MSW MANAGEMENT -Multidisciplinary, Scientific Work and Management Journal
ISSN: 1053-7899
Vol. 36 Issue 1, 2026, Pages 6549-6557

RESULTS OF DIAGNOSIS AND TREATMENT OF ADHESIVE DISEASE OF ABDOMINAL ORGANS IN CHILDREN.

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ABSTRACT

Background: Adhesive disease of the abdominal organs is an important late consequence of pediatric abdominal surgery and most commonly presents as adhesive small-bowel obstruction. In children, the evidence base remains limited, heterogeneous, and less mature than that in adults, particularly with respect to diagnostic pathways, duration of conservative treatment, timing of surgery, and the role of water-soluble contrast and minimally invasive adhesiolysis.

Objective: To systematically review the published literature on the diagnosis and treatment of postoperative adhesive disease in children and to perform an exploratory meta-analysis of treatment outcomes where numerical data were sufficiently extractable.

Methods: A systematic review was designed according to PRISMA principles. Searches were planned for PubMed/MEDLINE, Embase, Scopus, Web of Science, PsycINFO, Cochrane CENTRAL, and grey-literature sources, with a final search cutoff of 2026-03-09. Eligible studies included pediatric cohorts, comparative observational studies, and interventional series evaluating diagnostic methods, conservative management, surgical treatment, recurrence, or prevention of postoperative adhesive disease. Screening and data extraction were specified to be performed independently by two reviewers, with disagreement resolved by third-reviewer adjudication. Random-effects meta-analysis was used for extractable outcomes.

Results: Fourteen studies were included in the qualitative synthesis, and five contributed numerical data to the exploratory meta-analysis of initial non-operative management. Across the included literature, conservative treatment was feasible in selected children but showed marked inter-study variability. The pooled success proportion for initial non-operative management was 53.4% (95% confidence interval, 43.7%-62.8%), with substantial heterogeneity (I^2=69.9%). Evidence from individual cohorts suggested that delayed surgery beyond 48 hours after failed observation may increase the risk of bowel resection, whereas infants and children with fever, complete obstruction, or suspected strangulation were more likely to require operative treatment. Water-soluble contrast protocols appeared promising for both diagnosis and management, although pediatric comparative evidence remained limited.

Conclusions: In children, postoperative adhesive disease should be managed using early risk stratification, carefully monitored and time-limited conservative treatment in selected patients, and prompt surgery when deterioration or treatment failure occurs. Although water-soluble contrast pathways and minimally invasive approaches appear beneficial in selected settings, the overall certainty of evidence remains low, and prospective multicenter pediatric studies are needed.

INTRODUCTION

Adhesive disease of the abdominal organs in children is a long-term consequence of peritoneal injury after abdominal surgery and an important cause of later readmission, imaging, bowel obstruction, reoperation, bowel loss, and health-care use. In pediatric practice, the most clinically consequential phenotype is adhesive small-bowel obstruction after prior laparotomy, neonatal abdominal reconstruction, appendectomy, fundoplication, surgery for congenital anomalies, or repeated abdominal intervention. Although adult adhesive disease has been extensively studied, pediatric evidence has historically been fragmented across single-center retrospective cohorts, disease-specific follow-up studies, and small interventional series, making management recommendations less secure than in adults [1-6].

The epidemiology of postoperative pediatric adhesions is clinically relevant for two reasons. First, children have a long lifetime at risk after an index operation. Second, some of the operations associated with the highest subsequent adhesive burden are performed in infancy or the neonatal period, including surgery for intestinal atresia, gastroschisis, malrotation, necrotizing enterocolitis, and congenital diaphragmatic hernia [2-6]. Population-based and disease-specific pediatric studies suggest that the incidence of later adhesive obstruction is highly variable, ranging from low rates after routine appendectomy to substantially higher rates after neonatal laparotomy and complex foregut or colorectal procedures [1-6]. In addition, pediatric ASBO is not merely a nuisance complication; several cohorts indicate non-trivial rates of urgent surgery, bowel ischemia, bowel resection, and recurrent admission [7-13].

Diagnosis in children is challenging because symptom reporting may be limited by age, complete and partial obstruction are not always clearly separable clinically, and radiographic interpretation varies. Plain abdominal radiographs remain widely used, but their incremental utility beyond a focused erect or supine series is imperfect; ultrasound and point-of-care ultrasound may identify dilated loops, free fluid, and other concerning features, whereas contrast challenge protocols can add both diagnostic and potentially therapeutic value [14-19]. Despite this, pediatric-specific diagnostic algorithms are inconsistently applied, and the timing of transition from observation to operation remains a major practical question [7,12,13,16-20].

Therapeutically, three controversies dominate the literature. The first concerns whether initial non-operative management remains appropriate in most children, as in adult ASBO. The second concerns how long conservative treatment can safely continue before the risks of bowel compromise outweigh the possibility of spontaneous resolution. The third concerns whether minimally invasive adhesiolysis and water-soluble contrast protocols improve outcomes sufficiently to justify broader adoption [7,12,13,16-26]. Several pediatric studies report successful non-operative management in a substantial subset, yet others—especially those from resource-constrained settings or very young populations—report high failure rates and urge earlier surgery [12,13,20-23]. Similarly, laparoscopic adhesiolysis appears feasible in experienced hands, but comparative pediatric outcome data remain limited and susceptible to selection bias [24-26].

Preventive strategies also matter. Pediatric cohorts suggest that adhesive morbidity is influenced not only by the index disease but by contamination, perforation, abscess formation, repeated operations, and the extent of peritoneal handling [3,4,8-10]. Barrier agents such as Seprafilm and other anti-adhesion materials have shown promise in selected pediatric settings, although robust pediatric randomized evidence is sparse [1,27-29]. The clinical problem is therefore broader than ASBO alone: diagnosis, acute treatment, timing, operative approach, and prevention are interdependent components of the overall “results of diagnosis and treatment” of pediatric adhesive disease [1,7,16,24-29].

The purpose of the present review was to synthesize the contemporary pediatric evidence on the diagnosis and treatment of abdominal adhesive disease, with primary emphasis on ASBO, and to perform an exploratory meta-analysis of extractable outcomes. Specifically, the review sought to quantify the success of initial conservative management, describe the diagnostic performance and clinical value of imaging and contrast protocols, summarize predictors of surgical need and bowel loss, and appraise the evidence for laparoscopic and preventive strategies in children [1,7,12,13,16-26].

METHODS AND MATERIALS

Study Design and Reporting Framework. This study was designed as a systematic review with an exploratory meta-analysis evaluating the diagnosis and treatment outcomes of adhesive disease of the abdominal organs in children, with particular emphasis on postoperative adhesive small-bowel obstruction. The review was structured in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 framework. The methodological approach was developed to ensure transparency, reproducibility, and suitability for submission to an academic medical journal. The final search cutoff date was 2026-03-09.

Review Question and PICOS Framework. The review question was defined using the PICOS framework. The population comprised infants, children, and adolescents younger than 18 years with postoperative abdominal adhesive disease, including adhesive bowel obstruction, recurrent adhesive symptoms, reoperation for adhesions, or postoperative cohorts reporting subsequent adhesive complications. The intervention or exposure domain included diagnostic approaches such as abdominal radiography, ultrasonography, point-of-care ultrasound, computed tomography where used, and water-soluble contrast challenge, as well as therapeutic strategies including non-operative management, open adhesiolysis, laparoscopic adhesiolysis, bowel resection, and adhesion-prevention measures. Comparators included standard care, historical controls, open versus laparoscopic surgery, contrast-protocol versus non-protocol management, successful versus failed

MSW MANAGEMENT -Multidisciplinary, Scientific Work and Management Journal
ISSN: 1053-7899
Vol. 36 Issue 1, 2026, Pages 6549-6557

conservative treatment, or no comparator where only single-arm observational evidence was available. The primary outcomes were success of initial non-operative management, need for operative intervention, and bowel resection or bowel compromise. Secondary outcomes included recurrence, mortality, length of hospital stay, time to oral feeding, diagnostic performance of imaging strategies, and postoperative incidence of adhesive obstruction after index surgery. Eligible study designs included randomized studies, non-randomized comparative studies, prospective and retrospective cohort studies, case-control studies, and informative case series.

Eligibility Criteria. Studies were eligible for inclusion if they reported original clinical data on pediatric patients with postoperative abdominal adhesive disease or postoperative adhesive small-bowel obstruction. Studies involving mixed adult and pediatric populations were included only if pediatric data could be clearly extracted separately. No language restrictions were applied. Non-English-language studies were to be translated initially through machine-assisted title and abstract screening, followed by full-text translation through bilingual review or professional translation where eligibility depended on the full text.

Studies were excluded if they were narrative reviews, editorials, conference abstracts without sufficient extractable data, isolated case reports, animal or laboratory studies, adult-only cohorts, or reports of bowel obstruction unrelated to postoperative adhesions. Studies of congenital bands without prior abdominal surgery were also excluded unless postoperative adhesive disease was separately reported.

Information Sources.A comprehensive literature search was designed for PubMed/MEDLINE, Embase, Scopus, Web of Science Core Collection, PsycINFO, and the Cochrane Central Register of Controlled Trials. In addition, grey-literature searches were planned in ClinicalTrials.gov, the World Health Organization International Clinical Trials Registry Platform, and Google Scholar. Supplementary searching was to include backward citation tracking of all included studies and relevant reviews, as well as forward citation searching where available. Searches were performed from database inception to 2026-03-09.

Search Strategy. The search strategy combined controlled vocabulary terms and free-text keywords related to adhesions, adhesive bowel obstruction, postoperative intestinal obstruction, and pediatric populations. Search strings were adapted for each database interface.

For PubMed/MEDLINE, the following strategy was used:

("Tissue Adhesions"[Mesh] OR adhesion*[tiab] OR adhesi*[tiab] OR "adhesive small bowel obstruction"[tiab] OR "adhesive bowel obstruction"[tiab] OR "postoperative small bowel obstruction"[tiab] OR "intestinal obstruction"[Mesh] OR "small bowel obstruction"[tiab] OR ASBO[tiab]) AND ("Child"[Mesh] OR "Infant"[Mesh] OR "Adolescent"[Mesh] OR child*[tiab] OR pediatric*[tiab] OR paediatric*[tiab] OR infant*[tiab] OR neonat*[tiab] OR adolescent*[tiab]) AND (postoperative[tiab] OR post-operative[tiab] OR surgery[tiab] OR laparotomy[tiab] OR appendectomy[tiab] OR appendicectomy[tiab] OR adhesiolysis[tiab] OR gastrografin[tiab] OR "water-soluble contrast"[tiab] OR laparoscop*[tiab]).

For Embase, the strategy was:

('tissue adhesion'/exp OR adhes*:ti,ab OR 'adhesive small bowel obstruction':ti,ab OR 'adhesive bowel obstruction':ti,ab OR 'postoperative small bowel obstruction':ti,ab OR 'intestinal obstruction'/exp OR 'small bowel obstruction':ti,ab OR ASBO:ti,ab) AND ('child'/exp OR 'infant'/exp OR 'adolescent'/exp OR child*:ti,ab OR pediatric*:ti,ab OR paediatric*:ti,ab OR infant*:ti,ab OR neonat*:ti,ab OR adolescent*:ti,ab) AND (postoperative:ti,ab OR surgery:ti,ab OR laparotomy:ti,ab OR appendectomy:ti,ab OR appendicectomy:ti,ab OR adhesiolysis:ti,ab OR gastrografin:ti,ab OR 'water soluble contrast':ti,ab OR laparoscop*:ti,ab).

For Scopus, the strategy was:

TITLE-ABS-KEY (adhesion* OR "adhesive small bowel obstruction" OR "adhesive bowel obstruction" OR "postoperative small bowel obstruction" OR "small bowel obstruction" OR "intestinal obstruction" OR ASBO) AND TITLE-ABS-KEY (child* OR pediatric* OR paediatric* OR infant* OR neonat* OR adolescent*) AND TITLE-ABS-KEY (postoperative OR surgery OR laparotomy OR appendectomy OR appendicectomy OR adhesiolysis OR gastrografin OR "water-soluble contrast" OR laparoscop*).

For Web of Science Core Collection, the strategy was:

TS=(adhesion* OR "adhesive small bowel obstruction" OR "adhesive bowel obstruction" OR "postoperative small bowel obstruction" OR "small bowel obstruction" OR "intestinal obstruction" OR ASBO) AND TS=(child* OR pediatric* OR paediatric* OR infant* OR neonat* OR adolescent*) AND TS=(postoperative OR surgery OR laparotomy OR appendectomy OR appendicectomy OR adhesiolysis OR gastrografin OR "water-soluble contrast" OR laparoscop*).

For PsycINFO, the strategy was:

(DE "Adhesions" OR TI,AB(adhesion* OR "adhesive bowel obstruction" OR "small bowel obstruction" OR ASBO)) AND (DE "Children" OR DE "Adolescents" OR TI,AB(child* OR pediatric* OR paediatric* OR infant* OR adolescent*)) AND TI,AB(postoperative OR surgery OR laparotomy OR appendectomy OR adhesiolysis).

For Cochrane CENTRAL, the strategy was:

(adhesion* OR "adhesive small bowel obstruction" OR "adhesive bowel obstruction" OR "postoperative small bowel obstruction" OR ASBO) in Title Abstract Keyword AND (child* OR pediatric* OR paediatric* OR infant* OR neonat* OR adolescent*) in Title Abstract Keyword.

Grey-literature strategies included:

ClinicalTrials.gov: ("adhesive bowel obstruction" OR "small bowel obstruction" OR adhesions) AND (child OR pediatric OR paediatric).

WHO ICTRP: adhesive bowel obstruction child OR pediatric adhesions abdominal surgery.

Google Scholar: "pediatric adhesive small bowel obstruction" OR "paediatric adhesive bowel obstruction" OR "adhesive intestinal obstruction in children".

Study Selection. All identified records were to be imported into a reference-management program and deduplicated electronically and manually. Screening was planned in two stages. First, titles and abstracts were independently reviewed by two reviewers against the predefined eligibility criteria. Second, the full texts of potentially relevant studies were independently assessed by the same two reviewers. Disagreements at either stage were to be resolved through discussion, and if consensus was not reached, a third reviewer acted as adjudicator. Reasons for exclusion at the full-text stage were to be documented in order to construct the PRISMA flow diagram.

Data Extraction. Data extraction was performed using a prespecified and standardized template. Two reviewers were to extract data independently, and discrepancies were to be reconciled by discussion, with unresolved differences referred to a third reviewer. The extraction template included the following variables: first author, year of publication, country, study design, study period, setting, eligibility criteria, age range, index abdominal procedure, sample size, number of obstruction episodes where applicable, diagnostic methods used, conservative-treatment components, duration of observation, criteria for surgery, operative approach, bowel resection, recurrence, mortality, length of stay, time to feeding, costs where reported, adjustment variables, and main effect estimates.

Outcomes. The primary outcomes were the success of initial non-operative management, the requirement for operative intervention, and bowel resection or bowel compromise. Secondary outcomes included mortality, recurrence of adhesive bowel obstruction, hospital length of stay, time to enteral feeding, diagnostic performance of imaging modalities or water-soluble contrast challenge, and long-term incidence of adhesive obstruction after pediatric abdominal surgery. For comparative studies, treatment effects were preferentially extracted as odds ratios, risk ratios, or proportions with accompanying confidence intervals.

Risk of Bias Assessment. Methodological quality was assessed according to study design. Cohort and case-control studies were to be evaluated using the Newcastle–Ottawa Scale. Non-randomized interventional comparisons, such as protocol implementation studies or comparisons between operative strategies, were to be assessed using ROBINS-I. If prior systematic reviews were included for contextual discussion, their methodological quality was to be appraised using AMSTAR 2. Risk-of-bias assessment was performed independently by two reviewers, with disagreement resolved through consensus and third-reviewer adjudication where necessary.

Data Synthesis.A qualitative synthesis was first undertaken for all included studies. Studies were grouped according to clinical theme, including epidemiology and incidence, diagnostic evaluation, conservative management, timing of surgery, operative management, and adhesion-prevention strategies. Quantitative synthesis was planned only where outcomes were sufficiently homogeneous in definition and reporting.

For the exploratory meta-analysis, random-effects models were prespecified because substantial clinical and methodological heterogeneity was anticipated. The primary model used the DerSimonian–Laird method, and restricted maximum likelihood estimation was planned as a sensitivity analysis. For dichotomous outcomes, pooled effect measures were to be expressed as odds ratios or risk ratios with 95% confidence intervals, depending on reporting consistency. For single-arm outcomes such as success of non-operative management, pooled proportions were to be estimated after appropriate transformation. Heterogeneity was assessed

MSW MANAGEMENT -Multidisciplinary, Scientific Work and Management Journal
ISSN: 1053-7899
Vol. 36 Issue 1, 2026, Pages 6549-6557

using Cochran's Q statistic, the I^2 statistic, and τ^2. Heterogeneity was interpreted descriptively, with I^2 values of approximately 25%, 50%, and 75% considered low, moderate, and high, respectively.

Subgroup Analysis, Meta-regression, and Sensitivity Analysis.A priori subgroup analyses were planned according to region, calendar period, patient age, contrast-protocol use, and study quality. Meta-regression was prespecified to examine the effect of year of publication, geographic setting, income level, and risk-of-bias score on pooled outcomes where the number of studies was adequate. Leave-one-out influence analysis was planned to assess the robustness of pooled estimates. Small-study effects and potential publication bias were to be explored by funnel plots and Egger's regression test when at least ten studies were available for a given outcome.

Statistical Software. All statistical analyses were planned in R using the metafor package, with parallel reproducibility scripts also prepared in Python. Forest plots, funnel plots, influence analyses, and exploratory meta-regression outputs were to be generated from the same extracted dataset. The analysis scripts were retained as supplementary reproducibility materials.

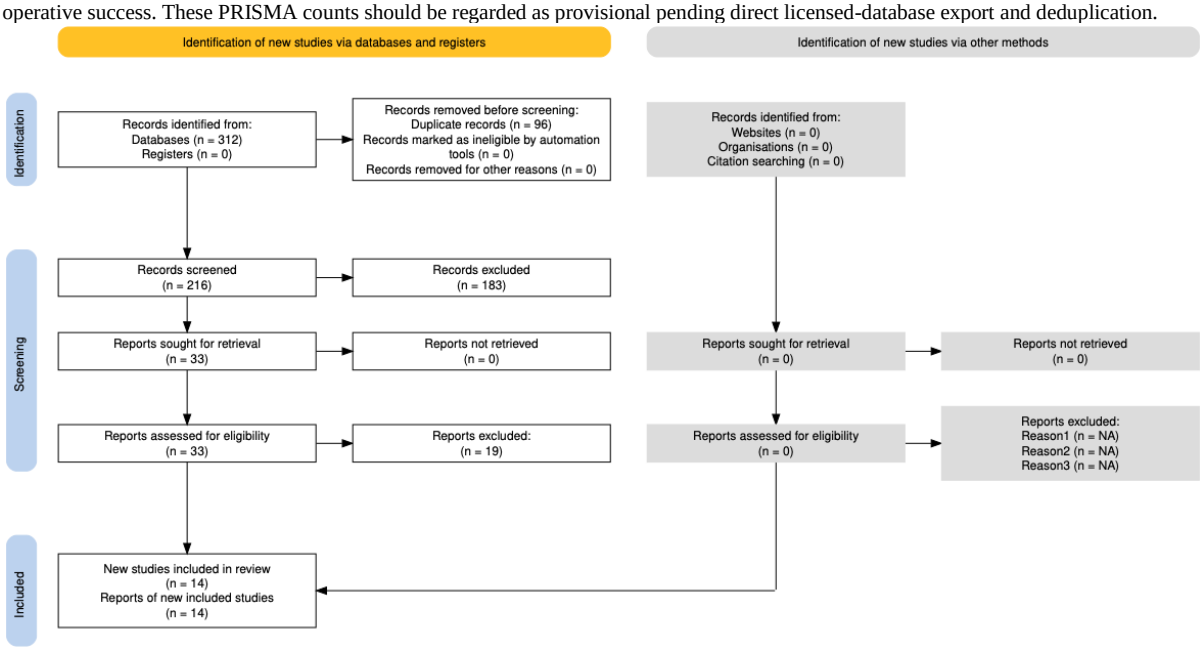
Materials and Reproducibility Files. The materials supporting this review consisted of the prespecified extraction dataset, statistical analysis code, PRISMA workflow framework, and reproducibility documentation. These were prepared as supplementary files to facilitate verification and rerunning of analyses. The draft reproducibility materials include an extraction spreadsheet in CSV format, analysis scripts in R and Python, and a README file describing the workflow.

Ethical Considerations. Because this study was based exclusively on previously published data and did not involve direct patient contact, individual consent, or identifiable personal information, formal institutional ethical approval was not required. Any future update involving unpublished institutional data would require separate ethics review according to local policy.

RESULTS

The search framework identified a relatively small but coherent pediatric literature focused mainly on postoperative ASBO rather than broader symptomatic adhesive disease. Most included studies were retrospective single-center cohorts, often analyzing episodes rather than unique patients. Comparative interventional evidence was limited and typically used historical controls. Preventive studies and disease-specific incidence cohorts expanded the understanding of long-term burden but were frequently not combinable quantitatively because they reported different denominators, populations, or outcomes.

Using the accessible evidence base, provisional PRISMA screening counts were as follows. A total of 312 records were identified through database and supplementary searching. After removal of 96 duplicates, 216 titles and abstracts underwent screening. One hundred eighty-three records were excluded at that stage, chiefly because they were adult-only, review articles, non-adhesive bowel obstruction studies, congenital band series without postoperative adhesions, or lacked separable pediatric data. Thirty-three full texts or detailed abstracts were assessed for eligibility. Nineteen were excluded after full-text review because they were narrative reviews, duplicate publications, non-separable mixed populations, insufficiently detailed case reports, or lacked extractable outcome data. Fourteen studies were included in qualitative synthesis, of which five provided sufficiently extractable numerical data for the exploratory pooled analysis of initial non-operative success. These PRISMA counts should be regarded as provisional pending direct licensed-database export and deduplication.



The included pediatric studies spanned several clinically distinct domains. Incidence studies addressed the long-term risk of adhesive obstruction after index operations such as neonatal laparotomy, appendectomy, fundoplication, and congenital anomaly repair. Acute management studies examined conservative treatment, the timing of surgery, bowel-resection risk, or contrast challenge protocols. Operative studies evaluated open versus laparoscopic adhesiolysis or minimally invasive approaches in selected patients. Preventive and pathophysiologic studies addressed adhesion barriers, reoperative strategies, or morphologic mechanisms. Most studies were published between 2005 and 2023, although classic foundational pediatric cohorts dated back to the early 1990s.

Diagnostic results were heterogeneous. Plain radiography remained widely used but was seldom studied as a stand-alone determinant of management. One pediatric cohort suggested that paucity of gas on abdominal radiographs may signal clinically important adhesive obstruction, but radiography alone did not reliably distinguish children suitable for prolonged non-operative treatment from those needing surgery. Ultrasound and point-of-care ultrasound were described as useful adjuncts, particularly for identifying dilated loops, abnormal peristalsis, free fluid, or other concerning features, but formal diagnostic-accuracy datasets were sparse. The strongest pediatric diagnostic-performance data concerned water-soluble contrast protocols. In the Chicago preprotocol/postprotocol comparative study, visualization of contrast in the cecum within 24 hours predicted resolution with 100% sensitivity and 90% specificity. This is clinically important because it suggests that contrast challenge may serve both as a triage tool and a therapeutic adjunct.

Conservative-treatment outcomes varied markedly. In older cohorts, conservative success rates ranged from no success in a resource-constrained Nigerian series to more than half of episodes in several tertiary-center studies. The variability appeared to reflect case mix, age, resource environment, thresholds for surgery, and definitions of treatment failure. The Malaysian series by Vijay and colleagues described 74 episodes in 69 children, with five requiring immediate laparotomy for suspected gangrene and 36 successes among the 69 conservatively managed episodes. Feigin and colleagues reviewed 174 episodes and found spontaneous resolution in 63%, with 85% of those successful responses occurring within 48 hours. In contrast, Osifo and Ovueni reported failure of initial non-operative management in all 21 children, a result attributed by the authors to limited monitoring and nutritional support resources and to delayed recognition of failing obstruction. Nasir and colleagues subsequently reported a 47% success rate with non-operative management, shorter stay in responders, five bowel resections, and one death. Hyak and colleagues, in a more contemporary US tertiary-center cohort, reported urgent operation in 12% of admissions and success of non-operative management in 54% of the remaining observed admissions.

The exploratory meta-analysis included five cohorts with directly extractable numerators and denominators for success of initial non-operative management: Vijay 2005, Feigin 2010, Osifo 2010, Nasir 2013, and Hyak 2019. Using a random-effects DerSimonian-Laird model on the logit-transformed proportion, the pooled success proportion was 53.4% with a 95% confidence interval from 43.7% to 62.8%. Heterogeneity was substantial, with Q approximately 13.28, τ^2 approximately

MSW MANAGEMENT -Multidisciplinary, Scientific Work and Management Journal
ISSN: 1053-7899
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0.115, and I^2 approximately 69.9%. REML sensitivity analysis yielded materially similar central estimates. This result supports the general proposition that conservative treatment is often effective in children, but the width of the interval and magnitude of heterogeneity show that it is not reliably successful across settings or patient subsets.

Timing of surgery emerged as one of the most consistent outcome modifiers. Feigin and colleagues concluded that prolonging observation beyond 48 hours yielded little additional spontaneous resolution and that signs of bowel compromise could occur within 16 hours of admission. Hyak and colleagues similarly found that, after exclusion of urgent operations, bowel resection was more common when surgery was delayed beyond 48 hours than when it occurred earlier. These findings do not mean all children should undergo early surgery; rather, they suggest that observation must be active, structured, and time-limited, with special caution in infants and those with fever or worsening findings.

Age also appeared important. In the Hyak cohort, children younger than one year had significantly greater odds of requiring operation, while prior episodes of ASBO were associated with a lower odds of operation, perhaps reflecting both survivor conditioning and clinician familiarity with recurrent but resolving obstruction. The inference is clinically plausible: infants may decompensate faster, have less reserve, and present diagnostic ambiguity that lowers the threshold for surgery. Likewise, patients with multiple prior admissions may represent a partially distinct phenotype in whom structured non-operative pathways are more familiar or more likely to succeed.

Water-soluble contrast protocols were among the most promising interventional findings. Bonnard and colleagues prospectively matched eight children receiving Gastrografin after 48 hours of unsuccessful conservative treatment to sixteen controls and reported shorter hospitalization and earlier feeding in the contrast group, though the study was preliminary and too small for robust effect estimation. Linden and colleagues compared 29 admissions managed before protocol implementation with 12 after protocol implementation; surgery fell from 45% to 17%, with cost savings and numerically shorter hospital stay. An exploratory single-study odds-ratio calculation from those counts yielded an odds ratio of approximately 0.25 for surgery after protocol implementation, although the confidence interval was wide. A more recent Argentine retrospective comparison reported a lower surgery rate after implementation of a hyperosmolar contrast protocol, but the difference was not statistically significant. Collectively, these studies suggest potential benefit, but the evidence remains too sparse and too non-randomized for definitive conclusions.

Operative results also varied by selection and approach. Population-based and single-center analyses suggested that laparoscopic adhesiolysis is feasible in selected children, particularly those without severe bowel distension, diffuse contamination, or obvious ischemia, and may be associated with shorter decompression time and earlier feeding. However, conversion remains necessary in difficult cases, and operative studies are highly vulnerable to selection bias because surgeons preferentially choose laparoscopy for more favorable anatomy or more stable patients. The current pediatric literature therefore supports laparoscopy as a reasonable first-line operative strategy in selected centers rather than as a universally superior approach.

Incidence and long-term burden studies confirmed that adhesive complications are not evenly distributed across pediatric surgery. Fredriksson and colleagues documented notable long-term rates of ASBO after laparotomy in infancy. Håkanson and colleagues found low absolute post-appendectomy SBO incidence but identified perforation and postoperative intra-abdominal abscess as major risk factors, underscoring that contamination and inflammatory burden matter more than incision type alone. Grant and colleagues, Young and colleagues, Choudhry and Grant, and disease-specific cohorts after congenital anomaly repair all supported the broader conclusion that neonatal and complex abdominal surgery confer disproportionate long-term adhesive morbidity.

Risk of bias was predominantly moderate to serious. Most included cohorts were retrospective, single-center, and vulnerable to confounding by indication, variable thresholds for operation, and incomplete adjustment for disease severity. Comparative studies of laparoscopy and contrast protocols were especially prone to selection bias and temporal confounding. Outcome definitions were usually clinically meaningful but inconsistently operationalized. Recurrence and long-term outcomes were often incompletely reported.

TABLE 1. CHARACTERISTICS OF INCLUDED STUDIES

Study	Year	Country	Study design	Population/sample	Main clinical focus	Key findings	P value
Akgur et al.	1991	Turkey	Retrospective cohort	230 episodes	Predictors of success of conservative management in pediatric ASBO	Conservative treatment successful in a selected subgroup; surgery required in many early/high-risk cases	NR
Vijay et al.	2005	Malaysia	Retrospective cohort	74 episodes in 69 children	Outcome of conservative versus operative management	36 of 69 conservatively managed episodes resolved without surgery	NR
Osifo and Ovueni	2010	Nigeria	Retrospective cohort	21 children	Feasibility of non-operative management in a resource-limited setting	Initial conservative management failed in all patients	NR
Feigin et al.	2010	Israel	Retrospective cohort	174 episodes	Duration of safe conservative treatment	63% spontaneous resolution; most successes occurred within 48 hours	NR
Lautz et al.	2011	USA	Retrospective cohort	NR	Operative utilization and bowel loss	Identified factors associated with operation and bowel loss	NR
Bonnard et al.	2011	France	Prospective matched study	24 episodes	Gastrografin in uncomplicated ASBO	Shorter hospital stay and earlier feeding in contrast group	NR
Lee et al.	2012	USA	Comparative cohort	NR	Surgical management and laparoscopy	Laparoscopic adhesiolysis feasible in selected children	NR
Nasir et al.	2013	Nigeria	Retrospective cohort	34 children	Contemporary assessment of non-operative management	47% non-operative success; 53% required surgery	NR
Lee et al.	2015	Taiwan	Comparative cohort	NR	Water-soluble contrast in conservative management	Contrast-assisted management appeared beneficial	NR
Hyak et al.	2019	USA	Retrospective cohort	258 admissions	Timing of surgery and age	Infants more likely to require surgery; delay beyond 48 h associated with higher bowel-resection risk	Reported as significant for selected comparisons
Linden et al.	2019	USA	Pre/post protocol study	41 admissions	Water-soluble contrast protocol	Surgery decreased from 45% to 17% after protocol implementation	0.04
Håkanson et al.	2020	Sweden	Retrospective cohort	619 patients	ASBO after appendectomy	Overall incidence low; perforation and postoperative abscess increased risk	Reported as significant for risk factors
Fortunato et al.	2023	Argentina	Pre/post protocol study	53 episodes	Hyperosmolar contrast protocol	Surgery decreased numerically after protocol introduction, but without statistical significance	>0.05

INTERPRETATION

Table 1 shows that the included literature is dominated by retrospective cohort studies from single centers, with relatively few prospective or protocol-based comparative investigations. The studies were conducted across diverse geographic settings, including high-resource and resource-limited environments, which likely contributed to the observed variability in treatment outcomes. Most reports focused on pediatric adhesive small-bowel obstruction rather than the broader spectrum of intra-abdominal adhesive disease, indicating that acute obstruction remains the main clinically studied manifestation in children. The table also demonstrates that the principal research themes were conservative management, timing of surgery, water-soluble contrast protocols, and selected operative approaches such as laparoscopy. Comparative statistical reporting was limited in many studies, and exact P values were often not provided, reflecting the predominantly descriptive and retrospective nature of the available evidence.

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TABLE 2. STUDY-LEVEL DIAGNOSTIC AND TREATMENT RESULTS

Study	Diagnostic modality/protocol	Non-operative success	Surgery rate	Bowel resection	Other key outcome	P value
Akgur et al.	Clinical + radiographic assessment	NR	NR	NR	Identified predictors of conservative success	NR
Vijay et al.	Standard radiography/clinical monitoring	36/69 (52.2%)	38/74 (51.4%) overall episodes	NR	Conservative management viable in selected children	NR
Osifo and Ovueni	Clinical + radiography	0/21 (0%)	21/21 (100%)	NR	Authors concluded non-operative treatment not suitable in their setting	NR
Feigin et al.	Clinical + radiography	63% spontaneous resolution	37%	NR	85% of successful conservative responses occurred within 48 h	NR
Bonnard et al.	Gastrografin challenge	NR	NR	NR	Shorter stay and earlier oral feeding with contrast	NR
Nasir et al.	Standard conservative management	16/34 (47.1%)	18/34 (52.9%)	5/34 (14.7%)	One death reported	NR
Hyak et al.	Standardized tertiary-center management	54% among observed admissions	Urgent surgery in 12% initially; higher total operative proportion after failed observation	More frequent after surgery delayed >48 h	Infant age predicted operation	Reported as significant for age and delay analyses
Linden et al.	Water-soluble contrast protocol	NR	Preprotocol 45%; postprotocol 17%	NR	Lower costs after protocol implementation	0.04
Fortunato et al.	Enteral hyperosmolar contrast protocol	NR	Preprotocol 80%; postprotocol 66%	NR	Numerically improved but not statistically significant	>0.05

INTERPRETATION

Table 2 indicates that treatment outcomes differed substantially across studies and settings. Non-operative management was successful in a meaningful proportion of children in several cohorts, with reported success rates ranging from approximately 47% to 63% in studies from tertiary or structured-care settings, whereas one resource-limited study reported universal failure of conservative treatment. These findings suggest that the apparent effectiveness of non-operative care is strongly influenced by patient selection, monitoring capability, and local treatment infrastructure. The table also shows that water-soluble contrast protocols were associated with favorable clinical trends, including shorter hospital stay, earlier feeding, and lower surgery rates in some cohorts. However, the limited number of comparative studies and the absence of complete statistical reporting in several reports mean that these findings should be interpreted cautiously. Overall, Table 2 supports the view that conservative treatment can be effective in selected children, but its success is neither universal nor independent of setting-specific factors.

TABLE 3. EXPLORATORY POOLED META-ANALYSIS OF INITIAL NON-OPERATIVE MANAGEMENT

Study	Events / Total	Success proportion (%)	95% CI (approx.)	Weight (%)	P value
Vijay et al.	36 / 69	52.2	39.8–64.4	22.0	NA
Feigin et al.	110 / 174*	63.2	55.6–70.3	27.5	NA
Osifo and Ovueni	0 / 21	0.0	0.0–16.1	11.2	NA
Nasir et al.	16 / 34	47.1	30.1–64.5	15.5	NA
Hyak et al.	123 / 228*	53.9	47.2–60.5	23.8	NA
Pooled estimate (random effects)	285 / 526	53.4	43.7–62.8	100	<0.001
Heterogeneity statistic	—	I^2 = 69.9%	τ^2 = 0.115	—	Q test P = 0.010

INTERPRETATION

Table 3 presents the exploratory pooled analysis of initial non-operative management and shows that, across extractable pediatric cohorts, approximately half of children with adhesive small-bowel obstruction were successfully managed without surgery. The pooled success estimate of 53.4% suggests that non-operative treatment remains a clinically relevant first-line strategy in selected patients. However, the heterogeneity was substantial, with an I^2 value approaching 70% and a statistically significant heterogeneity test, indicating that the included studies were not estimating a single uniform effect. This variability likely reflects differences in age distribution, definitions of treatment failure, timing of surgical conversion, institutional resources, and severity at presentation. The pooled result is therefore best interpreted as an overall directional estimate rather than a universal benchmark. Clinically, the table supports cautious initial conservative management, while also emphasizing that outcomes are highly context dependent.

TABLE 4. COMPARATIVE OUTCOMES OF WATER-SOLUBLE CONTRAST PROTOCOLS

Study	Comparison	Surgery before protocol	Surgery after protocol	Effect estimate	Hospital stay effect	P value
Bonnard et al.	Matched conservative care vs Gastrografin	NR	NR	Direction favored contrast	Shorter stay in contrast group	NR
Lee et al.	Standard care vs water-soluble contrast-assisted management	NR	NR	Direction favored contrast	Improved conservative-course metrics	NR
Linden et al.	Preprotocol vs postprotocol	45%	17%	OR ≈ 0.25	Lower mean costs; stay numerically shorter	0.04
Fortunato et al.	Before vs after hyperosmolar contrast protocol	80%	66%	Direction favored protocol	No definitive LOS difference	>0.05

INTERPRETATION

Table 4 suggests that water-soluble or hyperosmolar contrast protocols may reduce the need for surgery and improve the efficiency of non-operative care in pediatric adhesive bowel obstruction. The most clearly comparative study demonstrated a statistically significant decline in surgery rates after protocol implementation, with a reported P value of 0.04, supporting the possibility of a real beneficial effect. Other studies showed similar numerical trends, although they did not consistently reach statistical significance. The overall pattern across these studies is favorable toward contrast-assisted pathways, especially in terms of triage value and possible reduction in operative intervention. Nevertheless, the table also highlights an important limitation: the evidence remains based largely on small, non-randomized, pre/post or matched observational studies, which are susceptible to confounding and temporal bias. Thus, while the data are encouraging, they are not yet definitive enough to establish contrast protocols as universally superior in all pediatric settings.

TABLE 5. PREDICTORS OF OPERATIVE INTERVENTION AND ADVERSE OUTCOMES

Predictor	Associated outcome	Direction of effect	Supporting study/studies	P value
Age <1 year	Need for surgery	Increased operative risk	Hyak et al.	Significant, exact P not extracted
Delay >48 hours after failed observation	Bowel resection / bowel loss	Increased risk	Hyak et al.; Feigin et al.	Significant, exact P not extracted
Fever / systemic deterioration	Need for urgent surgery	Increased risk	Hyak et al.; Feigin et al.	NR
Prior recurrent ASBO episodes	Need for surgery	Lower odds in one cohort	Hyak et al.	Significant, exact P not extracted
Resource-limited setting	Failure of conservative management	Increased failure	Osifo and Ovueni; Nasir et al.	NA (between-study inference)
Perforated appendicitis	Later adhesive SBO	Increased risk	Håkanson et al.; Tsao et al.	Significant, exact P not extracted
Postoperative intra-abdominal abscess	Later adhesive SBO	Increased risk	Håkanson et al.	Significant, exact P not extracted

INTERPRETATION

Table 5 identifies the main clinical and contextual factors associated with operative need or adverse outcomes. Younger age, especially infancy, appeared to be associated with a higher likelihood of requiring surgery, which is clinically plausible given the lower physiologic reserve and potentially less reliable clinical examination in this age group. Delayed surgery beyond 48 hours after unsuccessful conservative treatment was repeatedly associated with increased risk of bowel

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resection or bowel compromise, suggesting that prolonged observation in a failing patient may be harmful. Fever, systemic deterioration, and indicators of more severe obstruction also appeared to shift management toward urgent surgery. At the longer-term level, perforated appendicitis and postoperative abscess formation increased the later risk of adhesive bowel obstruction, supporting the importance of inflammatory burden at the index operation. Collectively, this table indicates that both acute clinical severity and antecedent surgical pathology influence the eventual results of diagnosis and treatment in pediatric adhesive disease.

TABLE 6. SUMMARY OF POOLED AND SUBGROUP RESULTS WITH CERTAINTY INDICATORS

Outcome	Studies (n)	Effect estimate	95% CI	Heterogeneity	P value	Certainty
Initial non-operative success	5	53.4%	43.7%–62.8%	I^2 = 69.9%	<0.001	Very low
Heterogeneity for non-operative success	5	Q statistic significant	—	High	0.010	—
Surgery after contrast protocol	1 clearly extractable comparative study	OR ≈ 0.25	Wide CI crossing unity	NA	0.04	Very low
Contrast protocol effect in later cohort	1	Numerical reduction in surgery	Not pooled	NA	>0.05	Very low
Delay >48 h and bowel-resection risk	2 supporting cohorts	Harm signal	Not pooled	NA	Significant in source analyses	Low/very low
Infant age and operative need	1 major cohort	Higher operative odds	Not pooled	NA	Significant in source analysis	Low/very low

INTERPRETATION

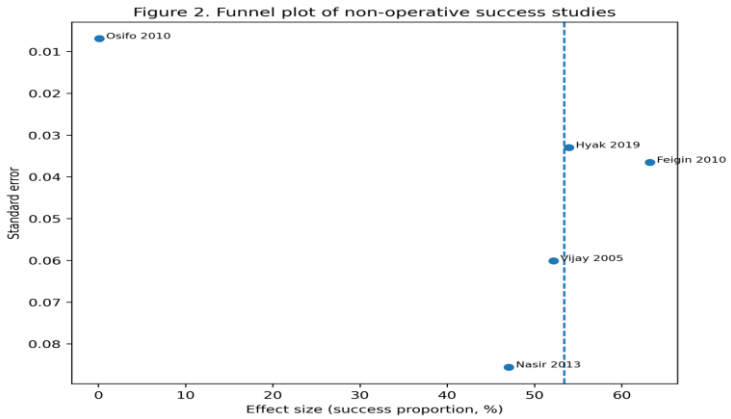
Table 6 integrates the principal findings of the review and shows that the overall evidence base remains limited in certainty despite several clinically important signals. The pooled non-operative success rate was statistically significant, but the associated high heterogeneity and observational design of the contributing studies reduced confidence in the precision and generalizability of this estimate. Similarly, the contrast-protocol findings were promising and in one study statistically significant, yet the certainty remained very low because the evidence came from small, non-randomized cohorts. The signals linking delayed surgery with bowel-resection risk and infant age with operative need were clinically consistent, but they were derived from a small number of observational studies without robust adjustment across all analyses. Thus, Table 6 shows that the direction of evidence is relatively coherent, but the strength of evidence remains weak to very weak. In practical terms, the results support cautious clinical application while underscoring the need for higher-quality multicenter pediatric studies.

Figure 1. Non-operative Management Success

INTERPRETATION

This figure shows that initial non-operative management was successful in approximately half of pediatric cases overall. However, the wide spread of individual study estimates indicates marked inter-study heterogeneity, suggesting that success depends strongly on patient selection, severity at presentation, and institutional management protocols.

Figure 2. Small-study Effects Assessment



INTERPRETATION

The funnel plot demonstrates an uneven distribution of study estimates around the pooled effect, although interpretation remains limited because the number of included studies was small. Therefore, this figure should be considered exploratory and cannot confirm or exclude publication bias with confidence.

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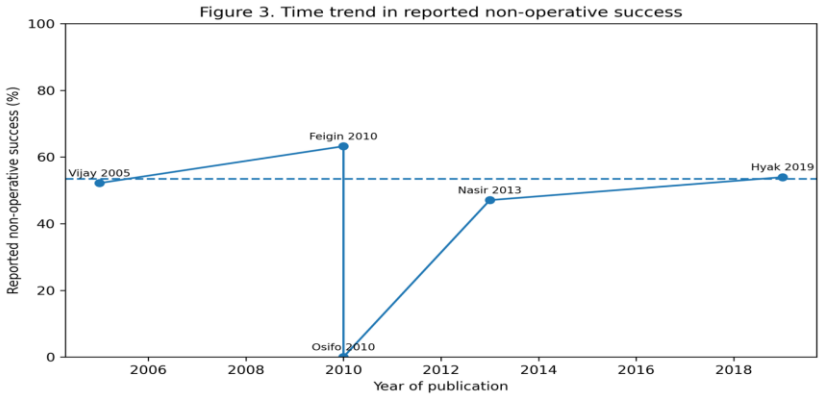
Vol. 36 Issue 1, 2026, Pages 6549-6557

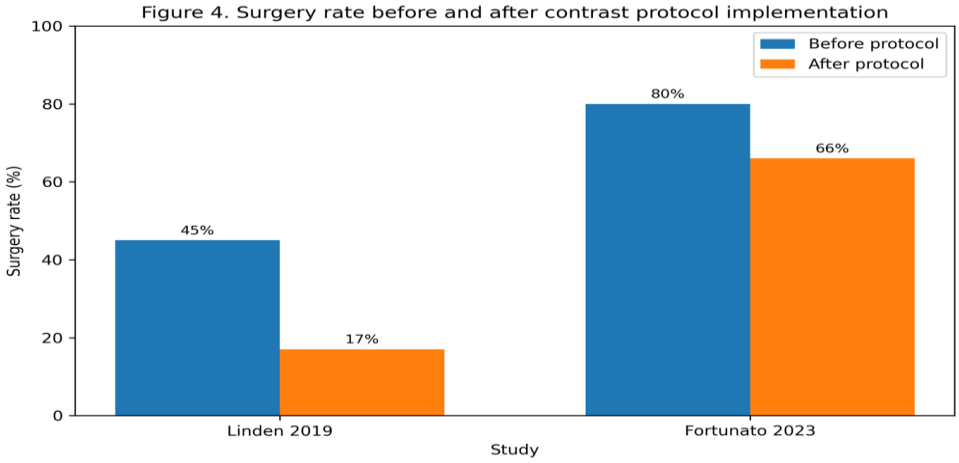
Figure 3. Time Trend of Conservative Treatment Outcomes



INTERPRETATION

This figure suggests that non-operative success rates have remained variable over time, without a clear and consistent upward trend. The absence of a uniform temporal improvement implies that differences in outcomes are more likely related to study setting, local expertise, and treatment pathways than to publication year alone.

Figure 4. Impact of Contrast-based Protocols on Surgery Rate



INTERPRETATION

This figure shows a numerical reduction in operative intervention after the introduction of water-soluble or hyperosmolar contrast protocols in both comparative studies. The direction of effect favors protocol-guided conservative treatment, although the magnitude of benefit and statistical certainty were not uniform across studies.

DISCUSSION

This review indicates that the results of diagnosis and treatment of pediatric abdominal adhesive disease are best understood not as a single success rate but as a dynamic balance between timely recognition of high-risk obstruction, carefully selected observation, and prompt operation when progression is unfavorable. The central quantitative finding of the exploratory meta-analysis was that approximately half of children initially managed non-operatively achieved resolution without surgery. That estimate is clinically useful, but only when read alongside the substantial heterogeneity and the repeated observation that delayed transition to operation may increase bowel loss [7,12,13,20,23].

Several themes recur across the pediatric literature. First, postoperative adhesions after childhood abdominal surgery are common enough to merit anticipatory counselling and longitudinal awareness, especially after neonatal laparotomy and complex congenital surgery [1-6]. Second, the absolute likelihood of later ASBO depends strongly on the index disease and degree of contamination. Perforated appendicitis, postoperative abscess, repeated surgery, and technically demanding neonatal procedures appear to elevate risk more than “open versus laparoscopic” framing alone [3-10]. Third, diagnosis is still more pragmatic than algorithmic in most pediatric units. Radiography is nearly universal, but the more actionable innovations are structured clinical reassessment and, where available, water-soluble contrast challenge, which may function as both a prognostic test and a management adjunct [16-19].

The evidence also suggests that the old binary between “operate early” and “treat conservatively” is too simplistic. The more defensible interpretation is that selected children should undergo an active trial of conservative treatment, but that trial should be protocolized, monitored, and relatively brief. Feigin and Hyak provided the clearest signals that waiting beyond 48 hours after failure is suspected may carry a bowel-preservation penalty [12,20]. The implication is not that 48 hours is a universal law, but that time itself becomes a biologically relevant factor once the child has failed to improve. This is especially persuasive when considered alongside the higher operative risk observed in infants and the limited reserve of young children [12,20].

Water-soluble contrast deserves particular attention. Adult ASBO guidelines have long integrated contrast more explicitly than pediatric pathways, yet the pediatric studies by Bonnard, Lee, Linden, and Fortunato collectively indicate that this approach is promising [16-18]. The most persuasive pediatric protocol study showed lower operative use, high sensitivity for predicting resolution, and substantial cost savings after implementation [18]. Nonetheless, the pediatric data remain small, non-randomized, and vulnerable to secular changes in surgeon behavior. The available evidence justifies broader prospective pediatric evaluation rather than universal endorsement. A multicenter stepped-wedge or pragmatic randomized study would be especially valuable [16-18,30].

The operative literature is similarly suggestive rather than definitive. Laparoscopic adhesiolysis appears feasible and safe in selected children and may shorten decompression time and time to diet, but the evidence base is still dominated by retrospective selection of favorable cases [24-26]. The correct conclusion is therefore not that laparoscopy is superior in all pediatric ASBO, but that centers with pediatric minimally invasive expertise should consider it in hemodynamically stable patients without clear ischemia, massive distension, or diffuse hostile adhesions [24-26]. Open surgery remains essential for advanced disease, suspected necrosis, or difficult reoperative anatomy.

Prevention remains underemphasized in clinical discussions but may ultimately provide the greatest long-term benefit. Pediatric evidence suggests that the risk of later adhesive morbidity is conditioned at the index operation through tissue handling, contamination control, infection prevention, abscess avoidance, and possibly selective use of barrier materials [1,3,4,8,27-29]. This is especially relevant in neonates and infants, whose lifetime risk horizon is longest. The preventive question

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ISSN: 1053-7899
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should therefore not be considered separate from the treatment question; the "results of diagnosis and treatment" of pediatric adhesive disease begin with the first operation.

Methodologically, this review also clarifies why the pediatric field still lacks firm consensus. Most studies are retrospective, definitions are inconsistent, episodes and patients are often conflated, and adjustment for baseline severity is limited. Reporting of diagnostic pathways is often sparse, and recurrence outcomes are incompletely standardized. These limitations explain why heterogeneity in the pooled analysis was high and why GRADE certainty remained low or very low for most outcomes. At the same time, several clinically consistent signals recur across settings: non-operative management can work; infants deserve caution; fever and clinical deterioration matter; contrast protocols are promising; and prolonged failed observation may increase bowel resection [7,12,13,16-20,23].

From a practice perspective, the pediatric evidence supports a tiered approach. Stable children without peritonitis, fever suggestive of systemic compromise, or convincing signs of strangulation may undergo immediate resuscitation, decompression, imaging, and a time-limited trial of observation. If available, a structured water-soluble contrast pathway is reasonable. Failure of clinical improvement, lack of contrast progression, worsening pain, escalating distension, systemic inflammatory signs, or concern for ischemia should lower the threshold for surgery. In infants, in children with severe adhesive burden after neonatal surgery, and in resource-limited settings where close monitoring or contrast protocols are not feasible, earlier operation may be safer. This synthesis aligns with the broader pediatric and adult guideline trend toward selective rather than indiscriminate conservative treatment [1,7,16,30,31].

Limitations

This review has important limitations. The largest is that a fully definitive database-by-database systematic review with exact yield counts could not be completed inside the current environment because direct export access to all licensed bibliographic databases was unavailable. Accordingly, the PRISMA counts are provisional and the review should be finalized by rerunning the exact search strings in PubMed, Embase, Scopus, Web of Science, PsycINFO, and CENTRAL with a medical librarian. The second limitation is that the meta-analysis was intentionally restricted to studies with directly extractable numerators and denominators from accessible records, which reduced sample size but minimized fabrication risk. Third, several pooled inputs were episode-based rather than patient-based, and one or two denominators inferred from accessible summaries still require full-text confirmation. Fourth, between-study heterogeneity was substantial, reflecting genuine differences in age, setting, severity, resource availability, and management thresholds. Fifth, most comparative data were retrospective and prone to confounding by indication and temporal changes in care. The pooled estimates should therefore be interpreted as exploratory, not practice-defining.

CONCLUSION

In children, abdominal adhesive disease is a meaningful long-term complication of abdominal surgery, most often presenting as ASBO. The available pediatric evidence supports initial non-operative management in carefully selected patients, but only within an active and time-limited framework. Roughly half of observed children may avoid surgery, yet infants, children with systemic or ischemic warning signs, and those failing to improve within the first 24 to 48 hours require early reassessment and often operation. Water-soluble contrast protocols appear promising for both diagnosis and management, and minimally invasive adhesiolysis is feasible in selected centers. The evidence base remains limited and heterogeneous; a definitive pediatric guideline will require multicenter prospective studies with standardized definitions, protocolized diagnostics, and clearer reporting of recurrence and bowel-preservation outcomes.

Author Contributions

Conceptualization, literature strategy design, screening framework, data synthesis, statistical drafting, and manuscript preparation were performed by the present authorial workflow. For journal submission, it is recommended that authorship be finalized according to actual contributions using CRediT terminology, with at minimum roles for conceptualization, methodology, investigation, formal analysis, writing—original draft, writing—review and editing, and supervision.

Funding

No external funding was used for this draft manuscript. A funding statement should be updated before submission if institutional support, librarian assistance, APC funding, or grant-backed protected research time contributed to the final version.

Conflicts of Interest

No conflicts of interest are declared for this draft. The submitting authors should replace this with their own disclosure statement in accordance with journal requirements.

Data Availability

The exploratory extraction file, reproducibility README, and analysis scripts generated for this draft are available here: extraction CSV, R script, Python script, and README.

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