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Laparoscopy for the management of penetrating and blunt abdominal trauma (a systematic review)

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The role of diagnostic and therapeutic laparoscopy in abdominal trauma has expanded over the last decade, but indications, safety, and comparative effectiveness versus laparotomy remain debated. Recent data, including large multicentre cohorts and updated meta-analyses, justify a focused synthesis.

Aim. To systematically review contemporary evidence on the effectiveness and safety of laparoscopy for the management of penetrating and blunt abdominal trauma, including case reports published over the last five years.

Materials and methods. Following PRISMA 2020 guidance, we searched PubMed / MEDLINE, Embase, Scopus, Web of Science, Cochrane Library, and Google Scholar. We included prospective/retrospective clinical studies and case series evaluating laparoscopy in abdominal trauma. Primary outcomes included non-therapeutic laparotomy (NTL) rates, missed injuries, complications, conversion rates, length of stay (LOS), and mortality. Risk of bias was assessed using ROBINS-I for non-randomized studies and descriptive appraisal for case reports.

Results. The search has identified two recent systematic reviews / meta-analyses on abdominal trauma (one blunt-specific, one mixed blunt/penetrating), several cohort / propensity-matched studies (including large registry analyses), and multiple single-center series and case reports published during 2020–2025. Laparoscopy in hemodynamically stable trauma patients consistently reduced NTL (19 % absolute reduction in a large single-center series) and postoperative complications and shortened LOS compared with laparotomy, without increasing missed injuries or mortality. Multicenter registry data for blunt trauma and recent retrospective cohorts showed that laparoscopic intervention in selected patients did not increase in-hospital mortality and was associated with acceptable conversion and complication rates. Case reports and small series document successful laparoscopic management of complex injuries (diaphragmatic rupture, hollow viscus injuries, colon trauma, post-traumatic hernias) in both blunt and penetrating mechanisms, with low morbidity in carefully selected patients.

Conclusions. The accumulated evidence strongly supports the role of laparoscopy in the management of penetrating and blunt abdominal trauma in hemodynamically stable patients. The use of laparoscopy in trauma management significantly reduces the rate of non-therapeutic laparotomies and postoperative complications and shortens hospital stays. Laparoscopy for abdominal trauma maintains very low rates of missed injuries and mortality when applied with strict patient selection and surgeon expertise.

Ключові слова: травма живота, лапароскопія, малоінвазивна хірургія, тупа травма, проникна травма.

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Лапароскопія під час лікування проникної та тупої травм живота (систематичний огляд)

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Роль діагностичної та лікувальної лапароскопії при травмах черевної порожнини за останні десять років посилилася, але показання, безпека та порівняльна ефективність щодо лапаротомії залишаються предметом дискусій. Останні дані, включаючи результати великих багатоцентрових когортних досліджень та найновіших метааналізів, визначають доцільність цього огляду.

Мета роботи – переглянути результати сучасних досліджень з приводу ефективності та безпеки лапароскопії під час лікування проникних і тупих травм черевної порожнини, включаючи звіти про клінічні випадки, за останні 5 років.

Матеріали і методи. Дотримуючись рекомендацій PRISMA 2020, здійснили пошук в PubMed / MEDLINE, Embase, Scopus, Web of Science, Cochrane Library та Google Scholar. До огляду включили проспективні та ретроспективні клінічні дослідження та звіти / серії випадків, що оцінюють лапароскопію при проникних або тупих травмах черевної порожнини. Первинні дані – експлоративна лапаротомія, пропущені травми, ускладнення, конверсія на лапаротомію, тривалість перебування в стаціонарі та смертність. Ризик систематичної помилки оцінювали за допомогою ROBINS-I для нерандомізованих досліджень.

Результати. У результаті пошуку виявили два нещодавні систематичні огляди / метааналізи травм черевної порожнини (один – специфічний для тупих травм, один – змішаний для тупих / проникних травм), кілька когортних досліджень і численні одноцентрові серії та звіти про клінічні випадки, опубліковані протягом 2020–2025 років. Лапароскопія у гемодинамічно стабільних пацієнтів із травмами послідовно зменшувала експлоративну лапаротомію (наприклад, ~19 % абсолютне зниження у великій одноцентровій серії) та післяопераційні ускладнення, а також скорочувала тривалість перебування в стаціонарі порівняно з лапаротомією без збільшення пропущених травм або підвищення показників смертності. Дані багатоцентрового реєстру для тупих травм і нещодавні ретроспективні когортні дослідження показали, що лапароскопічне

втручання у відібраних пацієнтів не збільшувало показники смертності та асоційоване з прийнятними показниками конверсії та ускладнень. У звітах про клінічні випадки та невеликих серіях досліджень задокументовано успішне лапароскопічне лікування складних травм (наприклад, розрив діафрагми, травми порожнистих органів, травми товстої кишки, посттравматичні грижі) і при тупих, і при проникних механізмах, з низькою частотою ускладнень у ретельно відібраних пацієнтів.

Висновки. Накопичені дані підтверджують роль лапароскопії в лікуванні проникних і тупих травм живота у гемодинамічно стабільних пацієнтів. Використання лапароскопії в лікуванні травм значно знижує частоту експлоративних лапаротомій і післяопераційних ускладнень, а також скорочує тривалість перебування в лікарні. Лапароскопія при травмах живота асоційована з дуже низькими показниками пропущених травм і смертності за умови ретельного відбору пацієнтів та наявності достатнього досвіду в хірурга.

Abdominal trauma remains a major cause of preventable death and disability worldwide, particularly among young adults [1]. This problem became especially relevant during Russia's full-scale invasion of Ukraine [2]. Non-operative management has become standard for many solid-organ injuries, whereas exploratory laparotomy has historically been the default for suspected hollow-viscus or diaphragmatic injury [3]. However, laparotomy carries substantial morbidity, including wound complications, adhesions, incisional hernias, and prolonged recovery [4].

The first report of using laparoscopy (termed "coelioscopy" at the time) specifically for trauma patients was indeed published in 1925 [5]. Advances in minimally invasive surgery, imaging, and critical care have driven increasing use of laparoscopy in trauma. Initially limited to diagnostic purposes in penetrating anterior abdominal stab wounds, it is now employed for both diagnostic and therapeutic management of penetrating and blunt injuries in hemodynamically stable patients [6].

Early concerns focused on potential missed injuries and prolonged operative times. However, more recent observational studies and meta-analyses suggest that, in selected patients, laparoscopy may reduce non-therapeutic laparotomy and postoperative morbidity without compromising patient safety [7]. Updated trauma guidelines and consensus statements now explicitly consider a "laparoscopy-first" approach in stable patients [8].

Given rapid evolution of the field and multiple recent high-quality publications, we undertook a systematic review of the literature from the last five years focusing on the effectiveness and safety of laparoscopy for both penetrating and blunt abdominal trauma, incorporating large-scale studies and illustrative case reports.

Aim

The aim of this study was to systematically review contemporary evidence regarding the effectiveness and safety of laparoscopy in the management of penetrating and blunt abdominal trauma, including case reports published over the last five years.

Materials and methods

This review was conducted in accordance with the PRISMA 2020 (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) recommendations. All major PRISMA components including the structured research question, predefined eligibility criteria, explicit search strategy, study selection, data extraction, and risk-of-bias assessment, were addressed.

The inclusion criteria for this study involved patients presenting with abdominal trauma encompassing both penetrating and blunt mechanisms across adult and pediatric populations. A critical eligibility criterion was the patient's hemodynamic status, with a primary focus on individuals who were stable or stabilized. Studies containing mixed populations were admissible only if the outcomes specific to the laparoscopic intervention were distinctly reported or if the cohort was predominantly composed of stable patients. The required intervention involved the application of laparoscopy (either diagnostic or therapeutic, conventional or single-incision) as a component of the initial operative management.

Comparisons were established against several treatment modalities, including open laparotomy, non-operative management (NOM), and historical control groups where feasible. Additionally, single-arm series evaluating the efficacy of laparoscopy were incorporated to broaden the analysis.

Study designs included systematic reviews, meta-analyses (for context), prospective or retrospective cohort studies, registry analyses, case-control studies, case series, and individual case reports detailing the laparoscopic management of traumatic abdominal injuries.

Publications were analyzed for the period from November 2020 to November 2025. Earlier studies were considered only when included within recent meta-analyses or international guidelines.

The primary outcomes were defined as the rate of non-therapeutic laparotomy (or avoided laparotomy), missed intra-abdominal injuries, postoperative complications (overall and major), conversion rate from laparoscopy to laparotomy, length of hospital stay (LOS), and in-hospital or 30-day mortality. Secondary outcomes included operative time, intensive care unit stay, readmission rates, and cost-effectiveness where data were available.

Exclusion criteria were animal or purely experimental studies, non-trauma laparoscopy (elective cholecystectomy), purely thoracoscopic or robotic procedures unless combined with abdominal laparoscopy, commentaries, letters without original data, and abstracts without available full text.

Electronic searches were performed in PubMed / MEDLINE, Embase, Scopus, Web of Science, Cochrane Library, and Google Scholar. The core PubMed strategy (adapted for other databases) utilized a combination of MeSH and free-text terms: ("laparoscopy" [MeSH] OR laparoscop* OR "minimally invasive") AND ("abdominal injuries" [MeSH] OR abdom* OR injur* OR wound* OR stab* OR shot* OR shoot* OR lacerat* OR trauma*) AND (penetrat* OR blunt*). Filters for publication date (last five years), human studies, and English language were applied. Reference lists of relevant articles and recent reviews were screened for additional eligible studies.

Table 1. Characteristics of the included studies (2021–2025)

Study category	Study reference	Sample size, n
Systematic reviews / meta-analyses (abdominal trauma)	Y. J. Ki et al. (2021) – meta-analysis of laparoscopy for blunt abdominal trauma [7]	19 studies, 1,520 patients
	J. Wang et al. (2022) – meta-analysis comparing laparoscopy vs laparotomy for blunt and penetrating abdominal trauma (multiple observational studies) [10]	64 studies, 2594 patients
	Y. Alalawi et al. (2025) – systematic review of penetrating abdominal trauma comparing laparoscopy with laparotomy [11]	5 studies, 211 patients
Narrative guidelines / reviews	Global narrative review on laparoscopy, thoracoscopy and robotics in trauma (J. Victory et al., 2025) [12]	64 studies, 9058 patients
	Narrative review on single-incision trauma laparoscopy (S. Jeon, K. K. Choi, 2025) [13]	n/a
	WSES / consensus "laparoscopy-first" guidelines for emergencies and trauma (Cesena guidelines, 2023) [14]	323 studies, 9817 patients
Cohort and registry studies (blunt and mixed trauma)	Multicenter Japan Trauma Data Bank study on blunt abdominal trauma laparoscopy (K. Omoto et al., 2024) [15]	1301 patients
	Retrospective analysis of laparoscopic surgery in blunt trauma (R. Alyami et al., 2025, BMC Surgery) [16]	32 patients
	Role of laparoscopy in patients with abdominal trauma (N. Alzarouni et al., 2022) [17]	74 patients
	Role of laparoscopic surgery in managing hemodynamically stable abdominal trauma patients: a single level I trauma center, propensity score matching study (D. H. Kim et al., 2024) [18]	128 patients
Case reports / case series	Laparoscopic colon resection with primary anastomosis for combat-related penetrating thoracoabdominal trauma (Iu. O. Mikheiev et al., 2025) [19]	1 patient
	Laparoscopic repair of a traumatic diaphragmatic rupture (C. M. Pesch et al., 2024) [20]	1 patient
	Laparoscopic Repair of Ileal Perforation Post Blunt Abdominal Trauma (M. M. Elgeldawy et al., 2025) [21]	1 patient
	Laparoscopic exploration for a thoracoabdominal gunshot wound and retrieval of a wandering bullet (K. Abu Aagla et al., 2024) [22]	1 patient
	Surgical tactics in fire kidney injury and the first experience in performing laparoscopic nephrectomy in combat conditions: Case report (K. Gumeniuk et al., 2023) [23]	1 patient

Titles and abstracts were screened for relevance, and potentially eligible full texts were assessed against the inclusion criteria. Systematic reviews/meta-analyses were included for context and effect estimates; primary data from included trials were not re-extracted individually if fully captured in a recent meta-analytic synthesis.

For comparative non-randomized studies, the risk of bias was qualitatively assessed using the ROBINS-I tool domains (confounding, selection of participants, classification of interventions, deviations from intended interventions, missing data, outcome measurement, and reporting) [9].

Case reports and series were appraised for the clarity of case description, appropriateness of indication, technical feasibility, complications, and follow-up data.

Given the heterogeneity in design and reporting, a narrative synthesis was performed rather than a *de novo* meta-analysis.

Results

The body of evidence evaluated for this analysis, spanning the last five years, is strategically structured to capture the full spectrum of methodological rigor, consistent with the accepted hierarchy of evidence. The characteristics of the included studies are summarized in *Table 1*.

Across these sources, the vast majority of patients undergoing trauma laparoscopy were hemodynamically stable or stabilized, often presenting with equivocal CT findings or suspected hollow-viscus or diaphragmatic injuries.

Regarding the assessment of study quality and risk of bias: all primary trauma studies were non-randomized, predominantly retrospective consisting of retrospective single-center cohorts, while a minority were prospective observational cohorts or registry-based analyses. Confounding by indication and selection bias were prevalent, as laparoscopy was preferentially offered to stable patients with fewer associated injuries. Outcome assessments for complications and mortality were generally robust and derived from verified hospital records. Although the included case reports have inherently limited generalizability, they provided detailed technical descriptions and clinical insights.

Overall, the certainty of evidence, evaluated using a GRADE-informed approach, ranges from low to moderate for most comparative outcomes. However, this certainty is strengthened by the high degree of consistency across multiple large-scale datasets and meta-analyses.

Effectiveness and safety outcomes

Laparoscopy vs. laparotomy (all abdominal trauma). The 2022 systematic review and meta-analysis by J. Wang et al. pooled observational data comparing laparoscopy with laparotomy for both blunt and penetrating abdominal trauma [10]. Laparoscopy was associated with lower postoperative complication rates (including wound infections), a shorter LOS, and lower rates of non-therapeutic laparotomy (NTL), reflecting its efficacy in ruling out significant injury. No significant differences were observed in mortality or missed-injury rates compared with laparotomy.

While operative time tended to be slightly longer for laparoscopy in several series, this was offset by the reduction in complications and LOS. Subsequent single-center cohorts and registry analyses published after 2022 have generally confirmed these findings, indicating no increase in mortality or catastrophic missed injuries when laparoscopy is applied to hemodynamically stable, carefully selected patients [15].

Blunt abdominal trauma. The 2021 meta-analysis by Y. J. Ki et al. [7], which included 19 studies and 1,520 patients, focused specifically on blunt abdominal trauma. In hemodynamically stable patients, laparoscopy was associated with reduced NTL rates, lower overall morbidity, and a shorter hospital stay, while maintaining very low missed-injury rates and acceptable conversion rates.

Subsequent single-center and multicenter studies from 2022 to 2025 have further extended these findings. Alyami R. et. al. (2025, BMC Surgery, 74 blunt trauma patients managed laparoscopically) reported that laparoscopy in stable patients with blunt abdominal trauma was safe and feasible, with conversion required mainly for complex injuries and no increase in mortality [16]. Similarly, J. N. Fu et. al. (2023, Heliyon), con-

cluded that laparoscopic diagnosis and treatment provided high diagnostic accuracy and rapid recovery, supporting its wider adoption in blunt trauma management [24]. Rayan Y. et. al. (2024), also reported shorter LOS and fewer wound complications in laparoscopic groups compared to laparotomy, with comparable safety outcomes, rates of missed injury and mortality [25]. Furthermore, a Japan Trauma Data Bank analysis (K. Omoto et al., 2024/2025) showed that in hemodynamically stable patients, laparoscopic intervention for blunt injury did not increase in-hospital mortality and was feasible across multiple centers [15].

Collectively, these data support laparoscopy as a safe and effective modality for the evaluation and treatment of blunt trauma in stable patients, particularly when CT findings are equivocal or hollow-viscus injury is suspected.

Case reports have further expanded the spectrum of managed conditions, including two recent publications [21,26] that highlight the technical feasibility of laparoscopy for complex sequelae such as small bowel perforations and diaphragmatic injuries, provided there is timely diagnosis and stable physiology.

Penetrating abdominal trauma. Several studies, particularly from high-volume trauma centers, have evaluated the utility of laparoscopy in penetrating abdominal trauma (PAT). Alzarouni N. et al. (Rashid Hospital, 2022) reported on a mixed trauma cohort with a significant penetrating component, demonstrating that diagnostic laparoscopy reduced NTL rates by approximately 19.4 %. Notably, no missed injuries were reported in the laparoscopic group, and both complication rates and LOS were significantly lower compared to open exploration [17].

A 2025 systematic review by Y. Alalawi et al. [11], which focused specifically on PAT, found that compared with laparotomy, laparoscopy in stable patients was associated with shorter hospital stays, faster recovery, fewer overall complications, and reduced healthcare costs. Furthermore, no increase in mortality or missed injuries was observed when the procedures were performed by experienced surgical teams.

Contemporary narrative resources and clinical databases (StatPearls) concur that laparoscopy is feasible for managing stable patients with penetrating injuries. It is associated with lower odds of mortality and morbidity compared to laparotomy, with missed-injury rates now reported at <1 % in expert centers [27].

Case reports regarding combat and penetrating trauma provide insights into complex, high-risk scenarios. Ukrainian military surgeons have documented successful laparoscopic interventions for gunshot wounds to the kidney [23] and laparoscopic resection of the transverse colon with intracorporeal stapled anastomosis [19]. Similarly, laparoscopic repair of penetrating diaphragmatic ruptures and other thoracoabdominal injuries has been associated with shorter recovery times compared to traditional open approaches [20].

Although limited to individual case experiences, these reports suggest that in well-resourced settings with skilled surgeons, even complex ballistic injuries can be addressed via minimally invasive or hybrid techniques, with conversion to laparotomy performed when necessary.

Single-incision and advanced minimally invasive techniques. A 2025 narrative review by S. Jeon & K. K. Choi summarized the evidence for single-incision laparoscopy in abdominal trauma. The authors concluded that while single-incision approaches are technically feasible for selected stable patients, they should currently be confined to centers with advanced MIS expertise and are not yet considered the standard of care [13].

Robotic-assisted surgery has also been reported in isolated cases, such as the repair of traumatic diaphragmatic hernias. However, it remains experimental in the acute trauma setting due to significant cost, time constraints, and logistical challenges [28].

Safety profile: complications, missed injuries, conversions. Complication rates in laparoscopic cohorts were consistently lower than those in laparotomy groups, particularly regarding wound infections and pulmonary complications [10].

Missed-injury rates were minimal (frequently reported as 0 %) in experienced centers; meta-analyses have found no statistically significant difference in missed injuries between laparoscopy and laparotomy when standardized exploration protocols are followed [7].

Conversion rates varied widely, ranging from 10 % to 30 %, reflecting differences in case-mix and institutional thresholds. Conversions were generally driven by the discovery of complex injuries, bleeding, or inadequate visualization rather than technical failures or iatrogenic complications [17].

Finally, mortality rates did not differ significantly between laparoscopic and open cohorts after adjusting for baseline injury severity; registry data suggest that in appropriately selected stable patients, laparoscopy does not increase the risk of in-hospital mortality [15].

Discussion

Over the last five years, evidence from meta-analyses, multicenter registries, and single-center cohorts has converged on several key points. Laparoscopy is safe and effective for hemodynamically stable abdominal trauma patients (both penetrating and blunt) when performed in specialized centers. It significantly reduces the rate of NTL, a historical challenge, particularly in penetrating trauma, thereby decreasing postoperative morbidity and shortening the LOS [17]. Missed-injury rates are notably low and comparable to laparotomy, provided that a systematic exploration is performed, and strict indications/contraindications are observed [7]. Mortality rates have not increased and appear lower in certain adjusted analyses, although this likely reflects the selection of less severely injured patients for minimally invasive approaches [15]. Case reports and small series further demonstrate that technically demanding procedures, such as diaphragmatic repair, hollow viscus resection, colon resection, nephrectomy, and foreign body (bullet) removal, can be safely performed laparoscopically in a trauma setting, though these should be reserved for highly experienced surgical teams [19,20,22,23].

Comparison with existing guidelines and reviews. Narrative reviews and international guidelines [8] increasingly endorse a “laparoscopy-first” strategy for stable trauma patients where resources permit. These guidelines highlight its utility in assessing peritoneal violation in stab and gunshot wounds; evaluating equivocal CT findings in blunt trauma

(specifically suspected hollow viscus injury); diagnosing and treating diaphragmatic injuries; and facilitating minimally invasive repair while avoiding unnecessary open surgery.

Our findings align closely with these recommendations and provide additional contemporary data, particularly from the Japanese registry and recent retrospective cohorts, that reinforce the safety and utility of laparoscopy in blunt trauma management.

Clinical implementation summary. Laparoscopic intervention is indicated for hemodynamically stable patients with suspected penetrating or blunt abdominal trauma when imaging is inconclusive, or when there is a clinical suspicion of diaphragmatic injury, hollow viscus perforation, or a need to confirm peritoneal integrity.

Absolute and relative contraindications include hemodynamic instability, uncontrolled hemorrhage, significant bowel distension, or severe concomitant thoracic trauma that precludes the creation of a pneumoperitoneum. In the latter case, the risk of tension pneumothorax can be mitigated by prior chest tube drainage of the pleural cavity [19]. A lack of specialized equipment or skilled surgical and anesthesia personnel also remains a primary contraindication.

Critical technical aspects include the requirement for a systematic four-quadrant exploration of the abdominal cavity using atraumatic techniques. Surgeons must maintain a low threshold for conversion to laparotomy in the event of unsatisfactory visualization or patient physiological deterioration. Institutional protocols are essential to ensure the safe and standardized application of these techniques.

The primary limitations of the current evidence base include the non-randomized nature of clinical comparative data, which introduces inherent confounding factors and selection biases. Furthermore, there is limited generalizability of results from high-volume specialized centers to resource-limited settings. Significant heterogeneity in indications, surgical methods, and outcome definitions across studies continues to hinder robust quantitative data synthesis (meta-analysis).

Conclusions

1. Current evidence strongly supports the clinical role of laparoscopy in the management of both penetrating and blunt abdominal trauma in hemodynamically stable patients.

2. The implementation of laparoscopy in trauma significantly reduces the rates of non-therapeutic laparotomies and postoperative complications while effectively shortening hospital stays.

3. Laparoscopy is associated with exceptionally low rates of missed injuries and mortality when performed by experienced surgical teams and contingent upon rigorous patient selection.

Prospects for further research. Future research should prioritize prospective multicenter registries and, where feasible, pragmatic randomized or stepped-wedge trials comparing standardized laparoscopy-first algorithms against conventional pathways, particularly in blunt trauma and mixed injury patterns.

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