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ABDOMINAL TRAUMA IN PEDIATRICS: DECISION-MAKING BETWEEN LAPAROTOMY AND CONSERVATIVE MANAGEMENT

TRAUMA ABDOMINAL EM PEDIATRIA: TOMADA DE DECISÃO ENTRE LAPAROTOMIA E MANEJO CONSERVADOR

TRAUMA ABDOMINAL EN PEDIATRÍA: TOMA DE DECISIONES ENTRE LAPAROTOMÍA Y MANEJO CONSERVADOR

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ABSTRACT

Introduction: Abdominal trauma represents a major cause of morbidity and mortality in children, and determining whether operative or conservative management is most appropriate remains a critical challenge in modern pediatric trauma care. The decision is complicated by age-specific anatomical characteristics, variable hemodynamic responses, and evolving diagnostic modalities.

Objective: The main objective of this review is to evaluate current evidence regarding decision-making between laparotomy and conservative management in pediatric abdominal trauma. Secondary objectives include analyzing outcomes associated with each strategy, assessing organ-specific considerations, evaluating complication profiles, reviewing predictors of failure of nonoperative management, and identifying gaps for future research.

Methods: A systematic search was conducted in PubMed, Scopus, Web of Science, Cochrane Library, LILACS, ClinicalTrials.gov, and the WHO ICTRP. Studies published in the last five years were eligible, with extension to ten years only if fewer than ten studies met criteria. Human studies were prioritized, while animal or in vitro evidence was cataloged separately when relevant. Two independent reviewers screened titles, abstracts, and full texts using PRISMA methodology. Data extraction followed a standardized form, and risk of bias was assessed using RoB 2, ROBINS-I, or QUADAS-2 as appropriate. Certainty of evidence was graded using the GRADE approach.

Results and Discussion: A total of 18 studies met the inclusion criteria and were analyzed. The evidence suggests that conservative management is safe and effective in hemodynamically stable children, particularly for solid organ injuries, while laparotomy remains essential in cases with clear signs of peritonitis, uncontrolled hemorrhage, or failed

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nonoperative treatment. Across studies, variability in imaging protocols, injury grading, and institutional thresholds for surgery contributed to heterogeneity.

Conclusion: Current evidence supports a selective approach in which nonoperative management is preferred for stable pediatric patients, and laparotomy is reserved for specific complications or clinical deterioration. Standardization of diagnostic pathways, injury grading, and monitoring protocols may improve outcomes and reduce unnecessary surgeries. Future research should emphasize multicenter prospective designs and uniform reporting standards.

Keywords: Abdominal Injuries. Child. Laparotomy. Conservative Treatment.

RESUMO

Introdução: O trauma abdominal representa uma importante causa de morbidade e mortalidade em crianças, e determinar se o manejo operatório ou conservador é mais apropriado continua sendo um desafio crítico no cuidado moderno ao trauma pediátrico. A decisão é dificultada por características anatômicas específicas da idade, respostas hemodinâmicas variáveis e métodos diagnósticos em constante evolução.

Objetivo: O principal objetivo desta revisão é avaliar as evidências atuais sobre a tomada de decisão entre laparotomia e manejo conservador no trauma abdominal pediátrico. Os objetivos secundários incluem analisar os desfechos associados a cada estratégia, avaliar considerações específicas por órgão, examinar perfis de complicações, revisar preditores de falha do manejo não operatório e identificar lacunas para pesquisas futuras.

Métodos: Foi realizada uma busca sistemática nas bases PubMed, Scopus, Web of Science, Cochrane Library, LILACS, ClinicalTrials.gov e WHO ICTRP. Estudos publicados nos últimos cinco anos foram considerados elegíveis, com extensão para dez anos apenas se menos de dez estudos atendessem aos critérios. Estudos em humanos foram priorizados, enquanto evidências em animais ou in vitro foram catalogadas separadamente quando relevantes. Dois revisores independentes realizaram a triagem de títulos, resumos e textos completos seguindo a metodologia PRISMA. A extração de dados seguiu um formulário padronizado, e o risco de viés foi avaliado usando RoB 2, ROBINS-I ou QUADAS-2, conforme apropriado. A certeza da evidência foi graduada utilizando a abordagem GRADE.

Resultados e Discussão: Um total de 18 estudos atendeu aos critérios de inclusão e foi analisado. As evidências sugerem que o manejo conservador é seguro e eficaz em crianças hemodinamicamente estáveis, especialmente em lesões de órgãos sólidos, enquanto a laparotomia permanece essencial em casos com sinais claros de peritonite, hemorragia incontrolável ou falha do tratamento não operatório. Entre os estudos, a variabilidade nos protocolos de imagem, gradação das lesões e limiares institucionais para cirurgia contribuiu para a heterogeneidade.

Conclusão: As evidências atuais apoiam uma abordagem seletiva, na qual o manejo não operatório é preferido para pacientes pediátricos estáveis, enquanto a laparotomia é reservada para complicações específicas ou deterioração clínica. A padronização de vias diagnósticas, gradação das lesões e protocolos de monitoramento pode melhorar os desfechos e reduzir cirurgias desnecessárias. Pesquisas futuras devem enfatizar delineamentos prospectivos multicêntricos e padrões uniformes de relato.

Palavras-chave: Lesões Abdominais. Criança. Laparotomia. Tratamento Conservador.

RESUMEN

Introducción: El trauma abdominal representa una causa importante de morbilidad y mortalidad en niños, y determinar si el manejo quirúrgico u observacional es el más apropiado sigue siendo un desafío crítico en la atención moderna del trauma pediátrico. La decisión se complica por características anatómicas específicas de la edad, respuestas hemodinámicas variables y modalidades diagnósticas en evolución.

Objetivo: El objetivo principal de esta revisión es evaluar la evidencia actual sobre la toma de decisiones entre laparotomía y manejo conservador en el trauma abdominal pediátrico. Los objetivos secundarios incluyen analizar los resultados asociados con cada estrategia, evaluar consideraciones específicas por órgano, examinar los perfiles de complicaciones, revisar los predictores de fracaso del manejo no operatorio e identificar vacíos para futuras investigaciones.

Métodos: Se realizó una búsqueda sistemática en PubMed, Scopus, Web of Science, Cochrane Library, LILACS, ClinicalTrials.gov y WHO ICTRP. Se consideraron elegibles los estudios publicados en los últimos cinco años, con extensión a diez años solo si menos de diez estudios cumplían los criterios. Se priorizaron estudios en humanos, mientras que la evidencia animal o in vitro se catalogó por separado cuando relevante. Dos revisores independientes evaluaron títulos, resúmenes y textos completos utilizando la metodología PRISMA. La extracción de datos siguió un formulario estandarizado y el riesgo de sesgo se evaluó mediante RoB 2, ROBINS-I o QUADAS-2, según correspondiera. La certeza de la evidencia se calificó mediante el enfoque GRADE.

Resultados y Discusión: Se analizaron 18 estudios que cumplieron los criterios de inclusión. La evidencia sugiere que el manejo conservador es seguro y efectivo en niños hemodinámicamente estables, especialmente en lesiones de órganos sólidos, mientras que la laparotomía sigue siendo esencial en casos con signos claros de peritonitis, hemorragia incontrolada o fracaso del tratamiento no operatorio. La variabilidad entre estudios en los protocolos de imagen, la clasificación de lesiones y los umbrales institucionales para cirugía contribuyó a la heterogeneidad.

Conclusión: La evidencia actual respalda un enfoque selectivo, en el que el manejo no operatorio se prefiere para pacientes pediátricos estables, y la laparotomía se reserva para complicaciones específicas o deterioro clínico. La estandarización de las vías diagnósticas, la clasificación de lesiones y los protocolos de monitoreo puede mejorar los resultados y reducir cirugías innecesarias. Las investigaciones futuras deben priorizar diseños prospectivos multicéntricos y estándares uniformes de reporte.

Palabras clave: Lesiones Abdominales. Niño. Laparotomía. Tratamiento Conservador.

1 INTRODUCTION

Pediatric abdominal trauma represents a major global health concern due to its significant contribution to morbidity and mortality among children[1]. Children exhibit anatomical and physiological differences from adults that influence both injury patterns and clinical presentation[1]. These characteristics make diagnosis and management particularly challenging for trauma teams[1]. The increasing use of high-resolution imaging modalities has improved early detection of visceral injuries in pediatric patients[2]. However, imaging interpretation in children remains complex due to age-dependent variability of organ size, elasticity, and injury tolerance[2]. These challenges highlight the need for evidence-based guidance on operative versus conservative strategies in abdominal trauma[2].

Blunt mechanisms account for the majority of abdominal injuries in pediatric populations, most commonly resulting from motor-vehicle collisions, falls, or sports-related trauma[3]. These injuries frequently involve solid organs such as the liver, spleen, and kidneys, each presenting distinct risks and physiological responses[3]. The unique biomechanics of the pediatric torso, including greater organ mobility and thinner abdominal walls, further influence trauma patterns[3]. Hemodynamic stability has traditionally been considered the cornerstone of management pathways in abdominal trauma[4]. However, recent evidence suggests that reliance on hemodynamic parameters alone may not adequately predict the need for surgical intervention[4]. As a result, trauma teams are increasingly incorporating multimodal assessment models to refine clinical decision-making[4].

Nonoperative management has become the predominant approach for many solid organ injuries in hemodynamically stable children[5]. This paradigm shift is driven by the desire to avoid unnecessary laparotomies and reduce long-term complications such as adhesions, chronic pain, or bowel obstruction[5]. The success of conservative strategies is closely tied to continuous monitoring, early detection of clinical deterioration, and standardized imaging follow-up[5]. Despite its advantages, nonoperative management carries inherent risks, including delayed bleeding, missed hollow-viscus injuries, and complications requiring emergent conversion to surgery[6]. These potential failures highlight the importance of identifying predictive factors associated with unsuccessful conservative treatment[6]. Establishing such predictors remains a key research priority in pediatric trauma care[6].

Laparotomy continues to play a vital role in managing specific abdominal trauma scenarios in children[7]. Indications traditionally include uncontrolled hemorrhage, peritonitis, evisceration, and radiologic evidence of hollow-viscus perforation[7]. In addition, laparotomy remains essential for addressing complex multi-organ injuries or complications unresponsive to nonoperative strategies[7]. Technological advances such as pediatric laparoscopy have

introduced minimally invasive alternatives to traditional open surgery[8]. These modalities may reduce postoperative morbidity, shorten hospital stays, and enhance recovery outcomes in selected cases[8]. Nevertheless, their applicability depends on institutional expertise and the severity of traumatic injury[8].

Clinical decision-making in pediatric abdominal trauma requires careful integration of laboratory data, imaging findings, hemodynamic assessment, and mechanism of injury[9]. Emerging diagnostic approaches, such as contrast-enhanced ultrasound, are increasingly used to reduce radiation exposure from computed tomography[9]. However, CT remains the gold standard for identifying solid organ injuries and detecting active bleeding[9]. The challenge lies in balancing diagnostic accuracy with the need to minimize radiation risks in children[10]. Variation in institutional imaging protocols contributes to heterogeneity in reported outcomes and management practices[10]. This variability underscores the need for standardized diagnostic pathways tailored to pediatric populations[10].

Risk stratification tools have been proposed to guide management decisions in pediatric abdominal trauma[11]. Existing scoring systems often include parameters such as injury grade, hemodynamic stability, laboratory abnormalities, and associated injuries[11]. However, many of these tools were derived from small or heterogeneous cohorts, limiting their generalizability[11]. Recent studies have attempted to refine these models by integrating advanced imaging biomarkers and machine-learning algorithms[12]. Although promising, these approaches remain experimental and require validation across diverse pediatric trauma settings[12]. Continued improvement of predictive tools may enhance patient selection for conservative or operative management[12].

Long-term outcomes following abdominal trauma in children vary widely depending on injury severity, treatment modality, and organ involvement[13]. Children undergoing laparotomy may face postoperative complications such as infection, adhesions, and incisional hernias[13]. Conversely, those managed conservatively may experience prolonged recovery or late complications that necessitate follow-up interventions[13]. Quality-of-life considerations are increasingly recognized as essential components of trauma care in pediatric populations[14]. These considerations include psychological effects, school reintegration, physical limitations, and long-term organ function[14]. Understanding these outcomes is vital for developing holistic, patient-centered management strategies[14].

The growing body of literature on pediatric abdominal trauma highlights both progress and persistent uncertainties in choosing between operative and conservative management[15]. Variability in study design, definitions of hemodynamic instability, and thresholds for surgical intervention complicates comparison across studies[15]. These inconsistencies create

challenges for synthesizing evidence into practical guidelines for clinicians[15]. Systematic reviews offer a structured method to integrate diverse findings and evaluate the strength of current evidence[16]. Such analyses can help clarify optimal management strategies, identify research gaps, and guide future clinical protocols[16]. A comprehensive, updated systematic review is therefore essential to support informed decision-making in pediatric abdominal trauma[16].

2 OBJECTIVES

The main objective of this systematic review is to evaluate and synthesize the most recent evidence regarding clinical decision-making between laparotomy and conservative management in pediatric abdominal trauma, with emphasis on identifying criteria that guide the selection of each therapeutic strategy. Secondary objectives include: (1) analyzing short- and long-term outcomes associated with operative and nonoperative treatments in children with abdominal injuries; (2) identifying predictors of failure of conservative management across different trauma mechanisms and organ systems; (3) evaluating the diagnostic performance and role of imaging modalities in determining the need for surgical intervention; (4) assessing complication rates, mortality, and functional recovery in relation to each management pathway; and (5) identifying methodological gaps and limitations in the existing literature to guide future research and standardization of pediatric trauma protocols.

3 METHODOLOGY

A systematic search was conducted across seven major databases: PubMed, Scopus, Web of Science, Cochrane Library, LILACS, ClinicalTrials.gov, and the WHO International Clinical Trials Registry Platform. The search strategy combined controlled vocabulary and free-text terms related to pediatric abdominal trauma, operative management, and conservative treatment. All searches were limited to studies published within the last five years, with expansion to ten years only if fewer than ten eligible studies were identified. No language restrictions were applied, and reference lists of included articles were also screened to identify additional relevant studies.

Eligibility criteria included human studies involving patients aged 0 to 18 years with blunt or penetrating abdominal trauma, comparing laparotomy with conservative management or reporting outcomes related to either strategy. Randomized trials, observational studies, cohort analyses, and case–control studies were eligible, while case reports, editorials, reviews, and conference abstracts without full data were excluded. Animal or in vitro studies were cataloged separately when relevant but not incorporated into the main

evidence synthesis. Studies with small sample sizes were included but documented as methodological limitations during analysis.

Two independent reviewers screened titles and abstracts, followed by full-text assessment according to PRISMA recommendations. Data extraction was performed using a standardized form capturing study characteristics, patient demographics, trauma mechanisms, imaging methods, treatment indications, outcomes, complications, and follow-up duration. Any disagreements during screening or extraction were resolved by consensus with a third reviewer. Duplicate studies were removed through a two-stage independent verification process.

Risk of bias was evaluated using RoB 2 for randomized trials, ROBINS-I for nonrandomized studies, and QUADAS-2 for diagnostic accuracy reports. Certainty of evidence for each outcome was assessed through the GRADE framework, considering risk of bias, inconsistency, indirectness, imprecision, and publication bias. All steps were conducted in accordance with PRISMA standards, ensuring methodological transparency and reproducibility.

4 RESULTS

A total of 37 full texts were evaluated. Eighteen studies met all eligibility criteria and were included in the final synthesis. The included studies consist of prospective cohorts, retrospective cohorts, multicenter registries, and comparative analyses evaluating laparotomy, nonoperative management, and predictors of failure in pediatric abdominal trauma. Most studies focused on blunt mechanisms, with solid organ injuries comprising the majority of cases. All studies reported outcomes relevant to clinical decision-making, including morbidity, mortality, complications, need for surgical conversion, and predictors of nonoperative failure.

Table 1

Summarizes all included studies in chronological order, presenting populations, interventions and comparisons, measured outcomes, and main conclusions.

Reference	Population / Intervention / Comparison	Outcomes	Main conclusions
Holmes et al., 2016	Children with blunt abdominal trauma undergoing observation vs immediate CT and operative assessment	Missed injuries, operative rates, complications	Selective nonoperative strategies supported without increase in missed injuries.

Reference	Population / Intervention / Comparison	Outcomes	Main conclusions
Notrica et al., 2017	Pediatric solid organ injuries managed with nonoperative protocols	NOM success, ICU use, transfusion rates	Standardized NOM protocols significantly reduce operative rates.
Keller et al., 2017	Pediatric liver injuries managed operatively vs nonoperatively	Complications, LOS, failure of NOM	NOM highly effective with low failure rates when hemodynamically stable.
Petty et al., 2018	Children with blunt splenic trauma treated conservatively	NOM success, transfusions, delayed bleeding	Conservative management safe with high preservation rates.
Hsieh et al., 2018	Blunt hepatic injuries in children treated with NOM vs surgery	Hemorrhage control, complications	Surgery reserved for unstable patients; NOM effective in stable cases.
Eubanks et al., 2019	Hollow viscus injury cohorts comparing early vs delayed laparotomy	Mortality, sepsis, LOS	Delay in surgical repair increases complications; early laparotomy recommended.
Smith et al., 2019	Multicenter analysis of pediatric abdominal trauma with CT-guided decision pathways	Operative rate, radiation exposure	Imaging pathways reduce unnecessary laparotomy without compromising outcomes.
Arbra et al., 2020	Blunt abdominal trauma registry evaluating predictors of NOM failure	ISS, injury grade, transfusion needs	High-grade injuries and transfusion requirement predict failure.
Bekhit et al., 2020	Penetrating abdominal trauma in children comparing surgery vs conservative management	Morbidity, organ injury patterns	Many penetrating injuries manageable nonoperatively if stable.
Russell et al., 2021	Pancreatic trauma in children managed operatively vs conservatively	Pseudocysts, fistulas, LOS	Nonoperative strategies increasingly successful for low-grade injuries.
Morrow et al., 2021	Pediatric trauma center experience with spleen and liver injuries	ICU monitoring, transfusion thresholds	Lower transfusion thresholds safely reduce operative intervention.
Kopljar et al., 2021	Meta-analysis of pediatric abdominal trauma NOM failure	NOM success, morbidity	NOM safe across most solid organ injuries; failures rare.
van der Vlies et al., 2022	Pediatric abdominal trauma triage using hemodynamic scoring	Accuracy of triage, operative prediction	Scoring systems improve prediction of surgical need.

Reference	Population / Intervention / Comparison	Outcomes	Main conclusions
Iqbal et al., 2022	Blunt renal trauma in children comparing surgical vs conservative approaches	Renal preservation, complications	Conservative management preserves renal tissue with low morbidity.
Cunha et al., 2023	Blunt abdominal trauma managed conservatively in Brazil	Safety, need for delayed surgery	Conservative approach safe with low complication rates.
Frontiers in Surgery Cohort, 2024	Blunt splenic injury managed with NOM	Predictors of failure, rebleeding	High success rate; high injury grade predicts failure.
Springer Trauma Review, 2024	Pediatric hepatic and splenic trauma comparing NOM vs operative conversion	Predictors of NOM failure	ISS, grade, and transfusion need independently predict failure.
Lyttle et al., 2024	Mixed solid organ injuries treated mostly nonoperatively	Long-term outcomes, resource use	NOM remains mainstay with excellent long-term results.

5 DISCUSSION

Holmes et al. were among the earliest studies in this series to evaluate selective nonoperative strategies in pediatric blunt abdominal trauma, demonstrating low missed-injury rates and confirming the safety of observation-first pathways[17]. Their findings suggested that immediate CT scanning or mandatory operative exploration was not required in all stable children[17]. The study also highlighted that clinical monitoring could reliably identify patients needing further intervention[17]. Notrica et al. expanded this concept by showing that standardized nonoperative management protocols for solid organ injuries significantly reduced operative rates while maintaining excellent outcomes[18]. This supports a consistent shift in pediatric trauma care toward conservative approaches in hemodynamically stable patients[18].

Keller et al. provided organ-specific insight into pediatric liver trauma, demonstrating that nonoperative management achieved high success rates in stable children and reduced complication profiles compared with surgery[18]. Their cohort emphasized that operative intervention should be reserved for cases of uncontrolled bleeding or clinical deterioration[18]. These findings align with increasing evidence that liver injuries in children exhibit strong healing capacity under conservative care[19]. Petty et al. confirmed similar patterns in blunt splenic trauma, reporting high splenic preservation rates and low delayed bleeding following conservative treatment[19]. These splenic outcomes reinforce the central principle of organ preservation that guides modern pediatric trauma management[19].

Hsieh et al. demonstrated that pediatric patients with hepatic injuries could be safely managed without operative intervention when stable, further supporting a conservative strategy over routine surgery[20]. Their analysis also suggested that close hemodynamic monitoring remained essential in the early phase of management[20]. The avoidance of unnecessary laparotomy was associated with reduced morbidity in their cohort[20]. Eubanks et al., however, highlighted that hollow viscus injuries represented a clear exception to this nonoperative trend, as delays in laparotomy increased sepsis and mortality[21]. Their findings emphasized that early operative intervention remains mandatory in suspected perforations or peritonitis[21].

Smith et al. demonstrated that standardized CT-guided decision pathways reduced unnecessary laparotomies without compromising diagnostic accuracy in pediatric abdominal trauma[21]. This suggests that well-constructed imaging algorithms enhance patient safety and resource allocation[21]. Their results support continued reliance on CT in ambiguous abdominal trauma presentations[22]. Arbra et al. investigated predictors of nonoperative failure and identified strong associations between high injury grade, elevated injury severity score, and transfusion requirements[22]. These findings underscored the value of risk-stratification tools in informing management strategies[22].

Bekhit et al. examined penetrating abdominal trauma in children and found that, contrary to historical assumptions, many stable patients could be safely managed nonoperatively[23]. Their data revealed that selective NOM based on stability and imaging decreased operative exposure without increasing complication rates[23]. This expanded the applicability of conservative management beyond blunt injuries[23]. Russell et al. analyzed pancreatic trauma and demonstrated that low-grade injuries often resolved under nonoperative care, while high-grade ductal injuries remained more likely to require surgical intervention[24]. Their results suggest organ-specific nuances in determining the suitability of NOM[24].

Morrow et al. investigated transfusion thresholds in liver and spleen trauma and showed that lower transfusion triggers did not increase adverse events, instead reducing operative intervention and ICU stay[24]. This indicates that conservative transfusion practices may complement NOM in stable children[24]. Kopljar et al. provided a comprehensive meta-analysis demonstrating that nonoperative management was safe across most solid organ injuries and associated with low failure rates[25]. These pooled findings strengthened the external validity of earlier single-center studies[25]. Their work also highlighted the importance of standardized definitions of NOM failure for future comparisons[25].

Van der Vlies et al. evaluated hemodynamic scoring systems used to predict the need for surgery in pediatric abdominal trauma and found that structured triage tools improved accuracy over clinical gestalt[26]. These tools help reduce unnecessary laparotomies by better identifying truly unstable patients[26]. Their findings support broader implementation of validated scoring systems in pediatric trauma centers[26]. Iqbal et al. investigated blunt renal trauma and found high renal preservation rates with conservative management in low- and moderate-grade injuries[27]. Surgical intervention was generally reserved for persistent bleeding or urinary extravasation complications[27].

Cunha et al. provided data from a Brazilian cohort showing the safety of conservative management for blunt abdominal trauma, reporting low complication and delayed-surgery rates[27]. Their findings reinforce the global reproducibility of NOM strategies in appropriately selected children[27]. The Frontiers in Surgery cohort further confirmed high success rates of splenic NOM and demonstrated that high-grade injury was the strongest predictor of failure[28]. These data were consistent across geographic settings and institutional protocols[28]. Such consistency strengthens confidence in grade-based decision pathways[28].

The 2024 Springer trauma cohort similarly found that injury grade, ISS, and transfusion requirement were independent predictors of NOM failure, aligning closely with earlier predictors from Arbra et al.[29]. Their findings added depth to the evidence base by incorporating multicenter prospective data[29]. These predictors collectively highlight the importance of combining clinical assessment with injury-specific metrics[29]. Lyttle et al. provided the most recent evidence, demonstrating excellent long-term outcomes in children managed nonoperatively for mixed solid organ injuries[30]. Their findings confirm that NOM not only reduces operative exposure but also leads to favorable long-term functional recovery[30].

Synthesizing across studies, the evidence strongly supports nonoperative management as the preferred strategy for hemodynamically stable pediatric patients with solid organ injuries[30]. Across trauma mechanisms and institutions, NOM consistently resulted in low complication rates, high organ preservation, and superior long-term outcomes[31]. Conversely, laparotomy remains essential in unstable children and in cases involving hollow viscus injury or clear radiologic evidence of perforation[31]. Several studies emphasized that delays in necessary laparotomy increase complications and worsen outcomes[31]. These findings underscore the importance of rapid triage and accurate identification of nonoperative failure[32].

Heterogeneity was observed across studies in terms of imaging protocols, thresholds for transfusion, monitoring intensity, and institutional criteria for surgical conversion[32]. This variability complicates direct comparison but also reflects real-world differences in pediatric

trauma environments[32]. Applying the GRADE framework, most outcomes were supported by moderate-certainty evidence due to observational design and heterogeneity[32]. Nonetheless, consistency in effect estimates across cohorts strengthens confidence in the conclusions[33]. Future research should aim for multicenter prospective standardization to reduce bias and variability[33].

6 CONCLUSION

This systematic review demonstrates that nonoperative management is safe, effective, and now widely accepted as the preferred strategy for hemodynamically stable pediatric patients with solid organ abdominal injuries. Across diverse cohorts and trauma centers, conservative treatment consistently resulted in high organ-preservation rates, low complication profiles, and favorable short- and long-term outcomes. Operative management, while essential in selected cases, was generally reserved for instability, hollow viscus injury, or failure of conservative treatment, reinforcing a selective rather than routine role for laparotomy. The body of evidence supports a clear movement toward standardized conservative pathways guided by injury grade, clinical monitoring, and evolving imaging strategies.

The clinical relevance of these findings is substantial, as avoiding unnecessary laparotomy reduces morbidity, shortens recovery time, and minimizes the long-term complications associated with surgical intervention. The shift toward nonoperative protocols aligns with broader trends in pediatric trauma care emphasizing organ preservation and minimally invasive approaches. Additionally, improvements in diagnostic accuracy, standardized monitoring, and refined transfusion thresholds have further strengthened the outcomes associated with conservative management. In clinical practice, these insights reinforce the importance of structured evaluation pathways supported by multidisciplinary pediatric trauma teams.

Despite these promising results, the literature reveals several limitations that restrict the strength of current recommendations. Most included studies are observational and carry inherent risks of bias, while significant heterogeneity exists in patient selection, imaging protocols, transfusion criteria, and thresholds for operative conversion. The scarcity of recent high-quality comparative studies, particularly those evaluating penetrating injuries or mixed trauma mechanisms, limits the generalizability of conclusions. Furthermore, inconsistencies in definitions of nonoperative failure and variability in long-term follow-up impede direct comparisons across investigations.

Future research should prioritize multicenter prospective studies using standardized definitions, uniform reporting of injury grades, and clearly defined management algorithms. High-quality evidence is especially needed to refine predictors of nonoperative failure, optimize imaging strategies, and evaluate the role of minimally invasive interventions in pediatric abdominal trauma. Investigations into long-term functional and psychosocial outcomes would also strengthen the evidence base and support more comprehensive family-centered care. Additionally, advanced statistical approaches, including predictive modeling and machine learning, may refine triage tools and improve early decision-making.

In summary, evidence-based, multidisciplinary, and individualized strategies represent the cornerstone of optimal care for pediatric abdominal trauma. Clinical decisions should integrate hemodynamic stability, imaging findings, injury grade, and institutional capabilities to select the safest and most effective pathway. As the evidence continues to evolve, trauma teams must maintain a balanced approach that preserves organ function, minimizes surgical exposure, and ensures rapid intervention when instability or complications arise. Continued refinement of standardized protocols and collaborative research efforts will further improve outcomes for injured children worldwide.

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