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ORIGINAL RESEARCH

Association of Preoperative Leukocyte-to-Albumin Ratio with Short- and Long-Term Outcomes After Valvular Heart Surgery: A Retrospective Cohort Study

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Background: The leukocyte-to-albumin ratio (LAR) serves as an integrated marker of both inflammation and nutritional status. However, there is currently a lack of research on the correlation between LAR and the prognosis of valvular heart disease (VHD) surgery patients. This study investigates the prognostic significance of LAR in patients undergoing VHD surgery.

Methods: This is a single-center, retrospective cohort study. From May 2021 to July 2024, we retrospectively analyzed the clinical data of 773 patients who underwent VHD surgery. Patients were categorized into low- and high-LAR groups using a threshold value of 0.2. Multivariable logistic regression models were used to assess the association between the LAR and adverse outcomes.

Results: This study included a total of 773 patients, with 615 in the low LAR group and 158 in the high LAR group. The main findings included that LAR $\geq$ 0.2 was an independent protective factor for severe arrhythmias(SA)(OR:0.231, 95% CI:0.103–0.518, p=0.000), but was also significantly associated with increased risk of acute kidney injury(AKI), prolonged mechanical ventilation(MV) time and prolonged length of stays(LOS)(p < 0.05). Multifactorial analysis further confirmed that LAR was independently and positively associated with LOS (B=16.453, t=3.090, p=0.002).

Conclusion: In summary, an elevated LAR ($\geq$0.2) exhibits a paradoxical role, serving as an independent predictor for reduced SA while concurrently correlating with an extended LOS, thereby establishing its dual nature as a perioperative risk biomarker.

Keywords: valvular heart disease, leukocyte to albumin ratio, severe arrhythmias, length of stays, poor prognosis

Introduction

Valvular heart disease (VHD) is one of the important cardiovascular disease burdens globally, mainly caused by rheumatic fever, degenerative changes and congenital anomalies that lead to abnormal valve function.[1] It has been reported that the prevalence of VHD in China is 3.8%, with over 25 million affected individuals.[2] Surgical intervention remains a cornerstone in VHD management. Severe arrhythmias (SA) and acute kidney injury (AKI) are among the severe perioperative complications it is often accompanied by, in addition to mortality. Foreign studies have shown that the incidence of new-onset atrial fibrillation after surgery is approximately 10% to 60%;[3] in addition, in patients with infective endocarditis, the incidence of AKI after valve surgery can be as high as 35.4%.[4] Numerous clinical studies have confirmed a significant correlation between postoperative atrial fibrillation, AKI, and patient outcomes such as length of hospital stay (LOS) and postoperative mortality.[5,6] It is necessary to identify simple biomarkers, and timely identification of high-risk patients will help improve the overall prognosis of VHD patients.

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The leukocyte-to-albumin ratio (LAR) is an important blood index in routine clinical tests, which can be obtained through peripheral venous blood analysis and has the advantages of easy access, convenient detection, and low cost. As an important component of the immune system, white blood cells mainly play a role in phagocytosing pathogens and maintaining immune defense. In recent years, white blood cells have been proven to be an independent risk factor for new-onset atrial fibrillation after heart surgery.[7] In addition, albumin, as the most abundant protein in plasma, is an important indicator for assessing nutritional status, liver and kidney function, and disease prognosis. A meta-analysis of nine studies showed that for every 10g/L increase in serum albumin levels, the risk of atrial fibrillation can be reduced by 36%.[8] Based on the biological characteristics and interaction of white blood cells and albumin, researchers have introduced a new inflammation-nutrition composite index, LAR. Research by Sheinenzon et al demonstrated a negative correlation between white blood cells and albumin levels ($r = -0.157$).[9] Moreover, LAR has been shown in multiple studies to be significantly related to the severity of atrial fibrillation and ischemic stroke severity.[10,11]

However, its association with adverse outcomes after VHD surgery remains understudied. Given the important roles and interrelationships of white blood cells and albumin in cardiovascular disease, we hypothesize that LAR may enhance early identification of high-risk patients. Therefore, our aim was to investigate the relationship between LAR at admission and clinical outcomes in VHD patients through a retrospective study. This could assist healthcare professionals in making more precise decisions, potentially lowering incidence of adverse outcomes in VHD patients.

Method

Study Design and Study Population

During the period from May 2021 to July 2024, Fujian Province Heart Center admitted a total of 2537 patients diagnosed with VHD by echocardiography. Inclusion criteria: ①Age ≥ 18 years old; ②Undergoing cardiac valve surgery under mild hypothermic cardiopulmonary bypass (CPB); ③Elective surgery; ④Postoperative admission to the ICU of Fujian Province Heart Center and receiving treatment. Exclusion criteria: ①Preoperative renal insufficiency; ②Preoperative liver insufficiency; ③Preoperative stroke; ④Myocardial infarction; ⑤Infectious endocarditis; ⑥Systemic infectious diseases; ⑦Patients with incomplete medical records.

According to the inclusion and exclusion criteria for patient selection, a total of 773 patients were included, and the specific selection process is shown in Figure 1. This study has been approved by the Ethics Committee of the Affiliated

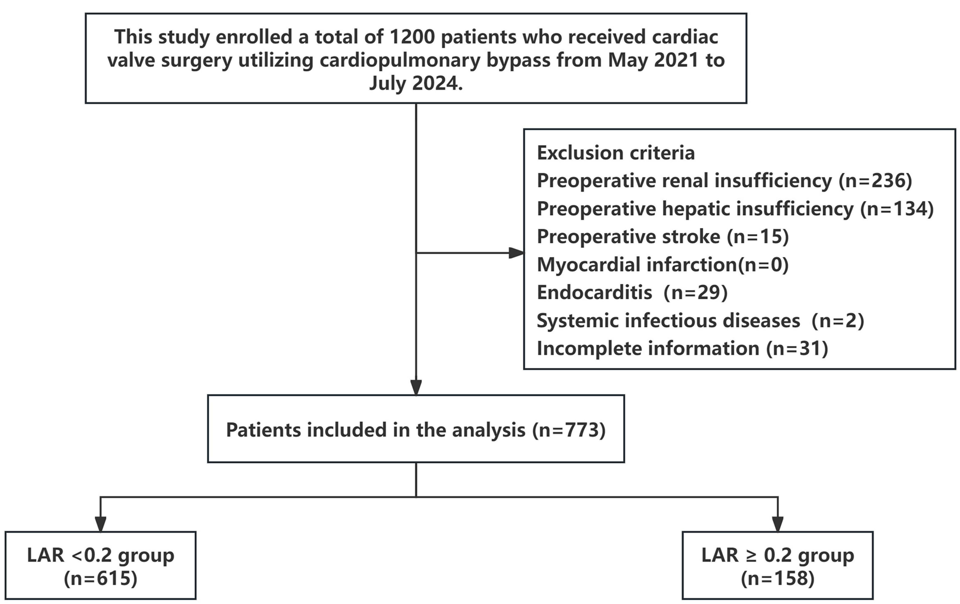

Figure 1 Flowchart of inclusion/exclusion process for study subjects.

Union Hospital of Fujian Medical University (Ethics Number:2024KY114) and strictly follows the ethical guidelines of the Helsinki Declaration.

Data Collection

In this study, clinical information of patients was retrospectively collected through the hospital's clinical electronic medical record system. Information extraction included demographic information, clinical characteristics, comorbidities, laboratory test data, intraoperative data, and clinical outcomes.

The venous blood samples collected in the laboratory were obtained after fasting for more than 8 hours and refraining from water for more than 3 hours. The first blood tests conducted upon admission included hemoglobin (HGB), white blood cell count (WBC), platelet count (Plt), albumin (Alb), total cholesterol (CHOL), triglycerides (TG), indirect bilirubin (IBIL), aspartate aminotransferase (AST), creatinine (CREA), glucose (Glu), potassium (K), magnesium (Mg), and thyroid-stimulating hormone (TSH) levels.

In-hospital outcomes included all-cause in-hospital mortality (ACIHM), low cardiac output syndrome (LCOS), SA, electrolyte disorders, coagulopathy, acute myocardial infarction (AMI), stroke, AKI, acute liver insufficiency (ALI), mechanical ventilation time (MV time), and LOS. Long-term endpoint was all-cause readmission rate, confirmed through medical records or communication. Follow-up averaged 1 year.

Clinical Definition

LAR is defined as white blood cell count (10^9/L)/albumin (g/L).[10] Hypertension, diabetes mellitus (DM), and coronary heart disease (CHD), were defined by International Classification of Diseases, 10th Revision (ICD-10) codes.[12] LCOS was diagnosed as cardiac index < 2.0 L/min/m² with clinical hypoperfusion (eg, oliguria, cold extremities) for >2 hours, or systolic BP < 90 mmHg with ≥2 hypoperfusion signs if CI was unavailable. AMI is defined as elevated serum myocardial enzyme activity, accompanied by symptoms of myocardial ischemia and hypoxia as well as changes in the electrocardiogram. SA mainly presents as new-onset postoperative atrioventricular block, atrial fibrillation, and ventricular fibrillation. Electrolyte disorders were diagnosed based on standard laboratory reference ranges for potassium, sodium, calcium, and magnesium levels. Coagulopathy was defined as >1000 mL/24h chest tube drainage, >5 RBC units transfused/24h, or reexploration for bleeding. AKI is defined as a 50% increase in creatinine within 7 days, or a 0.3 mg/dL (26.5 μmol/L) increase in creatinine within 2 days, or oliguria lasting ≥6 hours.[13] ALI is defined as postoperative alanine aminotransferase (0–46 IU/L) and/or aspartate aminotransferase (0–46 IU/L) exceeding normal values; total bilirubin (2–22 umol/L) and/or direct bilirubin (0–5.9 umol/L) elevated.[14,15]

Statistical Analysis

All data were statistically analyzed using IBM SPSS 25.0. The normal value of LAR was set at 0.2, which was calculated by dividing the normal upper limit of leukocyte count (10×10^9/L) by the normal upper limit of albumin (50 g/L).[10] Patients were divided into a low LAR group (LAR < 0.2) and a high LAR group (LAR ≥ 0.2) based on LAR levels, and the differences in characteristics between the two groups of patients were analyzed and compared. Continuous variables were expressed as mean ± standard deviation (SD) or interquartile range median (IQR), and Student's *t*-test or non-parametric test was used for between-group comparisons. Categorical variables were expressed as frequency (percentage), and the chi-squared test was used for between-group comparisons. Univariate logistic regression analysis identified potential risk factors for adverse outcomes (P<0.05), and multivariate logistic regression analysis identified previously significant variables as independent factors (P<0.05). Finally, Pearson correlation analysis was used to determine the association between LOS and LAR, while multiple linear regression analysis was used to determine the factors influencing LOS.

Results

Baseline Characteristics

This study included a total of 773 patients, with 615 in the low LAR group and 158 in the high LAR group. The average age of the patients was (56.40±11.18) years, with 388 female patients (50.2%). There was no statistically significant

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difference (p>0.05) between the two groups in terms of demographic data such as age, gender, systolic blood pressure-(SBP), diastolic blood pressure(DBP), and body mass index(BMI). However, the heart rate in the low LAR group was lower than in the high LAR group. (79.71±15.10 vs 85.13±17.19, p=0.000).

No statistically significant differences were observed between the two groups regarding comorbidities such as hypertension, diabetes mellitus(DM), and coronary heart disease(CHD), or in terms of clinical characteristics, including the valve involved and the type of valvular dysfunction (all $p > 0.05$). In laboratory analyses, the low LAR group exhibited significantly higher levels of triglycerides (TG) and magnesium (Mg), along with significantly lower platelet counts (Plt) and serum creatinine (CREA) levels compared to the high LAR group (all $p < 0.05$). No statistically significant differences were observed between the groups in indirect bilirubin (IBIL), aspartate aminotransferase (AST), total cholesterol (CHOL), glucose (Glu), potassium (K), thyroid-stimulating hormone (TSH), or hemoglobin (Hb) (all $p > 0.05$). Intraoperative data revealed that the amount of albumin in the priming solution was the only parameter that showed a significant difference between the two groups ($p < 0.05$), while no statistically significant differences were observed in the other indicators (all $p > 0.05$). Detailed demographic data and laboratory test results are shown in Table 1.

Table 1 Baseline Characteristics in Patients Undergoing Cardiac Valvular Surgery

Variables	Total (n=773)	LAR		*p*
		Low<0.2 (n=615)	High≥0.2 (n=158)	
Demographic and clinical characteristics				
Age (y), mean (SD)	54.40±11.18	54.03±11.27	55.85±10.72	0.067
Female, n(%)	388 (50.2)	318(51.7)	70(44.3)	0.097
HR(beats/min), mean (SD)	80.82±15.69	79.71±15.10	85.13±17.19	0.000*
SBP (mmHg), mean (SD)	122.41±18.07	121.96±16.91	124.16±21.97	0.171
DBP (mmHg), mean (SD)	74.92±13.44	74.67±13.09	75.89±14.72	0.308
BMI (kg/m2), mean(SD)	23.06±3.67	23.04±3.76	23.15±3.31	0.746
Comorbidites				
Hypertension, n (%)	161(20.8)	121(19.7)	40(25.3)	0.119
DM, n (%)	51(6.6)	36(5.9)	15(9.5)	0.100
CHD, n (%)	26(3.4)	21(3.4)	5(3.2)	0.876
Valve involved				
Aortic valve, n(%)	350 (45.3)	281 (45.7)	69 (43.7)	0.649
Mitral valve, n(%)	506 (65.5)	402 (65.4)	104 (65.8)	0.914
Tricuspid valve, n(%)	170 (22.0)	138 (22.4)	32 (20.3)	0.554
Pulmonary valve, n(%)	5 (0.6)	3 (0.5)	2 (1.3)	0.595
NVI, median (IQR)	1.00 (1.00–2.00)	1.00 (1.00–2.00)	1.00 (1.00–1.25)	0.582
Type of valvular dysfunction				
Stenosis, n(%)	224 (29.0)	173 (28.1)	51 (32.3)	0.305
Insufficiency, n(%)	435 (56.3)	352 (57.2)	83 (52.5)	0.288
Mixed lesion, n(%)	113 (14.6)	90 (14.6)	23 (14.6)	0.980

(*Continued*)

Table 1 (Continued).

Variables	Total (n=773)	LAR		p
		Low<0.2 (n=615)	High≥0.2 (n=158)	
Acute rupture, n(%)	2(0.3)	1(0.2)	1(0.6)	0.367
Baseline chemistry				
IBIL (umol/L), median (IQR)	7.80(5.30–11.70)	7.80(5.30–11.70)	8.20(5.10–11.50)	0.644
AST (IU/L), median (IQR)	21.00(17.00–27.00)	21.00(17.00–27.00)	21.00(17.00–28.00)	0.737
CHOL (mmol/l), median (IQR)	4.44(3.75–5.24)	4.50(3.80–5.29)	4.30(3.56–5.10)	0.075
TG (mmol/l), median (IQR)	1.15(0.87–1.57)	1.14(0.84–1.57)	1.21(0.96–1.62)	0.048*
Glu (mmol/l), median (IQR)	4.68 (4.22–5.27)	4.67(4.25–5.25)	4.72 (4.13–5.46)	0.887
K(mmol/L), median (IQR)	3.96 (3.70–4.24)	3.97 (3.72–4.23)	3.95 (3.61–4.27)	0.640
Mg (mmol/L), median (IQR)	0.87 (0.82–0.93)	0.88 (0.83–0.93)	0.85 (0.80–0.90)	0.000*
CREA (umol/L), median (IQR)	71.00(61.00–84.00)	70.00(61.00–82.00)	73.00(64.00–89.00)	0.008*
TSH (mIU/L), median (IQR)	2.07 (1.31–3.25)	2.05 (1.32–3.18)	2.17 (1.24–3.52)	0.728
Hb (g/L), median (IQR)	133.00 (122.00–145.00)	133.00 (122.00–145.00)	132.50 (122.00–145.00)	0.655
Plt (10^9/L), median (IQR)	200.50 (167.25–241.00)	195.50 (164.00–238.00)	217.50 (187.00–260.50)	0.000*
LAR, median (IQR)	0.15 (0.12–0.19)	0.14 (0.12–0.16)	0.22 (0.20–0.26)	0.000*
Intraoperative data				
SinoSCORE, median (IQR)	3.00(1.00–5.00)	3.00(1.00–5.00)	3.00(1.00–5.00)	0.884
CPB time(min), median (IQR)	121.00 (93.00–160.00)	120.00 (92.00–159.00)	127.00 (99.00–165.25)	0.060
Alb in Prime(mL), median (IQR)	150.00 (150.00–200.00)	150.00 (150.00–200.00)	150.00 (150.00–200.00)	0.024*
AT(mL), median (IQR)	500.00 (500.00–600.00)	500.00 (500.00–600.00)	500.00 (500.00–600.00)	0.399
Valvuloplasty, n (%)	213(27.3)	169(27.5)	44(27.8)	0.926
Valve replacement, n (%)	560(72.4)	446(72.5)	114(72.2)	0.926
CABG, n(%)	6(0.8)	4(0.7)	2(1.3)	0.781
Aortic surgery, n (%)	34(4.4)	30(4.9)	4(2.5)	0.200
Biological valve, n (%)	178(23.0)	135(22.0)	43(27.2)	0.161
Mechanical valve, n (%)	383(49.5)	312(50.7)	71(44.9)	0.194

Note: * p<0.05.
Abbreviations: HR, heart rate; SBP, systolic blood pressure; DBP, diastolic blood pressure; BMI, body mass index; DM, diabetes mellitus; CHD, coronary heart disease; NVI, number of valves involved; IBIL, indirect bilirubin; AST, aspartate aminotransferase; CHOL, total cholesterol; TG, triglyceride; Glu, glucose; K, potassium; Mg, magnesium; CREA, creatinine; TSH, thyroid stimulating hormone; Hb, hemoglobin; Plt, platelet; LAR, leukocyte albumin rate; SinoSCORE, Sino System for Valve Operative Risk Evaluation; CPB, time Cardiopulmonary bypass time; Alb in Prime, Albumin in Prime; AT, Autotransfusion; CABG, coronary artery bypass grafting.

Postoperative Clinical Outcome Between Different LAR Groups

Among in-hospital outcomes, the incidence of SA was significantly higher in the low LAR group compared to the high LAR group (14.1% vs 5.7%; $p = 0.004$). Conversely, the high LAR group exhibited a higher incidence of AKI, longer MV time, and longer LOS, all with statistically significant differences ($p < 0.05$). However, no significant differences

Table 2 Patient Outcomes Stratified by Leukocyte Albumin Rate

Outcomes	Total	LAR<0.2	LAR≥0.2	*P*-value
In-hospital outcomes				
ACIHM, n (%)	18(2.3)	14 (2.3)	4 (2.5)	1.000
LCOS, n (%)	3 (0.4)	2 (0.3)	1 (0.6)	0.497
SA, n (%)	96 (12.4)	87 (14.1)	9 (5.7)	0.004*
Electrolyte disorders, n (%)	32 (4.1)	25 (4.1)	7 (4.4)	0.837
Coagulopathy, n (%)	10 (1.3)	7 (1.1)	3 (1.9)	0.719
AMI, n (%)	2 (0.3)	1 (0.2)	1 (0.6)	0.367
Stroke, n (%)	12 (1.6)	10 (1.6)	2 (1.3)	1.000
AKI, n (%)	45 (5.8)	30 (4.9)	15 (9.5)	0.027*
ALI, n (%)	64 (8.3)	45 (7.3)	19 (12.0)	0.055
MV Time(h), median (IQR)	18.00(11.13–24.00)	17.00(10.38–23.25)	19.00(15.00–29.25)	0.005*
LOS(d), median (IQR)	17.08(13.87–23.03)	17.00(13.72–22.45)	19.03(15.01–26.24)	0.001*
Long-term outcome				
All-cause readmission, n (%)	64 (8.3)	46(7.5)	18(11.4)	0.111

Note: * p<0.05.

Abbreviations: ACIHM, All-cause in-hospital mortality; LCOS, Low cardiac output syndrome; SA, severe arrhythmia; AMI, acute myocardial infarction; AKI, acute kidney insufficiency; ALI, acute liver insufficiency; MV, Time mechanical ventilation time; LOS, length of stays.

were observed between the groups in ACIMH, LCOS, electrolyte disorders, coagulopathy, AMI, stroke, and ALI ($p > 0.05$). Regarding long-term outcomes, there was no statistically significant difference in all-cause readmission rates between the two groups ($p > 0.05$). The detailed comparison of all outcomes is presented in Table 2.

Multivariate Logistic Regression Analysis Results

Univariate and multivariate logistic regression analyses were conducted to identify factors associated with SA (Table 3). In the univariate analysis, female sex was significantly associated with an increased risk of SA (OR:2.709, 95% CI:1.701–4.314, *p*=0.000). However, after adjustment for age, heart rate, and systolic blood pressure in the multivariate model, female sex emerged as an independent protective factor against SA (OR:0.379, 95% CI:0.210–0.682, *p*=0.001).

Table 3 Results of Univariate and Multivariate Analysis of Severe Arrhythmia

Variables	Univariate Analysis		Multivariate Analysis	
	OR (95% CI)	p value	OR (95% CI)	p value
Age (y)	1.043(1.020–1.066)	0.000*	1.034(1.007–1.062)	0.015*
Female	2.709(1.701–4.314)	0.000*	0.379(0.210–0.682)	0.001*
HR (beats/min)	1.015(1.002–1.028)	0.020*	1.022(1.008–1.037)	0.003*
SBP (mmHg)	0.981(0.968–0.993)	0.003*	0.991(0.976–1.006)	0.247
DBP (mmHg)	1.002(0.987–1.019)	0.759		

(*Continued*)

Table 3 (Continued).

Variables	Univariate Analysis		Multivariate Analysis	
	OR (95% CI)	p value	OR (95% CI)	p value
BMI (kg/m2)	0.888(0.828–0.952)	0.001*	0.948(0.874–1.029)	0.205
Hypertension	0.797(0.457–1.388)	0.422		
DM	0.936(0.388–2.257)	0.883		
CHD	0.917(0.270–3.115)	0.890		
Stenosis	1.820(1.171–2.828)	0.008*	0.801(0.420–1.529)	0.502
Insufficiency	0.486(0.314–0.750)	0.001*	0.624(0.326–1.195)	0.155
Stenosis with insufficiency	1.530(0.885–2.645)	0.128		
IBIL (umol/L)	0.980(0.944–1.018)	0.301		
AST (IU/L)	1.005(0.995–1.015)	0.361		
CHOL (mmol/l)	0.769(0.626–0.945)	0.013*	0.825(0.660–1.032)	0.092
TG (mmol/l)	0.875(0.663–1.154)	0.344		
Glu (mmol/l)	0.993(0.823–1.199)	0.942		
K (mmol/L)	0.964(0.576–1.614)	0.890		
Mg (mmol/L)	0.649(0.046–9.223)	0.750		
CREA (umol/L)	1.009(1.000–1.018)	0.046*	1.020(1.006–1.034)	0.005*
TSH (mIU/L)	1.023(0.954–1.097)	0.525		
Hb (g/L)	0.996(0.985–1.008)	0.549		
Plt (10^9/L)	1.000(0.996–1.003)	0.858		
LAR≥0.2	0.367(0.180–0.746)	0.006*	0.231(0.103–0.518)	0.000*
SinoSCORE	1.206(1.133–1.284)	0.000*	1.105(1.015–1.204)	0.022*
CPB time (min)	1.001(0.997–1.004)	0.784		
Alb in Prime (mL)	0.990(0.981–0.999)	0.030*	0.989(0.979–1.000)	0.044*
AT (mL)	1.002(1.000–1.003)	0.042*	1.002(1.001–1.004)	0.008*
Valvuloplasty	0.808(0.491–1.328)	0.400		
Valve replacement	1.238(0.753–2.037)	0.400		
CABG	3.580(0.647–19.813)	0.144		
Aortic surgery	0.205(0.028–1.519)	0.121		
Biological valve	1.283(0.790–2.084)	0.314		
Mechanical valve	0.973(0.635–1.493)	0.902		

Note: * $p<0.05$.

Abbreviations: OR, odds ratio; CI, confidence interval; HR, heart rate; SBP, systolic blood pressure; DBP, diastolic blood pressure; BMI, body mass index; DM, diabetes mellitus; CHD, coronary heart disease; IBIL, indirect bilirubin; AST, aspartate aminotransferase; CHOL, total cholesterol; TG, triglyceride; Glu, glucose; K, potassium; Mg, magnesium; CREA, creatinine; TSH, thyroid stimulating hormone; Hb, hemoglobin; Plt, platelet; LAR, leukocyte albumin rate; SinoSCORE, Sino System for Valve Operative Risk Evaluation; CPB time, Cardiopulmonary bypass time; Alb in Prime, Albumin in Prime; AT, Autotransfusion; CABG, coronary artery bypass grafting.

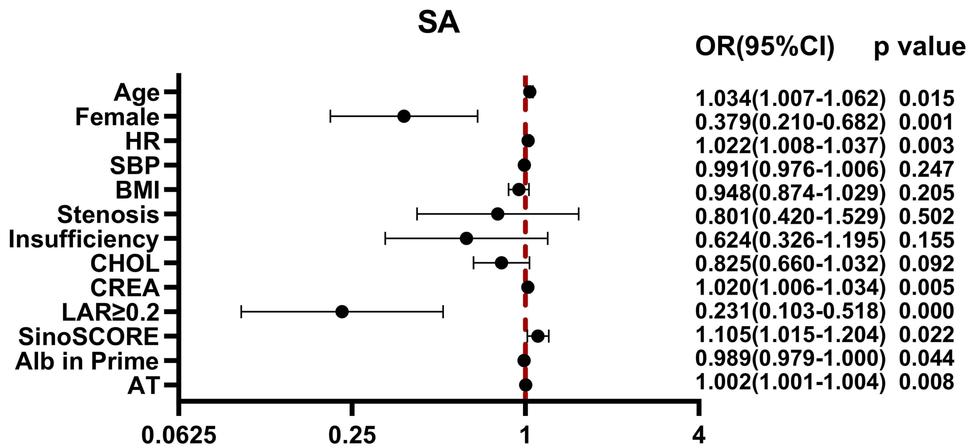

Figure 2 Predictors of SA in patients undergoing cardiac valvular surgery. Forest plot for the effects sizes of individual predictors of SA in patients undergoing cardiac valvular surgery.

Abbreviations: SA, severe arrhythmia; HR, heart rate; SBP, systolic blood pressure; BMI, body mass index; CHOL, total cholesterol; CREA, creatinine; LAR, leukocyte albumin rate; SinoSCORE, Sino System for Valve Operative Risk Evaluation; Alb in Prime, Albumin in Prime; AT, Autotransfusion.

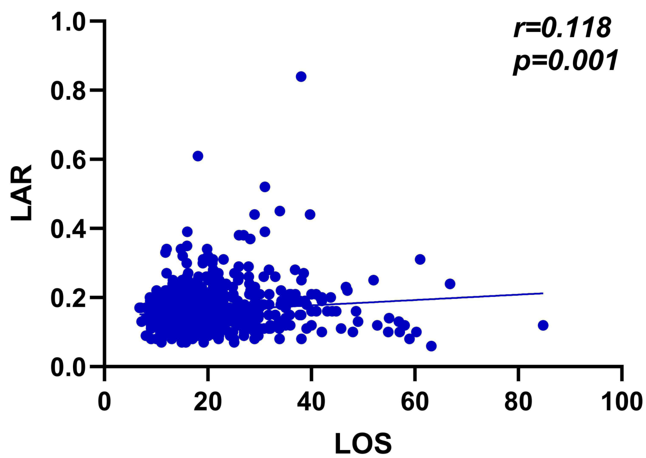

Figure 3 Analysis of the correlation between LOS and LAR.

Abbreviations: LOS, length of stays; LAR, leukocyte albumin rate.

Additionally, multivariate analysis identified age (OR:1.034, 95% CI:1.007–1.062, p=0.015), HR (OR:1.022, 95% CI:1.008–1.037, p=0.003), CREA (OR:1.020, 95% CI:1.006–1.034, p=0.005), SinoSCORE (Sino System for Valve Operative Risk Evaluation) (OR:1.105, 95% CI:1.015–1.204, p=0.022), and AT (OR:1.002, 95% CI:1.001–1.004, p=0.008) as independent risk factors for SA. In contrast, LAR $\geq$ 0.2 (OR:0.231, 95% CI:0.103–0.518, p=0.000) and Alb in prime (OR:0.989, 95% CI:0.979–1.000, p=0.044) were identified as independent protective factors (Figure 2).

Multivariate Linear Regression Analysis Results

Pearson correlation analysis showed a significant correlation between LAR and LOS (p=0.001), as shown in Figure 3. The results of the multiple linear regression analysis of LOS are shown in Table 4. The results indicated that LOS was positively correlated with LAR (B=16.453, t=3.090, p=0.002), age (B=0.107, t=3.387, p=0.001), NVI (B=1.621, t=3.304, p=0.003), Sinoscore (B=0.451, t=3.849, p=0.000), and MV time (B=0.042, t=7.240, p=0.000). Furthermore, there was no multicollinearity among the influencing factors (VIF<5). Model analysis showed that the independent variables explained 18.9% of the variability in the dependent variable LOS (R2=0.189, adjusted R2=0.173), and the regression model was statistically significant (F=11.662, p<0.001).

Table 4 Multiple Linear Regression Analysis of Length of Stays in Patients Undergoing Cardiac Valvular Surgery

	B	t	*P*-value	95% CI
Constant	10.217	1.829	0.068	−0.748~21.182
Age (years)	0.107	3.387	0.001*	0.045~0.170
HR (beats/min)	0.042	1.936	0.053	−0.001~0.084
SBP (mmHg)	−0.035	−1.803	0.072	−0.074~0.003
DBP (mmHg)	−0.042	−1.586	0.113	−0.095~0.010
BMI (kg/m2)	0.108	1.111	0.267	−0.083~0.298
NVI	1.621	3.034	0.003*	0.572~2.670
SinoSCORE	0.451	3.849	0.000*	0.221~0.681
Alb in Prime (mL)	−0.012	−0.956	0.339	−0.036~0.012
AT (mL)	−0.002	−0.766	0.444	−0.007~0.003
MV Time(h)	0.042	7.240	0.000*	0.030~0.053
TG (mmol/l)	−0.533	−1.894	0.059	−1.085~0.019
Mg (mmol/L)	1.267	0.310	0.756	−6.746~9.280
CREA (umol/L)	0.021	1.317	0.188	−0.010~0.051
Plt (10^9/L)	−0.003	−0.627	0.531	−0.014~0.007
LAR	16.453	3.090	0.002*	6.001~26.905

Note: * $p<0.05$.
Abbreviations: HR, heart rate; SBP, systolic blood pressure; DBP, diastolic blood pressure; BMI, body mass index; NVI, number of valves involved; SinoSCORE, Sino System for Valve Operative Risk Evaluation; Alb in Prime, Albumin in Prime; AT, Autotransfusion; MV, Time mechanical ventilation duration; TG, triglyceride; Mg, magnesium; CREA, creatinine; Plt, platelet; LAR, leukocyte albumin rate.

Discussion

In this study, we investigated the correlation between LAR and patients' postoperative outcomes by retrospectively analysing the clinical data of 773 cardiac valve surgery patients. The main findings included that LAR ≥ 0.2 was an independent protective factor for SA, but was also significantly associated with increased risk of AKI, prolonged MV time and prolonged LOS. However, multifactorial logistic regression analysis showed that high LAR was not an independent risk factor for AKI (OR=1.919, 95% CI:0.942–3.910; p=0.073). Multifactorial analysis further confirmed that LAR was independently and positively associated with LOS (B=16.453, t=3.090, p=0.002). These results suggest that LAR may have a complex two-sided role in the perioperative management of cardiac valve surgery.

Multifactorial logistic regression analysis showed that LAR≥0.2 was an independent protective factor for SA (OR:0.231, 95% CI:0.103–0.518, *p*=0.000). This finding may be related to the balance between immune and nutritional status as reflected by LAR. Fabrice et al[10] also found that LAR was an independent predictor of the severity of atrial fibrillation (OR:0.657, 95% CI:0.549–0.787; *p*=0.000), which may be related to the activation of inflammatory response in cardiovascular and cerebrovascular damage and the corresponding antagonistic pathways. The interaction between white blood cells and albumin leads to the accumulation of white blood cells in the vascular wall, myocardium, and other organs, with these proteins adhering to endothelial cells that are prone to plaque formation.[16] White blood cells infiltrate the cardiac tissue of atrial fibrillation patients and release enzymes such as matrix metalloproteinases (MMPS) and protease-activated receptors (PARs), which can degrade collagen.[17] Collagen, as an important component of cardiac connective tissue, its degradation severely affects the electrical conduction properties of cardiac myocytes, thereby promoting the occurrence and persistence of atrial fibrillation.[18] Furthermore, this study found that patients in the low LAR group had a significantly higher heart rate (85.13±17.19vs.79.71±15.10, p=0.000). Research by Yuhui et al indicated that the time within the target range of resting heart rate independently predicts the risk of cardiovascular outcomes in patients with atrial fibrillation.[19] Since elevated heart rate is itself a recognized risk factor for atrial fibrillation, this finding may partially account for the difference in the incidence of SA between the two groups.

In this study, the mean LOS of VHD patients was 17.08 (13.87–23.03) days. Multifactorial linear regression showed that for each unit increase in LAR, age, NVI, SinoSCORE, and MV time, LOS increased by 16.453, 0.107, 1.621, 0.451, and 0.042 days, respectively. Multifactorial linear regression identified LAR as the strongest independent predictor of prolonged LOS among the variables analyzed, with each unit increase in LAR corresponding to an additional 16.5 days of hospitalization. This effect size was substantially greater than that of other established predictors such as age, NVI, SinoSCORE, and MV time. The magnitude of this association underscores the profound clinical impact of a elevated pre-operative LAR, potentially identifying a patient subgroup in a state of immunonutritional depletion that severely impedes recovery. The LAR likely encapsulates a deleterious synergy between chronic immune activation (lymphocytosis) and impaired nutritional synthesis (hypoalbuminemia), leading to reduced resilience and heightened vulnerability to post-operative complications. Several studies have shown that LOS is influenced by a variety of factors, such as age, grip strength, comorbidities, and degree of infection.[20,21] A study by Horatiu et al demonstrated that leukocytes are a biological parameter that predicts LOS.[22] High preoperative albumin promotes incision healing, whereas low albumin leads to multiple complications and even death.[23] Consequently, pre-operative LAR assessment could serve as a potent tool for risk stratification, enabling early targeted interventions to optimize patient outcomes and resource allocation. Therefore, inflammation should be aggressively controlled and high-protein foods should be provided during the perioperative period to improve incision healing and shorten LOS.

This study systematically explored risk and protective factors associated with SA using both univariate and multi-variate logistic regression analyses. The results revealed that female sex emerged as a protective factor against SA after multivariate adjustment (OR:0.379, 95% CI:0.210–0.682, p=0.001), a finding consistent with previous research by Fabrice et al.[10] The protective effect observed in females may be attributed to factors such as hormonal levels, immunoregulatory mechanisms, or socio-behavioral characteristics, though the exact underlying mechanisms require further investigation.[24–26] Evidence suggests that estradiol may confer protection against atrial fibrillation by modulating mitochondrial calcium homeostasis, indicating a potential biological pathway involved.[27] Based on these findings, it is recommended to implement sex-differentiated strategies during perioperative management and postoperative follow-up, with particular attention to the specific needs of female patients, in order to optimize care quality and preventive measures.

In addition to gender, Alb in prime was also an independent protective factor for SA, suggesting that maintenance of albumin as an indicator of nutritional and inflammatory status contributes to a lower risk of SA and may be related to oncotic pressure maintenance, anti-inflammatory and antioxidant effects.[28,29] This study identified age, heart rate, creatinine, SinoSCORE and AT as independent risk factors for SA following valve surgery. Increasing age was associated with a corresponding rise in SA risk, which is a well-established risk factor in cardiovascular surgery,[30] likely reflecting the accumulated burden of comorbid conditions and a gradual decline in cardiac physiological function. An elevated heart rate often indicates sympathetic activation or cardiovascular stress, a known trigger for arrhythmias,[31] demonstrating a close pathophysiological relationship with the occurrence of SA. Higher creatinine levels typically reflect impaired renal function, which may indirectly contribute to SA development through systemic inflammation or metabolic disturbances. Although an elevated SinoSCORE suggests a complex, multifactorial risk profile for SA, this contrasts with Chen et al,[32] who reported poor predictive accuracy for the model. Differences in cohort characteristics or procedural techniques may explain this divergence. Although the absolute changes in AT were modest, its significance as a continuous variable underscores that even minor alterations may exert a cumulative effect on SA risk. Therefore, early identification of predictive factors for SA after heart valve surgery can enable healthcare providers to take targeted preventive measures before surgery and carry out effective perioperative management to improve patients' prognosis.

White blood cells and albumin are derived from blood samples obtained through routine clinical tests. This analytical method is simple and low-cost, yet it can provide rich information to help doctors diagnose and monitor various diseases. As a novel biomarker, LAR may contribute to the early prognosis of VHD patients and play a role in doctors' treatment decisions. Furthermore, monitoring LAR before surgery not only does not increase medical costs but also provides potential medical value. If applied in clinical practice, these values may have strong economic significance.

Limitations

This study has several limitations. First, its retrospective design may introduce uncontrollable biases. Second, the low event rates for certain clinical outcomes (eg, LCOS, coagulopathy, AMI, and stroke) may result in insufficient statistical power and increase the risk of Type II errors. Third, long-term follow-up relied solely on all-cause readmission rates, lacking assessment of valve heart disease-specific endpoints (such as prosthetic valve dysfunction, endocarditis, reoperation, or heart failure), which limits the interpretation of LAR's long-term predictive value. Additionally, the absence of detailed patient medication information (particularly antibiotics and thromboprophylaxis) hindered a thorough analysis of potential confounding effects. Finally, the lack of ROC curve analysis or comparison with established biomarkers impedes a comprehensive evaluation of LAR's discriminative ability. Future studies should incorporate longer-term, VHD-specific endpoints, detailed medication records, and external validation in larger cohorts to further verify the predictive utility of LAR.

Conclusions

In conclusion, this study suggests that an elevated LAR (≥0.2) may serve as a dual-effect perioperative risk biomarker, being independently associated with a reduced risk of SA but a longer LOS. These findings support its potential for early identification of high-risk patients and could inform individualized management strategies, though these applications require further validation in prospective studies with long-term follow-up.

Data Sharing Statement

All data can be obtained from the corresponding author upon reasonable request. Specifically, the data is available from Yanjuan Lin.

Ethics Approval and Consent to Participate

This study adheres to the Helsinki Declaration and has obtained approval from the Medical Ethics Committee of Fujian Medical University Union Hospital (Ethics Number: 2024KY114). This was a retrospective study and therefore informed consent was waived. In conducting this research project, we uphold the highest standards and a steadfast commitment to the confidentiality, security, and privacy protection of all patient medical record data.

Consent for Publication

Patient information was hidden in our study.

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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. Liangwan Chen and Yanjuan Lin contributed equally to this work and should be considered as co-corresponding authors.

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Disclosure

The authors declare no competing interests.

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