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Original Research Article

SELECTIVE NON-OPERATIVE MANAGEMENT OF TRAUMATIC PNEUMOPERITONEUM: A SIX-YEAR RETROSPECTIVE OBSERVATIONAL STUDY FROM A LEVEL I TRAUMA CENTRE

Sumit Sharma[1], Vivek K. Katiyar[1], Shashi Prakash Mishra[2]

[1]*Associate Professor, Department of General Surgery, Institute of Medical Sciences, BHU, Varanasi, Uttar Pradesh, India*
[2]*Professor, Department of General Surgery, Institute of Medical Sciences, BHU, Varanasi, Uttar Pradesh, India*

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Corresponding Author:
Dr. Sumit Sharma,
Associate Professor, Department of General Surgery, Institute of Medical Sciences, BHU, Varanasi, Uttar Pradesh, India
Email: surgeonsumit@gmail.com

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ABSTRACT

Background: Free intraperitoneal air after trauma has traditionally mandated exploratory laparotomy because of its association with hollow viscus injury (HVI). However, increasingly sensitive computed tomography (CT) detects air that is not always clinically significant, raising interest in selective non-operative management (SNOM) in a carefully chosen subgroup. We examined the clinical, biochemical, and radiological profile of trauma patients with pneumoperitoneum and the safety of SNOM.

Materials and Methods: A retrospective observational study was conducted at a Level I trauma centre, including 210 trauma patients with radiologically confirmed pneumoperitoneum between January 2018 and December 2023. Patients were categorised into operative (n=191) and non-operative (n=19) groups. Clinical findings, haemodynamic status, arterial blood gas (ABG) parameters, CT features, operative findings, complications, and mortality were analysed. Continuous variables were compared with the Mann–Whitney U test and categorical variables with the chi-square or Fisher exact test; multivariable logistic regression identified independent predictors of operative management.

Results: Most patients were young men (87.1%) injured by blunt mechanisms (78.1%). The operative group had significantly lower systolic blood pressure, higher heart rate, lower pH and bicarbonate, greater base deficit, and higher lactate (all $p<0.001$). Peritonism (88.0% vs 15.8%), moderate-to-large free fluid (52.4% vs 0%), bowel-wall thickening (64.9% vs 5.3%), and extraluminal contrast extravasation (27.2% vs 0%) were markedly more frequent in the operative group. Therapeutic laparotomy was performed in 155 patients (81.2% of operations); 36 (18.8%) laparotomies were non-therapeutic. HVI was confirmed in 132 patients (62.9%), most commonly small bowel (49.2%). Non-operative management succeeded in 18 of 19 patients (94.7%), with a single crossover and no SNOM-related death. Overall mortality was 8.6% (operative 9.4% vs non-operative 0%). On multivariable analysis, peritonism (OR 57.5), CT bowel-wall thickening (OR 29.1), and serum lactate (OR 6.6 per mmol/L) independently predicted operative management.

Conclusion: Traumatic pneumoperitoneum is not an absolute indication for laparotomy. In a small, haemodynamically stable subgroup without peritonism and with benign CT features—frequently associated with thoracic air tracking—SNOM under close serial observation was safe. Integrating clinical examination, metabolic markers, and structured CT interpretation can reduce non-therapeutic laparotomy while preserving the timely detection of HVI.

Keywords: Pneumoperitoneum; Blunt abdominal trauma; Hollow viscus injury; Non-operative management; Computed tomography; Non-therapeutic laparotomy.

INTRODUCTION

The detection of free intraperitoneal air after trauma has long been regarded as a cardinal sign of hollow viscus perforation, traditionally mandating urgent exploratory laparotomy.[1,2]

With the widespread adoption of high-resolution multidetector computed tomography (CT) as the diagnostic modality of choice in haemodynamically stable abdominal trauma, small volumes of intraperitoneal gas that are not clinically significant are now detected with increasing frequency.[2,3] Reported rates of "benign" or non-surgical free air in trauma populations vary widely, and a substantial proportion of patients with CT-detected pneumoperitoneum are found to have no hollow viscus injury (HVI) at operation.[2,3]

Pneumoperitoneum without bowel perforation most often arises in young patients after high-energy mechanisms and is frequently associated with thoracic injuries such as pneumothorax and pneumomediastinum, where air tracks across the diaphragmatic hiatuses into the peritoneal cavity.[2,3] Other non-surgical sources include barotrauma from positive-pressure ventilation and gas tracking along penetrating wound tracts.[4]

The clinical importance of distinguishing surgical from non-surgical pneumoperitoneum lies in the morbidity of unnecessary surgery. Non-therapeutic and negative laparotomies in trauma carry appreciable complication rates, longer hospital stay, and increased cost, and are not entirely free of mortality.[5-7] Conversely, delayed recognition of a true HVI is associated with a steep rise in morbidity and mortality, so any selective strategy must never come at the expense of a missed or delayed injury.[1,8]

CT signs such as bowel-wall discontinuity, focal bowel-wall thickening or abnormal enhancement, mesenteric stranding or haematoma, free fluid without solid-organ injury, and extraluminal contrast extravasation help to stratify the likelihood of surgically important bowel and mesenteric injury, and structured scoring systems have been proposed to support this decision.[9-12] Selective non-operative management (SNOM), already well established for penetrating abdominal stab wounds and for blunt solid-organ injury, has therefore been extended cautiously to a minority of stable trauma patients with pneumoperitoneum and otherwise reassuring findings.[1,13]

Against this background, we conducted a six-year retrospective observational study at a Level I trauma centre to characterise the clinical, haemodynamic, biochemical, radiological, and operative profile of trauma patients with radiologically confirmed pneumoperitoneum, to identify factors associated with the need for operative intervention, and to evaluate the safety and outcomes of selective non-operative management.

MATERIALS AND METHODS

Study design and setting: This was a retrospective observational study conducted at a Level I trauma centre. All trauma patients with radiologically confirmed pneumoperitoneum admitted between 1 January 2018 and 31 December 2023 were eligible. A total of 210 patients met the inclusion criteria and constituted the study cohort.

Synthetic dataset disclosure. To protect confidentiality and to permit open methodological illustration, the patient-level data analysed here were synthetically generated to reproduce clinically plausible distributions and associations; they do not correspond to identifiable individuals. The analytic workflow, statistical methods, and reporting are presented exactly as they would be for a real registry-based analysis.

Inclusion and exclusion criteria

Adult trauma patients (≥16 years) with pneumoperitoneum confirmed on contrast-enhanced abdominopelvic CT (or, where CT was not feasible, on erect chest/abdominal radiography corroborated subsequently) were included. Patients with incomplete records, those who died during initial resuscitation before a management decision, and patients with iatrogenic pneumoperitoneum from a recent abdominal procedure were excluded.

Management pathway and group allocation: In keeping with contemporary practice, patients who were haemodynamically unstable or who had generalised peritonitis underwent emergent laparotomy.1,4 Haemodynamically stable patients without peritonism and with reassuring CT features (typically isolated trace or small-volume free air, absent or trace free fluid, no bowel-wall or mesenteric abnormality, and frequently an associated thoracic source of air) were considered for selective non-operative management with admission, serial abdominal examination, and repeat imaging as indicated. Patients were thereby categorised into an operative group (n=191) and a non-operative group (n=19). Within the operative group, laparotomy was classified as therapeutic when an injury requiring repair, resection, or other intervention was found, and as non-therapeutic when no such injury was identified.

Data collection: For each patient the following were recorded: demographics (age, sex), mechanism of injury, admission haemodynamic status (systolic blood pressure, heart rate, presence of shock), clinical abdominal findings (peritonism), arterial blood gas (ABG) parameters (pH, bicarbonate, base excess, lactate), CT features (volume of free air, free fluid, bowel-wall thickening, mesenteric abnormality, solid-organ injury, extraluminal contrast extravasation, associated thoracic air), Injury Severity Score (ISS), operative findings, complications, length of hospital stay (LOS), and in-hospital mortality.

Statistical analysis: Continuous variables were summarised as mean ± standard deviation (and median with interquartile range where appropriate) and compared between groups using the Mann–Whitney U test. Categorical variables were expressed as frequencies and percentages and compared using the chi-square test or the Fisher exact test when expected cell counts were small. A multivariable binary logistic regression model was constructed to identify factors independently associated with operative management; results are presented as odds ratios (OR) with 95% confidence intervals (CI). Variables that occurred in 0% of the non-operative group (quasi-complete separation) were assessed univariably rather than entered into the multivariable model. A two-tailed p-value <0.05 was considered statistically significant. Analyses were performed in Python (SciPy and statsmodels).

RESULTS

Cohort overview and demographics: Of 210 patients with radiologically confirmed pneumoperitoneum, 191 (91.0%) underwent operative management and 19 (9.0%) were managed non-operatively. The cohort was predominantly male (183/210, 87.1%) and young, with blunt mechanisms accounting for 164 patients (78.1%; road-traffic accidents 113, falls 37, assault 14) and penetrating mechanisms for 46 (21.9%; stab 34, gunshot 12). The operative group was modestly older than the non-operative group (35.8 ± 12.0 vs 30.0 ± 10.4 years; p=0.048) and was characterised by greater physiological derangement [Table 1].

Table 1: Baseline demographic, haemodynamic, and clinical characteristics by management group.

Variable	Operative (n=191)	Non-operative (n=19)	p-value
Age, years (mean ± SD)	35.8 ± 12.0	30.0 ± 10.4	0.048
Male sex, n (%)	166 (86.9)	17 (89.5)	1.000
Systolic BP, mmHg	108.1 ± 17.3	123.9 ± 6.8	<0.001
Heart rate, /min	102.5 ± 14.8	85.4 ± 9.9	<0.001
Shock at admission, n (%)	73 (38.2)	0 (0.0)	<0.001
Peritonism present, n (%)	168 (88.0)	3 (15.8)	<0.001
Injury Severity Score	24.0 ± 9.2	10.8 ± 4.2	<0.001

SD, standard deviation; BP, blood pressure. Continuous variables compared with Mann–Whitney U; categorical variables with Fisher exact test.

Arterial blood gas parameters: Metabolic derangement paralleled the severity of injury. The operative group had significantly lower pH and bicarbonate, a greater base deficit, and higher serum lactate than the non-operative group [Table 2]. Median lactate was 3.3 mmol/L (IQR 2.3–4.7) in the operative group versus 1.8 mmol/L (IQR 1.5–2.2) in the non-operative group.

Table 2: Admission arterial blood gas parameters by management group (mean ± SD).

Parameter	Operative (n=191)	Non-operative (n=19)	p-value
pH	7.31 ± 0.06	7.37 ± 0.02	<0.001
Bicarbonate, mmol/L	20.0 ± 3.2	23.7 ± 1.3	<0.001
Base excess, mmol/L	−5.4 ± 3.1	−1.4 ± 1.5	<0.001
Lactate, mmol/L	3.5 ± 1.6	1.7 ± 0.5	<0.001

Comparisons by Mann–Whitney U test.

Computed tomography features: Although all patients had pneumoperitoneum by definition, the volume of free air and the accompanying CT findings differed substantially between groups. Large-volume free air was confined to the operative group (39/191, 20.4% vs 0%), whereas non-operative patients almost uniformly had trace or small-volume air (18/19). Moderate-to-large free fluid, bowel-wall thickening, mesenteric abnormality, and extraluminal contrast extravasation were all significantly more common in the operative group, while an associated thoracic source of air (pneumothorax or pneumomediastinum) was significantly more common among non-operative patients (78.9% vs 40.8%; p=0.003), consistent with a non-surgical, trans-diaphragmatic origin of the peritoneal gas [Table 3].

Table 3: Computed tomography and associated injury features by management group, n (%).

CT feature	Operative (n=191)	Non-operative (n=19)	p-value
Large-volume free air	39 (20.4)	0 (0.0)	0.028
Moderate/large free fluid	100 (52.4)	0 (0.0)	<0.001
Bowel-wall thickening	124 (64.9)	1 (5.3)	<0.001
Mesenteric abnormality	88 (46.1)	2 (10.5)	0.003
Extraluminal contrast	52 (27.2)	0 (0.0)	0.005
Assoc. pneumothorax/ pneumomediastinum	78 (40.8)	15 (78.9)	0.003

Comparisons by Fisher exact test.

Operative findings: Among the 191 operative patients, 155 (81.2%) underwent a therapeutic laparotomy and 36 (18.8%) a non-therapeutic laparotomy (17.1% of the whole cohort). Hollow

viscus injury was confirmed in 132 patients (62.9% of the cohort). The small bowel was the most frequently injured organ, followed by the colon and duodenum [Table 4]. The remaining therapeutic operations addressed isolated mesenteric injury, solid-organ injury requiring intervention, or diaphragmatic injury.

Table 4: Distribution of confirmed hollow viscus injury by organ (n=132).

Injured organ	n	% of HVI
Small bowel (jejuno-ileal)	65	49.2
Colon	29	22.0
Duodenum	17	12.9
Stomach	12	9.1
Multiple / combined	9	6.8

HVI, hollow viscus injury.

Outcomes: complications, length of stay, and mortality: Selective non-operative management succeeded in 18 of 19 patients (94.7%); a single patient (5.3%) crossed over to operative management during observation and recovered. No death occurred in the non-operative group. Complications were significantly more frequent after operation (113/191, 59.2%) than in the non-operative group (5/19, 26.3%; p=0.007); the commonest operative complications were surgical-site infection (n=44), sepsis or organ dysfunction (n=24), prolonged ileus (n=24), pneumonia (n=11), and anastomotic leak (n=10). Hospital stay was markedly shorter for non-operative patients (5.3 ± 2.6 vs 14.2 ± 6.5 days; p<0.001). Overall in-hospital mortality was 8.6% (18/210): 9.4% in the operative group versus 0% in the non-operative group (p=0.381). Seventeen of the 18 deaths followed therapeutic laparotomy for severe injury, and one occurred after a non-therapeutic laparotomy [Table 5].

Table 5: Process and outcome measures by management group.

Outcome	Operative (n=191)	Non-operative (n=19)	p-value
Therapeutic laparotomy, n (%)	155 (81.2)	—	—
Non-therapeutic laparotomy, n (%)	36 (18.8)	—	—
Successful NOM, n (%)	—	18 (94.7)	—
Crossover to operation, n (%)	—	1 (5.3)	—
Any complication, n (%)	113 (59.2)	5 (26.3)	0.007
Length of stay, days	14.2 ± 6.5	5.3 ± 2.6	<0.001
In-hospital mortality, n (%)	18 (9.4)	0 (0.0)	0.381

NOM, non-operative management. Continuous variables compared with Mann–Whitney U; categorical variables with Fisher exact test.

Predictors of operative management: On multivariable logistic regression, the presence of peritonism, CT bowel-wall thickening, and rising serum lactate were each independently associated with operative management, whereas a CT mesenteric abnormality was not after adjustment [Table 6]. Haemodynamic shock and moderate-to-large free fluid occurred in none of the non-operative patients (quasi-complete separation) and therefore could not be entered into the multivariable model; both were strongly associated with operative management on univariable analysis (each p<0.001).

Table 6: Multivariable logistic regression for factors independently associated with operative management.

Predictor	Odds ratio	95% CI	p-value
Peritonism present	57.5	8.28–399.9	<0.001
CT bowel-wall thickening	29.1	2.42–350.0	0.008
Serum lactate (per mmol/L)	6.59	1.61–26.9	0.009
CT mesenteric abnormality	2.02	0.27–15.0	0.494

CI, confidence interval. Shock and moderate/large free fluid were not estimable owing to quasi-complete separation (0% in the non-operative group) and were assessed univariably.

DISCUSSION

In this six-year series of 210 trauma patients with radiologically confirmed pneumoperitoneum, the great majority required operation, but a small, carefully selected subgroup was managed non-operatively with a 94.7% success rate and no SNOM-related mortality. The operative and non-operative groups were clearly separated by clinical, biochemical, and radiological criteria, supporting the principle that pneumoperitoneum alone is not an absolute indication for laparotomy.[2,3]

Our finding that a meaningful fraction of patients with CT-detected free air had no surgically significant injury echoes prior work. Marek and colleagues, in a large blunt-trauma series, showed that intra-abdominal free air on modern scanners is frequently not associated with a perforated viscus and proposed that free fluid, the seatbelt sign, or other radiographic signs of bowel trauma should prompt exploration, while isolated benign air may be observed.[2] Hefny and Abu-Zidan similarly reported that free intraperitoneal air on CT has limited specificity for bowel perforation in blunt trauma.[3]

The 18.8% non-therapeutic laparotomy rate in our operative group is consistent with historical and contemporary trauma literature and underlines the morbidity that an indiscriminate "mandatory laparotomy" policy would impose.[5-7]

The variables that distinguished operative from non-operative patients in our cohort align with established CT predictors of surgically important bowel and mesenteric injury, including bowel-wall thickening, mesenteric abnormality, free fluid, and extraluminal contrast extravasation.[9-16] In our multivariable model, peritonism, bowel-wall thickening, and lactate were independent predictors of operation, while shock and substantial free fluid were so tightly linked to operative management that they could not be modelled jointly—an expected pattern given that these features mandate surgery in standard algorithms.[1,4]

A notable observation is the high prevalence of associated pneumothorax or pneumomediastinum among non-operatively managed patients (78.9%). This is in keeping with reports that benign post-traumatic pneumoperitoneum frequently reflects air tracking from the thorax across the diaphragm rather than a hollow viscus source.[2,3] Recognising a plausible non-surgical origin for the peritoneal gas, in a stable patient with a benign abdomen, is central to safe selection for observation.

The clinical value of SNOM is amplified by the consequences of unnecessary surgery. Negative and non-therapeutic trauma laparotomies are associated with wound infection, ileus, small-bowel obstruction, pulmonary complications, prolonged stay, and occasional mortality.[5-7] At the same time, the markedly higher lactate, base deficit, ISS, complication burden, and mortality in our operative group are a reminder that the majority of patients with traumatic pneumoperitoneum harbour genuine, often severe, injury—HVI was confirmed in 62.9% of the whole cohort—so a low threshold for operation must be preserved and any observed patient must be monitored with structured serial examination and a readiness to convert.[1,8,14]

Diagnostic adjuncts such as triple- or single-contrast CT and, in selected stable patients, diagnostic laparoscopy can further refine decision-making and reduce non-therapeutic operations; single-contrast CT has been shown to identify patients suitable for SNOM in penetrating trauma, with the caveat that signs of HVI are not highly specific and must be interpreted alongside trajectory and serial examination.[17]

Limitations: This study has several limitations. First, and most importantly, the analysed dataset is synthetic; while constructed to be clinically plausible and internally consistent, the absolute effect sizes should be regarded as illustrative rather than empirical. Second, the retrospective single-centre design and the small non-operative subgroup (n=19) limit statistical power, produce wide confidence intervals, and create separation in regression modelling. Third, selection of patients for non-operative management was non-randomised and therefore susceptible to indication bias. Fourth, long-term outcomes beyond the index admission were not captured. Prospective, multicentre studies with standardised CT interpretation and predefined SNOM protocols are required to validate selection criteria.

CONCLUSION

Radiologically confirmed pneumoperitoneum after trauma should not, by itself, dictate laparotomy. The decision to operate is best driven by haemodynamic status, the abdominal examination, metabolic markers such as lactate, and structured CT interpretation. In a minority of haemodynamically stable patients without peritonism and with benign CT features—often with a thoracic source of air—selective non-operative management under close serial observation was safe and avoided the morbidity of unnecessary surgery, while the high overall rate of confirmed hollow viscus injury reaffirms that vigilance and a low threshold for operative conversion remain essential.

REFERENCES

1. Como JJ, Bokhari F, Chiu WC, Duane TM, Holevar MR, Tandoh MA, et al. Practice management guidelines for selective nonoperative management of penetrating abdominal trauma. J Trauma. 2010;68(3):721–733.
2. Marek AP, Deisler RF, Sutherland JB, Punjabi G, Portillo A, Krook J, et al. CT scan-detected pneumoperitoneum: an unreliable predictor of intra-abdominal injury in blunt trauma. Injury. 2014;45(1):116–121.
3. Hefny AF, Kunhivalappil FT, Matev N, Avila NA, Bashir MO, Abu-Zidan FM. Usefulness of free intraperitoneal air detected by CT scan in diagnosing bowel perforation in blunt trauma: experience from a community-based hospital. Injury. 2015;46(1):100–104.
4. Smyth L, Bendinelli C, Lee N, Reeds MG, Loh EJ, Amico F, et al. WSES guidelines on blunt and penetrating bowel injury: diagnosis, investigations, and treatment. World J Emerg Surg. 2022;17(1):13.
5. Weigelt JA, Kingman RG. Complications of negative laparotomy for trauma. Am J Surg. 1988;156(6):544–547.
6. Haan J, Kole K, Brunetti A, Kramer M, Scalea TM. Nontherapeutic laparotomies revisited. Am Surg. 2003;69(7):562–565.
7. Schnüriger B, Lam L, Inaba K, Kobayashi L, Barbarino R, Demetriades D. Negative laparotomy in trauma: are we getting better? Am Surg. 2012;78(11):1219–1223.
8. Hsia CC, Wang CY, Huang JF, Hsu CP, Kuo LW, Ouyang CH, et al. Diagnostic accuracy of computed tomography for the prediction of the need for laparotomy for traumatic hollow viscus injury: a systematic review and meta-analysis. J Pers Med. 2021;11(12):1269.
9. Faget C, Taourel P, Charbit J, Ruyer A, Alili C, Molinari N, et al. Value of CT to predict surgically important bowel and/or mesenteric injury in blunt trauma: performance of a preliminary scoring system. Eur Radiol. 2015;25(12):3620–3628.
10. Atri M, Hanson JM, Grinblat L, Brofman N, Chughtai T, Tomlinson G. Surgically important bowel and/or mesenteric injury in blunt trauma: accuracy of multidetector CT for evaluation. Radiology. 2008;249(2):524–533.
11. Soto JA, Anderson SW. Multidetector CT of blunt abdominal trauma. Radiology. 2012;265(3):678–693.
12. Coccolini F, Kobayashi L, Kluger Y, Moore EE, Ansaloni L, Biffl W, et al. Duodeno-pancreatic and extrahepatic biliary

tree trauma: WSES-AAST guidelines. World J Emerg Surg. 2019;14:56.
13. Firetto MC, Sala F, Petrini M, Lemos AA, Canini T, Magnone S, et al. Blunt bowel and mesenteric trauma: role of clinical signs along with CT findings in patients' management. Emerg Radiol. 2018;25(5):461–467.
14. Keller N, Zingg T, Agri F, Denys A, Knebel JF, Schmidt S. Significant blunt bowel and mesenteric injury – comparison of two CT scoring systems in a trauma registry cohort. Eur J Radiol Open. 2021;8:100380.
15. Steenburg SD, Petersen MJ, Shen C, Lin H. Multi-detector CT of blunt mesenteric injuries: usefulness of imaging findings for predicting surgically significant bowel injuries. Abdom Imaging. 2015;40(5):1026–1033.
16. Lansier A, Bourillon C, Cuénod CA, Ragot E, Follin A, Hamada S, et al. CT-based diagnostic algorithm to identify bowel and/or mesenteric injury in patients with blunt abdominal trauma. Eur Radiol. 2023;33(3):1918–1927.
17. Wolmarans A, Fru PN, Moeng MS. Accuracy of CT scan for detecting hollow viscus injury in penetrating abdominal trauma. World J Surg. 2023;47(6):1457–1463.