European Journal of Clinical Pharmacy
Print ISSN: 2385-409X **Online ISSN**: 3105-0409
Website: https://farmclin.com/

Original Research Article

Comparison of Non-Operative Vs Minimally Invasive Management in Stable Patients with Penetrating Abdominal Trauma

Article History:

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Received: 02-12-2025
Revised: 12-12-2025
Accepted: 23-12-2025
Published: 26-12-2025

Abstract: ***Background***: Penetrating abdominal trauma in hemodynamically stable patients is now increasingly managed selectively rather than with routine mandatory laparotomy. ***Objective***: To compare non-operative management and minimally invasive management in stable patients with penetrating abdominal trauma, focusing on diagnostic accuracy, therapeutic success, complication rates, and hospital resource utilization. ***Methods***: A comparative observational study was conducted at Bahawal Victoria Hospital Bahawalpur from October 2024 to October 2025 on 155 hemodynamically stable patients presenting with penetrating abdominal trauma. Patients were managed either non-operatively using structured serial examinations and imaging or with minimally invasive diagnostic and therapeutic laparoscopy, based on clinical criteria and institutional protocol. ***Results***: Out of 155 patients, 88 underwent non-operative management, with 68 achieving successful observation (77.3%) and 20 requiring delayed surgical intervention (22.7%). Minimally invasive management was performed in 67 patients, with successful completion in 53 (79.1%) and conversion to laparotomy in 14 (20.9%). Diagnostic accuracy was 77.3% in the non- operative group and 94% in the minimally invasive group. Complication rates were highest among non-operative failures (65%) compared with minimally invasive management (31.3%). Hospital stay was shortest in successful non-operative patients (mean 2.9 ± 1.1 days), followed by minimally invasive patients (4.1 ± 1.6 days), and longest in non-operative failures (6.8 ± 2.3 days). No mortality occurred, and the overall missed injury rate was 1.9%. ***Conclusion***: Non-operative and minimally invasive management are both safe and effective in hemodynamically stable penetrating abdominal trauma when guided by careful patient selection and close monitoring

Keywords Patients, SNOM, Abdominal, Trauma, Laparotomy, Management.

INTRODUCTION

Penetrating abdominal trauma remains one of the most rapidly evolving domains in acute care surgery, and honestly, it's wild how much has changed in just a few decades [1]. Patients with penetrating abdominal stab injuries who are hemodynamically stable and have no signs of evisceration or diffuse peritonitis are selected for conservative management. Selective non-operative management (SNOM) shortens the hospital stay length, reduces the rate of non-therapeutic laparotomy, and decreases morbidity and mortality of the patients [2]. The keystone of SNOM is to balance between

unnecessary laparotomy and the missed injury morbidity. This could be achieved by close observation for the patient clinical condition, and laboratory and radiological data. Any critical alteration should urge re-assessment for potential laparotomy requirement [3]. An observation period of at least 24 h is recommended by recent

literature. Minimally invasive surgery, meanwhile, has stepped into the spotlight as a compelling alternative when uncertainty remains [4]. Diagnostic laparoscopy is no longer reserved for highly selective cases; instead, it is increasingly used as a first-line tool in stable patients with equivocal findings [5]. Its appeal lies in its versatility: surgeons can inspect the diaphragm, bowel loops, mesentery, retroperitoneum, and liver with magnified visualization, allowing for rapid identification of clinically important but radiographically subtle injuries [6]. Moreover, therapeutic interventions such as controlling minor bleeding, repairing diaphragmatic defects, and managing isolated bowel injuries can often be completed laparoscopically without escalating to open surgery [7]. This blurs the line between diagnosis and treatment, placing laparoscopy at a strategic intersection between non-operative observation and full surgical exploration [8]. Despite these advances, the global evidence remains fragmented. Many trauma systems, especially in low- and middle-income countries, lack routine access to advanced imaging, structured observation units, or surgeons trained in minimally invasive trauma techniques [9]. In such settings, the threshold for operative intervention may be higher or lower depending on local expertise and resources. Even in high-resource environments, controversies persist around specific injuries like anterior abdominal stab wounds, tangential gunshot injuries, or suspected hollow-viscus trauma [10-12]. These scenarios continue to test the limits of SNOM because the clinical course can quietly deteriorate if injuries are missed [13]. Critics argue that over-reliance on non-operative protocols may delay necessary management, leading to complications such as sepsis, abscess formation, and longer hospital recovery. Conversely, proponents of SNOM argue that with precise imaging and vigilant monitoring, the risk of missing significant pathology is extremely low [14].

OBJECTIVE

To compare non-operative management and minimally invasive management in stable patients with penetrating abdominal trauma, focusing on diagnostic accuracy, therapeutic success, complication rates, and hospital resource utilization.

METHODOLOGY

This comparative, observational study was conducted at Bahawal Victoria Hospital Bahawalpur from October 2024 to October 2025. A total of 155 hemodynamically stable patients with penetrating abdominal trauma were included. A non-probability consecutive sampling technique was used. Patients of either gender aged 16 years and above; hemodynamically stable at presentation (systolic blood pressure ≥ 90 mmHg without vasopressor support); presenting with penetrating abdominal trauma caused by stab wounds, low-velocity gunshot injuries, or impalement injuries; and able to undergo CT imaging or diagnostic laparoscopy as per protocol. Stability was confirmed after initial resuscitation to rule out transient responders. Patients with hemodynamic instability requiring immediate laparotomy; evisceration of bowel or omentum; obvious peritonitis at presentation; associated major thoracic, cranial, or orthopedic injuries impairing serial abdominal examination; prior abdominal surgery limiting laparoscopic visualization; pregnancy; or refusal to participate.

DATA COLLECTION

All patients underwent a standardized trauma evaluation including FAST ultrasound, contrast-enhanced CT scan, baseline laboratory parameters, and mechanism-of-injury assessment. Data were collected using a structured proforma capturing demographics, mechanism of injury, physiological parameters, imaging findings, intraoperative findings (when applicable), interventions performed, postoperative course, length of stay, complications, and need for conversion to laparotomy. Patients were allocated into two groups based on clinical judgment and institutional protocol.

Group A (Non-operative Management): Patients observed with serial abdominal examinations every 2–4 hours, continuous hemodynamic monitoring, repeated labs, and contrast-enhanced CT. NOM was pursued in patients without radiological evidence of hollow viscous injury, diaphragmatic defect, hemoperitoneum requiring intervention, or retained foreign bodies.

Group B (Minimally Invasive Management): Patients underwent diagnostic laparoscopy when CT findings were equivocal, when peritoneal violation was suspected, or when serial examinations raised concern but without clear indication for open surgery.

Laparoscopy was used both diagnostically and therapeutically when possible. For NOM patients, failure was defined as development of peritonitis, new hemodynamic instability, rising inflammatory markers, or worsening CT findings necessitating delayed operative intervention. Primary outcomes included diagnostic accuracy, therapeutic success of each strategy, and rates of missed injuries. Secondary outcomes included complications (infection, bleeding, organ injury), conversion rates, length of hospital stay, morbidity, and mortality. NOM success was defined as completion of observation without surgical intervention, while MIM success was defined as

therapeutic completion without conversion to open surgery.

Data Analysis

All collected data were entered into a secure database and analyzed using SPSS v26.0. Continuous variables, such as age, vital signs, and hospital stay, were summarized as mean and standard deviation, while categorical variables, including success rates, complication frequencies, and need for surgical intervention, were presented as counts and %ages. Independent t-tests and chi-square tests were applied to compare outcomes between the non-operative and minimally invasive management groups, depending on the nature of the variables. Diagnostic accuracy, conversion rates, and failure rates were calculated using descriptive statistics. A p-value of less than 0.05 was considered statistically significant.

RESULTS

Data were collected from 155 patients, mean age of 31.4 ± 9.8 years, with similar age distribution across the non-operative management (NOM) group (30.9 ± 9.5 years) and the minimally invasive management (MIM) group (32.1 ± 10.1 years). Males made up the majority of cases at 79.3%, consistent across both groups. Stab wounds were the most common mechanism of injury overall (64.5%), with similar proportions in NOM (67.0%) and MIM (61.2%), followed by low-velocity gunshot injuries (27.7%) and other mechanisms (7.8%).

Table 1. Baseline Characteristics of the Study Population (n = 155)

Variable	Total (n = 155)	NOM (n = 88)	MIM (n = 67)
Age (years), Mean ± SD	31.4 ± 9.8	30.9 ± 9.5	32.1 ± 10.1
Gender			
Male	123 (79.3%)	69 (78.4%)	54 (80.6%)
Female	32 (20.7%)	19 (21.6%)	13 (19.4%)
Mechanism of Injury			
Stab wound	100 (64.5%)	59 (67.0%)	41 (61.2%)
Low-velocity gunshot	43 (27.7%)	23 (26.1%)	20 (29.8%)
Others (impalement, tools)	12 (7.8%)	6 (6.8%)	6 (9.0%)
Initial SBP (mmHg)	118.3 ± 10.4	118.9 ± 9.8	117.5 ± 11.2
Initial Hemoglobin (g/dL)	12.1 ± 1.4	12.2 ± 1.3	11.9 ± 1.5

NOM was successful in 68 out of 88 patients (77.3%), while 20 patients (22.7%) required escalation to surgery. The most common reasons for NOM failure were delayed recognition of hollow-viscus injury (40%) and progressive hemoperitoneum (30%), followed by rising inflammatory markers or worsening pain (20%), and concerning repeat imaging (10%). Among patients who failed NOM, 85% underwent delayed laparoscopy and 15% required open laparotomy.

Table 2. Outcomes of Non-Operative Management (NOM) (n = 88)

Outcome	n	Percentage (%)
NOM success	68	77.3%
NOM failure	20	22.7%
Reason for NOM failure		
Delayed hollow-viscus injury	8	40.0%

Progressive hemoperitoneum	6	30.0%
Rising inflammatory markers / worsening pain	4	20.0%
Unstable repeat imaging	2	10.0%
Intervention after failure		
Required laparoscopy	17	85.0%
Required open laparotomy	3	15.0%

67 patients managed with MIM, 53 (79.1%) completed laparoscopic management successfully, while 14 patients (20.9%) required conversion to open surgery. Intraoperative findings most commonly included minor hemoperitoneum (31.3%) and mesenteric oozing (20.9%), followed by diaphragmatic injuries (14.9%) and serosal tears (13.4%). Full-thickness bowel injuries were identified in 9% of cases. Therapeutic interventions performed laparoscopically included serosal tear repair (27.8%), diaphragmatic repair (20.4%), bleeding control (16.4%), and foreign body removal (7.5%).

Table 3. Outcomes of Minimally Invasive Management (MIM) (n = 67)

Outcome	n	Percentage (%)
MIM completed successfully	53	79.1%
Conversion to open surgery	14	20.9%
Intraoperative Findings		
Minor hemoperitoneum	21	31.3%
Mesenteric oozing	14	20.9%
Diaphragmatic injury	10	14.9%
Serosal tears (bowel)	9	13.4%
Full-thickness bowel injury	6	9.0%
Other findings	7	10.5%
Therapeutic Interventions		
Serosal tear repair	19	27.8%
Diaphragmatic repair	14	20.4%
Hemostasis for bleeding	11	16.4%
Foreign body removal	5	7.5%

Hospital stay was shortest in the NOM success group at 2.9 ± 1.1 days, intermediate in the MIM group at 4.1 ± 1.6 days, and longest in patients who failed NOM at 6.8 ± 2.3 days. Conversion to laparotomy occurred in 15% of NOM failures and 20.9% of MIM patients. The need for blood transfusion was highest in NOM failures (30%), compared with MIM patients (13.4%) and NOM successes (5.9%). Missed injuries occurred only in delayed intervention groups, with two cases in NOM failure (10%) and one case in MIM (1.5%).

Table 4. Length of Hospital Stay and Key Outcomes

Outcome	NOM Success (n = 68)	NOM Failure (n = 20)	MIM (n = 67)
Hospital stay (days), Mean ± SD	2.9 ± 1.1	6.8 ± 2.3	4.1 ± 1.6
Conversion to laparotomy	—	3 (15.0%)	14 (20.9%)
Need for blood transfusion	4 (5.9%)	6 (30.0%)	9 (13.4%)
Missed injury rate	—	2 (10.0%)	1 (1.5%)
Mortality	0	0	0

Diagnostic accuracy was significantly higher in MIM (94%) compared with NOM (77.3%), with a p-value of 0.004, indicating clear superiority of laparoscopy in identifying clinically relevant injuries. Missed injury rates were low and similar between groups. Need for escalation of care was comparable between NOM (22.7%) and MIM (20.9%). The time required to reach a clinical decision was much shorter in the MIM group (2.9 ± 1.4 hours) than in NOM (7.4 ±

3.1 hours), with $p < 0.001$, reflecting faster diagnostic clarity with laparoscopy. Overall complications were more frequent in MIM patients (31.3%), although mostly minor, compared with 14.7% in NOM.

Table 5. Diagnostic and Therapeutic Performance Comparison Between NOM and MIM

Parameter	NOM (n = 88)	MIM (n = 67)	p-value
Initial diagnostic accuracy*	68/88 (77.3%)	63/67 (94.0%)	0.004
Missed injury rate	2 (2.3%)	1 (1.5%)	0.71
Therapeutic success rate	—	53/67 (79.1%)	—
Need for escalation of care	20/88 (22.7%)	14/67 (20.9%)	0.78
Need for blood transfusion	10 (11.4%)	9 (13.4%)	0.68
Average intervention time (minutes)	—	58.2 ± 16.3	—
Time to clinical decision (hours)	7.4 ± 3.1	2.9 ± 1.4	<0.001
Overall complication rate	13 (14.7%)	21 (31.3%) (mostly minor)	0.012
Hospital readmission within 30 days	1 (1.1%)	2 (3.0%)	0.42

***** Diagnostic accuracy for NOM = completion of observation without need for delayed surgery; Diagnostic accuracy for MIM = ability of laparoscopy to detect or rule out clinically significant injuries.

DISCUSSION

The findings of this study highlight the evolving role of selective non-operative management (NOM) and minimally invasive management (MIM) in hemodynamically stable patients with penetrating abdominal trauma. As trauma care continues shifting away from mandatory laparotomy, our results reinforce that both strategies can be safely applied when patient selection is meticulous and institutional protocols are robust. However, they also underscore the unique strengths and limitations of each approach, suggesting that neither strategy should be used in isolation but rather integrated into a dynamic decision-making pathway. In this study, the success rate of non-operative management was 77.3 %, which is consistent with reported ranges in current literature. Most failures occurred due to delayed identification of hollow viscus injuries or progression of hemoperitoneum, both of which represent recognized limitations of observational management. These findings remind clinicians that although serial abdominal examinations, repeated laboratory testing, and CT imaging are powerful tools, they require highly trained teams and vigilant monitoring. The failure rate of 22.7 % is clinically relevant because the consequences of delayed intervention were evident in this group, shown by the higher complication rate of 65 % and the prolonged hospital stay of 6.8 ± 2.3 days. This reflects the well-documented risk that delayed diagnosis can convert an initially stable clinical situation into a more complex postoperative course [15].

Minimally invasive management performed well, with a successful completion rate of 79.1 %. Diagnostic laparoscopy again demonstrated strong value as an intermediate approach, particularly in patients with equivocal clinical or radiologic findings. The ability of laparoscopy to detect subtle injuries such as diaphragmatic tears, serosal defects, and minor bleeding explains the significantly higher diagnostic accuracy of 94 % in this group, compared with 77.3 % in the non-operative group [16]. The conversion-to-laparotomy rate of 20.9 % aligns with published international ranges and reflects appropriate operative thresholds. The lower complication profile of patients who underwent primary minimally invasive surgery, compared with those who required delayed surgery after failed observation, reinforces the benefit of early operative clarification in borderline cases. A key observation is the difference in hospital resource utilization [17]. Patients who successfully completed non-operative management had the shortest stay at 2.9 ± 1.1 days, underscoring the efficiency and low morbidity of non-operative protocols when carefully applied. Minimally invasive management patients had a moderate stay of 4.1 ± 1.6 days, which is understandable given their operative care but still clearly shorter than the delayed-surgery group. These patterns echo global data suggesting that non-operative management is the most cost-effective strategy for appropriately selected patients, while minimally invasive surgery offers diagnostic and therapeutic reassurance without the morbidity of open surgery [18].

The study also observed a low overall missed-injury rate of 1.9% and no mortality in either group. This outcome demonstrates that selective management pathways, when supported by structured clinical monitoring and timely escalation, are safe and effective in stable penetrating injuries [19]. These results align with international shifts toward more individualized care, where treatment is tailored according to mechanism, imaging findings, and clinical evolution rather than rigid adherence to traditional explorative practices [20-22]. Overall, this study supports the use of a hybrid approach in managing stable penetrating abdominal trauma. Non-operative management is suitable for straightforward presentations with reassuring imaging and reliable

examinations, while minimally invasive management is particularly valuable when uncertainty exists or when early therapeutic intervention is anticipated. By integrating both strategies into a structured decision-making algorithm, trauma teams can reduce unnecessary laparotomies, improve diagnostic accuracy, shorten hospital stays, and minimize complications.

CONCLUSION

It is concluded that non-operative management and minimally invasive management are both safe and effective strategies for hemodynamically stable patients with penetrating abdominal trauma when applied with appropriate patient selection and close clinical monitoring. Non-operative management offers the shortest hospital stay and lowest procedural morbidity in patients with clear imaging and reliable examinations, while minimally invasive management provides superior diagnostic accuracy and early therapeutic intervention in cases with equivocal findings. Patients who failed non-operative management experienced higher complication rates and longer hospital stays, reinforcing the importance of timely escalation when clinical deterioration occurs

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