



Original Research Article

CORRELATION OF PREOPERATIVE TUMOR MARKERS WITH AJCC STAGE, TUMOR DIFFERENTIATION, AND LYMPH NODE STATUS IN GASTRIC CARCINOMA

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ABSTRACT

Background: Gastric carcinoma remains one of the leading causes of cancer-related mortality worldwide. Accurate preoperative assessment of disease stage and nodal involvement is essential for prognostication and treatment planning. Serum tumor markers such as Carcinoembryonic Antigen (CEA), Carbohydrate Antigen 19-9 (CA19-9), and Cancer Antigen 72-4 (CA72-4) have been investigated as potential predictors of tumor burden and disease progression in gastric carcinoma. The aim is to correlate preoperative serum tumor markers with AJCC stage, tumor differentiation, and lymph node status in patients with gastric carcinoma. The objective is to determine preoperative serum levels of CEA, CA19-9, and CA72-4 in gastric carcinoma patients. To correlate preoperative tumor marker levels with AJCC stage and tumor differentiation. To evaluate the association between tumor marker levels and lymph node status.

Materials and Methods: This prospective observational study was conducted in the Department of Surgical Gastroenterology at a tertiary care center over a period of two years. A total of 51 patients with biopsy-proven gastric carcinoma were included. Preoperative serum levels of CEA, CA19-9, and CA72-4 were estimated using standard immunoassay techniques. Histopathological examination and AJCC staging were performed for all patients. Statistical analysis was carried out using Chi-square test, Fisher's exact test, and Student's t-test. A p-value <0.05 was considered statistically significant.

Results: CEA positivity (>5 ng/mL) was observed in 10 patients (19.6%), CA19-9 positivity (>37 U/mL) in 36 patients (70.5%), and CA72-4 positivity (>6 U/mL) in 4 patients (7.8%). Elevated CA19-9 levels showed statistically significant association with advanced AJCC stage (p=0.001) and lymph node positivity (p=0.007). CA19-9 positivity was highest in Stage III (88.9%) and Stage IV (80%) disease. CEA and CA72-4 did not show significant association with AJCC stage, tumor differentiation, or lymph node status. None of the studied tumor markers demonstrated significant correlation with histopathological differentiation.

Conclusion: Among the studied tumor markers, CA19-9 showed significant association with advanced stage and lymph node metastasis in gastric carcinoma, suggesting its usefulness as a prognostic biomarker. CEA and CA72-4 demonstrated limited predictive value in the present study. Preoperative CA19-9 estimation may aid in identifying patients with aggressive disease and advanced tumor burden.

Keywords: Gastric Carcinoma. CA19-9. Tumor Markers.

INTRODUCTION

Gastric carcinoma is one of the most common malignancies of the gastrointestinal tract and remains a major global health burden due to its high morbidity and mortality. Despite a gradual decline in incidence in several developed countries, gastric cancer continues to be the fifth most frequently diagnosed cancer and the fourth leading cause of cancer-related deaths worldwide. The disease is particularly prevalent in Eastern Asia, Eastern Europe, and certain developing countries. In India, the incidence varies geographically, with higher prevalence reported in southern and northeastern regions. Gastric carcinoma is more common in males and usually presents in the fifth to seventh decade of life. The major risk factors associated with gastric carcinoma include *Helicobacter pylori* infection, smoking, alcohol consumption, dietary intake of smoked and salted foods, chronic gastritis, pernicious anemia, obesity, and genetic predisposition. Unfortunately, most patients present at an advanced stage because early gastric carcinoma is often asymptomatic or associated with nonspecific symptoms, leading to poor overall survival rates. Surgical resection with adequate lymphadenectomy remains the cornerstone of curative treatment, while chemotherapy and radiotherapy are used as adjunctive modalities in advanced disease.^[1]

Accurate preoperative staging and assessment of tumor aggressiveness are essential for planning treatment and predicting prognosis in gastric carcinoma. The American Joint Committee on Cancer (AJCC) staging system, tumor differentiation, and lymph node involvement are among the most important prognostic indicators. However, radiological and pathological evaluations alone may not always provide complete information regarding tumor biology and metastatic potential. Hence, serum tumor markers have gained attention as non-invasive tools that may aid in predicting disease stage, nodal metastasis, recurrence, and survival outcomes. Among the commonly studied tumor markers in gastric carcinoma are Carcinoembryonic Antigen (CEA), Carbohydrate Antigen 19-9 (CA19-9), and Cancer Antigen 72-4 (CA72-4).^[2] CEA is a glycoprotein involved in cell adhesion and is widely used as a tumor marker in gastrointestinal malignancies. Elevated preoperative CEA levels have been associated with advanced gastric carcinoma, lymph node metastasis, and poor prognosis. CA19-9, originally developed for pancreatic malignancies, has also demonstrated clinical utility in gastric carcinoma and is often associated with tumor burden, depth of invasion, and metastatic disease. CA72-4, a tumor-associated glycoprotein antigen, has shown relatively higher specificity for gastric carcinoma compared to other markers and has been reported to correlate with advanced stages and peritoneal metastasis.^[3]

Several studies have suggested that elevated serum levels of these tumor markers are associated with higher AJCC stage, poor tumor differentiation, lymphovascular invasion, and nodal involvement. However, the sensitivity and specificity of individual markers vary considerably across different populations and studies. Combining these markers may improve prognostic accuracy and help identify patients with aggressive disease behavior. Moreover, preoperative evaluation of serum tumor markers is simple, minimally invasive, and economically feasible, making it useful in routine clinical practice.^[4]

The present study was undertaken to evaluate the correlation of preoperative serum tumor markers, namely CEA, CA19-9, and CA72-4, with AJCC stage, tumor differentiation, and lymph node status in patients with gastric carcinoma. Establishing such associations may help in predicting disease severity preoperatively and assist in therapeutic decision-making and prognostication.^[5]

Aim: To correlate preoperative serum tumor markers (CEA, CA19-9, and CA72-4) with AJCC stage, tumor differentiation, and lymph node status in patients with gastric carcinoma.

Objectives

1. To determine the preoperative serum levels of CEA, CA19-9, and CA72-4 in patients with gastric carcinoma.
2. To correlate preoperative tumor marker levels with AJCC stage and tumor differentiation in gastric carcinoma.
3. To evaluate the association between preoperative tumor marker levels and lymph node status in gastric carcinoma patients.

MATERIALS AND METHODS

Source of Data: The data for the present study were collected from patients diagnosed with biopsy-proven gastric carcinoma who underwent evaluation and treatment in the Department of Surgical Gastroenterology at a tertiary care teaching hospital. Clinical records, laboratory investigations, radiological findings, operative notes, and histopathological reports were reviewed and documented in a structured proforma.

Study Design: The present study was conducted as a prospective observational study.

Study Location: The study was conducted in the Department of Surgical Gastroenterology in association with the Department of Pathology and Department of Biochemistry at a tertiary care hospital.

Study Duration: The study was conducted over a period of two years from March 2017 to April 2019.

Sample Size: A total of 51 patients with biopsy-proven gastric carcinoma fulfilling the inclusion criteria were included in the study.

Inclusion Criteria

1. Patients aged more than 18 years.

2. Patients with histopathologically confirmed gastric carcinoma.
3. Patients undergoing surgical treatment or staging evaluation for gastric carcinoma.
4. Patients willing to participate in the study and provide informed consent.

Exclusion Criteria

1. Patients unfit for surgery or advanced intervention.
2. Patients who had received neoadjuvant chemotherapy or radiotherapy before evaluation.
3. Patients with recurrent gastric carcinoma.
4. Patients with associated malignancies of other organs.
5. Patients with severe systemic illness affecting serum tumor marker levels.

Procedure and Methodology: After obtaining approval from the Institutional Ethics Committee, all eligible patients with biopsy-proven gastric carcinoma were enrolled in the study. Detailed clinical history including presenting complaints, duration of symptoms, personal history, and comorbidities was obtained. Thorough general physical examination and systemic examination were carried out in all patients.

All patients underwent standard preoperative evaluation including complete blood count, liver function tests, renal function tests, coagulation profile, chest radiography, electrocardiography, upper gastrointestinal endoscopy with biopsy, and contrast-enhanced computed tomography (CECT) of the abdomen and thorax for staging purposes.

Preoperative venous blood samples were collected from all patients before initiation of definitive treatment. Serum levels of Carcinoembryonic Antigen (CEA), Carbohydrate Antigen 19-9 (CA19-9), and Cancer Antigen 72-4 (CA72-4) were estimated in the biochemistry laboratory using standardized immunoassay techniques. Serum CEA level >5 ng/mL, CA19-9 level >37 U/mL, and CA72-4 level >6 U/mL were considered elevated.

Patients subsequently underwent appropriate surgical procedures depending on tumor location and stage, including subtotal gastrectomy, total gastrectomy, or palliative procedures. Resected specimens were sent for histopathological examination. Tumors were classified according to AJCC TNM staging system. Histopathological grading was categorized as well differentiated, moderately differentiated, poorly differentiated adenocarcinoma, mucinous carcinoma, or signet ring carcinoma. Lymph node status was assessed based on pathological examination of dissected lymph nodes.

The preoperative tumor marker levels were correlated with AJCC stage, tumor differentiation, and lymph node status.

Sample Processing: Approximately 5 mL of venous blood was collected aseptically from each patient in plain sterile tubes before surgery. Blood samples were allowed to clot and subsequently centrifuged at 3000 rpm for 10 minutes to separate serum. Serum samples were analyzed for CEA, CA19-9, and CA72-

4 using standardized immunoassay methods in the central biochemistry laboratory according to manufacturer protocols.

Histopathological specimens obtained after surgery were fixed in 10% formalin, processed routinely, embedded in paraffin wax, sectioned, and stained with hematoxylin and eosin for microscopic examination.

Statistical Methods: The collected data were entered into Microsoft Excel spreadsheet and analyzed using Statistical Package for Social Sciences (SPSS) software version 20.0. Continuous variables were expressed as mean \pm standard deviation (SD) or median with interquartile range depending on distribution. Categorical variables were expressed as frequencies and percentages.

Association between tumor marker levels and AJCC stage, tumor differentiation, and lymph node status was analyzed using Chi-square test or Fisher's exact test wherever applicable. Student's t-test or ANOVA was used for comparison of continuous variables. Receiver Operating Characteristic (ROC) curve analysis was used to determine diagnostic performance and optimal cut-off values of tumor markers. A p-value of less than 0.05 was considered statistically significant.

Data Collection: Data were collected using a predesigned structured proforma. Information regarding demographic details, clinical presentation, laboratory parameters, imaging findings, serum tumor marker levels, operative findings, histopathological diagnosis, AJCC staging, tumor differentiation, and lymph node status were systematically recorded for each patient. All collected data were verified and compiled for statistical analysis.

RESULTS

[Table 1] shows the overall correlation of preoperative tumor markers with AJCC stage, tumor differentiation, and lymph node status in patients with gastric carcinoma. Among the three tumor markers studied, CA19-9 showed the highest positivity, being elevated in 36 patients (70.5%), whereas CEA was elevated in 10 patients (19.6%) and CA72-4 in only 4 patients (7.8%). The overall distribution of tumor marker positivity was statistically significant ($\chi^2=34.72$, $p<0.001$), indicating marked variation in positivity rates among the three markers.

On evaluating the association with AJCC stage, elevated CA19-9 levels demonstrated a statistically significant correlation with advancing stage of gastric carcinoma ($p=0.001$). In contrast, CEA ($p=0.562$) and CA72-4 ($p=0.844$) did not show significant association with AJCC staging. This finding suggests that CA19-9 may serve as a better marker for predicting advanced disease burden in gastric carcinoma.

With respect to tumor differentiation, none of the tumor markers showed statistically significant

correlation. The p-values for CEA, CA19-9, and CA72-4 were 0.736, 0.313, and 0.585 respectively, indicating that preoperative tumor marker positivity was not significantly influenced by histological grade or differentiation pattern. Similarly, in relation to lymph node status, CA19-9 showed significant association with lymph node

positivity (p=0.007), whereas CEA (p=0.591) and CA72-4 (p=0.414) did not demonstrate statistically significant association. Thus, among all the tumor markers studied, CA19-9 emerged as the most clinically significant marker associated with advanced stage disease and nodal metastasis.

Table 1: Overall correlation of preoperative tumor markers with AJCC stage, tumor differentiation and lymph node status

Parameter	CEA positive n(%)	CA19-9 positive n(%)	CA72-4 positive n(%)	Test significance	95% CI	p-value
Overall marker positivity	10 (19.6%)	36 (70.5%)	4 (7.8%)	$\chi^2 = 34.72$		<0.001
Correlation with AJCC stage	10 (19.6%)	36 (70.5%)	4 (7.8%)	χ^2 test		CEA=0.562; CA19-9=0.001; CA72-4=0.844
Correlation with tumor differentiation	9/51 (17.6%)*	36 (70.5%)	4 (7.8%)	χ^2 test		CEA=0.736; CA19-9=0.313; CA72-4=0.585
Correlation with lymph node status	9/41 (22.0%)	29/41 (70.7%)	3/41 (7.3%)	χ^2 /Fisher's exact test		CEA=0.591; CA19-9=0.007; CA72-4=0.414

Table 2: Preoperative serum tumor marker positivity among gastric carcinoma patients

Tumor marker	Cut-off	Positive n(%)	Negative n(%)	95% CI for positivity	Test of significance	p-value
CEA	>5 ng/mL	10 (19.6%)	41 (80.4%)	11.0-32.5%	One-sample z test	<0.001
CA19-9	>37 U/mL	36 (70.5%)	15 (29.5%)	57.0-81.3%	One-sample z test	0.003
CA72-4	>6 U/mL	4 (7.8%)	47 (92.2%)	3.1-18.5%	One-sample z test	<0.001

[Table 2] demonstrates the preoperative serum tumor marker positivity among patients with gastric carcinoma. CEA positivity, defined as serum levels >5 ng/mL, was observed in 10 patients (19.6%), while 41 patients (80.4%) had normal values. The 95% confidence interval for CEA positivity ranged from 11.0% to 32.5%, and the positivity was statistically significant on one-sample z-test analysis (p<0.001).

CA19-9 positivity, using a cut-off value of >37 U/mL, was observed in 36 patients (70.5%), whereas only 15 patients (29.5%) had normal values. The 95%

confidence interval ranged between 57.0% and 81.3%. The high positivity rate and statistically significant p-value (0.003) indicate that CA19-9 was the most frequently elevated tumor marker among gastric carcinoma patients in the present study.

CA72-4 positivity, defined as serum levels >6 U/mL, was observed in only 4 patients (7.8%), while 47 patients (92.2%) had normal levels. The 95% confidence interval ranged from 3.1% to 18.5%, and the positivity was statistically significant (p<0.001), although the proportion of positive cases remained considerably lower than CA19-9 and CEA.

Table 3: Correlation of preoperative tumor markers with AJCC stage and tumor differentiation

Marker	AJCC Stage I	Stage II	Stage III	Stage IV	χ^2 value	p-value
CEA positive	2/6 (33.3%)	1/8 (12.5%)	4/27 (14.8%)	3/10 (30.0%)	2.05	0.562
CA19-9 positive	1/6 (16.7%)	3/8 (37.5%)	24/27 (88.9%)	8/10 (80.0%)	17.40	0.001
CA72-4 positive	0/6 (0.0%)	1/8 (12.5%)	2/27 (7.4%)	1/10 (10.0%)	0.82	0.844

Marker	WDAC	MDAC	PDAC	Signet ring	Mucinous	χ^2 value	p-value
CEA positive	3 (30.0%)	2 (20.0%)	3 (30.0%)	2 (20.0%)	0	2.00	0.736
CA19-9 positive	8 (22.2%)	12 (33.3%)	8 (22.2%)	6 (16.7%)	2 (5.6%)	4.76	0.313
CA72-4 positive	1 (25.0%)	0	1 (25.0%)	2 (50.0%)	0	2.84	0.585

[Table 3] shows the correlation of preoperative tumor marker levels with AJCC stage and tumor differentiation in gastric carcinoma patients. Among patients with elevated CEA levels, positivity was observed across all AJCC stages, with the highest proportions in Stage I (33.3%) and Stage IV (30.0%). However, the association between CEA positivity and AJCC stage was not statistically significant ($\chi^2=2.05$, p=0.562).

In contrast, CA19-9 positivity showed a strong correlation with advanced AJCC stage. Elevated CA19-9 levels were present in only 16.7% of Stage I patients and 37.5% of Stage II patients, but increased markedly in Stage III (88.9%) and Stage IV disease

(80.0%). This association was statistically significant ($\chi^2=17.40$, p=0.001), suggesting that elevated CA19-9 levels are closely related to advanced and metastatic gastric carcinoma.

CA72-4 positivity was low across all stages, ranging from 0% in Stage I to 12.5% in Stage II, 7.4% in Stage III, and 10% in Stage IV disease. No statistically significant association was observed between CA72-4 positivity and AJCC stage ($\chi^2=0.82$, p=0.844).

Regarding tumor differentiation, none of the tumor markers showed statistically significant correlation with histopathological subtype. CEA positivity was distributed among well differentiated, moderately

differentiated, poorly differentiated, and signet ring carcinomas without significant variation ($p=0.736$). Similarly, CA19-9 positivity was seen across all histological grades, being highest in moderately differentiated adenocarcinoma (33.3%), but without

statistical significance ($p=0.313$). CA72-4 positivity was most commonly observed in signet ring carcinoma (50%), yet this association also failed to reach statistical significance ($p=0.585$).

Table 4: Association between preoperative tumor markers and lymph node status

Marker	N0 n(%)	Node positive n(%)	Odds ratio	95% CI	Test value	p-value
CEA positive	1/7 (14.3%)	8/34 (23.5%)	1.85	0.19-17.70	$\chi^2=0.29$	0.591
CA19-9 positive	2/7 (28.6%)	27/34 (79.4%)	9.64	1.53-60.63	$\chi^2=7.25$	0.007
CA72-4 positive	0/7 (0.0%)	3/34 (8.8%)	1.67	0.08-35.85	$\chi^2=0.67$	0.414

[Table 4] evaluates the association between preoperative tumor marker levels and lymph node status in gastric carcinoma patients. Among patients with node-negative disease (N0), CEA positivity was observed in 1 out of 7 patients (14.3%), whereas among node-positive patients, elevated CEA levels were seen in 8 out of 34 patients (23.5%). Although the odds ratio was 1.85, indicating slightly higher odds of lymph node positivity with elevated CEA, the association was not statistically significant ($\chi^2=0.29$, $p=0.591$). The wide 95% confidence interval (0.19-17.70) also reflects variability and lack of precision. CA19-9 positivity showed a strong association with lymph node metastasis. Elevated CA19-9 levels were found in only 28.6% of node-negative patients compared to 79.4% of node-positive patients. The odds ratio was 9.64 with a 95% confidence interval of 1.53-60.63, indicating significantly increased odds of nodal involvement among patients with elevated CA19-9 levels. This association was statistically significant ($\chi^2=7.25$, $p=0.007$), suggesting that CA19-9 may be a useful predictor of lymph node metastasis in gastric carcinoma.

CA72-4 positivity was absent in node-negative patients and present in only 8.8% of node-positive patients. Although the odds ratio was 1.67, the association was not statistically significant ($\chi^2=0.67$, $p=0.414$), and the wide confidence interval (0.08-35.85) indicated poor predictive reliability.

DISCUSSION

In the present study, preoperative serum tumor marker positivity showed significant variation among the three markers, with CA19-9 being the most frequently elevated marker in 36 patients (70.5%), followed by CEA in 10 patients (19.6%) and CA72-4 in 4 patients (7.8%). This overall difference was statistically significant ($\chi^2=34.72$, $p<0.001$). Similar findings were reported by Lin JX et al. (2018),^[1] who observed that preoperative tumor markers including CEA and CA19-9 independently predicted survival in Stage III gastric carcinoma patients and were frequently elevated in advanced disease. Lin JP et al. (2020),^[2] also demonstrated that elevated preoperative tumor marker levels were associated with poor clinicopathological outcomes and adverse prognosis in gastric carcinoma patients. However, in contrast to some studies where CA72-4 showed relatively higher positivity, the present study found

low CA72-4 positivity, possibly due to smaller sample size, assay variability, and differences in patient characteristics.

In relation to AJCC staging, CA19-9 showed a statistically significant association with advancing stage of gastric carcinoma ($p=0.001$). CA19-9 positivity increased from 16.7% in Stage I and 37.5% in Stage II to 88.9% in Stage III and 80.0% in Stage IV disease, indicating a strong relationship between elevated CA19-9 levels and advanced tumor burden. Similar observations were reported by Lin JX et al. (2018),^[1] who suggested that preoperative tumor marker positivity may improve prognostic stratification beyond conventional AJCC staging. Zubarayev et al. (2019),^[3] emphasized that tumor markers represent important adjunct prognostic indicators in gastric carcinoma in addition to the TNM staging system. Furthermore, Mranda et al. (2022),^[4] reviewed modifications in the AJCC system and highlighted the prognostic importance of lymph node burden and biochemical markers in predicting survival outcomes.

CEA positivity in the present study was 19.6%, but it did not show statistically significant correlation with AJCC stage ($p=0.562$), tumor differentiation ($p=0.736$), or lymph node status ($p=0.591$). Although CEA positivity was slightly higher in node-positive cases than node-negative cases, this difference was not statistically significant. Similar findings were reported by Suenaga et al. (2019),^[5] who observed that perioperative tumor marker levels may have prognostic value, but isolated CEA elevation has relatively low sensitivity in gastric carcinoma. Lin JP et al. (2020),^[2] also noted that CEA alone has limited predictive accuracy when compared to combined tumor marker assessment.

CA72-4 positivity was observed in only 7.8% of patients and did not show significant association with AJCC stage ($p=0.844$), tumor differentiation ($p=0.585$), or lymph node status ($p=0.414$). This finding differs from studies by Guo et al. (2021),^[6] and Lin JX et al. (2021),^[7] who reported that combinations of inflammatory markers and tumor markers including CA72-4 may improve prognostic assessment in gastric carcinoma. The low positivity of CA72-4 in the present study may be attributed to differences in assay methods, patient population, tumor stage distribution, and limited sample size.

Regarding tumor differentiation, none of the tumor markers showed statistically significant association.

CEA, CA19-9, and CA72-4 positivity were distributed across well differentiated, moderately differentiated, poorly differentiated, signet ring, and mucinous carcinoma groups without significant variation. Similar findings were observed by Zubarayev et al. (2019),^[3] who stated that serum tumor markers are more strongly associated with tumor burden and metastatic spread rather than histological grade alone.

Lymph node involvement remains one of the most important prognostic determinants in gastric carcinoma. In the present study, CA19-9 showed statistically significant association with lymph node positivity ($p=0.007$), with positivity observed in 79.4% of node-positive patients compared to 28.6% of node-negative patients. The odds ratio of 9.64 suggested a markedly increased likelihood of nodal metastasis among patients with elevated CA19-9 levels. Similar observations were reported by Zhang LX et al. (2018),^[8] who demonstrated that inflammatory and hematological markers correlate with lymph node metastasis and prognosis in gastric cancer. Luo et al. (2023),^[9] also emphasized the importance of accurate lymph node assessment in gastric adenocarcinoma and its relationship with advanced disease burden. Furthermore, Chen YR et al. (2021),^[10] highlighted that lymph node classification systems remain critical predictors of prognosis in gastric carcinoma patients.

CONCLUSION

The present study evaluated the correlation of preoperative serum tumor markers, namely Carcinoembryonic Antigen (CEA), Carbohydrate Antigen 19-9 (CA19-9), and Cancer Antigen 72-4 (CA72-4), with AJCC stage, tumor differentiation, and lymph node status in patients with gastric carcinoma. Among the three tumor markers studied, CA19-9 demonstrated the highest positivity rate and showed statistically significant association with advanced AJCC stage and lymph node metastasis. Elevated CA19-9 levels were more commonly observed in Stage III and Stage IV gastric carcinoma and in patients with node-positive disease, suggesting its potential utility as a prognostic marker reflecting tumor burden and metastatic spread.

CEA positivity was observed in a smaller proportion of patients and did not demonstrate statistically significant correlation with AJCC stage, tumor differentiation, or lymph node status. Similarly, CA72-4 showed low positivity rates and lacked statistically significant association with the studied clinicopathological parameters. None of the three tumor markers showed significant correlation with histopathological differentiation of gastric carcinoma.

The findings of the present study indicate that CA19-9 may serve as a useful preoperative biomarker for predicting advanced stage disease and nodal involvement in gastric carcinoma, whereas CEA and

CA72-4 have comparatively limited prognostic utility. Preoperative assessment of CA19-9 may therefore aid in risk stratification, treatment planning, and prognostic evaluation in patients with gastric carcinoma. However, larger multicentric studies with long-term follow-up are required to further validate the prognostic significance of these serum tumor markers.

Limitations of study

1. The study was conducted in a single tertiary care center, limiting generalizability of the findings.
2. The sample size was relatively small ($n=51$), which may have affected the statistical power of the study.
3. The study duration was limited and long-term follow-up for recurrence and survival analysis was not performed.
4. Patients receiving neoadjuvant chemotherapy were excluded, which may limit applicability to all gastric carcinoma patients.
5. CA72-4 positivity was observed in a very small number of patients, limiting meaningful subgroup analysis.
6. Variability in tumor marker assay techniques and laboratory standards may influence serum marker measurements.
7. Histological subtypes such as mucinous carcinoma had very few cases, reducing the reliability of statistical comparisons.
8. Serum tumor marker levels may be influenced by inflammatory or benign gastrointestinal conditions, potentially affecting specificity.
9. Dynamic postoperative changes in tumor marker levels were not assessed.
10. Molecular and genetic prognostic markers were not evaluated in the present study.

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