Samatya Ratio: A Novel Prognostic Indicator for Rectal Cancer

Ensar Cakir[1], Onur Olgac Karagulle[1], Kenan Buyukasik[1], Muhammed Gurluk[1], Ibrahim Taskin Rakici[2] and Mert Mahsuni Sevinc[1]

[1]*Department of General Surgery, Istanbul Training and Research Hospital, University of Health Sciences, Istanbul, Turkiye*
[2]*Department of Radiology, Istanbul Training and Research Hospital, University of Health Sciences, Istanbul, Turkiye*

ABSTRACT

Objective: To evaluate the prognostic potential of a new parameter, the Samatya ratio, calculated by dividing tumour volume by the albumin-derived neutrophil-to-lymphocyte ratio (Alb-dNLR), in rectal cancer patients.

Study Design: Descriptive study.

Place and Duration of the Study: Department of General Surgery, Istanbul Education and Research Hospital, Istanbul, Turkiye, from January 2019 to October 2023.

Methodology: The analysis was conducted involving 86 patients diagnosed with rectal cancer who underwent surgery. Patients with ileus, tumour perforation or other confounding factors were excluded. Tumour volumes were calculated using MRI-based automated segmentation, while Alb-dNLR was obtained from preoperative laboratory data. The Samatya ratio was computed and analysed using ROC curve analysis, and its diagnostic performance was assessed for tumour perforation and carbohydrate antigen 19-9 (CA 19-9) marker elevation. Statistical significance was set at $p < 0.05$.

Results: The mean Samatya ratio was 1177.64 ± 161. It was significantly associated with elevated CA 19-9 levels ($p = 0.031$) and tumour perforation ($p = 0.003$). At a cut-off value of >1069.34, the Samatya ratio demonstrated 72.7% sensitivity and 69.3% specificity for CA 19-9 levels ($p < 0.05$), and at a cut-off value of >771.25, it demonstrated 84.6% sensitivity and 56.1% specificity for tumour perforation ($p < 0.05$).

Conclusion: The results suggest that the Samatya ratio is a promising prognostic marker for rectal cancer, particularly in predicting tumour perforation and CA 19-9 levels. Its preoperative calculation may enhance prognostic assessment and guide clinical decision--making in oncology practice.

Key Words: *Rectal cancer, Alb-dNLR, Tumour volume, CA 19-9, Tumour perforation*.

How to cite this article: Cakir E, Karagulle OO, Buyukasik K, Gurluk M, Rakici IT, Sevinc MM. Samatya Ratio: A Novel Prognostic Indicator for Rectal Cancer. *J Coll Physicians Surg Pak* 2025; **35(05)**:606-610.

INTRODUCTION

A widely prevalent subtype of colorectal cancer, rectal cancer, accounts for a substantial proportion of cancer-related morbidity and mortality worldwide.[1] Numerous studies have sought to predict prognosis in rectal cancer patients using various clinical, pathological, and molecular markers.[1-3] Despite advancements in diagnostic imaging and biomarkers for prognostic evaluation, identifying reliable preoperative prognostic tools still remains a critical need.[2,3]

A significant indicator of disease progression and prognosis in several malignancies, including rectal cancer, is tumour volume. Studies have shown that larger tumour volumes are associated with poorer survival outcomes and increased rate of recurrence.[4-6] For instance, Tayyab *et al*. reported that rectal tumour volumes are strongly correlated with oncological outcomes, which makes tumour volume a critical parameter for risk stratification and treatment planning.[4] In another study of patients with rectal cancer, Jiang *et al*. showed that patients with large tumours had significantly worse disease-free survival and higher local recurrence rate than patients with small tumours.[5]

Another emerging biomarker—the albumin-derived neutrophil-to-lymphocyte ratio (Alb-dNLR)—integrates systemic inflammation and nutritional status to provide a composite prognostic score.[7] Alb-dNLR, calculated by dividing the serum albumin level by the derived neutrophil-to-lymphocyte ratio (dNLR), has gained attention for its predictive value in gastrointestinal cancers.[8] Studies have shown that elevated dNLR and low albumin levels independently predict poor outcomes in colorectal and rectal cancers, and the combination of these metrics enhances prognostic accuracy.[2,9]

This study introduces the Samatya ratio, calculated as the ratio of tumour volume to Alb-dNLR, as a novel preoperative prog-

Correspondence to: Dr. Onur Olgac Karagulle, Department of General Surgery, Istanbul Training and Research Hospital, University of Health Sciences, Istanbul, Turkiye
E-mail: onurolgackaragulle@gmail.com

Received: January 02, 2025; Revised: March 18, 2025; Accepted: April 18, 2025
DOI: https://doi.org/10.29271/jcpsp.2025.05.606

nostic marker. By combining imaging-derived tumour volume with a biochemical inflammation index, the aim was to evaluate the prognostic utility of the Samatya ratio in predicting outcomes for rectal cancer patients, irrespective of neoadjuvant treatment status. This approach may be a valuable addition to existing prognostic models and may help in developing personalised treatment strategies.

METHODOLOGY

This retrospective study was conducted at the Department of General Surgery, Istanbul Education and Research Hospital, Istanbul, Turkiye, from January 2019 to October 2023. The patients diagnosed with any stage of rectal cancer were included in the study if they satisfied the following inclusion criteria: Aged 18 years or older, had undergone surgical resection, and had available preoperative radiological and laboratory data. Patients with ileus, iatrogenic tumour perforation, colon perforation, secondary primary tumours, or macroscopic fragmentation were excluded to eliminate confounding variables. Similarly, cases of electrocautery artefacts near the tumours in pathological specimens were excluded to avoid misinterpretation of tumour perforation.

Demographic, clinical, radiological, and pathological data were retrospectively retrieved from the hospital's electronic medical records system. The collected patient data included age, gender, BMI, laboratory test results (albumin, neutrophil count, white blood cell count, *etc*.), radiological imaging reports, and surgical and pathology notes.

A power analysis was conducted using G*Power software to determine the minimum sample size required for this study. On the basis of prior literature and clinical expectations, the authors assumed a moderate effect size (Cohen's d = 0.5) with a significance level (α) of 0.05 and a power (1-β) of 0.80 (80%). With these parameters, the minimum required sample size to ensure adequate statistical power in detecting significant associations was 84 patients. The study sample consisted of 86 patients, which was sufficient to assess the diagnostic performance of the Samatya ratio and its relationship with key prognostic markers, such as CA 19-9 levels and tumour perforation, as well as to provide reliable statistical outcomes.

Tumour volumes were measured using preoperative magnetic resonance imaging (MRI) scans. An automated segmentation tool, MedSeg.ai, was employed to outline the tumour boundaries on axial T2-weighted MRI images. Tumour volume was determined in cubic millimetres (mm^3) by integrating the segmented areas across slices. A sample image demonstrating the segmentation process is shown in Figure 1.

The total white blood cell count, neutrophil count, and serum albumin levels were measured preoperatively, three days before the surgery. The dNLR was calculated using formula: dNLR = Neutrophil count / (WBC count−neutrophil count). Alb-dNLR was calculated by dividing the serum albumin levels (g/L) by dNLR.[2] Subsequently, the Samatya ratio was determined as Samatya ratio = tumour volume (mm^3) / (Alb-dNLR).

Statistical analysis was performed using SPSS for Mac (version 29; SPSS Inc., Chicago, IL, USA) and MedCalc trial software. Descriptive statistics were presented as frequencies and percentages for categorical variables and as means, minimum, maximum, and standard deviations (SD) for continuous variables. A receiver operating characteristic (ROC) curve analysis was performed to evaluate the performance of the Samatya ratio in predicting tumour perforation and CA 19-9 elevation. Each outcome was analysed separately to determine the optimal cut-off values, sensitivity and specificity. The Youden index was used to identify the threshold that maximised the sum of sensitivity and specificity. Statistical significance was set at $p < 0.05$, and the area under the ROC curve (AUC) with a 95% confidence interval (CI) was reported for each outcome.

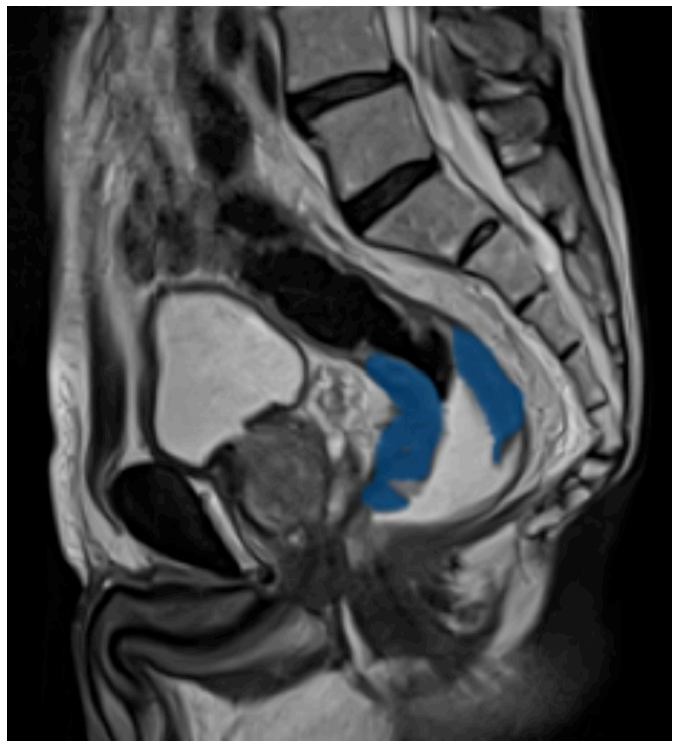

Figure 1: Tumour tissue uploaded to the system appears to be coloured blue by automatic segmentation (Medseg.ai).

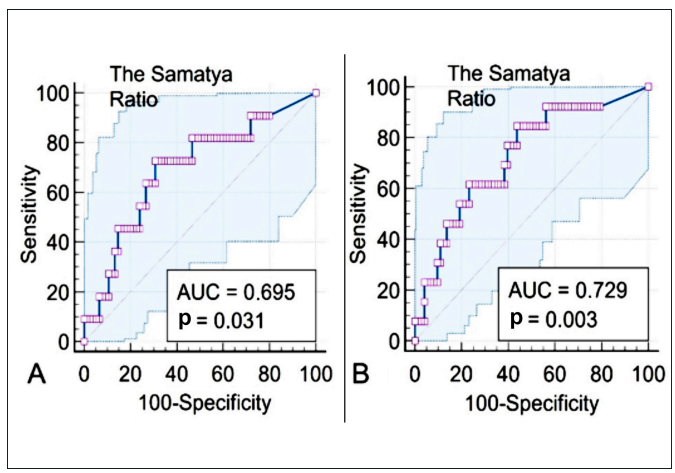

Figure 2: ROC curves of the diagnostic performance of the Samatya ratio on the tumour perforation frequencies (A) and CA 19-9 levels (B).

RESULTS

The study sample consisted of 86 patients, 31 (36.05%) females and 55 (63.95%) males. The mean age of the patients was 62 ± 12 years (range: 32–86), and their mean body mass index (BMI) was 25.3 ± 4.95 kg/m². The mean Samatya ratio across all participants was 1177.64 ± 161. Anastomotic leaks were observed in 4.7% of patients, distant organ metastases in 6%, and tumour recurrence in 10%. Tumour perforation was noted in 13% of pathological specimens, while incomplete mesorectal excision was observed in 41%. Among the patients, 61% had moderately differentiated adenocarcinomas. Other clinical and demographic parameters are summarised in Table I.

Table II shows ROC curve analysis of the diagnostic performance of the Samatya ratio on the independent variables, including CA 19-9 and CEA levels, the frequencies of perineural invasion, lymphovascular invasion, extramural tumour deposits, tumour perforation, mesorectum integrity, metastasis, recurrence, anastomotic leakage, and tumour location according to peritoneal reflection was given in Table II.

The p-values in this table were calculated using the DeLong test, which assesses whether the AUC is significantly different from 0.5 (no discriminatory ability). A p-value <0.05 indicates that the Samatya ratio has a statistically significant ability to differentiate between patients with and without the specified clinical condition. The Youden index was used to determine the optimal cut-off values by maximising the sum of sensitivity and specificity. Statistical analyses were performed using MedCalc trial software.

Table I: Demographic and clinical characteristics of patients.

Parameters	Mean ± standard deviation
Age (years)	62 ± 12
BMI (kg/m^2)	25.3 ± 4.95
Tumour volume (mm^3)	23516.56 ± 22101.43
Albumin (g/L)	39.14 ± 5.22
Lymphocyte (10^9/L)	1.15 ± 0.58
Neutrophil (10^9/L)	3.86 ± 1.6
WBC (10^9/L)	5.64 ± 1.92
dNLR	2.391 ± 1.34
Alb-dNLR	20.46 ± 10.83
Samatya ratio	1177.646 ± 16
SUVmax	23.75 ± 10.74

BMI: Body mass index, WBC: White blood cells, dNLR: Derived neutrophil-to-lymphocyte ratio, Alb-dNLR: Albumin-derived neutrophil-to-lymphocyte ratio, SUVmax: Maximum standardised uptake value.

The ROC curves of the ratio's diagnostic performance *vis-a-vis* the CA 19-9 level and tumour perforation frequency are also shown in Figure 2.

The analysis showed that the Samatya ratio was significantly associated with CA 19-9 elevation (AUC = 0.695, 95% CI: 0.587–0.790, p = 0.031) and tumour perforation (AUC = 0.729, 95% CI: 0.622–0.819, p = 0.003). The optimal cut-off value for predicting CA 19-9 elevation was >1069.34, with a sensitivity of 72.73% and a specificity of 69.33%. For tumour perforation, the cut-off value was >771.25, which yielded a sensitivity of 84.6% and a specificity of 56.1%. These findings suggest that the Samatya ratio may serve as a useful prognostic marker for rectal cancer, particularly for identifying patients at higher risk for tumour perforation and elevated CA 19-9 levels.

DISCUSSION

Numerous studies have sought to predict the prognosis of rectal cancer patients using diverse biomarkers.[10-12] Alb-dNLR, a biochemical indicator integrating systemic inflammation and nutritional status, has emerged as a noteworthy prognostic marker in gastrointestinal malignancies.[9] The present study contributes to the growing set of biomarkers by introducing the Samatya ratio as a novel prognostic marker for rectal cancer. To the best of the authors' knowledge, no previous study has investigated this ratio.

In this retrospective study of 86 patients, significant correlations were found between the Samatya ratio and two key clinical outcomes: Tumour perforation and elevated CA 19-9 levels. Tumour perforation, a critical prognostic factor associated with advanced disease, was significantly linked to higher Samatya ratios. Similarly, elevated CA 19-9 levels, often associated with larger tumour burdens and poorer prognoses, were also correlated with this novel metric. These findings align with earlier results showing that CA 19-9 levels correlate strongly with tumour volume and stage.[6,13,14] For instance, Zhou *et al*. showed that high CA 19-9 levels are directly related to metastasis and tumour volume in colorectal cancer patients. Moreover, CA 19-9 levels have been reported to increase with large tumour volume and poor prognosis.[15] However, it has also been observed that CA 19-9 levels do not increase uniformly in all cancer patients and may remain in the normal range for some patients.

Table II: ROC analysis of the diagnostic performance of the Samatya ratio on the independent variables.

Parameters	AUC	Cut-off	Sensitivity (%)	Specificity (%)	95% CI	p-value
CA 19-9	0.695	>1069.34	72.7	69.3	0.587-0.790	0.031
CEA	0.519	<771.25	57.6	54.7	0.408-0.628	0.774
Perineural invasion	0.573	>357.99	88.0	39.3	0.461-0.679	0.274
Lymphovascular invasion	0.554	>373.38	79.5	45.2	0.443-0.661	0.396
Extramural tumour deposits	0.530	>787.87	64.7	55.0	0.420-0.639	0.683
Tumour perforation	0.729	>771.25	84.6	56.1	0.622-0.819	0.003
Mesorectum integrity	0.550	>1707.18	29.2	86.6	0.439-0.657	0.434
Metastasis	0.617	<787.87	83.3	51.2	0.506-0.720	0.414
Recurrence	0.604	>861.70	80	59.2	0.493-0.708	0.296
Anastomotic leak	0.628	>2706.08	50	93.9	0.517-0.730	0.492
Below peritoneal reflection	0.546	>944.85	48.1	70.6	0.435–0.654	0.469

AUC: Area under the curve, CI: Confidence Interval; CA 19-9: Carbohydrate antigen 19-9; CEA: carcinoembryonic antigen.

Thus, although CA 19-9 is used for diagnostic and prognostic purposes in rectal cancer patients, this parameter alone may not be sufficient and may need to be evaluated along with other clinical indicators. This highlights the potential utility of a factor such as the Samatya ratio. In the present study, a significant correlation was found between the Samatya ratio and CA19-9, which supports the idea of using the ratio in combination with existing biomarkers for diagnosis and prognosis.

Research evidence has confirmed that inflammation is an indicator of tumour progression in various types of cancers.[9-12] Markers such as the neutrophil-to-lymphocyte ratio (NLR) and dNLR show prognostic value in rectal and other cancers.[8,16] Alb-dNLR, which combines serum albumin levels, is a superior predictor of survival in colorectal cancer.[2,9] In rectal cancer patients receiving neoadjuvant chemoradiotherapy, Alb-dNLR is shown to correlate significantly with prognosis.[2] Albumin's association with gastrointestinal cancer progression, particularly colorectal cancer, has been widely studied.[10] Using ROC curves, Sun *et al*. found that Alb-dNLR outperformed other gastric cancer prognostic indices.[17] However, while Alb-dNLR reflects systemic inflammation and nutritional status, it does not directly account for tumour burden, which is a critical determinant of prognosis. Tumour volume, assessed *via* MRI-based segmentation, provides direct insight into disease extent and aggressiveness. By integrating tumour volume with Alb-dNLR, the Samatya ratio offers a more comprehensive prognostic approach that captures both systemic inflammatory response and tumour burden in a single parameter. This novel index enhances preoperative risk stratification and may provide additional prognostic value beyond Alb-dNLR alone, particularly in predicting tumour perforation and CA 19-9 elevation. Given the multifactorial nature of rectal cancer prognosis, combining these two parameters into a unified metric could improve clinical decision-making and individualised treatment planning.

Perforation through the tumour into the peritoneal cavity is an adverse prognostic factor in colorectal cancer, according to the colorectal cancer structured reporting protocol issued by the Royal College of Pathologists of Australia.[18,19] The American Pathologists protocol, citing Anwar *et al*., notes that proximal perforation is a poor prognostic indicator.[20] Tumour perforation is a visible defect connecting the bowel and serosa in intact specimens.[21] Associated with locally advanced cancer, it often follows tumour necrosis and adjacent inflammation or results from iatrogenic injury during surgery.[18] The prognostic significance of tumour perforation is well-established, with studies reporting reduced survival rates in cases of intraoperative or spontaneous perfora- tions.[22] A retrospective study by Bundgaard *et al*. reported five-year survival rates of 40% for intraoperative perforation, 28% for free perforation, 42% for limited perforation, and 64% for non-perforated cases.[22] In the current study, the Samatya ratio differentiated patients with tumour perforation at a cut-off level of >771.25, supporting its predictive value. Excluding surgical inadequacies, this cut-off aligns with the findings of Bundgaard *et al*.[22] Reporting perforation, in high Samatya ratio groups may aid prognosis, and survival analyses may enhance the ratio's clinical relevance.

Despite its contributions, this study has several limitations. First, as a retrospective, single-centre study, the findings are inherently susceptible to selection bias and may not fully capture the variability of clinical practices across different institutions. Second, the relatively small sample size (86 patients) limits the generalisability of the findings, particularly for sub- analyses based on clinical or pathological subgroups. Third, the study did not include long-term survival or recurrence data, which impedes a thorough assessment of the Samatya ratio's utility in predicting overall and disease-free survival. Finally, potential confounding factors, such as comorbidities or treatment modalities, that could influence the relationship between the Samatya ratio and clinical outcomes were not considered. More prospective, multicentre studies with larger cohorts and comprehensive follow-up data are needed to validate these findings and explore their applicability in clinical practice.

CONCLUSION

The Samatya ratio shows a statistically significant correlation with preoperative cut-off values, tumour perforation observed in pathological tissues and CA 19-9 levels in blood. Hence, it can be used as a prognostic marker and may be valuable in medical/radiation follow-up in rectal cancer patients. Future studies should validate the prognostic utility of the Samatya ratio in larger, multicentre cohorts and explore its integration into treatment algorithms. Additionally, advanced survival analyses incorporating this novel metric may further elucidate its role in guiding therapeutic decision-making.

ETHICAL APPROVAL:

The study was approved by the Ethics Committee of Istanbul Education and Research Hospital, Istanbul, Turkiye (Approval No: 360; Dated: November 25, 2022).

PATIENTS' CONSENT:

Written informed consent was obtained from all patients prior to data collection.

COMPETING INTEREST:

The authors declared no conflict of interest.

AUTHORS' CONTRIBUTION:

EC, OOK, KB, MG, ITR, MMS: Conception and design of the study as well as the acquisition, and analysis and interpretation of data.

EC, OOK: Drafting of the manuscript.

KB, MG, ITR, MMS: Critical revision of the manuscript for the important intellectual content.

All authors approved the final version of the manuscript to be published and agreed to be accountable for all aspects of the work.

REFERENCES

1. Dayde D, Tanaka I, Jain R, Tai MC, Taguchi A. Predictive and prognostic molecular biomarkers for response to neoadjuvant chemoradiation in rectal cancer. *Int J Mol Sci* 2017; **18(3)**:573. doi: 10.3390/ijms18030573.
2. Pan Z, Wang Y, Li S, Cai H, Guan G. The prognostic role of the change in albumin-derived neutrophil-to-lymphocyte ratio during neoadjuvant chemoradiotherapy in patients with locally advanced rectal cancer. *Biomol Biomed* 2024; **24(3)**:612-24. doi: 10.17305/bb.2023.9787.
3. Yoshida D, Minami K, Sugiyama M, Ota M, Ikebe M, Morita M, *et al*. Prognostic impact of the neutrophil-to-lymphocyte ratio in stage I-II rectal cancer patients. *J Surg Res* 2020; **245**:281-7. doi: 10.1016/j.jss.2019.07.072.
4. Tayyab M, Razack A, Sharma A, Gunn J, Hartley JE. Correlation of rectal tumor volumes with oncological outcomes for low rectal cancers: Does tumor size matter? *Surg Today* 2015; **45(7)**:826-33. doi: 10.1007/s00595-014-1068-0.
5. Jiang Y, You K, Qiu X, Bi Z, Mo H, Li L, *et al*. Tumor volume predicts local recurrence in early rectal cancer treated with radical resection: A retrospective observational study of 270 patients. *Int J Surg* 2018; **49**:68-73. doi: 10.1016/j.ijsu.2017.11.052.
6. Xiao J, Cai Z, Li W, Yang Z, Gong J, Huang Y, *et al*. Tumor volume reduction rate predicts pathologic tumor response of locally advanced rectal cancer treated with neoadjuvant chemotherapy alone: Results from a prospective trial. *J Cancer* 2015; **6(7)**:636-44. doi: 10.7150/jca.11738.
7. Abe T, Oshikiri T, Goto H, Kato T, Horikawa M, Sawada R, *et al*. Albumin and derived neutrophil-to-lymphocyte ratio is a novel prognostic factor for patients with esophageal squamous cell carcinoma. *Ann Surg Oncol* 2022; **29(11)**:6860-6. doi: 10.1245/s10434-022-11868-8.
8. Corbeau I, Jacot W, Guiu S. Neutrophil to lymphocyte ratio as prognostic and predictive factor in breast cancer patients: A systematic review. *Cancers* 2020; **12(4)**:958. doi: 10.3390/cancers12040958.
9. Nakanishi T, Matsuda T, Yamashita K, Hasegawa H, Sawada R, Harada H, *et al*. Alb-dNLR score as a novel prognostic marker for patients with locally advanced rectal cancer undergoing neoadjuvant chemoradiotherapy. *Anticancer Res* 2024; **44(1)**:229-37. doi: 10.21873/anticanres.16806.
10. Li J, Zhu N, Wang C, You L, Guo W, Yuan Z, *et al*. Preoperative albumin-to-globulin ratio and prognostic nutritional index predict the prognosis of colorectal cancer: A retrospective study. *Sci Rep* 2023; **13(1)**:17272. doi: 10.1038/ s41598-023-43391-5.
11. Li X, Wen D, Li X, Yao C, Chong W, Chen H. Identification of an immune signature predicting prognosis risk and lymphocyte infiltration in colon cancer. *Front Immunol* 2020; **11**: 1678. doi: 10.3389/fimmu.2020.01678.
12. Yamamoto T, Kawada K, Obama K. Inflammation-related biomarkers for the prediction of prognosis in colorectal cancer patients. *Int J Mol Sci* 2021; **22(15)**:8002. doi: 10.3390/ijms22158002.
13. Lakemeyer L, Sander S, Wittau M, Henne-Bruns D, Kornmann M, Lemke J. Diagnostic and prognostic value of CEA and CA19-9 in colorectal cancer. *Diseases* 2021; **9(1)**:21. doi: 10.3390/diseases9010021.
14. Sato R, Oikawa M, Kakita T, Abe T, Akazawa N, Okano H, *et al*. Prognostic value of carcinoembryonic antigen (CEA) and CA 19-9 levels in patients with obstructive colorectal cancer treated with a self-expandable metallic stent and curative surgery. *Surg Today* 2024; **15**:1-9. doi: 10.1007/s00595-024-02943-6.
15. Zhou J, Hu L, Yu Z, Zheng J, Yang D, Bouvet M, *et al*. Marker expression in circulating cancer cells of pancreatic cancer patients. *J Surg Res* 2011; **171(2)**:631-6. doi: 10.1016/j.jss.2010.05.007.
16. Ou Y, Liang S, Gao Q, Shang Y, Liang J, Zhang W, *et al*. Prognostic value of inflammatory markers NLR, PLR, LMR, dNLR, ANC in melanoma patients treated with immune checkpoint inhibitors: A meta-analysis and systematic review. *Front Immunol* 2024; **15**:1482746. doi: 10.3389/fimmu.2024.1482746.
17. Sun X, Wang J, Liu J, Chen S, Liu X. Albumin concentrations plus neutrophil lymphocyte ratios for predicting overall survival after curative resection for gastric cancer. *Onco Targets Ther* 2016; **9**:4661-9. doi: 10.2147/OTT.S108631.
18. Loughrey MB, Quirke P, Shepherd NA, Williamson L. Standards and datasets for reporting cancers: Dataset for histopathological reporting of colorectal cancer. *London Royal Coll Pathol* 2018; **1**-62.
19. Eckstein R, Ackland S, Brown I, Ellis D, Hawkins N, Hicks S, *et al*. In: Colorectal cancer structured reporting protocol. 1st ed. Surry Hills, NSW: The Royal College of Pathologists of Australasia; 2012.
20. Anwar MA, D'Souza F, Coulter R, Memon B, Khan IM, Memon MA. Outcome of acutely perforated colorectal cancers: Experience of a single district general hospital. *Surg Oncol* 2006; **15(2)**:91-6. doi:10.1016/j.suronc.2006.09.001.
21. Nakao E, Kawamura H, Honda M, Takano Y, Kinuta S, Kamiga T, *et al*. Prognostic impact and survival outcomes of colon perforation in patients with metastatic colorectal cancer: A multicenter retrospective cohort study. *Int J Clin Oncol* 2024; **29(2)**:179-87. doi: 10.1007/s10147-023- 02444-5.
22. Bundgaard NS, Bendtsen VO, Ingeholm P, Seidelin UH, Jensen KH. Intraoperative tumor perforation is associated with decreased 5-year survival in colon cancer: A nationwide database study. *Scand J Surg* 2017; **106(3)**:202-10. doi: 10.1177/1457496916683091.