Indian Heart Journal 71 (2019) 303–308

Contents lists available at ScienceDirect

Indian Heart Journal

journal homepage: www.elsevier.com/locate/ihj

Original Article

CHA2DS2-VASc score as a novel predictor for contrast-induced nephropathy after percutaneous coronary intervention in acute coronary syndrome

Abhay Kumar Chaudhary [a, *], Vijay Pathak [a], Shekhar Kunal [a], Shubhra Shukla [b], Pooja Pathak [c]

[a] Department of Cardiology, S.M.S. Medical College and Attached Hospitals, Jaipur, Rajasthan, 302004, India
[b] Cosmetica Skin Clinic, Jaipur, Rajasthan, 302004, India
[c] Lady Health Officer, NIMS Medical College, Jaipur, Rajasthan, India

ARTICLE INFO

Article history:
Received 7 May 2019
Accepted 1 September 2019
Available online 9 September 2019

Keywords:
Acute coronary syndrome
CHA2DS2-VASc score
Contrast-induced nephropathy
Percutaneous coronary intervention
Radiocontrast media

ABSTRACT

Background: CHA2DS2-VASc score, used for atrial fibrillation to assess the risk of embolic complications, have shown to predict adverse clinical outcomes in acute coronary syndrome (ACS), irrespective of atrial fibrillation. This study envisaged to assess the predictive role of CHA2DS2-VASc score for contrast-induced nephropathy (CIN) in patients with ACS undergoing percutaneous coronary intervention (PCI).
Methods: A total of 300 consecutive patients with ACS undergoing PCI were enrolled in this study. CHA2DS2-VASc score was calculated for each patient. These patients were divided into two groups as Group 1 (with CIN) and Group 2 (without CIN). CIN was defined as increase in serum creatinine level $\geq$0.5 mg/dL or $\geq$25% increase from baseline within 48 h after PCI. After receiver operating characteristic curve analysis, the study population was again classified into two groups: CHA2DS2-VASc score $\leq$3 group (Group A) and score $\geq$4 group (Group B).
Results: CIN was reported in 41 patients (13.6%). Patients with CIN had a higher frequency of hypertension, diabetes mellitus, and had a lower left ventricular ejection fraction and baseline estimated glomerular filtration rate. Receiver operating characteristic curve analysis showed good predictive value of CHA2DS2-VASc score for CIN (area under the curve 0.81, 95% CI 0.73–0.90). Patients with a CHA2DS2-VASc score of $\geq$4 had a higher frequency of CIN as compared with patients with score $\leq$3 (56.8% vs 4.8%; $p = 0.0001$) with multivariate analysis demonstrating CHA2DS2-VASc score of $\geq$4 to be an independent predictor of CIN.
Conclusion: In patients with ACS undergoing PCI, CHA2DS2-VASc score can be used as a novel, simple, and a sensitive diagnostic tool for the prediction of CIN.

1. Introduction

CHA2DS2-VASc is a composite scoring system comprising congestive heart failure (CHF)/left ventricular dysfunction, hypertension, age $\geq$75 years, diabetes mellitus, previous stroke, vascular disease, age 65–74 years, and sex (female). It has been traditionally used as a prediction tool for risk of stroke in patients with atrial fibrillation.[1] The variables used in this score such as heart failure, hypertension, age, diabetes mellitus, and female sex are risk factors for poor clinical outcomes in cardiovascular diseases. Studies have shown CHA2DS2-VASc score to have a good predictive value for adverse clinical outcomes in patients with coronary artery disease such as stable angina pectoris and acute coronary syndrome (ACS) with or without atrial fibrillation.[2–6] In patients with stable coronary artery disease (CAD) as well as ACS, who undergo percutaneous coronary intervention (PCI), contrast-induced nephropathy (CIN) is a known complication and is often associated with an increased in-hospital and long-term morbidity including chronic renal dysfunction and mortality.[7] The incidence of CIN ranges from 7% to 25%[8,9] in different population subgroups based on the risk

* Corresponding author. 121/2, Shastri Nagar, Kanpur, Uttar Pradesh, Pin-208005, India.
E-mail addresses: abhayatgsvm@gmail.com (A.K. Chaudhary), vijalps2000@yahoo.com (V. Pathak), Shekhar.kunal09@gmail.com (S. Kunal), drshubhra2901@gmail.com (S. Shukla), poojapathak1304@gmail.com (P. Pathak).

https://doi.org/10.1016/j.ihj.2019.09.005

status. Hence, risk stratification has an important bearing to provide the appropriate preventive therapies to these high-risk individuals even before contrast media exposure.

In the past, several risk prediction models have been proposed to envisage the CIN incidence. Mehran et al[10] proposed a scoring system comprising eight variables which correlated well with the CIN risk. In 2013, Gurm et al[11] suggested another model consisting of 15 parameters, which had a better predictive value for CIN. Despite having a fair degree of accuracy, complexity was one of the major limitations of these models. The components of the CHADS2 score viz. age, diabetes, and heart failure have been suggested as risk factors for CIN; hence, this simple scoring system can be used to predict risk of CIN. This scoring system was used in a recent study of patients with stable CAD undergoing elective PCI, wherein it correlated well with the occurrence of CIN.[12] Because patients with ACS have a far greater risk for CIN compared to patients with stable CAD, its utility as a predictive tool cannot be undermined.[13] This study sought to analyze the predictive value of CHA2DS2-VASc score as a simpler tool for predicting CIN in patients with ACS undergoing PCI.

2. Methods

2.1. Study population

This was a single-center observational, cross-sectional study carried out in the Department of Cardiology, S.M.S. Medical College and attached Hospitals, Jaipur, Rajasthan, India. A total of 316 consecutive patients presenting with ACS and undergoing PCI were initially enrolled between March 2017 and October 2018. These patients with ACS comprised both ST elevation myocardial infarction (STEMI) and non–ST-elevation ACS subgroups who were planned for PCI. Patients with STEMI and undergoing primary PCI were not included. All these patients were diagnosed based on history, physical examination findings, electrocardiographic criteria, and cardiac biomarkers evaluation as per the task force definition.[14] The exclusion criteria included: patients with an estimated glomerular filtration rate (eGFR) < 30 mL/min, either with or without pre-existing dialysis, shock, acute renal failure, acute or chronic infection/inflammatory conditions, recent exposure to radiographic contrast media (within 10 days of enrollment), or having contraindications for PCI. Patients who died during or early after procedure ($n = 4$) or lack of data on serum creatinine during the 48 h after the procedure ($n = 12$) were excluded from the study.

2.2. Study protocol

The study conforms to widely accepted ethical principles guiding human research (the Declaration of Helsinki) and the study protocol was approved by the Institutional Ethical Committee. A written informed consent was obtained from all the patients before enrollment. Assuming an incidence of CIN among patients undergoing PCI to be 10%, the sample size was estimated to be a minimum of 225 subjects at 95% confidence interval and 4% absolute allowable error. After exclusion of the 16 patients, a total of 300 patients' data were analyzed, which consisted of detailed history including information regarding the symptomatology, presence of traditional cardiovascular risk factors (smoking/tobacco use, diabetes, hypertension), family history of CAD, previous history of CAD/coronary artery bypass graft, previous atherosclerotic cerebrovascular events, and current medical therapy. Serum creatinine and serum urea levels were determined at the time of admission, daily up to 48 h after PCI, and then at seventh day after PCI. The eGFR was calculated using the Cockcroft–Gault method: [140-age (years) × weight (kg)/72 × serum creatinine (mg/dl)] { × 0.85 for female subjects} taking the serum creatinine measured at admission.[15] Baseline investigations included complete blood counts, fasting and postprandial plasma sugar levels, glycated hemoglobin, and fasting lipid profiles. Left ventricular ejection fraction (LVEF) was estimated by 2D echocardiography at admission using Simpson's method.

CHA2DS2-VASc score was calculated for each patient by giving a score of 1 to each of these variables: (i) CHF or left ventricular systolic dysfunction EF ≤ 40%, (ii) hypertension, (iii) age 65–74 years, (iv) diabetes mellitus, (v) vascular disease, and (vi) female gender and 2 points for (vii) age 75 years or older, and (viii) previous stroke or transient ischemic attack each. A minimum score of 1 was assigned to every patient as they had an episode of CAD due to vascular atherosclerosis, hence, mandating a PCI. All these PCI procedures were performed by experienced interventional cardiologists either through the transfemoral or transradial approach depending on the expertise and technical feasibility. Nonionic, low-osmolar contrast medium (Iohexol, Omnipaque 350 mg/mL) or nonionic, IOCM (iso-osmolar dimeric contrast medium) (Iodixanol, Visipaque 320 mg/mL) were used during the PCI. Iodixanol was used in patients with a baseline eGFR <60 mL/min who were also hydrated with intravenous 0.9%, isotonic saline before the procedure, except for patients with frank congestive cardiac failure. Rate of intravenous hydration consisted of 1 mL/kg of body weight/hour or 0.5 mL/kg/hr for 12 h in patients with LVEF <40%. It was started 3–12 h before contrast agent injection and continued for 12 h after PCI. Nephrotoxic drugs such as metformin and nonsteroidal anti-inflammatory drugs were withdrawn before PCI. All patients were pretreated with aspirin (300 mg) and a P2Y12 antagonist (clopidogrel 600 mg or ticagrelor 180 mg or prasugrel 60 mg) before PCI. In addition, unfractionated heparin in a dose of 70–100 U/kg was administered during the procedure. The use of glycoprotein IIb/IIIa inhibitors during PCI was at the operator's discretion.

Table 1
Baseline demographic, clinical, and angiographic characteristics of overall study population.

Mean age (years)	55.04 ± 9.55
Male	215 (71.7%)
Female	85 (28.3%)
STEMI	118 (39.3%)
NSTE-ACS	182 (60.7%)
Mean LVEF%	46.63 ± 9.19
Smoking/tobacco use	198 (66.0%)
Hypertension	120 (40.0%)
Diabetes mellitus	62 (20.7%)
Previous CAD	39 (13.0%)
Previous CABG	5 (1.7%)
Previous CVA	9 (3.0%)
Peripheral vascular disease	19 (6.3%)
Pre-existing renal disease	10 (3.3%)
Killip class ≥ 2	54 (18%)
Mean hemoglobin (g/dL)	12.80 ± 1.44
Mean baseline serum creatinine (mg/dL)	1.00 ± 0.29
Mean baseline eGFR (mL/min)	89.68 ± 20.65
Mean contrast volume (mL)	145.37 ± 50.78
Multivessel CAD (no of vessels ≥2)	144 (48%)
Multivessel PCI (no of Stents ≥2)	162 (54%)
Use of ACE Inhibitor/ARB	168 (56%)
Previous use of Metformin	37 (12.3%)
CHA2DS2-VASc score	2.51 ± 1.18
Contrast-induced nephropathy (CIN)	41 (13.7%)

ACE; angiotensin converting enzyme; ARB, angiotensin receptor blocker; CAD, coronary artery disease; CVA, cerebrovascular accidents; CABG, coronary artery bypass graft; eGFR, estimated glomerular filtration rate; NSTE-ACS, non–ST-elevation ACS; PCI, percutaneous coronary intervention; LVEF, left ventricular ejection fraction; STEMI, ST elevation myocardial infarction.

2.3. Definitions

The primary outcome for this study was the occurrence of CIN. Based on the occurrence of CIN, the study population was divided into two groups: Group 1 (patients with ACS and CIN) and Group 2 (patients with ACS without CIN). CIN was defined as the elevation of serum creatinine ≥0.5 mg/dL or ≥25% increase in the baseline serum creatinine levels within 48 hrs after PCI.[16] Pre-existing renal disease was defined as past history of renal artery stenosis, renal failure, glomerulonephritis, renal obstruction, nephrotic syndrome, or nephrectomy. Previous history of CAD was defined as a definitive history of myocardial infarction or coronary obstruction ≥50% on angiography.

2.4. Statistical analysis

The results were calculated as mean ± standard deviation for quantitative variables and counts/percentages for categorical variables. The groups were compared using the chi-square test for the categorical variables, whereas unpaired Student *t*-test was used for analysis of quantitative variables. A multivariate logistic regression analysis was performed for confounding variables affecting CIN development. For this, the variables significantly associated with CIN in univariate analyses were taken for multivariate logistic regression analysis to investigate their significance as independent predictors. Odds ratios and 95% confidence interval were determined. A *p*-value ≤ 0.05 was considered to be statistically significant. Receiver operating characteristic (ROC) curve analysis was used to determine the optimum cutoff values of the CHA2DS2-VASc score and the number of CHA2DS2-VASc score to predict the development of CIN. The enrolled patients were further divided into two groups according to CHA2DS2-VASc score after ROC analysis. All statistical analyses were performed using SPSS version 24.0 (SPSS Inc., Chicago, Ill., USA).

3. Results

3.1. Clinical characteristics

A total of 300 patients with ACS (215 males, 71.7%) having a mean age of 55.04 ± 9.55 years were enrolled in this study. Non–ST-elevation ACS was the most frequent clinical diagnosis in 182/300 (60.7%) patients, followed by STEMI in 118/300 (39.3%). The mean CHA2DS2-VASc score in the study population was 2.51 ± 1.18 (range: 1 to 8). Baseline characteristics have been reported in Table 1.

3.2. Study outcomes

3.2.1. Univariate analysis

CIN occurred in 41/300 (13.7%) patients after PCI mandating dialysis in 3 (0.01%) of them. Based on the presence or absence of CIN, the enrolled participants were divided into Group 1 (CIN) and Group 2 (no CIN). The clinical, laboratory, and angiographic data of each of the groups have been depicted in Table 2. Patients in Group 1 (CIN subgroup) had significantly higher number of hypertensives and diabetics as well as a lower LVEF and baseline eGFR as compared with Group 2. In addition, a higher number of patients in Group 1 had multivessel CAD mandating multivessel PCI and hence were exposed to a significantly higher contrast volume. Pre-existing renal disease, previous history of CAD, cerebrovascular accidents, systolic blood pressure, Killip class ≥2 on admission

Table 2
Clinical, laboratory, and angiographic data of the patients with and without contrast-induced nephropathy.

Variables	Group 1 CIN ($n = 41$)	Group 2 No CIN ($n = 259$)	*P*-Value
Age (years)	55.68 ± 8.31	54.93 ± 9.74	0.64
Female	10 (24.3%)	75 (28.9%)	0.54
Smoking/tobacco use	29 (70.7%)	169 (65.3%)	0.49
Hypertension	28 (68.3%)	92 (35.5%)	0.0001
Diabetes mellitus	29 (70.7%)	33 (12.7%)	0.0001
Previous CAD	10 (24.4%)	29 (11.2%)	0.02
Previous CABG	2 (4.9%)	3 (1.2%)	0.08
Previous CVA	5 (12.2%)	4 (1.5%)	0.0001
Pre-existing renal disease	4 (9.8%)	6 (2.3%)	0.01
Peripheral vascular disease	3 (7.3%)	16 (6.2%)	0.78
LVEF (%)	40.29 ± 9.15	47.63 ± 8.81	0.0001
Killip class ≥2	29 (70.7%)	25 (9.6%)	0.0001
Weight (kg)	76.59 ± 10.63	76.47 ± 9.56	0.94
Body mass index (kg/m^2)	23.24 ± 2.20	23.10 ± 1.97	0.68
Total cholesterol (mg/dL)	213.39 ± 32.64	202.51 ± 29.98	0.034
HDL (mg/dL)	41.22 ± 4.13	42.56 ± 14.16	0.55
LDL (mg/dL)	141.90 ± 27.33	132.04 ± 29.07	0.04
Triglyceride (mg/dL)	151.93 ± 46.36	138.27 ± 30.15	0.01
Systolic blood pressure (mm of Hg)	148.39 ± 34.75	134.32 ± 24.29	0.001
Diastolic blood pressure (mm of Hg)	89.37 ± 15.12	85.08 ± 50.12	0.59
Hemoglobin (g/dL)	11.74 ± 1.35	12.97 ± 1.38	0.0001
Serum creatinine (mg/dL)	1.07 ± 0.35	0.99 ± 0.28	0.12
eGFR (mL/min)	83.76 ± 19.22	90.61 ± 20.75	0.04
48 h peak serum creatinine (mg/dL)	1.96 ± 0.33	1.07 ± 0.30	0.0001
7th day serum creatinine (mg/dL)	1.34 ± 0.46	1.01 ± 0.28	0.0001
Contrast volume (mL)	204.39 ± 52.49	136.03 ± 43.81	0.0001
Iodixanol use	5 (31.2%)	11 (68.8%)	0.04
No. of vessels	1.98 ± 0.79	1.55 ± 0.67	0.0001
No. of stents	2.24 ± 0.83	1.62 ± 0.70	0.0001
CHA2DS2-VASc score	4.15 ± 1.35	2.25 ± 0.92	0.0001
ACE inhibitor/ARB use	29 (70.7%)	139 (53.7%)	0.04
Previous metformin use	19 (46.3%)	18 (6.9%)	0.0001

ACE; angiotensin converting enzyme; ARB; angiotensin receptor blocker; CAD, coronary artery disease; CVA, cerebrovascular accidents; CABG, coronary artery bypass graft; CIN, contrast-induced nephropathy; eGFR, estimated glomerular filtration rate; HDL, high density lipoprotein; LDL, low density lipoprotein; LVEF, left ventricular ejection fraction.

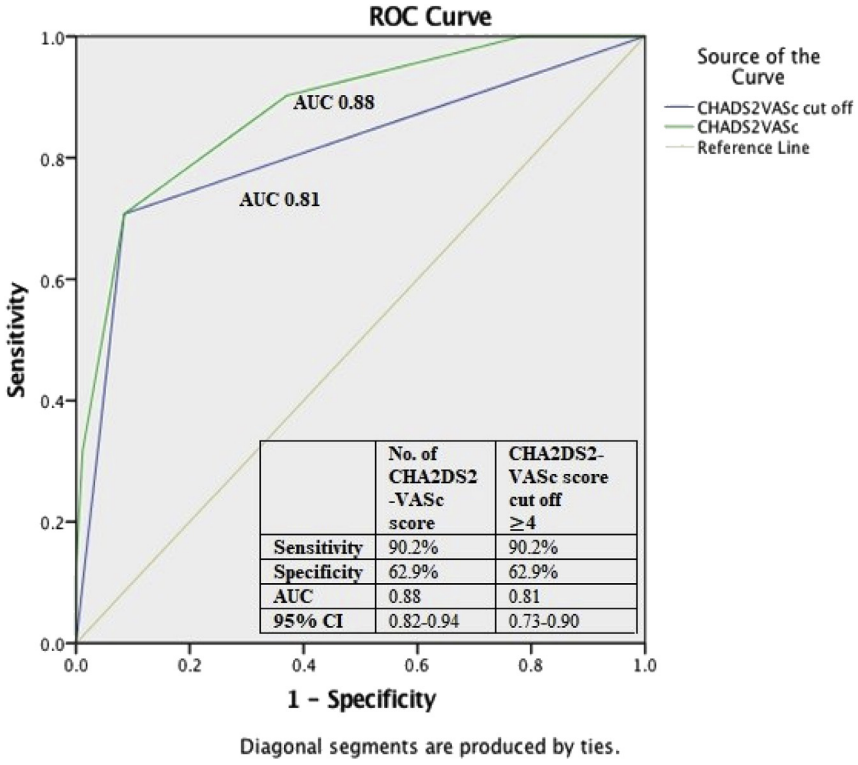

Fig. 1. ROC curve for CHA2DS2-VASc score for prediction of CIN. Area under the curve of ROC curve for no. of CHA2DS2-VASc score for prediction of CIN is 0.88 (CI 0.82–0.94). Optimal cutoff point of CHA2DS2-VASc score for prediction of CIN is 04 with sensitivity of 90.2% and specificity 62.9% for prediction of CIN with AUC 0.81(CI 0.73–0.90). AUC, area under the curve; ROC, receiver operating characteristic; CIN, contrast-induced nephropathy.

were significantly higher in patients developing CIN (Group 1). There was no significant difference in terms of age, sex, smoking status, and body mass index between the two groups. Previous use of metformin in diabetics and angiotensin converting enzyme (ACE) inhibitors/angiotensin receptor blockers were significantly associated with an increased risk of CIN. Use of IOCM had a protective role with a lower incidence of CIN ($p = 0.035$) in patients with a lower baseline eGFR. The mean CHA2DS2-VASc score was significantly higher in patients with CIN (Group 1) than those without CIN (4.15 ± 1.35 vs 2.25 ± 0.92, $p = 0.0001$).

3.2.2. *ROC curve analysis*

In the ROC curve analysis (Fig. 1), area under the curve for predicting CIN was 0.88 (sensitivity 90.2%, specificity 62.9%; 95% confidence interval [CI]: 0.82–0.94) for the number of CHA2DS2-VASc score and was 0.81 (sensitivity 90.2%, specificity 62.9%; 95% CI 0.73–0.90) for the presence of CHA2DS2-VASC score ≥4.

3.2.3. *Multivariate analysis*

Multivariate analysis reported that CHA2DS2-VASC score ≥4 ($p = 0.02$), diabetes mellitus ($p = 0.02$), Killip class ≥2 ($p = 0.001$), and contrast volume ($p = 0.001$) were independent predictors for CIN (Table 3).

Based on the optimum cutoff defined by the ROC curve analysis, the patients were also divided into two groups: subjects with CHA2DS2-VASC score ≤3 (Group A) and score ≥4 (Group B). The demographic, clinical, and angiographic characteristics of these two groups have been depicted in Table 4. The frequency of CIN was significantly higher in Group B with hypertension, diabetes mellitus, Killip class ≥2, left ventricular systolic dysfunction, higher SBP at admission, history of previous stroke/transient ischemic attack, pre-existing renal disease being higher in patients with CHA2DS2-VASC score ≥4. In addition, these patients had lower hemoglobin, eGFR, higher serum total cholesterol, serum LDL and triglyceride levels, and greater incidence of multivessel CAD.

4. Discussion

This study demonstrates the incidence of CIN in patients with ACS undergoing PCI. In addition, this is the first study in Indian population to report that CHA2DS2-VASc score ≥4 is independently associated with the occurrence of CIN in patients with ACS treated by PCI. CIN is an important and a notorious complication of PCI performed in an acute setting leading to a higher morbidity and mortality as well as greater health care utilization escalating the costs and duration of hospital stay.[17,18] The exact mechanisms of CIN is not clear and is thought to be multifactorial. Previous studies have shown that renal vasoconstriction, endothelial dysfunction, endothelial cell damage followed by renal tubular damage and medullary hypoxia are the various mechanisms responsible for contrast-induced renal injury.[19,20] Female gender, older age, diabetes, hypertension, high

Table 3
Independent predictors of CIN in multivariate regression analysis.

Variables	*p*-Value	Odds ratio	95% CI
Diabetes mellitus	0.02	0.11	0.02–0.70
Killip class	0.001	12.84	4.21–39.21
Contrast volume	0.001	1.04	1.02–1.05
CHADS2-VASc score	0.02	2.61	1.15–5.94
Previous metformin use	0.54	1.81	0.28–11.91
eGFR	0.22	0.98	0.95–1.01
ACE inhibitor/ARB use	0.06	0.19	0.03–1.05
Hypertension	0.76	1.28	0.27–6.09

ACE; angiotensin converting enzyme; ARB; angiotensin receptor blocker; eGFR, estimated glomerular filtration rate; CIN, contrast-induced nephropathy.

Table 4
Study population according to CHA2DS2-VASc score.

Variables	CHA2DS2-VASc score		*P*-Value
	Group A (score ≤3) ($n = 249$)	Group B (score ≥4) ($n = 51$)	
Age (year)	55.06 ± 9.7	54.92 ± 8.9	0.93
Females	74 (29.7%)	11 (21.5%)	0.24
Smoking/tobacco use	169 (67.8%)	29 (56.8%)	0.13
Hypertension	77 (30.9%)	43 (84.3%)	0.0001
Diabetes mellitus	32 (12.8%)	30 (58.8%)	0.0001
Previous CAD	29 (11.6%)	10 (19.6%)	0.12
Previous CABG	4 (1.6%)	1 (1.9%)	0.86
Previous CVA	1 (0.4%)	8 (15.6%)	0.0001
Pre-existing renal disease	4 (1.6%)	6 (11.7%)	0.0001
Peripheral vascular disease	15 (6.0%)	4 (7.8%)	0.63
ACE inhibitor/ARB use	130 (52.2%)	38 (74.5%)	0.003
Previous use of metformin	16 (6.4%)	21 (41.1%)	0.0001
LVEF (%)	48.11 ± 8.65	39.39 ± 8.37	0.0001
Weight (kg)	76.39 ± 9.64	77.00 ± 10.03	0.68
Body mass index (kg/m^2)	23.06 ± 1.99	23.41 ± 2.061	0.26
SBP (mm of Hg)	132.01 ± 23.73	156.94 ± 28.82	0.0001
DBP (mm of Hg)	84.41 ± 51.03	91.84 ± 13.94	0.30
Killip class	1.14 ± 0.45	1.78 ± 0.92	0.0001
Total cholesterol (mg/dL)	201.92 ± 28.97	214.18 ± 35.81	0.009
LDL (mg/dL)	131.76 ± 28.61	141.31 ± 29.83	0.03
HDL (mg/dL)	42.58 ± 14.40	41.35 ± 4.44	0.55
Triglyceride (mg/dL)	136.94 ± 29.38	155.78 ± 44.29	0.0001
Hemoglobin (g/dL)	12.92 ± 1.41	12.2 ± 1.47	0.001
Serum creatinine (mg/dL)	0.99 ± 0.28	1.04 ± 0.35	0.28
eGFR (mL/min)	91.16 ± 20.38	82.45 ± 20.66	0.006
48 h peak serum creatinine (mg/dL)	1.10 ± 0.33	1.60 ± 0.58	0.0001
7th day serum creatinine (mg/dL)	1.00 ± 0.28	1.26 ± 0.47	0.0001
CIN	12 (4.8%)	29 (56.8%)	0.0001
No. of vessels	1.55 ± 0.67	1.86 ± 0.83	0.004
No. of stents	1.64 ± 0.71	2.04 ± 0.87	0.0001
Contrast volume (mL)	138.54 ± 46.63	178.73 ± 57.16	0.0001

ACE; angiotensin converting enzyme; ARB; angiotensin receptor blocker; CAD, coronary artery disease; CVA, cerebrovascular accidents; CABG, coronary artery bypass graft; CIN, contrast-induced mephropathy; DBP, diastolic blood pressure; eGFR, estimated glomerular filtration rate; HDL, high density lipoprotein; LDL, low density lipoprotein; LVEF, left ventricular ejection fraction; SBP, systolic blood pressure.

central pulse pressure, CHF, and renal dysfunction are well known risk factors for development of CIN.[21–24]

Patients with CHF are further at an increased risk for CIN as poor renal perfusion leads to a greater degree of renal vasoconstriction in adjunct with a low preload status in these subjects.[24] Our study too demonstrated significant correlation between CIN and diabetes, hypertension, higher systolic blood pressure, CHF as evident from (i) a higher Killip class and (ii) a lower left ventricular systolic function, and pre-existing renal disease. Other predictors such as low hemoglobin and higher contrast volume were also found significantly correlated with risk of CIN, which are parts of Mehran risk model.[10] These findings were concurrent with those of a previous study carried out in 1408 patients with ACS undergoing urgent PCI.[13] No correlation could be established with age and gender in this study. Multivessel CAD and multivessel PCI were the new predictors of CIN established in our study probably due to the fact that a complete revascularization in these patients precluded a greater usage of radio contrast media. In the present study, baseline eGFR and not baseline serum creatinine was a better predictor for occurrence of CIN concurrent with the fact that eGFR is a more reliable indicator of renal function than serum creatinine.[15] Use of an iso-osmolar contrast media in patients with a lower baseline eGFR was significantly associated with reduced CIN in our study. Hence, limiting the amount of contrast media used along with use of iso-osmolar contrast agents and adequate hydration may serve as a crucial strategy to limit the incidence of CIN in patients with known baseline reduced renal function.[25]

Previously, CHADS2 and CHA2DS2-VASc scores were found to be associated with both short- and long-term adverse clinical outcomes and mortality in patients with stable CAD and ACS.[2–7,13,26,27] The study by Chou et al[12] demonstrated that CHADS2 score predicts the risk of CIN in patients with stable CAD undergoing elective PCI. However, in our study, we used the CHA2DS2-VASc score instead of CHADS2 as it's a more comprehensive tool and had applied it on patients with ACS rather than stable CAD. CHA2DS2-VASc score is a simpler risk score containing only preprocedural variables which makes it easy to compute and, hence, more practical. The current risk model Mehran risk score is more complex and contains both preprocedural variables and procedural parameters.[10] In our study, we also determined the adequate cutoff score of CHA2DS2-VASc to predict CIN in ACS setting. A score of ≥4 was highly predictive of developing CIN similar to the previous study carried out in the Turkish cohort by Kurtul et al.[13] Thus, CHA2DS2-VASc score due to its ease of usage permits us to predict the occurrence of CIN in patients with ACS and implement prophylactic measures (intravenous hydration) before contrast exposure to prevent CIN.[28]

5. Study limitations

There are certain limitations to this study: 1) this was a single-center study and had an adequate but smaller study population; 2) definition of CIN was based on absolute or relative increase in serum creatinine levels compared with baseline value. Other factors such as proteinuria and kidney morphology were not assessed; 3) Our study did not report long-term mortality and morbidity due to CIN. These findings should be confirmed in a large-scale multicentric trial and long-term effects of CIN should be evaluated.

6. Conclusions

The development of CIN after PCI in patients with ACS is a frequent complication even in patients with normal renal function

and is usually multifactorial. In resource-limited setups, CIN may remain underreported because of the day care procedures and early discharges. The course of CIN is mostly benign in patients with normal renal function and is usually followed by complete recovery in most of the cases. However, at times, there may be progressive decline in renal functions mandating dialysis further adding to morbidity and cost of hospitalization. Hence, risk stratification and early identification of patients predisposed for CIN should be carried out to provide preventive strategies of renal protection before, during, and after PCI. CHA2DS2-VASc score serves as a simple yet effective tool for predicting CIN preprocedure, which can be easily implemented in day-to-day clinical practice.

Key messages:

What is already known about this subject?

Contrast-induced nephropathy is an important and preventable complication of percutaneous coronary intervention (PCI) with a higher risk seen in patients with acute coronary syndrome, and CHA2DS2-VASc score has been previously reported as a good predicting tool for adverse clinical outcomes in patients with coronary artery disease such as stable angina pectoris and acute coronary syndrome, irrespective of atrial fibrillation.

What does this study add?

Preprocedural CHA2DS2-VASc score $\geq$4 can identify patients with acute coronary syndrome at high risk for contrast-induced nephropathy after PCI in whom renal protective preventive strategies may be used before, during, and after PCI.

Contributors

AKC and VP conceived and designed the study and obtained ethical approval. SK analyzed the data and provided the results. AKC and VP prepared the manuscript; SS and other authors contributed to critical revision of the manuscript.

Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Conflict of interests

Authors have none to disclose.

Patient consent for publication

Not required.

Ethical approval

Approval was obtained from local institutional ethical committee.

References

1. Lip GYH, Nieuwlaat R, Pisters R, et al. Refining clinical risk stratification for predicting stroke and thromboembolism in atrial fibrillation using a novel risk factor-based approach: the Euro Heart Survey on Atrial Fibrillation. *Chest*. 2010;137:263–272.
2. Huang SS, Chen YH, Chan WL, et al. Usefulness of the CHADS2 score for prognostic stratification of patients with acute myocardial infarction. *Am J Cardiol*. 2014;114:1309–1314.
3. Capodanno D, Rossini R, Musumeci G, et al. Predictive accuracy of CHA2DS2-VASc and HAS-BLED scores in patients without atrial fibrillation undergoing percutaneous coronary intervention and discharged on dual antiplatelet therapy. *Int J Cardiol*. 2015;199:319–325.
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;117:1433–1438.
5. 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 percutaneous intervention. *Angiology*. 2016;67:840–845.
6. Bozbay M, Uyarel H, Cicek G, et al. CHA2DS2-VASc score predicts in-hospital and long-term clinical outcomes in patients with ST-segment elevation myocardial infarction who were undergoing primary percutaneous coronary intervention. *Clin Appl Thromb Hemost*. 2017;23:132–138.
7. Rihal CS, Textor SC, Grill D, et al. Incidence and prognostic importance of acute renal failure after percutaneous coronary intervention. *Circulation*. 2002;105:2259–2264.
8. Rudnick MR, Goldfarb S, Wexler L, et al. Nephrotoxicity of ionic and nonionic contrast media in 1196 patients: a randomized trial. The Iohexol Cooperative Study. *Kidney Int*. 1995;47:254–261.
9. Brar SS, Shen AY, Jorgensen MB, et al. Sodium bicarbonate vs sodium chloride for the prevention of contrast medium-induced nephropathy in patients undergoing coronary angiography: a randomized trial. *J Am Med Assoc*. 2008;300:1038–1046.
10. Mehran R, Aymong ED, Nikolsky E, et al. A simple risk score for prediction of contrast-induced nephropathy after percutaneous coronary intervention: development and initial validation. *J Am Coll Cardiol*. 2004;44:1393–1399.
11. Gurm HS, Seth M, Kooiman J, et al. A novel tool for reliable and accurate prediction of renal complications in patients undergoing percutaneous coronary intervention. *J Am Coll Cardiol*. 2013;61:2242–2248.
12. Chou RH, Huang PH, Hsu CY, et al. CHADS2 score predicts risk of contrast-induced nephropathy in stable coronary artery disease patients undergoing percutaneous coronary interventions. *J Formos Med Assoc*. 2016;115:501–509.
13. 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;119:819–825.
14. Thygesen K, Alpert JS, Jaffe AS, et al. Writing group on the Joint ESC/ACC/AHA/WHF Task force for the Universal definition of myocardial infarction. Third Universal definition of myocardial infarction. *J Am Coll Cardiol*. 2012;60:1581–1598.
15. Cockcroft DW, Gault MH. Prediction of creatinine clearance from serum creatinine. *Nephron*. 1976;16:31–41.
16. Mehran R, Nikolsky E. Contrast-induced nephropathy: definition, epidemiology, and patients at risk. *Kidney Int Suppl*. 2006;100:S11–S15.
17. Bartholomew BA, Harjai KJ, Dukkipati S, et al. Impact of nephropathy after percutaneous coronary intervention and a method for risk stratification. *Am J Cardiol*. 2004;93:1515–1519.
18. Senoo T, Motohiro M, Kamihata H, et al. Contrast-induced nephropathy in patients undergoing emergency percutaneous coronary intervention for acute coronary syndrome. *Am J Cardiol*. 2010;105:624–628.
19. Heinrich MC, Kuhlmann MK, Grgic A, et al. Cytotoxic effects of ionic high-osmolar, nonionic monomeric and nonionic iso-osmolar dimeric iodinated contrast media on renal tubular cells in vitro. *Radiology*. 2005;235:843–849.
20. Caiazza A, Russo L, Sabbatini M, et al. Hemodynamic and tubular changes induced by contrast media. *BioMed Res Int*. 2014;2014:578974.
21. 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;31:2187–2194.
22. Heyman SN, Rosenberger C, Rosen S, et al. Why is diabetes mellitus a risk factor for contrast-induced nephropathy? *BioMed Res Int*. 2013;2013:123589.
23. 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;174:37–42.
24. Andreucci M, Solomon R, Tasanarong A. Side effects of radiographic contrast media: pathogenesis, risk factors, and prevention. *BioMed Res Int*. 2014;2014:741018.
25. Andò G, de Gregorio C, Morabito G, et al. Renal function adjusted contrast volume redefines the baseline estimation of contrast-induced acute kidney injury risk in patients undergoing primary percutaneous coronary intervention. *Circ Cardiovasc Interv*. 2014;7:465–472.
26. Poçi D, Hartford M, Karlsson T, et al. Role of the CHADS2 score in acute coronary syndromes: risk of subsequent death or stroke in patients with and without atrial fibrillation. *Chest*. 2012;141:1431–1440.
27. Uysal OK, Turkoglu C, Duran M, et al. Predictive value of newly defined CHA2DS2-VASc-HSF score for severity of coronary artery disease in STEMI. *Kardiol Pol*. 2016;74:954–960.
28. Chong E, Poh KK, Lu Q, et al. Comparison of combination therapy of high-dose oral N-acetylcysteine and intravenous sodium bicarbonate hydration with individual therapies in the reduction of Contrast-induced Nephropathy during Cardiac Catheterisation and Percutaneous Coronary Intervention (CONTRAST): a multi-centre, randomised, controlled trial. *Int J Cardiol*. 2015;201:237–242.