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Evaluation of Inflammatory Biomarkers in Predicting Strangulation in Incarcerated Inguinal Hernias in Adult Patients Admitted to the Emergency Department; Cross-Sectional Study

Acil Servise Başvuran Erişkin Hastalarda İnkarsere İnguinal Hernilerde Strangülasyonun Öngörülmesinde İnflamatuar Biyobelirteçlerin Değerlendirilmesi; Kesitsel Çalışma

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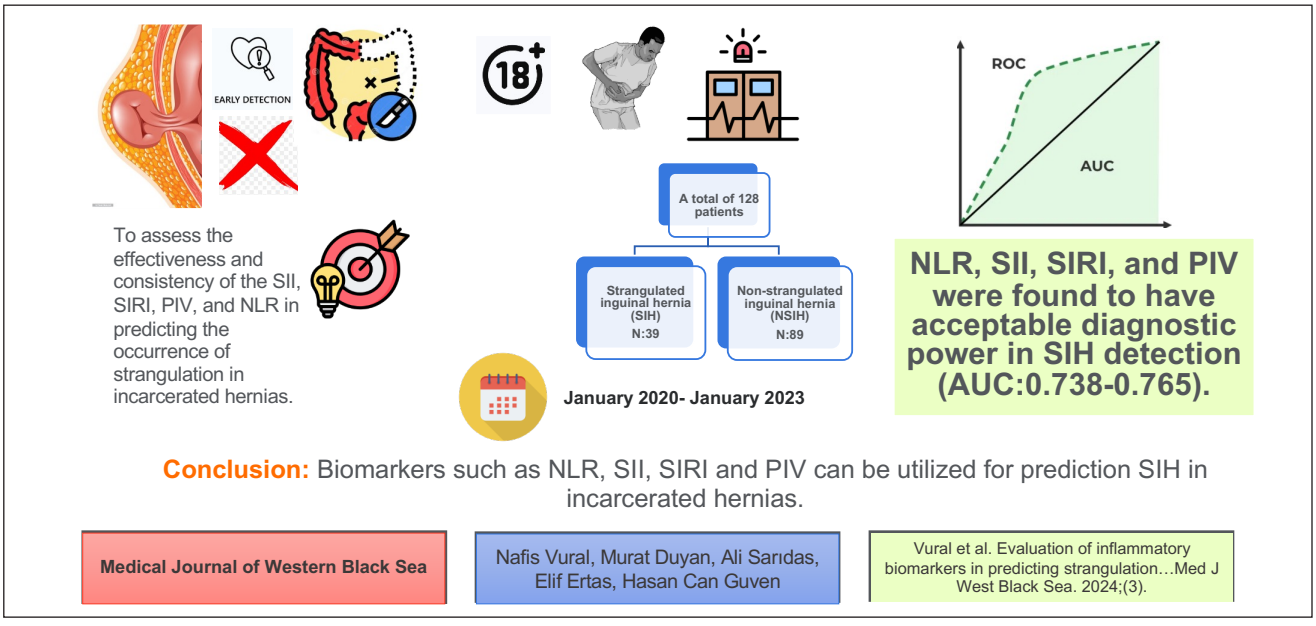
GRAPHICAL ABSTRACT



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ABSTRACT

Aim: It is very important to determine the diagnosis of strangulation quickly and with high accuracy in patients presenting with incarcerated hernia. Early diagnosis of strangulation reduces the rate of bowel resection. The objective of our study was to assess the effectiveness and consistency of recently established indices, namely neutrophil lymphocyte ratio (NLR), the systemic immune-inflammation index (SII), systemic inflammation response index (SIRI), and pan-immune-inflammation value (PIV) in predicting the occurrence of strangulation in incarcerated hernias.

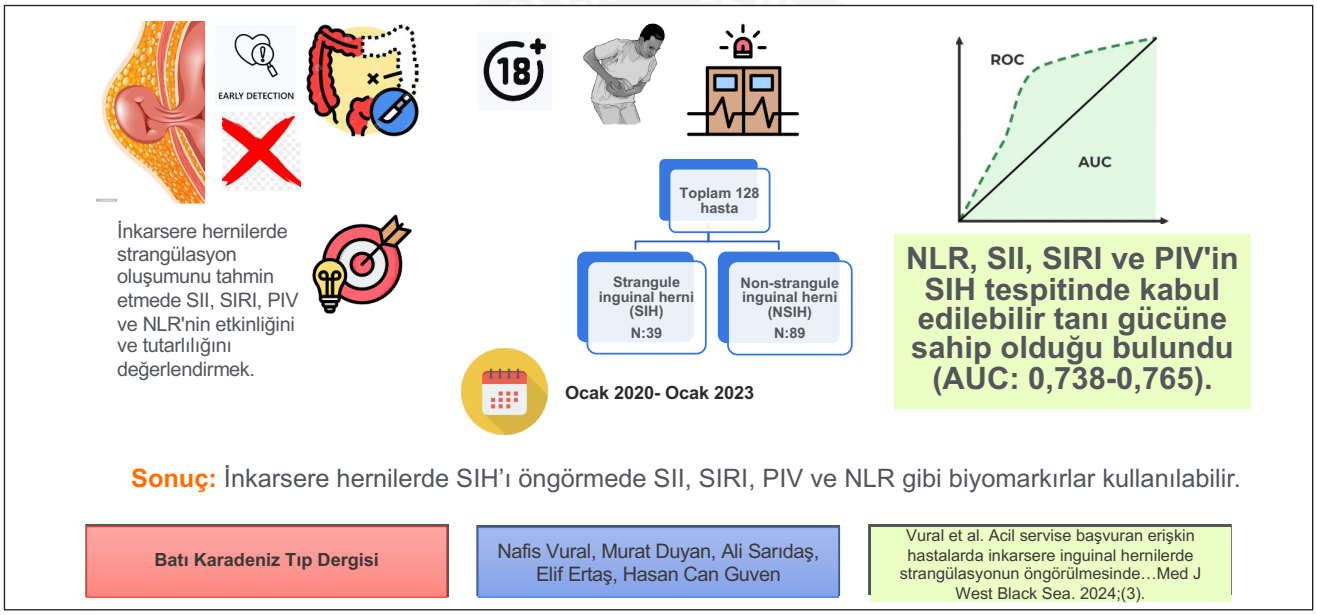
Material and Methods: Our study included patients over the age of 18 who presented to the emergency department with abdominal pain between 01.01.2020 and 01.01.2023 and were diagnosed with incarcerated inguinal hernia according to the examination results. There were two groups of patients with strangulated inguinal hernia (SIH) and non-strangulated inguinal hernia (NSIH). Receiver Operating Characteristic (ROC) analysis was used to define the cut-off in diagnostic value values.

Results: A total of 128 patients (39 SIH and 89 NSIH) were enrolled. Neutrophil lymphocyte ratio, There was determined to be acceptable diagnostic power for SIH detection using SII, SIRI, and PIV (AUC:0.738-0.765).

Conclusion: Biomarkers such as SII, SIRI, PIV and NLR can be utilized for prediction SIH in incarcerated hernias.

Keywords: Pan-immune-inflammation value, incarcerated hernia, neutrophil lymphocyte ratio, systemic immune-inflammation index, strangulated inguinal hernia, systemic inflammation response index

GRAFİKSEL ÖZET



ÖZ

Amaç: İnkarsere herni ile başvuran hastalarda strangulasyon tanısının hızlı ve yüksek doğrulukla belirlenmesi oldukça önemlidir. Strangulasyonun erken tanısı bağırsak rezeksiyonu azalmaktadır. Çalışmamızda nötrofil lenfosit oranı (NLR) ile birlikte sistemik immün-inflamasyon indeks (SII), sistemik inflamasyon yanıt indeksi (SIRI), pan-immün- inflamasyon değeri (PIV) gibi yeni tanımlanan indekslerin inkarsere hernilerde stangulasyonu öngörmedeki gücü ve güvenirliliği değerlendirme amaçlandı.

Gereç ve Yöntemler: Çalışmamız acil servise 01.01.2020 ile 01.01.2023 tarihleri arasında karın ağrısı ile başvuran ve tetkik sonucuna göre inkarsere inguinal herni tanısı konulan 18 yaş üstü hastalar dahil edildi. Boğulmuş kasık fıtığı (SIH) ve boğulmamış kasık fıtığı (NSIH) olmak üzere iki grup hasta vardı. Tanısal değer ölçümlerindeki kesme noktası, Alıcı İşletim Karakteristiği (ROC) analizi kullanılarak belirlendi.

Bulgular: Toplam 128 hasta (SIH:39 ve NSIH:89) kaydedildi. Nötrofil lenfosit oranı, SII, SIRI ve PIV'in SIH tespitinde kabul edilebilir tanısal güce sahip olduğu bulundu (AUC:0,738-0,765).

Sonuç: İnkarsere hernilerde SIH'ı öngörmede SII, SIRI, PIV ve NLR gibi biyomarkırlar kullanılabilir.

Anahtar Sözcükler: Pan-immün-inflamatuar değeri, inkarsere herni, nötrofil lenfosit oranı, strangule inguinal herni, sistemik immün-inflamatuar indeks, sistemik inflamasyon yanıt indeksi

INTRODUCTION

Abdominal hernias are classified into two categories: ventral hernias (including umbilical, incisional, epigastric, lumbar, and Spigelian) and inguinal hernias (comprising inguinal and femoral hernias). Hernias are classified as reducible when the hernia contents can be displaced into the abdomen through the layers of the abdominal wall. A hernia that is unreducible is referred to as "incarcerated." External hernias that have become incised rank second in terms of prevalence among minor bowel obstructions (1). A strangulated hernia transpires when the blood supply to the hernia's contents (such as omentum or intestine) is compromised. Prompt surgical intervention is crucial in cases of strangulated hernia with obstruction, as a delayed diagnosis can necessitate intestinal resection, resulting in a protracted recovery period and heightened risk of complications. Strangulated hernias have the potential to result in bowel perforation and bacterial translocation, as well as necrosis of the bowel wall. This significantly elevates the probability of necessitating urgent hernia repair, which may subsequently lead to an increased incidence of surgical site contamination and recurrence.

Presently, the use of intraoperative fluorescein evaluation and Doppler investigations is generally acknowledged and effective for diagnosing and evaluating the viability of the intestines (2). Inflammatory markers have recently been used in the treatment and prognosis monitoring of ophthalmic diseases, stroke patients, and conditions such as sleep apnea (3-5). Inflammatory markers such as ischemia modified albumin, D-dimer, lactate dehydrogenase (LDH) to white blood cell (WBC) ratio, neutrophil to albumin ratio (NAR) and neutrophil to platelet ratio (NPR) have previously been shown to be used as predictors of strangulated hernia (1,6,7).

While radiographic tests are commonly employed for diagnosing strangulated hernia, research on specialized laboratory tests is still in progress. It remains a significant issue due to the challenges in diagnosing it just by physical examination and the requirement for immediate surgical intervention.

The objective of the study was to assess the efficacy and dependability of systemic immune-inflammation index (SII), systemic inflammation response index (SIRI), and pan-immune-inflammation value (PIV) biomarkers in predicting strangulation in incarcerated hernias.

MATERIALS and METHODS

Study Design and Settings

The cross-sectional study comprised patients who arrived at the emergency department (ED) with abdominal discomfort and were diagnosed with an incarcerated inguinal hernia. A study was conducted on individuals aged 18 years or older who applied from January 1, 2020, to January 1, 2023. The study obtained approval, and the Ethics Committee waived the requirement for informed consent (determination number: 2023/243, date: November 20, 2023). The research was carried out in accordance with the Helsinki Declaration.

Study Protocol

Following the ethical committee's consent, a retrospective review of the data was conducted using the hospital's data network. The patients were divided into two groups: strangulated inguinal hernia (SIH) and non-strangulated inguinal hernia (NSIH). Patients who were diagnosed with incarcerated hernia by physical examination by emergency medicine specialists underwent ultrasonography to detect strangulation. Strangulated inguinal hernia was detected in 39 patients by ultrasonography performed by the radiologist. Doppler and gray scale ultrasonography findings were used to decide the presence of strangulation.

At the time of initial admission to the emergency department, all patients' demographic information, laboratory results, operation notes, ultrasound imaging results, and reports of pathology were recorded.

Patients were excluded if they were pregnant, experienced heart failure, had peripheral vascular disease, had hematological or liver diseases, were taking anticoagulants, antibiotics, or steroids, had other acute or chronic infections, had a pathology result indicating a tumor, or if their records were inaccessible. The study did not include patients who were under the age of eighteen those who had acute kidney injury that was more severe than stage 1 according to KDIGO criteria, and anyone who came to an emergency department complaining of trauma but were later confirmed with a strangulation hernia by ultrasonography.

Laboratory Analyses

A Coulter Gen-S Hematology Analyzer was employed to assess the complete blood count (CBC). Values for haematological variables were recorded, including total leucocyte count and differential, hemoglobin, hemocrit, platelet amounts, NLR, SII, SIRI, and PIV.

Levels of serum sodium, potassium, urea, glucose, creatinine, alanine aminotransferase (ALT), albumin, aspartate aminotransferase (AST), and C-reactive protein (CRP) were documented.

The definitions of neutrophil lymphocyte ratio, PIV, SII, and SIRI are as follows: "neutrophil count/lymphocyte count", "neutrophil count × platelet count/lymphocyte count", "neutrophil × monocyte/lymphocyte count", and "neutrophil count × platelet count × monocyte count/lymphocyte count", respectively.

Power Analysis

The cross-sectional study design utilized the NLR value, the primary outcome variable, to evaluate the reliability evaluation (post-study power) of the patient count in the groups. While NLR was 7.76±4.58 in Strangulated inguinal hernia patients, it was 5.01±2.84 in Non-strangulated inguinal hernia patients. The post-study power was 99%, based on the variance in NLR levels among the independent group averages. The post-study power exceeded 80%, as indicated by the differences in the secondary outcome variables SII, SIRI, and PIV.

Statistical Analyses

In continuous measurements, normality test according to groups was evaluated with Kolmogorow-Smirnow test statistics. In the evaluation of mean difference according to groups of continuous measurements suitable for normal distribution, parametric test Student's t test was used, otherwise non-parametric test Mann-Whitney U test statistics was used. The statistical evaluation of continuous data made use of the mean, standard deviation, minimum, and maximum values of the features in the data analysis. The frequency and percentage values were used to characterize the categorical variables. Student's t-test statistics were applied to compare patients with SIH and those with NSIH. To assess the correlation between the two separate category variables, chi-square test statistics were employed. Through the use of Receiver Operating Characteristic (ROC) analysis, the threshold for diagnostic value readings was established. In order to establish statistical significance, the specificity and sensitivity statistics were used. Comparison of ROC curves NLR, SII, SIRI, and PIV were assessed using a pairwise comparison of ROC curves and a 95% confidence interval. The Area Under the Curve (AUC) was classified as poor when it was 0.5 to 0.6, fair when it was 0.6 to 0.7, acceptable when it was 0.7 to 0.8, exceptional when it was 0.8 to 0.9, and outstanding when it was >0.9. When $P < 0.05$, the data is deemed to have a degree of statistical significance. Data evaluation was carried out using the MedCalc statistical tool, which is developed and owned by MedCalc Software Ltd. of Ostend, Belgium. We used the MedCalc statistical tool and the New York software from www.e-picos.com to review the data and analyze the power after the study.

RESULTS

In all, 128 patients were included, with 39 diagnosed with SIH and 89 diagnosed with NSIH. Table 1 illustrates the mean and standard deviation measurements for age, gender, and biomarkers. There is no gender-related link among the research groups (p>0.05). Males made up 53.6% of the NSIH group, compared to 58% of the SIH group. There is no apparent association between research groups and age. The mean age of both groups is comparable.

No significant difference was seen among the group mean values of serum sodium, glucose, serum potassium, urea, creatinine, ALT, AST, CRP, albümine, monocyte count (MON), and platelet count (PLT) (p>0.05).

A notable disparity existed among the group means of neutrophil count (NEU), lymphocyte count (LYM), SII, SIRI, PIV and NLR values (p<0.05) (Table 1).

Markers important for differentiating between SIH and NSIH in ROC analysis are detailed in Table 2 (Figure 1).

The neutrophil-lymphocyte ratio, SII, SIRI, and PIV demonstrated acceptable diagnostic efficacy in the identification of SIH (AUC: 0. 0.738-0.765).

When ROC curve comparisons were made to evaluate the diagnostic similarities of NLR, SII, SIRI and PIV in detecting strangulation in patients with incarcerated hernia, it was found that there was no difference between the inflammatory biomarkers (p>0.05). The comparison of ROC curves found a difference of 0.009 (%95 CI: -0.041-0.061, p=0.720) between the AUC for NLR and SII, a difference of 0.017 (%95 CI: -0.037-0.071, p=0.530) between NLR and SIRI, and a difference of 0.002 (%95 CI: -0.069-0.074, p=0.950) between NLR and PIV. The difference in the AUC between SII and SIRI was 0.026 (%95 CI: -0.039-0.091, p=0.430), and between SII and PIV it was 0.011 (%95 CI: -0.042-0.065, p=0.680). The difference in the AUC between SII and SIRI was 0.015 (%95 CI: -0.031-0.061, p=0.510). As a result, we found that MLR, NLR, SII, SIRI and PIV can be used interchangeably in diagnosing strangulation in patients with incarcerated hernia (Figure 2).

DISCUSSION

Abdominal pain is a prevalent cause for hospital admission to the ED (8). Inguinal hernia is the most common type of abdominal wall hernia (9). It is known that most incarcerated hernias are inguinal hernias (1). Incarcerated and/or strangulated hernias often require immediate surgical intervention (1). Inguinal hernia patients should have their hernia reducibility and ischemia status assessed. Currently, there is a lack of a simple and readily available biomarker for the detection and diagnosis of strangulation. Therefore, in the study, we sought for biomarkers that could serve as predictors of SIH in the ED.

Neutrophilia, which can suppress lymphocytes, is a form of inflammatory response (10). According to Bostancı et al.'s investigation, NLR was able to detect intestinal ischemia with a threshold of 12 or higher (11). Beji et al.'s study found that NLR predicted intestinal ischemia with a cut-off of 6.87, an AUC of 0.85, 92% sensitivity, and 79% specificity in patients with incarcerated femoral hernia (12). In the study

Table 1. Comparison of basic and laboratory characteristics of strangulated inguinal hernia and non-strangulated inguinal hernia groups.

	Strangulated inguinal hernia (SIH) (n=39)	Non-strangulated inguinal hernia (NSIH) (n=89)	p-value
Clinical variables	**x̄±SD**	**x̄±SD**	
Age (year ±SD)	52.82±22.75	50.10±16.32	0.440*
Sex	**n(%)**	**n(%)**	
Female	14(36.3)	23(25.4)	0.250***
Male	25(63.7)	66(74.6)	
Features	**x̄±SD**	**x̄±SD**	
Glucose (mg/dL±SD)	119.38±33.21	130.5±56.63	0.790**
Serum sodium (mEq/L±SD)	139.4±2.9	138.7±3.2	0.120**
Serum potassium (mEq/L±SD)	4.13±0.44	4.24±0.34	0.130*
Urea (mg/dL±SD)	35.64±22.64	33.1±17.89	0.270**
Creatinine (mg/dL±SD)	0.86±1.19	0.89±0.54	0.060**
AST (U/L±SD)	22.38±11.10	24.45±22.8	0.990**
ALT (U/L±SD)	18.14±13.71	20.47±13.38	0.140**
CRP (mg/L±SD)	27.58±22.27	24.86±22.45	0.550*
Albumine (g/L±SD)	38.49±4.28	38.72±4.49	0.150*
PLT (10^3mcL±SD)	279.95±81.51	268.54±77.54	0.850**
NEU (10^3mcL±SD)	10.46±3.95	8.53±2.64	0.030**
LYM (10^3mcL±SD)	1.51±0.53	2.1±1.01	<0.001**
MON (10^3mcL±SD)	0.83±0.31	0.73±0.22	0.110**
NLR	7.76±4.58	5.01±3.34	<0.001**
SII	2090.48±1093.71	1374.76±.990.6	<0.001**
SIRI	6.49±5.38	3.63±2.84	<0.001**
PIV	1776.93±1278.51	101.25±826.38	<0.001**

Student's t test*, **Mann-Whitney U test, Chi-square test*** (p<0.05 significance)

AST: Aspartate aminotransferase, **ALT:** Alanine aminotransferase, **CRP:** C-reactive protein, **PLT:** Platelets, **NEU:** Neutrophil, **LYM:** lymphocyte, **MON:** Monocyte, **NLR:** Neutrophil to lymphocyte ratio, **SII:** Systemic immune inflammation index, **SIRI:** Systemic Inflammation Response Index **PIV:** Pan-immune inflammation value

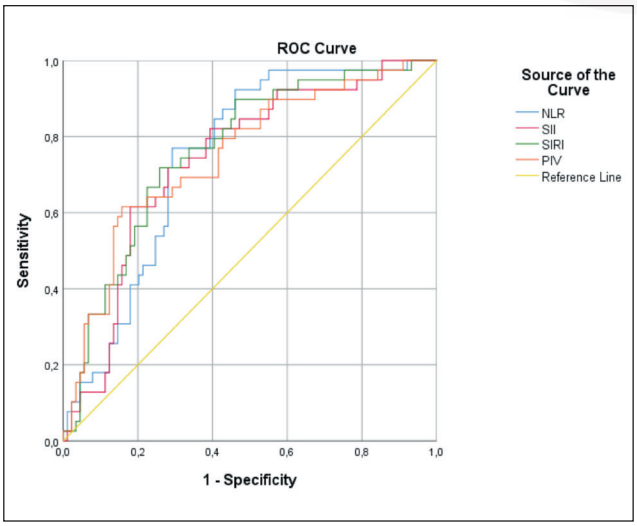


Figure 1. The receiver operating characteristic (ROC) curves of biomarkers for predicting strangulated inguinal hernia.

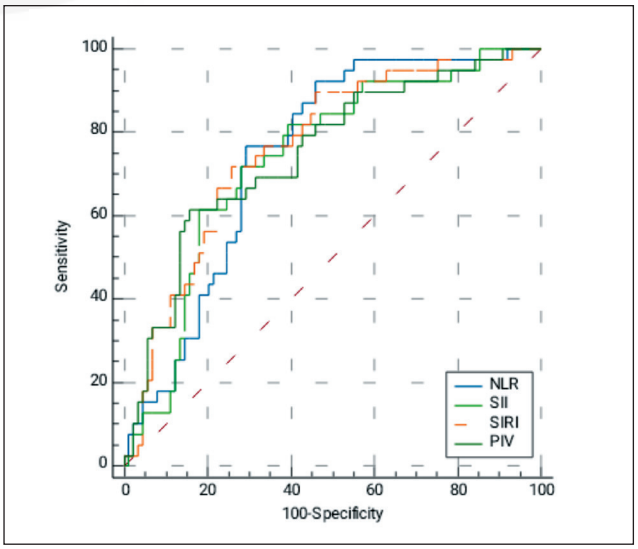


Figure 2. Pairwise comparison of ROC curves.

Table 2. Diagnostic accuracy of inflammatory parameters to predicting strangulated inguinal hernia

Inflammatory parameters	AUC	Cut-off	Sensitivity %	Specificity %	AUC 95% CI	P-value
NLR	0.748	>5.16	76.9	70.7	0.67-0.82	<0.001
SII	0.738	>1497.03	71.8	71.9	0.65-0.81	<0.001
SIRI	0.765	>3.95	71.9	74.2	0.68-0.84	<0.001
PIV	0.750	>1383.74	62.6	84.3	0.67-0.83	<0.001

AUC: Area under curve, **SE:** Standard error, **PPV:** Positive predictive value, **NPV:** Negative predictive value, **CI:** Confidence interval, **NLR:** Neutrophil to lymphocyte ratio**, SII:** Systemic immune inflammation index, **SIRI:** Systemic Inflammation Response Index **PIV:** Pan-immune inflammation value

conducted by Zhou et al., NLR predicted strangulation in incarcerated hernia with an AUC of 0.778 (13). We noticed that NLR has the potential to be helpful in predicting strangulation with an AUC of 0.748 and a cut-off of >5.16.

Systemic immune inflammation index and SIRI are indices that serve as markers of inflammation in different types of malignant diseases (14). In their investigation on 338 patients, Chen et al. determined that the SII could serve as a reliable indicator for predicting the need for entorotomy in patients with incarcerated inguinal hernia (15). A study on incarcerated abdominal wall hernias found SII useful in predicting bowel ischemia with a cut-off of 2401.6 (78.6% specificity, 45.7% sensitivity) (11). The results of our research indicated that SII may accurately predict strangulation with a threshold of more than 1497.03 (AUC: 0.738).

Ceran et al. found that SIRI was an independent factor in the diagnostic process in infants with hypoxic ischemic encephalopathy (16). Guo et al. discovered that SIRI has the potential to predict the severity of coronary artery stenosis in individuals suffering from ST-elevation myocardial infarction (17). Yi et al. discovered that SIRI is correlated with delayed cerebral ischemia in individuals with aneurysmal subarachnoid hemorrhage (18). However how SIRI relates to intestinal ischemia remains unknown. For the first time ever, our research shows that SIRI can foretell inguinal hernia strangulation (Cut-off: >3.95, AUC: 0.765).

Pan-immune inflammation value is a risk score that combines immunological and inflammatory factors, developed by Fuca et al. (19). Akkaya and Cakmak found that the risk of coronary slow flow phenomenon was higher in patients with high PIV levels and normal coronary angiography (20). Han et al. discovered a correlation between PIV and delayed cerebral ischemia in patients suffering from aneurysmal subarachnoid hemorrhage (21). In this study, PIV was found to be a predictor of strangulation in incarcerated hernia with an AUC of 0.750 (Cut-off: >1383.74) and contributed to the literature.

This study had several limitations. The results of the examination could not be acquired because our study was intended to be retrospective and conducted at a single center. There was no evaluation of the length of hospital stay following surgery; the only evaluation was whether or not the incarcerated hernias were strangulated. Clinical results and complications of the patients could not be evaluated because their data were not available. It is necessary to conduct validation studies with prospective and larger population samples.

The ongoing pursuit of inflammatory biomarkers that may be readily and economically measured from commonly used blood tests in the ED remains in progress. Rapid and precise identification of strangulation is of utmost significance in a patient who exhibits incarcerated hernia. The biomarkers NLR, SII, SIRI, and PIV can be utilized to forecast SIH in incarcerated hernias.

Acknowledgment

None.

Author Contributions

All of the authors declare that they have all participated in the design, execution, and analysis of the paper, and that they have approved the final version.

Conflicts of Interest

The authors have no conflicts of interest to declare.

Financial Support

The authors declared that this study has received no financial support.

Ethical Approval

The study received approval, and the requirement for informed consent was waived by the Ethics Commission (ethics committee decision number: 2023/243 date: November 20, 2023). The research was carried out in accordance with the Helsinki Declaration.

Review Process

Externally and extremely peer-reviewed.

REFERENCES

1. Kadioğlu H, Ömür D, Bozkurt S, Ferlengez E, Memm N, Ersoy YE, Çıpe G, Müslümanoğlu M. Ischemia Modified Albumin Can Predict Necrosis at Incarcerated Hernias. Dis Markers. 2013;35(6):807.
2. Horgan PG, Gorey TF. Operative assessment of intestinal viability. Surg Clin North Am. 1992;72(1):143–55.
3. Topçu H, Kemer Atik B, Ulaş MG, Çetin Efe A, Poslu Karademir F, Şerefoğlu Çabuk K. Farklı Seviyelerdeki Lakrimal Drenaj Sistemi Tıkanıklığı Olan Hastalarda Sistemik İnflamatuar Belirteçlerin ve Tedavi Başarısının Karşılaştırılması. Med J West Black Sea. 2023;7(3):331-7.
4. Açıkgöz M, Atasoy HT. İnme Hastalarında Lenfosit/Monosit Oranının Klinik ve Radyolojik Parametrelerle İlişkisi ve Kısa Süreli Sonuçlara Etkisi. Med J West Black Sea. 2023;7(2):148-55.
5. Dikbaş O, Erten N, Küçüker F, Yılmaz Akşehirli Ö. Relationship of Potential Inflammatory Markers Namely Neutrophile Lymphocyte Ratio and Platelet Lymphocyte Ratio With the Severity of Obstructive Sleep Apnea. Turk J Diab Obes. 2017;1(3):125-31.
6. Icoz G, Makay O, Sozbilen M, Gurcu B, Caliskan C, Firat O, Kurt Z, Ersin S. Is D-dimer a Predictor of Strangulated Intestinal Hernia? World J Surg. 2006;30(12):2165–9.
7. Buldanlı MZ, Kesikli SA, Çimen Ş, Uçaner B. Evaluation and clinical significance of predictors for strangulation and intestinal resection in emergency anterior abdominal wall hernia surgery. Ulus Travma Acil Cerrahi Derg. 2023 Feb;29(2):183–92.
8. Morley C, Unwin M, Peterson GM, Stankovich J, Kinsman L. Emergency department crowding: A systematic review of causes, consequences and solutions. PLoS One. 2018;13(8).
9. Vironen J. Treatment of incarcerated hernia in adults. Duodecim. 2017 Jan 1 [cited 2024 Mar 22];133(9):849–54. Available from: https://europepmc.org/article/med/29240314
10. Nathan C. Neutrophils and immunity: challenges and opportunities. Nat Rev Immunol. 2006;6(3):173–82.
11. Bostancı MT, Yılmaz I, Seki A, Saydam M, Kosmaz K, Kaya IO. Haematological inflammatory markers for indicating ischemic bowel in patients with incarcerated abdominal wall hernias. Hernia. 2022;26(1):349–53. Available from: https://link.springer.com/article/10.1007/s10029-021-02518-1
12. Beji H, Bouassida M, Chtourou MF, Zribi S, Laamiri G, Kallel Y, Mroua B, Mighri MM, Touinsi H. Predictive factors of bowel necrosis in patients with incarcerated femoral hernia. Hernia. 2023;27(6):1491–6.
13. Zhou H, Ruan X, Shao X, Huang X, Fang G, Zheng X. Clinical value of the neutrophil/lymphocyte ratio in diagnosing adult strangulated inguinal hernia. Int J Surg. 2016;36:76–80.
14. Koroglu M, Ayvaz MA, Bakan SB, Sirin A, Akyuz U. Can quantitative surface antigen levels and systemic immune-inflammation index be predictive as a new indicator for the initiation of treatment in chronic hepatitis b? Eur J Gastroenterol Hepatol. 2024;36(4):489–97.
15. Chen L, Chen L, Wang YY, Zhang LX, Xia XG. A predictive model of bowel resection for incarcerated inguinal hernia based on the systemic immune-inflammation index. Front Surg. 2022;9.
16. Ceran B, Dizdar EA, Beśer E, Karaçağlar NB, Sarl FN. Diagnostic Role of Systemic Inflammatory Indices in Infants with Moderate-to-Severe Hypoxic Ischemic Encephalopathy. Am J Perinatol. 2021;41(03):248–54.
17. Guo J, Huang Y, Pang L, Zhou Y, Yuan J, Zhou B, Fu M. Association of systemic inflammatory response index with ST segment elevation myocardial infarction and degree of coronary stenosis: a cross-sectional study. BMC Cardiovasc Disord. 2024;24(1).
18. Yi HJ, Shin DS, Kim BT. Dynamic changes of systemic inflammation response index and systemic immune-inflammation index are associated with delayed cerebral ischemia after aneurysmal subarachnoid hemorrhage. J Stroke Cerebrovasc Dis. 2024;33(5):107626.
19. Fucà G, Guarini V, Antoniotti C, Morano F, Moretto R, Corallo S, Marmorino F, Lonardi S, Rimassa L, Sartore-Bianchi A, Borelli B, Tampellini M, Bustreo S, Claravezza M, Boccaccino A, Murialdo R, Zaniboni A, Tomasello G, Loupakis F, Adamo V, Tonini G, Cortesi E, Braud F de, Cremolini C, Pietrantonio F. The Pan-Immune-Inflammation Value is a new prognostic biomarker in metastatic colorectal cancer: results from a pooled-analysis of the Valentino and TRIBE first-line trials. Br J Cancer. 2020;123(3):403–9.
20. Akkaya S, Cakmak U. Association between pan-immune-inflammation value and coronary slow flow phenomenon in patients with angiographically normal coronary arteries. Int J Cardiol. 2024;398:131631.
21. Han W, Yi HJ, Shin DS, Kim BT. Pan-immune-inflammation value predict delayed cerebral ischemia in patients with aneurysmal subarachnoid hemorrhage. J Clin Neurosci. 2024;121:47–52.