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Role of D-Dimer, Neutrophil to Lymphocyte Ratio, Platelet-Lymphocyte Ratio and CT Signs in Prediction of Intestinal Ischaemia in Patients with Non-Strangulated Adhesive Small Bowel Obstruction

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ABSTRACT

Background: Early prediction of intestinal ischaemia is a significant clinical problem in non-strangulated adhesive small bowel obstruction (ASBO) cases. Numerous biomarkers have been suggested as possible predictors, such as D-dimer, the neutrophil-to-lymphocyte ratio (NLR), and the platelet-to-lymphocyte ratio (PLR). Furthermore, computed tomography (CT) is essential for detecting ischaemia.

Patients and methods: This prospective observational study was conducted at Al-Ahrar Teaching Hospital on 130 patients diagnosed with adhesive small bowel obstruction, were divided into: those with ischaemia and those without, serving as the control group.

Results: Ischaemia group had significantly higher D-dimer levels, NLR, PLR, WBC count, and lactate levels, while haemoglobin and platelet count were significantly lower in the ischaemia group. CT imaging emerged as a critical diagnostic tool, with bowel wall enhancement was the most significant CT predictor. The study also found D-dimer as the most reliable biomarker, with an AUC of 0.836, sensitivity of 87.1%, and specificity of 83.1% at a cutoff of 1.5 mg/L.

Conclusion: In order to improve the early detection and treatment of intestinal ischaemia in ASBO patients, our results highlight the significance of a multimodal diagnostic approach that combines laboratory markers (such as D-dimer, NLR, and lactate) with CT imaging features (such as gut wall enhancement and mesenteric haziness). These revelations give physicians important direction for improving diagnostic methods and lowering death rate.

Keywords: D-dimer, Neutrophil to lymphocyte ratio, Platelet-lymphocyte ratio, CT, Intestinal ischaemia, Non-strangulated adhesive small bowel obstruction.

INTRODUCTION

The most frequent cause of intestinal blockage and a major contributor to morbidity in emergency surgery is adhesive small bowel obstruction (ASBO). Following abdominal or pelvic surgery, ASBO affects approximately 5% of patients, placing a heavy burden on the healthcare system. The initial evaluation, as per the Bologna Guidelines, includes laboratory testing, a physical examination, a clinical history, and an abdominal computed tomography (CT) scan with contrast **(1)**.

In 41% to 73% of cases of total ASBO, obstructive symptoms are resolved by non-operative first therapy, which includes nasogastric tube decompression, intravenous fluids, and bowel rest for patients with ASBO who show no signs of ischaemia **(2)**.

When SBO progresses to bowel ischaemia, bowel infarction, and intestinal perforation that results in sepsis and multiorgan failure, mortality may ensue. Accordingly, bowel ischaemia suspicion necessitates immediate surgical surgery; postponements increase morbidity and mortality **(3)**.

The choice and timing of an operational intervention are still difficult, though. Current decision-making is guided by clinical indicators, which have shown poor predictive value. It has been estimated that only 40–50% of cases can be properly predicted to have intestinal ischaemia based on clinical indications such pyrexia, persistent discomfort, and abdominal wall guarding. According to **Demir *et al.* (4) and Köstenbauer and Truskett (5),** common blood-based biomarkers like lactate and white cell count have poor sensitivity and specificity. Lactate has a sensitivity of 33% to 78% and a

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specificity of 36% to 72%, while white cell count >12 x 109/L has a sensitivity of 45% and a specificity of 74%.

It is generally acknowledged that the most accurate laboratory marker for identifying coagulation activity is D-dimer, a byproduct of fibrin breakdown. It is mostly used in clinical settings to rule out the risk of thrombotic conditions, such as pulmonary embolism or deep vein thrombosis. Despite having a high sensitivity for diagnosing acute intestinal ischaemia, D-dimer's limited specificity makes it less frequently utilised in clinical practice [(6)].

Immune disorders, vascular disorders, and some types of tumours are strongly correlated with the platelet-lymphocyte ratio (PLR), which is primarily utilised as a biomarker of the systemic inflammatory response. The ability of PLR to forecast the prognosis of patients with mesenteric ischaemia has been shown in a number of recent investigations. With a sensitivity of 59% and a specificity of 65%, PLR has also demonstrated potential uses in the diagnosis of mesenteric ischaemia. But according to **Augène *et al.* [(3)],** PLR by itself has an unstable detection impact and a poor diagnostic effect.

The serum biomarker known as the neutrophil-lymphocyte ratio (NLR) is computed by dividing the total number of neutrophils by the total number of lymphocytes. Numerous investigations attempted to link this biomarker ratio to ischaemia in various clinical contexts. Nevertheless, there is very little evidence that it can be used to predict intestinal ischaemia in ASBO patients [(7)].

CT is the preferred method for diagnosing small-bowel obstruction and showing strangulating obstruction in individuals with suspected acute small-bowel obstruction. About 10% of individuals with small-bowel obstruction experience strangulation obstruction. According to **Nielsen *et al.* [(8)],** the mortality rate for strangulation patients who get surgery within 36 hours after the start of symptoms is 8%, whereas the mortality rate for procedures that are postponed beyond 36 hours has climbed to 25%.

Bowel strangulation has been linked to a number of CT findings, including decreased or absent enhancement of the bowel wall on contrast-enhanced scans, mural thickening, mesenteric vascular engorgement, diffuse mesenteric haziness, a significant amount of ascites, and increased attenuation of the bowel wall on unenhanced scans. The importance of portomesenteric venous gas and pneumatosis intestinalis has been assessed in the assessment of transmural bowel infarction using CT. The most specific CT result for the diagnosis of intestinal ischaemia among the previously described symptoms is decreased or absent enhancement of the gut wall on contrast-enhanced CT scans [(9)].

However, because the bowel lesion of intestinal ischaemia is typically thin due to luminal distention, it is challenging to measure gut wall attenuation in individuals with small-bowel blockage. Furthermore, the intestinal lesion's mural thickness may be reduced to a paper-thin wall in cases of transmural infarction. Thus, visual evaluation has been used to determine if the gut wall's contrast-enhanced CT images show diminished or no enhancement [(10-20)].

We aimed to evaluate diagnostic value of D-dimer, neutrophil-to-lymphocyte ratio (NLR), platelet-to-lymphocyte ratio (PLR), and computed tomography (CT) signs in predicting intestinal ischaemia in patients with non-strangulated adhesive small bowel obstruction.

SUBJECTS AND METHODS

This prospective observational study was conducted at Al-Ahrar Teaching Hospital and Other Private Centers.

Ethical considerations:

All participants or their legal representatives provided written informed consent, and the study protocol was approved by Research Ethical Committee, General Organization for Teaching Hospitals and Institutes (GOTHI). The Helsinki Declaration was followed throughout the study's conduct.

Inclusion Criteria:

1. Adhesive small bowel obstruction (ASBO) with age ≥18 years.
2. An abdominal computed tomography (CT) scan confirmed the diagnosis of ASBO.
3. The first clinical examination revealed no indications of strangling.

Exclusion Criteria:

1. Patients who need surgery right away due to strangulation obstruction
2. Being pregnant
3. Inflammatory bowel disease history
4. Malignancy in progress
5. Recent (within 30 days) surgery
6. Individuals receiving anticoagulant medication

Upon admission, each patient had a detailed medical history, comprehensive clinical evaluation that included a physical examination and vital signs.

Clinical-pathological variables were analyzed:

- Systemic Inflammatory Response Syndrome presence, Charlson Comorbidity Index, and ASA score.
- Duration of occlusive symptoms.
- Count of prior abdominal surgeries.
- Time between operating room admissions.

When vascular compromise symptoms such hypoxia, discolouration, lack of arterial pulsation, subserosal haemorrhage, and the appearance of an imminent or real infarction were present during surgery, strangulation was taken into consideration. [(11)].

Laboratory Measurements

Within two hours of admission, blood samples were taken for routine biochemical analysis, D-dimer levels, and full blood counts, among other laboratory procedures.

1. D-dimer:

As soon as the ASBO diagnosis was confirmed, venous blood samples were obtained for the D-dimer level analysis. Using monoclonal antibodies that are specific to D-dimer neoantigens, the samples were examined using the NycoCard Reader technique. A D-dimer concentration of 0.5 mg/L was regarded as normal; any concentration above this threshold was regarded as pathologic.

2. **Complete Blood Count:** collected platelet numbers for the platelet to lymphocyte ratio (PLR) and neutrophil and lymphocyte counts for the neutrophil to lymphocyte ratio (NLR) using an automated haematology analyser.

3. **NLR Calculation**: The absolute neutrophil count was divided by the absolute lymphocyte count to determine the NLR.

4. **PLR Calculation:** The absolute platelet count was divided by the absolute lymphocyte count to determine the PLR.

Imaging Protocol

Prior to admission or surgery, all patients get contrast-enhanced abdomen CT images from the bilateral diaphragmatic domes to the symphysis pubes utilising an Aquilion device. The following were the scan parameters: Slice thickness: 1 mm, tube voltage: 120 kV, and tube current: 250 mA. The intravenous contrast was given.

CT Image Analysis

Blinded to the clinical and laboratory data, two board-certified radiologists with at least five years of experience independently examined the CT scans. Disputes were settled by agreement. The degree of bowel-wall enhancement, bowel-wall thickness, peritoneal effusion, mesenteric ambiguity, and the whirlpool sign were all subjectively evaluated signs that were thoroughly examined for the presence and degree of each symptom. The following criteria were used to analyse the CT signs: (1) Increased unenhanced bowel-wall attenuation, which is defined as a higher density of the bowel wall of a dilated loop on unenhanced CT images than a healthy dilated loop; (2) Mesenteric haziness, which is defined as increased attenuation of mesenteric fat; (3) Bowel wall thickening, which is defined as a thickness of the bowel wall exceeding 5 mm; (4) Peritoneal fluid, which is defined as fluid within the peritoneal cavity, but not mesenteric fluid; (5) Whirl sign, which is defined as a swirled appearance of the mesenteric fat and vessels at the root of the mesentery with an adjacent rotated bowel loop.

Patient Management and Outcome Assessment

The initial cautious management of patients involved close clinical monitoring, intravenous fluid resuscitation, and nasogastric tube decompression. Based on clinical deterioration, conservative therapy failure, or suspicion of intestinal ischaemia, the attending surgeon decided whether to do surgery or not.

In patients receiving conservative treatment, the main result was the presence of intestinal ischaemia, which could be verified either by clinical course or surgical findings. In order to confirm symptom relief and rule out missed ischaemia, conservatively managed patients were monitored for 30 days after discharge, and surgical findings were recorded during surgery.

Statistical Analysis

SPSS (IBM Corp., Armonk, NY, USA) was used for statistical analysis. Student's t-test, Mann-Whitney U test, Chi-square test, correlation analysis, receiver operating characteristic (ROC) curve analysis, and multivariate logistic regression analysis were used. p-value < 0.05 was considered statistically significant.

RESULTS

Based on demographic data, the ischaemia and control groups did not differ significantly in terms of age or gender distribution. Additionally, there was no discernible difference in the groups' histories of abdominal surgery (Table 1).

Table 1. Demographic data in study groups

Parameter	Category	Ischaemia (n=65)	Control (n=65)	p-value	Significance
Age (years)	Mean ± SD	64.12 ± 7.37	62.72 ± 7.84	0.240	NS
	Median (IQR)	66.00 (60.00-69.00)	63.00 (55.00-69.00)		
Gender	Male	35 (53.8%)	30 (46.2%)	0.380	NS
	Female	30 (46.2%)	35 (53.8%)		
History of Abdominal Surgery	Yes	11 (16.9%)	10 (15.4%)	0.811	NS
	No	54 (83.1%)	55 (84.6%)		

SD: Standard Deviation, IQR: Interquartile Range, NS: Not Significant.

According to clinical assessment, there was no significant difference between the ischaemia and control groups regarding ASA Score ≥3, Charlson Comorbidity Index ≥5, or Systemic Inflammatory Response Syndrome (SIRS) (Table 2).

Table 2. Clinical assessment in study groups

Parameter	Category	Ischaemia (n=65)	Control (n=65)	p-value	Significance
ASA Score ≥3	Yes	25 (38.5%)	19 (29.2%)	0.866	NS
	No	40 (61.5%)	46 (70.8%)		
Charlson Comorbidity Index ≥5	Yes	27 (41.5%)	21 (32.3%)	0.276	NS
	No	38 (58.5%)	44 (67.7%)		
Systemic Inflammatory Response Syndrome	Yes	26 (40.0%)	20 (30.8%)	0.271	NS
	No	39 (60.0%)	45 (69.2%)		

ASA: American Society of Anesthesiologists, NS: Not Significant

The results showed that the ischaemia group had significantly lower haemoglobin and platelet count, while the ischaemia group had significantly higher D-dimer levels, NLR, PLR, WBC count, and lactate levels (Table 3).

Table 3. Laboratory parameters in study groups

Parameter	Category	Ischaemia (n=65)	Control (n=65)	p-value	Significance
D-dimer (mg/L)	Mean ± SD	1.72 ± 0.64	0.50 ± 0.69	<0.001	HS
	Median (IQR)	1.89 (1.69-2.04)	0.23 (0.09-0.39)		
NLR	Mean ± SD	12.19 ± 2.57	10.92 ± 2.85	0.009	HS
	Median (IQR)	12.47 (10.81-13.98)	10.59 (8.69-13.24)		
PLR	Mean ± SD	277.16 ± 24.18	248.23 ± 27.96	<0.001	HS
	Median (IQR)	279.06 (258.78-290.37)	251.53 (234.71-261.34)		
WBC Count (×10⁹/L)	Mean ± SD	12.49 ± 2.16	11.09 ± 1.79	<0.001	HS
	Median (IQR)	12.60 (11.20-13.70)	11.00 (9.90-12.70)		
Lactate (mmol/L)	Mean ± SD	2.56 ± 0.57	0.60 ± 0.45	<0.001	HS
	Median (IQR)	2.60 (2.20-2.90)	0.50 (0.30-0.80)		
Haemoglobin (g/dL)	Mean ± SD	9.53 ± 0.99	11.52 ± 0.91	<0.001	HS
	Median (IQR)	9.50 (9.00-10.00)	11.50 (10.90-12.30)		
Platelet Count (×10⁹/L)	Mean ± SD	234.90 ± 39.69	261.65 ± 39.57	<0.001	HS
	Median (IQR)	230.30 (199.50-262.74)	262.00 (224.00-300.00)		

NLR: Neutrophil-to-Lymphocyte Ratio, PLR: Platelet-to-Lymphocyte Ratio, WBC: White Blood Cell, SD: Standard Deviation, IQR: Interquartile Range, HS: Highly Significant.

Regarding CT findings, the ischaemia group exhibited significantly higher rates of mesenteric haziness, peritoneal fluid, bowel wall enhancement, bowel wall thickening, and whirlpool sign in comparison to the control group. But there was no discernible difference in pneumatosis intestinalis (Table 4).

Table 4. CT findings in study groups

Parameter	Category	Ischaemia (n=65)	Control (n=65)	p-value	Significance
Bowel Wall Enhancement	Yes	45 (69.2%)	4 (6.2%)	<0.001	HS
	No	20 (30.8%)	61 (93.8%)		
Bowel Wall Thickening	Yes	30 (46.2%)	4 (6.2%)	<0.001	HS
	No	35 (53.8%)	61 (93.8%)		
Pneumatosis Intestinalis	Yes	10 (15.4%)	5 (7.7%)	0.170	NS
	No	55 (84.6%)	60 (92.3%)		
Mesenteric Haziness	Yes	40 (61.5%)	20 (30.8%)	<0.001	HS
	No	25 (38.5%)	45 (69.2%)		
Peritoneal Fluid	Yes	35 (53.8%)	15 (23.1%)	<0.001	HS
	No	30 (46.2%)	50 (76.9%)		
Whirlpool Sign	Yes	15 (23.1%)	4 (6.2%)	0.013	S
	No	50 (76.9%)	61 (93.8%)		

CT: Computed Tomography, HS: Highly Significant, S: Significant, NS: Not Significant

Follow-up data showed that the 30-day post-discharge readmission rate was considerably greater in the ischaemia group than in the control group (Table 5).

Table 5. Follow-up data in the studied groups

Parameter	Category	Ischaemia (n=65)	Control (n=65)	p-value	Significance
30-day Post-Discharge Follow-up Readmission	Yes	20 (30.8%)	3 (4.6%)	<0.001	HS
	No	45 (69.2%)	62 (95.4%)		

HS: Highly Significant.

The findings indicated that D-dimer levels were significantly positively correlated with lactate, PLR, and NLR. D-dimer also significantly correlated negatively with platelet count and haemoglobin. D-dimer showed a weak positive association with age and with WBC count in terms of non-significant correlations (Table 6).

Table 6. Correlation between D dimer and study parameter in all studied cases

Parameters	Spearman Correlation Coefficient	P-Value of Spearman Correlation
Age (years)	0.072	0.416
NLR	0.184	0.036*
PLR	0.347	<0.001*
WBC Count (×10⁹/L)	0.170	0.054
Lactate (mmol/L)	0.579	<0.001*
Haemoglobin (g/dL)	-0.459	<0.001*
Platelet Count (×10⁹/L)	-0.255	<0.001*

WBC: White Blood Cell, PLR: Platelet-to-Lymphocyte Ratio, NLR: Neutrophil-to-Lymphocyte Ratio, *: Significant.

Based on the findings, D-dimer, PLR, and NLR showed significant predictive power in terms of the validity of study parameters in predicting intestinal ischaemia. At a cutoff of 1.5 mg/L, D-dimer had the highest sensitivity (87.1%) and specificity (83.1%). Bowel wall enhancement showed the best diagnostic performance in terms of CT features, with excellent specificity (93.8%) and PPV (91.8%). Additionally, bowel wall thickening demonstrated lesser sensitivity (46.2%)

but outstanding specificity (93.8%). The predictive value of peritoneal fluid and mesenteric haziness was moderate. Conversely, the predictive accuracy of whirlpool sign and pneumatosis intestinalis was low (Table 7 and figures 1 and 2).

Table 7. Validity of study parameters in prediction of intestinal ischaemia

	Parameter	AUC	95% CI	p-value	Cut off	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)	Accuracy (%)
Markers	D-dimer (mg/L)	0.836	0.765 - 0.907	<0.001	1.5	87.1	83.1	83.1	87.1	85.0
	NLR	0.639	0.544 - 0.734	<0.001	10.7	76.9	50.8	61.0	68.8	63.8
	PLR	0.790	0.712 - 0.868	<0.001	266.8	67.7	81.5	78.6	71.6	74.6
CT findings	Bowel Wall Enhancement	0.815	0.742 - 0.889	<0.001	-	69.2	93.8	91.8	75.3	81.5
	Bowel Wall Thickening	0.700	0.610 - 0.790	<0.001	-	46.2	93.8	88.2	63.5	70.0
	Pneumatosis Intestinalis	0.538	0.439 - 0.638	0.448	-	15.4	92.3	66.7	52.2	53.8
	Mesenteric Haziness	0.654	0.560 - 0.748	0.001	-	61.5	69.2	66.7	64.3	65.4
	Peritoneal Fluid	0.654	0.560 - 0.748	0.001	-	53.8	76.9	70.0	62.5	65.4
	Whirlpool Sign	0.585	0.487 - 0.683	0.090	-	23.1	93.8	78.9	55.0	58.5

AUC: Area Under the Curve, CI: Confidence Interval, NPV: Negative Predictive Value, PPV: Positive Predictive Value, PLR: Platelet-to-lymphocyte ratio, NLR: Neutrophil-to-Lymphocyte Ratio, CT: Computed Tomography, HS: Highly Significant.

DISCUSSION

Regarding demographic information, we discovered no discernible difference between the ischaemia and control groups in terms of gender distribution (male: 53.8% vs. 46.2%, p=0.483) or age (64.12 ± 7.37 vs. 62.72 ± 7.84, p=0.240). Likewise, there was no discernible difference in the groups' histories of abdominal surgery (16.9% vs. 15.4%, p=1.000). These results imply that age, sex, and previous abdominal surgery had no discernible effects on ischaemia in individuals with adhesive small bowel obstruction (ASBO).

This is consistent with earlier research, including **Zhou *et al.* [6],** which examined the diagnostic use of CT signals, platelet-to-lymphocyte ratio (PLR), and D-dimer for intestinal ischaemia in patients with bowel obstruction. With a mean age of 66.05 ± 16 years, their study comprised 105 patients (56 males [53%] and 49 females [47%]). They also discovered no statistically significant differences in the groups' surgery histories, genders, or ages. All of these findings support the theory that pathophysiological alterations, not demographic variables, are the main cause of ischaemia in ASBO patients.

According to our findings, there was no significant difference between the two groups in clinical indicators including the Charlson Comorbidity Index ≥5 (p=0.364) and ASA score ≥3 (p=0.354). This implies that ischaemia may not always be accurately predicted by comorbidities alone. Though the difference was not statistically significant (p=0.359), ischaemic patients had a higher prevalence of systemic inflammatory response syndrome (SIRS) (40.0% vs. 30.8%), which may suggest a possible inflammatory role to ischaemic progression.

Friziero *et al.* [21], who looked at prognostic factors for the development of intestinal ischaemia in patients with conservatively treated non-strangulated ASBO, concur with the current study. Similarly, they did not find any significant differences between the ischaemic and non-ischemic groups in terms of the Charlson Comorbidity Index or the presence of SIRS at presentation.

In contrast to our findings, **Friziero *et al.* [21]** found a significant correlation between ischaemia (p=0.02) and higher ASA scores (≥3). Differences in study demographics, sample sizes, or the severity of comorbidities could be the cause of this disparity.

According to the current study, the ischaemia group had significantly higher levels of lactate (2.56 ± 0.57 vs. 0.60 ± 0.45, p<0.001), WBC (12.49 ± 2.16 vs. 11.09 ± 1.79, p<0.001), PLR (277.16 ± 24.18 vs. 248.23 ± 27.96, p<0.001), NLR (12.19 ± 2.57 vs. 10.92 ± 2.85, p=0.009), D-dimer (1.72 ± 0.64 vs. 0.50 ± 0.69, p<0.001), and other laboratory parameters. These results demonstrate how D-dimer functions as a sensitive biomarker for ischaemic alterations. A systemic inflammatory response, which is frequently seen in ischaemic circumstances, is suggested by the raised NLR and PLR levels. Additionally, the markedly elevated lactate and WBC counts point to a continuous inflammatory process and anaerobic metabolism, both of which are compatible with ischaemic

stress and tissue hypoxia. The ischaemia group had significantly lower haemoglobin (9.53 ± 0.99 vs. 11.52 ± 0.91, p<0.001) and platelet count (234.90 ± 39.69 vs. 261.65 ± 39.57, p<0.001), which could be explained by microvascular damage and platelet consumption, which are hallmarks of coagulopathy linked to ischaemic injury.

These findings are corroborated by **Zhou *et al.* [6],** who found that patients with intestinal ischaemia had greater levels of D-dimer, neutrophil-to-lymphocyte ratio (NLR), PLR, and C-reactive protein (CRP) (all p<0.05) than the non-ischaemia group. These results support the theory that intestinal ischaemia pathophysiology is significantly influenced by systemic inflammation and coagulation abnormalities.

Furthermore, these results are in line with those of **Friziero *et al.* [21]**, who found that the ischaemic group's preoperative NLR was considerably higher than that of the control group (p=0.002).

Our results, however, are not in agreement with those of **Friziero *et al.* [21]**, who discovered no significant variations between the ischaemic and control groups in PLR, neutrophil count, lymphocyte count, haemoglobin, platelet count, or lactate. These disparities could result from differences in the study demographics, sample sizes, or ischaemia severity. For example, variations in the timing of laboratory measures or the patients' underlying comorbidities may be the cause of the study's lack of significance in PLR.

Our results showed that CT imaging was essential for distinguishing between ischaemic and non-ischemic patients. In comparison to the control group, the ischaemia group exhibited significantly higher rates of mesenteric haziness (61.5% vs. 30.8%, p=0.001), peritoneal fluid (53.8% vs. 23.1%, p=0.001), bowel wall enhancement (69.2% vs. 6.2%, p<0.001), bowel wall thickening (46.2% vs. 6.2%, p<0.001), and whirlpool sign (23.1% vs. 6.2%, p=0.013). According to these results, these CT characteristics are very suggestive of ischaemia and can be used as trustworthy diagnostic indicators in clinical settings. Nevertheless, there was no statistically significant difference in pneumatosis intestinalis, which is sometimes seen as a marker of severe ischaemia (p=0.272). This might be explained by its comparatively poor sensitivity, the fact that it usually manifests in advanced ischaemia, or the fact that ischaemic ASBO may not always exhibit it.

According to **Zhou *et al.* [6]**, patients with intestinal ischaemia exhibited more prominent peritoneal irritation signs and CT imaging features, including increased unenhanced bowel-wall attenuation, bowel-wall thickening, mesenteric haziness, peritoneal fluid, and the whirl sign, than non-ischemic cases. These findings are consistent with those of our study. This reliability emphasises how crucial CT imaging is for ischaemia early identification, which is essential for prompt treatment and better patient outcomes.

Additionally, our data are consistent with **Friziero *et al.* [21]**, who discovered that the ischaemic group had a higher frequency of CT abnormalities including decreased intestinal wall enhancement (p=0.002), mesenteric haziness (p=0.03), and free fluid (p=0.03). The diagnostic utility of these CT features in detecting ischaemia is further supported by this alignment.

In contrast to our findings, **Friziero *et al.* [21]** did not find any significant differences between the ischaemic and non-ischemic groups in terms of whirl symptoms, pneumatosis intestinalis, bowel wall thickening, or the presence of a transition zone. This disparity could result from variations in the research populations, imaging techniques, or when CT scans were performed in relation to the beginning of symptoms. For instance, the intensity and stage of ischaemia may affect the indications of spin and thickening of the gut wall, which could account for the inconsistent outcomes.

This study's follow-up data showed that the 30-day post-discharge readmission rate was considerably greater in the ischaemia group than in the control group (30.8% vs. 4.6%, p<0.001). This research emphasises the long-term effects of ischaemic problems in patients with ASBO, indicating that these patients continue to be at a higher risk of worsening even after receiving initial treatment.

The current study supports the findings of **Friziero *et al.* [21]**, who found that 9% of emergency surgical admissions at their department are due to adhesive small intestinal obstruction, a common clinical entity with substantial morbidity and mortality. Their cohort's epidemiological characteristics are consistent with other series, with bowel resection rates ranging from 6 to 13% and conservative treatment failure rates of about 30% [22].

The significance of early diagnosis for this clinical condition is further supported by the analysis of **Margenthaler *et al.* [23],** which showed that patients undergoing resection for intraoperative findings of bowel ischaemia presented a risk of adverse outcomes up to four times higher when compared to those treated only with adhesion-lysis.

Our findings revealed that D-dimer levels had a substantial negative correlation with haemoglobin (p<0.001) and platelet count (p<0.001), but a significant positive correlation with NLR (p=0.036), PLR (p<0.001), and lactate (p<0.001). In terms of non-significant correlations, D-dimer had a slight link with age (p=0.416) and WBC count (p=0.054).

Zhou *et al.* [6] found that intestinal ischaemia in patients with bowel obstruction was caused by D-dimer (p = 0.046), PLR (p = 0.044), increased unenhanced bowel-wall attenuation (p = 0.023), and mesenteric haziness (p = 0.002). These results are in line with their findings. D-

dimer's function as a crucial biomarker in the pathophysiology of ischaemia, especially in the context of bowel obstruction, is further highlighted by the strong correlation it has with these indicators.

The current study showed that D-dimer (AUC=0.836, p<0.001), PLR (AUC=0.790, p<0.001), and NLR (AUC=0.639, p<0.001) exhibited significant predictive power in terms of the validity of study parameters in predicting intestinal ischaemia. At a cutoff of 1.5 mg/L, D-dimer achieved the highest sensitivity (87.1%) and specificity (83.1%). Bowel wall enhancement (AUC=0.815, p<0.001) was the most dependable diagnostic feature in terms of CT findings, with excellent PPV (91.8%) and specificity (93.8%). Additionally, bowel wall thickening (AUC=0.700, p<0.001) showed great specificity (93.8%), but its low sensitivity (46.2%) limited its use. Pneumatosis intestinalis (AUC=0.538, p=0.448) and the whirlpool sign (AUC=0.585, p=0.090) had low diagnostic accuracy, whereas mesenteric haziness (AUC=0.654, p=0.001) and peritoneal fluid (AUC=0.654, p=0.001) had intermediate predictive value.

These results are in line with those of **Friziero *et al.*** [21], who used ROC analysis for NLR to establish the cutoff value that predicted intestinal ischaemia prior to surgery. With 78% sensitivity and 65% specificity, they showed that small bowel ischaemia was linked to an NLR cutoff of 6.8 (AUC 0.7).

Additionally, this study is in line with **Millet *et al.*** [24]**,** who evaluated the diagnostic performance in identifying strangulation in small bowel obstruction (SBO) for five CT findings: wall thickening, reduced bowel wall enhancement, free peritoneal fluid, mesenteric fluid, and mesenteric venous congestion. They discovered that the mesenteric fluid sign had the best sensitivity (89%) and the decreased intestinal wall enhancement CT sign had the highest specificity (95%). The thickness of the intestinal wall has a specificity of 83% and a sensitivity of 48%. The diagnostic performance of the other CT findings was lower. They came to the conclusion that the absence of mesenteric fluid is a trustworthy way to rule out strangling, and that a diminished enlarged gut wall is significantly predictive of ischaemia.

In contrast, **Zhou *et al.*** [6] found that D-dimer had an AUC of 0.766 and moderate sensitivity (75.0%) and specificity (66.7%) for identifying intestinal ischaemia. Variations in patient groups, D-dimer assay techniques, and distinct ischaemic severity thresholds could all be responsible for the discrepancies in diagnosis accuracy between the two investigations. Although D-dimer's moderate sensitivity lends credence to its use as an early screening biomarker, its comparatively low specificity raises questions about false-positive results in thrombotic and inflammatory diseases. PLR also showed similar diagnostic performance to D-dimer (AUC = 0.753, sensitivity = 70.8%, specificity = 70.2%), confirming its potential as an inflammatory biomarker for the diagnosis of ischaemia. Although PLR may help with risk stratification, its intermediate PPV (66.7%) and NPV (74.1%) show that it is insufficient as a stand-alone diagnostic tool.

In terms of CT results, **Zhou *et al.*** [6] discovered that unenhanced bowel-wall attenuation had a low sensitivity (45.8%) but a very high specificity (96.5%), making it a very specific marker for ischaemia when it occurs, but its poor sensitivity makes it unreliable for early identification. Although this sign's AUC of 0.712 suggests that it has a limited relevance as a primary diagnostic criterion, its high specificity and PPV (91.7%) imply that it is highly indicative of ischaemia. Additionally, mesenteric haziness showed intermediate specificity (66.7%) but high sensitivity (79.2%), indicating that although it is helpful in identifying ischaemic patients, it is risky of producing false positives because it can overlap with other inflammatory disorders. Mesenteric haziness is nevertheless a useful supplemental feature rather than a conclusive diagnostic indicator, with an AUC of 0.729. The combination of D-dimer, PLR, and CT signals provides a high diagnostic value for intestinal ischaemia in patients with bowel obstruction, and it will lead to surgical exploration to assess intestinal blood flow, as they found.

Likewise, it was shown that intestinal ischaemia is closely associated with CT symptoms [25]. Additionally, in patients with small bowel obstruction (SBO), CT's sensitivity and specificity for identifying intestinal-wall ischaemia varied from 73% to 100% and 61% to 93%, respectively [9]. But according to a recent prospective multicenter research, CT can only identify ischaemia-related consequences in patients with intestinal obstruction with a sensitivity of 40% [8].

Conclusion:

Our results demonstrated the usefulness of laboratory markers as sensitive biomarkers for ischaemic alterations by showing a robust correlation between ischaemia and higher D-dimer, NLR, PLR, WBC count, and lactate levels. The pathophysiological mechanisms of ischaemic injury are further supported by the decreased haemoglobin and platelet counts in the ischaemia group, which most likely reflect microvascular damage and platelet consumption.

Gut wall enhancement, gut wall thickening, mesenteric haziness, peritoneal fluid, and the whirlpool sign all showed strong predictive value for ischaemia, making CT imaging an essential diagnostic tool. Interestingly, pneumatosis intestinalis, which is frequently regarded as a marker of severe ischaemia, did not show any significant diagnostic value in this group. This is probably because of its poor sensitivity and correlation with advanced stages of the disease.

At a threshold of 1.5 mg/L, the study also found that D-dimer was the most dependable biomarker, with an AUC of 0.836, sensitivity of 87.1%, and specificity of 83.1%. Additionally, the 30-day readmission rate was considerably higher in the ischaemia group (30.8% vs. 4.6%, p<0.001), highlighting the therapeutic significance of an accurate and timely diagnosis to enhance patient outcomes.

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