Sakari et al. (2020) [33]	Cohort	Low
Scott et al. (2021) [34]	Cohort	Low
Toneman et al. (2023) [35]	Cohort	Low
Toriumi et al. (2023) [36]	Cohort	Low
Wang et al. (2024a) [37]	Case-control	Low
Wang et al. (2024b) [38]	Cohort	Low
Watanabe et al. (2022) [39]	RCT	Low
Yamada et al. (2022) [40]	Cohort	Low
Yu et al. (2023) [41]	Case-control	Low
Yukawa et al. (2024) [42]	Cohort	Low
Zahn et al. (2022) [43]	Cohort	Low
Zulgarnain et al. (2024) [44]	Cohort	Low

RESULTS

Table 2 presents characteristics of studies conducted in various countries, including Denmark, Canada, and China, encompassing RCTs, cohort studies, observational research, and case-control studies included in the meta-analysis. Sample sizes vary widely, ranging from 59 participants to more than 148,000. The age of participants spans from 33 to 70 years, and gender distribution differs across studies, with some reporting as high as 89.7 percent female participants, while others show a predominance of male subjects.

To enhance clarity, the included studies were categorized according to the type of preventive intervention evaluated

- (1) surgical techniques,
- (2) adhesion barrier materials, and
- (3) conservative or adjunctive preventive measures.

This structure allows clearer interpretation of comparative effectiveness across different preventive strategies. **Table 3** outlines the preventive surgical and non-surgical interventions used to minimize the incidence of acute ASBO in the postoperative period. Several studies investigated advanced surgical techniques, such as laparoscopic colorectal surgery [30], and radical cystectomy for bladder cancer reported in [32]. Comparative analyses such as those in [31, 35] showed that laparoscopic methods generally resulted in lower postoperative obstruction rates compared to open surgery, indicating preventive rather than therapeutic benefits. Other investigations focused on adhesion barrier applications, such as Seprafilm® [36], and bioabsorbable membranes [26], both demonstrating favorable outcomes in reducing adhesion formation. Conservative or adjunctive interventions such as timing of reoperation, drainage models, or pharmacologic adjuncts were evaluated for their preventive contribution rather than curative intent [20, 34].

Table 2. Study characteristics and demographics

Author's/year	Study design	Country	Sample size	Average age years	Gender distribution
Aaen et al. (2021) [20]	RCT	Denmark	312	Mean 70.00	57.0% female
Behman et al. (2020) [21]	Cohort	Canada	3,174	Mean 61.20	51.1% female
Beukel et al. (2023) [22]	Cohort	Netherlands	122	Mean 50.00	78.3% female
Fan et al. (2024) [23]	Cohort	China	175	Mean 69.10	57.4% male
Gu et al. (2021) [24]	Cohort	China	59	Mean 53.90	31.2% male
Håkanson et al. (2020) [25]	Cohort	Sweden	619	Median 10.00	61.0% male
Iwata et al. (2024) [26]	Cohort	Japan	587	Median 55.50	64.1% male
Li et al. (2023) [27]	Observational	China	133	Median 56.30	54.0% female
Maemoto et al. (2021) [28]	Observational	Japan	155	Mean 63.00	33.0% female
Medvecz et al. (2020) [29]	Cohort	USA	6,191	Mean 61.20	53.0% male
Nakamura et al. (2021) [30]	Cohort	Japan	706	Median 70.00	44.5% female
Patwardhan et al. (2024) [31]	Cohort	USA	545	Mean 10.80	71.0% male
Qi et al. (2022) [32]	Cohort	China	139	Median 66.00	54.0% male
Sakari et al. (2020) [33]	Cohort	Sweden	402	Median 70.00	60.0% female
Scott et al. (2021) [34]	Cohort	UK	148,601	Mean 49.60	72.6% female
Toneman et al. (2023) [35]	Cohort	Scotland	18,452	Mean 50.46	100% female
Toriumi et al. (2023) [36]	Cohort	Japan	1,200	Median 64.00	69.9% male
Wang et al. (2024a) [37]	Case-control	China	253	Mean 60.50	67.4% male
Wang et al. (2024b) [38]	Cohort	China	221	Mean 63.30	64.0% male
Watanabe et al. (2022) [39]	RCT	Japan	123	Median 63.00	89.7% male
Yamada et al. (2022) [40]	Cohort	Japan	2,058	Mean 69.00	-
Yu et al. (2023) [41]	Case-control	China	173	Median 62.00	82.1% male
Yukawa et al. (2024) [42]	Cohort	Japan	953	Median 69.00	65.6% male
Zahn et al. (2022) [43]	Cohort	Germany	337	-	70.6% female
Zulqarnain et al. (2024) [44]	Cohort	USA	335	Mean 33.00	31.5% female

Table 3. Surgical procedures and interventions for preventing acute adhesive intestinal obstruction in the postoperative period

Author's/year	Type of surgery	Type of intervention
Aaen et al. (2021) [20]	Emergency GI surgery for obstruction/perforation	Timing and adjunctive therapies
Behman et al. (2020) [21]	EOM vs. TNOM for ASBO	Timing and adjunctive therapies
Beukel et al. (2023) [22]	Elective adhesiolysis	Adhesion barriers
Fan et al. (2024) [23]	Total gastrectomy with esophagojejunostomy	Surgical techniques & approaches
Gu et al. (2021) [24]	Surgery for ASBO and CRE-induced SBO	Conservative & non-operative management
Håkanson et al. (2020) [25]	Laparoscopic vs. Open appendectomy	Surgical techniques & approaches
Iwata et al. (2024) [26]	Colectomy for colon cancer	Adhesion barriers
Li et al. (2023) [27]	Laparoscopy and Laparotomy	Drainage procedures & models
Maemoto et al. (2021) [28]	Laparoscopic colorectal surgery with DI	Surgical techniques & approaches
Medvecz et al. (2020) [29]	Operative vs. non-operative management	Conservative & non-operative management
Nakamura et al. (2021) [30]	Laparoscopic colorectal cancer surgery	Surgical techniques & approaches
Patwardhan et al. (2024) [31]	Laparoscopic vs. open adhesiolysis	Surgical techniques & approaches
Qi et al. (2022) [32]	Radical cystectomy for bladder cancer	Surgical techniques & approaches
Sakari et al. (2020) [33]	Surgery for ASBO following abdominal surgery	Surgical techniques & approaches
Scott et al. (2021) [34]	Intra-abdominal surgeries	Timing and adjunctive therapies
Toneman et al. (2023) [35]	Gynecological surgery (laparotomy/laparoscopy)	Surgical techniques & approaches
Toriumi et al. (2023) [36]	Open gastrectomy with reconstruction	Adhesion barriers
Wang et al. (2024a) [37]	Non-surgical treatment (NIT/TC)	Conservative & non-operative management
Wang et al. (2024b) [38]	Radical surgery for rectal cancer	Drainage procedures & models
Watanabe et al. (2022) [39]	Laparoscopic rectal surgery	Adhesion barriers
Yamada et al. (2022) [40]	Colorectal, gastroduodenal, esophageal surgery	Adhesion barriers
Yu et al. (2023) [41]	Radical gastrectomy for gastric cancer	Surgical techniques & approaches
Yukawa et al. (2024) [42]	Liver resection (laparoscopic/open)	Surgical techniques & approaches
Zahn et al. (2022) [43]	Neonatal CDH repair	Surgical techniques & approaches
Zulqarnain et al. (2024) [44]	Ileocolonic and small bowel resection	Surgical techniques & approaches

Reoperation rates and hospital stays varied depending on the intervention category. For example, laparoscopic approaches demonstrated shorter hospital stays (23 days) and significantly lower reoperation rates (4.9% in laparoscopic vs. 17.1% in open surgery), as reported in [31]. Adhesion barrier uses also correlated with reduced recurrence and shorter recovery durations, as shown in [22] (1.4% vs. 5.7% reoperation; average stay: 4 days). In contrast, conservative or delayed-surgery approaches were associated with longer hospital stays, such as 17 days in [37] and 9 days in [29]

indicating only modest effectiveness compared with early surgical or minimally invasive strategies. Overall, studies demonstrated that preventive interventions especially surgical refinement and barrier application were associated with reduced recurrence and hospitalization durations, confirming their value in ASBO prevention (**Table 4**).

Figure 3 indicates that 55 percent of the studies included follow-up periods of two years or longer, reflecting a strong focus on evaluating the long-term outcomes of interventions for postoperative adhesive intestinal obstruction (AIO).

Table 4. Reoperation and hospital stay in studies evaluating preventive strategies for ASBO

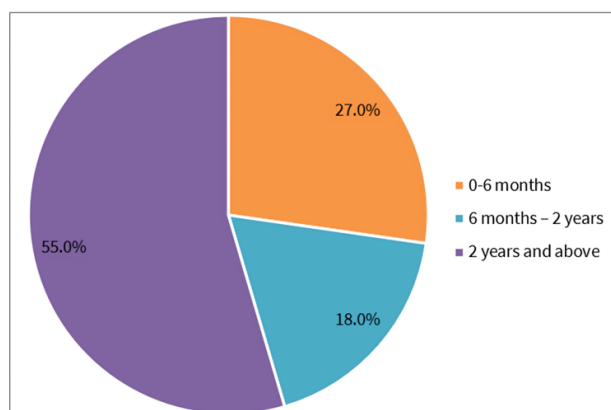
Author's/year	Reoperation	HS
Aaen et al. (2021) [20]	No significant difference	7.0 days
Behman et al. (2020) [21]	11.7% delayed surgery	7.0 days
Beukel et al. (2023) [22]	1.4% vs. 5.7% reoperation	4.0 days
Fan et al. (2024) [23]	-	-
Gu et al. (2021) [24]	Lower operative rate	5.0 days
Håkanson et al. (2020) [25]	2.4% conversion to open	4.0 days
Iwata et al. (2024) [26]	-	-
Li et al. (2023) [27]	-	9.0 days
Maemoto et al. (2021) [28]	67.0% stoma closure, all required revision	5.0 days
Medvecz et al. (2020) [29]	11.7% delayed surgery	9.0 days
Nakamura et al. (2021) [30]	-	7.2 days
Patwardhan et al. (2024) [31]	4.9% LAP vs. 17.1% OPEN reoperation	23.0 days
Qi et al. (2022) [32]	7.0% postoperative ileus	10.0 days
Sakari et al. (2020) [33]	10.0% reoperation	11.0 days
Scott et al. (2021) [34]	-	-
Toneman et al. (2023) [35]	14.5% reoperation	7.0 days
Toriumi et al. (2023) [36]	14.1% (TC) vs. 34.3% (NIT) reoperation	7.0 days
Wang et al. (2024a) [37]	-	17.0 days
Wang et al. (2024b) [38]	-	-
Watanabe et al. (2022) [39]	No significant difference	-
Yamada et al. (2022) [40]	No significant difference	7.0 days
Yu et al. (2023) [41]	-	13.0 days
Yukawa et al. (2024) [42]	20.0% reoperation	6.0 days
Zahn et al. (2022) [43]	92.0% required surgery	6.0 days
Zulqarnain et al. (2024) [44]	20.7% reoperation for SBO	8.0 days

Note. HS: Hospital stay

Additionally, 27 percent of the studies had follow-up durations between 0 and 6 months, while 18 percent followed patients for periods ranging from 6 months to 2 years.

To facilitate interpretation, **Figure 4** presents the meta-analysis outcomes by intervention type. An OR < 1 indicates a reduction in the risk of ASBO, while an OR > 1 represents a higher preventive efficacy compared to the control group. Surgical techniques, such as those described in [32], demonstrated strong preventive effects (OR = 12.01; 95% CI: 3.71-38.85), while adhesion barrier interventions showed significant risk reduction [22] (OR = 0.21; 95% CI: 0.07-0.65). Conservative or adjunctive strategies, including optimized postoperative management [24], also showed positive preventive outcomes (OR = 4.58; 95% CI: 3.34-6.28). When all preventive interventions were pooled, the overall OR was 1.91 (95% CI: 1.13-3.24), supporting their collective benefit in reducing postoperative ASBO. Thus, **Figure 4** clearly differentiates preventive effectiveness across intervention types rather than comparing unrelated treatment outcomes.

Figure 5 presents a funnel plot that reveals a generally symmetrical funnel shape, suggesting minimal publication bias in the included studies. Most studies clustered near the central effect size (OR = 1), indicating consistency in preventive effect estimates across diverse study designs. The analysis confirms that both operative and non-operative preventive measures especially adhesion barrier use and minimally invasive techniques contribute to a significant reduction in postoperative ASBO risk.

**Figure 3.** Distribution of follow-up duration among studies (Source: Authors' own elaboration)

DISCUSSION

The current meta-analysis highlights various approaches' effectiveness in preventing acute ASBO during the follow-up period. The range of research is evidenced by the sample size, participant characteristics, and the studies' design. The variation in age, gender, and construction of studies adds value to the applicability of the findings in practice, thus increasing the realization of ASBO prevention in different populations. One study with 79 patients identified that rebound tenderness, procalcitonin levels > 0.5 ng/mL, and reduced bowel wall enhancement on computed tomography (CT) scan were significant risk factors for intestinal ischaemia in ASBO. The study also developed an intestinal ischaemia risk score, with the rate of intestinal ischaemia increasing from 0% to 100% as the number of risk factors increased [45]. A scoping review on enhanced recovery after surgery protocols for the postoperative management of intestinal obstruction emphasizes the need for a multimodal approach, recommending the design of custom, multidisciplinary, tailored care pathways [46]. In another study, patients with small bowel obstruction (SBO) from multiple hospitals were included. This large, multicentre approach enhances the generalizability of the findings, making them relevant to a broad range of healthcare settings, particularly in understanding factors such as surgical timing, complications, malnutrition, acute kidney injury, and underlying causes such as hernia or malignancy, which can vary across different clinical environments [47].

The current meta-analysis highlights important inconsistencies in reoperation frequencies, length of hospital stays, and follow-up times in acute studies regarding postoperative ASBO. The range of reoperation rates was from 0% to 20.7%, and the duration of hospital stays was from 4 days to 23 days, with longer stays associated with more complex surgical procedures. There are also inconsistencies in these numbers, demonstrating the need for uniform evaluation techniques. The International Surgery Journal highlights that postoperative adhesions, reported as the leading cause (40.07%) of acute intestinal obstruction, demand surgical management, most commonly adhesiolysis (43.8%), to address this frequent and serious complication [48]. Different surgical techniques significantly influence ASBO reoperation rates. Laparoscopic adhesiolysis has proven to be safer and more effective than open surgery for treating SBO, showing reduced blood loss, complications, and readmission rates [49].

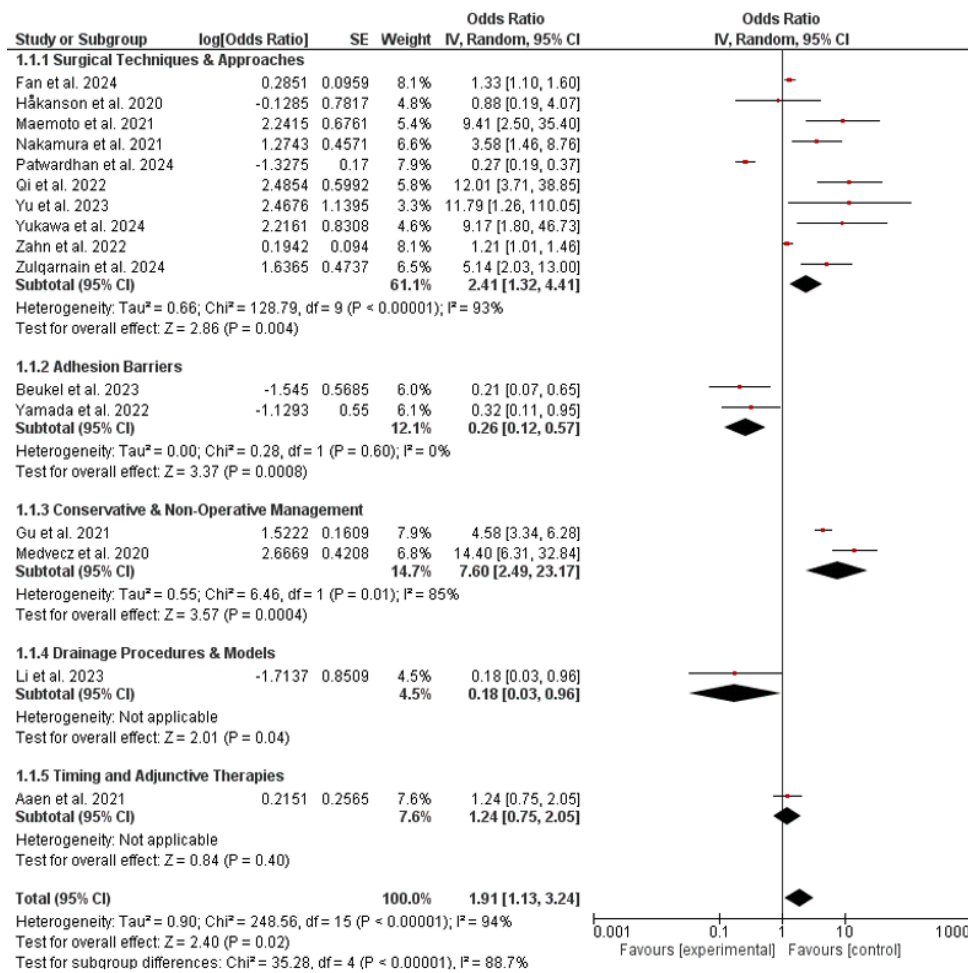


Figure 4. Forest plot showing preventive effectiveness of surgical, barrier, and conservative strategies (Source: Authors' own elaboration)

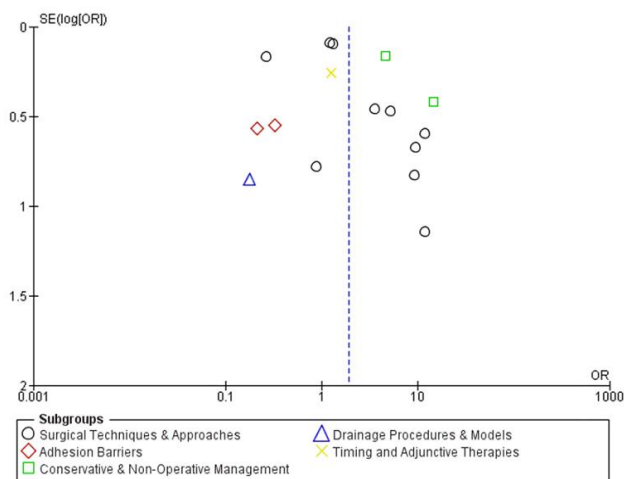


Figure 5. Funnel plot (Source: Authors' own elaboration)

Specifically, fewer SBO-related re-admissions and re-operations were observed in the LA group. Similarly, individualized transfusion strategies in acute MI patients with anemia may reduce the risk of major adverse cardiovascular events [50, 51]. Additionally, non-operative management is supported for adhesive SBO without signs of severe complications, while laparoscopy is gaining acceptance for selected cases [52].

The current meta-analysis underscores that 55% of studies had a follow-up of 2 years or more, focusing on longitudinal outcomes relating to interventions for postoperative ASBO. Also, 27% followed up for 0-6 months, 18% for 6 months to two years, and 35% between two years and four years. Another study shows that it is crucial to perform long-term follow-up as ASBO has the potential to manifest or wax and wane for several years following surgery. The risk of recurrence increases with the number of prior ASBO episodes, with most recurrences occurring within 5 years, but a significant risk remains 10 to 20 years later. Additionally, ASBO patients are more likely to experience abdominal pain, particularly those with mated adhesions, compared to the general population [53].

The current study emphasizes that surgical techniques, particularly advanced methods like laparoscopic surgery and adhesion barriers, significantly reduce the risk of ASBO. While laparoscopic adhesiolysis is an effective surgical treatment for established adhesive obstructions, adhesion barriers such as Sefrapilm® are preventive measures applied during surgery to reduce new adhesion formation. Therefore, they serve different clinical purposes and are not directly comparable alternatives. Recently, transmembrane myostimulation (TMS) [54] has emerged as a potential preventive strategy alongside physical barriers like Sefrapilm®. TMS delivers low-frequency electrical stimulation through the abdominal wall, aiming to improve peritoneal healing and reduce adhesion formation by modulating inflammation and tissue repair processes.

Although still under investigation, TMS offers an innovative approach that may complement or provide alternatives to traditional barrier methods in preventing postoperative adhesions. Adhesion barriers (e.g., Seprafilm® and bioabsorbable barriers) showed strong preventive effects with a notable reduction in ASBO risk. Conservative and non-operative management approaches were also effective, such as Gastrografin and nasointestinal tube treatment. The combined data from all interventions revealed a favorable overall outcome, indicating that surgical and conservative strategies play essential roles in reducing ASBO risk post-surgery. This study advocates the use of strategies that are less invasive and aimed at maximizing outcomes.

Another study assessed 87 patients with acute adhesive intestinal obstruction (AAIO) treated between 2018 and 2021 and found that AAIO incidence has increased by 1.9 times over 20 years, with relapse rates of 20.3-71.0%. To improve outcomes, the study emphasizes reducing surgical trauma through local viscerolysis, careful tissue handling, bypass anastomoses, and barrier agents to prevent adhesion formation [55]. A 2024 systematic review of 17 observational studies (62,886 patients) found Seprafilm® use associated with a 45% lower risk of ASBO (OR 0.449, 95% CI: 0.327-0.612, $p < 0.001$). Efficacy persisted in laparoscopic surgeries, though reintervention rates were unchanged [56]. An experimental study in 60 laparotomy patients found significantly fewer adhesions in the Seprafilm® group (4 of 30) compared to controls (16 of 30), as confirmed by CT imaging ($p = 0.037$), suggesting Seprafilm® effectively reduces postoperative adhesion formation [57]. SBO, primarily caused by adhesions, can often be managed conservatively in up to 70% of cases without strangulation or bowel ischemia [58]. However, emerging evidence suggests that early surgical intervention, particularly laparoscopic adhesiolysis, offers better short-term outcomes, including reduced operative time, blood loss, and complications when preoperative CT scans showed single-band adhesive formations [59]. Proper patient selection is crucial, and early surgical management during the first episode of adhesive SBO results in improved long-term outcomes and lower recurrence rates [60].

Another study examines late AIO in two children following organ transplantation. Both children underwent successful surgical treatment using local adhesiolysis combined with sodium hyaluronate (SH), which restored gastrointestinal function and alleviated adhesions. The careful consideration of altered abdominal anatomy and the use of SH proved effective in preventing recurrence. Five years of follow-up demonstrated the procedure's success in maintaining intestinal function and preventing adhesions [61].

In addition to recent therapeutic advancements, natural antimicrobial agents such as *ferula asafoetida* L. have demonstrated significant potential in clinical applications. The CO₂ extract of *ferula asafoetida* L. exhibits notable antimicrobial activity against both gram-positive and gram-negative bacteria, as well as fungi. The integration of such natural agents may complement existing pharmaceutical interventions, potentially reduce the economic burden and improve patient outcomes [62, 63]. In a 2023 study, pediatric AIO relapses were found to decrease threefold to a 1.4% relapse rate in the treatment group as opposed to 6.3% in the control group. This was achieved through sentinel loop mobilization, which demonstrated fewer relapses while maintaining surgical wound integrity, thereby minimizing

postoperative complications and promoting enhanced recovery [64].

Postoperative AIO remains a significant complication after surgery. The use of hyaluronate carboxymethylcellulose has shown to reduce recurrence rates but may not be cost-effective due to minimal long-term benefits in preventing AIO [65]. Current strategies, such as physical barriers and pharmacological agents, are being explored to improve prevention. Research explores drug-free and drug-loaded membranes, including micro/nano delivery systems, but clinical-ready solutions remain elusive [66-68]. Among these, polysaccharide-based hydrogels have gained attention for their potential to prevent AIO, aiding wound healing and reducing inflammation [69-71]. In pediatric cases, emergency procedures and specific clinical signs predict surgical need; surgery shows lower recurrence than conservative care [72]. Anti-adhesive gels used intraoperatively in children reduce AIO recurrence and improve recovery outcomes, proving safe and effective [73].

Postoperative ASBO remains a significant complication after surgery. The use of hyaluronic acid solution (HAS) has also been shown to reduce both the incidence and recurrence of adhesion syndrome. Another systematic review assessed Seprafilm® (composed of chemically modified SH and carboxymethylcellulose, forming a translucent membrane) effectiveness in preventing ASBO after abdominal and colorectal surgeries. It found that Seprafilm® significantly reduced ASBO events, particularly in laparoscopic cases, but did not reduce reintervention rates. The safety profile showed rare but notable inflammatory reactions, suggesting selective use in patients [56]. HAS significantly reduced recurrence of AIO in children. In a 4-year follow-up, only 7.14% of HAS-treated patients had recurrence versus 35.71% in the untreated group. HAS proved effective and safe, marking progress toward preventing pediatric postoperative adhesions [63, 74]. The application of these solutions offers a highly effective strategy in pediatric surgeries to prevent postoperative adhesion formation, enhancing the overall quality of postoperative patient care and lowering the recurrence rates of the condition

Strengths/Limitations

The strengths of this meta-analysis include numerous studies from several countries, different types of interventions, and high sample sizes, all of which were in accordance with PRISMA guidelines for transparency. On the other hand, there are gaps regarding publication bias, variation in the frameworks of studies, and a lack of information on certain variables.

Clinical Implications

This meta-analysis highlights major clinical implications. Adhesion barriers effectively decrease the risk of ASBO, particularly in high-risk surgeries like gastrectomy and colectomy. Moreover, laparoscopic surgery is associated with fewer complications and faster recovery. Bioengineering technologies, particularly bioabsorbable barriers, need to be applied. Besides, artificial intelligence (AI) can improve planning, enhance AI treatment with the ability to foresee ASBO risk and suggest appropriate measures, and improve surgical methods and postoperative care for more beneficial long-term results.

Future Research

To provide further evidence on the effectiveness of adhesion barriers and surgical techniques in ASBO prevention, future studies should be directed towards performing long-term multicenter RCTs. Furthermore, AI can improve ASBO outcomes through a personalized surgical approach by customizing treatments for individual patients, adjusting predictive models for ASBO, and fine-tuning surgical and postoperative care plans.

CONCLUSIONS

This meta-analysis accurately achieved its aim of assessing the effectiveness of different approaches in preventing acute ASBO in the postoperative period. It strongly favors the use of surgical methods, especially laparoscopic surgeries and the use of adhesion barriers, as effective ways to mitigate the chances of ASBO. These methods clearly enhance, aside from reducing the risk of complications, the recovery speed and long-term outcomes for the patients. The review highlights the significance of adhesion barriers, such as Seprafilm® and bioabsorbable barriers, in mitigating the adhesion restriction, which aids the development of ASBO. Also, laparoscopic surgery continues to prove its advantages over traditional open surgery because it has lower complication rates and is less invasive.

Alongside the suggested surgical interventions, the meta-analysis acknowledges the effectiveness of conservative strategies of managing ASBO, such as the use of Gastrografin and nasointestinal tubes, which have the potential to mitigate the risk of ASBO, particularly in patients with milder forms of obstruction. These methods provide an alternative to surgical procedures that are non-invasive and inexpensive in some instances. There is evidence supporting the need to use both surgical and conservative approaches, which work simultaneously for effective ASBO preventative measures.

The meta-analysis is also an important contribution to the literature because it provides rigorous, quantitative evidence that such preventive measures result in better outcomes for patients, such as decreased ASBO incidence, shorter length of hospital stay, and fewer reoperations. This is critical for changing and improving clinical practices and developing robust guidelines for postoperative care. It is also important to highlight the need for active longitudinal monitoring of the recurrence of ASBO to gauge the impact of various measures over time. Clinically, it is suggested that providers focus on the application of adhesion barriers for ASBO during and after high-risk surgeries and the use of laparoscopic techniques to lower the rates of ASBO. Moreover, applying AI in the planning of surgery and the care given after the surgery has the potential to improve outcomes by predicting complication risks and tailoring treatment plans to patients' specific characteristics and preoperative information. Future studies should concentrate on postoperative longitudinal studies evaluating the ASBO prevention strategies in regard to their cost-effectiveness, novel bioengineering approaches, and drug-eluting adhesion barriers. Furthermore, incorporating AI-driven personalized care models could be pivotal in optimizing ASBO prevention and improving postoperative management.

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