International Journal of General Medicine

Dovepress
Taylor & Francis Group

Open Access Full Text Article

ORIGINAL RESEARCH

The Prognostic and Early Efficacy Prediction Value of Baseline C-Reactive Protein-Albumin-Lymphocyte (CALLY) Index in Advanced Pancreatic Cancer

Liangxue Zhu, Yuanyuan Kong, Yajun Xing, Mingyun Wang

Department of Oncology, Nanjing Gaochun People's Hospital, Nanjing, 211300, People's Republic of China

Correspondence: Mingyun Wang, Department of oncology, Nanjing Gaochun People's Hospital, 53 Maoshan Road, Nanjing, People's Republic of China, Tel +86-025-66937151, Email xinyue_0222@163.com

Purpose: In this retrospective study, we aimed to investigate the prognostic and early efficacy prediction value of baseline CALLY index in advanced pancreatic cancer.

Patients and Methods: We analyzed the clinical and follow-up data of 252 metastatic pancreatic cancer patients diagnosed at Nanjing Gaochun People's Hospital from January 2019 to June 2024. The optimal cut-off for the CALLY index was determined by maximizing Youden's index (J = sensitivity + specificity - 1) through receiver operating characteristic (ROC) curve analysis. Early treatment efficacy was evaluated according to RECIST 1.1 criteria based on radiological assessments at 6~9 weeks after initiating first-line therapy. The effect of the CALLY index on survival and early efficacy in first-line treatment was analyzed using the Kaplan–Meier method and the Cox proportional hazards model. The CALLY index was calculated as: (Albumin × Lymphocyte)/(CRP × 104).

Results: The cut-off value of the CALLY index for predicting survival was determined at 0.27. The area under the curve (AUC) was 0.725. With a cut-off value of 0.27, patients were divided into two groups: those with CALLY ≥0.27 and those with CALLY <0.27. The median overall survival was 12 and 5 months respectively ($P < 0.01$). CALLY Index ≥ 0.27 was associated with better survival outcomes. Cox regression analysis revealed that a low CALLY index (<0.27) was independent predictors of poor prognosis. CALLY index of 0.27 for predicting early efficacy in advanced pancreatic cancer patients with an area under the curve (AUC) of 0.73, and there was a statistically significant difference in early efficacy of first-line therapy between the high and low CALLY groups ($P = 0.022$).

Conclusion: Our findings suggest that the baseline CALLY index is a promising predictive biomarker for early efficacy and prognosis of patients with Pancreatic cancer, though its reliability requires validation in multicenter prospective studies.

Keywords: cally index, metastatic pancreatic cancer, survival analysis, treatment response

Introduction

Pancreatic cancer is the sixth leading cause of cancer-related mortality in China.[1] The disease's insidious onset and atypical early symptoms contribute to the majority of patients being diagnosed at advanced stages. Chemotherapy remains a cornerstone of treatment, yet the 5-year survival rate remains dismal at less than 10%,[2] despite advances in therapeutic strategies and cancer research such as nanoparticle-based drug delivery systems and The patient-derived xenograft (PDX) model.[3,4] The American Joint Committee on Cancer (AJCC) staging system is currently the most widely utilized tool for the stratification, treatment decision-making, and survival prediction of pancreatic cancer patients. Nevertheless, substantial heterogeneity in survival outcomes is frequently observed among patients with identical TNM staging. Consequently, there is an urgent need for more effective strategies to optimize risk stratification and survival prediction.

Beyond tumor-specific characteristics, host-related factors such as nutrition status, systemic inflammation, and immune function not only contribute to tumor initiation and progression, but also exert significant influence on patient prognosis.[5–7] Emerging evidence highlights the pivotal effects of inflammatory responses within the tumor

Received: 3 April 2025
Accepted: 18 June 2025
Published: 24 June 2025

microenvironment (TME) on disease progression.[8] Concurrently, cancer-associated malnutrition has been increasingly recognized as a correlative factor of therapeutic resistance and diminished outcomes during cytotoxic interventions.[9] Therefore, a growing number of studies have identified the high value of using nutrition and inflammation parameters, such as the levels of albumin and serum C-reactive protein (CRP), to predict outcomes in patients with advanced pancreatic cancer.[10,11] In addition, lymphocytes are pivotal components of the host anticancer immune response,[12] neutrophil-to-lymphocyte ratio(NLR) is also reported associated with poor prognosis in pancreatic cancer patients.[13] In cancer patients, the interaction between malnutrition, compromised immune function, and systemic inflammation often results in lower albumin levels, decreased lymphocyte counts, and higher CRP values. Based on the above theories and studies, we believe that composite biomarkers integrating systemic inflammatory responses, nutritional status, and immunological competence may provide enhanced prognostic accuracy for patients with pancreatic cancer.

Iida et al[14] established the C-reactive protein-albumin-lymphocyte index (CALLY index) for prognostic evaluation in cancer patients for the first time, demonstrating its superior prognostic capability over traditional indicators such as mGPS, NLR, and PLR in hepatocellular carcinoma patients undergoing hepatic resection. Subsequent studies have identified the high value of the CALLY index to predict outcomes across various malignancies, including colorectal cancer, ovarian cancer, esophageal cancer, and breast cancer.[15–19] It is noteworthy that the application of the CALLY index in the prognostic evaluation of advanced pancreatic cancer has not been reported. Therefore, In this study we aimed to investigate the prognostic value of the CALLY index in metastatic pancreatic cancer patients and to evaluate its potential as a predictive biomarker for early efficacy to first-line treatment.

Materials and Methods

Study Design and Population

This study investigated 252 metastatic pancreatic cancer patients diagnosed at Nanjing Gaochun People's Hospital from January 2019 to June 2024. The following eligibility criteria were employed: 1) All patients were confirmed pancreatic cancer histologically or cytologically and diagnosed with metastatic disease based on clinical and imaging data; 2) availability of complete clinicopathological data, laboratory test results, and follow-up information. The exclusion criteria included: 1) patients with concurrent malignancies in other organ systems; 2) individuals with hematological or immunological disorders; 3) patients with recent infections.

Data Collection

Clinical and pathological data were systematically collected from the medical records system of Nanjing Gaochun People's Hospital. The collected data included demographic characteristics (age and gender), tumor characteristics (location and presence of liver metastasis), and treatment regimens. Laboratory parameters, including complete blood count and biochemical profiles, which were obtained within one week prior to the initiation of first-line treatment. Baseline imaging data before treatment and follow-up imaging after 2–3cycles of therapy were also collected. This study was approved by the Ethics Committee of Nanjing Gaochun People's Hospital.

Treatment response was evaluated according to the Response Evaluation Criteria in Solid Tumors (RECIST 1.1), categorizing outcomes into complete response (CR), partial response (PR), stable disease (SD), and progressive disease (PD). Early treatment efficacy was defined as the disease control rate (DCR) after completing 2~3cycles (six-nine weeks) of first-line treatment, DCR = CR + PR + SD. Patient survival time was determined through follow-up.

Treatment and Follow Up

The enrolled patients received first-line chemotherapy regimens primarily based on gemcitabine. Follow-up was conducted through medical record review, outpatient visits, and telephone interviews, with the follow-up period extending until December 31, 2024. Among the cohort, seven cases were lost to follow-up; however, their clinicopathological data were included in the analysis. In this study, overall survival (OS) calculated as the time from the date of tumor diagnosis to either the date of death or the end of follow-up.

Statistical Analysis

Statistical analyses were performed using SPSS 26.0. Descriptive statistical methods were employed to analyze baseline patient characteristics, including age, gender, clinical features, CALLY index, and tumor location. Categorical variables were expressed as frequencies and percentages [n (%)], while continuous variables were presented as mean ± standard deviation. Intergroup comparisons were conducted using the chi-square test or Fisher's exact test. Receiver operating characteristic (ROC) curves was drawn, the optimal cutoff value was obtained based on the Youden's index, and the optimal cutoff value subsequently used to stratify patients into groups. The survival rate was calculated by the Kaplan–Meier method using the Log rank test. Multivariate analysis was conducted using the Cox proportional hazards regression model. The hazard ratio (HR) and 95% confidence interval (CI) for each factor are presented, and P-values < 0.05 was considered statistically significant.

Results

Baseline Characteristics of the Enrolled Cohort

A total of 252 patients were enrolled in the study, comprising 168 males (66.67%) and 84 females (33.33%). The mean age of the cohort was 66.69 ± 9.36 years (range: 47–86 years). Tumor localization included 70 cases (27.78%) in the pancreatic head and 182 cases (72.22%) in the body or tail of the pancreas. Liver metastasis was presented in 143 patients (56.74%) prior to the initiation of first-line treatment. Palliative surgery or exploratory laparotomy was performed in 47 patients (18.75%). 23 patients received only palliative supportive care, including localized interventions such as particle implantation and biliary drainage.

186 patients were evaluable for treatment response, the outcomes were as follows: progressive disease (PD) in 63 cases (33.87%), partial response (PR) in 20 cases (10.75%), stable disease (SD) in 103 cases (55.38%), and complete response (CR) in 0 cases (0%). The objective response rate (ORR) was 10.75%, and the disease control rate (DCR) was 66.13%.

Association Between the CALLY Index and Clinicopathological Characteristics in Pancreatic Cancer Patients

A total of 252 patients were included in this study. The pretreatment CALLY index levels ranged from 0.005 to 27.3. The optimal cutoff value for the CALLY index in predicting patient survival status was determined using receiver operating characteristic (ROC) curve analysis according to Youden's index. The optimal OS cutoff of the CALLY index was 0.27. The area under the ROC curve (AUC) was 0.725 (95% confidence interval [CI]: 0.60–0.85, sensitivity 58.06%, specificity 86.25%, $P = 0.0021$). We also make the comparison between different biomarkers mentioned before to contribute to the prognosis of pancreatic cancer patients. ROC analysis revealed that the area under the curve (AUC) for the the CRP-albumin ratio (CAR) (0.71), NLR (0.62); the AUC for the CALLY index was the most accurate (Figure 1). Patients were stratified into two categories based on the CALLY index; those with a value above 0.27 and those with a value below. The high CALLY index group had 156 individuals (61.90%) while the low CALLY index group had 96 (38.1%). Statistical analysis revealed that a low CALLY index was significantly associated with the presence of liver metastasis ($P < 0.05$). However, no significant correlations were observed between the CALLY index and other clinicopathological features, including age, gender, tumor location, or high expression of CA199 (defined as > 400 U/L). Detailed results are presented in Table 1.

Predictive Value of CALLY Index for Early Efficacy in First-Line Treatment

The CALLY index cutoff of 0.27 demonstrated significant predictive utility for early efficacy in first-line treatment, with an area under the curve (AUC) of 0.73 (95% confidence interval [CI]: 0.55–0.89, $P = 0.022$, Figure 2). The sensitivity and specificity for this cutoff were 83.33% and 57.14%, respectively. Among the 186 patients evaluable for treatment response, high CALLY (CALLY ≥ 0.27, n = 129) and low CALLY (CALLY < 0.27, n = 57) groups revealed statistically significant differences in early efficacy (Table 2). These results suggest that patients in the high CALLY group exhibited better early treatment outcomes, highlighting the potential predictive value of the CALLY index.

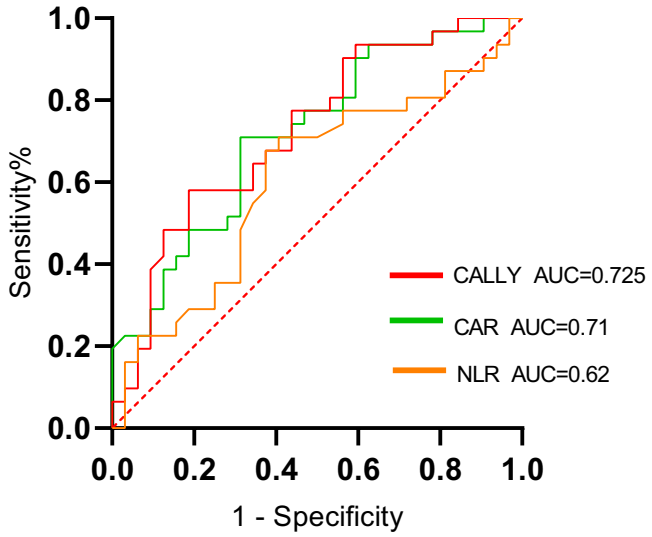

Figure 1 ROC curve of CALLY index, NLR, CAR for predicting survival.

Furthermore, survival analysis was conducted by comparing patients who achieved disease control rate (DCR) with those who experienced progressive disease (PD). The median overall survival (OS) was significantly longer in the DCR group (15 months) compared to the PD group (5.5 months) (95% CI: 0.19–0.72, P < 0.001), as illustrated in Figure 3. This statistically significant difference revealed the association between early treatment efficacy and prolonged overall survival, emphasizing the clinical relevance of achieving disease control in the initial phases of therapy. These findings collectively support the utility of the CALLY index as a biomarker for early efficacy and survival outcomes in pancreatic cancer patients undergoing first-line therapy.

Association Between the CALLY Index and Survival Time in Pancreatic Cancer Patients

Till the end of follow-up, 13patients remained alive, 7 patients were lost, and 232 patients died. The median overall survival (OS) for the entire cohort was 7 months. Using cutoff of 0.27, patients were stratified into high CALLY (CALLY

Table 1 The Relationship Between CALLY Index and Clinical Characteristics of Patients with Advanced Pancreatic Cancer

Variable	CALLY < 0.27 n=96	CALLY ≥0.27 n=156	x^2	P value
Gender				
Male	65	103		
Female	31	53	0.076	0.783
Age				
>65y	61	88		
≤65y	35	68	1.251	0.263
Location of pancreas				
Head	31	39		
Body and tail	65	117	1.575	0.209
Liver metastasis				
Yes	63	80		
No	33	76	4.981	0.026
CA199 level				
≤400U/L	40	83		
>400U/L	56	73	3.167	0.075

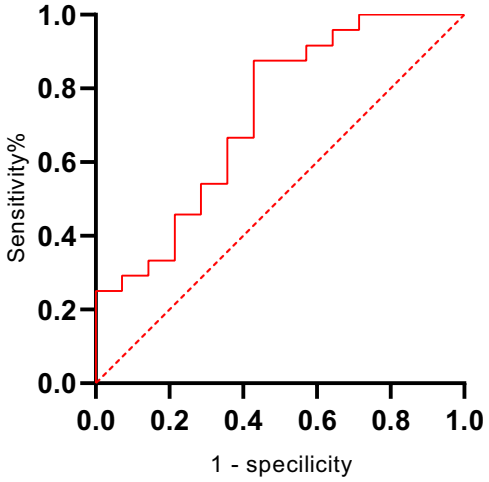

Figure 2 ROC curve of CALLY index for predicting early efficacy.

≥ 0.27) and low CALLY (CALLY < 0.27) groups. Kaplan-Meier survival curves were used to compare the survival outcomes between these two groups (Figure 4). The median OS was significantly longer in the high CALLY group (12 months) compared to the low CALLY group (5 months) (95% confidence interval [CI]: 0.24–0.71, P < 0.01). This result indicated that a low CALLY index is associated with poorer prognosis in pancreatic cancer patients which further underscore the prognostic value of the CALLY index in predicting survival and its potential utility in risk stratification and treatment planning.

Prognostic Factors in Advanced Pancreatic Cancer Patients

Univariate Cox regression analysis revealed that overall survival (OS) was significantly associated with whether patients received chemotherapy and the pretreatment CALLY index (P < 0.01). In contrast, no significant associations were observed between OS and other factors, including age, gender, tumor location, high CA199 expression (> 400 U/L), or the presence of liver metastasis. Subsequently, multivariate Cox regression analysis was performed, using the significant variables identified in the univariate analysis. The results demonstrated that a high CALLY index and chemotherapy were independent prognostic factors influencing OS (P < 0.01). Detailed results are presented in Table 3.

Discussion

Cancer development is closely related to the nutritional state of the body, the immune state and the inflammatory response in the tumor microenvironment.[20] Inflammatory response plays a crucial role in different stages of tumor development.[21] C-reactive protein is an acute time-phase reactive protein synthesized by hepatocytes under inflammatory conditions such as tissue injury and infection, and it is a commonly used marker of inflammation in clinical practice. Several studies have demonstrated that elevated C-reactive protein is associated with shorter survival in pancreatic cancer patients[22] and correlates with tumor size.[23] Malnutrition is a frequent problem for cancer patients and can lead to reduced quality of life, decreased response to treatment, increased risk of chemotherapy-induced toxicity and decreased survival.[24] Albumin is a major protein synthesized in the liver and is a valid indicator of nutritional status due to its relatively long half-life. In advanced stages of the disease, albumin levels decrease due to malnutrition and inflammatory response, and low albumin levels can also indicate

Table 2 Early Efficacy of First-Line Treatment in Patients with High and Low CALLY Groups

Therapeutic Efficacy	Number	Low CALLY Group n=57	High CALLY Group n=129	P value
PD	63 (33.87%)	29 (15.59%)	34 (18.28%)	
DCR(PR+SD)	123 (66.13%)	28 (15.05%)	95 (51.08%)	0.001

https://doi.org/10.2147/IJGM.S529776

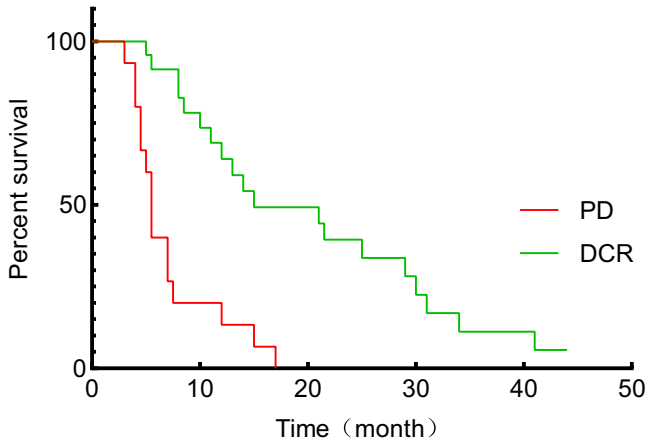

Figure 3 Survival curves of different early efficacy of first-line therapy.

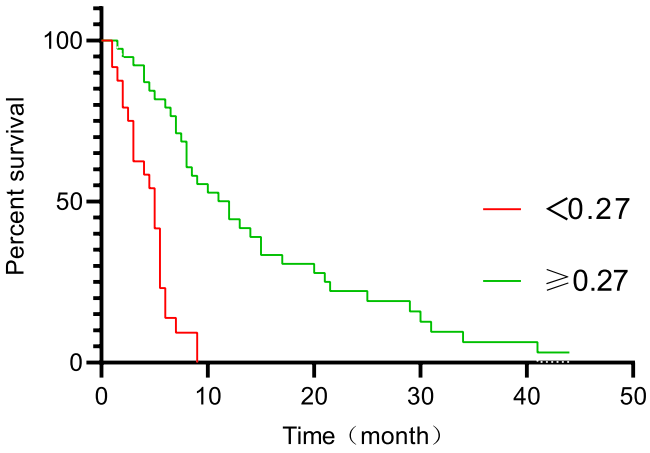

Figure 4 Survival curves of patients in different CALLY index groups.

a poor prognosis in patients with pancreatic cancer.[25] The C-reactive protein to serum albumin level ratio (CAR) based on these two parameters has been shown to be an independent prognostic predictor in patients with pancreatic cancer.[26] The tumorigenesis process involves different types of immune cells, and peripheral blood lymphocyte count can reflect the cytotoxic immune response function and health status of the body,[27] which is commonly used as a representative immune indicator. Previous studies have shown that circulating lymphocytes can improve patient prognosis by enhancing tumor immune surveillance and inhibiting tumor cell proliferation.[28] Lymphopenia is common in a variety of cancers and is

Table 3 COX Regression Analysis of Prognostic Factors in Patients with Pancreatic Cancer

Variable	Univariate Analysis		Multivariate Analysis	
	HR (95% CI)	P value	HR (95% CI)	P value
Age (>65y, ≤65y)	0.762 (0.44~1.32)	0.333	—	—
Gender (Male, Female)	0.852 (0.485~1.498)	0.575	—	—
Location of pancreas (head, body and tale)	1.518 (0.854~2.699)	0.155	—	—
Liver metastasis (yes, no)	0.954 (0.559~1.627)	0.861	—	—
CALLY (≥0.27, <0.27)	5.728 (2.84~11.552)	P<0.01	0.232 (0.118~0.454)	P<0.01
CA199 level (≤400, >400)	1.431 (0.838~2.442)	0.189	—	—
Chemotherapy (yes, no)	3.817 (1.996~7.298)	P<0.01	0.158 (0.077~0.326)	P<0.01

considered to be a reflection of the declining state of immune function, which is particularly evident in pancreatic cancer and is associated with poor prognosis in pancreatic cancer patients.[29] The CALLY index, which integrates C-reactive protein, serum albumin, and lymphocyte counts, reflects the inflammatory status, nutritional condition, and immune function of pancreatic cancer patients, making it an ideal prognostic indicator. In this study, we established a specific association between the CALLY index and prognosis in advanced pancreatic cancer patients. An increased CALLY index was associated with a reduced risk of mortality, consistent with previous studies[15–19] demonstrating its prognostic value in other malignancies and offered superior predictive value compared to NLR and CAR. Furthermore, the CALLY index emerged as an independent prognostic factor. Additionally, the CALLY index showed potential in predicting early efficacy in first-line treatment for advanced pancreatic cancer, as patients with a high CALLY index were more likely to benefit from initial treatment. These findings underscore the clinical utility of the CALLY index in risk stratification and treatment planning for advanced pancreatic cancer patients.

Although this study corroborates the association between a high CALLY index and improved prognosis or better response to first-line therapy, The precise mechanisms underlying remain unclear.[30] Inflammation level, nutrition status and immune function not only independently influence cancer, but their interactions cannot be ignored, and these interactions would further promote the progression of cancer.[31] In pancreatic malignancies, subclinical inflammatory states characterized by elevated C-reactive protein (CRP) are frequently observed.[32] It contributes to elevated energy expenditure and anorexia. CRP synthesis is predominantly induced by interleukin-6 (IL-6), a proinflammatory cytokine overproduced in pancreatic cancer (PC).[9] Thus, serum CRP levels may indicate tumor burden in these patients. Serum albumin is widely used to assess nutritional status, as in patients with extensive diseases, serum albumin synthesis can be impeded by malnutrition. Nutrition plays a key role in determining the fate and functions of immune cells.[33] Hypoproteinemia is confirmed associating with impaired immune responses (such as macrophage activation and granuloma formation) and leading to increased levels of inflammation in patients,[34,35] which have great promotion roles on cancer incidence and progression and finally shorten survival. The tumor infiltrating lymphocyte (TIL) population in pancreatic cancer shows clinical correlates that higher proportions of CD4+, CD8+ and dendritic cells (DCs) of TILs can improve the prognosis.[28] Among these immune cells, CD8+ T cells play an essential role in killing tumor cells, and a greater number of cancer cell adjacent cytotoxic T cells significantly correlates with survival. Advanced-stage tumors exhibit CD8+ T cells with elevated expression of exhaustion signatures, paralleling the observed peripheral lymphocytopenia and diminished T-cell multiplication capacity in late-stage pancreatic cancer.[36] This establishes peripheral lymphocyte counts as a potential biomarker reflecting cumulative immune dysfunction and disease progression. Our study revealed that patients in the low CALLY index group had a higher proportion of liver metastases. Liver metastases often lead to impaired liver function and reduced serum albumin levels, which can contribute to a lower CALLY index. Therefore, the significant correlation between the CALLY index and liver metastasis is biologically plausible. However, multivariate analysis indicated that the presence of liver metastasis was not an independent prognostic factor for pancreatic cancer patients. This evidence demonstrates the inadequacy of relying solely on hepatic metastasis status for prognostic stratification. The superior predictive capability of the CALLY index in advanced pancreatic cancer likely stems from its multidimensional reflection of systemic inflammation(CRP), immunity-(lymphocytes), and nutritional status (albumin).

Combining inflammatory and nutritional markers, such as the CALLY index, with TNM staging may improve the accuracy of prognostic assessments. In colorectal cancer, the integration of TNM staging with immune scoring systems has been shown to provide superior prognostic prediction compared to TNM staging alone.[37] Similarly, Iida et al[14] demonstrated that combining TNM staging with the CALLY index enhanced prognostic prediction in hepatocellular carcinoma patients. However, since all patients in our study had advanced-stage disease, the prognostic utility of combining TNM staging with the CALLY index could not be evaluated. Future studies with larger sample sizes should explore the prognostic predictive power of integrating TNM staging with the CALLY index in pancreatic cancer patients. Such investigations could provide a more comprehensive framework for risk stratification and treatment planning in this challenging disease.

In our study, the optimal cutoff value for the CALLY index in predicting prognosis in advanced pancreatic cancer patients was determined to be 0.27. Previous studies have reported that the prognostic value of the C-reactive protein-to-albumin ratio (CAR) with a cutoff of 0.18 was significant only in stage III and IV pancreatic cancer cohorts but not in stage I or II cohorts.[38] Similarly, a CAR cutoff of 0.47 was identified as an independent predictor of overall survival (OS)

in stage III gastric cancer patients,[39] while a different cutoff was required for stage II gastric cancer patients.[40] Additionally, studies have observed that an albumin-bilirubin (ALBI) score of 2.6 could serve as a unified optimal cutoff for prognostic evaluation in hepatocellular carcinoma and pancreatic cancer.[41,42] Iida et al[14] determined an optimal CALLY index cutoff of 5 for predicting prognosis in hepatocellular carcinoma (HCC) patients, which remained valid in their external validation cohort. However, Zhuang et al[18] found that a preoperative CALLY index < 2.285 was an independent predictor of poor prognosis in breast cancer patients. These findings suggest that the optimal cutoff value may vary depending on the primary tumor site, cancer stage, and study population. This variability highlights the ongoing controversy in establishing universal cutoff values, which may hinder the clinical application of these biomarkers. To minimize discrepancies, it is crucial to determine optimal biomarkers and their cutoff values based on specific populations, such as single tumor stages within each cancer type. This approach would enhance the accuracy and reliability of prognostic assessments, facilitating their integration into clinical practice. Future research should focus on validating these biomarkers in well-defined cohorts to establish standardized guidelines for their use.

This study had some limitations. First, Our study is a single-center retrospective analysis, some selection bias may exist. With a limited sample size, the results may also be subject to bias due to the influence of various factors on peripheral blood indicators in clinical practice. Additionally, the CALLY index was assessed only at baseline preventing longitudinal assessment and dynamic monitoring of this index before and after treatment might provide a more accurate evaluation of its association with mortality risk in pancreatic cancer patients. Furthermore, the lack of external validation data limits the generalizability of our findings. Finally, due to the lack of consensus regarding standardized cutoff values for the CALLY index, the application of this study's results to Stage IV pancreatic cancer patients from other regions should be considered as a provisional reference only. Therefore further validation through prospective, large-scale randomized controlled trials is necessary to establish the clinical utility of the CALLY index as a predictive biomarker for treatment efficacy and prognosis.

Conclusion

Our findings suggest that the baseline CALLY index show potential for predicting early efficacy of first-line chemotherapy and is associated with survival outcomes in advanced pancreatic cancer patients. The CALLY index is easily obtainable, cost-effective, highly reproducible, and widely applicable as a hematological biomarker, may serve as a useful marker, pending validation in prospective studies.

Data Sharing Statement

The data that support the findings of this study are not openly available due to reasons of privacy and are available from the corresponding author upon reasonable request. Data are located in controlled access data storage at Nanjing gaochun people's hospital.

Research Ethics and Consent

This study is a retrospective study that only collected clinical data from patients, did not intervene in their treatment plans, and did not pose any risks to patients. The researchers will do their best to protect the information provided by patients from leaking personal privacy. Therefore, we have applied for exemption from informed consent. Our study have been performed in accordance with the principles stated in the Declaration of Helsinki. Prior to starting the study, we have obtained ethical approval for all protocols from the Ethics Committee of Nanjing Gaochun People's Hospital. We confirmed the study meets national and international guidelines for research on humans. The permit ethics Review Numbers of this study was AF/SC-05/01.0.

Acknowledgments

The authors express gratitude to all study participants and research staff who participated in the work.

Author Contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

Funding

This study did not receive any external funding support, and all expenses were borne by the authors themselves.

Disclosure

All authors have no conflicts of interest or financial ties to disclose for this work.

References

1. Yang H, Wang XK, Fan JH. Epidemiology, risk factors, and screening status of pancreatic cancer in China. *Cancer Res Prevention Treatment*. 2021;48(10):909–915.
2. Hu JX, Zhao CF, Chen WB, et al. Pancreatic cancer: a review of epidemiology, trend, and risk factors. *World J Gastroenterol*. 2021;27(27):4298–4321. doi:10.3748/wjg.v27.i27.4298
3. Gu A, Li J, Li M-Y, Liu Y. Patient-derived xenograft model in cancer: establishment and applications. *MedComm*. 2025;6(2):e70059. doi:10.1002/mco2.70059
4. Ma P, Wang G, Men K, et al. Advances in clinical application of nanoparticle-based therapy for cancer treatment: a systematic review. *Nano Trans Med*. 2024;3:100036. doi:10.1016/j.ntm.2024.100036
5. Steele NG, Carpenter ES, Kemp SB, et al. Multimodal mapping of the tumor and peripheral blood immune landscape in human pancreatic cancer. *Nat Cancer*. 2020;1(11):1097–1112. doi:10.1038/s43018-020-00121-4
6. Takamizawa Y, Shida D, Boku N, et al. Nutritional and inflammatory measures predict survival of patients with stage IV colorectal cancer. *BMC Cancer*. 2020;20(1):1092. doi:10.1186/s12885-020-07560-3
7. Huang M, Gong G, Deng Y, et al. Crosstalk between cancer cells and the nervous system. *Med Adv*. 2023;1(3):173–189. doi:10.1002/med4.27
8. McGovern J, Dolan RD, Skipworth RJ, Laird BJ, McMillan DC. Cancer cachexia: a nutritional or a systemic inflammatory syndrome? *Br J Cancer*. 2022;127(3):379–382. doi:10.1038/s41416-022-01826-2
9. Dang C, Wang M, Qin T, Qin R. How can we better predict the prognosis of patients with pancreatic cancer undergoing surgery using an immune-nutritional scoring system? *Surgery*. 2022;172(1):291–302. doi:10.1016/j.surg.2021.12.009
10. An X, Li J, Li Y, et al. Combined influence of physical activity and C-reactive protein to albumin ratio on mortality among older cancer survivors in the United States: a prospective cohort study. *Eur Rev Aging Phys Act*. 2024;21(1):26. doi:10.1186/s11556-024-00361-8
11. Hajibandeh S, Hajibandeh S, Romman S, et al. Preoperative C-reactive protein-to-albumin ratio and its ability to predict outcomes of pancreatic cancer resection: a systematic review. *Biomedicines*. 2023;11(7):1983. doi:10.3390/biomedicines11071983
12. Ménétrier-Caux C, Ray-Coquard I, Blay JY, Caux C. Lymphopenia in cancer patients and its effects on response to immunotherapy: an opportunity for combination with cytokines? *J Immunother Cancer*. 2019;7(1):85. doi:10.1186/s40425-019-0549-5
13. Zahorec R. Neutrophil-to-lymphocyte ratio, past, present and future perspectives. *Bratisl Lek Listy*. 2021;122(7):474–488. doi:10.4149/BLL_2021_078
14. Iida H, Tani M, Komeda K, et al. Superiority of CRP-albumin-lymphocyte index (CALLY index) as a non-invasive prognostic biomarker after hepatectomy for hepatocellular carcinoma. *HPB*. 2022;24(1):101–115. doi:10.1016/j.hpb.2021.06.414
15. Yang M, Lin SQ, Liu XY, et al. Association between C-reactive protein-albumin-lymphocyte (CALLY) index and overall survival in patients with colorectal cancer: from the investigation on nutrition status and clinical outcome of common cancers study. *Front Immunol*. 2023;14:1131496. doi:10.3389/fimmu.2023.1131496
16. Wang W, Gu J, Liu Y, et al. Pre-treatment CRP-albumin-lymphocyte index (CALLY Index) as a prognostic biomarker of survival in patients with epithelial ovarian cancer. *Cancer Manag Res*. 2022;14:2803–2812. doi:10.2147/CMAR.S359968
17. Ma R, Okugawa Y, Shimura T, et al. Clinical implications of C-reactive protein-albumin-lymphocyte (CALLY) index in patients with esophageal cancer. *Surg Oncol*. 2024;53:102044. doi:10.1016/j.suronc.2024.102044
18. Zhuang J, Wang S, Wang Y, Wu Y, Hu R. Prognostic value of CRP-albumin-lymphocyte (CALLY) index in patients undergoing surgery for breast cancer. *Int J Gen Med*. 2024;17:997–1005. doi:10.2147/IJGM.S447201
19. Tsai YT, Ko CA, Chen HC, et al. Prognostic value of CRP-albumin-lymphocyte (CALLY) index in patients undergoing surgery for oral cavity cancer. *J Cancer*. 2022;13(10):3000–3012. doi:10.7150/jca.74930
20. Greten FR, Grivennikov SI. Inflammation and cancer: triggers, mechanisms, and consequences. *Immunity*. 2019;51(1):27–41. doi:10.1016/j.immuni.2019.06.025
21. Grivennikov SI, Greten FR, Karin M. Immunity, inflammation, and cancer. *Cell*. 2010;140(6):883–899. doi:10.1016/j.cell.2010.01.025
22. Yuan C, Morales-Oyarvide V, Khalaf N, et al. Prediagnostic inflammation and pancreatic cancer Survival. *J Natl Cancer Inst*. 2021;113(9):1186–1193. doi:10.1093/jnci/djab040
23. Basso D, Fabris C, Meani A, et al. C reactive protein in pancreatic cancer and chronic pancreatitis. *Ann Clin Res*. 1988;20(6):414–416. PMID: 3218913.
24. Barreira JV. The role of nutrition in cancer patients. *Nutr Cancer*. 2021;73(11–12):2849–2850. doi:10.1080/01635581.2020.1839519
25. Gupta D, Lis CG. Pretreatment serum albumin as a predictor of cancer survival: a systematic review of the epidemiological literature. *Nutr J*. 2010;9(1):69. doi:10.1186/1475-2891-9-69

26. Zang Y, Fan Y, Gao Z. Pretreatment C-reactive protein/albumin ratio for predicting overall survival in pancreatic cancer: a meta-analysis. *Medicine*. 2020;99(23):e20595. doi:10.1097/MD.0000000000020595
27. Zhang R, Hu C, Zhang J, et al. Prognostic significance of inflammatory and nutritional markers in perioperative period for patients with advanced gastric cancer. *BMC Cancer*. 2023;23(1):5. doi:10.1186/s12885-022-10479-6
28. Karimi S, Chattopadhyay S, Chakraborty NG. Manipulation of regulatory T cells and antigen-specific cytotoxic T lymphocyte-based tumour immunotherapy. *Immunology*. 2015;144(2):186–196. doi:10.1111/imm.12387
29. Hu RJ, Ma JY, Hu G. Lymphocyte-to-monocyte ratio in pancreatic cancer: prognostic significance and meta-analysis. *Clin Chim Acta*. 2018;481:142–146. doi:10.1016/j.cca.2018.03.008
30. Zhou Y, Wei Q, Fan J, Cheng S, Ding W, Hua Z. Prognostic role of the neutrophil-to-lymphocyte ratio in pancreatic cancer: a meta-analysis containing 8252 patients. *Clin Chim Acta*. 2018;479:181–189. doi:10.1016/j.cca.2018.01.024
31. Scrimshaw NS, SanGiovanni JP. Synergism of nutrition, infection, and immunity: an overview. *Am J Clin Nutr*. 1997;66(2):464S–477S. doi:10.1093/ajcn/66.2.464S
32. Moses AG, Maingay J, Sangster K, Fearon KC, Ross JA. Pro-inflammatory cytokine release by peripheral blood mononuclear cells from patients with advanced pancreatic cancer: relationship to acute phase response and survival. *Oncol Rep*. 2009;21(4):1091–1095. doi:10.3892/or_00000328
33. Dunbar CL, Aukema HM, Calder PC, et al. Nutrition and immunity: perspectives on key issues and next steps. *Appl Physiol Nutr Metab*. 2023;48(7):484–497. doi:10.1139/apnm-2022-0276
34. Ren B, Cui M, Yang G, et al. Tumor microenvironment participates in metastasis of pancreatic cancer. *Mol Cancer*. 2018;17(1):108. doi:10.1186/s12943-018-0858-1
35. Rivadeneira DE, Grobmyer SR, Naama HA, et al. Malnutrition-induced macrophage apoptosis. *Surgery*. 2001;129(5):617–625. doi:10.1067/msy.2001.112963
36. Xu J, Sai H, Li Y, et al. Peripheral blood T-cell fitness is diminished in patients with pancreatic carcinoma but can be improved with homeostatic cytokines. *Cell Mol Gastroenterol Hepatol*. 2019;8(4):656–658. doi:10.1016/j.jcmgh.2019.07.008
37. Mlecnik B, Tosolini M, Kirilovsky A, et al. Histopathologic-based prognostic factors of colorectal cancers are associated with the state of the local immune reaction. *J Clin Oncol*. 2011;29(6):610–618. doi:10.1200/JCO.2010.30.5425
38. Liu Z, Jin K, Guo M, et al. Prognostic value of the CRP/Alb ratio, a novel inflammation-based score in pancreatic cancer. *Ann Surg Oncol*. 2017;24(2):561–568. doi:10.1245/s10434-016-5579-3
39. Toyokawa T, Muguruma K, Yoshii M, et al. Clinical significance of prognostic inflammation-based and/or nutritional markers in patients with stage III gastric cancer. *BMC Cancer*. 2020;20(1):517. doi:10.1186/s12885-020-07010-0
40. Toyokawa T, Muguruma K, Tamura T, et al. Comparison of the prognostic impact and combination of preoperative inflammation-based and/or nutritional markers in patients with stage II gastric cancer. *Oncotarget*. 2018;9(50):29351–29364. doi:10.18632/oncotarget.25486
41. Zhang TN, Yin RH, Wang LW. The prognostic and predictive value of the albumin-bilirubin score in advanced pancreatic cancer. *Medicine*. 2020;99(28):e20654. doi:10.1097/MD.0000000000020654
42. Yagyu T, Saito H, Sakamoto T, et al. Preoperative albumin-bilirubin grade as a useful prognostic indicator in patients with pancreatic cancer. *Anticancer Res*. 2019;39(3):1441–1446. doi:10.21873/anticanres.13260