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RESEARCH ARTICLE

Relationship Between Platelet-to-Lymphocyte Count Ratio and Acute Kidney Injury Following Surgery of Stanford Type A Aorta Dissection

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Abstract

Objective The aim of this study was to evaluate the correlation between the hematological index of platelet to lymphocyte ratio (PLR) and the occurrence of acute kidney injury (AKI) following surgery of Stanford acute type A aorta dissection (ATAAD).

Methods We analyzed the perioperative data of patients with ATAAD who were treated surgically in Fujian Provincial Hospital from December 2016 to December 2021.

Results Patients were divided into AKI (n = 66) and non-AKI (n = 36) groups based on the Kidney Disease: Improving Global Outcomes (KDIGO). There was no difference in preoperative PLR values (T0 PLR). In addition, the PLR within 24 h (T1 PLR) following surgery was higher in the AKI group than in the non-AKI group ($P = 0.001$). Reintubation rates, intensive care unit (ICU) stay, and 30-day mortality were significantly different in the AKI group ($P = 0.004$, $P = 0.002$ and $P = 0.002$). Multivariate analyses showed that higher body mass index (BMI) and reduced T1 PLR were the risk factors for postoperative AKI. Receiver operating characteristic (ROC) curve analysis revealed that the decline in the cut-off level of T1 PLR predicted AKI:144.6, the area under the curve (AUC):[95%*CI*] 0.7146, 0.6112–0.8181, and $P = 0.0004$, with a sensitivity of 58.33% and a specificity of 77.27%.

Conclusions This retrospective study demonstrated that a decreased T1 PLR after surgery is a risk factor for the occurrence of postoperative AKI in ATAAD patients and has possible predictive value for AKI.

Keywords Acute aorta dissection · Acute kidney injury · PLR

1 Background

Stanford acute type A aortic dissection (ATAAD) is a life-threatening cardiovascular disease and the most frequent dissection with high mortality. Even with immediate surgical intervention, ATAAD mortality remained high [1]. Moreover, the most common complication is acute kidney injury (AKI) which is one of Cardiac surgery-associated acute kidney injury(CSV-AKI). The reported incidence of AKI after ATAAD surgery is 18–65% [2, 3]. The pathophysiology of CSV-AKI is very complex and probably includes renal ischaemia–reperfusion injury, inflammation, oxidative stress, haemolysis and nephrotoxins [4]. As we know, ATAAD can induce a systemic inflammatory response, which leads to multiple organ damage and thus, influence prognosis [5]. After acute aortic dissection, mechanical damage to the aortic wall stimulates neutrophil, chemokine and granulocyte colony-stimulating factor expression, inducing neutrophil proliferation; a large number of neutrophils

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are recruited to the dissected vascular wall, releasing IL-6 and MMP-9, thereby promoting the outer membrane inflammatory reaction process [6–8]. Platelet to lymphocyte ratio (PLR) as a novel inflammatory biomarker has been widely studied and considered one of the predictors of acute exacerbations of chronic obstructive pulmonary disease(AECOPD),arteriosclerotic heart disease(AHF),acute coronary syndromes (ACS), sepsis, and renal disease prognosis [9–13]. However, to the best of our knowledge, no research has examined the relationship between PLR and the incidence of AKI following ATAAD surgery. Therefore, we hypothesize that PLR can predict the incidence of AKI.

2 Methods

All patients were diagnosed by preoperative thoracoabdominal aortic angiography (CTA) examination. Inclusion criteria were as follows: ① age ≥ 18 years; ② surgical treatment; ③ need for in-patient intensive care unit (ICU) monitoring and treatment; and ④ no chronic renal insufficiency or required renal replacement therapy (RRT) before this visit. Exclusion criteria were as follows: ① age < 18 years; ② intraoperative death. We conducted a retrospective study, which neither interfered with patients' treatment plans nor brought risks to patients' physiology and collected only clinical data. We protected patient confidentiality and applied for an exemption from informed consent. The flowchart of the research process is shown in Fig. 1.

2.1 Data Collection

The demographic data of the patients included: gender, age, body mass index (BMI), smoking status, underlying diseases such as diabetes and hypertension. Preoperative clinical assessment included whether there was a combination of shock and renal artery tear, and whether the surgical status was emergency or elective. Intraoperative indices included duration of surgery, the duration of cardiopulmonary bypass (CBP) and aortic cross-clamping time (AOT) and the deep hypothermic circulatory arrest (DHCA) time. Laboratory indicators comprised of preoperative lymphocyte and platelet levels (T0 PLR) and the preoperative level of creatinine clearance (T0 CCR), Perioperative renal function insufficient, postoperative within 24 h lowest platelet to lymphocyte ratio value (T1 PLR), and serum albumin levels. Postoperative data comprised the length of ICU stay, reintubation rate, needs for RRT, and 30-day mortality. The worst value was selected if more than one outcome was available.

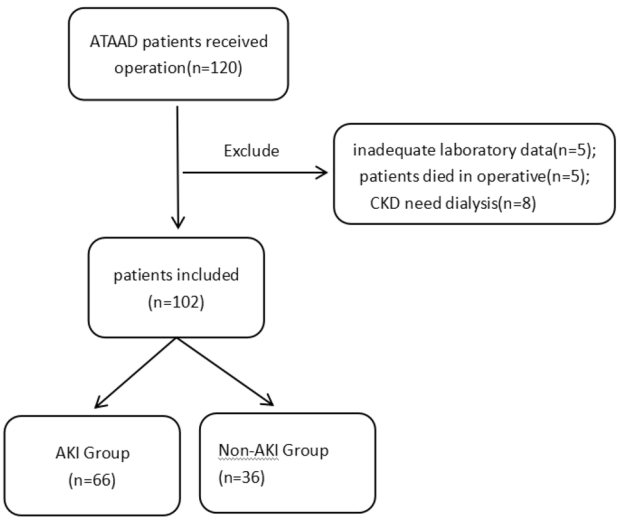

Fig. 1 Flowchart of patient inclusion

2.2 Definitions

This study classified patients by their highest sCr levels within seven days after surgery. Furthermore, AKI was diagnosed according to the 2012 Kidney Disease: Improving Global Outcomes (KDIGO) criteria as follows, stage1: sCr increases by 0.3 mg/dL or 1.5–1.9 times the preoperative value within 48 h; stage 2: sCr increases by 2.0–2.9 times the preoperative value; stage 3: sCr increases by greater than or equal to 3.0 times the preoperative value or 4.0 mg/dL or RRT is initiated. The last highest sCr before surgery was used as a baseline value, and all AKI stages based on KDIGO criteria were analyzed.

Hypoalbumin refers to postoperative serum albumin levels below 30 g/L.

2.3 Statistical Analysis

The statistical software SPSS 23.0 and GraphPad Prism 9.3.0 were used to analyze the data. The mean ± standard deviation was used for measurement data conforming to a normal distribution, and the independent sample t-test was used to compare groups. Furthermore, nonparametric continuous variables were expressed as median (interquartile range) [M(IOR)], and the rank sum test was used for comparison between groups; the count data were expressed as [n (%)], and the x^2 test was used. The variables with statistically significant differences were analyzed by univariate analysis, and the risk factors for the occurrence of postoperative AKI were analyzed by multivariate logistic regression analysis. Receiver operating characteristic (ROC) curves were plotted to calculate the sensitivity and specificity of PLR in assessing patient prognosis and the value of PLR in evaluating the occurrence of AKI in ATAAD patients. $P < 0.05$ represented a statistical significant difference.

3 Results

A total of 120 ATAAD patients who underwent surgery in our center between December 2016 and December 2021 were included. However, 15 patients (12.5%) were excluded due to inadequate laboratory data, 5 patients (4.17%) died in operation, and 8 patients (6.67%) were excluded because of preoperative chronic kidney disease necessitating dialysis. Finally, 102 patients including 75 males were enrolled in this study. The demographic features and preoperative blood parameters of the study subjects are reported in Table 1. Medical histories included hypertension (62.70%), diabetes (5.88%), and Marfan syndrome (11.77%). Overall, 59 patients (57.84%) underwent emergency surgery. Of the 102 patients, 66 (64.71%) exhibited AKI, and 19 (18.63%) AKI patients required RRT. Univariate analysis of the preoperative platelet counts (T0 platelet), lymphocyte counts (T0 lymphocyte), and PLR (T0 PLR) revealed no statistical difference ($P > 0.05$), and the intraoperative duration of the CBP, AOT, duration of surgery time, DHCA time and red blood cell infusion between the two groups were not different ($P > 0.05$). The PLR within 24 h (T1 PLR) and BMI were different ($P < 0.05$).

The length of ICU stays, reintubation rates, and need for RRT in the AKI group were significantly higher than that of the non-AKI group ($P < 0.05$). Myasthenia, postoperative coma, and total hospital stay were not statistically significant ($P > 0.05$) (Table 2).

Multivariable regression analysis was utilized to assess the risk factors of AKI in ATAAD patients after surgery. Indicators with $P < 0.2$ from the univariate analysis were included in the multifactorial regression analysis. Analysis showed that BMI (odds ratio 1.187; 95% *CI* 1.009–1.396, $P = 0.038$) and T1 PLR (odds ratio 0.996; 95% *CI* 0.993–1.000, $P = 0.035$) were risk factors for postoperative AKI in ATAAD patients after surgery (Fig. 2).

ROC curves were utilized to evaluate the predictive efficacy of T1 PLR for postoperative AKI in ATAAD patients. Results showed that the area under the curve (AUC) of AKI following ATAAD predicted by T1 PLR was 0.7146 (95% *CI* 0.6112–0.8181, $P = 0.0004$) with a sensitivity of 58.33% and a specificity of 77.27% (Fig. 3).

Perioperative renal function insufficient: The preoperative serum creatinine exceeded the upper limit

BMI body mass index, *T0* preoperative time, *T0 PLR* preoperative platelet to lymphocyte ratio, *AKI* acute kidney injury, *Non-AKI* none acute kidney injury, *T0 CCR* the preoperative level of creatinine clearance

Table 1 Baseline characteristics of study population

Characteristics	AKI Group (N = 66)	Non-AKI Group (N = 36)	$t/z/x^2$	*P*
Age (years) (mean ± sd)	54.45 ± 11.8	53.22 ± 13.09	*t = 0.485*	0.629
Male/female, n/n	53/13	22/14	$x^2 = 4.408$	0.036
Height (m) (mean ± sd)	1.69 ± 0.07	1.69 ± 0.08	*t = -0.207*	0.836
Weight (kg) (mean ± sd)	72.97 ± 14.65	67.61 ± 12.33	*t = 1.864*	0.065
BMI (kg/m^2) (mean ± sd)	25.52 ± 4.45	23.52 ± 3.20	*t = 2.377*	0.019
Smoking, n (%)	14 (21.2%)	7(19.4%)	$x^2 = 0.045$	0.833
Hypertension, n (%)	46 (69.7%)	18 (50%)	$x^2 = 3.866$	0.049
Diabetes mellitus, n (%)	4 (6.06%)	2 (5.56%)	$x^2 = 0.000$	1.000
Marfan syndrome, n (%)	5 (7.6%)	7 (19.44%)	$x^2 = 2.121$	0.145
T0 Lymphocyte (109/L) (M(IQR))	1.5 (1.5)	1.50 (1.2)	*z = − 1.143*	0.253
T0 Platelet (109/L) (M(IQR))	198.50 (81.00)	186.50 (53.00)	*z = − 0.144*	0.886
T0 PLR (109/L) (M(IQR))	127.89 (112.97)	144.14 (132.49)	*z = − 1.372*	0.170
AOT(min)(mean ± sd)	167.17 ± 49.10	178.72 ± 45.45	*t = − 1.165*	0.247
Duration of surgery (min) (mean ± sd)	583.69 ± 216.143	516.67 ± 90.738	*t = 0.504*	0.628
CPB (min) (M(IQR))	282.50 (91.00)	285.00 (85.00)	*t = 0.508*	0.785
Perioperative renal function insufficient, n (%)	27 (40.91%)	4 (11.1%)	$x^2 = 9.777$	0.002
T0 CCR (ml/min) (M(IQR))	98.86 (49.42)	74.15 (46.70)	*z = − 2.339*	0.019
Shock preoperative, n (%)	9 (13.6%)	2 (5.6%)	$x^2 = 1.581$	0.209
Renal artery tear, n (%)	19 (28.8%)	11 (30.6%)	$x^2 = 0.035$	0.851
Emergent surgery, n (%)	42 (63.6%)	17 (47.2%)	$x^2 = 2.574$	0.109

Table 2 Intraoperative and postoperative outcomes of patients with and without AKI after surgery for ATAAD

Characteristics	AKI group (N = 66)	Non-AKI Group (N = 36)	t/*z*/x^2	*P*
T1 Lymphocyte (10^9/L) (M(IQR))	0.8 (0.7)	0.60 (0.40)	*z* = − 2.966	*0.003*
T1 Platelet (10^9/L) (M(IQR))	69.5 (59.00)	105.50 (74.00)	*z* = − 3.235	*0.001*
T1 PLR (10^9/L) (M(IQR))	87.35 (101.13)	184.00 (222.28)	*z* = − 3.571	*0.001*
Hypoalbumin, n (%)	16 (24.24)	45 (68.18)	×2 = 5.460	*0.019*
RBC infusion intraoperative (ml) (M(IQR))	480 (470)	480 (480)	*z* = − 0.741	*0.459*
DHCA (min) (M(IQR))	35 (26)	38 (22)	*z* = − 0.084	*0.933*
30 day-mortality, n (%)	22 (33.3%)	2 (5.6%)	x^2 = 9.989	*0.002*
Coma postoperative, n (%)	15 (23.1)	1 (2.8)	x^2 = 7.161	*0.007*
Reintubation, n (%)	13 (20%)	0 (0)	x^2 = 8.264	*0.004*
Myasthenia, n (%)	18 (27.3%)	4 (11.1%)	x^2 = 3.597	*0.058*
ICU-stay (h) (M(IQR))	176.63 (228.21)	88.79 (81.46)	*z* = − 3.053	*0.002*
RRT needs,n(%)	19 (28.8%)	0 (0)	x^2 = 10.908	*0.001*
Hospital-stay(hour) (M(IQR))	19.5 (21)	23.5 (15)	*z* = − 1.734	*0.083*

AOT aortic cross-clamping time, *CPB* cardiopulmonary bypass, *DHCA* deep hypothermia circulatory arrest, *Hypoalbumin* postoperative albumin level < 30 g/L, *RBC* red blood cell, *RRT* renal replacement therapy, *T1* postoperative within 24 h, *T1 PLR* postoperative within 24 h lowest platelet to lymphocyte ratio value

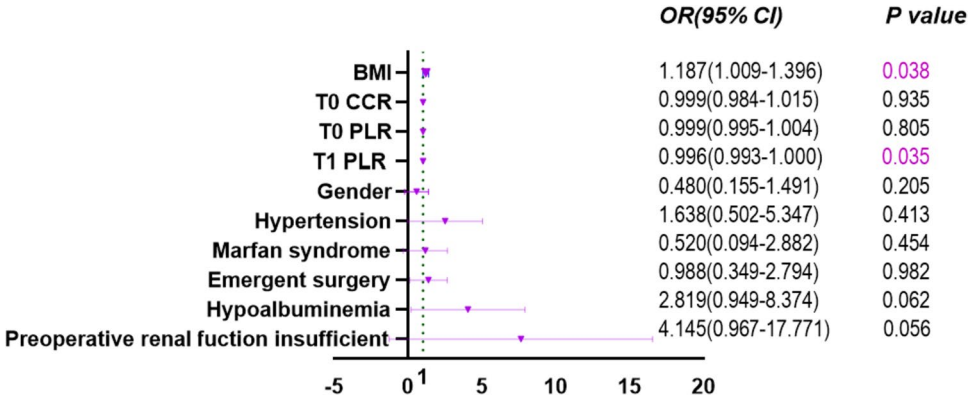

Fig. 2 Forest plot for multivariable analysis of patient related risk factors for AKI following surgery for ATAAD

4 Discussion

AKI is one of the most common complications after cardiac extracorporeal circulation procedures resulting in prolonged hospitalization and increased mortality. The occurrence of AKI after cardiac surgery is 40.6–52.7% [3, 14, 15].In this study, the incidence of AKI after ATAAD operation was 64.7%, but the number of patients who needed RRT treatment was 19 (18.6%), consistent with Tian yu Zhou's study [16].However, AKI prevalence was 64.7% in our study, which is relatively high because we included patients of all stages based on the KIDGO criteria, including those with renal failure and requiring RRT.

Platelets have a pro-inflammatory effect and can release self-stored pro-inflammatory factors after platelet activation. In recent years, a lot of studies have confirmed that platelets participate in inflammatory reactions by the release of IL-6 and IL-1 after platelet activation. They induce the expression of monocytes, promote their adhesion to endothelial cells, and synthesize TNF- and IL-6. This suggests that platelet activation is involved in the systemic inflammatory response process of aortic dissection [17, 18].

Numerous studies have explored the pathophysiology of cardiac surgery-associated acute kidney injury, which include inflammation [19], oxidative stress, ischemia–reperfusion injury, surgical trauma, blood exposed to the artificial surface of CPB circuit, etc. [20, 21]. A reduction in platelet counts is observed after CPB [22]. Studies have shown that decreased platelet counts increases the risk of AKI [23, 24]. In our study, we found that the postoperative early PLR were significantly low in patients with AKI. Multivariate logistic regression analysis showed that the postoperative reduced PLR within 24 h is a risk factor for the occurrence of AKI in ATAAD patients, which could be used as a predictor of AKI

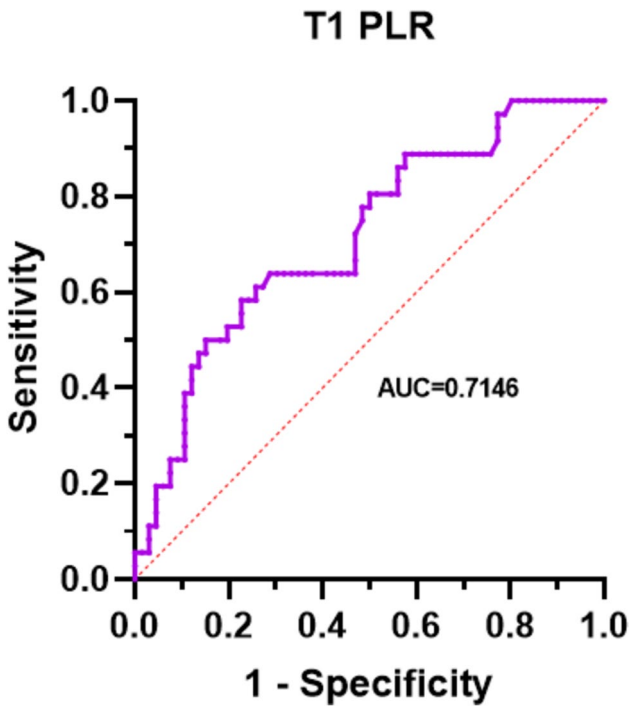

Fig. 3 ROC curve and AUC (area under the curve) for T1 PLR to predict AKI (T1 PLR cut-off level: 0.3257, AUC 0.7146, 95% CI 0.6112–0.8181, $P=0.0004$, sensitivity 58.33%, specificity 77.27%)

in ATAAD patients after surgery. The ROC curve analysis suggested that T1 PLR can predict the incidence of AKI in ATAAD patients after surgery. Chen-Fei Zheng observed that both low and high PLR were increased the 30-day and 90-day mortality [25]. As different design of the study protocol, we did not classify PLR into low and high PLR, and did not study their correlation with the occurrence of postoperative AKI. We found that the T1 PLR in the AKI group was lower than that in the non-AKI group, and T1 PLR had some predictive value for the occurrence of AKI. There are no differences in T0 PLR between the two groups. Hakan Parlar found that a greater inflammatory response is triggered in patients who will develop AKI in later days after surgery [23]. Maybe the inflammation reaction had not reached its peak, the inflammation indicators had no predictive value at preoperative. Moreover, the different surgical method selection and postoperative monitoring measures, can result in conflicting results.

Based on multivariate logistic regression analysis, Higher BMI was a contributor to AKI development. Higher BMI was associated with AKI. In fact, several studies have shown that obesity is associated with a high incidence and severity of AKI [26, 27]. However, the exact mechanism remains unclear. Some studies reported that the expression of inflammatory cytokines, including C-reactive protein (CRP), interleukin (IL)-1β, IL-6, white blood count (WBC) and tumor necrosis factor-α(TNF-a) in acute aorta dissection (AAD) patients remarkably increased in obese patients compared with non-obese AAD patients [28, 29]. Obesity play a role in the production of reactive oxygen species and oxidative stress [30]. It is reasonable to assume that patients with a high inflammatory state are more susceptible to AKI due to oxidative stress. In the future, more targeted and prospective studies such as dynamic monitoring of changes in inflammatory mediators in obese patients and changes in inflammatory mediators when AKI occurs, are needed to validate our hypothesis.

In the multivariate analysis, several variables which were associated with AKI in the univariate analysis were not significant. Gender, hypertension, T0 PLR, AND hypoalbumin were not risk factors. At the same time, we found that the duration of CPB and AOT is not an independent risk factors for AKI, which is in contrast to other studies [7, 12, 13, 31, 32]. The conflicting research results may be due to differences in cardiopulmonary bypass and surgical techniques. In our study, the duration of cardiopulmonary bypass time was 282.50 (91.00) min, and the aortic occlusion time was 167.17 ± 49.10 min, which were longer than other study [33, 34]. Furthermore, different results may also be obtained due to the choice of population and sample size.

5 Limitations

There are some limitations to our study. First, due to the difference in individual medical treatment, we could not acquire the real baseline sCr values of the patients; instead, we used admission sCr as the baseline value, which might have underestimated the incidence of AKI. Secondly, this is a single-center retrospective study with small sample size. Consequently, a larger sample size and prospective randomized trials are required to confirm the association between the prevalence of AKI and PLR levels.

6 Conclusions

This retrospective study verified that decreased T1 PLR after surgery was associated with the occurrence of postoperative AKI in ATAAD patients. Therefore, it has some predictive value for AKI. Moreover, PLR could be a useful parameter for describing systemic inflammation.

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Author Contributions XD made a substantial contribution to the concept or design of the work and drafted the article; YC revised the article critically for important intellectual content; XZ and LZ contributed to

the data collection and data analysis; XZ approved the version to be published.

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Data Availability The data that support the findings of this study are available from the corresponding author upon reasonable request.

Declarations

Conflict of Interests The Authors declare that there is no conflict of interest.

Ethical Approval The study was also approved by the Ethics Commission of Fujian provincial Hospital (K2021-03–072). The Ethics Commission of Fujian provincial Hospital waived the requirement for obtaining informed consent.

Consent to Participate The data are anonymous, and the requirement for informed consent was therefore waived.

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