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Association Between Admission Inflammatory Indices and Surgically Confirmed Hollow Viscus Injury in Abdominal and Thoracoabdominal Stab Wounds: A Retrospective Observational Study

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ABSTRACT

Objective: This study evaluated the association between admission inflammatory indices and surgically confirmed hollow viscus injury in patients undergoing surgery for abdominal or thoracoabdominal stab wounds.

Materials and Methods: Patients aged 16 years or older who underwent surgery between January 2015 and December 2023 were retrospectively reviewed. Patients with diaphragmatic, concomitant intra-abdominal solid-organ or vascular or extra-abdominal injuries, those requiring another surgical specialty, and those undergoing tube thoracostomy were excluded. Fifty patients with hollow viscus injury and 50 without hollow viscus injury were included. Admission laboratory parameters and derived inflammatory indices were assessed using logistic regression and receiver operating characteristic analysis.

Results: The mean age of the 100 patients was 31.4±11.6 years, and 95% were male. Neutrophil, monocyte, platelet, C-reactive protein (CRP), and several derived inflammatory indices were higher in patients with hollow viscus injury, whereas the lymphocyte-to-monocyte ratio (LMR) and lymphocyte-to-CRP ratio were lower. Platelet count (odds ratio [OR]=1.008; 95% confidence interval [CI], 1.001–1.015; p=0.036) and LMR (OR=0.679; 95% CI, 0.559–0.825; p<0.001) were independently associated with hollow viscus injury. The area under the curve for LMR was 0.764 (95% CI, 0.671–0.857). An LMR cutoff of <5.5 yielded 64% sensitivity and 80% specificity.

Conclusion: A lower admission LMR and a higher platelet count were independently associated with surgically confirmed hollow viscus injury. LMR is insufficient as a stand-alone diagnostic test but may provide a low-cost adjunct to clinical and radiological assessment. Validation in larger independent cohorts is required.

Keywords: Abdominal stab wound, Hollow viscus injury, Inflammatory indices, Lymphocyte-to-monocyte ratio, Platelet count, Thoracoabdominal stab wound

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INTRODUCTION

Abdominal and thoracoabdominal stab wounds are among the most challenging clinical presentations in trauma surgery because a seemingly limited external wound may cause injuries of varying depth involving the peritoneum, diaphragm, or gastrointestinal tract.[1,2] The primary clinical challenge in these patients is not merely to establish peritoneal violation but to identify, at an early stage and with adequate reliability, a hollow viscus injury requiring urgent surgical treatment.[2,3] The indication for surgery is generally clear in the presence of hemodynamic instability, generalized peritonitis, or evisceration. In contrast, clinical decision-making becomes more challenging in hemodynamically stable patients with limited physical examination findings and equivocal radiological findings.[3,4]

A missed hollow viscus injury may result in leakage of intestinal contents into the peritoneal cavity, delayed peritonitis, sepsis, and increased morbidity and mortality. Conversely, unnecessary surgical exploration in patients without an intra-abdominal injury requiring operative treatment may lead to avoidable adverse outcomes, including anesthesia-related complications, surgical site infection, adhesions, incisional hernia, and prolonged hospitalization.[3-5] Balancing these opposing risks forms the basis of selective management strategies for abdominal and thoracoabdominal stab wounds.[3] Current practice supports the combined use of serial physical examinations, laboratory investigations, and contrast-enhanced computed tomography rather than routine laparotomy in hemodynamically stable patients without signs of peritonitis.[3,6] Although diagnostic laparoscopy is effective for detecting peritoneal violation and diaphragmatic injury, it has limitations, including its invasive nature and the potential for small perforations to be missed when the gastrointestinal tract cannot be examined completely.[4,5]

Contrast-enhanced computed tomography is a key imaging modality for evaluating organ injuries and wound trajectories in hemodynamically stable patients with penetrating trauma.[6,7] Although direct findings such as free intraperitoneal air, bowel wall discontinuity, and extravasation of enteric contrast material have high specificity, they are not present in every patient. Indirect findings, including free fluid, bowel wall thickening, and mesenteric infiltration, may occur in different types of injury.[6,7] A recent study evaluating patients with penetrating abdominal trauma reported that computed tomography had high sensitivity and a high negative predictive value but low specificity for detecting hollow viscus injury.[7] These limitations highlight the need for rapid, readily available, and reproducible biomarkers that could support clinical assessment, particularly when clinical and radiological findings are discordant.

Traumatic tissue injury induces an early and dynamic systemic inflammatory response involving both the innate and adaptive immune systems.[8,9] During this process, changes may occur in the total leukocyte count as well as in the numbers, distribution, and functions of neutrophils, lymphocytes, and monocytes. Although neutrophilia and lymphopenia are frequently observed during the early period after trauma, the magnitude and temporal course of these changes may vary according to injury severity and the patient's clinical condition.[8-10] Platelet count may be influenced by bleeding, consumptive coagulopathy, resuscitation, and the inflammatory response. C-reactive protein (CRP) levels may remain normal or only slightly elevated immediately after trauma but may increase substantially over the subsequent days.[11] These hematological and inflammatory changes have provided the basis for investigating markers such as the neutrophil-to-lymphocyte ratio (NLR), platelet-to-lymphocyte ratio (PLR), lymphocyte-to-monocyte ratio (LMR), lymphocyte-to-CRP ratio (LCR), systemic immune-inflammation index (SII), systemic inflammation response index (SIRI), and aggregate index of systemic inflammation (AISI) in trauma patients.[12,13] However, previous studies have primarily focused on prognostic outcomes such as acute kidney injury, mortality, and in-hospital outcomes, whereas evidence regarding surgically confirmed isolated hollow viscus injury remains limited.[12,13]

This study aimed to evaluate the associations of routine hematological and biochemical parameters obtained at admission, together with the inflammatory indices derived from these parameters, with surgically confirmed hollow viscus injury in patients undergoing surgical exploration for abdominal or thoracoabdominal stab wounds. We also aimed to identify parameters independently associated with hollow viscus injury and to evaluate the discriminative performance and potential cutoff value of the inflammatory index that remained independently significant in the multivariable analysis.

MATERIALS AND METHODS

Study Design and Patient Selection

This single-center, retrospective, observational study reviewed the electronic medical records and operative reports of patients aged 16 years or older who underwent surgery for abdominal or thoracoabdominal stab wounds between January 2015 and December 2023. Of the 453 patients who underwent surgery during the study period, hollow viscus injury was identified during surgical exploration in 154 patients, whereas no hollow viscus injury was found in 299 patients.

Patients with diaphragmatic injury, concomitant intra-abdominal solid organ or vascular injury, an injury requiring intervention

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by another surgical specialty, or a concomitant extra-abdominal injury, as well as those who underwent tube thoracostomy, were excluded. After the exclusion criteria were applied, 50 eligible patients comprised the hollow viscus injury-positive (HVIP) group, and 50 comprised the hollow viscus injury-negative (HVIN) group. All patients who met the eligibility criteria were included in the analysis, resulting in a final study population of 100 patients. The patient selection process is presented in Figure 1.

A full-thickness injury to the wall of the stomach, small intestine, colon, or rectum identified during surgery was defined as a hollow viscus injury. The primary outcome was hollow viscus injury confirmed by surgical exploration. Operative findings were used as the reference standard for classifying patients into the HVIP and HVIN groups.

The study protocol was approved by the Bakırköy Dr. Sadi Konuk Training and Research Hospital Ethics Committee (decision date: January 22, 2024; decision no.: 2024-01-31). The study was conducted in accordance with the principles of the Declaration of Helsinki and relevant national regulations.

Data Collection

The recorded patient characteristics included age, sex, body mass index, comorbidities, smoking and alcohol use, history of abdominal surgery, American Society of Anesthesiologists (ASA) physical status classification, and Charlson Comorbidity Index (CCI). Injury location, presence of peritonitis at admission, time from hospital admission to surgery, surgical approach, duration of surgery, injured organs, surgical procedures performed, post-operative complications, length of hospital stay, and in-hospital mortality were also evaluated.

Laboratory analyses were based on the first venous blood samples obtained upon admission to the emergency department within the first 6 h after injury. All blood samples included in the analysis were collected before surgical intervention. White blood cell, neutrophil, lymphocyte, monocyte, and platelet counts and CRP, aspartate aminotransferase (AST), alanine aminotransferase (ALT), and lactate levels were recorded. Blood cell counts were expressed as $\times10^3/\mu L$, CRP as mg/dL, AST and ALT as U/L, and lactate as mmol/L. To avoid a mathematically undefined result when calculating LCR, CRP values reported as zero were assigned a value of 0.1 mg/dL solely for this calculation.

Inflammatory Indices

The NLR, PLR, LMR, LCR, SII, SIRI, and AISI were calculated using the laboratory values obtained at admission.

The following formulas were used: NLR=Neutrophil count/Lymphocyte count; PLR=Platelet count/Lymphocyte count; LMR=Lymphocyte count/Monocyte count; LCR=Lymphocyte count/CRP; SII=(Platelet count×Neutrophil count)/Lymphocyte count; SIRI=(Neutrophil count×Monocyte count)/Lymphocyte count; and AISI=(Neutrophil count×Monocyte count×Platelet count)/Lymphocyte count.

Computed Tomography Assessment

Pre-operative computed tomography findings were classified according to the presence or absence of predefined findings considered suspicious for perforation, based on the official radiology reports. Bowel wall discontinuity, findings explicitly interpreted as direct evidence of perforation in the radiology report, or free intraperitoneal air was considered suspicious for perforation. Because free intraperitoneal air may enter the peritoneal cavity through the penetrating wound tract, this finding alone was not considered definitive evidence of perforation. The computed tomography classification was compared with the findings of surgical exploration.

Statistical Analysis

Statistical analyses were performed using IBM Statistical Package for the Social Sciences Statistics version 26.0. The normality of continuous variables was evaluated using the Shapiro–Wilk test and graphical methods. Normally distributed continuous variables are presented as mean±standard deviation, non-normally distributed continuous variables as median and interquartile range, and categorical variables as number and percentage.

Continuous variables were compared between the HVIP and HVIN groups using the independent-samples t-test or Mann–Whitney U test, as appropriate for their distributions. Categorical variables were compared using Pearson's Chi-square test or Fisher's exact test, as appropriate. Missing values were not imputed, and analyses for each variable were performed using the available data.

Variables associated with hollow viscus injury were initially evaluated using univariable logistic regression analysis. Variables that were statistically significant in the univariable analysis and available before surgery were entered into a multivariable logistic regression model using the forward stepwise likelihood-ratio method. Variables determined during or after surgical exploration, such as duration of surgery, surgical approach, and length of hospital stay, were not included in the diagnostic multivariable model. Results are reported as odds ratios (ORs) with 95% confidence intervals (CIs). The OR for platelet count was calculated for each $1\times10^3/\mu L$ increase.

The ability of the inflammatory index that remained independently associated with hollow viscus injury in the multivariable analysis to discriminate between the HVIP and HVIN groups was evaluated using receiver operating characteristic (ROC) analysis. The area under the ROC curve and its 95% CI were calculated. The optimal cutoff value was determined using the Youden index, which maximizes the sum of sensitivity and specificity. Sensitivity, specificity, and sample-specific positive and negative predictive values were calculated for the identified cutoff. Statistical significance was set at $p<0.05$.

RESULTS

Patient Selection and Overall Characteristics

A total of 453 patients who underwent surgery for abdominal or thoracoabdominal stab wounds during the study period were evaluated. Hollow viscus injury was identified during surgical exploration in 154 patients, whereas no hollow viscus injury was found in 299 patients. After the exclusion criteria were applied, 104 patients with hollow viscus injury and 249 patients without hollow viscus injury were excluded. The remaining 50 eligible patients comprised the HVIP group, and 50 comprised the HVIN group. All eligible patients were included in the analysis, resulting in a final study population of 100 patients (Fig. 1).

Patient ages ranged from 16 to 76 years. The mean age was 31.4±11.6 years, and the median age was 29.5 years. The study population included 95 men (95%) and five women (5%). The mean body mass index was 24.9±3.8 kg/m^2. Six patients (6%) were classified as ASA I, 66 (66%) as ASA II, 24 (24%) as ASA III, and four (4%) as ASA IV. The CCI was zero in 93 patients (93%). Smoking was reported in 49 patients (49%), alcohol use in 26 (26%), comorbidities in nine (9%), and a history of abdominal surgery in 12 (12%). Signs of peritonitis were present at emergency department admission in five patients (5%).

Comparison of Demographic and Clinical Characteristics

The median age was 29.5 (19.8–38.5) years in the HVIN group and 29.5 (23.0–38.0) years in the HVIP group, with no significant

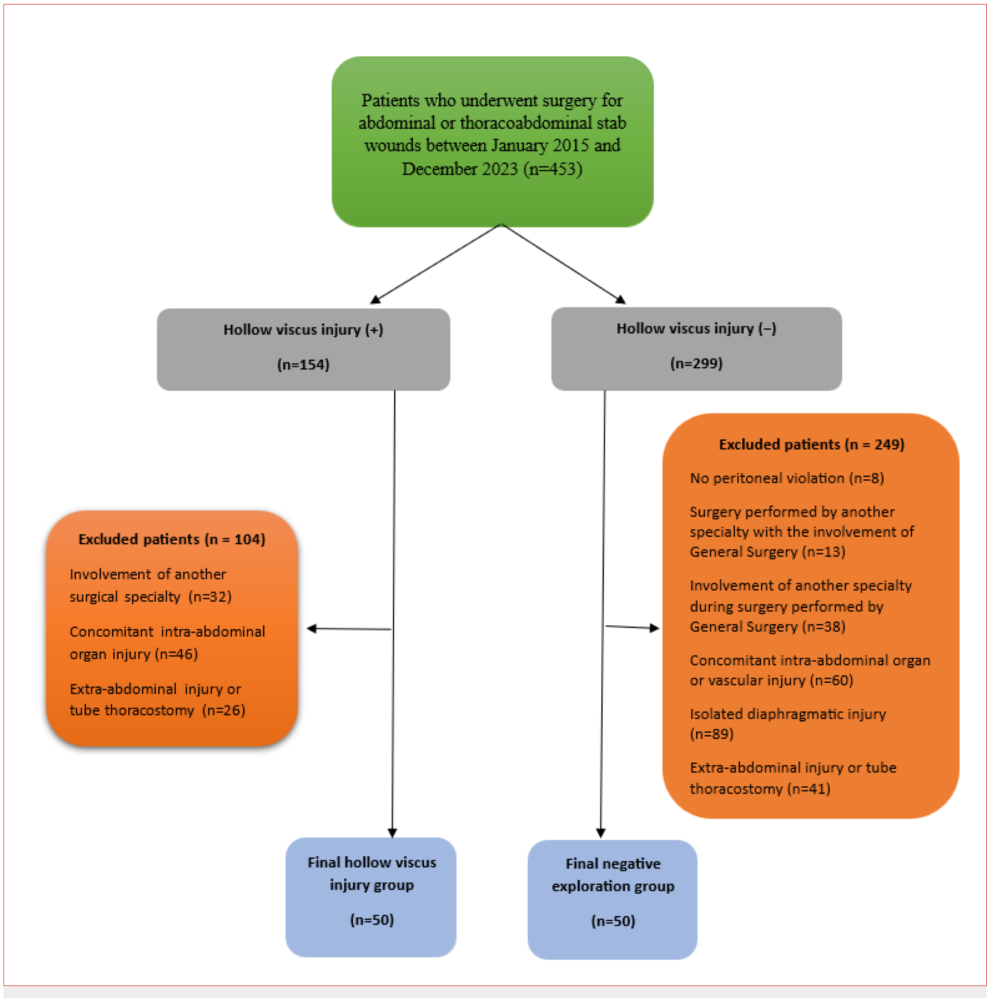

Figure 1. Flowchart of patient selection and allocation to the hollow viscus injury and negative exploration groups.

between-group difference (p=0.486). Men accounted for 96% of the HVIN group and 94% of the HVIP group (p=0.646). The mean body mass index was 24.5±3.0 kg/m^2 in the HVIN group and 25.3±4.4 kg/m^2 in the HVIP group (p=0.294).

The distribution of ASA physical status classifications differed significantly between the groups (p=0.001). In the HVIN group, 80% of patients were classified as ASA II, whereas the proportions of ASA II and ASA III patients in the HVIP group were 52% and 40%, respectively. The difference in the distribution of the CCI did not reach statistical significance (p=0.050). No significant between-group differences were observed in smoking (p=0.072), alcohol use (p=0.362), presence of comorbidities (p=0.081), history of abdominal surgery (p=0.538), or signs of peritonitis at admission (p=0.169).

Injury-location data were unavailable for four patients. In the available-case analysis, abdominal injury locations were recorded more frequently in the HVIP group, whereas thoracoabdominal injury locations were recorded more frequently in the HVIN group (p<0.001 for both). Demographic and clinical characteristics according to study group are presented in Table 1.

Laboratory Findings

The median CRP level was significantly higher in the HVIP group than in the HVIN group (2.0 [1.0–5.0] vs. 1.0 [0.1–3.0] mg/dL; p=0.006). The median white blood cell count was 11.0 (7.0–13.0)×10^3/µL in the HVIN group and 12.0 (10.0–15.0)×10^3/µL in the HVIP group. Despite the higher value in the HVIP group, the difference did not reach statistical significance (p=0.057).

The median neutrophil count was significantly higher in the HVIP group than in the HVIN group (7.75 [5.88–14.13] vs. 5.60 [4.20–7.83]×10^3/µL; p<0.001). The median monocyte count was also higher in the HVIP group (0.65 [0.50–0.93] vs. 0.50 [0.40–0.70]×10^3/µL; p=0.001).

The median lymphocyte count was 3.50 (2.48–5.35)×10^3/µL in the HVIN group and 3.00 (2.00–4.05)×10^3/µL in the HVIP group. Although the value was lower in the HVIP group, the difference did not reach statistical significance (p=0.064). The median platelet count was significantly higher in the HVIP group than in the HVIN group (289 [243.8–325.3] vs. 244 [214.5–291.5]×10^3/µL; p=0.007). No significant differences were observed in AST (p=0.871), ALT (p=0.632), lactate (p=0.954), or the AST/ALT ratio (p=0.677).

Comparison of Inflammatory Indices

The median LMR was significantly lower in the HVIP group than in the HVIN group (4.37 [2.59–6.85] vs. 7.29 [5.76–8.81]; p<0.001). In contrast, NLR, PLR, SII, SIRI, and AISI were all significantly higher in the HVIP group.

The median NLR values in the HVIN and HVIP groups were 1.52 (1.14–2.01) and 2.60 (1.40–6.42), respectively (p=0.001), and the corresponding PLR values were 74.83 (50.77–88.72) and 95.21 (60.44–163.16) (p=0.005). Median SII values were 393.49 (253.96–522.88) in the HVIN group and 875.38 (399.76–1954.82) in the HVIP group (p<0.001). The median SIRI was 0.72 (0.53–1.21) in the HVIN group and 1.82 (0.81–5.51) in the HVIP group (p<0.001), whereas the corresponding AISI values were 188.59 (127.61–309.23) and 563.88 (227.08–1582.91) (p<0.001).

The median LCR was significantly lower in the HVIP group than in the HVIN group (1.60 [0.42–3.41] vs. 3.57 [1.23–18.00]; p=0.005). Comparisons of laboratory findings and inflammatory indices between the study groups are presented in Table 2.

Computed Tomography Findings

All 100 patients underwent pre-operative computed tomography. None of the patients in the HVIN group had a predefined finding considered suspicious for perforation. In the HVIP group, the radiology reports described direct findings suggestive of perforation in 12 patients and free intraperitoneal air in three. Because free intraperitoneal air was considered suspicious for perforation, these three patients were also classified as radiologically positive.

Consequently, 15 patients (30%) in the HVIP group had computed tomography findings suspicious for perforation, whereas none of the predefined suspicious findings were identified in the remaining 35 patients (70%). Computed tomography findings suspicious for perforation were significantly more frequent in the HVIP group (p<0.001).

Operative Findings and Surgical Outcomes

The median time from hospital admission to surgery was 15 (4.5–31.0) h in the HVIN group and 4 (2.5–7.0) h in the HVIP group. Patients in the HVIP group underwent surgery significantly earlier (p<0.001). The median duration of surgery was significantly longer in the HVIP group than in the HVIN group (115 [90.0–150.0] vs. 29 [20.0–61.3] min; p<0.001).

In the HVIN group, 43 of 50 patients (86%) underwent laparoscopic exploration and seven (14%) underwent laparotomy. In the HVIP group, six of 50 patients (12%) underwent laparoscopic exploration and 44 (88%) underwent laparotomy. The proportion of patients undergoing laparotomy was significantly higher in the HVIP group (p<0.001).

Among the 50 patients in the HVIP group, gastric injury was identified in 20 (40%), small bowel injury in 26 (52%), colonic

Table 1. Comparison of demographic, clinical, radiological, operative, and post-operative characteristics between the study groups

	HVIN (n=50)		HVIP (n=50)		p
	Mean±SD/n (%)	Median	Mean±SD/n (%)	Median	
Age (years)	30.3±10.8	29.5	32.4±12.2	29.5	0.486^{m}
Sex					
Male	48 (96.0)		47 (94.0)		0.646$^{\chi^2}$
Female	2 (4.0)		3 (6.0)		
BMI	24.5±3.0	24.4	25.3±4.4	24.8	0.294^{t}
ASA physical status					
I	5 (10.0)		1 (2.0)		**0.001**$^{\chi^2}$
II	40 (80.0)		26 (52.0)		
III	4 (8.0)		20 (40.0)		
IV	1 (2.0)		3 (6.0)		
CCI					
0	49 (98.0)		44 (88.0)		**0.050**$^{\chi^2}$
1	1 (2.0)		3 (6.0)		
2	0 (0.0)		1 (2.0)		
3	0 (0.0)		1 (2.0)		
4	0 (0.0)		1 (2.0)		
Smoking	20 (40.0)		29 (58.0)		0.072$^{\chi^2}$
Alcohol use	11 (22.0)		15 (30.0)		0.362$^{\chi^2}$
Comorbidity	2 (4.0)		7 (14.0)		0.081$^{\chi^2}$
Previous abdominal surgery	5 (10.0)		7 (14.0)		0.538$^{\chi^2}$
Injury location					
Abdominal	12 (25.0)		29 (60.4)		**<0.001**$^{\chi^2}$
Thoracoabdominal	40 (83.3)		19 (39.6)		**<0.001**$^{\chi^2}$
Other	1 (2.1)		4 (8.3)		0.168$^{\chi^2}$
CT finding suspicious for perforation	0 (0.0)		15 (30.0)		**<0.001**$^{\chi^2}$
Time from hospital admission to surgery (hours)	22.8±25.8	15.0	5.4±3.8	4.0	**<0.001**^{m}
Duration of surgery (min)	44.9±41.4	29.0	121.7±42.5	115.0	**<0.001**^{m}
Surgical approach					
Laparoscopic	43 (86.0)		6 (12.0)		**<0.001**$^{\chi^2}$
Open	7 (14.0)		44 (88.0)		
Post-operative complication	0 (0.0)		1 (2.0)		1.000$^{\chi^2}$
Length of hospital stay (days)	2.2±1.5	2.0	5.4±2.0	5.0	**<0.001**^{m}

ASA: American Society of Anesthesiologists, BMI: Body mass index, CCI: Charlson comorbidity ındex, CT: Computed tomography, HVIN: Hollow viscus injury negative, HVIP: Hollow viscus injury positive, SD: Standard deviation. Statistical tests: t, independent-samples t-test, m: Mann–Whitney U test, χ^2: Chi-square test

injury in 12 (24%), and rectal injury in two (4%). Because some patients had injuries involving more than one hollow viscus, the sum of organ-specific counts exceeded the number of patients.

The surgical procedures included gastric repair in 20 patients (40%), small bowel repair in 20 (40%), colonic repair in eight (16%), and rectal repair in two (4%). Small bowel resection was

Table 2. Comparison of admission laboratory parameters and systemic inflammatory indices between the study groups

	HVIN (n=50)		HVIP (n=50)		p
	Mean±SD/n-%	Median	Mean±SD/n-%	Median	
CRP (mg/dL)	2.9±5.9	1.0	5.6±13.5	2.0	0.006^{m}
WBC count ($\times10^3/\mu L$)	10.8±3.9	11.0	12.9±5.3	12.0	0.057^{m}
Neutrophil count ($\times10^3/\mu L$)	6.4±3.3	5.6	11.0±9.4	7.8	<0.001^{m}
Lymphocyte count ($\times10^3/\mu L$)	3.9±1.7	3.5	3.3±1.8	3.0	0.064^{m}
Monocyte count ($\times10^3/\mu L$)	0.57±0.24	0.50	0.96±1.06	0.65	0.001^{m}
Platelet count ($\times10^3/\mu L$)	257.6±65.1	244.0	288.5±61.1	289.0	0.007^{m}
AST (U/L)	26.9±15.9	22.0	25.9±15.5	23.0	0.871^{m}
ALT (U/L)	24.6±17.2	19.0	23.1±16.6	18.5	0.632^{m}
Lactate (mmol/L)	4.4±3.1	3.7	4.4±3.2	3.6	0.954^{m}
LMR	7.6±3.8	7.3	4.6±2.5	4.4	<0.001^{m}
NLR	2.1±2.4	1.5	5.1±5.7	2.6	0.001^{m}
PLR	76.5±33.4	74.8	125.1±93.6	95.2	0.005^{m}
LCR	10.8±15.8	3.6	4.5±11.3	1.6	0.005^{m}
SII	524.0±594.0	393.5	1498.0±1768.0	875.4	<0.001^{m}
SIRI	1.5±2.8	0.7	6.1±13.6	1.8	<0.001^{m}
AISI	367.1±675.8	188.6	1880.8±4149.1	563.9	<0.001^{m}
AST/ALT ratio	1.26±0.50	1.17	1.34±0.72	1.23	0.677^{m}

AISI: Aggregate index of systemic inflammation, ALT: Alanine aminotransferase, AST: Aspartate aminotransferase, CRP: C-reactive protein, HVIN: Hollow viscus injury negative, HVIP: Hollow viscus injury positive, LCR: Lymphocyte-to-C-reactive protein ratio, LMR: Lymphocyte-to-monocyte ratio, m: Mann–Whitney U test, NLR: Neutrophil-to-lymphocyte ratio, PLR: Platelet-to-lymphocyte ratio, SD: Standard deviation, SII: Systemic immune-inflammation index, SIRI: Systemic inflammation response index. WBC: White blood cell

performed in six patients (12%), and colonic resection in four (8%). Because more than one repair or resection procedure could be performed in the same patient, the sum of the procedure-specific percentages exceeded 100%.

Post-operative Outcomes

A subcutaneous abscess developed in one patient (2%) in the HVIP group, whereas no post-operative complications occurred in the HVIN group. The complication rates did not differ significantly between the groups (p=1.000). No in-hospital deaths occurred in either group.

The median length of hospital stay was 2 (1–3) days in the HVIN group and 5 (4–6) days in the HVIP group. Hospital stay was significantly longer in the HVIP group (p<0.001). Between-group comparisons of computed tomography findings, surgical characteristics, and post-operative outcomes are also presented in Table 1.

Logistic Regression Analysis

In the univariable logistic regression analysis, ASA physical status, injury location, neutrophil, monocyte, and platelet counts, and LMR, NLR, PLR, LCR, SII, SIRI, and AISI were significantly associated with hollow viscus injury. The results of the univariable and multivariable logistic regression analyses are presented in Table 3.

In the multivariable logistic regression analysis performed using the forward likelihood-ratio method, platelet count and LMR remained independently associated with hollow viscus injury. Each $1\times10^3/\mu L$ increase in platelet count was positively associated with hollow viscus injury (OR=1.008; 95% CI, 1.001–1.015; p=0.036). Each one-unit increase in LMR was inversely associated with hollow viscus injury (OR=0.679; 95% CI, 0.559–0.825; p<0.001).

In the logistic regression model in which LMR was the sole predictor, the predicted probability of hollow viscus injury decreased as LMR increased (Fig. 2).

ROC Analysis

In the ROC analysis evaluating the ability of LMR to discriminate between the HVIP and HVIN groups, the area under the curve

Table 3. Univariable and multivariable logistic regression analyses for hollow viscus injury

	Univariable model			Multivariable model		
	OR	95% CI	p	OR	95% CI	p
CRP	1.034	0.976 - 1.095	0.260			
Neutrophil count	1.190	1.064 - 1.331	0.002			
Monocyte count	9.919	1.833 - 53.68	0.008			
Platelet count	1.008	1.001 - 1.015	0.019	1.008	1.001 - 1.015	0.036
LMR	0.686	0.571 - 0.826	<0.001	0.679	0.559 - 0.825	<0.001
NLR	1.269	1.073 - 1.501	0.005			
PLR	1.014	1.005 - 1.024	0.004			
LCR	0.960	0.923 - 0.999	0.043			
SII	1.001	1.000 - 1.002	0.002			
SIRI	1.239	1.048 - 1.466	0.012			
AISI	1.001	1.000 - 1.002	0.007			

The multivariable logistic regression model was constructed using the forward likelihood-ratio method. AISI: Aggregate index of systemic inflammation, CI: Confidence interval, CRP: C-reactive protein, LCR: Lymphocyte-to-C-reactive protein ratio, LMR: Lymphocyte-to-monocyte ratio, LR: Likelihood ratio, NLR: Neutrophil-to-lymphocyte ratio, OR: Odds ratio, PLR: Platelet-to-lymphocyte ratio, SII: Systemic immune-inflammation index, SIRI: Systemic inflammation response index

was 0.764 (95% CI, 0.671–0.857; p<0.001 (Table 4 and Fig. 3). The optimal LMR cutoff determined using the Youden index was 5.5. When an LMR of <5.5 was considered positive, sensitivity was 64.0%, specificity was 80.0%, the positive predictive value was 76.2%, and the negative predictive value was 69.0%.

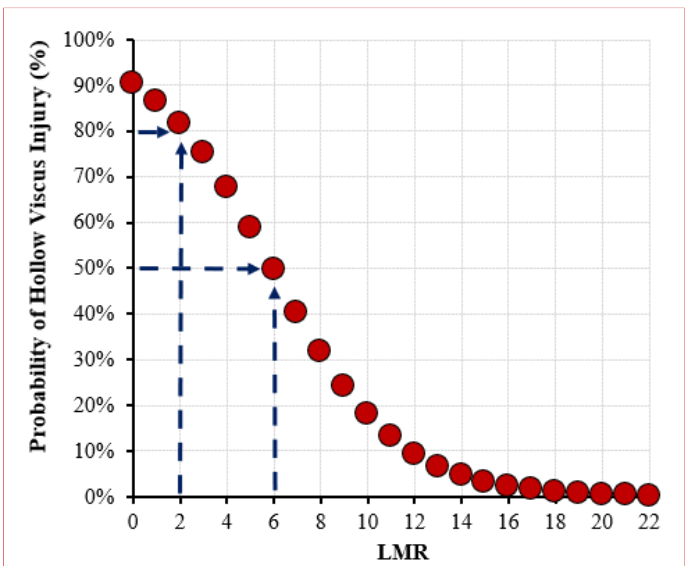

Figure 2. Predicted probability of hollow viscus injury according to LMR.

Among the 42 patients with an LMR of <5.5, 32 were in the HVIP group, and 10 were in the HVIN group. Of the 58 patients with an LMR of ≥5.5, 18 were in the HVIP group, and 40 were in the HVIN group. The positive and negative predictive values were considered specific to the present study sample, which included equal numbers of patients in the HVIP and HVIN groups.

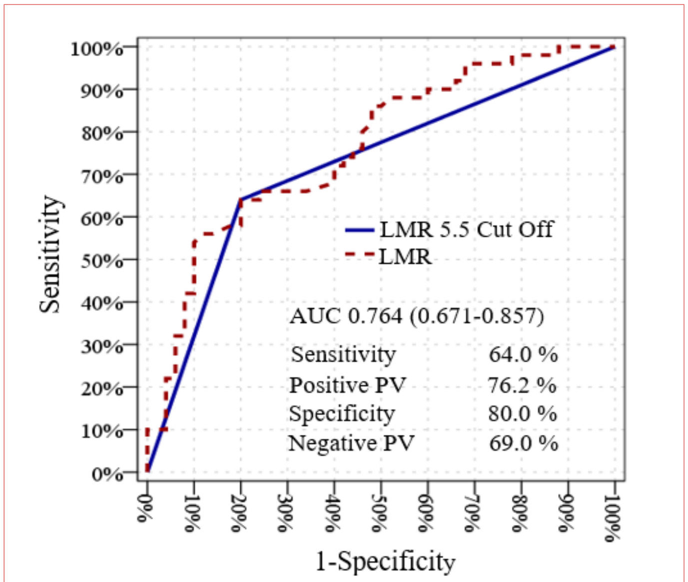

Figure 3. Receiver operating characteristic curve of LMR for predicting hollow viscus injury.

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Table 4. ROC analysis and diagnostic performance of LMR

	AUC		95% CI		p
LMR	0.764		0.671	0.857	**<0.001**
LMR <5.5 Cut Off	0.720		0.618	0.822	**<0.001**
	HVIN (n=50)	**HVIP (n=50)**			**%**
LMR category					
<5.5	10	32	Sensitivity		64.0
≥5.5	40	18	Positive predictive value		76.2
			Specificity		80.0
			Negative predictive value		69.0

The optimal cutoff value was determined using the Youden index. AUC: Area under the curve, CI: Confidence interval, HVIN: Hollow viscus injury negative, HVIP: Hollow viscus injury positive, LMR: Lymphocyte-to-monocyte ratio, ROC: Receiver operating characteristic

DISCUSSION

This study investigated the association between inflammatory markers obtained at admission and surgically confirmed hollow viscus injury in a selected cohort of patients who underwent surgery for abdominal or thoracoabdominal stab wounds. Neutrophil, monocyte, platelet, CRP, NLR, PLR, SII, SIRI, and AISI values were higher in the HVIP group, whereas LMR and LCR were lower. Only platelet count and LMR retained independent associations with hollow viscus injury in the multivariable analysis. The area under the ROC curve for LMR was 0.764, and a cutoff value of 5.5 yielded a sensitivity of 64% and a specificity of 80%. These findings suggest that LMR is insufficient to establish or exclude hollow viscus injury when used alone but may serve as an adjunct to clinical and radiological assessment.

Traumatic tissue injury induces an early inflammatory and immune response involving neutrophils, monocytes, lymphocytes, and platelets. Ratios incorporating different cell populations may therefore reflect the systemic response to trauma more comprehensively than a single cell count. In our study, differences in total white blood cell and lymphocyte counts did not reach statistical significance, whereas neutrophil and monocyte counts and the indices derived from these cells differed significantly between the groups. These findings are consistent with the biological basis of the cellular response to trauma described in previous studies.[8,9]

Yucel et al.[14] evaluated patients with penetrating abdominal stab wounds and reported higher white blood cell, neutrophil, monocyte, NLR, and PLR values and lower lymphocyte counts among patients who subsequently required surgery. They also showed that NLR and PLR could contribute to identifying the need for surgery. However, their study compared surgically treated patients with those managed non-operatively, whereas all patients in our study underwent surgical exploration and were classified according to the presence or absence of hollow viscus injury confirmed at surgery.

Demirpolat and Islam reported that NLR, PLR, and SII values measured at admission did not discriminate the need for surgery, whereas values measured during follow-up could predict therapeutic surgery.[15] In contrast, admission NLR, PLR, and SII values differed significantly between the HVIP and HVIN groups in our study. This difference between studies may be attributable to differences in patient selection, the timing of blood sampling, and the outcomes evaluated. The exclusion of concomitant organ and vascular injuries in our study may also have reduced their confounding effects on the inflammatory response.

In a recent study, Colapkulu-Akgul et al.[16] evaluated initial complete blood count parameters and computed tomography findings in 91 patients who underwent laparotomy for abdominal stab wounds. The investigators reported that NLR, PLR, free air, and free fluid did not reliably predict therapeutic laparotomy. This finding is consistent with our observation that NLR and PLR differed between the study groups but lost their independent associations in the multivariable analysis. In contrast, the independent association of LMR suggests that inflammatory indices incorporating the monocyte component warrant further investigation in this patient population.

One of the most notable findings of our study was the independent association between a lower LMR and hollow viscus injury. Combining an increase in monocyte count with a relative decrease in lymphocyte count within a single ratio may have revealed a distinction that was not evident from either cell count alone. A higher monocyte-to-lymphocyte ratio has previously been associated with adverse clinical outcomes in patients with abdominal trauma. Because the monocyte-to-lymphocyte ratio is the mathematical inverse of LMR, the direction of this association is consistent with the lower LMR observed in our study. However, previous studies have primarily evaluated prognostic outcomes such as mortality and organ failure rather than the detection of hollow viscus injury.[13]

Platelet count was also independently associated with hollow viscus injury in the multivariable analysis. The platelet response after trauma follows a time-dependent course. During the early period, platelet counts may decrease because of hemorrhage, consumption, dilution, shock, and resuscitation, whereas bone marrow activity and inflammatory stimulation may subsequently lead to platelet recovery and reactive thrombocytosis. In a prospective study of 276 patients with major trauma, Schofield et al.[17] reported that immature platelets exhibited distinct early and late dynamics and that these changes were associated with clinical outcomes. Similarly, Rossetto et al.,[18] in a cohort of 803 critically ill trauma patients, demonstrated that platelet counts initially decreased after injury, generally reached their nadir within 48–72 h, recovered by approximately day 7, and could rise above the normal range by day 14. However, all blood samples in our study were obtained within the first 6 h after injury, and the median platelet counts in both the HVIN and HVIP groups remained within normal laboratory reference ranges (244 and 289×10^3/µL, respectively). Therefore, the higher platelet count observed in the HVIP group represents an early relative difference in platelet count rather than thrombocytosis or a delayed bone marrow response. Because platelet function was not evaluated and the biological mechanism underlying this association cannot be determined from the observational study design, this finding should be interpreted as an adjunctive marker rather than a mechanistic observation or a stand-alone diagnostic indicator.

Although NLR, PLR, SII, SIRI, and AISI were higher in the HVIP group, they did not retain independent associations in the multivariable analysis. Because these indices are derived from the same neutrophil, lymphocyte, monocyte, and platelet measurements, they may be strongly correlated mathematically. Furthermore, the limited sample size may have made it difficult to distinguish the independent contributions of several interrelated indices. The significant between-group differences in these indices should therefore not be disregarded, but the indices should not be interpreted as independent diagnostic markers.

Predefined computed tomography findings considered suspicious for perforation were identified in only 30% of patients in the HVIP group. The absence of these findings in 70% of patients with HVIP indicates that the absence of direct signs of perforation cannot, by itself, exclude hollow viscus injury in this selected operative population. However, only findings explicitly reported as direct evidence of perforation and free intraperitoneal air were classified as positive in our study. Therefore, this proportion should not be interpreted as the overall sensitivity of computed tomography for all bowel and mesenteric injury findings. The WSES guidelines similarly recommend that imaging findings be interpreted together with clinical assessment and serial physical examinations.[19]

Although free intraperitoneal air was considered suspicious for perforation, it may have entered the peritoneal cavity through the penetrating wound tract. Kong et al.[20] evaluated patients with isolated pneumoperitoneum following abdominal stab wounds and reported that approximately one-third had no intra-abdominal injury. Free intraperitoneal air should therefore be regarded as a finding that increases the likelihood of perforation but does not provide a definitive diagnosis when considered alone.

The main limitations of this study were its retrospective, single-center design, limited sample size, and inclusion of only surgically treated patients. Because patients managed non-operatively were not evaluated, the performance of LMR for determining the need for surgery could not be investigated. Although excluding concomitant injuries reduced potential confounding, it also limited the generalizability of the findings to patients with multiple trauma. The interval between injury and blood sampling was not standardized, and inflammatory markers were measured only at admission, preventing assessment of their temporal changes. The computed tomography classification was based on official radiology reports rather than a standardized retrospective review of the images; therefore, differences in imaging protocols and reporting radiologists could not be controlled. In addition, evaluating several mathematically correlated inflammatory indices in a limited sample may have increased the risk of model instability and chance findings. Because the HVIP and HVIN groups contained equal numbers of patients and did not reflect the true clinical prevalence of hollow viscus injury, the positive and negative predictive values are applicable only to the present study sample. Finally, deriving and evaluating the LMR cutoff in the same cohort may have resulted in optimistic performance estimates, and the cutoff requires validation in larger, independent patient populations.

CONCLUSION

A lower LMR and a higher platelet count at admission were independently associated with surgically confirmed hollow viscus injury in this selected cohort of patients who underwent surgery for abdominal or thoracoabdominal stab wounds. The moderate discriminative performance of LMR indicates that it is insufficient to confirm or exclude hollow viscus injury when used alone. LMR may be considered a low-cost and readily available adjunct to clinical examination and imaging findings. However, the findings and the identified cutoff value should be validated in larger, multicenter, independent cohorts before clinical implementation.

DECLARATIONS

Ethics Committee Approval: The study protocol was approved by the Bakırköy Dr. Sadi Konuk Training and Research Hospital Ethics Committee (No: 2024-01-31,Date: 22/01/2024).

Informed Consent: Written informed consent was obtained from all individual participants included in this study.

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Authorship Contributions: Concept – NS, TD, AS; Design – NS, MSD; Supervision – NS, FTO; Fundings – NS, SB; Materials – NS, AM; Data collection &/or processing – NS, AM; Analysis and/or interpretation – NS, AS; Literature search – NS, FTO, SB; Writing – NS, MSD; Critical review – NS, TD, AS.

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