Research Square

Preprints are preliminary reports that have not undergone peer review.
They should not be considered conclusive, used to inform clinical practice,
or referenced by the media as validated information.

Diagnostic Performance of Complete Blood Count Parameters in Acute Small Bowel Obstruction: Modification by Comorbidity

Fedir Grynchuk

fedir.grynchuk@bsmu.edu.ua

Bukovinian State Medical University

Viktor Horditsa

Bukovinian State Medical University

Research Article

Keywords: Intestinal Obstruction, Comorbidity, Peritonitis, Intestinal Ischemia, Leukocyte Count, Neutrophils Count, Immature Granulocytes Count, Neutrophil-to-lymphocyte Ratio.

Posted Date: June 10th, 2026

DOI: https://doi.org/10.21203/rs.3.rs-8804686/v1

License: This work is licensed under a Creative Commons Attribution 4.0 International License.
Read Full License

Additional Declarations: No competing interests reported.

Abstract

Objective

Early detection of bowel necrosis and peritonitis is crucial for choosing a treatment strategy in patients with acute small bowel obstruction (ASBO). The aim of this study was to evaluate the effect of comorbidity on the diagnostic ability of white blood cell count (WBC), neutrophils (NEU), immature granulocytes (IG), and the neutrophil-to-lymphocyte ratio (NLR) in detecting ASBO complications.

Methods

A single-center retrospective cohort study of 130 patients operated on for ASBO was conducted. Parameters were compared between groups according to the presence of complications and comorbidity. For statistical analysis, standard comparative methods, receiver operating characteristic (ROC) analysis with determination of the area under the curve (AUC), and regression models were used.

Results

In complicated ASBO, despite increased WBC, NEU, and NLR levels, only NEU showed a significant increase ($p = 0.03$) in patients without comorbidity; in comorbid patients, none of the parameters differed significantly. IG were detected only in 3 (8.8%) comorbid patients with peritonitis. In patients without comorbidity, the AUC was: for WBC, 0.69 (95% CI 0.49–0.88), optimal cutoff 11.2*10⁹/L (sensitivity 85%, specificity 57.1%); for NEU, 0.73 (95% CI 0.56–0.90), cutoff 9.49*10⁹/L (sensitivity 92.9%, specificity 50%); for NLR, 0.68 (95% CI 0.50–0.86), cutoff 4.06 (sensitivity 100%, specificity 52.4%). In comorbid patients, the AUC was: for WBC, 0.55 (95% CI 0.45–0.65), cutoff 11.5*10⁹/L (sensitivity 64.7%, specificity 53.2%); for NEU, 0.55 (95% CI 0.45–0.66), cutoff 8.72 *10⁹/L (sensitivity 64.1%, specificity 54.4%); for NLR, 0.53 (95% CI 0.42–0.65), cutoff 7.5 (sensitivity 65.4%, specificity 52.2%). In the regression model, the Charlson comorbidity index showed the most consistent effect on changes in these parameters, whereas the clinical form of ASBO had an independent effect only on NEU.

Conclusions

In comorbid patients with complicated ASBO, the discriminative ability of WBC, NEU, and NLR is reduced. NEU levels showed relatively higher diagnostic value in patients without comorbidity, with moderate overall discriminative performance. In this study, IG did not demonstrate sensitivity as an early marker of ASBO complications.

Introduction

Deciding on the need for emergency surgical intervention is central to the treatment strategy for ASBO, as delays significantly increase the risk of complications and mortality, which reaches 10–30% [1, 2, 3]. The main indications for urgent surgery are the presence of generalized peritonitis and bowel necrosis [1–7]. Rapid diagnosis of these conditions is a key factor for patient survival [3, 4, 8]. However, this can be challenging, as their clinical manifestations are nonspecific [1, 5, 7, 9, 10], and clear symptoms are not always present [7], particularly in elderly patients [11]. Imaging methods play a leading role in diagnosing ASBO and its complications [1, 3, 4, 6, 12, 13, 14], with computed tomography (CT) considered the gold standard [15]. Nevertheless, the informativeness of CT, as well as other imaging modalities, is limited [15, 16, 17]. Therefore, clinical management is always based on the assessment of a combination of clinical, laboratory, and imaging findings [1, 3, 6, 7, 12, 18, 19].

Numerous studies have proposed including white blood cell count (WBC), neutrophils (NEU), immature granulocytes (IG), and the neutrophil-to-lymphocyte ratio (NLR) as components of this assessment [1, 6, 7, 11, 18, 20, 21, 22, 23, 24, 25, 26]. In recent years, several authors have suggested measuring immature granulocytes (IG) specifically [27, 28, 29, 30]. The advantage of these parameters lies in their accessibility and rapid assessment, making them attractive for the initial stratification of complications. At the same time, data on their informativeness and diagnostically significant thresholds vary.

Leukocytosis is a recognized diagnostic marker [1, 7, 10, 11, 28], which, according to a meta-analysis, is the only informative non-imaging criterion [31]. However, this parameter is known to be nonspecific and often insufficiently informative [6], particularly in elderly patients with comorbidities [11], so some researchers consider its use unnecessary [32, 33, 34, 35, 36]. Generally, a WBC level > 10* *10⁹/L is considered a marker indicating the need for surgical intervention [4, 6, 22, 37, 38]. In contrast, Yao Z et al. [39] reported that this level did not show a strong association with complications, while several studies have reported higher [18, 31, 40] or lower levels [21, 30]. At the same time, Uprak TK et al. [41] noted that in ASBO patients treated conservatively, WBC levels were significantly higher than in those requiring surgery.

According to Chen N et al. [21], NEU level is an independent predictor of the risk of bowel necrosis. Most authors mention only neutrophilia, and the reported criteria for NEU level thresholds vary [21, 26].

Several studies indicate that NLR level is an independent predictor of ischemia development in ASBO, although the reported threshold values vary [22, 24, 25, 26]. In contrast, IG count is reported by some researchers as an independent predictor of bowel necrosis [20, 21, 22, 23].

However, analyses of the diagnostic accuracy of these markers have focused on comparisons of patients with different complications and clinical forms of ASBO, as well as on predicting treatment outcomes [42, 43, 44, 45]. Such studies often report the presence of comorbidities in patients, but do not analyze their impact on the diagnostic informativeness of the parameters. At the same time, it is known that comorbidities can affect laboratory parameters [20, 30], require faster diagnostic decisions [2, 46], worsen ASBO treatment outcomes [47, 48, 49, 50], and are one of the independent factors associated with the need for surgical intervention [51]. Therefore, we hypothesized that the presence of

comorbidities is not only associated with worse clinical outcomes in ASBO, but also alters the diagnostic performance of complete blood count parameters and may partially explain the inconsistencies reported in the literature. In this study, we investigated the impact of comorbidities on the diagnostic value of WBC, NEU, IG, and NLR for detecting ASBO complications.

Materials and Methods

Study design and population

The primary endpoint of the study was the differentiation of uncomplicated and complicated ASBO (bowel necrosis and/or peritonitis) based on complete blood count parameters. This study included 130 patients with mechanical ASBO treated in the surgical department of Chernivtsi Regional Clinical Hospital, which serves as the clinical base of Bukovinian State Medical University (BSMU), from October 2023 to August 2025. Patients' ages ranged from 18 to 89 years (median 59; IQR 37–69).

All patients underwent examination and treatment according to current protocols. All patients were operated on. Uncomplicated ASBO was diagnosed in 56 (43.08%) patients, while complicated ASBO was diagnosed in 74 (56.92%) patients. Comorbidities were present in 96 (73.85%) patients (Table 1). One concomitant disease was present in 40 (41.67%) patients, two concomitant diseases in 35 (36.46%) patients, and three or more concomitant diseases in 21 (21.88%) patients. Diagnoses were established based on relevant clinical data, laboratory tests, and instrumental examinations.

Table 1
Comorbidity characteristics

Diagnosis	Number of cases
Ischemic heart disease	85
Chronic bronchitis	18
Hypertensive disease	17
Liver cirrhosis	11
Cerebral atherosclerosis	6
Type II diabetes mellitus	6
Obesity	8
Chronic pyelonephritis	4
Rheumatism, combined mitral valve disease	3
Uterine cancer	3
Acute community-acquired pneumonia	2
Others	12
Total	175

Informed consent

for diagnostic and therapeutic procedures was obtained from all patients after providing comprehensive information about the procedures and potential outcomes, as documented in the medical records.

Data collection

Data were obtained from patients' medical records. All patient data were anonymized and de-identified prior to collection and analysis. Patients were divided into comparison groups: uncomplicated ASBO, complicated ASBO, ASBO with bowel necrosis (without peritonitis), and ASBO with peritonitis. In the first stage of the study, parameters were assessed in the overall patient cohort. In the second stage, parameters were evaluated in patients with and without comorbidities.

The following data were analyzed: age, sex, causes and clinical forms of ASBO, absolute counts (*10^9/L) of WBC, NEU, and IG, and NLR values determined preoperatively, Mannheim Peritonitis Index (MPI), and Charlson Comorbidity Index (CCI). Complete blood counts were performed using the BC-30S Mindray automated hematology analyzer. The reference intervals provided by the manufacturer were: WBC count (4.0–10.0 10^9/L), NEU (2.0–7.5 10^9/L), and IG count (≤ 0.03 *10^9/L). The primary criterion for

determining the presence and type of ASBO complication was the surgical findings, which were compared with preoperative laboratory parameters.

Statistical analysis

Normality of quantitative variables was assessed using the Shapiro–Wilk test. Variables with a normal distribution were presented as mean ± standard deviation (SD) and compared using Student's t-test. Variables with a non-normal distribution were described as median and interquartile range (IQR) and compared using the Mann–Whitney U test. Comparisons among three groups were performed using the Kruskal–Wallis test with effect size ε^2; negative ε^2 values were interpreted as zero effect. Categorical variables were analyzed using Pearson's χ^2 test or Fisher's exact test. Given the exploratory nature of the analysis, adjustments for multiple comparisons were not applied. ROC analysis was performed using DeLong's method to calculate the AUC, its 95% confidence interval (CI), and statistical comparison of curves (with Z-statistic calculation). Outliers were not excluded to preserve natural variability. Optimal cutoff points were determined using Youden's J statistic, with calculation of positive and negative predictive values. Sensitivity was defined as the proportion of true-positive results among all patients with complicated ASBO, and specificity as the proportion of true-negative results among patients with uncomplicated ASBO.

To assess the independent effect of ASBO clinical form, age, and comorbidities on WBC, NEU, and NLR levels, a general linear model (GLM) was used. Absence of multicollinearity was confirmed by variance inflation factor (VIF < 2). Model quality was evaluated using the coefficient of determination (R^2, Adjusted R^2) and the Durbin–Watson statistic to assess residual autocorrelation. The effect of age on CCI was assessed using negative binomial regression. Due to the zero-inflated distribution of IG, it was analyzed as a binary variable (presence/absence). Statistical significance was set at $\alpha = 0.05$. Analyses were performed using IBM SPSS Statistics, version 23.0.

Results

Study characteristics

The distribution of ASBO causes in the comparison groups is presented in Table 2.

Table 2
Characteristics of comparison groups by causes of ASBO

Group	**Clinical form ASBO**		**Type of complication**	
Overall cohort	**Uncomplicated (n = 56)**	**Complicated (n = 74)**	**Bowel necrosis (n = 28)**	**Peritonitis (n = 46)**
Adhesive disease (n, %)	23 (41.07)	34 (45.95)	2 (7.14)	32 (69.57)
Strangulated hernias (n, %)	31 (55.36)	35 (47.30)	23 (82.14)	12 (26.09)
Intussusception (n, %)	–	4 (5.41)	3 (10.71)	1 (2.17)
Volvulus (n, %)	1 (1.79)	–	–	–
Bowel tumor (n, %)	1 (1.79)	1 (1.35)	–	1 (2.17)
With comorbidities	**Uncomplicated (n = 45)**	**Complicated (n = 51)**	**Bowel necrosis (n = 17)**	**Peritonitis (n = 34)**
Adhesive disease (n, %)	17 (37.78)	25 (49.02)	2 (11.76)	23 (67.65)
Strangulated hernias (n, %)	26 (57.78)	25 (49.02)	14 (82.35)	11 (32.35)
Intussusception (n, %)	–	1 (1.96)	1 (5.88)	–
Volvulus (n, %)	1 (2.22)	–	–	–
Bowel tumor (n, %)	1 (2.22)	–	–	–
Without comorbidities	**Uncomplicated (n = 11)**	**Complicated (n = 23)**	**Bowel necrosis (n = 11)**	**Peritonitis (n = 12)**
Adhesive disease (n, %)	6 (54.55)	9 (39.13)	–	9 (75.00)
Strangulated hernias (n, %)	5 (45.45)	10 (43.48)	9 (81.82)	1 (8.33)
Intussusception (n, %)	–	3 (13.04)	2 (18.18)	1 (8.33)
Bowel tumor (n, %)	–	1 (4.35)	–	1 (8.33)

In the overall patient cohort, there were no significant differences in the distribution of ASBO causes between patients with uncomplicated and complicated ASBO ($p = 0.291$). When comparing the groups of patients with uncomplicated ASBO, ASBO with bowel necrosis, and ASBO with peritonitis, statistically significant differences in the distribution of ASBO causes were observed ($p < 0.01$). Similar patterns were observed both in patients with comorbidities and in those without comorbidities: no significant

differences were found between the uncomplicated and complicated groups, whereas differences remained statistically significant between the uncomplicated, bowel necrosis, and peritonitis groups ($p < 0.05–0.01$). No differences in the distribution of ASBO causes were found within the uncomplicated and complicated groups between patients with and without comorbidities ($p = 0.222$).

Age and gender characteristics of the comparison groups are presented in Table 3.

Table 3
Age and gender characteristics of comparison groups

Group	**Clinical form ASBO**		**Type of complication**	
Overall cohort	**Uncomplicated (n = 56)**	**Complicated (n = 74)**	**Overall cohort**	**Uncomplicated (n = 56)**
Age	63.5 (IQR: 40–69.75)	54.5 (IQR: 33.25–68)	48.5 (IQR: 26.75–69)	55.5 (IQR: 38.25–68)
Women (n, %)	31 (55.36%)	43 (58.11%)	15 (53.57%)	28 (60.87%)
Men (n, %)	25 (44.64%)	31 (41.89%)	13 (46.43%)	18 (39.13%)
With comorbidities	**Uncomplicated (n = 45)**	**Complicated (n = 51)**	**Bowel necrosis (n = 17)**	**Peritonitis (n = 34)**
Age	67 (IQR: 61–74)	62 (IQR: 53.5–73)	64 (IQR: 52–77)	61 (IQR: 54.25–70)
Women (n, %)	24 (53.33%)	29 (56.86%)	11 (64.71%)	18 (52.94%)
Men (n, %)	21 (46.67%)	22 (43.14%)	6 (35.29%)	16 (47.06%)
Without comorbidities	**Uncomplicated (n = 11)**	**Complicated (n = 23)**	**Bowel necrosis (n = 11)**	**Peritonitis (n = 12)**
Age	31.09 ± 6.02	31.26 ± 8.82	21.82 ± 7.22	34.42 ± 9.24
Women (n, %)	7 (63.64%)	14 (60.87%)	4 (36.36%)	10 (83.33%)
Men (n, %)	4 (36.36%)	9 (39.13%)	7 (63.64%)	2 (16.67%)

In the overall cohort, the age of patients with uncomplicated and complicated ASBO did not differ significantly ($p = 0.06$; $r = 0.168$). Patients with uncomplicated ASBO were older compared to those with bowel necrosis ($p = 0.04$). No significant differences were found between the uncomplicated and peritonitis groups ($p = 0.203$), or between the bowel necrosis and peritonitis groups ($p = 0.339$).

In the comorbid group, the age of patients with uncomplicated and complicated ASBO did not differ significantly ($p = 0.175$; $r = 0.138$). Age of patients with uncomplicated ASBO did not differ significantly from those with bowel necrosis ($p = 0.556$) or peritonitis ($p = 0.143$), nor between patients with bowel necrosis and peritonitis ($p = 0.578$).

In the non-comorbid group, the age of patients with uncomplicated and complicated ASBO did not differ significantly ($p = 0.954$; $r = 0.010$). Age of patients with uncomplicated ASBO did not differ significantly from those with bowel necrosis ($p = 0.303$) or peritonitis ($p = 0.437$), nor between patients with bowel necrosis and peritonitis ($p = 0.067$).

The age of patients without comorbidities (30; IQR 25.25–37.5) and with comorbidities (66; IQR 55–73.25) differed significantly ($p = 0.000$; $r = 0.673$). Negative binomial regression demonstrated a significant association between age and CCI scores (Rate Ratio = 1.06; $p < 0.001$). With each one-year increase in age, the expected CCI level increased by approximately 6%. The model was statistically significant ($\chi^2 = 163.4$; $p < 0.001$), indicating its adequacy. The root mean square error was 6.18, and the mean absolute error was 1.22, confirming acceptable predictive accuracy.

In the overall cohort, no gender differences were observed between patients with uncomplicated and complicated ASBO ($\chi^2 = 0.112$, $p = 0.738$), nor among the groups with uncomplicated ASBO, bowel necrosis, and peritonitis ($\chi^2 = 0.476$, $p = 0.788$). Similar patterns were observed in patients with comorbidities ($\chi^2 = 0.224$, $p = 0.636$; $\chi^2 = 0.755$, $p = 0.686$) and in patients without comorbidities ($\chi^2 = 0.049$, $p = 0.825$; $\chi^2 = 5.386$, $p = 0.068$). No significant gender differences were found between patients with and without comorbidities ($\chi^2 = 0.447$, $p = 0.504$).

In patients with comorbidities, the CCI scores in the group without bowel necrosis (2; IQR 2–4) did not differ significantly from those in the group with bowel necrosis (3; IQR 1–4, $p = 0.815$) or the group with peritonitis (3; IQR 1–4, $p = 0.732$), nor between the bowel necrosis and peritonitis groups ($p = 0.627$) or between the uncomplicated (2; IQR 2–4) and complicated (3; IQR 1–4, $p = 0.887$) groups.

MPI scores in patients with peritonitis without comorbidities (17.75 ± 4.88) did not differ significantly from those in patients with comorbidities (22.08 ± 7.53, $p = 0.071$, $r = 0.269$).

Comparative analysis of parameters

Comparative analysis of WBC, NEU, and NLR according to complication type in the overall cohort (Table 4) showed that WBC and NEU levels differed significantly between groups, with the highest values observed in patients with bowel necrosis. NLR values did not show significant intergroup differences.

Table 4
WBC, NEU, and NLR values according to ASBO complication type in the overall cohort

Parameter	Uncomplicated ASBO (n = 56)	Bowel necrosis (n = 28)	Peritonitis (n = 46)	H (df)	p–value	ε²
WBC	10.20 (8.51–11.84)	13.25 (10.7–15.4)	10.40 (8.27–12.52)	7.99 (2)	0.018	0.047
NEU	7.51 (5.68–9.34)	10.57 (9.49–12.48)	7.46 (6.17–12.48)	10.61 (2)	0.004	0.067
NLR	3.79 (2.36–6.54)	6.00 (3.70–9.04)	4.17 (2.55–7.60)	4.19 (2)	0.123	0.017

Post hoc pairwise comparisons revealed that patients with bowel necrosis had significantly higher WBC levels compared to those with uncomplicated ASBO (p = 0.005) and peritonitis (p = 0.030). Similar patterns were observed for NEU counts (p = 0.002 and p = 0.006, respectively). No significant differences in WBC or NEU levels were found between the uncomplicated ASBO and peritonitis groups (p = 0.531 and p = 0.729, respectively). NLR values were significantly higher in patients with bowel necrosis compared to uncomplicated ASBO (p = 0.047), while differences between the uncomplicated ASBO and peritonitis groups (p = 0.760) and between peritonitis and bowel necrosis groups (p = 0.096) were not significant.

Comparison of parameters by ASBO clinical form (Table 5) in patients with complications revealed a tendency toward higher WBC and NEU values and a non-significant increase in NLR. Effect sizes for WBC and NEU corresponded to a small effect, while those for NLR were slightly closer to a medium effect.

Table 5
Comparison of WBC, NEU, and NLR values according to ASBO clinical form in the overall cohort

Parameter	Uncomplicated ASBO (n = 56)	Complicated ASBO (n = 74)	p–value	Effect size
WBC	10.2 (8.51–11.84)	11.30 (8.60–13.90)	0.07	0.16
NEU	7.51 (5.68–9.34)	8.90 (6.28–11.34)	0.08	0.16
NLR	3.79 (2.36–6.54)	4.84 (2.76–8.55)	0.23	0.10

Comparative analysis by complication type in patients without comorbidities showed that, unlike the overall cohort, all parameters differed significantly between groups, with the highest values observed in patients with bowel necrosis (Table 6).

Table 6
Comparison of WBC, NEU, and NLR values according to the type of ASBO complication in patients without comorbidities

Parameter	Uncomplicated ASBO (n = 11)	Bowel necrosis (n = 11)	Peritonitis (n = 12)	H (df)	p–value	ε²
WBC	10.20 (8.50–11.75)	13.60 (13.1–15.6)	11.20 (8.65–11.72)	9.97 (2)	0.007	0.257
NEU	6.66 (5.22–7.34)	11.09 (10.04–12.94)	6.48 (6.27–7.54)	15.19 (2)	0.000	0.426
NLR	2.38 (2.12–2.93)	6.00 (4.97–12.03)	2.61 (1.66–4.08)	10.65 (2)	0.005	0.279

Post hoc pairwise comparisons demonstrated that patients with bowel necrosis had significantly higher WBC levels compared to those with uncomplicated ASBO (p = 0.004) and peritonitis (p = 0.008). Similar patterns were observed for NEU counts (p = 0.000 and p = 0.001, respectively) and NLR values (p = 0.004 and p = 0.005, respectively). No significant differences in WBC, NEU, or NLR levels were found between the uncomplicated ASBO and peritonitis groups (p = 0.798, p = 0.736, and p = 0.861, respectively).

Comparative analysis by complication type in patients with comorbidities revealed no statistically significant differences in any parameters (Table 7).

Table 7
Comparison of WBC, NEU, and NLR values according to the type of ASBO complication in patients with comorbidities

Parameter	Uncomplicated ASBO (n = 45)	Bowel necrosis (n = 17)	Peritonitis (n = 34)	H (df)	p–value	ε²
WBC	10.20 (8.68–11.62)	13.00 (8.0–14.7)	10.10 (8.28–12.60)	1.20 (2)	0.548	-0.008
Neutrophils	7.60 (5.76–10.23)	9.84 (5.52–11.42)	7.75 (5.88–10.91)	1.73 (2)	0.423	-0.003
NLR	4.47 (3.04–7.27)	6.00 (3.09–8.90)	4.84 (2.89–8.55)	0.43 (2)	0.806	-0.016

The highest WBC and NLR values were observed in patients with bowel necrosis, while the highest NEU counts were found in patients with peritonitis. Post hoc pairwise comparisons between patients with uncomplicated ASBO and those with bowel necrosis or peritonitis showed no significant differences in WBC (p = 0.277 and p = 0.607), NEU (p = 0.189 and p = 0.670), or NLR (p = 0.533 and p = 0.683), respectively. No significant differences in any parameters were observed between patients with bowel necrosis and those with peritonitis (p = 0.516, p = 0.351, and p = 0.776, respectively).

Comparison by ASBO clinical form in patients without comorbidities (Table 8) showed that in complicated ASBO, WBC and NLR tended to be higher, while NEU counts were significantly elevated.

Table 8
Comparison of WBC, NEU, and NLR values according to the presence of comorbidities across different clinical forms of ASBO

Comorbidity	ASBO Form	WBC	NEU	NLR
No	Uncomplicated (n = 11)	10.20 (8.50–11.75)	6.66 (5.22–7.34)	2.38 (2.12–2.93)
No	Complicated (n = 23)	12.70 (10.95–14.15); p = 0.09; effect size = 0.29	9.55 (6.48–11.26); p = 0.03; effect size = 0.37	4.17 (1.98–6.15); p = 0.09; effect size = 0.29
Yes	Uncomplicated (n = 45)	10.20 (8.08–11.62)	7.60 (5.76–10.23)	4.47 (3.04–7.27)
Yes	Complicated (n = 51)	10.70 (8.15–13.80); p = 0.38; effect size = 0.09	8.10 (5.66–11.26); p = 0.36; effect size = 0.09	5.33 (2.93–8.80); p = 0.56; effect size = 0.06

Effect sizes for WBC and NEU approached the threshold for a medium effect, and for NLR were within the medium effect range. In contrast, in patients with comorbidities and complicated ASBO, no significant differences in parameters were observed, and effect sizes corresponded to a small effect.

No significant differences in WBC ($p = 0.784$, $r = 0.037$) and NEU ($p = 0.212$, $r = 0.167$) were observed between patients with and without comorbidities in the absence of complications. However, NLR values were significantly higher in patients with comorbidities, with an effect size approaching a large effect ($p = 0.002$, $r = 0.403$). Among patients with complications, no significant differences were found in WBC ($p = 0.113$, $r = 0.184$), NEU ($p = 0.417$, $r = 0.094$), or NLR ($p = 0.301$, $r = 0.120$).

IG were detected only in three (8.8%) comorbid patients with peritonitis. In all other study groups, IG values were zero in every case. The frequency of IG detection was significantly higher in comorbid patients with peritonitis compared to all other patients combined into a single group ($p = 0.017$). Similarly, within the cohort of patients with comorbidities, IG detection frequency was higher in the peritonitis group compared to other forms of ASBO combined ($p = 0.042$).

ROC curve and AUC analysis

Quantitative results of the ROC analysis are presented in Table 9.

Table 9
Diagnostic performance of complete blood count parameters for distinguishing uncomplicated and complicated ASBO according to the presence of comorbidities

Group	WBC (AUC, cut-off, Sensitivity, Specificity, Youden's index)	NEU (AUC, cut-off, Sensitivity, Specificity, Youden's index)	NLR (AUC, cut-off, Sensitivity, Specificity, Youden's index)
Overall cohort	0.59 (0.50–0.69), 11.1, 70.69%, 54.17%, 0.250	0.59 (0.49–0.69), 9.08, 71.15%, 52.56%, 0.232	0.56 (0.46–0.66), 4.17, 64.28%, 51.67%, 0.162
Without comorbidities	0.69 (0.49–0.88), 11.2, 85.00%, 57.14%, 0.466	0.73 (0.56–0.90), 9.49, 92.86%, 50.00%, 0.474	0.68 (0.50–0.86), 4.06, 100.00%, 52.38%, 0.565
With comorbidities	0.55 (0.45–0.65), 11.5, 64.71%, 53.23%, 0.164	0.55 (0.45–0.66), 8.72, 64.10%, 54.39%, 0.179	0.53 (0.42–0.65), 7.5, 65.38%, 52.17%, 0.133

In the overall cohort, all investigated markers showed low discriminative ability, with AUC values only slightly above 0.5 (Fig. 1). Statistical comparison of the areas under the curves did not demonstrate superiority of any marker (Table 10).

Table 10
Comparison of ROC curve areas (AUC) using DeLong's test across patient groups

Group	Comparison pair	Z-statistic	p-value
Overall cohort	WBC vs NEU	0.043	0.965
	NEU vs NLR	1.341	0.180
	WBC vs NLR	1.258	0.208
Without comorbidities	NEU vs WBC	1.832	0.067
	NEU vs NLR	0.514	0.607
	WBC vs NLR	1.425	0.154
With comorbidities	WBC vs NEU	0.312	0.755
	NEU vs NLR	0.824	0.410
	WBC vs NLR	0.745	0.456

After stratifying patients by the presence of comorbidities, differences were observed. In patients without comorbidities, the discriminative ability of WBC, NEU, and NLR slightly increased, with the highest AUC observed for NEU counts (Fig. 2); however, DeLong's test showed no statistically significant differences between the markers. In contrast, in patients with comorbidities, the discriminative ability of the markers slightly decreased, with the lowest AUC values (Fig. 3) and no significant differences between markers. Intergroup comparison (Table 11) demonstrated a significant decrease in the diagnostic accuracy of NEU in patients with comorbidities, while no significant differences were found for the other markers.

Table 11
Intergroup comparison of ROC curve areas (AUC) using DeLong's test

Parameter	Comparison groups	AUC difference	Z-statistic	p-value
WBC	Overall vs Without comorbidities	0.10	1.023	0.306
	Overall vs With comorbidities	0.04	0.432	0.665
	Without comorbidities vs With comorbidities	0.14	1.342	0.179
NEU	Overall vs Without comorbidities	0.11	1.224	0.221
	Overall vs With comorbidities	0.07	0.784	0.433
	Without comorbidities vs With comorbidities	0.18	1.968	0.049
NLR	Overall vs Without comorbidities	0.12	1.185	0.236
	Overall vs With comorbidities	0.03	0.314	0.753
	Without comorbidities vs With comorbidities	0.15	1.354	0.176

Optimal cutoff values determined by the Youden J-statistic varied depending on the presence of comorbidities. The highest sensitivity of the markers was observed in patients without comorbidities, while specificity was variable. It should be noted that the ROC analysis in comorbidity-stratified subgroups was exploratory due to the limited sample size and wider AUC confidence intervals.

Regression analysis

Results of the GLM demonstrated varying degrees of association between changes in the parameters and the included predictors (Table 12).

Table 12
Results of GLM for WBC, NEU, and NLR accounting for ASBO clinical form, age, and CCI

Parameter	Factor	F	p– value
WBC	Overall model	3.40	0.020
	ASBO clinical form	2.91	0.091
	Age	5.52	0.020
	CCI	3.88	0.051
NEU	Overall model	3.12	0.029
	ASBO clinical form	3.99	0.048
	Age	3.54	0.062
	CCI	3.77	0.055
NLR	Overall model	3.56	0.016
	ASBO clinical form	1.35	0.248
	Age	1.97	0.163
	CCI	7.02	0.009

WBC levels were significantly influenced by patient age, with the association with CCI at the borderline of statistical significance, while the ASBO clinical form showed only a trend toward an effect. The model explained 7.5% of WBC variation (Adjusted R^2 = 5.3%). The root mean square error was 27.3, and the mean absolute error was 3.68, indicating a moderate level of predictive error. Durbin–Watson statistics (1.89; p = 0.26) confirmed the absence of residual autocorrelation.

In contrast, NEU levels were significantly influenced by the ASBO clinical form, while associations with age and CCI were at the borderline of statistical significance. The model explained 6.9% of NEU variation (Adjusted R^2 = 4.7%). The root mean square error was 19.6, and the mean absolute error was 3.29, indicating a moderate level of predictive error. Durbin–Watson statistics (1.80; p = 0.133) confirmed the absence of residual autocorrelation.

NLR values were significantly influenced by CCI, with no significant association with age or ASBO clinical form. The model explained 7.8% of NLR variation (Adjusted R^2 = 5.6%). The root mean square error was 56.2, and the mean absolute error was 4.61, indicating a moderate level of predictive error. Durbin–Watson statistics (1.76; p = 0.089) confirmed the absence of residual autocorrelation.

Discussion

The distribution of ASBO causes in our study, with a predominance of incarcerated hernias and adhesive disease, is consistent with published epidemiological data [3, 11, 52]. The groups with uncomplicated and complicated ASBO were comparable in etiology, minimizing the impact of this factor on the interpretation of laboratory parameters. The presence of comorbidities was also not associated with changes in the distribution of ASBO causes within individual clinical forms, allowing comorbidity to be considered a modifier of laboratory parameter changes.

The comparison groups within the overall cohort, as well as among patients with and without comorbidities, were comparable in terms of age, sex, CCI, and MPI scores. The strong association between increasing patient age and CCI scores is an expected epidemiological pattern, as CCI progressively rises with age and reflects the cumulative burden of chronic diseases, which carries independent clinical significance.

When discussing the results of the comparative analysis, it should be emphasized that our study focused not on identifying diagnostically significant parameter thresholds, but on assessing the impact of comorbidities. Therefore, the data are primarily of an exploratory nature, and the specific parameter values and the significance levels observed should not be considered definitive. The results, however, confirmed previously published findings [1, 6, 7, 11, 18, 20, 21, 22, 23, 24, 25, 26] that increases in WBC, NEU, and NLR levels serve as markers of ASBO complications. Yet, the threshold values and their diagnostic informativeness depended on the presence of comorbidities. In the overall cohort, WBC and NEU levels were higher in patients with complicated ASBO; however, these differences were mainly driven by patients with bowel necrosis and were accompanied by a small effect size, limiting their clinical utility. NLR did not show convincing between-group differences and had a minimal effect size. This suggests that WBC and NEU may reflect the severity of bowel ischemia, whereas their ability to distinguish between complicated and uncomplicated forms overall is limited.

Fundamentally different patterns were observed after stratifying patients by the presence of comorbidities. In patients without comorbidities, these parameters differed significantly according to the presence of complications, with the highest values observed in cases of bowel necrosis. Moreover, in this subgroup, the parameters showed medium or near-medium effect sizes, supporting their clinical relevance. In contrast, among patients with comorbidities, none of the parameters demonstrated statistically significant between-group differences, and the effect sizes were small or negligible, indicating a reduced diagnostic performance.

From a clinical perspective, it is important that when deciding on emergency surgical intervention, the key distinction is between complicated and uncomplicated ASBO, whereas the type of complication (bowel necrosis or peritonitis) usually does not alter management strategies. In this context, among patients with complicated ASBO, only the NEU count showed significant differences in those without comorbidities.

The results of the ROC analysis are consistent with these observations. The highest AUC values, sensitivity, and specificity were observed in patients without comorbidities, whereas in patients with

comorbidities, the discriminative ability of all parameters decreased, most notably for NEU. DeLong's test showed that the differences in AUC between patients with and without comorbidities were more pronounced than the differences between markers within individual groups, with the highest Z-statistic values observed for NEU. This indicates the limited clinical applicability of fixed cutoff values in patients with comorbidities. Unlike previously published data, which identified WBC [31, 53], NEU [21], and NLR [22, 24, 25, 26] as informative predictors of complications, in our study, only NEU demonstrated acceptable discriminative ability in patients without comorbidities, although it did not show a significant advantage over other markers, highlighting the limited potential for its universal application.

The GLM analysis demonstrated that changes in these parameters are determined by different factors. Age was an independent predictor for WBC, clinical form of ASBO for NEU, and CCI for NLR. At the same time, CCI exerted the most consistent influence, showing a trend toward association with changes in WBC and an even stronger trend with changes in NEU than age, whose effect was not significantly associated with NLR. Thus, these parameters reflect not only the presence of ASBO complications but also background alterations in the activity of relevant cellular components of inflammatory regulation driven by comorbidities and patient age. Results of the Negative Binomial regression, which confirmed the close association between increasing CCI and age, indicate that CCI integrates the effect of age inherent in its structure and serves as a more robust predictor of laboratory parameter changes than chronological age alone. This supports the use of CCI as an integrated index that incorporates the age component. In this context, NEU was the parameter most sensitive to the clinical form of ASBO, suggesting it may serve as a marker that, compared with other parameters, better reflects the presence of complicated disease, although its prognostic value remains limited.

Unlike studies in which the number of IG was shown to be an independent predictor of bowel necrosis [27, 28, 29, 30], we detected IG exclusively in comorbid patients with ASBO complicated by peritonitis. Given that the appearance of IG indicates pronounced activation of hematopoiesis at late stages of inflammation [54], it can be assumed that the presence of these cells reflects this process in individual patients. Therefore, IG should be considered primarily as a marker of septic processes, consistent with the literature [54, 55, 56], rather than as an early screening marker of ASBO complications.

In conclusion, our data indicate that comorbidity is an important modifier of changes in complete blood count parameters in ASBO. We believe this may partly explain the variability and discrepancies reported in the literature regarding their diagnostic performance. Ignoring this factor may lead to overestimation or underestimation of the diagnostic value of these laboratory markers, whose interpretation should take comorbidity into account when assessing the presence of ASBO complications.

Study limitations

The retrospective design does not allow full control of potential confounders or establishment of causal relationships. Since only surgically treated patients were included, the studied markers do not assess the need for surgery, but rather reflect the presence and type of ASBO complications in an already selected

population of operated patients. The relatively small sample size, particularly in subgroups, may have limited the statistical power of some comparisons. The single-center design, absence of external validation of regression models, and ROC threshold values limit the generalizability of the results; therefore, the findings should be considered hypothesis-generating. Assessment of diagnostic performance in subgroups, especially in patients without comorbidities, was accompanied by wide AUC confidence intervals, reflecting the limited sample size and reducing estimate precision. IG were detected in only a small number of patients, limiting the interpretation of their diagnostic significance. The impact of specific diseases within the comorbidity structure was not evaluated, which could differently influence laboratory parameters.

Conclusions

Complete blood count parameters should not be interpreted universally without considering comorbidities. Although WBC, NEU, and NLR levels increased in complicated ASBO, only NEU demonstrated significant differences with a clinically relevant effect size in patients without comorbidities. In patients with comorbidities, none of the parameters showed significant differences, their discriminative ability decreased, and AUC values approached the level of random chance. The most consistent background modifier of these parameters was comorbidity, assessed by the CCI, which was associated with reduced ability to distinguish clinical forms of ASBO, while clinical forms independently influenced only NEU levels. IG did not demonstrate sensitivity as an early marker of ASBO complications in this study.

Abbreviations

ASBO:

Acute small bowel obstruction

WBC:

White blood cell count

NEU:

Neutrophils

IG:

Immature granulocytes

NLR:

Neutrophil-to-lymphocyte ratio

CCI:

Charlson Comorbidity Index

CT:

Computed tomography

MPI:

Mannheim Peritonitis Index

IQR:

Interquartile range

SD:

Standard deviation

ROC:

Receiver operating characteristic

AUC:

Area under the curve

GLM:

Generalized linear model

BSMU:

Bukovinian State Medical University

Declarations

Ethics approval and consent to participate

Ethics Statement

The study was conducted in accordance with the ethical principles of the Declaration of Helsinki and approved by the Bioethics Committee of BSMU. Informed consent for diagnostic and therapeutic procedures was obtained after patients were fully informed, as documented in the medical records. As the study was retrospective and data anonymized, consent for publication was not required.

Consent for publication

Not applicable

Availability of data and materials

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Competing interests

The authors declare that they have no competing interests.

Funding

The study was conducted without financial support, within the framework of the institutional research plan of the Department of Surgery No. 1, BSMU.

Authors' contributions

FG designed the study, performed data analysis, drafted the original manuscript, and supervised all processes. VH collected the data, participated in data analysis, and contributed to drafting the manuscript. All authors read and approved the final manuscript.

Acknowledgements

The authors thank the staff of the Surgery Department of Chernivtsi Regional Clinical Hospital for their assistance and support.

Authors' information

Authors and Affiliations

1. FG is MD, PhD, DSci, Professor at the Department of Surgery No. 1, Bukovinian State Medical University, Chernivtsi, Ukraine. He also serves as Advisor on surgical matters to the General Director of Chernivtsi Regional Clinical Hospital. e-mail: fedir.grynchuk@bsmu.edu.ua

2. VH is MD, Surgeon at the Department of General Surgery, Chernivtsi Regional Clinical Hospital, and a postgraduate student at the Department of Surgery No. 1, Bukovinian State Medical University, Chernivtsi, Ukraine. e-mail: viktorgordica2@gmail.com

Corresponding author

Fedir Grynchuk – Department of Surgery No. 1, Bukovinian State Medical University, Chernivtsi, Ukraine. e-mail: fedir.grynchuk@bsmu.edu.ua

References

1. Rami Reddy SR, Cappell MS. A systematic review of the clinical presentation, diagnosis, and treatment of small bowel obstruction. Curr Gastroenterol Rep. 2017;19(6):28. https://doi.org/10.1007/s11894-017-0566-9.
2. Rani S, Puranik A, Chaudhary R, Elhence P, Yadav T, Varshney VK. Clinico-epidemiological analysis of small bowel obstruction in adults at a tertiary care center in India. Cureus. 2024;16(6):e63278. https://doi.org/10.7759/cureus.63278.
3. Walshaw J, Smith HG, Lee MJ. Small bowel obstruction. Br J Surg. 2024;111(7):znae167. https://doi.org/10.1093/bjs/znae167.
4. Tong JWV, Lingam P, Shelat VG. Adhesive small bowel obstruction – an update. Acute Med Surg. 2020;7(1):e587. https://doi.org/10.1002/ams2.587.
5. Kalpana Devi AK, Sridevi K, Arun D, Sujitha S. A study on prognostic scoring in acute intestinal obstruction. Int J Life Sci Biotechnol Pharma Res. 2025;14(2):1127–32. https://doi.org/10.69605/ijlbpr_14.2.2025.203.
6. Ten Broek RPG, Krielen P, Di Saverio S, Coccolini F, Biffl WL, Ansaloni L, et al. Bologna guidelines for diagnosis and management of adhesive small bowel obstruction (ASBO): 2017 update of the evidence-based guidelines from the World Society of Emergency Surgery ASBO working group. World J Emerg Surg. 2018;13:24. https://doi.org/10.1186/s13017-018-0185-2.
7. Amara Y, Leppaniemi A, Catena F, Ansaloni L, Sugrue M, Fraga GP, et al. Diagnosis and management of small bowel obstruction in virgin abdomen: a WSES position paper. World J Emerg Surg. 2021;16(1):36. https://doi.org/10.1186/s13017-021-00379-8.
8. Orozco CA, Alvarez del Castillo Gonzalez J, Osuna Gutiérrez F, Zepeda Torres JM. Acute small bowel obstruction. Int J Med Sci Clin Res Stud. 2022;2(7):676–9. https://doi.org/10.47191/ijmscrs/v2-i7-14.
9. Long B, Robertson J, Koyfman A. Emergency medicine evaluation and management of small bowel obstruction: evidence-based recommendations. J Emerg Med. 2019;56(2):166–76. https://doi.org/10.1016/j.jemermed.2018.10.024.
10. Gómez Corral J, Niño Rojo C, de la Fuente Olmos R. Bowel obstruction: signs indicating the need for urgent surgery. Radiologia (Engl Ed). 2023;65(1):92–8. https://doi.org/10.1016/j.rxeng.2022.09.007.
11. Ozturk E, van Iersel M, Stommel MM, Schoon Y, Ten Broek RR, van Goor H. Small bowel obstruction in the elderly: a plea for comprehensive acute geriatric care. World J Emerg Surg. 2018;13(1):48. https://doi.org/10.1186/s13017-018-0208-z.
12. Coco D, Leanza S, Fiume I. Small bowel obstruction: a prognostic score index for surgery – a review. Prz Gastroenterol. 2022;17(3):177–82. https://doi.org/10.5114/pg.2022.118454.
13. Scaglione M, Galluzzo M, Santucci D, Trinci M, Messina L, Laccetti E, et al. Small bowel obstruction and intestinal ischemia: emphasizing the role of MDCT in the management decision process. Abdom Radiol (NY). 2022;47(5):1541–55. https://doi.org/10.1007/s00261-020-02800-3.

14. Zins M, Frandon J, Millet I. Assessment of ischemia in mechanical small bowel obstruction: the time has come for dual-energy CT. Diagn Interv Imaging. 2025;106(4):113–4. https://doi.org/10.1016/j.diii.2025.01.001.
15. Brower C, Karam A, Schulwolf S, Stein D, Baugh C, Shokoohi H, et al. Clinical and imaging predictors of need for emergent surgical intervention for small bowel obstruction. Ann Emerg Med. 2024;84(4):S14. https://doi.org/10.1016/j.annemergmed.2024.08.039.
16. Rondenet C, Millet I, Corno L, Khaled W, Boulay-Coletta I, Taourel P, et al. CT diagnosis of closed loop bowel obstruction mechanism is not sufficient to indicate emergent surgery. Eur Radiol. 2020;30(2):1105–12. https://doi.org/10.1007/s00330-019-06413-3.
17. Feister K, Konstantinoff K, Hamade M, Mellnick V. Pearls and pitfalls of imaging small bowel obstruction. Can Assoc Radiol J. 2024;75(3):631–43.
18. Ghabisha S, Ahmed F, Altam A, Hassan F, Badheeb M. Small bowel obstruction in virgin abdomen: predictors of surgical intervention need in resource-limited setting. J Multidiscip Healthc. 2023;16:4003–14. https://doi.org/10.2147/JMDH.S441958.
19. Al-Wageeh S, Alyhari Q, Ahmed F, Mohammed H, Dahan N, Almohtadi AM, et al. Clinical and radiological factors associated with nonoperative management failure for small bowel obstruction: a retrospective study from a resource-limited setting. Ther Clin Risk Manag. 2024;20:893–906. https://doi.org/10.2147/TCRM.S496629.
20. Li H, Sun D, Xiao Z, Zhuang J, Yuan C. The diagnostic value of coagulation indicators and inflammatory markers in distinguishing between strangulated and simple intestinal obstruction. Surg Laparosc Endosc Percutan Tech. 2021;31(6):750–5. https://doi.org/10.1097/SLE.0000000000000982.
21. Chen N, Lv M, Chen Y, Yao D, Yin W, Liu J, et al. Investigation of risk factors and predictive model development for the progression of incarcerated inguinal hernia to strangulation. Hernia. 2025;29(1):301. https://doi.org/10.1007/s10029-025-03480-y.
22. Xie X, Feng S, Tang Z, Chen L, Huang Y, Yang X. Neutrophil-to-lymphocyte ratio predicts the severity of incarcerated groin hernia. Med Sci Monit. 2017;23:5558–63. https://doi.org/10.12659/msm.905728.
23. Taşcı Hİ. The role of neutrophil-to-lymphocyte ratio in predicting disease progression and emergency surgery indication in benign intestinal obstructions. Ulus Travma Acil Cerrahi Derg. 2022;28(9):1238–47. https://doi.org/10.14744/tjtes.2022.46944.
24. Woodford EP, Woodford HM, Hort AR, Pang TC, Lam VWT, Nahm CB. Neutrophil-lymphocyte ratio and platelet-lymphocyte ratio use in detecting bowel ischaemia in adhesional small bowel obstruction. ANZ J Surg. 2022;92(11):2915–20. https://doi.org/10.1111/ans.18073.
25. Friziero A, Rosso E, Zuin IS, Vallese L, Serafini S, Amico A, et al. Neutrophil to lymphocyte ratio predicts bowel ischemia in non-strangulated adhesive small bowel occlusions: a retrospective analysis from an acute care surgical service. BMC Surg. 2024;24(1):179. https://doi.org/10.1186/s12893-024-02476-2.

26. Chen P, Yang W, Zhang J, Wang C, Yu Y, Wang Y, et al. Analysis of risk factors associated bowel resection in patients with incarcerated groin hernia. Med (Baltim). 2020;99(23):e20629. https://doi.org/10.1097/MD.0000000000020629.
27. Durak D, Turhan VB, Alkurt EG, Tutan MB, Şahiner I. The role of immature granulocyte count and delta neutrophil index in the early prediction of mesenteric ischemia. Eur Rev Med Pharmacol Sci. 2022;26(12):4238–43. https://doi.org/10.26355/eurrev_202206_29060.
28. Çaparlar MA, Durhan A, Süleymanov M, Binarbaşı C, Koşmaz K. Immature granulocyte percentage as an early predictor of necrosis in volvulus. Niger J Clin Pract. 2024;27(2):268–71. https://doi.org/10.4103/njcp.njcp_452_23.
29. Senlikci A, Kosmaz K, Durhan A, Orhan SM, Bezirci R, Mercan U, et al. A new marker evaluating the risk of ischemic bowel in incarcerated hernia: immature granulocytes. Indian J Surg. 2024;86(2):351–5. https://doi.org/10.1007/s12262-021-03014-7.
30. Su Q, Wang Q, Cao Y. Immature granulocyte: an early predictor of strangulated adhesive small bowel obstruction. BMC Gastroenterol. 2025;25(1):770. https://doi.org/10.1186/s12876-025-04355-3.
31. Eze VN, Parry T, Boone D, Mallett S, Halligan S. Prognostic factors to identify resolution of small bowel obstruction without need for operative management: systematic review. Eur Radiol. 2024;34(6):3861–71. https://doi.org/10.1007/s00330-023-10421-9.
32. Zielinski MD, Eiken PW, Bannon MP, Heller SF, Lohse CM, Huebner M, et al. Small bowel obstruction – who needs an operation? A multivariate prediction model. World J Surg. 2010;34(5):910–9. https://doi.org/10.1007/s00268-010-0479-3.
33. Xu WX, Zhong QH, Cai Y, Zhan CH, Chen S, Wang H, et al. Prediction and management of strangulated bowel obstruction: a multi-dimensional model analysis. BMC Gastroenterol. 2022;22(1):304. https://doi.org/10.1186/s12876-022-02363-1.
34. Besler E, Teke E, Akkuş D, Demir MH, Aksaray S, Aydın Aksu S, et al. A new risk scoring system for early prediction of surgical need in patients with adhesive small bowel obstruction: a single-center retrospective clinical study. Ann Surg Treat Res. 2023;105(3):165–71. https://doi.org/10.4174/astr.2023.105.3.165.
35. Wassmer CH, Revol R, Uhe I, Chevallay M, Toso C, Gervaz P, et al. A new clinical severity score for the management of acute small bowel obstruction in predicting bowel ischemia: a cohort study. Int J Surg. 2023;109(6):1620–8. https://doi.org/10.1097/JS9.0000000000000171.
36. Li X, Tian M, Liu Y, Zhang Y, Chen J. Predictive factors of intestinal ischaemia in adhesive small bowel obstruction. J Coll Physicians Surg Pak. 2024;34(2):146–50. https://doi.org/10.29271/jcpsp.2024.02.146.
37. Schwenter F, Poletti PA, Platon A, Perneger T, Morel P, Gervaz P. Clinicoradiological score for predicting the risk of strangulated small bowel obstruction. Br J Surg. 2010;97(7):1119–25. https://doi.org/10.1002/bjs.7037.
38. Murao S, Fujino S, Danno K, Takeda T, Yamamoto K, Higashiguchi M, et al. Ischemia prediction score (IsPS) in patients with strangulated small bowel obstruction: a retrospective cohort study. BMC

Gastroenterol. 2023;23(1):133. https://doi.org/10.1186/s12876-023-02761-z.

39. Yao Z, Zhang Y, Jiang L. Commentary on 'A new clinical severity score for the management of acute small bowel obstruction in predicting bowel ischemia: a cohort study'. Int J Surg. 2023;109(11):3673–4. https://doi.org/10.1097/JS9.0000000000000628.
40. Sun Y, Hu Y, Sun Y. Development of a predictive model for the need for early surgery in patients with adhesive small-bowel obstruction. J Int Med Res. 2024;52(12):3000605241308386. https://doi.org/10.1177/03000605241308386.
41. Uprak TK, Akin MI, Coskun M, Yegen C. Factors predicting surgical treatment in patients with adhesive small bowel obstruction: retrospective single-centre study. J Coll Physicians Surg Pak. 2022;32(9):1127–31. https://doi.org/10.29271/jcpsp.2022.09.1127.
42. Yoon JB, Lee SH. The neutrophil-to-lymphocyte ratio has feasible predictive value for hospital mortality in patients with small bowel obstruction in the emergency department. Am J Emerg Med. 2021;44:428–33. https://doi.org/10.1016/j.ajem.2020.05.049.
43. Xu WX, Zhong QH, Cai Y, Zhan CH, Chen S, Wang H, et al. Comprehensively evaluate the short outcome of small bowel obstruction: a novel medical-economic score system. World J Gastroenterol. 2023;29(9):1509–22. https://doi.org/10.3748/wjg.v29.i9.1509.
44. Wang Z, Sun B, Yu Y, Liu J, Li D, Lu Y, et al. A novel nomogram integrating body composition and inflammatory-nutritional markers for predicting postoperative complications in patients with adhesive small bowel obstruction. Front Nutr. 2024;11:1345570. https://doi.org/10.3389/fnut.2024.1345570.
45. Zhong QH, Zhan CH, Xu WX, Cai Y, Chen S, Wang H, et al. A novel scoring system for better management of small bowel obstruction. Eur J Trauma Emerg Surg. 2025;51(1):91. https://doi.org/10.1007/s00068-024-02715-4.
46. Karamanos E, Dulchavsky S, Beale E, Inaba K, Demetriades D. Diabetes mellitus in patients presenting with adhesive small bowel obstruction: delaying surgical intervention results in worse outcomes. World J Surg. 2016;40(4):863–9. https://doi.org/10.1007/s00268-015-3338-4.
47. Jeppesen MH, Tolstrup MB, Watt SK, Gögenur I. Risk factors affecting morbidity and mortality following emergency laparotomy for small bowel obstruction: a retrospective cohort study. Int J Surg. 2016;28:63–8. https://doi.org/10.1016/j.ijsu.2016.02.059.
48. Quero G, Covino M, Laterza V, Fiorillo C, Rosa F, Menghi R, et al. Adhesive small bowel obstruction in elderly patients: a single-center analysis of treatment strategies and clinical outcomes. Scand J Gastroenterol. 2021;56(7):784–90. https://doi.org/10.1080/00365521.2021.1921256.
49. Almeida Filho GF, Silva PPCE, Valverde Filho MT, Morais MCA, Chagas PBO, D'Oliveira RAC, et al. Acute abdomen in intensive care unit: etiology, comorbidity and severity of 1,523 patients. Arq Bras Cir Dig. 2023;36:e1778. https://doi.org/10.1590/0102-672020230060e1778.
50. Jose AM, Kirsch J, Prabhakaran K, Rafieezadeh A, Mehta R, Shnaydman I, et al. Should we let the sun set or rise on a small bowel obstruction: mortality and readmission rates in operative versus

nonoperative management. Surg Endosc. 2025;39(11):7698–706. https://doi.org/10.1007/s00464-025-12059-8.

51. Berman DJ, Mahler AW, Burke RC, Bennett AE, Shapiro NI, Bilello LA. Associations of the need for surgery in emergency department patients with small bowel obstructions. West J Emerg Med. 2025;26(1):135–41. https://doi.org/10.5811/westjem.18455.
52. Catena F, De Simone B, Coccolini F, Di Saverio S, Sartelli M, Ansaloni L. Bowel obstruction: a narrative review for all physicians. World J Emerg Surg. 2019;14:20. https://doi.org/10.1186/s13017-019-0240-7.
53. Bouassida M, Laamiri G, Zribi S, Slama H, Mroua B, Sassi S, et al. Predicting intestinal ischaemia in patients with adhesive small bowel obstruction: a simple score. World J Surg. 2020;44(5):1444–9. https://doi.org/10.1007/s00268-020-05377-6.
54. Nierhaus A, Klatte S, Linssen J, Eismann NM, Wichmann D, Hedke J, et al. Revisiting the white blood cell count: immature granulocytes count as a diagnostic marker to discriminate between SIRS and sepsis – a prospective, observational study. BMC Immunol. 2013;14:8. https://doi.org/10.1186/1471-2172-14-8.
55. Ayres LS, Sgnaolin V, Munhoz TP. Immature granulocytes index as early marker of sepsis. Int J Lab Hematol. 2019;41(3):392–6. https://doi.org/10.1111/ijlh.12990.
56. Bhansaly P, Mehta S, Sharma N, Gupta E, Mehta S, Gupta S. Evaluation of immature granulocyte count as the earliest biomarker for sepsis. Indian J Crit Care Med. 2022;26(2):216–23. https://doi.org/10.5005/jp-journals-10071-23920.

Figures

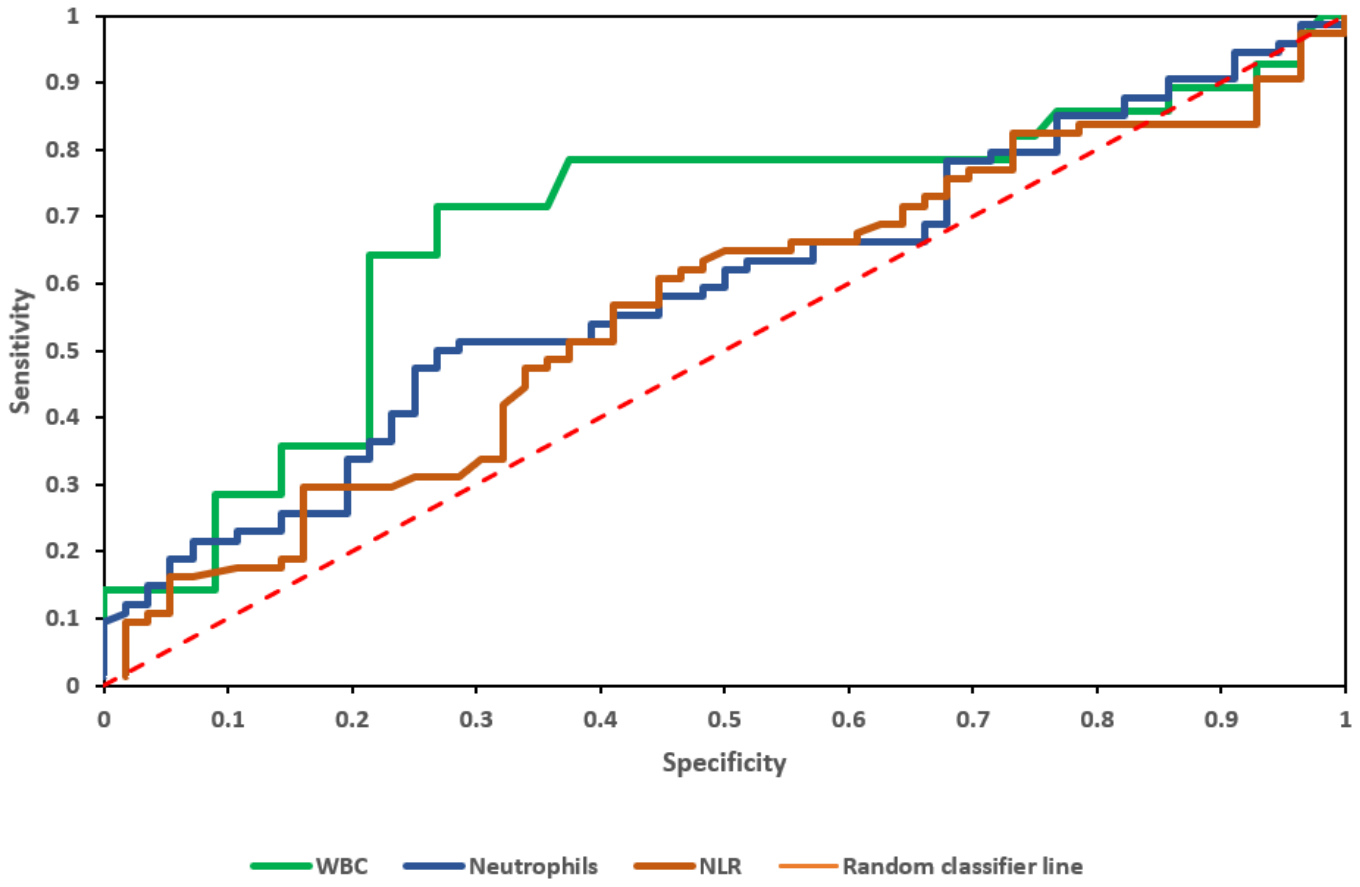


Figure 1

ROC curve of WBC, NEU, and NLR for discrimination between patients with and without complications in the overall cohort

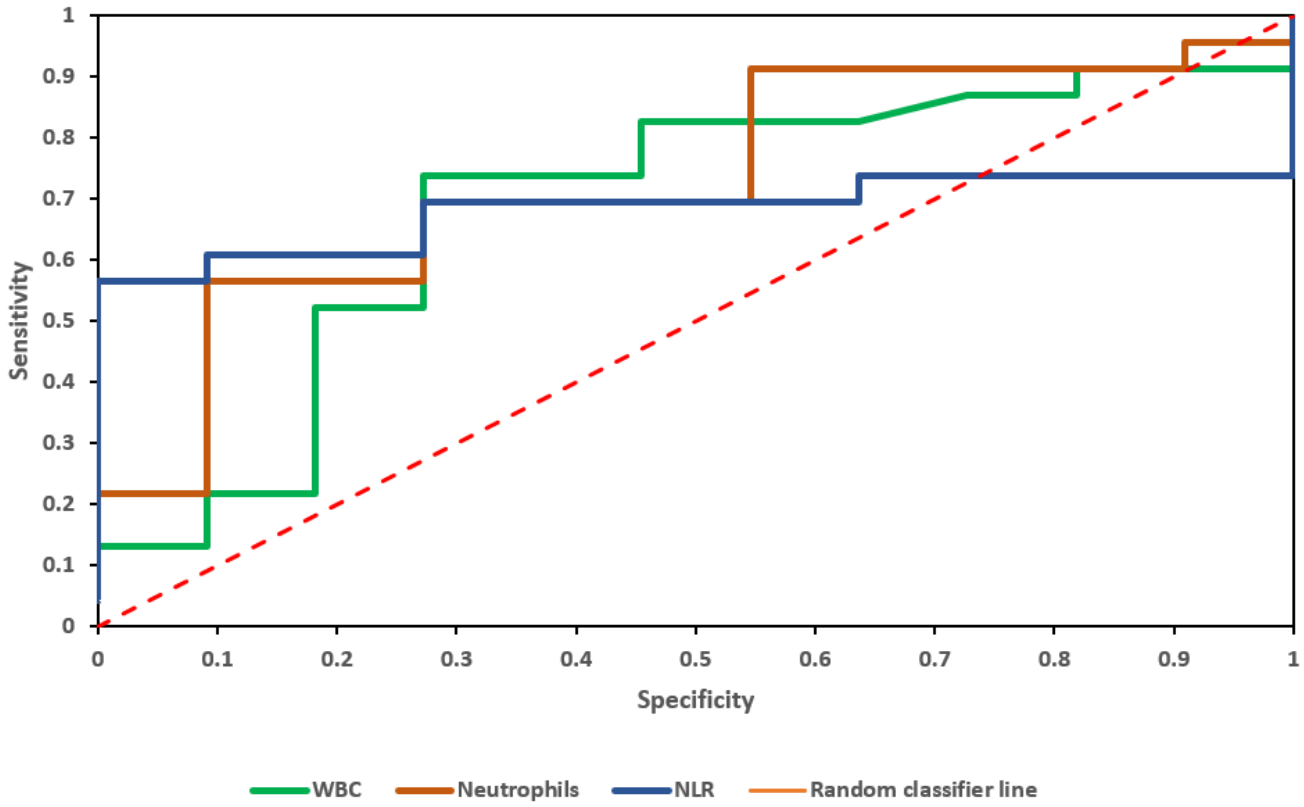


Figure 2

ROC curve of WBC, NEU, and NLR for discrimination between patients without comorbidities with and without complications

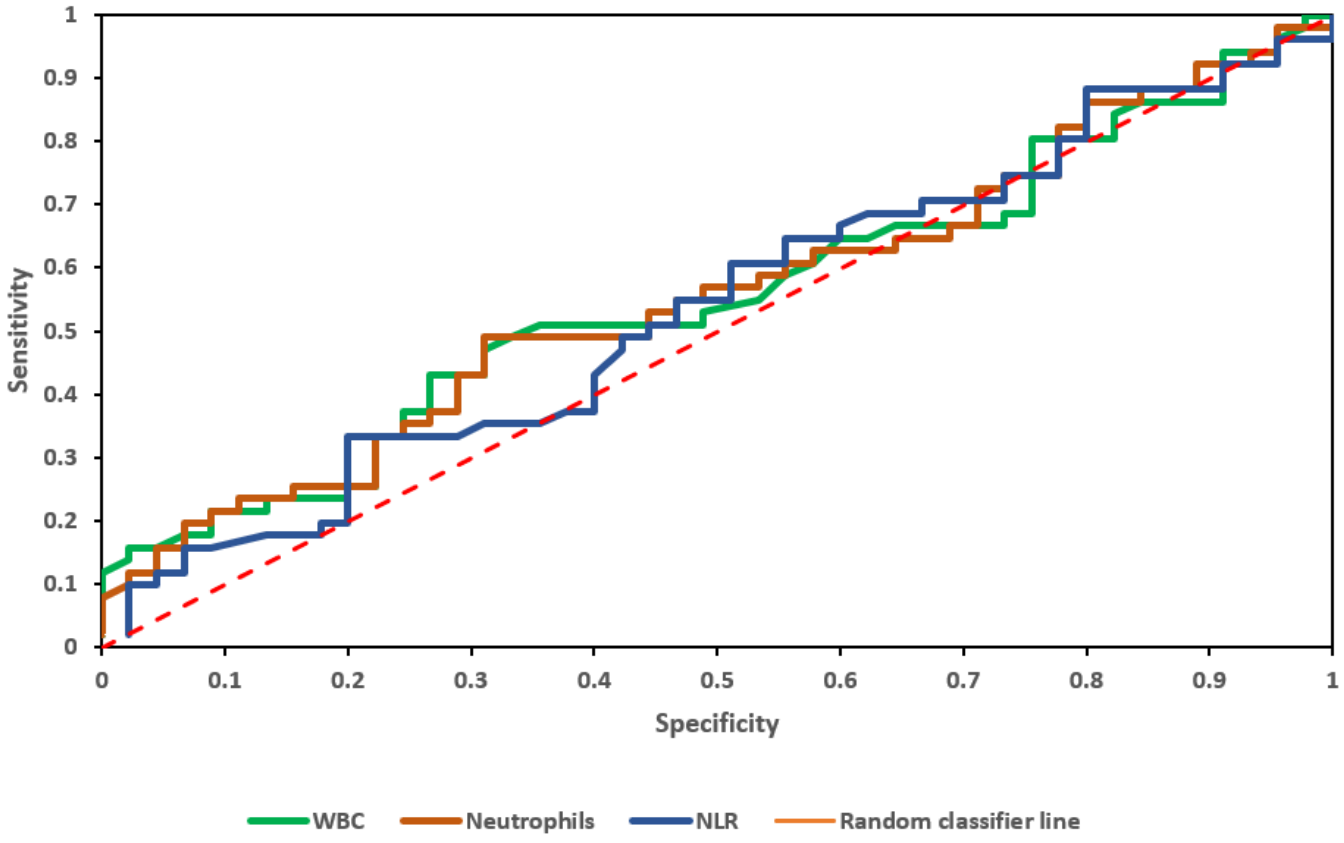


Figure 3

ROC curve of WBC, NEU, and NLR for discrimination between patients with comorbidities with and without complications