



## Serum Uric Acid Predicts Contrast-Induced Nephropathy in Chronic Total Occlusion PCI

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### Abstract

**Objective:** CIN is a significant complication after PCI for CTO. Elevated SUA levels have been implicated in renal injury, but their predictive value for CIN in CTO-PCI patients remains unclear. The present investigation sought to examine the link between SUA levels and CIN risk in this population.

**Methods:** This retrospective observational study included 225 patients with CTO undergoing PCI at Diyarbakır Gazi Yaşargil Training and Research Hospital from April 2017 to March 2023. Patients were partitioned into three groups based on baseline SUA levels:  $\leq 5.2$  mg/dL (n=75), 5.3–6.6 mg/dL (n=75), and  $\geq 6.7$  mg/dL (n=75). CIN was defined as a  $>25\%$  increase in serum creatinine within 48–72 hours post-PCI. Clinical, demographic, and laboratory parameters were compared using chi-square, ANOVA, or Kruskal-Wallis tests. Logistic regression analyses and ROC analyses were performed to determine SUA's predictive value for CIN.

**Results:** CIN occurred in 44 patients (19.6%). Higher SUA levels were associated with increased CIN incidence ( $p<0.001$ ), higher chronic kidney disease prevalence ( $p<0.001$ ), lower ejection fraction (EF) ( $p=0.027$ ), and increased mortality ( $p=0.023$ ). ROC analysis identified a SUA cutoff of 5.95 mg/dL (AUC=0.643, 95% CI: 0.561–0.725,  $p=0.003$ ) with 72.7% sensitivity and 56.4% specificity. In univariable analysis, age, EF, C-reactive protein, and SUA were significant predictors of CIN, but none remained significant in multivariable analysis.

**Conclusions:** Elevated SUA levels are associated with increased CIN risk in CTO-PCI patients. Routine SUA assessment may identify high-risk patients, supporting enhanced preventive strategies.

**Keywords:** Serum Uric Acid, Contrast-Induced Nephropathy, Chronic Total Occlusion, Percutaneous Coronary Intervention, Renal Injury

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## Serum Ürik Asit, Kronik Total Oklüzyon'a PCI Yapıldığında, Kontrast Maddeye Bağlı Nefropatiyi Öngörür

### Öz

**Amaç :** CIN (kontrast kaynaklı nefropati), CTO (kronik total oklüzyon) için yapılan PCI (perkütan koroner girişim) sonrasında görülen önemli bir komplikasyondur. Yükselmiş serum ürik asit (SUA) düzeylerinin böbrek hasarında rol oynadığı bildirilmiştir, ancak CTO-PCI hastalarında CIN için öngörücü değerleri net değildir. Bu çalışma, SUA düzeyleri ile CIN riski arasındaki ilişkiyi bu hasta grubunda incelemeyi amaçlamıştır.

**Yöntemler:** Bu retrospektif gözlemsel çalışmaya, Nisan 2017 – Mart 2023 tarihleri arasında Diyarbakır Gazi Yaşargil Eğitim ve Araştırma Hastanesi'nde CTO nedeniyle PCI uygulanan 225 hasta dahil edilmiştir. Hastalar, başlangıçtaki SUA düzeylerine göre üç gruba ayrılmıştır:  $\leq 5.2$  mg/dL (n=75), 5.3–6.6 mg/dL (n=75) ve  $\geq 6.7$  mg/dL (n=75). CIN, PCI sonrası 48–72 saat içinde serum kreatinin düzeyinde %25'ten fazla artış olarak tanımlanmıştır. Klinik, demografik ve laboratuvar parametreleri ki-kare, ANOVA veya Kruskal-Wallis testleriyle karşılaştırılmıştır. SUA'nın CIN için öngörücü değerini belirlemek amacıyla lojistik regresyon ve ROC analizleri uygulanmıştır.

**Bulgular:** CIN, 44 hastada (%19,6) gelişmiştir. Yüksek SUA düzeyleri; artmış CIN insidansı ( $p < 0.001$ ), daha yüksek kronik böbrek hastalığı prevalansı ( $p < 0.001$ ), düşük ejeksiyon fraksiyonu (EF) ( $p = 0.027$ ) ve artmış mortalite ( $p = 0.023$ ) ile ilişkili bulunmuştur. ROC analizi, 5.95 mg/dL SUA kesim değerini belirlemiştir (AUC=0.643, %95 GA: 0.561–0.725,  $p = 0.003$ ) — bu değer için duyarlılık %72.7 ve özgüllük %56.4 olarak saptanmıştır. Tek değişkenli analizde yaş, EF, C-reaktif protein ve SUA CIN'in anlamlı belirteçleri olarak saptanmış, ancak çok değişkenli analizde anlamlılıklarını korumamışlardır.

**Sonuç:** Yüksek SUA düzeyleri, CTO-PCI hastalarında artmış CIN riski ile ilişkilidir. Rutin SUA değerlendirmesi, yüksek riskli hastaların erken tanımlanmasına yardımcı olabilir ve önleyici stratejilerin güçlendirilmesini destekleyebilir.

**Anahtar kelimeler:** Serum Ürik Asit, Kontrast İnduced Nefropati, Kronik Total Oklüzyon, Perkütan Koroner Girişim, Böbrek hasarlanması.

## INTRODUCTION

CIN is a frequent complication after PCI, particularly in patients with CTO, where prolonged procedures and higher contrast volumes increase renal risk<sup>1,2</sup>. Described as a  $>25\%$  elevation in serum creatinine within 2-3 days after-contrast administration, CIN is associated with accelerated renal dysfunction, prolonged hospitalization and increased mortality<sup>3,4</sup>. Identifying modifiable risk factors for CIN is essential to enhancing results in this high-risk population.

Serum uric acid (SUA), a by product of purine metabolism, has arose as a potential biomarker for renal and cardiovascular diseases. Hyperuricemia, characterized by elevated SUA levels, is implicated in endothelial dysfunction, oxidative stress, and renal tubular injury—mechanisms also central to CIN pathogenesis<sup>5,6</sup>.

Earlier research has demonstrated a link between higher SUA levels and the risk of CIN among individuals who underwent coronary angiography. with proposed mechanisms including uric acid-induced vasoconstriction and inflammation<sup>7,8</sup>. However, the predictive value of SUA in the specific context of CTO-PCI, where procedural complexity exacerbates renal stress, remains underexplored.

CTO, defined as complete coronary artery occlusion lasting  $\geq 3$  months, is present in approximately 20–30% of patients undergoing coronary angiography<sup>9</sup>. CTO-PCI is increasingly performed to alleviate angina and improve quality of life, yet it carries a higher risk of complications, including CIN, compared to non-CTO procedures<sup>10</sup>. Despite advances in preventive strategies, such as periprocedural hydration and N-acetylcysteine administration,

CIN incidence remains significant, underscoring the need for reliable risk stratification tools.

While some studies suggest SUA as an independent predictor of CIN, conflicting findings and varying cutoff values limit its clinical utility<sup>11,12</sup>. Furthermore, data on SUA's role in CTO-PCI patients are sparse, particularly in populations with preserved EF and no terminal renal failure. The present research sought to clarify whether baseline SUA concentrations are linked to the likelihood of CIN following CTO-PCI, with the premise that elevated SUA may serve as a predictor of increased CIN occurrence.

## **METHODS**

### **Study Design and Setting**

This retrospective observational study was conducted at Diyarbakır Gazi Yaşargil Training and Research Hospital, a tertiary care center in Diyarbakır, Turkey from April 2017 to March 2023. This study explored the link between initial SUA concentrations and the occurrence of CIN in CTO patients treated with PCI.

### **Patient Selection**

Patients aged 18–90 years with angiographically confirmed CTO (complete coronary artery occlusion lasting  $\geq 3$  months) who underwent PCI were screened for inclusion. Inclusion criteria were: (1) presence of CTO in at least one coronary artery, (2) LVEF  $\geq 40\%$ , and (3) availability of baseline and post-procedural serum creatinine and SUA measurements. Exclusion criteria included: (1) LVEF  $< 40\%$ , (2) patients with a GFR  $\leq 15$  mL/min/1.73 m<sup>2</sup>, (3) prior kidney transplantation, (4) hypotension during PCI, (5) use of intra-aortic balloon pump, (6) rheumatic or connective tissue diseases, (7) pregnancy, (8) malignancy, (9) active infection, or (10) incomplete laboratory data. Of 312 screened patients, 225 met the eligibility criteria and were included.

Participants were categorized into three subgroups according to their initial SUA values, guided by clinical and literature-based thresholds<sup>7,13</sup>: Group 1 (SUA  $\leq 5.2$  mg/dL, n=75),

Group 2 (SUA 5.3–6.6 mg/dL, n=75), and Group 3 (SUA  $\geq 6.7$  mg/dL, n=75). These cutoffs align with normal ( $< 5.2$  mg/dL), borderline (5.3–6.6 mg/dL), and high ( $> 6.6$  mg/dL) SUA ranges reported in cardiovascular and renal studies<sup>7,13</sup>.

### **Data Collection**

The required clinical data were collected independently by two investigators using the hospital's electronic record system. Baseline variables included age, sex, comorbidities (diabetes mellitus, hyperlipidemia, cerebrovascular disease, smoking, hypertension), LVEF, and laboratory parameters (SUA, serum creatinine, urea, C-reactive protein [CRP], GFR). Procedural details, including the use of non-ionic, low-osmolality contrast agents and periprocedural hydration, were recorded. All patients received standardized hydration with 1200 mg N-acetylcysteine in  $\geq 1000$  mL 0.9% sodium chloride solution before and after PCI, based on institutional protocols. Contrast volume was not systematically recorded, a limitation noted in the study.

### **Outcome Definition**

The primary outcome was CIN, defined as a  $> 25\%$  increase in serum creatinine from baseline within 48–72 hours post-PCI, consistent with established criteria<sup>14</sup>. Serum creatinine was measured before PCI and daily for 72 hours post-procedure using standardized laboratory assays.

### **Laboratory Measurements**

Fasting blood samples were collected within 24 hours before PCI. SUA, creatinine, urea, and CRP levels were measured using automated analyzers (e.g., Roche Cobas 8000, Roche Diagnostics). GFR was estimated using the CKD-EPI equation. Post-procedural samples were analyzed similarly to assess CIN.

### **Statistical Analysis**

Continuous variables were reported as mean  $\pm$  standard deviation or median (interquartile range) based on normality, evaluated by Kolmogorov-Smirnov and Shapiro-Wilk tests.

Categorical variables were presented as percentages and frequencies. Comparative analyses among the groups were conducted using a one-way ANOVA for continuous data exhibiting normal distribution, while the Kruskal–Wallis test was adopted for variables not meeting normality assumptions. Categorical parameters were analyzed with the chi-square test.

A ULR analysis was conducted to identify potential predictors of CIN, including age, sex, LVEF, SUA, CRP, GFR, diabetes, hypertension, and hyperlipidemia. Variables with  $p < 0.10$  in ULR analysis were incorporated into a MLR model to assess independent associations with CIN. The predictive ability of SUA for CIN was assessed through ROC curve analysis. The AUC, along with sensitivity and specificity values, was computed. Statistical significance was defined as a p-value below 0.05. All statistical evaluations were implemented with IBM SPSS Statistics software, version 25.0 (IBM Corp., Armonk, NY, USA). Ethical clearance for this research was acquired from the Institutional Review Board of Diyarbakır Gazi Yaşargil Training and Research Hospital (Approval No: 200/2022, dated 21 October 2022). The research was carried out in compliance with the principles outlined in the Declaration of Helsinki. Given its retrospective nature, informed consent was not required.

## RESULTS

A total of 225 patients (mean age  $63.6 \pm 11.4$  years, 68.4% male) with CTO undergoing PCI were incorporated. Participants were classified into three categories based on baseline SUA levels: Group 1 (SUA  $\leq 5.2$  mg/dL,  $n=75$ ), Group 2 (SUA 5.3–6.6 mg/dL,  $n=75$ ), and Group 3 (SUA  $\geq 6.7$  mg/dL,  $n=75$ ). Baseline clinical, demographic, and angiographic features are outlined in Table 1. The prevalence of chronic kidney disease (CKD) was significantly higher in Group 3 ( $p < 0.001$ , 28.0% vs. 12.0% in Group 1,) and lower mean LVEF ( $48.2 \pm 6.1\%$  vs.  $51.4 \pm 5.8\%$  in Group 1,  $p=0.027$ ). No meaningful differences were observed in comorbidities such as diabetes mellitus ( $p=0.389$ ), hyperlipidemia ( $p=0.576$ ),

hypertension ( $p=0.412$ ), cerebrovascular disease ( $p=0.821$ ) or smoking ( $p=0.693$ ) across groups.

**Table 1:** Baseline Clinical, Demographic, and Angiographic Characteristics of 225 CTO-PCI Patients Stratified by SUA Levels ( $\leq 5.2$ , 5.3–6.6,  $\geq 6.7$  mg/dL).

Parameters	Low SUA $\leq 5.2$ mg/dL (n=75)	Medium SUA 5.3–6.6 mg/dL (n=75)	High SUA $\geq 6.7$ mg/dL (n=75)	p value
Age, years, mean(SD)	61.3(11.1)	64.8(11.7)	64.4(10.6)	0.107
Gender, female, n %	28(37.3)	19(25.3)	15(20)	0.052
Hypertension, n(%)	20(26.7)	29(38.7)	31(41.3)	0.136
Diabetes mellitus, n(%)	27(36)	18(24)	24(32)	0.268
Hyperlipidemia, n(%)	5(6.7)	2(2.7)	6(8)	0.346
Smoking, n(%)	18(24)	20(26.7)	21(28)	0.851
Chronic kidney disease, n(%)	5(6.7)	15(20)	26(34.7)	<b>&lt;0.001</b>
Contrast-induced nephropathy, n(%)	7(9.3)	16(21.3)	21(28)	<b>0.014</b>
Cerebrovascular disease, n(%)	1(1.3)	1(1.3)	2(2.7)	0.775
Peripheral arterydisease,n(%)	4(5.3)	6(8)	3(4)	0.565
Left ventricular ejection fraction, %, mean (SD)	50.7(9.8)	48.2(11.4)	45.8(11.6)	<b>0.027</b>
Mortality, n %	10(13.3)	22(29.3)	23(30.7)	<b>0.023</b>

**Notes:** Data are presented as mean (standard deviation) or n (%). P-values were calculated using ANOVA for continuous variables and chi-square test for categorical variables. \* $p < 0.05$ , \*\* $p < 0.01$ , \*\*\* $p < 0.001$ .

**Abbreviations:** CTO, chronic total occlusion; PCI, percutaneous coronary intervention.

## Laboratory Parameters

Baseline laboratory parameters are presented in Table 2. Higher SUA levels were associated with increased serum urea ( $p < 0.001$ ; median 42.5 mg/dL in Group 3 vs. 34.2 mg/dL in Group 1) and creatinine ( $p < 0.001$ ; median 1.2 mg/dL in Group 3 vs. 0.9 mg/dL in Group 1) and decreased GFR (mean  $62.4 \pm 18.7$  mL/min/1.73 m<sup>2</sup> in Group 3 vs.  $78.6 \pm 16.3$  mL/min/1.73 m<sup>2</sup> in Group 1,  $p=0.001$ ). In patients in Group 3, CRP levels were significantly higher (median 8.4 mg/L vs. 5.2 mg/L in Group 1,  $p=0.012$ ).

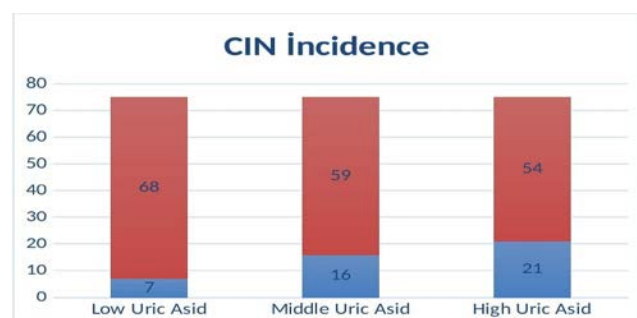
**Table II:** Baseline Laboratory Parameters by SUA Levels.

Parameters	Low SUA ≤5.2 mg/dL (n=75)	Medium SUA 5.3–6.6 mg/dL (n=75)	High SUA≥6.7 mg/dL (n=75)	p value
White blood cells, 10 <sup>3</sup> /uL, mean(SD)	9.4(2.7)	9.8(3.7)	9.7(3.9)	0.684
Red blood cells,mean(SD)	4.9(0.6)	4.9(0.7)	4.9(0.6)	0.846
Hemoglobin, g/dL, mean(SD)	13.7(1.8)	13.4(1.9)	13.6(1.8)	0.634
Platelets, 10 <sup>3</sup> /uL, mean(SD)	241.6(69.7)	255.9(89.0)	240.7(67.8)	0.389
Neutrophile, 10 <sup>9</sup> /L,median IQR	6.1(2.6)	7.0(3.7)	6.7(3.8)	0.263
Lymphocyte, 10 <sup>9</sup> /L,mean(SD)	2.3(0.9)	2.0(0.7)	2.0(0.9)	0.071
Glucose,median IQR	112.5(110.2)	115(96)	127(94)	0.361
GFR, mL/min/1.73 m <sup>2</sup> ,mean(SD)	88.7(20.8)	83.2(23.2)	73.8(26.1)	<b>0.001</b>
Urea,mg/dL, median IQR	35.5(11.4)	44.7(19.0)	52.1(23.2)	<b>&lt;0.001</b>
Creatinine,mg/dL,mean(SD)	0.85(0.17)	1.01(0.57)	1.14(0.41)	<b>&lt;0.001</b>
Sodium, mEq/L, mean(SD)	134.7(15.7)	136.6(3.0)	136.0(3.5)	0.467
Potassium, mEq/L, median IQR	4.3(0.6)	4.4(0.8)	4.4(1.0)	0.894
Total Protein, g/dL,mean(SD)	7.22(0.66)	7.15(0.67)	7.02(0.72)	0.275
Total cholesterol, mg/dL,mean(SD)	181.5(42.8)	181.4(50.7)	177.1(49.3)	0.815
Triglyceride,mg/dL,medianIQR	136.5(132.5)	146.5(93.7)	172(129)	0.562
LDL-C,mg/dL, mean(SD)	109.4(33.7)	108.1(40.1)	100.6(35.1)	0.285
HDL-C, mg/dL,mean(SD)	38.9(7.6)	38.6(8.5)	38.0(7.0)	0.782

**Notes:** Data are presented as mean (standard deviation) or median (interquartile range) based on normality. P-values were calculated using ANOVA for normally distributed variables, Kruskal-Wallis test for non-normally distributed variables, and chi-square test for categorical variables. \* $p<0.05$ , \*\* $p<0.01$ , \*\*\* $p<0.001$ . **Abbreviations:** GFR, glomerular filtration rate; LDL, low-density lipoprotein; HDL, high-density lipoprotein; CTO, chronic total occlusion; PCI, percutaneous coronary intervention.

### Primary Outcome: CIN

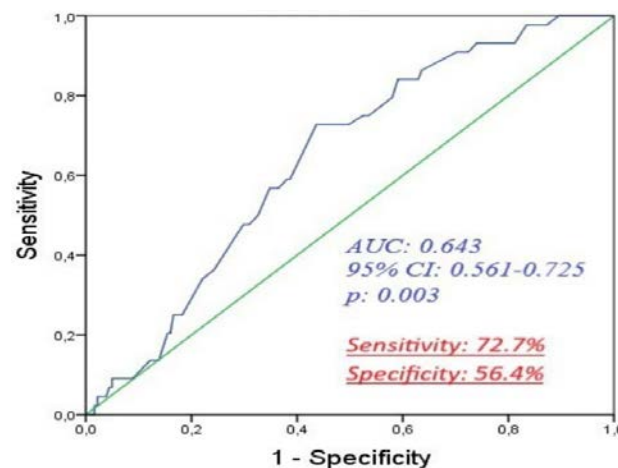
CIN, described as a >25% elevation in serum creatinine within 2-3 days after PCI, occurred in 44 patients (19.6%). The incidence of CIN rose markedly with higher SUA levels (8.0% in Group 1, 18.7% in Group 2, 32.0% in Group 3;  $p<0.001$ ) (Figure 1). Mortality during follow-up period was meaningfully elevated in Group 3 (9.3% vs. 2.7% in Group 1,  $p=0.023$ ).



**Figure 1.** Incidence of CIN Across SUA Tertiles.[CIN rates were 8.0%, 18.7%, and 32.0% in Groups 1, 2, and 3, respectively ( $p<0.001$ ).]

### Predictive Value of Serum Uric Acid

ROC analysis was undertaken to investigate SUA's predictive value for CIN (Figure 2). A SUA cutoff of 5.95 mg/dL yielded an AUC of 0.643 (95% CI: 0.561–0.725,  $p=0.003$ ), with a specificity of 56.4% and sensitivity of 72.7%.



**Figure 2.** Receiver Operating Characteristic (ROC) Curve for Serum Uric Acid (SUA) in Predicting Contrast-Induced Nephropathy (CIN) in 225 CTO-PCI Patients.

### Logistic Regression Analysis (LRA)

Univariable LRA identified age (p=0.018, OR 1.04, 95% CI: 1.01–1.07), LVEF (p=0.026, OR 0.95, 95% CI: 0.91–0.99), CRP (p=0.009, OR 1.08, 95% CI: 1.02–1.14), and SUA (p=0.004, OR 1.32, 95% CI: 1.09–1.60,) as significant predictors of CIN (Table 3). However, in multivariable LRA adjusting for LVEF, CRP, sex, GFR, diabetes, age, hypertension and hyperlipidemia, no variables remained independently linked to CIN (SUA: OR 1.19, 95% CI: 0.94–1.51, p=0.147).

**Table III:** Univariable and Multivariable Logistic Regression Analysis for Predictors of Contrast-Induced Nephropathy (CIN) in 225 CTO-PCI Patients.

Parameters	Univariable analysis		Multivariable analysis	
	OR (95% CI)	p value	OR (95% CI)	p value
Age	1.03(1.00-1.06)	<b>0.032</b>	1.03(0.98-1.07)	0.166
Ejection Fraction	0.95(0.92-0.98)	<b>0.004</b>	0.97(0.93-1.01)	0.218
GFR	0.98(0.97-1.0)	0.078	0.99(0.97-1.01)	0.826
CRP	1.14(1.04-1.25)	<b>0.005</b>	1.08(0.98-1.20)	0.103
Serum Uric Acid	1.29(1.06-1.58)	<b>0.012</b>	1.36(0.99-1.85)	0.051
LDL	1.0(1.0-1.01)	0.062	1.01(0.99-1.02)	0.102

**Notes:** Univariable analysis included age, sex, ejection fraction, hypertension, diabetes mellitus, smoking, cerebrovascular disease, GFR, hemoglobin, C-reactive protein, HDL cholesterol, and LDL cholesterol. Variables with p<0.10 in univariable analysis were included in multivariable analysis, adjusted for sex, hypertension, diabetes mellitus, smoking, cerebrovascular disease, and hemoglobin. \*p<0.05, \*\*p<0.01, \*\*\*p<0.001.

**Abbreviations:** OR, odds ratio; CI, confidence interval; GFR, glomerular filtration rate; LDL, low-density lipoprotein; CTO, chronic total occlusion; PCI, percutaneous coronary intervention.

### DISCUSSION

This retrospective analysis reveals a notable correlation between heightened SUA concentrations and elevated risk of CIN in patients receiving PCI for CTO. With a CIN incidence of 19.6%, consistent with reported rates of 10–20% in similar populations<sup>1,15</sup>, our findings propose that SUA could function as a significant biomarker for detecting patients at elevated risk, particularly in the context of CTO-PCI, where procedural complexity heightens renal stress.

Our observation that CIN risk increased across SUA tertiles (8.0% in SUA ≤5.2 mg/dL vs. 32.0% in SUA ≥6.7 mg/dL, p<0.001) aligns with prior studies linking hyperuricemia to renal injury. Kanbay et al. (2017) found that SUA concentrations exceeding 6.5 mg/dL were linked to a 2.5-fold greater risk for CIN in coronary angiography patients<sup>7</sup>. Similarly, Okuyan et al. (2022) found that hyperuricemia predicted CIN in acute coronary syndrome patients receiving PCI, with a cutoff of 6.0 mg/dL<sup>4</sup>. Our identified SUA cutoff of 5.95 mg/dL (AUC=0.643, sensitivity 72.7%, specificity 56.4%) is slightly lower, potentially reflecting the unique risk profile of CTO-PCI patients, who face prolonged contrast exposure. However, the moderate AUC suggests that SUA’s predictive value may be augmented when combined with other biomarkers, such as baseline GFR or CRP.

The pathophysiological link between SUA and CIN likely involves multiple mechanisms. Hyperuricemia induces endothelial dysfunction, oxidative stress and renal tubular injury, all of which exacerbate contrast-mediated renal damage<sup>5,6</sup>. Uric acid, by activating the renin-angiotensin-aldosterone system, can stimulate arterial vasoconstriction, reducing perfusion in the vulnerable outer medulla of the kidney, which is vulnerable to ischemia<sup>16</sup>. These effects are particularly pronounced in CTO-PCI, where higher contrast volumes and longer fluoroscopy times amplify renal stress<sup>8</sup>. Our finding of increased CKD prevalence and reduced GFR in patients with higher SUA levels further supports the role of hyperuricemia in renal vulnerability, consistent with recent data from the URRAH study, which linked SUA >5.6 mg/dL to adverse renal outcomes<sup>13</sup>.

Notably, while SUA was a significant predictor of CIN in univariable analysis (OR 1.32, p=0.004), it did not retain significance in multivariable analysis (OR 1.19, p=0.147). This may be explained by the small sample size,

which limited statistical power, or confounding by covariates such as baseline GFR and CKD. Similar findings were reported by Guo et al. (2023), who noted that SUA's predictive value for CIN diminished after adjusting for renal function<sup>17</sup>. Larger, multicenter studies are needed to clarify SUA's independent role and establish optimal cutoff values for clinical use.

The clinical consequences of our findings are meaningful. Routine SUA measurement, a widely available and cost-effective test, could enhance CIN risk stratification in CTO-PCI patients. Patients with SUA levels >5.95 mg/dL may benefit from intensified preventive strategies, such as extended periprocedural hydration, N-acetylcysteine administration, or minimized contrast volume<sup>18</sup>. Additionally, our observation of higher mortality in patients with elevated SUA (9.3% vs. 2.7%, p=0.023) underscores the prognostic importance of hyperuricemia, aligning with studies linking SUA to cardiovascular and renal mortality<sup>19</sup>.

### Limitations

This research has several constraints. The retrospective nature and single-center design of this research might introduce selection bias and limit the generalizability of the results. Second, the lack of data on contrast volume, a key CIN risk factor, precluded adjustment for this confounder. Third, the small sample size (n=225) may have reduced the statistical power to detect independent associations in multivariable analysis. Fourth, we did not assess long-term renal outcomes, such as progression to chronic kidney disease, which could further elucidate SUA's role. Finally, unmeasured confounders, such as periprocedural medications or hydration variability, may have influenced results.

### CONCLUSIONS

Higher SUA concentrations were found to correlate with a greater likelihood of developing CIN among individuals treated with PCI for CTO

with a cutoff of 5.95 mg/dL offering moderate predictive value. Routine SUA assessment may aid in identifying high-risk patients, supporting tailored preventive strategies such as enhanced hydration and N-acetylcysteine administration. Prospective multicenter studies involving larger cohorts and detailed data on contrast volume and long-term outcomes are necessary to confirm SUA as a dependable biomarker for risk stratification of CIN.

### ABBREVIATIONS

- SUA: Serum Uric Acid
- CIN: Contrast-Induced Nephropathy
- CTO: Chronic Total Occlusion
- PCI: Percutaneous Coronary Intervention
- EF: Ejection Fraction
- LVEF: Left Ventricular Ejection Fraction
- GFR: Glomerular Filtration Rate
- CKD: Chronic Kidney Disease
- CRP: C-Reactive Protein
- AUC: Area Under the Curve
- OR: Odds Ratio
- ULR: Univariable Logistic Regression
- MLR: Multivariable Logistic Regression
- CKD-EPI : Chronic Kidney Disease Epidemiology Collaboration

**Ethical Approval:** Ethical clearance for this research was acquired from the Institutional Review Board of Diyarbakır Gazi Yaşargil Training and Research Hospital (Approval No: 200/2022, dated 21 October 2022). The research was carried out in compliance with the principles outlined in the Declaration of Helsinki. Given its retrospective nature, informed consent was not required.

**Conflict of Interest:** The authors declared no conflicts of interest.

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## REFERENCES

1. Solomon RJ, Mehran R, Natarajan MK, et al. Contrast-induced nephropathy and long-term adverse events: cause and effect? *Clin J Am Soc Nephrol.* 2009;4(7):1162–9.
2. McCullough PA, Adam A, Becker CR, et al. Risk prediction of contrast-induced nephropathy. *Am J Cardiol.* 2006;98(6A):27K–36K.
3. James MT, Gali WA, Tonelli M, et al. Acute kidney injury following coronary angiography is associated with a long-term decline in kidney function. *Kidney Int.* 2010;78(8):803–9.
4. Okuya Y, Ishii H, Takahashi H, et al. Hyperuricemia as a risk factor for contrast-induced nephropathy in acute coronary syndrome. *Clin Exp Nephrol.* 2022;26(4):321–8.
5. Kang DH, Nakagawa T. Uric acid and chronic renal disease: possible implication of hyperuricemia on progression of renal disease. *Semin Nephrol.* 2005;25(1):43–9.
6. Johnson RJ, Nakagawa T, Jalal D, et al. Uric acid and chronic kidney disease: which is chasing which? *Nephrol Dial Transplant.* 2013;28(9):2221–8.
7. Kanbay M, Solak Y, Afsar B, et al. Serum uric acid and risk for acute kidney injury following contrast. *Angiology.* 2017;68(2):132–44.
8. Brilakis ES, Banerjee S, Karmpaliotis D, et al. Procedural outcomes of chronic total occlusion percutaneous coronary intervention. *JACC Cardiovasc Interv.* 2015;8(2):245–53.
9. Fefer P, Knudtson ML, Cheema AN, et al. Current perspectives on coronary chronic total occlusions: the Canadian Multicenter Chronic Total Occlusions Registry. *J Am Coll Cardiol.* 2012;59(11):991–7.
10. Sapontis J, Salisbury AC, Yeh RW, et al. Early procedural and health status outcomes after chronic total occlusion angioplasty. *JACC Cardiovasc Interv.* 2017;10(15):1523–34.
11. Bhatt H, Turkistani A, Sanghani D, et al. Do cardiovascular risk factors and coronary SYNTAX score predict contrast volume use during cardiac catheterization? *Angiology.* 2015;66(10):933–40.
12. Mendi MA, Afsar B, Oksuz F, et al. Uric acid is a useful tool to predict contrast-induced nephropathy. *Angiology.* 2017;68(7):627–32.
13. Viazzi F, Leoncini G, Ratto E, et al. Serum uric acid as a risk factor for cardiovascular and renal disease: an update from the URRAH study. *J Nephrol.* 2021;34(3):709–18.
14. Mehran R, Aymong ED, Nikolsky E, et al. A simple risk score for prediction of contrast-induced nephropathy after percutaneous coronary intervention. *J Am Coll Cardiol.* 2004;44(7):1393–9.
15. Tsai TT, Patel UD, Chang TI, et al. Contemporary incidence, predictors, and outcomes of acute kidney injury in patients undergoing percutaneous coronary interventions. *JACC Cardiovasc Interv.* 2014;7(1):1–9.
16. Lapsia V, Johnson RJ, Dass B, et al. Elevated uric acid increases the risk for acute kidney injury. *Am J Med.* 2012;125(3):302.e9–17.
17. Guo W, Liu Y, Chen JY, et al. Hyperuricemia and contrast-induced acute kidney injury: a systematic review and meta-analysis. *Int J Cardiol.* 2023;370:100–6.
18. Weisbord SD, Palevsky PM. Prevention of contrast-induced nephropathy with volume expansion. *Clin J Am Soc Nephrol.* 2008;3(1):273–80.
19. Zhao G, Xu L, Wu Y, et al. Serum uric acid and risk of cardiovascular mortality: a systematic review and dose-response meta-analysis. *J Am Heart Assoc.* 2021;10(15):e020678.