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ORIGINAL RESEARCH

Prognostic Value of the CALLY Index in Hospitalized Patients with Pelvic Inflammatory Disease and Tubo-Ovarian Abscess

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Introduction: The C-reactive protein–albumin–lymphocyte (CALLY) index is a novel immunonutritional marker reflecting systemic inflammation and host immune status. This study aimed to evaluate the diagnostic and prognostic value of the CALLY index and compare its performance with other systemic inflammatory indices in hospitalized patients with pelvic inflammatory disease (PID) and tubo-ovarian abscess (TOA).

Methods: This retrospective observational study included 124 patients hospitalized with PID and/or TOA between January 2020 and November 2025. Patients were classified into TOA and non-TOA groups based on clinical and radiological findings. Demographic data, laboratory parameters, and length of hospital stay were recorded. Inflammatory and immunonutritional indices, including neutrophil-to-lymphocyte ratio (NLR), platelet-to-lymphocyte ratio (PLR), systemic inflammatory index (SII), systemic inflammatory response index (SIRI), C-reactive protein-to-albumin ratio (CAR), hemoglobin–albumin–lymphocyte–platelet (HALP) score, neutrophil percentage-to-albumin ratio (NPAR), and CALLY index, were calculated using admission laboratory values. Receiver operating characteristic (ROC) analysis was performed to evaluate diagnostic performance.

Results: Patients with TOA had significantly higher C-reactive protein (CRP), procalcitonin, C-reactive protein-to-albumin ratio (CAR), hemoglobin–albumin–lymphocyte–platelet (HALP) score, systemic inflammatory response index (SIRI), and neutrophil percentage, and significantly lower CALLY index compared to non-TOA PID patients ($p<0.05$). The CALLY index showed a significant negative correlation with length of hospital stay ($r = –0.283$, $p = 0.001$), whereas CRP, CAR, HALP, and neutrophil percentage-to-albumin ratio (NPAR) demonstrated positive correlations. ROC analysis revealed moderate diagnostic accuracy of the CALLY index for predicting TOA (AUC = 0.671, $p = 0.001$). The HALP score demonstrated the highest diagnostic performance among evaluated parameters.

Conclusion: The CALLY index is a promising immunonutritional biomarker associated with disease severity and hospitalization burden in patients with TOA. Its integration into routine clinical evaluation may improve early risk stratification and clinical decision-making in PID management.

Keywords: pelvic inflammatory disease, tubo-ovarian abscess, CALLY index, systemic inflammatory markers, immunonutritional indices, disease severity, hospitalization, risk stratification

Introduction

Pelvic inflammatory disease (PID) is a polymicrobial, ascending infection of the upper female genital tract, including endometritis, salpingitis, pelvic peritonitis, and, in severe cases, tubo-ovarian abscess formation. It represents a substantial health burden among women of reproductive age due to its association with serious long-term sequelae such as tubal factor infertility, ectopic pregnancy, chronic pelvic pain, and recurrent pelvic infections.[1] In the United States alone, PID is diagnosed in hundreds of thousands of women each year, with the highest incidence observed in sexually active young women.[1]

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Although classic sexually transmitted pathogens such as *Chlamydia trachomatis* and *Neisseria gonorrhoeae* are well-established etiologic agents, PID is now recognized as a highly complex, polymicrobial disease. Emerging evidence has demonstrated the significant role of anaerobic and bacterial vaginosis–associated organisms, including *Sneathia sanguinegens, Sneathia amnionii, Atopobium vaginae* and BV-associated bacterium-1 (BVAB1), which have been linked to persistent endometrial inflammation, treatment failure, recurrent PID, and infertility.[2] These findings have reshaped current treatment strategies, leading to the inclusion of metronidazole to ensure adequate coverage of anaerobic pathogens in most treatment regimens, as emphasized in both randomized clinical trials and international guidelines.[3,4]

The pathophysiology of pelvic inflammatory disease is largely driven not only by microbial invasion but also by the host's exaggerated inflammatory and immune response. Increasing evidence suggests that the severity of tissue damage, clinical course, and treatment outcomes in PID are closely associated with systemic inflammation and immune dysregulation.[1] In this context, composite inflammatory indices, such as the systemic immune-inflammation index (SII), have been investigated in PID-related conditions like tubo-ovarian abscess, where higher SII values were found to significantly predict treatment failure and the need for surgical intervention.[5] These findings support the hypothesis that systemic inflammatory markers may serve as valuable prognostic tools in inflammatory gynecological disorders.

The C-reactive protein–albumin–lymphocyte (CALLY) index is a novel biomarker that integrates systemic inflammation, immune function, and nutritional status into a single parameter. Unlike conventional inflammatory markers such as NLR or HALP, the CALLY index integrates C-reactive protein, albumin, and lymphocyte count, thereby reflecting both systemic inflammatory burden and immunonutritional status. This combined assessment may offer additional or complementary value in evaluating disease severity in pelvic inflammatory conditions. It is calculated using CRP levels, serum albumin concentration, and total lymphocyte count. Recent large-scale population-based studies have demonstrated that a higher CALLY index is associated with improved outcomes in a variety of clinical conditions, including reduced all-cause mortality in cancer patients, as well as a significantly lower risk of chronic inflammatory diseases such as erectile dysfunction, stroke in hypertensive individuals, angina pectoris, and asthma–COPD overlap.[6–10] Importantly, in several of these studies, the CALLY index has shown superior predictive value compared to traditional inflammatory markers including NLR, PLR, and SII.[7–10]

Given that PID is characterized by acute and chronic inflammation, elevated CRP levels, possible hypoalbuminemia, and dynamic immune alterations, it is biologically plausible that the CALLY index could reflect disease severity and predict clinical outcomes in this population. However, to date, the role of the CALLY index in pelvic inflammatory disease has not been investigated.

Therefore, the aim of the present study is to evaluate the association between the CALLY index and clinical outcomes in patients diagnosed with pelvic inflammatory disease and to explore its potential utility as a novel prognostic biomarker in gynecological inflammatory conditions.

Materials and Methods

Study Design and Population

This retrospective observational study included women who were hospitalized with a diagnosis of pelvic inflammatory disease (PID) and/or tubo-ovarian abscess (TOA) between 01 January 2020 and 01 November 2025. Patients were identified from the electronic medical records of a tertiary referral center. The patients who met the inclusion criteria were enrolled in the study.

Inclusion and Exclusion Criteria

Patients aged ≥18 years who were admitted with a clinical and/or radiological diagnosis of PID or TOA were included. TOA diagnosis was confirmed based on transvaginal ultrasonography and/or computed tomography findings consistent with adnexal abscess formation.

Patients with hematologic malignancies, chronic inflammatory diseases, autoimmune disorders, chronic liver or renal failure, active malignancy, or incomplete laboratory data were excluded.

Data Collection

Demographic characteristics (age, gravidity, parity), clinical presentation, intrauterine device (IUD) status, treatment modality (medical treatment, abscess drainage, or laparoscopic surgery), and length of hospital stay were recorded. Laboratory parameters obtained at admission included complete blood count, albumin, C-reactive protein (CRP), and procalcitonin levels.

Calculation of Inflammatory and Immunonutritional Indices

The following systemic inflammatory and immunonutritional indices were calculated using baseline laboratory values:

- NLR (Neutrophil-to-Lymphocyte Ratio) = Neutrophil count/Lymphocyte count
- MLR (Monocyte-to-Lymphocyte Ratio) = Monocyte count/Lymphocyte count
- PLR (Platelet-to-Lymphocyte Ratio) = Platelet count/Lymphocyte count
- SII (Systemic Immune-Inflammation Index) = (Platelet × Neutrophil)/Lymphocyte
- SIRI (Systemic Inflammation Response Index) = (Neutrophil × Monocyte)/Lymphocyte
- NPAR (Neutrophil-to-Albumin Ratio) = Neutrophil count/Albumin
- CAR (CRP-to-Albumin Ratio) = CRP/Albumin
- HALP score (Hemoglobin–Albumin–Lymphocyte–Platelet Score) = (Hemoglobin × Albumin × Lymphocyte)/Platelet
- CALLY Index = (serum albumin [g/dL] × lymphocyte count [$10^3/\mu L$])/CRP [mg/L]
- All indices were calculated from blood samples obtained within the first 24 hours of hospital admission.

Statistical Analysis

All statistical analyses were performed using IBM SPSS Statistics for Windows, Version 26.0 (IBM Corp., Armonk, NY, USA) and JASP statistical software (Version 0.19.3; JASP Team, Amsterdam, Netherlands). The normality of continuous variables was examined using the Shapiro–Wilk test and histogram analysis. Variables exhibiting a normal distribution were presented as the mean ± standard deviation (SD), while variables failing to demonstrate a normal distribution were expressed as the median with the minimum-maximum range. Categorical data were expressed as n (%).

A comparison was made of continuous variables between patients with and without tubo-ovarian abscesses. The Independent Samples *t*-test was used for parameters showing a normal distribution, and the Mann–Whitney *U*-test was used for those violating the normality assumptions. Categorical variables were summarised as frequencies and percentages, and differences between groups were assessed using Pearson's chi-square or Fisher's exact test, as appropriate.

Spearman correlation coefficients were utilised to analyse the relationships between demographic variables, laboratory parameters and inflammatory indices. The interpretation of correlation strength followed established conventions, with values less than 0.40 designated as weak, those ranging from 0.40 to 0.69 designated as moderate, and values greater than 0.70 designated as strong. The results were presented using a heatmap graph with the JASP program.

Receiver operating characteristic (ROC) curve analysis was applied to evaluate the discriminatory performance of inflammatory indices in distinguishing TOA from non-TOA conditions. The area under the curve (AUC), optimal cut-off points (based on the Youden index), sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) were calculated for each parameter. It is imperative to note that all statistical tests were two-tailed, and a p-value less than 0.05 was considered to be statistically significant.

Ethical Approval

The study was conducted in accordance with the principles of the Declaration of Helsinki and was approved by the Ethics Committee of Necmettin Erbakan University Faculty of Medicine (Approval No: 2024/5268). Due to the retrospective nature of the study, the requirement for informed consent was waived by the Ethics Committee. All patient data were anonymized, and confidentiality was strictly maintained in accordance with institutional and international data protection regulations.

Results

A total of 124 female patients satisfied the inclusion criteria. The median age of the study population was 38 (range, 18–87), with a median gravidity and parity of 2. The median length of hospital stay was seven days (range, 1–29). Tubo-ovarian abscess (TOA) was identified in 59 patients (47.6%). Furthermore, an intrauterine device was present in 29.8% of cases. Regarding treatment modalities, 37.9% of patients received medical treatment, while 26.6% underwent abscess drainage and 35.5% underwent laparoscopic surgery. The most common presenting symptom was abdominal pain, reported in 75.8% of cases (Table 1).

The baseline laboratory and inflammatory characteristics of the study population are presented in Table 2. The median white blood cell (WBC) count was $11.97\times10^3/\mu L$, with median neutrophil and lymphocyte counts of $8.45\times10^3/\mu L$ and $1.72\times10^3/\mu L$, respectively. The mean C-reactive protein (CRP) level was 129.5 mg/L, the median CALLY index was 454, and the mean procalcitonin level was 1.60 ng/mL. In terms of inflammatory indices, the median neutrophil-to-lymphocyte ratio (NLR), platelet-to-lymphocyte ratio (PLR), systemic inflammatory index (SII), and systemic inflammatory response index (SIRI) were 5.14, 188.35, 1675.52, and 3.75, respectively. The median HALP score was 2.38.

Comparative analysis between patients with and without TOA is summarized in Table 3. Patients with TOA had a significantly longer hospital stay compared to those without abscess formation (median 11 vs 5 days, p=0.001). Although intrauterine device use was numerically higher in the TOA group (37.3% vs 23.1%), this difference was not

Table 1 Demographic and Clinical Characteristics of the Study Population

Variable (n=124)	Mean ± SD	Median (Min–Max)
Age (years)	40.69 ± 14.90	38 (18–87)
Gravida	2.32 ± 1.63	2 (0–7)
Parity	1.73 ± 1.11	2 (0–5)
Length of hospital stay (days)	8.30 ± 5.27	7 (1–29)
Presence of TOA		
Present	59 (47.6%)	
Absent	65 (52.4%)	
Presence of IUD		
Present	37 (29.8%)	
Absent	87 (70.2%)	
Intervention		
Medical treatment	47 (37.9%)	
Abscess drainage	33 (26.6%)	
Laparoscopic surgery	44 (35.5%)	
Presenting Complaint		
Abdominal pain	94 (75.8%)	
Abdominal pain + fever	9 (7.3%)	
Abdominal pain + nausea/vomiting	10 (8.1%)	
Abdominal pain + vaginal discharge	9 (7.3%)	
Isolated nausea/vomiting	2 (1.6%)	

Abbreviations: TOA, tubo-ovarian abscess; IUD, intrauterine device.

Table 2 Baseline Laboratory Parameters and Inflammatory Indices of the Study Population

Variable (n=124)	Mean ± SD	Median (Min–Max)
Hemoglobin (g/dL)	11.50 ± 1.96	11.50 (7–15.5)
WBC ($\times 10^3$/μL)	12.74 ± 5.58	11.97 (3.5–27)
Neutrophils ($\times 10^3$/μL)	9.23 ± 4.95	8.45 (1.19–22.05)
Lymphocytes ($\times 10^3$/μL)	1.75 ± 0.86	1.72 (0.10–3.91)
Monocytes ($\times 10^3$/μL)	0.81 ± 0.79	0.58 (0.05–3.35)
Platelets ($\times 10^3$/μL)	333.53 ± 139.63	322 (155–770)
IG ($\times 10^3$/μL)	0.14 ± 0.12	0.11 (0.01–0.45)
IG (%)	0.80 ± 0.57	0.60 (0.10–1.90)
Albumin (g/L)	32.43 ± 5.90	32.45 (22–49.9)
CRP (mg/L)	135.20 ± 84.36	129.50 (12–425)
CALLY index	830.0 ± 1123	454 (16.1–6378)
Procalcitonin (ng/mL)	1.65 ± 1.44	1.60 (0.05–6.20)
NLR	9.68 ± 19.79	5.14 (0.84–157.50)
MLR	0.77 ± 2.07	0.33 (0.016–22.23)
PLR	310.98 ± 504.57	188.35 (50.16–3915.39)
SII	2986.59 ± 5562.47	1675.52 (145.71–48,623.40)
SIRI	6.37 ± 7.57	3.75 (0.14–55.13)
Neutrophil (%)	0.703 ± 0.120	0.706 (0.399–0.930)
NPAR	2.20 ± 0.58	2.19 (0.69–3.96)
CAR	4.23 ± 2.74	3.96 (0.29–13.83)
HALP score	2.47 ± 0.89	2.38 (0.81–5.71)

Abbreviations: WBC, white blood cell; PLT, platelet; IG, immature granulocyte; CRP, C-reactive protein; CALLY index, CRP–Albumin–Lymphocyte Index; NLR, neutrophil-to-lymphocyte ratio; MLR, monocyte-to-lymphocyte ratio; PLR, platelet-to-lymphocyte ratio; SII, systemic immune-inflammation index; SIRI, systemic inflammation response index; NPAR, neutrophil-to-albumin ratio; CAR, CRP-to-albumin ratio; HALP, hemoglobin-albumin-lymphocyte-platelet score.

Table 3 Comparison of Demographic, Clinical, and Laboratory Parameters Between Patients with and without Tubo-Ovarian Abscess

Variable	TOA Absent (n=65)	TOA Present (n=59)	p-value
Age (years)	38 (18–87)	39 (18–87)	0.480
Gravida	2 (0–7)	2 (0–6)	0.832
Parity	2 (0–4)	2 (0–5)	0.860
Presence of IUD	15 (23.1%)	22 (37.3%)	0.084

(*Continued*)

Table 3 (Continued).

Variable		TOA Absent (n=65)	TOA Present (n=59)	p-value
Intervention	Medical treatment	24 (36.9%)	23 (39.0%)	0.954
	Abscess drainage	18 (27.7%)	15 (25.4%)	
	Laparoscopic surgery	23 (35.4%)	21 (35.6%)	
Length of hospital stay (days)		5 (1–16)	11 (1–29)	**0.001**
Hemoglobin (g/dL)		11.24 ± 1.88	11.79 ± 2.03	0.120
WBC ($\times 10^3$/μL)		11.88 (3.5–23.34)	13.23 (5.11–27)	0.235
Neutrophils ($\times 10^3$/μL)		8.10 (1.19–20.22)	9.30 (2.23–22.05)	0.167
Lymphocytes ($\times 10^3$/μL)		1.76 ± 0.81	1.75 ± 0.91	0.911
Monocytes ($\times 10^3$/μL)		0.60 (0.05–2.94)	0.57 (0.05–3.35)	0.381
Platelets ($\times 10^3$/μL)		332 (155–766)	268 (156–770)	0.402
IG ($\times 10^3$/μL)		0.11 (0.01–0.45)	0.11 (0.01–0.45)	0.812
IG (%)		0.60 (0.10–1.90)	0.80 (0.10–1.90)	0.086
Albumin (g/L)		32.40 ± 6.15	32.46 ± 5.66	0.950
CRP (mg/L)		110 (12–425)	152 (38–368)	**0.001**
CALLY index		587 (39.8–6378)	372 (16.1–1495)	**0.001**
Procalcitonin (ng/mL)		1.10 (0.05–4.80)	2.00 (0.05–6.20)	**0.016**
NLR		5.10 (1.05–39.52)	5.22 (0.84–157.50)	0.244
MLR		0.31 (0.02–22.23)	0.33 (0.02–4.00)	0.820
PLR		204.86 (50–1200)	175.42 (54–3915)	0.522
SII		1708 (214–11,580)	1672 (146–48,623)	0.613
SIRI		3.23 (0.14–21.89)	5.25 (0.25–55.13)	**0.046**
Neutrophil (%)		0.693 (0.399–0.908)	0.731 (0.469–0.930)	**0.033**
NPAR		2.13 (0.69–3.96)	2.24 (1.17–3.64)	0.260
CAR		3.07 (0.29–12.64)	4.59 (1.33–13.83)	**0.001**
HALP score		1.93 (0.81–3.75)	2.68 (1.04–5.71)	**0.001**

Notes: Continuous variables were analysed according to their distribution; those reported as mean ± SD were evaluated using the Independent Samples *t*-test, and those presented as median (min–max) were assessed using the Mann–Whitney *U*-test. The comparison of categorical variables was conducted employing either the Pearson chi-square or Fisher's exact test, as deemed appropriate. Bold values indicate statistically significant results ($p < 0.05$).

Abbreviations: TOA, Tubo-ovarian abscess; WBC, white blood cell; PLT, platelet; IG, immature granulocyte; CRP, C-reactive protein; CALLY index, CRP–Albumin–Lymphocyte Index; NLR, neutrophil-to-lymphocyte ratio; MLR, monocyte-to-lymphocyte ratio; PLR, platelet-to-lymphocyte ratio; SII, systemic immune-inflammation index; SIRI, systemic inflammation response index; NPAR, neutrophil-to-albumin ratio; CAR, CRP-to-albumin ratio; HALP, hemoglobin-albumin-lymphocyte-platelet score.

statistically significant (p=0.084). Similarly, treatment strategies did not differ significantly between groups (p=0.954). In addition, inflammatory markers were significantly elevated in the TOA group, including CRP (median 152 vs 110 mg/L, p=0.001) and procalcitonin (median 2.00 vs 1.10 ng/mL, p=0.016). Moreover, patients with TOA had significantly lower CALLY index values (median 372 vs 587, p=0.001), along with higher SIRI (median 5.25 vs 3.23, p=0.046), neutrophil

percentage (median 0.731 vs 0.693, p=0.033), CAR (median 4.59 vs 3.07, p=0.001), and HALP score (median 2.68 vs 1.93, p=0.001). In contrast, no significant differences were observed between groups in terms of age, reproductive history, leukocyte and platelet counts, albumin levels, NLR, MLR, PLR, SII, NPAR, and other inflammatory indices.

Furthermore, correlation analysis demonstrated that the length of hospital stay was associated with several inflammatory and immunonutritional parameters. The strongest positive correlation was observed with the HALP score (r=0.38, p=0.001). This was followed by neutrophil percentage (r=0.29, p=0.001), CRP-to-albumin ratio (CAR) (r=0.26, p=0.003), NPAR (r=0.25, p=0.005), NLR (r=0.24, p=0.006), and CRP (r=0.24, p=0.009). Weaker but still significant correlations were found for MLR (r=0.22, p=0.014), SIRI (r=0.20, p=0.028), SII (r=0.19, p=0.032), and procalcitonin (r=0.18, p=0.049). Conversely, the CALLY index showed a moderate negative correlation with length of hospital stay (r=–0.28, p=0.001). No significant associations were observed for platelet-based indices, immature granulocyte levels, or demographic variables, including age (p>0.05) (Figure 1).

Finally, receiver operating characteristic (ROC) analysis was performed to evaluate the diagnostic performance of inflammatory and immunonutritional markers in distinguishing TOA from non-TOA cases (Figure 2 and Table 4). Among all evaluated parameters, the HALP score demonstrated the highest diagnostic accuracy (AUC=0.792; 95% CI, 0.711–0.873). At a cut-off value of ≥2.18, HALP yielded a sensitivity of 84.8% and a specificity of 63.1%. CRP (AUC=0.697) and CAR (AUC=0.694) showed comparable moderate diagnostic performance. The CALLY index also demonstrated significant discriminatory ability (AUC=0.671; 95% CI, 0.575–0.767), with a cut-off value of ≤459.4 providing 71.1% sensitivity and 67.6% specificity. In contrast, neutrophil percentage, procalcitonin, and SIRI showed lower but still statistically significant AUC values (range 0.604–0.626). Among the evaluated indices, the HALP score exhibited the highest diagnostic performance, exceeding that of the CALLY index.

Discussion

In this study, the diagnostic and prognostic value of several systemic inflammatory and immunonutritional indices were evaluated, including the novel CALLY index, in hospitalized patients with PID and TOA. Our results demonstrated that patients with TOA had significantly lower CALLY values and higher inflammatory markers compared to non-TOA patients, and CALLY showed a significant inverse correlation with length of hospital stay, suggesting an association with disease severity. Low CALLY values in TOA patients may reflect both elevated CRP due to intense inflammation and relative lymphopenia associated with systemic immune dysregulation during severe infection.

Previous studies have consistently shown that TOA represents a severe spectrum of PID with substantial morbidity and potential mortality if not promptly managed.[11] Inflammatory burden increases with abscess formation, and laboratory markers such as WBC, CRP, and ESR are frequently elevated, although their individual predictive value varies across studies.

CRP has been widely investigated as a predictor of TOA and treatment failure. Several studies reported CRP as the strongest single laboratory marker for differentiating TOA from uncomplicated PID and predicting need for invasive intervention.[12,13] Similarly, elevated CRP levels were independently associated with intraoperative complications in surgically treated TOA patients.[14] Our findings are consistent with these reports, as CRP and CAR were significantly higher in the TOA group and correlated positively with hospital stay.

However, reliance on single inflammatory markers may be insufficient, as inflammatory response reflects only one dimension of disease severity. Composite indices integrating immune response and nutritional status may better represent the systemic impact of infection. HALP, NLR, SII, and SIRI have been investigated as predictors of severity and adverse surgical outcomes in TOA.[15,16] In line with these studies, significantly elevated SIRI and HALP values in patients with TOA were observed, supporting their role as indicators of systemic inflammatory burden.

CALLY index, which combines albumin, lymphocyte count, and CRP, reflects both inflammatory activity and nutritional-immune reserve. To our knowledge, this is one of the first studies to evaluate CALLY index in the context of PID and TOA. Significantly lower CALLY values in patients with TOA were found, and importantly, CALLY showed a negative correlation with hospital stay, indicating that lower CALLY scores may reflect more severe disease requiring prolonged treatment.

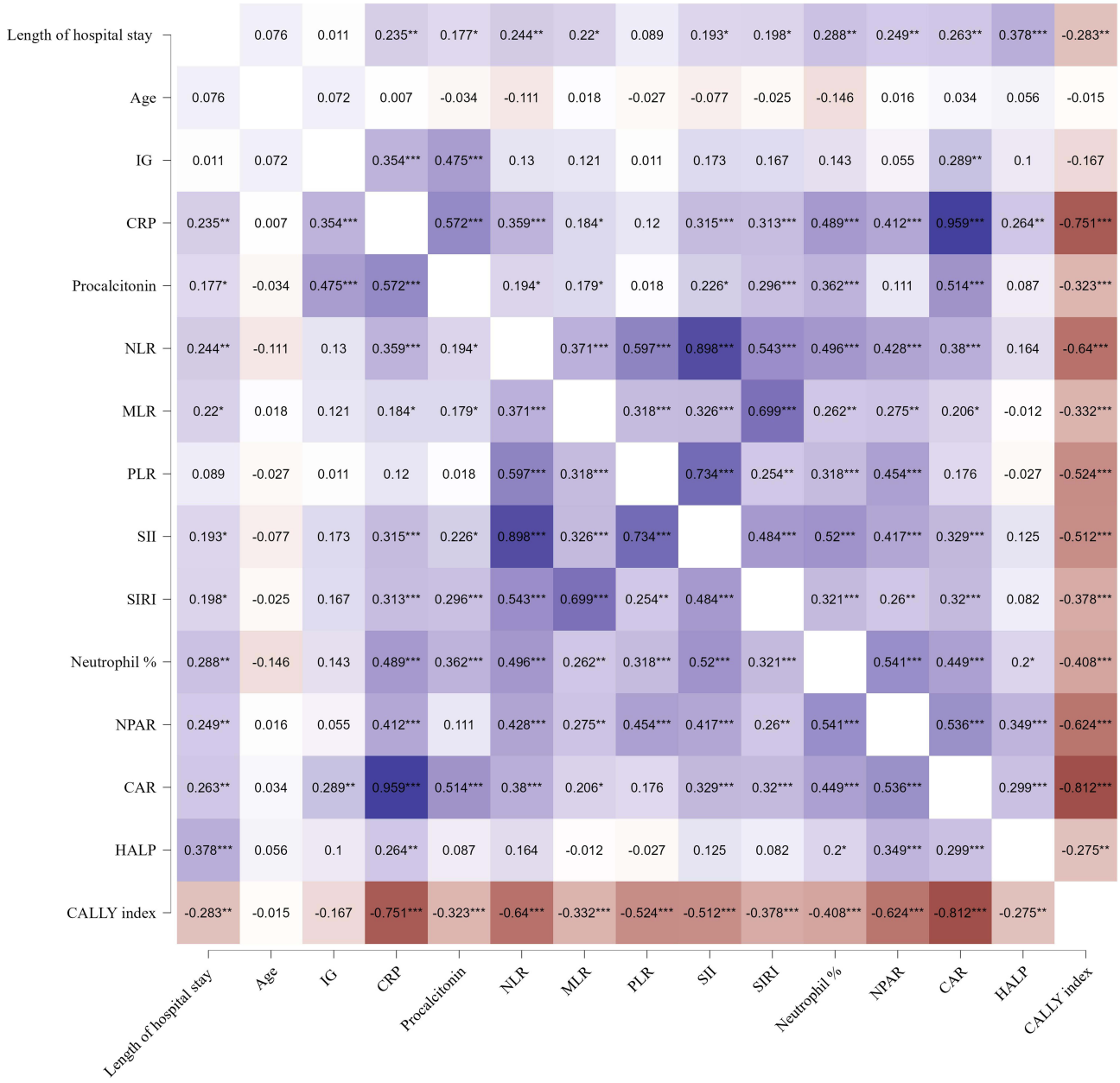

Figure 1 Correlation matrix showing the relationship between inflammatory and immunonutritional parameters and length of hospital stay. Positive correlations are shown in blue and negative correlations in red. The intensity of color represents the strength of the correlation.

Notes: *p < 0.05, **p < 0.01, ***p < 0.001.

Abbreviations: WBC, white blood cell; CRP, C-reactive protein; NLR, neutrophil-to-lymphocyte ratio; MLR, monocyte-to-lymphocyte ratio; PLR, platelet-to-lymphocyte ratio; SII, systemic inflammatory index; SIRI, systemic inflammatory response index; CAR, C-reactive protein-to-albumin ratio; HALP, hemoglobin–albumin–lymphocyte–platelet score; NPAR, neutrophil percentage-to-albumin ratio; CALLY, C-reactive protein–albumin–lymphocyte index; IG, immature granulocyte.

This finding is clinically relevant, as prolonged hospitalization in TOA is associated with increased risk of complications, need for surgical intervention, and healthcare costs.[17] Previous meta-analyses identified age, abscess size, CRP, WBC, ESR, diabetes, and postmenopausal status as predictors of antibiotic treatment failure.[17] Our study adds that impaired immunonutritional status, as reflected by low CALLY index, may also contribute to poorer clinical course.

ROC analysis demonstrated that CALLY had moderate diagnostic accuracy for distinguishing TOA from non-TOA PID cases. Although its AUC was lower than HALP, its balanced sensitivity and specificity suggest potential utility as an adjunctive marker rather than a standalone diagnostic test. Given that CALLY incorporates CRP, albumin, and lymphocytes, it may better reflect systemic inflammatory stress and host response than single laboratory parameters. Notably, the

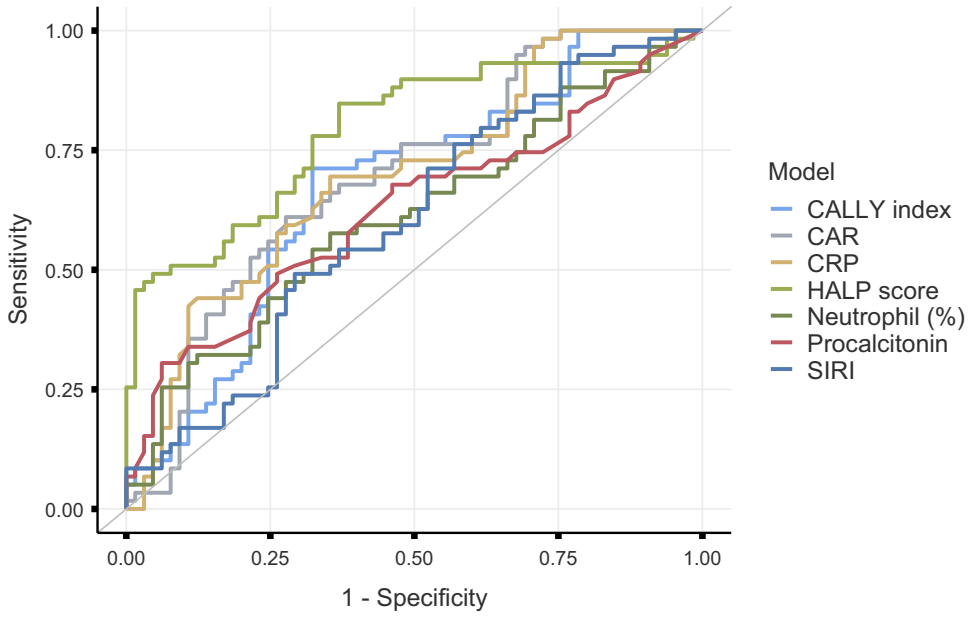

Figure 2 Receiver operating characteristic (ROC) curves of inflammatory and immunonutritional markers in predicting tubo-ovarian abscess (TOA). The HALP score demonstrated the highest diagnostic performance, followed by CRP, CAR, and the CALLY index. The diagonal line represents the reference line for no discrimination.

HALP score demonstrated superior diagnostic accuracy compared to the CALLY index in our cohort, suggesting that while CALLY provides valuable complementary information, HALP may be a more powerful discriminator in this clinical setting.

Furthermore, inflammatory markers fluctuate during treatment and postoperative periods. Sacıntı et al showed that CRP normalization may take up to two weeks after surgery, whereas WBC and NLR normalize earlier.[16] This limits CRP's usefulness for short-term monitoring. In this context, indices such as CALLY, which integrate multiple biological dimensions, may offer a more stable reflection of disease burden at admission.

Delta neutrophil index has also been proposed as a strong predictor of surgical complications and ICU requirement in TOA.[15] While DNI was not available in our dataset, our findings suggest that composite indices incorporating immune and inflammatory components may outperform single parameters in risk stratification.

Table 4 Diagnostic Performance of Inflammatory Indices in Differentiating Tubo-Ovarian Abscess

Inflammatory Index	AUC (95% CI)	Cut-off	Sensitivity	Specificity	PPV	NPV	p-value
CALLY index	0.671 (0.575–0.767)	≤459.4	71.1	67.6	66.7	62.6	**0.001**
CAR	0.694 (0.601–0.787)	≥4.27	61.0	72.3	66.7	67.1	**0.001**
CRP	0.697 (0.604–0.790)	≥127.7	69.5	64.6	64.1	70.0	**0.001**
HALP score	0.792 (0.711–0.873)	≥2.18	84.8	63.1	67.6	82.0	**0.001**
Neutrophil %	0.611 (0.511–0.711)	≥0.716	57.6	64.6	59.7	62.7	**0.030**
Procalcitonin	0.626 (0.526–0.726)	≥2.85	30.5	93.8	81.8	59.8	**0.014**
SIRI	0.604 (0.504–0.704)	≥6.09	49.2	70.8	60.4	60.5	**0.041**

Note: Bold values indicate statistically significant results ($p < 0.05$).
Abbreviations: CALLY index, CRP–Albumin–Lymphocyte Index; CRP, C-reactive protein; Procalcitonin, serum procalcitonin level; SIRI, systemic inflammation response index; Neutrophil %, neutrophil percentage; CAR, CRP-to-albumin ratio; HALP score, hemoglobin–albumin–lymphocyte–platelet score.

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Clinically, early identification of patients who are unlikely to respond to medical therapy is crucial to avoid delayed intervention, rupture, sepsis, and surgical morbidity. Imaging remains essential, but laboratory-based indices may provide rapid, inexpensive tools for early triage, especially in centers with limited access to advanced imaging or interventional radiology.[11,18]

Previous studies have also evaluated various systemic inflammatory indices such as NLR, PLR, SII, and CAR in predicting disease severity and treatment outcomes in pelvic infections and gynecological conditions. These markers have demonstrated varying levels of diagnostic and prognostic performance, highlighting the ongoing need for more comprehensive indices that integrate multiple biological parameters.[19,20] In this context, the CALLY index may provide additional value by simultaneously reflecting inflammatory burden, immune status, and nutritional reserve.

This study has several limitations. Its retrospective design limits causal inference and may introduce selection bias. Additionally, abscess size and detailed imaging characteristics were not incorporated into multivariate models, which are known contributors to treatment failure. Prospective multicenter studies integrating clinical, radiological, and immuno-nutritional indices are needed to validate CALLY as a predictive biomarker. A key limitation of this study is the absence of multivariate analysis to adjust for potential confounding variables. Therefore, the findings should be interpreted as demonstrating an association rather than definitive independent predictive value. Future prospective studies with larger cohorts are needed to validate the independent prognostic role of the CALLY index.

Despite these limitations, our study provides novel evidence supporting the role of CALLY index as a marker of disease severity and hospitalization burden in TOA. Incorporating CALLY into routine laboratory evaluation may help clinicians identify high-risk patients earlier and tailor management strategies accordingly.

Conclusion

The results of this study demonstrate that systemic inflammatory and immunonutritional indices are closely associated with disease severity in patients hospitalized with PID and TOA. Among these markers, the CALLY index was significantly lower in patients with TOA and showed a negative correlation with length of hospital stay, suggesting its potential role as an indicator of a more severe clinical course.

While CRP and other conventional inflammatory markers remain useful for identifying severe infection, composite indices such as the CALLY index may provide additional information by integrating inflammatory burden and host nutritional–immune status. Therefore, the CALLY index may serve as a practical adjunctive biomarker for early risk stratification in patients with PID.

Prospective multicenter studies are needed to validate the clinical utility of the CALLY index and to determine whether its integration into clinical algorithms can improve early decision-making regarding imaging, antibiotic escalation, and the need for invasive intervention.

Use of AI Assistance

In the preparation of this manuscript, the authors utilized OpenAI's ChatGPT-5.2 for assistance with English language refinement, structural organization, and formatting of references. The AI tool was employed strictly to enhance clarity, grammar, and consistency, without contributing to the study design, data analysis, or scientific interpretation. All intellectual and analytical content remains the sole responsibility of the authors.

Data Sharing Statement

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

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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.

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Disclosure

The authors declare that they have no competing interests in this work.

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