

Laparoscopy Vs Open Study for Abdominal Injuries

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Abstract

Background: Abdominal injuries, resulting from both blunt and penetrating mechanisms, constitute a major source of emergency surgical admissions and critical morbidity globally. While conventional exploratory laparotomy has long served as the standard diagnostic and therapeutic approach, it is frequently limited by high rates of non-therapeutic laparotomies (NTL) and notable wound-related or pulmonary complications. Diagnostic and therapeutic laparoscopy has evolved as a minimally invasive alternative aimed at mitigating these interventions. This study presents a prospective observational evaluation of clinical outcomes, operative metrics, and postoperative complication profiles between laparoscopic evaluation and open exploration for abdominal trauma managed at a single tertiary care center. **Material and Methods:** A prospective observational study was conducted on 30 adult patients presenting with blunt or penetrating abdominal trauma who were hemodynamically stable and required surgical evaluation. Patients were partitioned into two cohorts based on the executed surgical approach determined by injury characteristics and clinical protocol parameters (hemodynamically stable patients with a negative or equivocal Focused Assessment with Sonography for Trauma (FAST) or CT scan suspected of isolated peritoneal violation/diaphragmatic injury were planned for laparoscopic evaluation, while patients presenting with immediate evisceration, severe haemorrhage, peritonitis, or macroscopic bowel perforation on imaging were managed via open laparotomy): Laparoscopic Trauma Evaluation/Repair (n = 18) and Open Exploratory Laparotomy (n = 12). Intraoperative parameters (measured from skin incision to skin closure), postoperative complications, length of hospital stay, and rates of missed injury or negative exploration were tracked. Statistical evaluation utilised Student's t-test for continuous metrics and Fisher's exact test for categorical proportions. **Results:** The study population (N = 30) exhibited a mean age of 32±9 years with a definitive male predominance (21 males, 9 females). The baseline presentation consisted of 16 blunt abdominal injuries (53.3%) and 14 penetrating injuries (46.7%), with stab wounds representing the majority of penetrating mechanisms. Laparoscopic management demonstrated a statistically significant reduction in mean operative duration compared to the open laparotomy cohort. Furthermore, the laparoscopic approach significantly decreased the mean postoperative hospital stay to 2-4 days compared to 8-10 days in the open surgery. The overall complication incidence across the study was 26.7% (n = 8). Strikingly, the laparoscopic group experienced only 1 complication (1/18, 5.6%), which manifested as a localized port-site infection. Conversely, 7 complications occurred within the open laparotomy cohort (7/12, 58.3%), representing a statistically lower early localized and systemic morbidity profile for the laparoscopic arm (p = 0.002). At the conclusion of the follow-up period, there were zero missed injuries (0%) or delayed presentations across either surgical cohort. **Conclusion:** Laparoscopic evaluation and repair for abdominal trauma represents a safe, highly effective, and clinically superior alternative to conventional exploratory laparotomy in hemodynamically stable patients. It provides statistically sound advantages by substantially decreasing skin-to-skin operative duration, reducing the post-surgical hospital footprint, minimising non-therapeutic laparotomies, and significantly reducing wound-related morbidity.

Keywords: Abdominal Trauma, Blunt Injury, Penetrating Trauma, Laparotomy, Diagnostic Laparoscopy, Non-Therapeutic Laparotomy, Wound Infection, Trauma Management.

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INTRODUCTION

Abdominal trauma includes blunt (often from road traffic accidents or falls) and penetrating (mainly stab and gunshot wounds) trauma and is a major cause of morbidity and mortality in the young to middle aged population worldwide. The accepted approach to manage a ruptured and/or suspected ruptured vascular and/or visceral disruption is to perform immediate exploratory laparotomy in the midline. Historically, the accepted approach to manage a ruptured and/or suspected ruptured vascular and/or visceral disruption has been to perform immediate exploratory laparotomy in the midline. Laparotomy offers the greatest exposure for damage control surgery but has a high clinical tax. In the past, non-therapeutic laparotomy (NTL) has been experienced in up to

40% of cases in trauma patients with seemingly normal laparotomies, however, it poses significant surgical stress, incisional hernias, chronic small bowel obstruction from adhesions, and major surgical complications.

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Non-operative protocols have been refined successfully with the use of advanced imaging modalities, such as multi-detector Computed Tomography (CT) and Focused Assessment with Sonography for Trauma (FAST). Imaging, however, is often inadequate for the diagnosis of diaphragmatic laceration, hollow viscus perforation or small mesenteric tears which can result in delayed diagnosis and ultimately in catastrophic peritonitis or sepsis. Recent advances in minimally invasive interventions have created an alternative path in the last 30 years. The last decade has witnessed the shift of Laparoscopic management in trauma from a purely diagnostic instrument developed to distinguish if there was violation of the peritoneum with tangential stab wounds, to a definitive therapeutic option. The use of "laparoscopic-first" philosophy is growing more popular in the treatment of hemodynamically stable trauma patient, in line with the guidelines issued by World Society of Emergency Surgery (WSES). Laparoscopy allows for high-definition panoramic visualization of the anterior and posterior surfaces of the lungs, the entire surface of the abdomen, and the surface of the deep pelvis, areas in which mobility of the tissue can, in open surgery, be excessive and destabilising. The advantages of this minimally invasive technique include less disruption to the abdominal wall musculature, decreased surgical site infections, quicker hospital stays and lower rates of return to baseline functional status.

To directly assess and compare the clinical outcomes, surgical efficiency and complication rates of these two types of operations for laparoscopic evaluation/repair versus conventional exploratory open laparotomy within our clinical population, following patient selection via hemodynamic stability, and with abdominal clearance ranging in a systematic fashion.

MATERIALS AND METHODS

Study Design and Setting: This prospective observational study was carried out within the Department of General Surgery at Hindu Rao Hospital, Delhi, India. The clinical protocol tracked adult patients presenting with acute blunt or penetrating abdominal trauma who were sequentially admitted and prepared for surgical intervention over an institutional window spanning from March 2025 through May 2026.

Participant Selection and Sample Size: A cohort of 30 consecutive adult patients meeting all eligibility mandates was enrolled. The allocation of patients to either the laparoscopic or open cohort was strictly determined based on physiological stability, Advanced Trauma Life Support (ATLS) presentation parameters, and pre-operative imaging findings. Standard pre-operative planning dictated that hemodynamically stable patients with suspected isolated peritoneal violation, indeterminate CT/FAST imaging, or high risk for occult diaphragmatic/hollow viscus laceration were assigned to laparoscopic exploration. Conversely, patients presenting with immediate hemodynamic instability unresponsive to fluid/blood resuscitation, evisceration of hollow viscera, frank peritonitis, or definitive imaging

evidence of major vascular or severe solid organ disruption were planned directly for open midline exploratory laparotomy.

Inclusion Criteria

Patients aged >18 years presenting within 24 hours of blunt or penetrating abdominal trauma, demonstrating initial hemodynamic stability (systolic blood pressure > 90 mmHg and heart rate < 110 bpm), or maintaining stability following initial fluid resuscitation, deemed physically fit to undergo standard general anesthesia.

Exclusion Criteria

Patients in profound, refractory hemorrhagic shock requiring immediate resuscitative damage control laparotomy; patients with severe concurrent traumatic brain injury or severe craniofacial trauma preventing reliable monitoring; and individuals who demonstrated incomplete or non-compliant follow-up records.

Surgical Techniques and Procedures

Laparoscopic Trauma Evaluation and Repair: Under standard endotracheal general anesthesia, patients were placed in a supine position. Intravenous broad-spectrum cephalosporins were administered within 60 minutes of skin incision. Pneumoperitoneum was established cautiously utilising a closed Veress needle approach at the infra-umbilical or Palmer's point to maintain a constant intra-abdominal pressure of 11–12 mmHg, carefully monitoring for gas embolism or sudden tension pneumothorax in cases of potential diaphragmatic defects. A standard multi-port configuration was utilised: a 10 mm umbilical camera port combined with two or three 5 mm working ports in the right and left upper quadrants or iliac fossae to achieve optimal triangulation.

The operating surgeon systematically inspected the abdominal cavity, aspirating free fluid, blood, or bile. Complete exploration was executed by inspecting both hemidiaphragms, the liver capsule, the spleen, and the anterior gastric wall. Using atraumatic graspers in a sequential cross-handed technique, the entire small bowel was "run" from the ligament of Treitz to the ileocecal valve. The colon, retroperitoneum, and pelvic organs were similarly surveyed. When minor therapeutic intervention was required, it was performed laparoscopically: Small serosal tears or stable mesenteric bleeders were controlled with electrocautery or hemoclips. Favourable hollow viscus lacerations were closed using intracorporeal continuous delayed-absorbable sutures. Diaphragmatic defects were repaired using heavy non-absorbable horizontal mattress sutures.^[1] For intermediate injuries requiring localised resection, a laparoscopy-assisted approach (mini-laparotomy via a slightly extended port site) was used to exteriorise the loop, keeping tissue disruption minimal. Complete hemostasis was verified under direct vision, the abdominal cavity was deflated, and port sites were securely closed in layers.

Open Exploratory Laparotomy: The open cohort underwent standard emergent exploratory laparotomy via a long midline incision. Following rapid abdominal entry, immediate packing of all four quadrants was executed if severe bleeding was encountered. Standard systematic exploration of all intra-abdominal organs, mesenteric axes, and retroperitoneal zones was completed. Complex repairs, including continuous running bowel anastomoses, bowel resections,^[2] splenectomy, or hepatic packing, were performed as dictated by the injury profile.

Following irrigation, closure was executed using continuous heavyweight loop sutures for the fascial architecture, and subcutaneous close-suction drains were placed when massive contamination or dead space was present.

Statistical Evaluation and Data Variables: The primary clinical endpoints included: total operative duration—strictly measured from initial skin incision to final skin closure (skin-to-skin duration); total duration of postoperative hospital stay (measured in days); immediate and early postoperative complications (stratified into surgical site wound infection, intra-abdominal abscess, pneumonia, prolonged postoperative ileus, and incisional dehiscence); and the incidence of missed injuries or negative/non-therapeutic laparotomies. Continuous variables were summarized as Mean \pm Standard Deviation (SD), while categorical variables were evaluated as absolute values and percentages. Statistical comparative analysis between the laparoscopic and open arms was executed using specialised testing frameworks. For continuous variables (operative duration and hospital stay), the standard Student's t-test was utilised. For categorical proportions (complication incidence and cohort distributions), Fisher's exact test was performed due to its

high precision in small sample cohorts (N = 30). A two-tailed p-value of < 0.05 was defined as the threshold for statistical significance.

Baseline Demographics and Clinical Presentations: The study population (N = 30) comprised 21 males (70.0%) and 9 females (30.0%), reflecting a standard trauma demographic profile dominated by younger males.^[3] The cohort exhibited a young distribution with a mean age of 32 ± 9 years (range: 19–58 years). The primary mechanism of injury was evenly split between blunt abdominal trauma (n = 16, 53.3%) and penetrating injuries (n = 14, 46.7%). Road traffic accidents (RTAs) were the primary source of blunt trauma,^[3] while stab wounds accounted for the majority of penetrating injuries, supplemented by two low-velocity gunshot wounds. Following implementation of the protocol selection criteria, the distribution yielded n = 18 patients in the Laparoscopic cohort and n = 12 patients in the Open Laparotomy cohort. Crucially, within the laparoscopic arm, 10 patients presented with penetrating stab wounds (where laparoscopy was utilized to assess peritoneal violation) and 8 patients presented with blunt deceleration injuries. The cross-tabulation of injury mechanisms across the two surgical arms is broken down in [Table 1].

Table 1: Injury Mechanism Cross-Tabulation

Injury Mechanism Type	Laparoscopic Approach (n=18)	Open Surgical Approach (n=12)	Combined Total (N=30) / %
Blunt trauma (RTA/ fall)	08	08	16 (53.3%)
Penetrating stab wound	10	02	12 (40.0%)
Penetrating gunshot wound	00	02	02 (6.7%)
Total (n)	18	12	30 (100.0%)

RESULTS

Comparative Intraoperative and Postoperative Metrics: Analysis of the raw data ledger revealed distinct, statistically significant divergences between the laparoscopic and open arms regarding both skin-to-skin operative duration and subsequent post-surgical recovery timelines.

Operative Duration (Skin-to-Skin): The laparoscopic cohort (n = 18) demonstrated a consistently shorter skin-to-skin operative footprint. Among the 18 cases, 11 were purely diagnostic explorations that confirmed intact peritoneum or minor non-bleeding serosal tears, requiring an average of only 35 minutes. The remaining 7 cases required minor therapeutic interventions (including 3 laparoscopic diaphragmatic repairs, 2 seromuscular bowel suturing, and 2 laparoscopy-assisted segmental small bowel exteriorisation repairs), which brought the overall mean laparoscopic operative time to 42.5 ± 8.4 min (range: 30–65 minutes). Conversely, the open midline laparotomy cohort (n = 12), which involved extensive layered abdominal wall opening and meticulous closing, demonstrated a mean operative time of 74.2 ± 14.6 minutes (range: 55–110 minutes). Standard Student's t-test analysis revealed that this reduction in procedural time in favour of the laparoscopic approach was highly significant statistically (t = -7.42, p < 0.001).

Length of Hospital Stay: The minimally invasive group had significantly shorter hospital convalescence after the surgery. In contrast, the laparoscopic arm had a significantly shorter hospital stay of 2.4 ± 0.6 days (median: 2 days; range: 2–4 days) [4]. The recovery time for the open laparotomy group

was however significantly longer with a mean hospital duration of 6.8 ± 1.8 days (range 4–12 days, median 6 days) [4]. Analyzing the decreased length of stay in the laparoscopic group with the Student's t-test, the result was extremely significant (t = -9.18, p < 0.001).

Comprehensive Complication Analysis: Finally, the overall complication rate for the entire study population was 26.7% (8 different patients out of 30 patients). The distribution of these complications, however, was significantly different between the cohorts, and were assessed using Fisher's exact test to obtain statistical validity.

Laparoscopic Arm Complications: The laparoscopic group had an extremely low complication rate of 1/18 or 5.6%. In this single case, localized infection at the camera port site (slashed 10 mm) was treated with oral antimicrobial titration and use of a localized dressing care and was resolved without intra-peritoneal drainage. No cases of delayed intra abdominal haemorrhage, no hollow viscus injury could be missed, no deep organ space abscess and no postoperative pneumonia were recorded. With careful patient selection, the cohort of patients did not require conversion to open laparotomy.

Open Arm Complications: A total of 7 documented post-surgical complications occurred within the open laparotomy arm (n = 12), resulting in an intra-cohort morbidity rate of 58.3% (7/12). The precise tracking of these events from the clinical records is detailed below:

- **Prolonged Postoperative Ileus (n = 2):** Developed in two patients following extensive small bowel handling and retroperitoneal exploration. These cases resolved fully with

conservative nasogastric decompression and intravenous fluid support over extended hospital stays.

- **Superficial Surgical Site Infection (n = 3):** Three patients experienced superficial wound dehiscence and active purulent drainage along the midline incision. These required active open wound care, chemical debridement, and tailored antibiotic therapy, extending their hospitalizations to 8–10 days.
- **Postoperative Pneumonia (n = 1):** A 48-year-old male patient experienced significant pain-induced hypoventilation secondary to the long midline upper abdominal incision, culminating in respiratory compromise and confirmed lobar pneumonia. This required targeted intravenous antimicrobial therapy and intensive chest physiotherapy.
- **Deep Organ-Space Abscess (n = 1):** One patient who underwent open repair for a contaminated jejunal perforation developed an inter loop fluid collection on postoperative day 6, which necessitated ultrasound-guided percutaneous drain placement.

To compare the overall complication rate between the two surgical approaches (5.6% in Laparoscopic vs. 58.3% in Open), Fisher's exact test was performed. The two-tailed p-value was calculated at 0.002, establishing that the laparoscopic approach provides a statistically significant benefit in reducing early postoperative morbidity and wound-related or pulmonary occurrences.

DISCUSSION

Contemporary multi-center registries and outcome audits are used to continually improve the surgical selection between the laparoscopy approaches and the open approaches to exploratory laparotomy in trauma care. Given the large number of stable patients with blunt or penetrating abdominal trauma, we show in our prospective study that laparoscopy offers a number of operational advantages (absolute avoidance of unnecessary laparotomy, early reduction of local and systemic morbidity), which are not seen with open surgery.

One important result from our study is that the mean time of skin-skin operative duration was significantly different between the two groups (42.5 vs 74.2 min; $p < 0.001$). An open abdomen exploration to find a pigtail is conceptually straightforward, but the truth is that this procedure requires opening the abdomen in a long vertical midline incision, dealing with bleeding from the abdominal wall, and then closing multiple layers of fascia and skin, which brings into play a significant amount of operative volume. Laparoscopy, on the other hand, requires only small access sites which can be closed within minutes. Injuries that are potentially treatable with a minimally invasive surgical approach (e.g. minor tears in the mesentery, simple liver laceration, diaphragmatic defects) can be treated quickly under high definition visualisation. This is consistent with the recent global surveys conducted by Mikheiev et al. 2026,^[5] who reported that the laparoscopic methods have significantly reduced the non-therapeutic laparotomy rate, and have shown reduced operative time.

The laparoscopic group also demonstrated a statistically significant decrease in their surgical site and pulmonary complication occurrence reported (5.6% complication rate) compared with the open cohort (58.3% complication rate; $p = 0.002$) in our outcome data. Open laparotomies are also vulnerable to local wound issues,^[5] because of the vast expanse of tissue opened up and the risk of bacterial contamination from abdominal cavity contents and wounds. In addition, large midline vertical upper abdominal incisions will also significantly decrease chest wall compliance and diaphragmatic excursion after surgery as a consequence of pain, which may increase the risk of atelectasis and splinting induced pneumonia. With minimally invasive port placement, abdominal wall mechanics are maintained, which enables optimal postoperative pain management, early mobilization, and pro-active pulmonary clearance. This is confirmed by Victory (2025),^[6] whose work showed laparoscopy dramatically reduces postoperative pneumonia, wound infections and ultimately long-term incisional hernia in trauma patients.^[5]

Perhaps most importantly, 11 of 18 patients in the laparoscopic group were, at the end of the day, found to be undergoing a diagnostic laparoscopy or a non-therapeutic procedure. In an open paradigm, these 11 patients would have sustained a full exploratory laparotomy, facing substantial morbidity for a negative finding. Laparoscopy acted as an effective diagnostic filter, preventing the trauma of an open incision while providing definitive visual proof of an intact peritoneum or self-limiting injury.

A major historical critique of laparoscopy in trauma has been the risk of missed hollow viscus injuries, particularly along the mesenteric borders of the small intestine or the posterior aspect of the stomach. However, our series achieved a 0% missed injury rate, a result attributed to our rigid adherence to a structured, systematic exploration protocol where the bowel is completely "run" link-by-link using a double-handed technique, paired with appropriate case selection limited to hemodynamically stable individuals.

CONCLUSION

This prospective observational study demonstrates that laparoscopic evaluation and repair for abdominal injuries provides significant clinical advantages over conventional open exploratory laparotomy for well-selected, hemodynamically stable patients presenting with blunt or penetrating trauma. Laparoscopic management led to a substantial reduction in skin-to-skin operating times, a shortened hospital convalescence footprint, and a significantly lower rate of early wound-related and pulmonary complications ($p = 0.002$). Adhering to key technical principles—specifically a rigid protocol of systematic abdominal clearance, direct visualization of the diaphragmatic surfaces, and selecting cases based strictly on hemodynamic stability - is essential for maximizing diagnostic precision, avoiding unnecessary open laparotomies, and ensuring favourable intermediate-term clinical outcomes.

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Conflicts of interest

There are no conflicts of interest.

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