Journal of Cardiovascular Disease Research

ISSN: 0975-3583, 0976-2833 VOL 14, ISSUE 06, 2023

A PROSPECTIVE STUDY ON CHA2DS2-VASC SCORE AS A NOVEL PREDICTOR FOR CONTRAST-INDUCED NEPHROPATHY AFTER PERCUTANEOUS CORONARY INTERVENTION IN ACUTE CORONARY SYNDROME IN NORTH KARNATAKA

[1]Dr. Rajiv S Konin, [2]Dr. Sandeep Bijapur, [3]Dr. Akshay S.Chincholi, [4] Dr. Veeresh Patil

[1]Assistant Professor of Cardiology, Sri Jayadeva Institute of Cardiovascular Sciences and Research, Kalaburagi, Karnataka.

[2]Associate Professor of Cardiology, Sri Jayadeva Institute of Cardiovascular Sciences and Research, Kalaburagi, Karnataka

[3]Assistant Professor of Cardiology, Sri Jayadeva Institute of Cardiovascular Sciences and Research, Kalaburagi, Karnataka

[4]Associate Professor of Cardiology, Sri Jayadeva Institute of Cardiovascular Sciences and Research, Kalaburagi, Karnataka

Corresponding Author: Dr. Akshay S.Chincholi

Abstract

Objective: This study aims at analyzing the predictive value of the CHA2DS2-VASc score as a simplertool for predicting CIN in patients with ACS undergoing PCI.

Background:CHA2DS2-VASc is a prediction tool for the risk of stroke in patients with atrial fibrillation. It is a composite scoring system including congestive heart failure (CHF)/left ventricular dysfunction, hypertension, age ≥75 years, diabetes mellitus, previous stroke, vascular disease, age 65– 74 years, and sex (female).

Patients and method: This study included 130 patients presented with the acute coronary syndrome who underwent percutaneous coronary intervention Sri Jayadeva Institute of cardiovascular sciences and research, Kalaburagi, Karnataka from September 2020 to March 2022. CHA2DS2 VASC score was calculated for each patient. Patients were divided into two groups as group 1(patients who did not develop CIN) while group 2 (patients who developed CIN).Whole History taking, thorough clinical examination, echocardiography, and laboratory investigations were done for all patients included inthis study. serum creatinine at admission & 48 hrs after PCI were done to search for CIN . CIN was defined as increase in serum creatinine level more than 0.5 mg /dl or more than 25% increase from baseline within 48 h after PCI.

Results: There was a significant difference between studied groups as regards CHA2DS2 VASC score. The cutoff value of the CHA2DS2 VASC score for the prediction of contrast-induced nephropathy cases is 4 with sensitivity of 69.57 % & specify of 76.64%.

Conclusion: CHA2DS2-VASc score serves as a simple yet effective tool for predicting CIN pre- procedure, which can be easily implemented in day-to-day clinical practice.

Keywords: Acute Coronary syndrome, CHA2DS2-VASc, Contrast induced nephropathy, percutaneous Coronary intervention.

Introduction

The CHA2DS2-VASC risk score (CVRS) was developed for embolic risk stratification in patients with atrial fibrillation (AF) to provide further optimal anticoagulant therapy [1]. Studies have confirmed that the CVRS could be used for the prediction of coronary artery disease [2, 3] and long-term prognosis in patients undergoing percutaneous coronary intervention (PCI) [4, 5]. More- over, it was feasible in predicting acute stent thrombosis in AF-free patients [6] and the no-reflow phenomenon among patients with ST-segment

ISSN: 0975-3583, 0976-2833 VOL 14, ISSUE 06, 2023

elevation myocardial infarction (STEMI) who underwent primary PCI [7]. Since the CVRS is widely used, whether it can be useful to predict contrast-induced nephropathy (CIN), which is one of the most common complications in patients who undergo PCI, is unclear. Evidences have suggested that the scoring system also has a predictive value for CIN after PCI among patients with acute coronary syndrome (ACS) [8] and STEMI [9]. However, the usefulness of the CVRS in predicting the occurrence of CIN among patients with chronic total occlusion (CTO) undergoing PCI remains unknown. In this study, we aimed to deter- mine CVRS as a predictor of CIN among these patients.

Materials & Method

This study included 130 patients presented with the acute coronary syndrome who underwent percutaneous coronary intervention Sri Jayadeva Institute of cardiovascular sciences and research, Kalaburagi, Karnataka from September 2020 to March 2022. The serum creatinine level was monitored for 72 h after the procedure to determine the occurrence of CIN. Exclusion criteria included patients who underwent haemodialysis or those with glomerular filtration rate (GFR) < 15 mL/min/1.73 m^2, severe heart failure [New York Heart Association (NYHA) IV], pulmonary oedema, recent (past 2 days) use of contrast, and the use of potential nephrotoxic drugs within 72 h prior to the procedure and 72 h after the catheterization. PCI was performed among patients with angina or silent ischaemia with viable myocardium in the occluded coronary artery using the myocardial nuclear scan, stress dobutamine echo- cardiography, or cardiac magnetic resonance imaging. All patients were prescribed a loading dose of aspirin 300 mg and clopidogrel 300 mg prior to the procedure. The CAG was performed via the radial artery approach, and bilateral CAG was performed when necessary. We attempted to open the CTO lesion using antegrade cross- ing techniques. The femoral artery path was used during vasospasm or vascular tortuosity or based on the opera- tor's decision. Retrograde crossing techniques were used if the antegrade crossing techniques failed and the patient had a good collateral circulation. Heparin 100 U/kg was administered as an anticoagulant. The use of glycoprotein IIb/IIIa receptor inhibitor and the type of stents were based on the physician's discretion. All patients signed an informed consent. Iopromide [for patients with estimated GFR (eGFR) ≥40 mL/min/1.73 m^2] and iodixanol (for patients with eGFR < 40 mL/min/1.73 m^2) were used during the pro- cedure. Patients with a baseline eGFR < 40 mL/min/1.73 m^2 received intravenous hydration with a standard nor- mal saline at a rate of 1 mL/kg/h (or 0.5 mL/kg/h in patients with heart failure) for at least 12 h before and after the cardiac catheterization. Potential nephrotoxic drugs were withdrawn for at least 72 h before and after the catheterization.

Statistical analysis

Normally distributed continuous variables were expressed as mean ± standard deviation, and non-normally distributed variables were represented as median (min-max). Similarly, categorical variables were expressed as percentages. To compare the differences of continuous data, the analysis of variance was used to analyse parametric data, and the Kruskal–Wallis H test was carried out for nonparametric data. Categorical data were analysed using the Chi-square or Fisher's exact test based on the actual situation. The receiver operating characteristic (ROC) curve analysis was used to determine the optimum cutoff values of the CVRS to predict the incidence of CIN. Add- itionally, the logistic regression model was used to deter- mine the independent predictors of CIN that were not included in the CVRS. A P-value < 0.05 was considered statistically significant.

ISSN: 0975-3583, 0976-2833 VOL 14, ISSUE 06, 2023

Results and Observation

A total of 130 patients with CTO (82 females, 34.3%) who underwent angiography were included in this study, and all enrolled patients were followed-up for 72 h after the procedure. The incidence of CIN was 16.3%. In this study, the incidence of CTO lesions was predominant in the right coronary artery (97, 40.6%). Transradial approach was the predominant access route (69%). The retrograde approach accounted for 23.8% of the proce- dures, and the success rate of the operation was 92.1%. None of the patients had SRD which required early dialysis and major bleeding which needed transfusion; however, a groin haematoma > 5 cm was observed in 2.1% (n = 5) of the patients

Table 1: Clinical characteristics of study population according to CHA2DS2-VASC

Variable	CHA2DS2-VASc Score			*p*-value
	low risk (1 point, *n* = 64)	intermediate risk (2–3 points, *n* = 135)	high risk (≥4 points, *n* = 40)	
Age (years), mean (SD)	53.0 ± 7.5	59.1 ± 6.4	67.9 ± 7.9	P<0.001
Gender (female), n(%)	0	63 (47.4)	19 (47.5)	P<0.001
Body mass index (Kg/m^2)	25.3 ± 1.8	24.4 ± 2.9	24.3 ± 2.6	0.04
Diabetes Mellitus, n(%)	0	20 (14.8)	20 (50.0)	P<0.001
Hypertension, n(%)	0	34 (25.2)	27 (67.5)	P<0.001
Stroke history, n(%)	0	2 (1.5)	6 (15.0)	P<0.001
Current smoker, n(%)	17 (26.6)	45 (33.3)	8 (20.0)	0.23
Previous MI, n(%)	19 (29.2)	46 (34.1)	11 (25.5)	0.67
Systolic blood pressure (mmHg)	119.1 ± 13.7	121.8 ± 12.1	124.6 ± 14.2	0.28
Diastolic blood pressure (mmHg)	74.7 ± 10.0	74.2 ± 9.3	72.4 ± 5.8	0.015
Pulse pressure (mmHg)	44.4 ± 10.2	47.6 ± 9.7	52.2 ± 12.2	0.001
LVEF	0.51 ± 0.04	0.45 ± 0.06	0.43 ± 0.04	P<0.01
NYHA 2–3 on admision	0	20 (14.8)	17 (42.5)	P<0.01
Total Cholesterol (mmol/L)	4.2 ± 1.0	4.3 ± 1.1	4.3 ± 0.9	0.70
LDL-C (mmol/L)	2.6 ± 0.6	2.5 ± 0.6	2.7 ± 0.6	0.23
HDL-C (mmol/L)	1.1 ± 0.3	1.1 ± 0.3	1.2 ± 0.4	0.25
Triglyceride (mmol/L)	1.6 ± 1.2	1.5 ± 1.3	1.3 ± 0.8	0.59
Fasting Glucose (mmol/L)	5.3 ± 0.5	5.5 ± 0.8	5.8 ± 1.0	0.027
eGFR baseline (ml/min/1.73m^2)	102.0 ± 13.8	92.8 ± 17.0	89.5 ± 17.6	P<0.001
eGFR after PCI (ml/min/1.73m^2)	98.4 ± 14.2	87.4 ± 19.5	76.2 ± 21.3	P<0.001
First Day Creatinine (μmol/l)	68.8 ± 19.2	69.5 ± 16.9	65.0 ± 17.6	0.37
Uric acid (μmol/l)	330.3 ± 69.9	330.8 ± 69.8	336.1 ± 75.6	0.90
Total amount of conrrast (ml)	181.8 ± 63.5	241.8 ± 104.0	320.3 ± 92.5	P<0.001
Total time of procedure (min)	74.4 ± 45.6	96.1 ± 47.7	129.7 ± 51.6	P<0.001
The retrograde approach, n(%)	14 (21.5)	29 (21.5)	14 (35.0)	0.19
Transradial + transfemoral approach, n(%)	21 (32.8)	42 (31.1)	17 (42.5)	0.40
IABP, n(%)	4 (6.3)	6 (4.4)	7 (17.5)	0.02
IVUS, n(%)	4 (6.3)	9 (6.7)	5 (12.5)	0.42
Stent number	1.9 ± 0.3	2.3 ± 0.6	2.6 ± 1.1	P<0.001
Glycoprotein IIb/IIIa receptor inhibitor, n(%)	12 (18.8)	24 (17.8)	13 (32.5)	0.12
CIN	4 (6.3)	20 (14.8)	15 (37.5)	P<0.001

ISSN: 0975-3583, 0976-2833 VOL 14, ISSUE 06, 2023

MI myocardial infarction, *LVEF* left ventricular ejection fraction, *NYHA* New York Heart Association (classification), *LDL-C* low density lipoprotein-cholesterol, *HDL-C* high density lipoprotein-cholesterol, *IABP* intra-aortic balloon pump, *IVUS* intravascular ultrasound, *CIN* contrast induced nephropathy

The mean age of our study population was 59.4 ± 9.9 years, and the mean CVRS was 2.3 ± 1.3. The patients' demographic and clinical characteristics were compared among the 3 groups (Table 1). Data on the age, female gender, and the incidence of hypertension, pulse pressure, diabetes mellitus, stroke, and NYHA II–III on admission were higher in the group with CVRS ≥4. The patients in the high-risk group had higher pulse pres- sure, total contrast volume, total procedure time, rate of intra-aortic balloon pump (IABP) insertion, and number of stent implantation and lower eGFR and diastolic blood pressure. The overall rate of CIN was 16.3%, and a significant difference was noted in the high-risk group compared to the low-risk and intermediate-risk groups (6.3% VS 14.8% VS 37.5%, P < 0.001).

Table 2 Clinical characteristics of the patients with and without contrast-induced nephropathy

Variable	contrast-induced nephropathy		*P*-value
	Yes (*n* = 39)	NO (*n* = 200)	
Age (years), mean (SD)	58.4 ± 8.4	64.5 ± 14.7	P<0.001
Gender (female), n(%)	17 (43.6)	65 (32.5)	0.13
Body mass index (Kg/m^2)	24.6 ± 2.7	24.7 ± 2.4	0.85
Diabetes Mellitus, n(%)	11 (28.2)	29 (14.5)	0.04
Hypertension, n(%)	21 (53.8)	40 (20.0)	P<0.001
Stroke history, n(%)	5 (12.8)	3 (1.5)	0.004
Current smoker, n(%)	7 (17.9)	63 (31.5)	0.06
Previous MI, n(%)	15 (38.5)	50 (25.0)	0.11
Systolic blood pressure (mmHg)	120.6 ± 12.6	126.5 ± 13.8	0.009
Diastolic blood pressure (mmHg)	74.5 ± 9.2	72.1 ± 8.1	P<0.001
Pulse pressure (mmHg)	54.4 ± 12.1	46.1 ± 9.7	P<0.001
LVEF	0.47 ± 0.07	0.44 ± 0.06	0.02
NYHA 2–3 on admision	7 (17.9)	30 (15.0)	0.40
Total Cholesterol (mg/dl)	4.4 ± 0.7	4.3 ± 1.1	0.33
LDL-C (mmol/L)	2.8 ± 0.5	2.5 ± 0.6	0.007
HDL-C (mmol/L)	1.0 ± 0.2	1.1 ± 0.3	0.09
Triglyceride (mmol/L)	1.4 ± 0.6	1.5 ± 1.3	0.35
Fasting Glucose (mmol/L)	5.4 ± 0.7	5.8 ± 1.3	0.004
Baseline eGFR (ml/min/1.73m^2)	94.6 ± 17.6	92.7 ± 20.3	0.53
Baseline Creatinine (μmol/l)	69.2 ± 18.0	65.3 ± 15.6	0.21
Uric acid (μmol/l)	355.4 ± 72.4	326.9 ± 69.4	0.02
Total amount of conrrast (ml)	299.2 ± 105.2	227.1 ± 98.3	P<0.001
The retrograde approach, n(%)	6 (15.4)	51 (25.5)	0.12
Transradial + transfemoral approach, n(%)	12 (30.8)	68 (34.0)	0.85
Procedural duration (min)	91.0 ± 50.0	120.9 ± 48.4	P<0.001
IABP, n(%)	3 (7.7)	14 (7.0)	0.75
IVUS, n(%)	4 (10.3)	14 (7.0)	0.51
Stent number	2.2 ± 0.9	2.2 ± 0.6	0.96

ISSN: 0975-3583, 0976-2833 VOL 14, ISSUE 06, 2023

Glycoprotein IIb/IIIa receptor inhibitor, n(%)	18 (46.2)	31 (15.5)	P<0.001
CHA2DS2-VASc Score	3.1 ± 1.2	2.1 ± 1.1	P<0.001

MI myocardial infarction, *LVEF* left ventricular ejection fraction, *NYHA* New York Heart Association (classification), *LDL-C* low density lipoprotein-cholesterol, *HDL-C*
high density lipoprotein-cholesterol, *IABP* intra-aortic balloon pump, *IVUS* intravascular ultrasound

The incidence of CIN was 16.3%. Table 2 demonstrates that patients diagnosed with CIN were older and required longer procedure time. A significant difference was observed in the age, female, systolic and diastolic blood pressure, pulse pressure, and incidence of diabetes mellitus, hypertension, and stroke history between the 2 groups. Furthermore, patients with CIN had higher LDL-C, fasting glucose, uric acid, total contrast volume, rate of glycoprotein IIb/IIIa receptor inhibitor, and CVRS than those without CIN (3.1 ± 1.2 VS 2.1 ± 1.1; P < 0.001). The ROC curve analysis revealed that the area under the curve for predicting CIN was 0.742 (sen- sitivity, 69.2%; specificity, 78.0%; 95% CI, 0.682–0.797;

Table 3: Independent Predictors of Pre-procedural Contrast-Induced Nephropathy in Patients with CTO

Variable	Univariate analysis		Multivariate analysis	
	OR	*P*-value	OR(95%)	*P*-value
Pulse pressure (mmHg)	1.126	0.042	1.042 (1.012–1.197)	0.014
LDL-C (mg/dl)	1.014	<0.001	1.174 (1.023–1.347)	0.492
Uric acid (μmol/l)	1.008	0.029	1.002 (1.000–1.013)	0.193
Baseline eGFR (ml/min/1.73m^2)	0.549	<0.001	0.662 (0.521–0.789)	0.012
Total amount of conrrast (ml)	1.971	<0.001	1.772 (1.342–2.128)	0.039
CHA2DS2-VASC risk score ≥ 3	7.743	<0.001	6.679 (3.169–15.531)	<0.001
LDL-C low density lipoprotein-cholesterol				

The incidence of CIN in- creased as the risk score increased. Multivariate analysis showed that higher pulse pressure [odds ratio (OR), 1.042; 95% CI, 1.012–1.197; P = 0.004] and contrast volume (OR, 1.772; 95% CI, 1.342–2.128; P = 0.039), lower baseline eGFR (OR, 0.662; 95% CI, 0.521–0.789; P =
0.012), and CVRS ≥3 (OR, 6.679; 95% CI, 3.169–15.531; P < 0.001) were independent predictors of CIN pre-procedure in CTO patients (Table 3).

Discussion

This is the first study demonstrating that CVRS ≥3 was an independent predictor of CIN among patients with CTO who underwent PCI. CIN is one of the most important complications of PCI, especially in patients with CTO lesions, and its pathogenesis is still not completely elucidated. It is a common complication and iatrogenic renal failure following invasive procedures, resulting in increased medical resources, longer hospital stay, and higher mor- tality [10–14]. According to the literature, the incidence of CIN is between 0.6 and 2.3% after contrast exposure in the general population [15]. A systematic review revealed that the incidence of CIN is approximately 3.8% among patients with CTO undergoing PCI [16]. Al- though identification of high-risk patients for CIN is challenging before the procedure, other studies suggested that congestive heart failure, hypertension, advanced age, diabetes mellitus, female gender, and pre-existing renal insufficiency are risk factors for CIN [17–20]. In this study, the CVRS had a similar predictive value with

ISSN: 0975-3583, 0976-2833 VOL 14, ISSUE 06, 2023

the Mehran risk score, which is the most widely used and classic model for predicting CIN. However, it is used for CIN risk assessment only after contrast medium exposure, which is restricted in clinical practise. In addition, inclusion of peri-procedural factors may re- strict the application of precautionary measures before the procedure. Although CVRS excludes peri-procedural factors (e.g. contrast volume), it has a similar predictive value to the Mehran risk score. Patients with CTO undergoing PCI may be older and have poor cardiac and renal function, which are risk factors of CIN. The long procedure time for CTO-PCI requires a large contrast volume, which adds to the problem of CIN. Hence, it is of utmost clinical importance to identify high-risk patients for CIN before PCI and prepare pre-procedural therapeutic intervention to minimise the risk of such complication. In addition, CVRS is widely used in clinical practise and it is easy to be calculated and remembered. We found that the incidence of CIN was 5.6 times higher in the high-risk group than that in low-risk patients ac- cording to the CVRS. Thus, we need to pay attention to high-risk patients and initiate preventive measures to minimise the risk of CIN, such as intravenous hydration and sodium bicarbonate and N-acetylcysteine administration before the procedure [21, 22]. Compared to other CIN risk stratification tools, the CHA2DS2-VASC scoring system may be convenient and easily applied in clinical practise.

Conclusion

In this study, we concluded that the CHA2DS2-VASc score serves as a simple, effective tool for predicting the development of CIN, which can be easily implemented in day-to-day clinical practice. The present study demonstrated that the CHA2DS2-VASC score >4 was independently associated withthe development ofCIN in patients presenting with Acute Coronary Syndrome who were treated by PCI. The more CHADS2- VASC score, the more risk for developing CIN after PCI, Thus CHA2DS2 VASC Score can be used as a simple pre-procedural predictor of CIN among patients with Acute Coronary Syndrome undergoing.

References

1. Camm AJ, Lip GY, De Caterina R, Savelieva I, et al. ESC Committee for practice guidelines (CPG). 2012 focused update of the ESC guidelines for the management of atrial fibrillation: an update of the 2010 ESC guidelines for the management of atrial fibrillation. Developed with the special contribution of the European heart rhythm association. Eur Heart J. 2012; 33(21):2719–47.
2. Cetin M, Cakici M, Zencir C, et al. Prediction of coronary artery disease severity using CHADS2 and CHA2DS2-VASc scores and a newly defined CHA2DS2-VASc-HS score. Am J Cardiol. 2014;113(6):950–6.
3. Modi R, Patted SV, Halkati PC, et al. CHA2DS2-VASc-HSF score-new predictor of severity of coronary artery disease in 2976 patients. Int J Cardiol. 2016; 228:1002–6.
4. Orvin K, Bental T, Assali A, et al. Usefulness of the CHA2DS2-VASC score to predict adverse outcomes in patients having percutaneous coronary intervention. Am J Cardiol. 2016;117(9):1433–8.
5. Huang FY, Huang BT, Pu XB, et al. CHADS2, CHA2DS2-VASc and R2CHADS2 scores predict mortality in patients with coronary artery disease. Intern Emerg Med. 2017;12(4):479–86.
6. Ünal S, Açar B, Yayla Ç, et al. Importance and usage of the CHA2DS2-VASc score in predicting acute stent thrombosis. Coron Artery Dis. 2016;27(6): 478–82.
7. Ipek G, Onuk T, Karatas MB, et al. CHA2DS2-VASc score is a predictor of no- reflow in patients with ST-segment elevation myocardial infarction who underwent primary

ISSN: 0975-3583, 0976-2833 VOL 14, ISSUE 06, 2023

percutaneous intervention. Angiology. 2016;67(9):840–5.
8. Kurtul A, Yarlioglues M, Duran M. Predictive value of CHA2DS2-VASC score for contrast-induced nephropathy after percutaneous coronary intervention for acute coronary syndrome. Am J Cardiol. 2017;119(6):819–25
9. Cicek G, Yıldırım E. CHA2DS2-VASc score predicts contrast induced nephropathy in patients with ST-segment elevation myocardial infarction who were undergoing primary percutaneous coronary intervention[J]. Kardiol Pol. 2018;76(1):91–8
10. Mccullough PA, Adam A, Becker CR, et al. Epidemiology and prognostic implications of contrast-induced nephropathy. Am J Cardiol. 2006;98(6A):5–13.
11. Chang CF, Lin CC. Current concepts of contrast-induced nephropathy: a brief review. J Chin Med Assoc. 2013;76(12):673–81.
12. Sato A, Aonuma K, Watanabe M, et al. Association of contrast-induced nephropathy with risk of adverse clinical outcomes in patients with cardiac catheterization: from the CINC-J study. Int J Cardiol. 2017;227:424–9.
13. James MT, Ghali WA, Knudtson ML, et al. Associations between acute kidney injury and cardiovascular and renal outcomes after coronary angiography. Circulation. 2011;123(4):409–16.
14. Budano C, Levis M, D'Amico M, et al. Impact of contrast-induced acute kidney injury definition on clinical outcomes. Am Heart J. 2011;161(5):963–71.
15. Meharn R, Nikolsky E. Contrast-induced nephropathy: definition, epidemiology, and patients at risk. Kidney Int Suppl. 2006;69(100):S11–5.
16. Patel VG, Brayton KM, Tamayo A, et al. Angiographic success and procedural complications in patients undergoing percutaneous coronary chronic total occlusion interventions: a weighted meta-analysis of 18,061 patients from 65 studies. JACC Cardiovasc Interv. 2013;6(2):128–36.
17. Lucreziotti S, Centola M, Salerno-Uriarte D, et al. Female gender and contrast-induced nephropathy in primary percutaneous intervention for ST- segment elevation myocardial infarction. Int J Cardiol. 2014;174(1):37–42.
18. Silver SA, Shah PM, Chertow GM, et al. Risk prediction models for contrast induced nephropathy: systematic review. BMJ. 2015;351:h4395.
19. Heyman SN, Rosenberger C, Rosen S, Khamaisi M. Why is diabetes mellitus a risk factor for contrast-induced nephropathy? Biomed Res Int. 2013;2013: 123589.
20. Huang SS, Huang PH, Leu HB, et al. Association of central pulse pressure with contrast-induced nephropathy and clinical outcomes in patients undergoing coronary intervention. J Hypertens. 2013;31(11):2187–94
21. Fähling M, Seeliger E, Patzak A, et al. Understanding and preventing contrast-induced acute kidney injury. Nat Rev Nephrol. 2017;13(3):169–80.
22. Mamoulakis C, Tsarouhas K, Fragkiadoulaki I, et al. Contrast-induced nephropathy: basic concepts, pathophysiological implications and prevention strategies. Pharmacol Ther. 2017;180:99–112