Journal of Inflammation Research

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ORIGINAL RESEARCH

Elevated Serum Uric Acid/Albumin Ratio as a Predictor of Post-Contrast Acute Kidney Injury After Percutaneous Coronary Intervention in Patients with ST-Segment Elevation Myocardial Infarction

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Background: The serum uric acid/albumin ratio (sUAR), a novel inflammatory marker, effectively predicts acute kidney injury (AKI) and cardiovascular outcomes. However, whether the sUAR predicts post-contrast acute kidney injury (PC-AKI) in patients with ST-segment elevation myocardial infarction (STEMI) undergoing percutaneous coronary intervention (PCI) remains uncertain. In this study, we evaluated the association between the sUAR and PC-AKI in patients with STEMI undergoing PCI.

Methods: We consecutively recruited patients with STEMI who underwent PCI and stratified them into three groups according to the terciles of the sUAR. The primary outcome was the incidence of PC-AKI. The association between the sUAR and PC-AKI was assessed by multivariate logistic regression analysis.

Results: A total of 2861 patients with STEMI were included in this study. The incidence of PC-AKI increased stepwise with increasing sUAR tercile (2.6% vs 4.0% vs 11.6%, $p < 0.001$), and the incidence of in-hospital major adverse clinical events (MACEs) was highest among patients in the Q3 group. Multivariate logistic regression analysis revealed that the sUAR was also an independent predictor of PC-AKI (continuous sUAR, per 1-unit increase, odds ratio [OR] [95% confidence interval (CI)]: 1.06 [1.02–1.10], $p = 0.005$; tercile of sUAR, OR [95% CI] for Q2 and Q3: 1.18 [0.69–2.01] and 1.85 [1.12–3.06], respectively, with Q1 as a reference) but not in-hospital MACEs. In the receiver operating characteristic (ROC) analysis, the area under the curve (AUC) of the sUAR for predicting PC-AKI was 0.708 (95% CI: 0.666–0.751), and ROC analysis also showed that the sUAR was superior to uric acid and albumin alone in predicting PC-AKI.

Conclusion: Increasing sUAR was significantly associated with a higher risk of PC-AKI but not in-hospital MACEs in patients with STEMI who underwent PCI, suggesting that sUAR had a predictive value for PC-AKI after PCI in patients with STEMI. Further studies are required to confirm this finding.

Keywords: serum uric acid/albumin ratio, post-contrast acute kidney injury, ST-segment elevation myocardial infarction

Received: 15 June 2022
Accepted: 22 August 2022
Published: 15 September 2022

Introduction

Post-contrast acute kidney injury (PC-AKI) is one of the major complications after percutaneous coronary intervention (PCI) for patients with coronary artery disease, and it is associated with increased short- and long-term adverse events and mortality.[1] The incidence of PC-AKI in the general population after coronary angiography is estimated to be 7.5%–21.9%, and higher in patients with ST elevation myocardial infarction (STEMI) undergoing primary PCI.[2,3] Owing to the complexity of the mechanisms, effective preventative or therapeutic measures for PC-AKI are still lacking.[4,5] Therefore, the ability to estimate the risk of developing PC-AKI after PCI in a patient with STEMI may have great clinical importance in reducing the incidence of PC-AKI.

Many studies have demonstrated that serum uric acid, as an inflammatory mediator, is an independent predictor of PC-AKI in patients undergoing PCI.[6,7] In contrast, an increased inflammatory response is associated with decreased serum albumin.[8] Serum albumin also has antioxidant properties, and it is associated with the level of renal dysfunction.[9,10] Accumulating evidence proposes that oxidative stress and immune/inflammation play important roles in the development of PC-AKI.[11–13] Therefore, the determination of several rapidly available and reliable biomarkers together may have greater clinical significance compared to the use of a single biomarker.[14] The serum uric acid/albumin ratio (sUAR), which is derived from serum uric acid and serum albumin, has been reported as a novel inflammatory marker in predicting AKI, and is associated with mortality in patients with AKI.[15,16] Recently, Faysal et al conducted a retrospective study and found that sUAR was an independent predictor of contrast-induced nephropathy.[17] However, the sample size was relatively small and the definition of contrast-induced nephropathy was proved to be not often use in patients with STEMI.[18,19] Therefore, it is still uncertain whether the sUAR has predictive value for predicting PC-AKI and in-hospital major adverse clinical events (MACEs) after PCI in patients with STEMI. We conducted this study to investigate whether sUAR has a predictive value for the risk of PC-AKI and in-hospital MACEs in patients with STEMI who received PCI.

Methods

Study Design and Population

This observational study was conducted at Guangdong Provincial People's Hospital. Patients with STEMI (n = 4486) who underwent PCI from January 2010 to February 2020 were consecutively enrolled. The diagnostic criteria for STEMI were based on the 2013 American College of Cardiology Foundation/American Heart Association guideline.[20] The exclusion criteria were as follows: (1) cardiogenic shock; (2) pregnant or lactating women; (3) patients with end-stage nephropathy or who had undergone renal transplantation; (4) patients treated with nephroprotective or nephrotoxic drugs; (5) administration of contrast media within the previous 7 days or allergic to contrast media; and (6) severe organic disease, infection, or inflammatory disease. We also excluded patients who died during the PCI procedure or who had an intra-aortic balloon pump inserted.

After admission, all of the patients received PCI in accordance with clinical guidelines. During the PCI procedure, patients received nonionic low-osmolar contrast medium at a contrast dose determined by the cardiologist. All of the patients received isotonic (0.9%) saline solution intravenously during the PCI procedure and for 6 to 12 h after contrast exposure at a rate of 1 mL/kg/h (0.5 mL/kg/h for patients with left ventricular ejection fraction (LVEF) < 40%). This study complied with the Declaration of Helsinki and was approved by the Institutional Research Ethics Committee of Guangdong Provincial People's Hospital. All of the patients provided written informed consent.

Data Collection

Clinical data on demographics, personal medical history, and medication history were collected from the electronic medical recording system by trained research doctors or nurses. The first fasting blood samples during the hospitalization were obtained within 24 h of admission, and laboratory parameters, including serum uric acid and serum albumin, were documented. The concentrations of serum creatinine (SCr) were measured at admission and 72 h after the PCI procedure. Estimated glomerular filtration rate (eGFR) was calculated according to the formula defined in previous study.[21] The sUAR was calculated as serum uric acid/serum albumin.

Endpoints and Definitions

The primary endpoint was the development of PC-AKI, which defined as an absolute increase in SCr level ≥ 0.5 mg/dl (44.2 μmol/L) from baseline within 72 h after administration of contrast media (PC-AKI_1). The other definitions of PC-AKI included: an absolute increase in the SCr level ≥ 0.5 mg/dL or an increase ≥ 25% over baseline within 48–72 h (PC-AKI_2); an absolute increase ≥ 0.3 mg/dL within 48 h (PC-AKI_3); and an increase ≥ 50% (1.5-fold over baseline) within 48h (PC-AKI_4) after administration of contrast media.[22] The secondary endpoint was in-hospital MACEs, defined as the composite of in-hospital death, stroke, recurrent myocardial infarction, and target vessel revascularization. All of the endpoint events were assessed by well-trained cardiologists who were blinded to the study.

Statistical Analysis

All of the included patients were stratified into three groups (Q1 [sUAR < 9.409], Q2 [9.409 ≤ sUAR < 12.260], and Q3 [sUAR ≥ 12.260]) in accordance with the sUAR tercile. Comparisons between continuous variables, expressed as the mean (standard deviation) or median (interquartile range), were analyzed using the *t*-test or Kruskal–Wallis test based on the normality of the distribution. Categorical variables are presented as numbers (percentages), which were compared using chi squared test or Fisher's exact test. To evaluate the sUAR accuracy to identify patients with PC-AKI or in-hospital MACEs, the area under the curve (AUC) was determined for the sUAR through receiver operating characteristic (ROC) curve analysis. Furthermore, univariate logistic regressions were performed to identify the variables associated with PC-AKI or in-hospital MACEs. Multivariate analyses were performed using a backward stepwise procedure and included variables with P-value < 0.1 and clinical plausibility in univariate analysis. Odd ratios (ORs) with their 95% confidence intervals (CIs) were calculated. In addition, subgroup analyses for the primary endpoint were conducted according to the eGFR, age, sex, contrast volume, diabetes mellitus, hypertension, and anemia. Meanwhile, the predictive value of the sUAR for PC-AKI was compared to that of uric acid and albumin, and pairwise comparison of AUC was performed by the DeLong test.

All of the statistical analyses were performed using SPSS 20.0 (IBM, Armonk, New York) and SAS version 9.4 (SAS Institute, Cary, NC). All of the probability values were two-tailed, and statistical significance was defined as $P < 0.05$.

Results

Baseline Characteristics

In total, 2861 patients with STEMI undergoing PCI were included in the final analysis (Figure 1). The patients' clinical characteristics are presented in Table 1. The mean age of the included patients was 62.42 ± 12.22 years, and 499 (17.44%) patients were female. The patients were further divided into three groups and the mean sUAR levels were 7.71 ± 1.30 (Q1: n = 953), 10.76 ± 0.80 (Q2: n = 954), and 15.88 ± 3.55 (Q3: n = 954), respectively. Age, sex, Killip classification, smoking, hypertension, chronic obstructive pulmonary disease, anemia, prior stroke, and almost all of the laboratory measurements were significantly different among the three groups. The prior use of medication was similar across the groups, except for the use of ticagrelor, statins, beta-blockers, and angiotensin converting enzyme inhibitor/angiotensin receptor blocker. Regarding the PCI procedure, with increasing sUAR tercile, patients were more likely to have multi-vessel stenosis and receive more contrast medium.

Association of sUAR with the Clinical Outcomes

The incidence of PC-AKI_1 was significantly increased with increasing sUAR tercile (2.6% vs 4.0% vs 11.6%, p < 0.001) (Figure S1). As demonstrated in Figure 2A, a non-linear relationship appears to exist between sUAR and PC-AKI_1, and the risk of PC-AKI_1 increased linearly with sUAR when the sUAR was >12. In univariate logistic regression analysis, sUAR as a continuous variable was positively associated with the risk of PC-AKI_1 after PCI in patients with STEMI (OR = 1.17, 95% CI: 1.13–1.20, p < 0.001) (Table S1). The sUAR was also independently associated with an increased risk of PC-AKI_1 after adjusting for confounders (OR = 1.06, 95% CI: 1.02–1.10, p = 0.05) (Table 2). When the sUAR was modulated as a categorical variable, univariate logistic regression analysis demonstrated that the risk of PC-AKI_1 was increased in the tercile 3 group (OR = 4.89, 95% CI: 3.14–7.62, p < 0.001) but not in the tercile 2 group (OR = 1.54, 95%

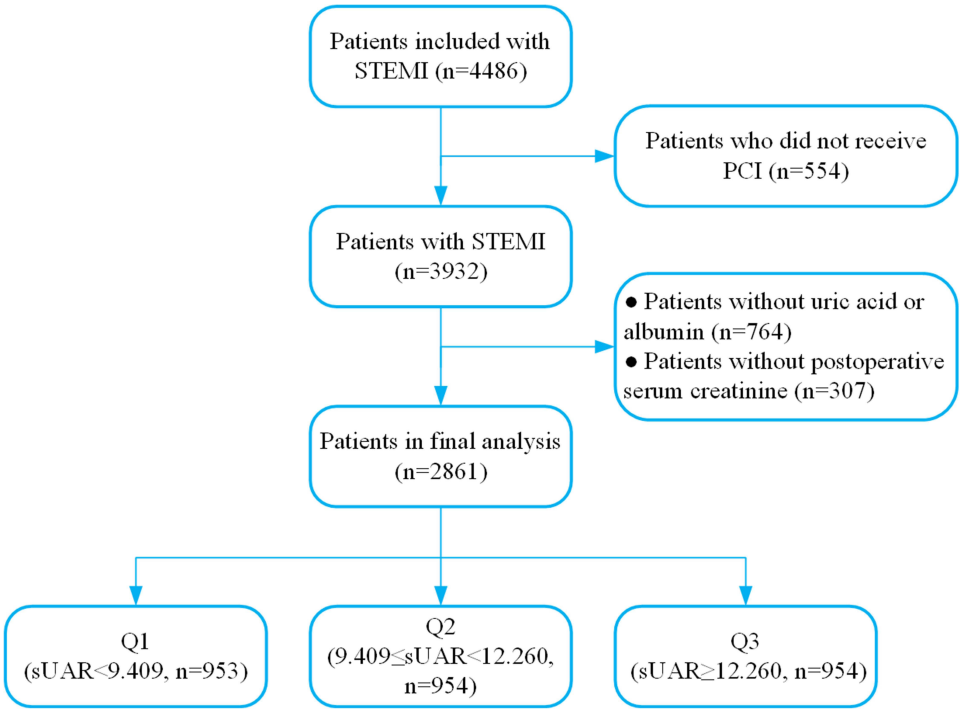

Figure 1 Study flowchart of the enrolled patients.

CI: 0.92–2.57, p = 0.099) compared to the tercile 1 group (Table S2). Similarly, only the tercile 3 group exhibited an elevated risk of PC-AKI$_1$ (OR = 1.85, 95% CI: 1.12–3.06, p = 0.016) but not the tercile 2 group (OR = 1.18, 95% CI: 0.69–2.01, p = 0.541) after fully adjusting for the multiple confounders (Table 3).

Table 1 Baseline Characteristics of Patients Stratified by Tercile of the sUAR

Variables	Q1 (n=953) sUAR<9.409	Q2 (n=954) 9.409≤sUAR<12.260	Q3 (n=954) sUAR≥12.260	*P* value
Demographics and clinical characteristics				
Age, years	60.20±11.73	61.55±12.01	65.52±12.29	<0.001
Male, n (%)	749 (78.6)	821 (86.1)	792 (83.0)	<0.001
SBP, mm Hg	123.51±21.46	122.58±20.66	121.34±23.50	0.095
DBP, mm Hg	75.47±13.78	74.85±13.08	73.01±13.76	<0.001
Killip classification				
I	743 (78.0)	699 (73.3)	544 (57.0)	<0.001
II	160 (16.8)	199 (20.9)	239 (25.1)	
III	22 (2.3)	32 (3.4)	105 (11.0)	
IV	28 (2.9)	24 (2.5)	65 (6.8)	
Comorbidities, n (%)				
Current smoking	393 (41.2)	430 (45.1)	337 (35.3)	<0.001
Hypertension	418 (43.9)	475 (49.8)	591 (61.9)	<0.001
Diabetes mellitus	279 (29.3)	258 (27.0)	306 (32.1)	0.054
Hyperlipidemia	117 (12.3)	143 (15.0)	111 (11.6)	0.069
Anemia	243 (25.5)	281 (29.5)	402 (42.1)	<0.001
COPD	16 (1.7)	20 (2.1)	32 (3.4)	0.044
Previous MI	216 (22.7)	221 (23.2)	237 (24.8)	0.502

(*Continued*)

Table 1 (Continued).

Variables	Q1 (n=953) sUAR<9.409	Q2 (n=954) 9.409≤sUAR<12.260	Q3 (n=954) sUAR≥12.260	*P* value
Prior PCI	82 (8.6)	83 (8.7)	98 (10.3)	0.367
Prior stroke	48 (5.0)	51 (5.3)	111 (11.6)	<0.001
Laboratory measurements				
Uric acid, mg/L	280.49±54.07	381.27±48.14	523.22±109.64	<0.001
Albumin, g/L	36.44±3.96	35.49±3.98	33.30±4.51	<0.001
LVEF, %	53.03±10.50	52.10±11.56	48.09±12.55	<0.001
Hemoglobin, g/L	136.22±18.93	135.38±20.16	129.78±21.95	<0.001
Baseline creatinine, mg/dL	0.94±0.69	1.08±0.86	1.49±1.12	<0.001
eGFR, mL/min	99.75±29.64	87.68±27.98	64.34±27.68	<0.001
HbA1c, %	6.00 (5.60~7.30)	6.10 (5.70~6.90)	6.10 (5.80~7.10)	0.041
Total cholesterol, mmol/L	4.94±1.19	4.96±1.23	4.75±1.28	<0.001
LDL-C, mmol/L	3.22±0.98	3.28±1.00	3.12±1.03	0.002
HDL-C, mmol/L	1.04±0.26	0.99±0.24	0.95±0.27	<0.001
Triglycerides, mmol/L	1.59±1.24	1.64±1.13	1.68±1.05	0.197
Prior medication use, n (%)				
Aspirin	936 (98.2)	942 (98.7)	938 (98.3)	0.621
Clopidogrel	836 (87.7)	838 (88.0)	855 (89.6)	0.401
Ticagrelor	138(14.5)	165(17.3)	132(13.8)	<0.001
GP IIb/IIIa inhibitor	336(35.3)	372(39.0)	370(38.8)	0.169
Warfarin	11(1.2)	11(1.2)	21(2.2)	0.096
Statins	936 (98.2)	943 (98.8)	918 (96.2)	<0.001
Beta-blockers	823 (86.4)	801 (84.0)	737 (77.3)	<0.001
ACEI/ARB	789 (82.8)	781 (81.9)	737 (77.3)	0.005
Angiography				
Multi-vessel stenosis, n (%)	643(67.5)	679 (71.2)	770 (80.7)	<0.001
No. of stents used	1.40±1.29	1.46±0.92	1.63±3.31	0.043
Length of stents, mm	35.09±22.56	37.53±26.15	39.54±25.30	<0.001
Contrast volume, mL	111.52±38.91	117.66±42.56	122.12±42.64	<0.001
Length of hospital stay, days	6.00(5.00~8.00)	7.00(5.00~8.00)	8.00(6.00~12.00)	<0.001

Abbreviations: SBP, systolic blood pressure; DBP, diastolic blood pressure; COPD, chronic obstructive pulmonary disease; MI, myocardial infarction; PCI, percutaneous coronary intervention; LVEF, left ventricular ejection fraction; WBC, white blood cell; eGFR, estimated glomerular filtration rate; HbA1c, glycosylated hemoglobin; LDL-C, low-density lipoprotein cholesterol; HDL-C, high-density lipoprotein cholesterol; ACEI/ARB, angiotensin converting enzyme inhibitor/angiotensin receptor blocker.

The association of the sUAR with the incidence of in-hospital MACEs also showed a non-linear relationship, and the risk of in-hospital MACEs increased linearly with sUAR when the sUAR was > 12 (Figures 2B and S2). In univariate logistic regression analysis, the sUAR as a continuous variable was positively related to the risk of in-hospital MACEs after PCI in patients with STEMI (OR = 1.12, 95% CI: 1.08–1.16, p < 0.001) (Table S1). The multivariate analyses showed that the elevated sUAR was not correlated with the occurrence of in-hospital MACEs (OR = 1.02, 95% CI: 0.98–1.06, p = 0.354) (Table 2). Taking the tercile 1 group as a reference, the tercile 3 (OR = 2.23, 95% CI: 1.50–3.32, p < 0.001) but not tercile 2 group (OR = 0.89, 95% CI: 0.56–1.43, p = 0.628) was associated with increased risk of in-hospital MACEs in univariate logistic regression analysis (Table S2). However, multivariate analysis revealed that both tercile 2 (OR = 0.70, 95% CI: 0.42–1.14, p = 0.150) and tercile 3 (OR = 0.86, 95% CI: 0.54–1.39, p = 0.546) groups showed no elevated risk of in-hospital MACEs (Table 3).

Predictive Value of the sUAR for Clinical Outcomes

As presented in Figure 3, the ROC analysis showed that the AUC of the sUAR for predicting PC-AKI$_1$ was 0.708 (95% CI: 0.666–0.751). The predictive value of the sUAR was also detected in the context of other definitions of PC-AKI (Table S3). Meanwhile, ROC analysis also showed that the sUAR was superior to uric acid (P for comparison < 0.001) and albumin (P for comparison = 0.025) alone in predicting PC-AKI$_1$ (Figure 3). Additionally, subgroup analyses

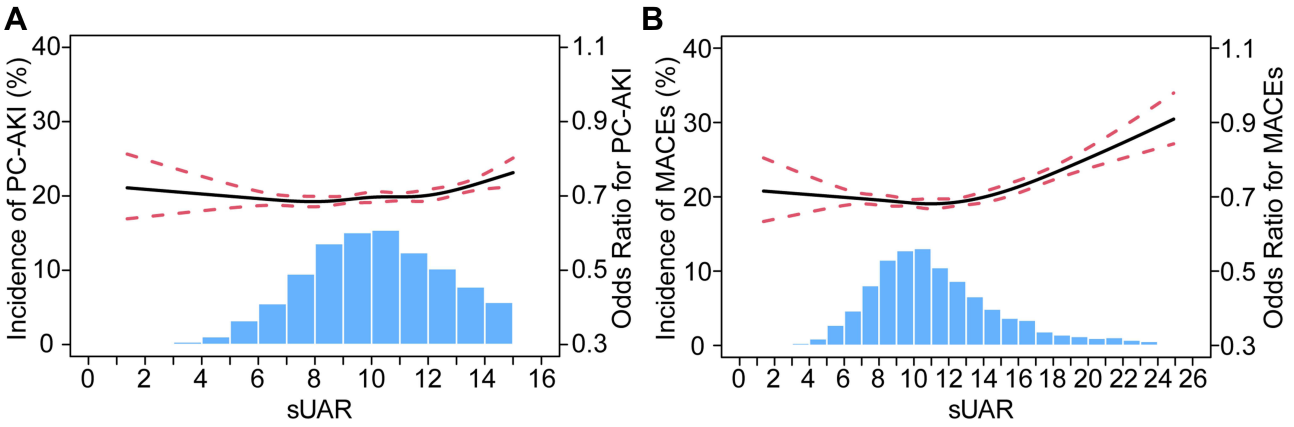

Figure 2 Spline curve of the PC-AKI adjusted odds ratio (**A**) and the MACEs adjusted odds ratio (**B**).

stratified by eGFR, age, sex, contrast volume, diabetes mellitus, hypertension, anemia also confirmed the predictive value of the sUAR for the development of PC-AKI$_1$ (Table S4).

Discussion

The main finding of this study was that a non-linear relationship exists between sUAR and PC-AKI, and patients with a higher sUAR were more likely to develop PC-AKI, even after adjusting for potential confounding risk factors. Moreover, the sUAR was not associated with increased risk of in-hospital MACEs in patients with STEMI after PCI.

In clinical practice, uric acid and albumin are two independent predictors of AKI.[23,24] Previous studies have found that hyperuricemia was independently associated with an increased risk of PC-AKI and used to predict PC-AKI among patients undergoing coronary angiography or PCI in clinical practice,[25–27] while serum albumin levels were significantly lower in patients with PC-AKI than in those without and also had a predictive value for PC-AKI.[28,29] We showed similar results in this study that uric acid and albumin were associated with the presence of PC-AKI. As a new predictive index, the prognostic value of the sUAR

Table 2 Multivariable Logistic Regression Analysis for the sUAR as Continuous Variable

Variables	PC-AKI			In-Hospital MACEs		
	OR	95% CI	*P* value	OR	95% CI	*P* value
sUAR, per 1-unit increase	1.06	1.02~1.10	0.005	1.02	0.98~1.06	0.354
eGFR	0.98	0.98~0.99	<0.001	0.99	0.98~0.99	<0.001
Age	1.03	1.02~1.05	<0.001	1.02	1.00~1.04	0.038
Female	0.67	0.43~1.05	0.080	1.22	0.78~1.90	0.395
Killip classification	1.91	1.35~2.71	<0.001	2.62	1.81~3.79	<0.001
Anemia	1.02	0.72~1.45	0.893	0.87	0.60~1.27	0.476
Current smoking	0.86	0.59~1.27	0.460	1.10	0.74~1.64	0.641
Diabetes	1.59	1.12~2.24	0.009	1.05	0.72~1.54	0.784
Hypertension	0.95	0.67~1.36	0.789	0.85	0.59~1.22	0.380
COPD	0.70	0.29~1.66	0.417	1.22	0.53~2.76	0.642
Previous MI	0.50	0.31~0.80	0.004	0.74	0.47~1.18	0.207
Prior PCI	0.81	0.49~1.33	0.399	0.75	0.44~1.29	0.298
Prior stroke	1.89	1.21~2.96	0.005	1.61	0.98~2.62	0.059
Aspirin	0.82	0.26~2.53	0.729	0.50	0.18~1.42	0.193
GP IIb/IIIa inhibitor	1.02	0.72~1.45	0.919	1.53	1.07~2.19	0.020
Multi-vessel stenosis	1.08	0.76~1.56	0.658	1.47	0.99~2.21	0.059
PCI access	1.41	0.96~2.07	0.076	2.20	1.51~3.21	<0.001

Abbreviations: eGFR, estimated glomerular filtration rate; COPD, chronic obstructive pulmonary disease; MI, myocardial infarction; PCI, percutaneous coronary intervention.

Table 3 Multivariable Logistic Regression Analysis for the sUAR as Categorical Variable

Variables	PC-AKI			In-Hospital MACEs		
	OR	95% CI	*P* value	OR	95% CI	*P* value
Q1	Reference			Reference		
Q2	1.18	0.69~2.01	0.541	0.70	0.42~1.14	0.150
Q3	1.85	1.12~3.06	0.016	0.86	0.54~1.39	0.546
eGFR	0.98	0.98~0.99	<0.001	0.98	0.98~0.99	0.000
Age	1.03	1.02~1.05	<0.001	1.02	1.00~1.04	0.035
Female	0.69	0.45~1.08	0.104	1.20	0.77~1.89	0.417
Killip classification	1.93	1.36~2.73	<0.001	2.67	1.84~3.86	<0.001
Anemia	1.05	0.74~1.48	0.800	0.88	0.61~1.28	0.504
Current smoking	0.87	0.59~1.28	0.482	1.12	0.75~1.67	0.595
Diabetes	1.61	1.14~2.27	0.007	1.05	0.72~1.52	0.817
Hypertension	0.93	0.66~1.33	0.708	0.86	0.60~1.24	0.413
COPD	0.71	0.30~1.69	0.444	1.19	0.52~2.72	0.684
Previous MI	0.49	0.30~0.78	0.003	0.73	0.46~1.16	0.179
Prior PCI	0.80	0.49~1.31	0.373	0.76	0.44~1.30	0.311
Prior stroke	1.88	1.21~2.95	0.005	1.61	0.99~2.64	0.056
Aspirin	0.81	0.26~2.51	0.718	0.51	0.18~1.44	0.204
GP IIb/IIIa inhibitor	1.00	0.70~1.42	0.990	1.55	1.08~2.22	0.017
Multi-vessel stenosis	1.08	0.76~1.55	0.658	1.47	0.98~2.20	0.059
PCI access	1.43	0.98~2.09	0.066	2.19	1.50~3.20	<0.001

Abbreviations: eGFR, estimated glomerular filtration rate; COPD, chronic obstructive pulmonary disease; MI, myocardial infarction; PCI, percutaneous coronary intervention.

has been investigated in patients with STEMI, non-ST segment elevation myocardial infarction, and AKI for predicting mortality.[16,30,31] Yeter et al found that a sUAR > 1.7 was significantly associated with AKI in critically ill patients.[15] Recently, Faysal et al also demonstrated that sUAR (>1.62) had a greater predictive value for contrast-induced nephropathy, and was superior to serum uric acid and albumin.[17] In our study, we found that sUAR had a moderate predictive value for PC-AKI after PCI in patients with STEMI, and it was also superior to serum uric acid and albumin. However, when the definition of PC-AKI was

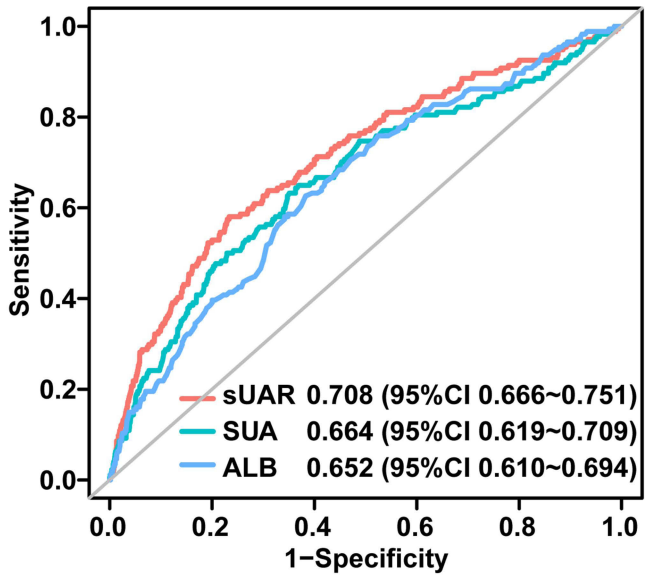

Figure 3 Receiver operating characteristic curve analysis of the sUAR to predict PC-AKI and comparison of the AUC between the sUAR, uric acid, and albumin.

consistent with that described by Faysal et al, our result showed that the AUC of sUAR for predicting PC-AKI was not a good predictive value (AUC=0.548). There are several reasons that may account for this discrepancy. First, the sample size in our study is twice larger than theirs, and it makes our data more reliable. Second, the definition of PC-AKI was different. The definition of PC-AKI (a rise in SCr of ≥ 0.5 mg/dL) in our study might be the optimal definition for identifying the risk for adverse events in STEMI patients according to previous studies.[18,19] An absolute increase in SCr level ≥ 0.5 mg/dl was sensitive because it identified patients with a higher mortality risk more selectively, while many patients with a serum creatinine increase ≥ 25% showed no deterioration of renal function postoperatively and little risk of adverse events.[18] Therefore, the predictive value of sUAR for different definitions of PC-AKI needs to be further confirmed. In our study, the risk of PC-AKI$_1$ increased linearly with sUAR when the sUAR was >12. Therefore, sUAR may be a useful biomarker for PC-AKI risk stratification in STEMI patients undergoing PCI, and enhance clinicians' ability to recognize patients at high risk. Additionally, personalize perioperative hydration and adjusting contrast volume should be considered to reduce the occurrence of PC-AKI in patients with higher sUAR level.

A non-linear relationship was also observed between the sUAR and the in-hospital MACEs in patients with STEMI undergoing PCI. Serum uric acid has been widely evaluated as a prognostic biomarker for patients with STEMI. Several cohort studies have reported that the serum uric acid level on admission was a strong predictor of in-hospital MACEs among patients with STEMI.[32–34] Conversely, a previous retrospective study including 1167 patients with STEMI undergoing PCI reported that serum uric acid was not significantly associated with in-hospital MACEs.[35] In another cohort study, high uric acid levels had a higher incidence of MACEs, but this correlation disappeared after adjustment for several parameters.[36] The results of these previous studies implied that there are other factors that may strongly affect the incidence of MACEs, and serum uric acid is not a robust biomarker for predicting in-hospital MACEs. Therefore, obtaining new biomarkers or considering their combination may be more accurate in predicting prognosis. A recent study showed that low serum albumin levels were associated with worse hospital adverse events in STEMI patients.[37] The sUAR, calculated using serum uric acid and albumin, has been investigated as a predictor of mortality in patients with STEMI.[30] However, we found that the sUAR was not significantly associated with a higher risk of in-hospital MACEs in patients with STEMI who underwent PCI. This observation was explained by the fact that we only observed in-hospital MACEs, while stroke, recurrent myocardial infarction, and target vessel revascularization were more common during follow-up; thus, the association between the sUAR and long-term MACEs remains to be further studied.[38] Additionally, previous studies have confirmed that PC-AKI increased mortality, but the association between PC-AKI and stroke, recurrent myocardial infarction, and target vessel revascularization still unclear. This may be another reason for this observation.

Despite this correlation, the exact mechanisms accounting for the association between the sUAR and PC-AKI remain unclear. The functions of serum uric acid and serum albumin may partly account for this association. First, uric acid is the end product of purine metabolism. Physiologically, uric acid exerts its protective role through an antioxidant effect, but turns into a pro-oxidant agent in some pathological states.[39] A previous study demonstrated a U-shaped association of uric acid with renal disease and cardiac events.[40] Elevated uric acid is also known to be associated with increased inflammation and endothelial dysfunction.[41–43] Second, serum albumin is a circulating antioxidant protein, and its decreased synthesis and increased catabolism reflect an inflammatory state.[8,44] Importantly, serum albumin is also associated with the inhibition of platelet activation and aggregation, which may be associated with the occurrence of MACEs.[45] Third, the pathophysiology of PC-AKI is multifactorial, among which renal medullary hypoxia, direct toxicity of contrast agents, oxidative stress, and immune/inflammation play important roles in its development.[11–13] Therefore, the sUAR was closely related to the pathogenesis of PC-AKI, which may account for the association.

Limitations

Our study also had several limitations. First, although we attempted to reduce confounding factors in the statistical process, this was a retrospective analysis based on a single center observational study; thus, we were unable to exclude the influence of some unmeasured confounders. Additionally, the causality between the sUAR and PC-AKI could not be determined. Second, we did not include patients with an intra-aortic balloon pump inserted, consequently, a large proportion of patients with high killip class were excluded that may cause a potential selection bias. Third, serum uric acid and albumin values of some patients in this study were measured 23 hours after hospital admission, therefore, those values could not be considered strictly "baseline". Fourth, we

only recorded the hospital adverse events without follow-up; therefore, the association between the sUAR and long-term adverse events remains unknown in such populations. Finally, it is unclear whether the dynamics of the sUAR may relate to PC-AKI, and the cardiovascular outcomes for the sUAR were only evaluated once after admission.

Conclusions

Increasing sUAR was significantly associated with a higher risk of PC-AKI but not in-hospital MACEs in patients with STEMI who underwent PCI, suggesting that the sUAR had a predictive value for PC-AKI after PCI in patients with STEMI. Further studies are required to confirm this finding.

Data Sharing Statement

None of the datasets generated for this study are publicly available but are available from the corresponding author upon reasonable request.

Author Contributions

Yeshen Zhang, Zhengrong Xu, and Wenfei He conceived the study, designed the protocol and wrote the first draft of the paper; Zehuo Lin, Yaoxin Liu, Yining Dai, Wei Chen, Weikun Chen, and Wenlong He performed the data acquisition; Pengcheng He performed the data analysis/interpretation; Chongyang Duan synthesized and analyzed the data; Ning Tan and Yuanhui Liu conducted the supervision and mentorship. All authors made substantial contributions to conception and design, acquisition of data, or analysis and interpretation of data; took part in drafting the article or revising it critically for important intellectual content; agreed to submit to the current journal; gave final approval of the version to be published; and agree to be accountable for all aspects of the work.

Funding

This work was supported by the Shuangqing Talent Program Project of Guangdong Provincial people's Hospital (Grant No. KJ012019095 to Y.H.L. and Grant No. KJ012019084 to P.C.H), and High-level Hospital Construction Project (Grant No. DFJH2020021), Project of Administration of Traditional Chinese Medicine of Guangdong Province (20221007), and Guangdong Provincial People's Hospital Clinical Research Fund (Y012018085).

Disclosure

The authors declare that they have no conflicts of interest in this work.

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