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Preoperative systemic inflammatory biomarkers, tumor characteristics, and postoperative outcomes in geriatric patients undergoing brain tumor surgery

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Abstract

Purpose

Brain tumor surgery in geriatric patients is very difficult as it can cause many complications. Systemic inflammatory biomarkers are readily available from routine blood tests; however, their associations with tumor characteristics and postoperative outcomes in older adults undergoing brain tumor surgery remain uncertain.

Methods

This retrospective cohort study. Patients included were elderly with age ≥ 65 years from January 2016 to December 2025, admitted to Khoula hospital for brain tumor excision, with a total number of 138 patients after exclusion. preoperative systemic inflammatory biomarkers and tumor characteristics studied to predict postoperative outcomes.

Results

138 patients with an average age of 72.3 ± 6.2 years. 71 patients (51%) were men. Postoperative complications were seen in 78 out of 135 patients (58%), whereas significant postoperative complications were observed in 36 of 133 patients (27%). NLR were significantly correlated with tumor pathology classification ($p = 0.001$). PLR also exhibited a significant correlation with tumor pathology classification ($p = 0.005$). LMR correlation with tumor pathology classification were ($p = 0.013$). SII relation with tumor pathology type were ($p < 0.001$). After adjustments for age, Charlson Comorbidity Index (CCI), and WHO grade, none of the inflammatory biomarkers were statistically significant with postoperative results.

Conclusion

In conclusion, preoperative inflammatory biomarkers, particularly NLR and SII, were associated with several tumor characteristics. Associations with postoperative outcomes were less consistent after adjustment, although SII showed an association with major postoperative complications.

Introduction

The life span of the population is increasing worldwide and progressively [1]. However, with this increase in age there will be an increase in risks of different health conditions [1]. Brain tumors are one of those conditions [1]. Brain tumors in elderly are concerning, since most of the patients will present with several comorbidities and are more prone to surgical complications [1]. Therefore, the decision of brain surgery for this age group is difficult depending on several factors including age, surgical complexity, quality of

life etc. [1]. This increasing number of older adults undergoing intracranial tumor surgery highlights the need for accessible preoperative markers that may assist with risk assessment [2, 3].

Previous studies have indicated that there is a complex relation between the inflammation and tumors [4]. Although inflammation is a normal process of the body against the tumors, chronic inflammation contributes to the development and progression of the tumor [4, 5]. In this situation the tumor causes an increase in neutrophils and decreases in lymphocytes [5]. Therefore, assessing inflammatory markers in the blood especially Neutrophil-to-Lymphocyte Ratio (NLR) can give clues about the outcome [5]. Therefore, these inflammatory biomarkers have attracted attention as they are easy and quick to assess in routine blood collection [6]. Previous studies have investigated NLR, PLR, LMR, and SII as potential prognostic biomarkers in intracranial tumors, with findings varying across tumor types, populations, and endpoints [6].

However, the role of different inflammatory biomarkers especially in elderly patients with brain tumor surgery remain unclear. Hence, this study evaluated associations between preoperative systemic inflammatory biomarkers, tumor characteristics, and postoperative outcomes among patients aged 65 years or older undergoing intracranial tumor surgery.

Methodology

The study was reviewed and approved by the research ethics committee under the directorate general of Khoula Hospital under the ministry of health, sultanate of Oman and was conducted in accordance with the principles outlined in the committee.

A retrospective cohort was collected from January 2016 to December 2025 yielded 1219 patients who were geriatrics aged ≥ 65 years. 1018 patients were excluded because they were not intracranial tumor patients, leaving us with 201 patients after the initial exclusion process. Among these, only 140 met the inclusion and exclusion criteria and were included in the data analysis as presented in the study flow diagram.

Inclusion criteria were as follows:

All geriatric patients aged ≥ 65 years old who were diagnosed and examined with brain tumors were admitted to Khoula hospital under neurosurgery department from January 2016 to December 2025.

Exclusion criteria were as follows:

Not intracranial tumor patients, patients with neurosurgical conditions other than intracranial tumors, non-geriatric patients under 65 years at admission, patients who did not undergo surgery, and patients who have died before or during surgery.

Baseline clinical data, including age, sex, body mass index (BMI), hypertension, diabetes mellitus, coronary artery disease, chronic kidney disease, charison comorbidity index, admission GCS, WHO grade

of the tumor, tumor pathology being glioblastoma, meningioma, brain metastasis, pituitary adenoma, vestibular schwannoma, lymphoma, low grade glioma or others, tumor volume, extent of resection being GTR, STR, NTR, biopsy, any postoperative complication, or major postoperative complication. Major postoperative complications are adverse events following brain tumor surgery associated with significant clinical deterioration, life-threatening conditions, substantial new or worsening neurological deficits, or requiring unplanned surgical intervention, intensive care treatment, or other major therapeutic intervention within 30 days postoperatively. While other postoperative complications are the non-life threatening adverse events following brain tumor surgery that generally require conservative management or routine medical treatment, without significant permanent neurological deterioration or major invasive intervention within 30 days postoperatively and excluding expected postoperative sequelae which is inherent to the anatomical location and surgical objectives, which may be anticipated based on preoperative condition and tumor involvement. We also included ICU admission, hospital length of stay in days, 30 day and 90 day mortality were all documented.

All statistical analyses and plotting were conducted using SPSS 21.0. Missing data were handled using complete-case analysis. Patients with missing data for variables required in a specific analysis were excluded from that analysis making our sample size 138 patients. No data imputation was performed, and the available sample size was reported for each analysis

Biomarker derivation

neutrophil-to-lymphocyte ratio (NLR) was analyzed as previously reported, without modification. Platelet-to-lymphocyte ratio (PLR), lymphocyte-to-monocyte ratio (LMR), and systemic immune-inflammation index (SII = platelets × neutrophils / lymphocytes) were derived from preoperative complete blood count components. Component values outside physiologically plausible ranges were treated as missing before ratio calculation, to avoid propagating data-entry artifacts. All four biomarkers were analyzed as continuous variables.

Comparative analyses

the Mann-Whitney U test was used for two-level comparisons (e.g., high- vs. low-grade tumor) and the Kruskal-Wallis test for multi-level comparisons (e.g., WHO grade). This approach was applied to all four biomarkers against every prespecified tumor characteristic and clinical outcome. Continuous-outcome associations (e.g., tumor volume, midline shift, length of stay) were assessed with Spearman rank correlation.

Receiver operating characteristic (ROC) analysis was performed for NLR predicting high- vs. low-grade tumor; the optimal cutoff was determined by the Youden index, with area under the curve (AUC) reported with 95% confidence intervals (DeLong method).

Multivariable regression

logistic regression was used for binary clinical outcomes, and negative binomial regression (selected over Poisson regression after confirming overdispersion) was used for length-of-stay outcomes. Each biomarker was modelled separately as a continuous predictor, adjusted for age, Charlson Comorbidity Index, and WHO grade. For the complications forest plot only, biomarkers were standardized (z-scored) so effect sizes are visually comparable across biomarkers measured on very different scales; the underlying regression tables report per-1-unit estimates.

All analyses used available-case data for each specific test; the denominator and completeness percentage are reported for every result. Statistical significance was defined as two-sided $p < 0.05$. Analyses were performed in R (version 4.x).

Results

The ultimate group comprised 138 patients with an average age of 72.3 ± 6.2 years. 71 patients (51%) were men. In patients with BMI data available, the average BMI was 29.4 ± 6.7 kg/m².

Hypertension was observed in 98 out of 137 patients (72%), diabetes mellitus in 67 out of 136 (49%), coronary artery disease in 23 out of 132 (17%), and chronic kidney disease in 20 out of 132 (15%). The average Charlson Comorbidity Index was 4.8 ± 2.8, while the average admission GCS was 14.3 ± 1.6.

Out of 97 patients with accessible WHO grade data, 28 (29%) were diagnosed with grade 1 tumors, 23 (24%) had grade 2 tumors, no patients were recorded with grade 3 tumors (0%), and 46 (47%) had grade 4 tumors. The documented tumor types included meningioma in 46 patients (33%), glioblastoma in 31 (22%), brain metastasis in 12 (9%), pituitary adenoma in 10 (7%), lymphoma in 4 (3%), vestibular schwannoma in 1 (1%), low grade glioma in 1 (1%), and other tumor categories in 33 (24%).

Based on our 130 patients with accessible extent of resection information, 79 (60%) had GTR, 44 (33%) had STR, 1 (1%) had NTR, and 6 (5%) had a biopsy.

Postoperative complications were noted in 78 out of 135 patients (58%), whereas significant postoperative complications were observed in 36 of 133 patients (27%). ICU admission took place in 119 out of 137 patients (87%). The average duration of hospital stay was 16.1 ± 13.8 days for 135 patients with accessible data. 30-day mortality occurred in 4 out of 122 patients (3%), while 90-day mortality was noted in 13 out of 122 patients (11%). (Table 1)

Table 1 Baseline demographic, clinical, and perioperative characteristics of the study cohort

Characteristic	Value (N=138)	Available N
Age (years), mean ± SD	72.3 ± 6.2	n=138
Sex, male	71 (51%)	n=138
BMI (kg/m2), mean ± SD	29.4 ± 6.7	n=20
Hypertension	98 (72%)	n=137
Diabetes mellitus	67 (49%)	n=136
Coronary artery disease	23 (17%)	n=132
Chronic kidney disease	20 (15%)	n=132
Charlson Comorbidity Index, mean ± SD	4.8 ± 2.8	n=138
Admission GCS, mean ± SD	14.3 ± 1.6	n=134
WHO grade		n=99
Grade 1	28 (28%)	
Grade 2	23 (23%)	
Grade 3	0 (0%)	
Grade 4	46 (46%)	
Tumor pathology		n=138
Glioblastoma	31 (22%)	
Meningioma	46 (33%)	
Brain metastasis	12 (9%)	
Pituitary adenoma	10 (7%)	
Vestibular schwannoma	1 (1%)	
Lymphoma	4 (3%)	
Low-grade glioma	1 (1%)	
Other	33 (24%)	
Tumor volume (cm3), mean ± SD	33.8 ± 37.6	n=109
Extent of resection		n=132
GTR	79 (60%)	
STR	44 (33%)	

NTR	1 (1%)	
Biopsy	6 (5%)	
Any postoperative complication	78 (58%)	n=135
Major postoperative complication	36 (27%)	n=133
ICU admission	119 (87%)	n=137
Hospital length of stay (days), mean ± SD	16.1 ± 13.8	n=135
30-day mortality	4 (3%)	n=122
90-day mortality	13 (11%)	n=122

The Mann–Whitney U test produced a p value of 0.002. NLR varied among WHO grades 1–4, showing a statistically significant result from the Kruskal–Wallis test (p<0.001). (Table 2)

Table 2 NLR by tumor grade (unadjusted comparison)

Comparison	Test	P value
NLR by High vs Low Grade	Mann-Whitney U	0.002
NLR by WHO Grade (1-4)	Kruskal-Wallis	<0.001

The ROC analysis of admission NLR for distinguishing high grade from low grade tumors revealed an AUC of 0.709 (95% CI, 0.594–0.825). The best cutoff determined through Youden's index was 1.93. The sensitivity was 0.746, while the specificity was 0.630. The positive predictive value stood at 0.815, while the negative predictive value was 0.531. (Table 3)(Figure 1)

Table 3 ROC curve analysis: admission NLR predicting high-grade tumor

Metric	Value
AUC	0.709
95% CI (AUC)	0.594 - 0.825
Optimal NLR cutoff (Youden)	1.93
Sensitivity	0.746
Specificity	0.630
PPV	0.815
NPV	0.531

NLR correlated with tumor volume (Spearman ρ=0.23, p=0.022), midline shift (ρ=0.36, p<0.001), high-grade versus low-grade tumor (p=0.002), peritumoral oedema (p<0.001), WHO grade (p<0.001), and tumor pathology classification (p=0.001). PLR exhibited a significant correlation with high-grade versus low-grade tumors (p=0.032) and tumor pathology classification (p=0.005).

LMR correlated with tumor volume (ρ=−0.23, p=0.021), midline shift (ρ=−0.25, p=0.007), duration of hospital stay (ρ=−0.22, p=0.013), high grade versus low-grade tumor (p=0.006), discharge status (p=0.008), 30-day mortality rate (p=0.007), WHO grading (p=0.002), and tumor pathology classification (p=0.013).

SII correlated with tumor volume (ρ=0.20, p=0.047), midline shift (ρ=0.24, p=0.009), high grade versus low grade tumor (p=0.002), peritumoral oedema (p<0.001), WHO grade (p=0.001), and tumor pathology type (p<0.001). (Table 4) (Figure 2)

Table 4 Statistically significant biomarker associations with tumor characteristics and clinical outcomes (p<0.05)

Biomarker	Outcome	N	% Available	Test	Statistic	P value
NLR	Tumor volume (cm3)	100	72%	Spearman correlation	rho = 0.23	0.022
NLR	Midline shift (mm)	118	86%	Spearman correlation	rho = 0.36	<0.001
NLR	High- vs. low-grade tumor	86	62%	Mann-Whitney U	median Low=1.53 vs High=3.40	0.002
NLR	Peritumoral edema (presence)	121	88%	Mann-Whitney U	median No=1.74 vs Yes=3.78	<0.001
NLR	WHO grade (1-4)	90	65%	Kruskal-Wallis	chi-sq=16.23, df=2	<0.001
NLR	Tumor pathology category	129	93%	Kruskal-Wallis	chi-sq=24.00, df=7	0.001
PLR	High- vs. low-grade tumor	82	59%	Mann-Whitney U	median Low=135.77 vs High=161.24	0.032
PLR	Tumor pathology category	125	91%	Kruskal-Wallis	chi-sq=20.36, df=7	0.005
LMR	Tumor volume (cm3)	99	72%	Spearman correlation	rho = -0.23	0.021
LMR	Midline shift (mm)	117	85%	Spearman correlation	rho = -0.25	0.007
LMR	Hospital LOS (days)	126	91%	Spearman correlation	rho = -0.22	0.013
LMR	High- vs. low-grade tumor	85	62%	Mann-Whitney U	median Low=4.30 vs High=2.63	0.006
LMR	Discharge disposition (home vs. non-home)	123	89%	Mann-Whitney U	median Home=3.55 vs Non-home=2.29	0.008
LMR	90-day mortality	113	82%	Mann-Whitney U	median No=3.57 vs Yes=1.85	0.007
LMR	WHO grade (1-4)	89	64%	Kruskal-Wallis	chi-sq=12.50, df=2	0.002
LMR	Tumor pathology category	128	93%	Kruskal-Wallis	chi-sq=17.72, df=7	0.013
SII	Tumor volume (cm3)	97	70%	Spearman correlation	rho = 0.20	0.047

SII	Midline shift (mm)	114	83%	Spearman correlation	rho = 0.24	0.009
SII	High- vs. low-grade tumor	82	59%	Mann-Whitney U	median Low=485.60 vs High=950.04	0.002
SII	Peritumoral edema (presence)	117	85%	Mann-Whitney U	median No=409.96 vs Yes=947.23	<0.001
SII	WHO grade (1-4)	87	63%	Kruskal-Wallis	chi-sq=13.77, df=2	0.001
SII	Tumor pathology category	125	91%	Kruskal-Wallis	chi-sq=26.44, df=7	<0.001

The modified OR was 1.10 (95% CI, 0.98–1.25; p=0.136) for NLR, 1.00 (95% CI, 1.00–1.01; p=0.352) for PLR, 0.98 (95% CI, 0.75–1.29; p=0.896) for LMR, and 1.00 (95% CI, 1.00–1.00; p=0.217) for SII.

NLR demonstrated an adjusted OR of 1.10 (95% CI, 0.99–1.23; p=0.072), PLR exhibited an OR of 1.00 (95% CI, 1.00–1.01; p=0.062), and LMR indicated an OR of 0.78 (95% CI, 0.54–1.06; p=0.141). (Table 5) (Table 6)(Figure 3)

Table 5 Adjusted association with any postoperative complication

Biomarker	N	OR	95% CI	P value
NLR	88	1.10	0.98 - 1.25	0.136
PLR	85	1.00	1.00 - 1.01	0.352
LMR	87	0.98	0.75 - 1.29	0.896
SII	85	1.00	1.00 - 1.00	0.217

Table 6 Adjusted association with major postoperative complication (Clavien-Dindo)

Biomarker	N	OR	95% CI	P value
NLR	86	1.10	0.99 - 1.23	0.072
PLR	83	1.00	1.00 - 1.01	0.062
LMR	85	0.78	0.54 - 1.06	0.141
SII	83	1.00	1.00 - 1.00	0.016

No statistically significant adjusted association was observed between any biomarker and ICU admission. The adjusted ORs were 1.12 (95% CI, 0.94–1.50; p=0.326) for NLR, 1.01 (95% CI, 1.00–1.02; p=0.136) for PLR, 1.17 (95% CI, 0.78–1.92; p=0.485) for LMR, and 1.00 (95% CI, 1.00–1.00; p=0.392) for SII. (Table 7)

Table 7 Adjusted association with ICU admission

Biomarker	N	OR	95% CI	P value
NLR	90	1.12	0.94 - 1.50	0.326
PLR	87	1.01	1.00 - 1.02	0.136
LMR	89	1.17	0.78 - 1.92	0.485
SII	87	1.00	1.00 - 1.00	0.392

In the adjusted analysis of 30-day mortality, none of the four biomarkers was significantly associated with mortality. The ORs were 0.77 (95% CI, 0.32–1.13; p=0.412) for NLR, 1.00 (95% CI, 0.99–1.01; p=0.930) for PLR, 0.89 (95% CI, 0.31–2.03; p=0.800) for LMR, and 1.00 (95% CI, 0.99–1.00; p=0.340) for SII. (Table 8)

Table 8 Adjusted association with 30-day mortality

Biomarker	N	OR	95% CI	P value
NLR	79	0.77	0.32 - 1.13	0.412
PLR	76	1.00	0.99 - 1.01	0.930
LMR	78	0.89	0.31 - 2.03	0.800
SII	76	1.00	0.99 - 1.00	0.340

The same pattern was observed for 90-day mortality. NLR had an OR of 0.94 (95% CI, 0.77–1.08; p=0.434), PLR 1.00 (95% CI, 0.99–1.00; p=0.648), LMR 0.65 (95% CI, 0.32–1.14; p=0.182), and SII 1.00 (95% CI, 1.00–1.00; p=0.957). (Table 9)

Table 9 Adjusted association with 90-day mortality

Biomarker	N	OR	95% CI	P value
NLR	79	0.94	0.77 - 1.08	0.434
PLR	76	1.00	0.99 - 1.00	0.648
LMR	78	0.65	0.32 - 1.14	0.182
SII	76	1.00	1.00 - 1.00	0.957

The original NLR analysis likewise found no significant association between continuous NLR and 30-day mortality (OR 0.87, 95% CI 0.51–1.10; p=0.429) or 90-day mortality (OR 0.93, 95% CI 0.76–1.08; p=0.403). Dichotomization of NLR at the ROC-derived cutoff of 1.93 also did not demonstrate a significant association with 30-day mortality (OR 0.83, 95% CI 0.13–6.91; p=0.848). (Table 10)(Table 11) (Table 12)

Table 10 Multivariable logistic regression: 30-day mortality (NLR, continuous)

Term	OR	95% CI	P value
NLR (per unit)	0.87	0.51 - 1.10	0.429
Age (per year)	1.21	0.98 - 1.61	0.104

Table 11 Multivariable logistic regression: 90-day mortality (NLR, continuous)

Term	OR	95% CI	P value
NLR (per unit)	0.93	0.76 - 1.08	0.403
Age (per year)	1.12	0.98 - 1.31	0.105

Table 12 Multivariable logistic regression: 90-day mortality (NLR, dichotomized at Youden cutoff of 1.93)

Term	OR	95% CI	P value
NLR ≥1.93 (vs. <1.93)	0.83	0.13 - 6.91	0.848
Age (per year)	1.11	0.97 - 1.27	0.136

Note: The dichotomized-NLR 30-day mortality model is not reported: with only 4 deaths at 30 days across the cohort, splitting by both NLR cutoff and WHO grade produced an empty cell and a non-interpretable odds ratio (quasi-complete separation). The continuous-NLR version of this model (above) is stable and is reported instead.

In the adjusted negative binomial models, none of the biomarkers was significantly associated with ICU length of stay. The IRR was 1.01 (95% CI, 0.96–1.08; p=0.633) for NLR, 1.00 (95% CI, 1.00–1.00; p=0.517)

for PLR, 0.88 (95% CI, 0.77–1.01; p=0.097) for LMR, and 1.00 (95% CI, 1.00–1.00; p=0.342) for SII. (Table 13)

Table 13 Adjusted association with ICU length of stay (incidence rate ratio)

Biomarker	N	Model	IRR	95% CI	P value
NLR	86	Negative Binomial	1.01	0.96 - 1.08	0.633
PLR	83	Negative Binomial	1.00	1.00 - 1.00	0.517
LMR	85	Negative Binomial	0.88	0.77 - 1.01	0.097
SII	83	Negative Binomial	1.00	1.00 - 1.00	0.342

Similarly, none of the biomarkers was significantly associated with hospital length of stay. The IRR was 1.01 (95% CI, 0.97–1.04; p=0.676) for NLR, 1.00 (95% CI, 1.00–1.00; p=0.525) for PLR, 0.97 (95% CI, 0.90–1.05; p=0.553) for LMR, and 1.00 (95% CI, 1.00–1.00; p=0.209) for SII. (Table 14)

Table 14 Adjusted association with hospital length of stay (incidence rate ratio)

Biomarker	N	Model	IRR	95% CI	P value
NLR	88	Negative Binomial	1.01	0.97 - 1.04	0.676
PLR	85	Negative Binomial	1.00	1.00 - 1.00	0.525
LMR	87	Negative Binomial	0.97	0.90 - 1.05	0.553
SII	85	Negative Binomial	1.00	1.00 - 1.00	0.209

Overall survival information was accessible for just 48 out of the 138 patients (35%). Due to the restricted completeness of follow-up, overall survival was excluded from the formal inferential analysis. A Kaplan–Meier curve was created as an exploratory illustration of the existing survival data. The significant level of absent survival follow-up restricts the understanding of the noted survival trend.

In general, the analyses revealed multiple statistically significant connections between preoperative inflammatory biomarkers and tumor features. NLR, specifically, showed a correlation with tumor grade and exhibited moderate differentiation of high-grade tumors in the ROC analysis. PLR, LMR, and SII demonstrated notable correlations with specific tumor and clinical features.

Following adjustments for age, Charlson Comorbidity Index, and WHO grade, many associations with postoperative results lost their statistical significance. SII continued to be strongly linked to major postoperative complications, while none of the four biomarkers demonstrated a significant relationship with any postoperative complication, ICU admission, 30-day mortality, 90-day mortality, ICU length of stay, or hospital length of stay. The results from the comparisons must be understood considering the

exploratory character of the multiple comparisons and the differing sample sizes caused by complete-case analysis.

Discussion

The relationship between inflammation and cancer has been studied extensively over the last decades. Studies reveal that chronic inflammation plays a major role in tumor progression through the release of pro-tumorigenic mediators, including growth factors and pro-angiogenic factors [5].

This retrospective cohort study included 138 patients ages 65 years and older who underwent resection of brain tumors at Khoula hospital between January 2016 and December 2025. The study aimed to evaluate the clinical utility of the inflammatory markers including neutrophil-lymphocyte ratio (NLR), Platelet-lymphocyte ration (PLR), Lymphocyte-Monocyte Ratio (LMR) and Systemic-Immune-Inflammation Index (SII), as a potential prognostic markers, and assess their association with tumor grade, post-operative complications, hospital and intensive care unit (ICU) length of stay, 30- and 90-day mortality in geriatric patients undergoing brain tumor resection.

Among the four biomarkers evaluated, NLR demonstrated the most consistent and clinically relevant associations with tumor grade and local aggressiveness, with an AUC of 0.709 for distinguishing high-grade from low-grade tumors. Higher NLR was observed in high grade tumors. This is consistent with finding reported in a previous study [7]. However, the NLR cutoff identified in our study was 1.93, which was lower than the cutoff in that same study (NLR ≥ 3). This difference may be explained by differences in the study population, as the previous study focused specifically on high grade gliomas, while our cohort included a more heterogeneous range of tumor types and grades.

SII demonstrated significant associations across several tumor-related characteristics, including tumor volume, midline shift, peritumoral edema, WHO grade, and tumor pathology. NLR showed a similar pattern, with associations with tumor volume, midline shift, peritumoral oedema, WHO grade, and tumor pathology, suggesting a potential relationship between systemic inflammation and more aggressive tumor characteristics. PLR did not show meaningful associations with the tumor characteristics assessed, while the associations observed with LMR were not maintained after adjustment. Overall, these findings suggest that NLR and SII may serve as adjunctive preoperative markers of tumor biology, while PLR and LMR offer limited independent prognostic value in our geriatric cohort.

Postoperative complications, which consist of relatively common and less severe events, such as infections, atelectasis, or transient neurological changes that can occur following intracranial surgery and may vary according to the anatomical location and functional area involved, occurred in 58% of our cohort. However, none of the four inflammatory biomarkers was independently associated with postoperative complications. On the other hand, major postoperative complications that represent more clinically significant events, such as complications requiring unplanned ICU admission or additional surgical intervention, occurred in 27%. SII was the only biomarker with statistically significant association with major postoperative complications ($p = 0.016$), however, the corresponding odds ratio

was 1.00, indicating that the magnitude of association has limited clinical significance. Previous literature linked postoperative complications in neurosurgical geriatric cohort to low performance status on admission [8].

The rate of ICU admissions in our cohort was 87%. None of the four inflammatory biomarkers had significant association with admission rates, ICU length of stay, or overall hospital length of stay.

In addition, none of the four inflammatory indices showed significant independent association with either 30-day or 90-day mortality. This is perhaps related to the low mortality rates observed in our cohort with 30-day mortality and 90-day mortality rates of 3% and 11% respectively, reducing result precision. Other previously established risks [9] including advanced age, preoperative Karnofsky Performance Status (KPS) < 60, high-grade malignancy, infratentorial location of the tumor, as well as the physical status classification system (ASA) score of ≥ 3, may have influenced mortality rate in our cohort [9]. In contrast, a previous study reported significant association between pretreatment NLR and overall survival in patients with glioblastoma [4]. In particular, a high pretreatment NLR (≥ 4) was associated with increased neutrophil infiltration, reduced CD3 + T-cell infiltration within tumors, and poorer overall survival. The differences between these findings and ours may be partly explained by differences in tumor type, patient characteristics, and the mortality outcomes assessed.

Conclusion

In summary, NLR showed significant association with tumor grade and aggressiveness, while SII showed significant association with tumor characteristics and major postoperative outcomes. None of the four inflammatory biomarkers independently predicted postoperative outcome or short-term mortality.

Limitations

Several limitations of this study should be considered. First, the study was conducted at a single tertiary hospital, which may limit the generalizability of the findings to the wider population and may have contributed to the relatively small sample size. Second, the retrospective design carries the possibility of missing, incomplete, or inconsistently recorded clinical and laboratory data, as well as incomplete follow up results, which may have affected the availability and accuracy of some variables. In addition, the low number of observed events may have reduced statistical power and produced imprecise estimates. Moreover, the use of corticosteroids of treatment may have affected inflammatory marker levels, making it difficult to distinguish between medication-related changes and tumor related inflammation. Finally, the heterogeneity of the tumour population is another limitation, as the cohort included different intracranial tumour types that may have varying inflammatory profiles. This may have influenced the observed associations between inflammatory biomarkers and tumour characteristics.

Declarations

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Mentor, Conceptualization, Methodology and, ethical committee letter preparation and acquired approval by T.A. Material preparation: T.A and H.A. All A.E, H.A, K.A, S.M, R.G, M.A, Y.A, E.A, L.A, R.A participated in the data collection. Statistical analysis by TA and AA. Original draft preparation: A.E, L.A and, Y.A. Supervision: T.A. All authors read and approved the manuscript. Submission by A.E.

Data Availability Statement: From medical records of patients from the “Al-Shifa Health Information System” of the Ministry of Health in the Sultanate of Oman used in Khoula Hospital.

Human Ethics and Consent to Participate statement: This study was approved by the Research Ethics Committee, Directorate General of Khoula Hospital, Ministry of Health, Muscat, Oman (Approval code: PR0122020072). Ethical approval authorized access to the medical records for this retrospective study without requiring individual informed consent for each participants in this study.

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Figures

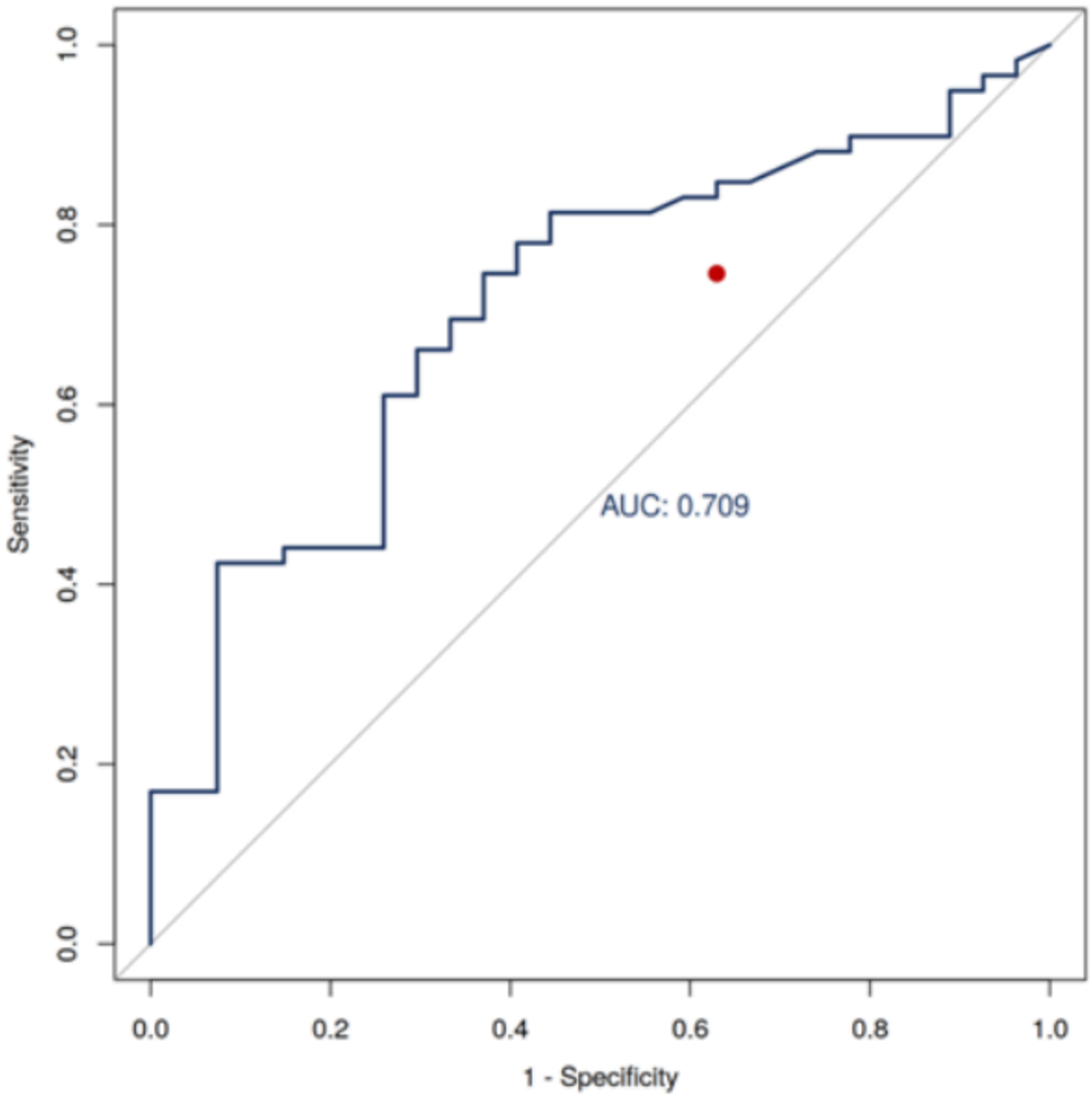

Figure 1

ROC curve, admission NLR predicting high-grade tumor

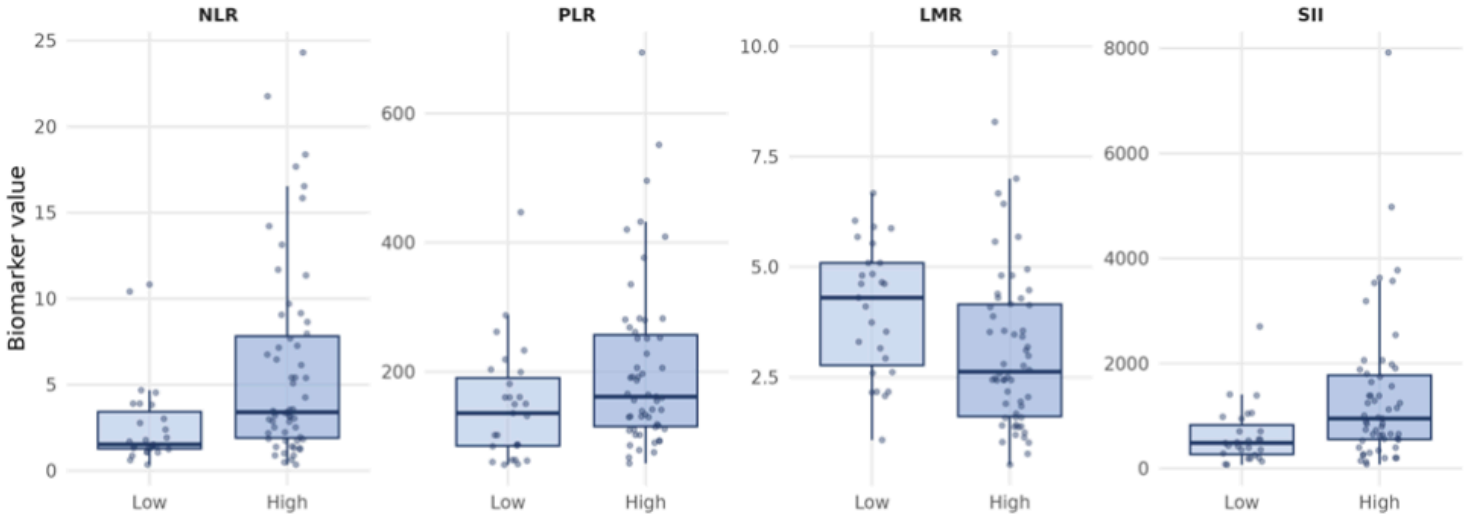

Figure 2

Systemic inflammatory biomarkers by tumor grade

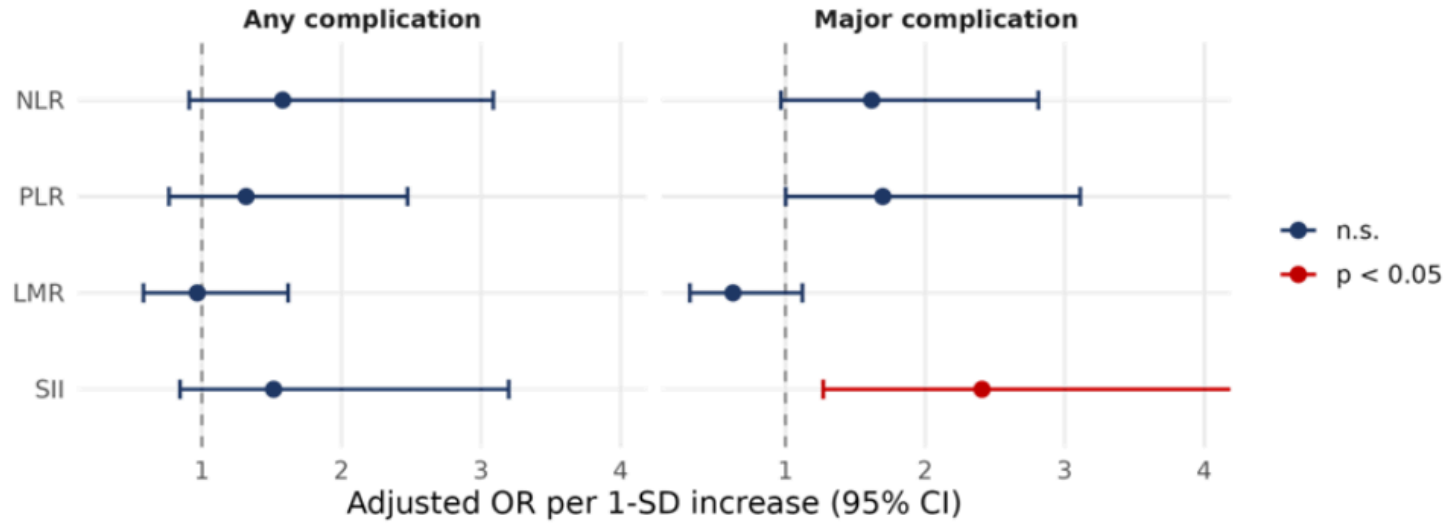

Figure 3

Adjusted odds ratios (per 1-SD biomarker increase) for postoperative complications