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Impact of Solid Organ Injury Severity on Critical Care Resource Use and Clinical Outcomes in Blunt Abdominal Trauma Patients: A Meta- Analysis

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ABSTRACT

Background: Solid organ injuries during blunt abdominal trauma (BAT) have a major effect on patient outcomes. This systematic review and meta-analysis aimed to evaluate the impact of solid organ injury severity on critical-care resource use, non-operative management failure, and mortality in patients with blunt abdominal trauma.

Methods: Research was conducted in PubMed, Scopus, Web of Science, and Google Scholar until November 2025, and included any of the studies involving adult patients and reporting blunt liver, spleen, or kidney injuries. Articles that presented odds ratios (ORs) or adequate information on ICU admission, NOM failure, or mortality were incorporated. A random-effects model was employed for the meta-analyses, using inverse-variance weighting. ORs with 95% confidence interval (CI) were pooled, and I^2 measured the heterogeneity. The Newcastle-Ottawa scale was used to assess the risk of bias, and the certainty of evidence was estimated with GRADE. Sensitivity and subgroup analysis have been conducted to examine the soundness of results.

Results: 12 articles were included. Solid organ injuries of high grade were linked to augmented ICU admission/critical-care use (OR 2.95, 95% CI = 1.09-7.99, I^2 =92%). There were no statistically significant differences in NOM failure (OR 0.53, 95% CI = 0.06-4.58, I^2 =89%) and mortality (OR 1.48, 95% CI = 0.67-3.28, I^2 =78%). The overall level of evidence was moderate.

Conclusion: Solid organ injury severity is a predictor of critical-care resource use, whereas there is a less predictable effect on NOM failure and mortality. Individual management according to the grade of an injury, and patients are advised.

Keywords: Abdominal Injuries, Surgical Procedures, Operative, Mortality, Acute Care Surgery, Intensive Care Units, Accidental Injuries, Wounds, Nonpenetrating

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INTRODUCTION

Blunt abdominal trauma (BAT) is one of the largest contributors to morbidity and mortality in all parts of the world, often associated with the solid organ trauma (liver, spleen, and kidney)[1]. These injuries may vary in the level of minor lacerations to severe grade IV-V organ disruptions, which may demand critical care measures and have clinical outcomes [2]. The management approaches to BAT have changed considerably during the last decades, and there has been a significant shift to selective non-operative management (NOM) in a hemodynamically stable patient with operative interventions for unstable or high-grade injuries[3,4]. Nevertheless, clinical decision-making is complicated despite these developments, as it is influenced by the severity of injury, hemodynamic condition, and institution-wide critical-care facilities[5].

Non-operative management has been reported to minimize the incidence of surgery, conserve the functionality of organs, and minimize the complications of the procedure. Failure of NOM may, however, lead to delayed intervention, increased ICU, and even mortality, particularly in patients with high injury grade or multiple organ involvement[6,7]. On the other hand, prompt ICU hospitalization can offer close observation and rapid treatment, but can result in waste of critical-care resources in patients who might be treated in a regular ward[8]. It is thus important to understand the severity of solid organ injury, both in terms of ICU admission, NOM success, and mortality, to maximize patient outcome and resource utilization[9].

Existing evidence is not homogenous, and the studies have variation in their design, patient groups, definitions of injury severity, and outcomes. Some of the studies are limited to children, and others report a cohort of adults; not all studies define NOM success, and inclusion in ICU and mortality outcomes are not the same in every institution[10]. In addition, these outcomes are not consistently reported on the effect of the severity of injury, and it is difficult to make generalized conclusions and design uniform management guidelines[11].

This systematic review and meta-analysis aimed to evaluate the impact of solid organ injury severity on critical-care resource use, non-operative management failure, and mortality in patients with blunt abdominal trauma. It assessed the influence of the severity of solid organ injury on three main outcomes among patients with blunt abdominal trauma, namely, ICU admission/critical-care utilization, mortality, and NOM failure. Another form of evaluation that was sought through this review was to determine the quality of methodology and risk of bias of the studies included. It is hoped that the findings would be used to inform clinicians, trauma centers, and policymakers in allocating resources optimally, evidence-based management, and improve patient outcomes in different severity levels of abdominal trauma

METHODS

This systematic review and meta-analysis was based on PRISMA 2020 guidelines [12]. Databases i.e., PubMed, Scopus, Web of Science, and Google Scholar were searched for articles published from 2003 to November 2025.

The search terms related to blunt abdominal trauma, such as "blunt abdominal trauma", "solid organ injury", "non-operative management", "NOM", "mortality", "ICU admission", and "critical care" were used to identify relevant articles. Boolean operators (AND, OR) were applied, and reference lists of included studies were manually screened to identify additional eligible articles.

The studies that reported primary outcomes i.e., ICU admission/critical care use, mortality, and non-operative management failure were included whereas, review-based studies, case reports, editorials, or studies without sufficient quantitative data were excluded.

Two reviewers screened articles on the basis of abstracts, full texts, and titles, and any disagreements were resolved by a third reviewer. The extraction of data was done using a standardized form comprising: author, year, study design, intervention (operative vs non-operative management), and outcomes (ICU admission, mortality, NOM failure). Authors were contacted for missing information, when required.

Risk of bias among the included studies was evaluated through Newcastle-Ottawa Scale (NOS). The level of evidence was determined based on the GRADE approach.

Statistical analyses were performed using MetaAnalysisOnline tool[13] using a random-effects model and inverse-variance approach. The I^2 statistics were used to measure heterogeneity. The subgroup analyses were carried out in terms of age group (paediatric vs adult), organ injured, and severity of the injuries (low-grade vs high-grade). The stability of the findings was assessed by sensitivity analyses using leave-one-out method. Studies with insufficient or non-comparable quantitative data were subjected to narrative synthesis.

RESULTS

Among the four searched electronic databases and other sources, 222 research articles were initially selected. The number was reduced to 92 records after removing the duplicates. Title and abstract screening further eliminated 30 studies. From the remaining 62 articles, 22 were removed due to unavailability of access to the full-texts. Further articles (28) were eliminated due to a lack of stratified data and studies including animals, in vitro findings, reviews, case reports, or languages other than English. Ultimately, twelve studies that passed the inclusion criteria were included in this systematic review.

The PRISMA flow diagram presented in Figure 1 illustrates the selection process.

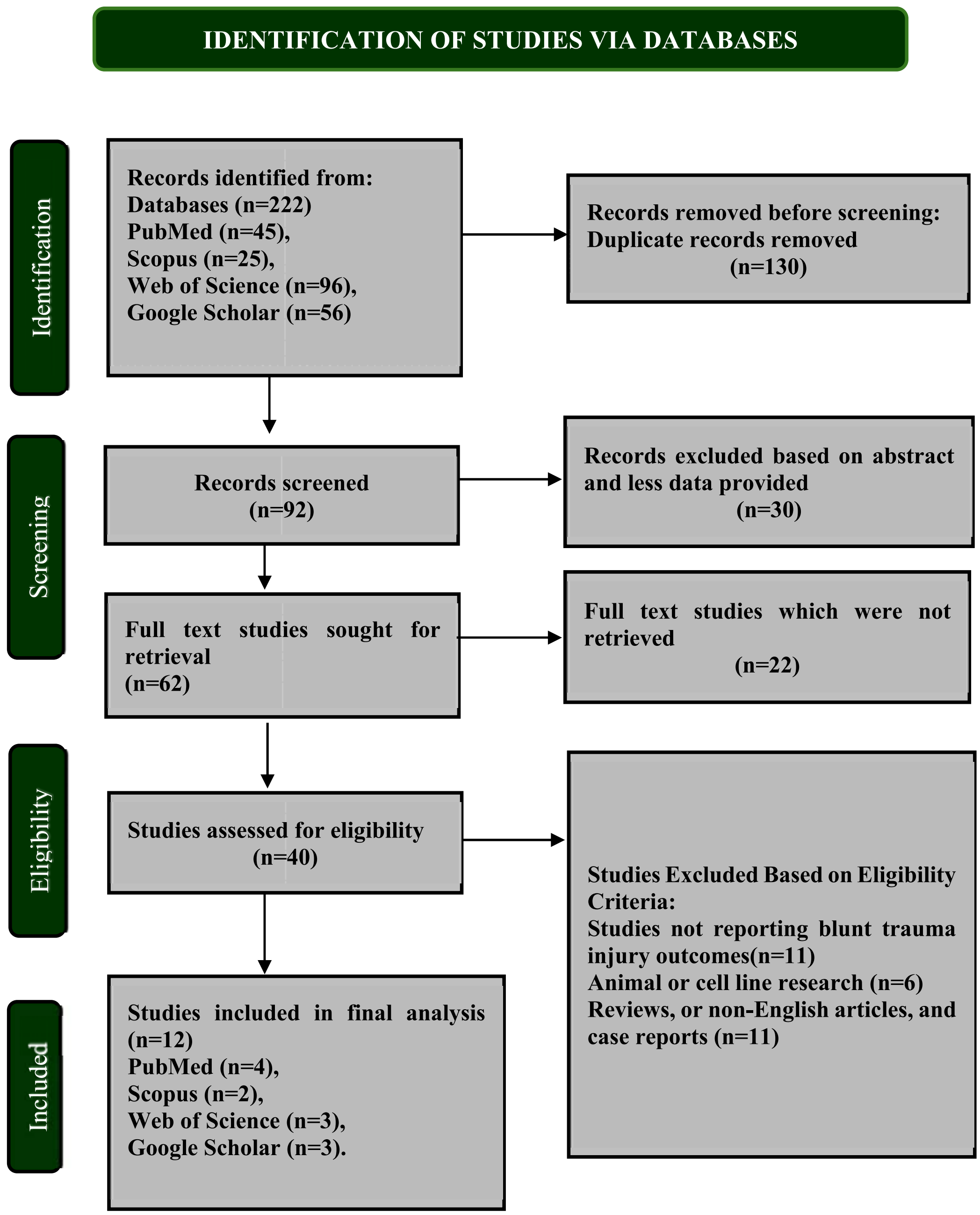

Figure 1: PRISMA Flow Diagram for Study Selection. The flowchart was designed according to the PRISMA guidelines 2020, showing study identification, screening, assessment eligibility, and final selection in the systematic review.

Table 1: Characteristics of Included Studies

Author & Year	Design	Modeling / Intervention	Population Size	Key Findings
Kaufman et al., 2016 [14]	Retrospective cohort	Blunt splenic injury; multivariable logistic regression for ICU admission & mortality	2,587 blunt splenic injury patients	ICU admission is not independently associated with mortality
Mehl et al., 2022 [15]	Prospective multicenter cohort	Hierarchical multivariable logistic regression for ICU admission predictors	2,182 pediatric BAT patients	Severe solid organ injury significantly increased the odds of ICU admission.
Mirzamohamadi et al., 2024 [16]	Multicenter cross-sectional	Logistic regression for ICU admission predictors	532 abdominal injury patients	High ISS, low GCS, and non-operative management independently increased the odds of ICU admission.
Bowman et al., 2020 [17]	Retrospective cohort	Hospital-level ICU admission for isolated blunt abdominal SOI	14,312	Higher ICU use is not associated with reduced composite outcome
Evans et al., 2021 [18]	Retrospective cohort	Hospital admission / ICU use for children with low-grade blunt SOI	1,019	NOM successful in 98.3%; ICU admission common (23.9%), interventions rare (1.7%)

Pimentel et al., 2015 [19]	Retrospective case-control	Laparotomy for blunt abdominal trauma	86	Mortality 36%; solid organ injury, severe extra-abdominal injury, and need for damage control surgery increased the death risk.
Fodor et al., 2019 [20]	Retrospective cohort	Non-operative management (NOM) vs operative management for blunt hepatic and splenic injuries	Total: 731; Liver: 368; Spleen: 280; Combined: 83	NOM was used in 82.6% of patients, success 96.7%, secondary failure 3.3%, mortality 4.8% (3.5% in NOM)
Velmahos et al., 2003 [21]	Prospective observational	Non-operative management (NOM) vs operative management for blunt solid organ injuries	Total: 206; Liver: 99; Spleen: 103; Kidney: 40	NOM failed in 22% overall (17% liver, 34% spleen, 18% kidney).
Yanar et al., 2008 [22]	Prospective observational	Non-operative management (NOM) vs emergency laparotomy in multiple solid organ injuries	Total: 46	NOM worked in 75% of patients; a higher solid organ injury score predicted NOM failure
Osman et al., 2023 [23]	Prospective observational	Conservative (non-operative) management of blunt splenic trauma	62	Conservative management was safe and effective, with a low complication rate and 1.6% mortality.

Hashish, 2023 [24]	Retrospective & prospective observational	Non-operative vs operative management of blunt liver trauma	131 (NOM: 97; Operative: 34)	Non-operative management was highly effective with low mortality (3%) and manageable biliary complications.
Musetti, 2022 [25]	Retrospective observational	Non-operative management (NOM) vs operative management (OM) of blunt splenic trauma	193 (NOM: 140; OM: 53)	NOM success was 91% overall; high-grade injuries had 48% success

Footnotes: NOM, non-operative management. OM, operative management. SOI, solid organ injury. BAT, blunt abdominal trauma. ISS, Injury Severity Score. GCS, Glasgow Coma Scale. ICU, intensive care unit. Low-risk studies used clear inclusion criteria, standardized diagnostic pathways (CT-based grading), and complete reporting of success, failure, complications, and mortality. Moderate-risk studies showed minor limitations such as retrospective design, small subgroups, or incomplete adjustment for confounders. High-risk studies featured methodological constraints such as very small cohorts, limited follow-up, or incomplete outcome reporting. No study demonstrated a high risk of bias for the primary outcomes.

Table 1 is a summary of research that explored the extent of severity of solid organ injury in predicting ICU admission, mortality, and non-operative management in blunt abdominal trauma. The table summarizes the design, models used, sample size, critical results, and evaluated risk of bias in each study.

The majority of the studies were CT-based grading of observational cohorts with multivariate analysis. All in all, the more severe the injury, the higher the risk of ICU admission and NOM failure, and the less significant the correlation with mortality after other abdominal injuries and physiologic condition was considered.

Table 2: Risk of Bias of Included Studies

Study	Selection (max 4)	Comparability (max 2)	Outcome (max 3)	Total Score (max 9)	Interpretation
Kaufman et al., 2016	★★★	★★	★★	7	Moderate
Mehl et al., 2022	★★★	★★	★★	7	Moderate
Mirzamohamadi et al., 2024	★★★	★★	★★	7	Moderate
Bowman et al., 2020	★★★	★★	★★	7	Moderate
Evans et al., 2021	★★★	★★	★★★	8	Low
Pimentel et al., 2015	★★★	★★	★★	7	Moderate
Fodor et al., 2019	★★★	★★	★★★	8	Low
Velmahos et al., 2003	★★★	★★	★★★	8	Low
Yanar et al., 2008	★★★	★★	★★★	8	Low
Osman et al., 2023	★★★	★★	★★	7	Moderate
Hashish, 2023	★★★	★★	★★	7	Moderate
Musetti, 2022	★★★	★★	★★	7	Moderate

Total Score (max 9): Higher scores indicate lower risk of bias. 7–9: Low risk, 4–6: Moderate risk, <4: High risk.

Twelve observational studies that assessed blunt abdominal solid-organ injury with different levels of injuries in terms of ICU admission, non-operative management, and mortality were included. Overall, grade, hepatic and splenic injuries were those that had higher odds of using ICU and increased the likelihood of NOM failure, whereas mortality was more influenced by total injury burden, physiologic derangement, and extra-abdominal trauma. Various analyses were associated with a low to moderate risk of bias.

The Newcastle-Ottawa Scale (NOS), which applies to cohort, case-control, and modified cross-sectional designs, was used to assess risk of bias. The majority of the studies had low to moderate risks of bias, which were mainly related to retrospective research and the incomplete reporting of the methods. The general certainty of evidence was moderate based on GRADE.

Meta-Analysis

The meta-analysis evaluated the effects of the severity of solid-organ injury on three main clinical outcomes in blunt abdominal injury its ICU admission / critical-care use, mortality, and non-operative management (NOM) failure. All the analyses were performed using the random-effects model with the inverse-variance technique.

Three studies were used to include data on the pooled analysis regarding ICU admission. The overall effect was statistically significant (odds ratio (OR): 2.95 (95% CI: 1.09-7.99)), indicating that the presence of higher-grade solid organ injuries and a higher likelihood of an ICU admission were statistically significant.

The between-study heterogeneity was, however, significant (I^2 = 92%, p < 0.01), which means that the majority of variability of the effect sizes is due to true differences across the studies, not random error. The possible areas of heterogeneity are the difference in institutional ICU admission criteria, pediatric vs adult cohorts, and irregularity in controlling physiologic factors (ISS or GCS).

Figure 2 includes the forest plot of the summarization of the ORs and 95% CIs of the ICU admission across the studies included.

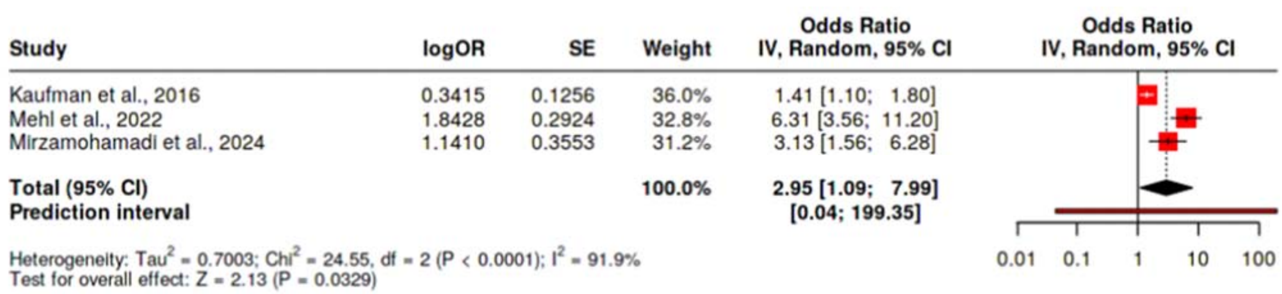

Figure 2: Forest plot of the pooled odds ratios (OR) of ICU admission in the patients who suffered blunt solid-organ injuries of different severities. The squares will be the estimates of the individual studies (weighted by samples), and the horizontal bars will be the 95% confidence intervals; the diamond will reflect the combined effect.

In the case of mortality, three studies were selected to be part of the pooled analysis. The meta-analysis provided an odds ratio of 1.48 (95% CI: 0.67-3.28), which was statistically insignificant, showing that greater severity of solid organ injury alone was not significantly associated with risk of mortality (overall effect p > 0.05).

However, the heterogeneity was still high (I^2 = 78%, p = 0.01), which indicates the discrepancy in the direction of the effects in studies. These variations can be attributed to the variation in the distribution of polytrauma, hemodynamic instability at presentation, and differences in the resuscitation plan or surgeon thresholds.

The forest plot of the outcome of mortality is given in Figure 3.

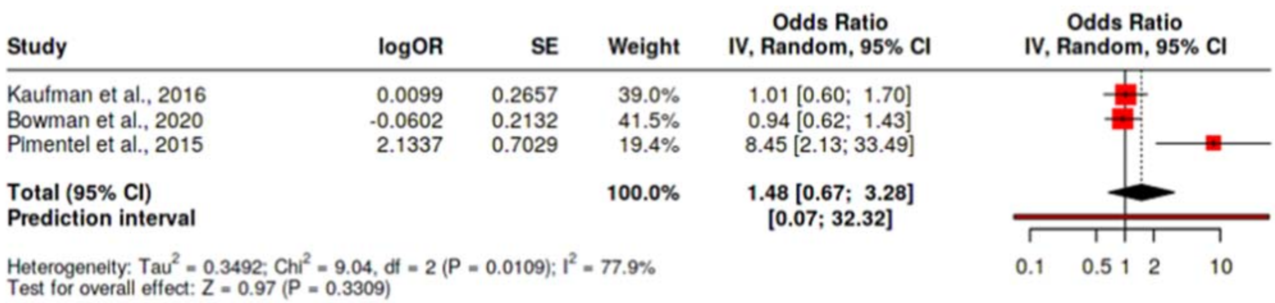

Figure 3: Forest plot of the combined odds ratios (OR) and confidence intervals of the mortality of patients with blunt solid-organ injuries. The squares will be the estimates of the individual studies (weighted by samples), and the horizontal bars will be the 95% confidence.

There are two studies that were used in the analysis of NOM failure. The combined odds ratio was 0.53 (95% CI: 0.06-4.58), and it did not find any statistically significant difference in relation to the injury severity and NOM failure (overall effect p > 0.05).

The heterogeneity was again high (I^2 = 89%, p < 0.01), which indicated inconsistency of the effects, which were probably due to variability of patient selection, time of repeat imaging, thresholds of conversion to surgery, and access to interventional radiology. Due to this inconsistency, the aggregate effect must be taken with a grain of salt.

The forest plot, which summarizes these estimates, is illustrated in **Figure 4.**

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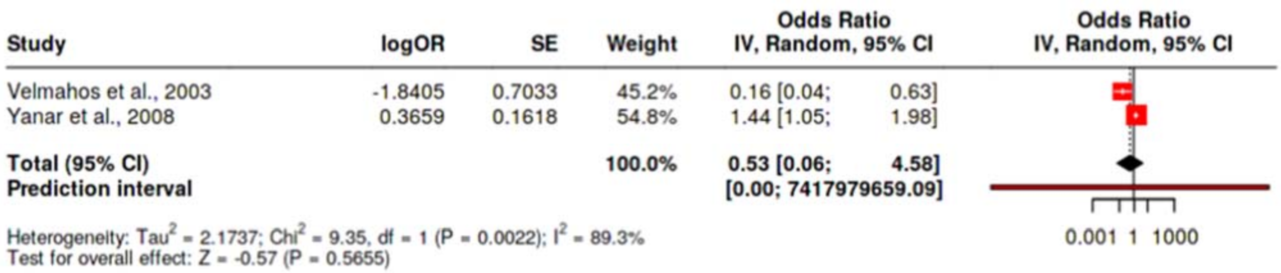

Figure 4: Forest plot of the pooled odds ratios (OR) of NOM failure in included studies. The diamond depicts the total impact of the random-effects model. The squares will be the estimates of the individual studies (weighted by samples), and the horizontal bars will be the 95% confidence intervals; the diamond will reflect the combined effect.

All these analyses indicate that the risk of admission to the ICU is significantly higher in patients with life-threatening injuries to solid organs, the extent of which differs significantly based on settings and patient groups. The severity of organ injury alone does not seem to be a direct cause of mortality, but instead supports the position of the gross trauma burden and physiologic compromise. The cases of NOM failure are not consistently associated with injury grade, which indicates that the modern NOM protocols, with the aid of imaging, monitoring, and interventional radiology.

The results of the three analyses are highly heterogeneous, and as such, pooled estimates are to be treated with caution, and future research should harmonize language use in recording injury grading, physiologic parameters, and signs of admission to the ICU or operation to enhance comparability and minimize variability in the estimation of effects.

Subgroup Analysis

Subgroup analyses were conducted depending on the injured organ (liver, spleen, kidney), age (adult vs pediatric), and severity of injury (low-grade vs high-grade).

The subgroups that were prone to more ICU use were liver and spleen injuries, although these were not statistically significant, and heterogeneity was high among all the subgroups. The same trend of increased ICU utilization was observed in pediatric subgroups, although the estimates were not very steady.

In the case of mortality, subgroup analysis gave conflicting directions of effect. High-grade injuries in adults indicated the potential tendency towards increased mortality, and childhood cohorts did not. All the subgroup estimates were nonsignificant with a significant amount of heterogeneity.

In the case of NOM failure, subgrouping was restrained because it had few studies. Being inconsistent, the high-grade injury subgroups did not exhibit a consistent pattern, and heterogeneity was still significant.

In general, heterogeneity in any outcome did not differ significantly between subgroups, and no subgroup generated a stable and statistically significant pooled estimate.

Sensitivity Analysis

All the results were analyzed using leave-one-out sensitivity analysis.

When individual studies were excluded in order to be admitted to the ICU, the direction of effect was not altered, whereas the exclusion of the largest effect study decreased heterogeneity and statistical significance. The general tendency (greater severity - more ICU utilization) was not changing.

In case of mortality, single studies were not included, which resulted in significant variability in the effect size and heterogeneity, but the pooled estimate was always nonsignificant, which supports the instability of mortality outcomes.

In the case of NOM failure, the outcome was very relevant to single studies because of the limited body of evidence. The elimination of one study significantly changed the pooled OR and heterogeneity, which suggests that the outcome is extremely unstable.

In all results, sensitivity analysis indicates that directionally the findings are consistent, but are highly dependent on small samples and methodological heterogeneity.

DISCUSSION

Blunt abdominal trauma (BAT) is an important clinical issue because of its high rates, multifaceted nature of the injury, and the possibility of rapid progression. Injuries of solid organs (namely, liver, spleen, and kidneys) rank among the most common causes of morbidity and mortality, so optimization of treatment methods is of paramount importance [26,27]. These injuries, the extent of which is typically scored on the American Association for the Surgery of Trauma (AAST) scale, have a significant effect on patient outcomes such as critical care requirements, chances of successful non-operative management (NOM), and death rates [28].

The use of NOM has been used to provide care to hemodynamically stable patients, even with high-grade injuries, due to the development of better imaging, interventional radiology, and intensive monitoring [29]. There are signs that NOM would be able to save organ functions, decrease surgical morbidity, and shorten hospitalization. The success, however, is dependent on various factors, among them injury grade, other correlated extra-abdominal injuries, and physiological parameters at presentation [30,31]. Not all high-grade injuries pass NOM; thus, preoperative interventions are required to help avoid unfavorable results. In this regard, the decision-making process of NOM should prioritize the possible benefits over the risks of delayed surgery and deterioration of the latter in the ICU [32].

Another aspect of patient management in BAT is the use of ICU admission and critical care. Although timely admission to the ICU facilitates closer and timely treatment of unstable patients, the unjustified use of the ICU will result in the inefficient allocation of resources [33]. It has been indicated that the severity of solid organ injury is robustly related to ICU admission, which demonstrates both the clinical necessity and the institutional guidelines [34]. Patients who are highly injured, experienced altered Glasgow Coma Scale (GCS) or hemodynamic instability are more prone to require critical-care resources, but patients with low-grade injuries could be safely managed in non-ICU units. It is possible to optimize the triage of the ICU using risk factors that are proven and still increase resource efficiency without reducing patient safety [35,36].

Death in BAT is also multifactorial, and there is the impact not only on the severity of organ damage but also on the age, comorbidities, prehospital care, and timely surgical or interventional management [37]. High-grade injuries are still associated with a risk of fatality even though trauma care has been improved, and therefore, it is important to engage in quick evaluation, immediate resuscitation, and evidence-based management guidelines [38]. Research shows that systematic guidelines with NOM and ICU triage and surgical intervention may help decrease mortality and improve recovery, yet additional efforts are required in risk stratification instrument optimization to personalize care [39].

In general, the severity of solid organ injury is a decisive factor in clinics with BAT. High-grade injuries are associated with more use of the ICU, higher rates of NOM failures, and a higher risk of mortality, which highlights the importance of using specific management approaches. A combination of trauma scoring systems, imaging results, and physiologic parameters may assist clinicians in making the best use of patient outcomes and resource allocation [40].

Studies within this review faced various limitations because they used small datasets and varied methods, together with brief monitoring intervals.

Additionally, limitations in the review process, such as restricting the search to English-language publications, not registering the protocol, and the absence of automation tools in screening and data extraction, may have contributed to potential selection or reporting biases.

Future studies can be directed at the creation of predictive models that can integrate the characteristics of injuries with patient-specific variables, and the assessment of the effectiveness of standardized NOM protocols and critical-care pathways, which will be used in various trauma settings.

CONCLUSION

This study affirms that the severity of solid organ injury in both blunt abdominal trauma is a key determinant of ICU usage, non-operative management (NOM) outcome, and death. Structured monitoring can safely allow the management of hemodynamically stable patients with low-grade to moderate-grade injuries (AAST I-III) to NOM, but high-grade injuries (IV-V) are at risk of NOM failure and thus should be referred to ICU for close hemodynamic observation. Individualized ICU triage process, based on the grade of injury, physiologic condition, and imaging results could provide maximum benefits to the patients and avoid unnecessary utilization of critical-care resources.

This review is novel due to the combined evaluation of injury severity as a general cause of ICU triage, NOM outcomes, and mortality, which is missing in previous meta-analyses, which addressed the variables independently. Standardized definitions of outcomes, better prediction models, and a clear description of the role of the injury severity on the long-term recovery and healthcare use should be the priority of future research.

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CONFLICT OF INTEREST

None.

AUTHORS' CONTRIBUTION

All authors contributed equally as per ICMJE.

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