ORIGINAL ARTICLE

# Utility of $CHA_2DS_2$-VASc Score in Predicting Contrast-induced Nephropathy in Patients with Acute Myocardial Infarction Following Percutaneous Coronary Angiography: A Cross-sectional Study in South India

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## Abstract

**Background:** Contrast-induced nephropathy (CIN) is an iatrogenic impairment to the kidneys that can occur in susceptible persons after intravascular injections of contrast agents. Individuals undergoing percutaneous coronary intervention (PCI) for acute coronary syndrome (ACS) often bear the risk of developing CIN. The likelihood of CIN can be predicted using several techniques, although none of them are very accurate. $CHA_2DS_2$-VASc score is used to predict unfavorable clinical outcomes in patients with ACS and atrial fibrillation. The score comprises preprocedural variables and is simple to calculate and can be used for predicting CIN. This study aims to validate $CHA_2DS_2$-VASc score to predict occurrence of CIN among patients undergoing PCI.

**Materials and methods:** This cross-sectional research has been carried out at a tertiary care hospital. The study comprised a total of 182 patients who were admitted with ACS and underwent PCI. CIN incidence was computed. The study population was divided into two groups (the CIN group and the non-CIN group) based on the incidence of CIN. The $CHA_2DS_2$-VASc score was computed for every patient. The best cutoff values of the $CHA_2DS_2$-VASc score to predict the development of CIN were found using receiver operating characteristic (ROC) curve analysis. The incidence of CIN was computed both above and below the $CHA_2DS_2$-VASc score's optimal cutoff point.

**Results:** The incidence of CIN among patients undergoing PCI was 14.3%, and the ROC value for the $CHA_2DS_2$-VASc score was 0.896. Statistically significant increases in the incidence of CIN were observed in patients undergoing PCI who had a $CHA_2DS_2$-VASc score of >2. Additionally, a significant relationship was discovered between CIN and age, diabetes, hypertension, prior coronary artery disease (CAD), and Killip class ≥2.

**Conclusion:** Patients with $CHA_2DS_2$-VASc score of >2 had higher incidence of CIN. $CHA_2DS_2$-VASc score was found to be useful in predicting contrast nephropathy among patients with acute myocardial infarction undergoing angiography.


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## Introduction

An iatrogenic kidney injury referred to as contrast-induced nephropathy (CIN) or contrast-induced acute kidney injury (CI-AKI) may occur in individuals who are vulnerable following an intravascular injection of radio-opaque dyes or contrast agents. CIN is defined as a rise in serum creatinine >0.5 mg/dL or >25% from baseline levels 48–72 hours after contrast agent administration, provided that all other possible causes of renal impairment have been ruled out.[1,2]

Patients suffering from both chronic coronary artery disease (CAD) and acute coronary syndromes (ACS) have been reported to develop CIN after percutaneous coronary intervention (PCI). CIN can lead to prolonged hospitalization, need of hemodialysis, and sometimes permanent impairment of kidney function.[3] The incidence of CIN was found to be in the range of 7–25% in various subgroups of patients.[4,5] Therefore, high-risk patients who may develop CIN need to be identified, and preventive therapies to such individuals should be initiated before administration of contrast agents.

The occurrence of CIN has been predicted using numerous risk prediction models. Because of their complexity, these models are impractical for everyday use. The risk factors for the development of CIN are also present among the components of the $CHA_2DS_2$-VASc score. The $CHA_2DS_2$-VASc score has been routinely used to predict the risk of embolic stroke in patients having atrial fibrillation.[6] The $CHA_2DS_2$-VASc score has been known to predict unfavorable clinical events in patients with ischemic heart disease with or without atrial fibrillation.[7–11] It is a scoring system comprising the variables summarized in Table 1.

$CHA_2DS_2$-VASc score has components like presence of hypertension, diabetes mellitus, vascular diseases, cardiac failure, occurrence of transient ischemic attack, and advancing age. These parameters are also the risk factors for developing AKI. $CHA_2DS_2$-VASc score comprises preprocedural variables and is simple to calculate and can be used for predicting CIN. This study aims to validate $CHA_2DS_2$-VASc score to predict CIN among patients undergoing PCI.

## Materials and Methods

### Study Design

A hospital-based cross-sectional study.

### Study Period

February 2021 to October 2022.

### Source of Data

Patients admitted to a tertiary care center in South India for acute myocardial infarction undergoing PCI.

### Study Subjects

Patients admitted with ACS undergoing PCI were included in the study after obtaining informed consent. The study was approved by the Institutional Ethics Committee (MSRMC/EC/PG-01-2021).

### Methods of Collecting Data

A thorough clinical history was obtained. Physical examination was done and recorded. Specific history like symptoms of

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cardiac disease and presence of risk factors like smoking or tobacco use was asked. Comorbidities like diabetes, hypertension, family history of CAD, previous history of CAD, previous atherosclerotic cerebrovascular events, and ongoing medications were taken. Serum creatinine level was measured at admission and was repeated daily up to 48 hours after PCI. Baseline investigations like complete blood count, fasting blood sugar (FBS) and postprandial blood sugar, and fasting lipid profile were done. Two-dimensional (2D) echocardiography was used to calculate the left ventricular ejection fraction (LVEF). CIN was defined as a rise in serum creatinine >0.5 mg/dL or >25% from baseline levels after 48–72 hours of contrast agent administration, provided that all other possible causes of renal impairment had been ruled out.[1,2] The study population was divided into two groups (the CIN group and the non-CIN group) based on the incidence of CIN. The $CHA_2DS_2$-VASc score was computed for every patient. The best cutoff values of the $CHA_2DS_2$-VASc score to predict the development of CIN were found using receiver operating characteristic (ROC) curve analysis.

After ROC curve analysis, enrolled patients were further divided into two groups according to $CHA_2DS_2$-VASc score. The incidence of CIN above and below the optimum cutoff value of $CHA_2DS_2$-VASc score was calculated.

**Table 1:** $CHA_2DS_2$-VASc parameters and the scores

| *$CHA_2DS_2$-VASc score and its parameters* | *Score* |
|---|---|
| C: Congestive cardiac failure | 1 |
| H: Hypertension | 1 |
| A: Age >75 years | 2 |
| D: Type 2 diabetes mellitus | 1 |
| S: Prior history of stroke or transient ischemic attack | 2 |
| V: Vascular disease | 1 |
| A: Age 65–74 years old | 1 |
| Sc: Sex category (female) | 1 |

## Inclusion Criteria

Patients aged ≥18 years with ACS comprising both ST-elevation myocardial infarction (STEMI) and non-STEMI planned (elective or emergency) for PCI. Age ≥18 years, received iodinated contrast media during PCI.

## Exclusion Criteria

Patients who did not give informed consent to take part in the study; patients with end-stage renal disease (ESRD) on dialysis; AKI prior to PCI (confounds CIN diagnosis); use of nephrotoxic drugs during the CIN risk window (e.g., aminoglycosides, amphotericin B); patients with known contrast allergy (may receive special precautions affecting contrast dose and hydration); pregnancy (different renal physiology and ethical considerations); and severe hemodynamic instability or cardiogenic shock prior to PCI (may independently affect kidney function and increase bias) were excluded.

## Sample Size Estimation

As per the study by Chaudhary et al.,[12] which included 300 patients, CIN was reported in 41 patients (13.7%). The $CHA_2DS_2$-VASc score was found to be an excellent predictor of CIN, according to ROC curve statistics [area under the curve (AUC) 0.81, 95% CI: 0.73–0.90]. Individuals with a score of four or higher were more likely to have CIN than those with a score of <3 ($p = 0.0001$). In the present study, expecting a similar result with 5% level of significance, 5% absolute precision, and 90% power, it was estimated that a minimum of 182 patients need to be recruited for the study.

## Statistical Analysis

Frequencies and proportions are utilized to present categorical data. The Fisher's exact test or the Chi-squared test is used for assessing the statistical significance of qualitative data. Continuous data is represented in the form of mean and standard deviation. For the $CHA_2DS_2$-VASc score and the incidence of CIN in patients following PCI, ROC curves were generated. Values for specificity, sensitivity, and positive and negative predictiveness were calculated. An area under the ROC curve of 0.5 indicates that a test predicts an outcome no better than chance. A ROC curve area <0.8 signified a well-predicted outcome. The significance of two quantitative variables was tested using the independent *t*-test. Assuming that all statistical test rules are followed, a *p*-value (probability that the result is true) of <0.05 was deemed statistically significant.

## Statistical Software

MS Excel and SPSS version 22 (IBM SPSS Statistics, Somers, NY, USA) were used to analyze data.

# Results

The study comprised 182 patients with age-group ranging from 28 to 89 years. Mean age of patients studied is 62 years [standard deviation (SD) 13]. Age-group from 61 to 70 years accounts for 31.9% of the study population ($N = 58$). About 71.4% ($N = 130$) of the patients were males, and 28.6% ($N = 52$) were females. A total of 14.3% ($N = 26$) developed CIN after PCI, while 85.7% ($N = 156$) did not develop CIN after PCI ($p = 0.002$). About 53.8% ($N = 14$) among the age-group of 61–70 years developed CIN, and 38.5% ($N = 10$) in the age-group of 71–80 years developed CIN, while none of the patients <40 years developed CIN (Table 2).

About 76.9% ($N = 20$) of male patients and 23.1% ($N = 6$) of female patients developed CIN. This gender difference was not statistically significant ($p = 0.065$). Mean age of patients who developed CIN was 69 ± 10 years (SD). Subjects with a mean ejection fraction of 42 ± 5% developed CIN ($p < 0.001$); however, subjects with a mean ejection fraction of 52 ± 4% did not develop CIN. Subjects with mean baseline estimated glomerular filtration rate (eGFR) of 71.26 ± 17.7 mL/minute were at risk of developing CIN ($p < 0.002$). In this study, it was also noted that the volume of contrast used in PCI was directly linked with the risk of developing CIN. Mean contrast volume of 200 ± 73 mL had a statistically significant risk of developing CIN ($p < 0.001$) (Table 3).

**Table 2:** Distribution of subjects according to CIN and age-group

| *Age-group (years)* | *Non-CIN* | | *CIN* | | *p-value* |
|---|---|---|---|---|---|
| | *N* | *%* | *N* | *%* | |
| <40 | 13 | 8.3 | 0 | 0.0 | 0.002 |
| 41–50 | 17 | 10.9 | 2 | 7.7 | |
| 51–60 | 46 | 29.5 | 0 | 0.0 | |
| 61–70 | 44 | 28.2 | 14 | 53.8 | |
| 71–80 | 36 | 23.1 | 10 | 38.5 | |

Of the total 54 diabetic patients, 19 patients developed CIN ($p < 0.001$). Among 82 hypertensive patients, 19 patients developed CIN ($p < 0.01$). Ten out of 24 patients with previous CAD developed CIN ($p < 0.001$) (Table 4).

Among the 182 subjects, 168 patients received iohexol as contrast media for PCI, and 14 patients received iodixanol as contrast media. All patients who developed CIN ($N = 26$) in this study had iohexol used as the contrast media for PCI. None of the patients where iodixanol was used developed CIN. These findings are summarized in Table 4.

Area under the ROC curve was 0.896, standard error of 0.0248 (95% CI: 0.842–0.936) with $p < 0.0001$. Optimal cutoff point of $CHA_2DS_2$-VASc score for predicting CIN is 2, with a sensitivity of 92.3% and specificity of 75.6% (Table 5 and Fig. 1).

About 33 out of 77 patients with multiple vessel CAD and 38 out of 91 patients with multiple vessel stenting had a $CHA_2DS_2$-VASc score >2, which had a statistically significant correlation ($p = 0.04$). Again 32 out of 69 patients using ACE inhibitors and 26 out of 42 patients using metformin had a $CHA_2DS_2$-VASc score >2, which was statistically significant ($p = 0.01$ and <0.001, respectively) (Table 6).

**Table 5:** Sensitivity, specificity, PPV, and NPV of $CHA_2DS_2$-VASc in predicting CIN

| | *Value* | *95% CI* |
|---|---|---|
| Sensitivity | 92.31% | 74.9–99.1% |
| Specificity | 75.64% | 68.1–82.1% |
| PPV | 38.7% | 26.6–51.9% |
| NPV | 98.3% | 94.1–99.8% |

PPV, positive predictive value; NPV, negative predictive value

**Table 3:** Comparison of age and laboratory parameters according to CIN

| | *Non-CIN* | | *CIN* | | *p-value* |
|---|---|---|---|---|---|
| | *Mean* | *SD* | *Mean* | *SD* | |
| Age (years) | 61 | 13 | 69 | 10 | 0.005 |
| LVEF (%) | 52 | 4 | 42 | 5 | <0.001 |
| Hemoglobin (gm/dL) | 12.63 | 1.58 | 12.56 | 0.99 | 0.824 |
| Baseline serum creatinine (mg/dL) | 0.87 | 0.34 | 1.05 | 0.28 | 0.015 |
| Creatinine at 48 hours | 0.9212 | 0.365 | 1.57 | 0.4539 | <0.001 |
| Baseline eGFR (mL/minute) | 87.37 | 24.94 | 71.26 | 17.72 | 0.002 |
| Contrast volume (mL) | 127 | 44 | 200 | 73 | <0.001 |

**Table 4:** Comparison of various factors according to CIN

| | *Non-CIN* | | *CIN* | | *p-value* |
|---|---|---|---|---|---|
| | *N* | *%* | *N* | *%* | |
| Diabetes | 35 | 22.4 | 19 | 73.1 | <0.001 |
| Hypertension | 63 | 40.4 | 19 | 73.1 | 0.003 |
| Dyslipidemia | 32 | 20.5 | 7 | 26.9 | 0.447 |
| Smoking | 50 | 32.1 | 13 | 50.0 | 0.117 |
| Tobacco use | 25 | 16.0 | 5 | 19.2 | 0.775 |
| Previous CAD | 14 | 9.0 | 10 | 38.5 | <0.001 |
| Previous CABG | 4 | 2.6 | 1 | 3.8 | 0.542 |
| PVD | 4 | 2.6 | 6 | 23.1 | <0.001 |
| Killip class ≥2 | 16 | 10.3 | 18 | 69.2 | <0.001 |
| NSTEMI | 101 | 64.7 | 9 | 34.6 | <0.005 |
| STEMI | 55 | 35.3 | 17 | 65.4 | |
| Iohexol | 142 | 91.0 | 26 | 100.0 | 0.226 |
| Iodixanol | 14 | 9.0 | 0 | 0.0 | |
| Multivessel CAD (no. of vessels ≥2) | 54 | 34.6 | 23 | 88.5 | <0.001 |
| Use of ACE inhibitors/ARB | 56 | 35.9 | 13 | 50.0 | 0.194 |

**Table 6:** Comparison of angiographic and medical therapy related factors according to $CHA_2DS_2$-VASc score

| | *<2 score* | | *>2 score* | | *p-value* |
|---|---|---|---|---|---|
| | *Mean* | *SD* | *Mean* | *SD* | |
| Age | 56 | 11 | 73 | 8 | <0.001 |
| LVEF (%) | 52 | 5 | 48 | 6 | <0.001 |
| Hb (gm/dL) | 12.9492 | 1.5858 | 12.0032 | 1.1491 | <0.001 |
| Baseline serum creatinine (mg/dL) | 0.8838 | 0.3712 | 0.9437 | 0.2772 | 0.265 |
| Creatinine at 48 hours | 0.9280 | 0.3944 | 1.1823 | 0.4820 | <0.001 |
| Baseline eGFR (mL/minute) | 91.6356 | 25.1958 | 72.3802 | 17.8258 | <0.001 |
| Contrast volume (mL) | 131 | 46 | 151 | 69 | 0.043 |
| Multivessel CAD (no. of vessels ≥2) | 44 | 36.7% | 33 | 53.2% | 0.040 |
| Use of ACE inhibitors/ARB | 37 | 30.8% | 32 | 51.6% | 0.010 |
| Previous use of metformin | 16 | 13.3% | 26 | 41.9% | <0.001 |

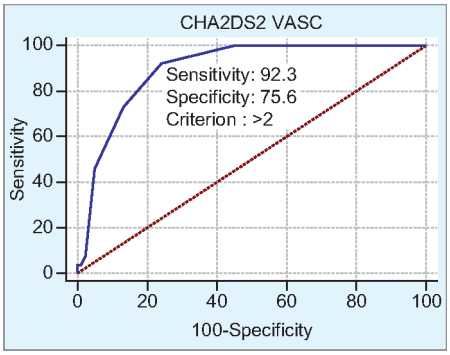


**Fig. 1:** ROC curve for $CHA_2DS_2$-VASc in predicting CIN

## Discussion

Contrast-induced nephropathy is a major complication and can lead to increased morbidity and mortality among patients following PCI for ACS.[13,14]

Early detection of CIN is important as patients will require closer monitoring of vital parameters and fluid control.[15] Congestive heart failure (CHF), renal impairment, age, female sex, and diabetes mellitus are known risk factors for CIN.[16–19] The parameters are also the components of $CHA_2DS_2$-VASc score.[1] Its use can be extended to nonatrial fibrillation populations[7–11,20,21] to help in risk stratification of high-risk individuals. In individuals with stable CAD and ACS, an elevated $CHA_2DS_2$-VASc score has been predictive of unfavorable clinical outcomes.[7–11,22,23] The purpose of this study was to ascertain whether the $CHA_2DS_2$-VASc score could be utilized to predict CIN in ACS patients receiving PCI.

This study indicated that 14.3% of patients undergoing PCI for ACS had CIN, which was similar to the study conducted by Chaudhary et al.,[12] where the incidence of CIN was found to be 13.7%. Similarly, the incidence of CIN was 11.3% in a study by Kurtul et al.[1] and 16.3% in a study by Wang et al.[23] However, the incidence was higher in a study conducted by Cicek and Yıldırım,[24] which was 23.3% compared to our study, and the incidence was lower in a study conducted by Kumar et al.,[25] where it was 9.1%.

The present study showed that the incidence of CIN increased with the age of the patients. This result corresponded with those of Wang et al.[23] and Kumar et al.[25] The study conducted by Chaudhary et al.,[12] however, did not show any statistically significant difference between age-groups and the development of CIN. There was no statistical correlation between gender distribution and CIN.

Presence of comorbidities like diabetes and hypertension showed a positive correlation with the development of CIN. About 73.1% of patients who developed CIN in the study were diabetic and hypertensive. This finding was consistent with previous studies[1,14,22–26] and shows that patients with these comorbidities are at high risk of developing CIN, and appropriate preventive strategies should be employed in these patients.

Other comorbidities, like a previous history of CAD and peripheral vascular disease, accounted for 38.5 and 23.1% of patients who developed CIN, respectively. History of CAD also had a similar relationship with CIN in studies conducted by Chaudhary et al.[12] and Cicek and Yıldırım.[24]

This study was the first to compare the risk of CIN with multiple comorbidities, which was statistically significant ($p$-value < 0.001). About 92.3% of the patients who had CIN had a history of multiple comorbidities.

Killip class >2, multivessel CAD, multivessel PCI, and CIN showed a $p$-value of <0.001, which was significant. Studies like Chaudhary et al.[12] also ascertained this relationship.

Interesting to note that in the study, of the 14 patients who received iodixanol as the contrast agent, none developed CIN. With regard to the volume of contrast media administered, in the CIN group, the volume of contrast was 200 ± 73 mL, and for the non-CIN group, 127 ± 44 mL was used ($p$ < 0.001). Patients in whom a higher amount of contrast volume is used are prone to CIN. It was observed that the patients with CIN had a lower baseline eGFR. Mean eGFR in Kurtul et al.[1] and Chaudhary et al.[12] was 52.4 ± 19.5 and 83.76 ± 19.22 mL/minute, respectively.

Receiver operating characteristic curve analysis of the study data showed a good predictive value of $CHA_2DS_2$-VASc score for predicting CIN in patients undergoing PCI for ACS, with AUC of 0.896 (0.842–0.936). $CHA_2DS_2$-VASc score of >2 had a sensitivity of 92.31% (CI: 74.9–99.19) and specificity of 75.64% (CI: 68.1–82.1), with a $p$-value of <0.001. Patients with $CHA_2DS_2$-VASc score of >2 had a significantly higher incidence of CIN.

Patients with $CHA_2DS_2$-VASc score of >2 had a significantly higher number of patients with diabetes (51.6%), hypertension (72.6%), history of CAD (25.8%), CVA (24.2%), Killip class ≥2 (35.5%) with $p$-value < 0.001, and PVD (11.3%) with $p$-value of 0.033.

In patients with normal renal function, the course of CIN is often benign and is almost always followed by full recovery.[12] In this study, two patients out of the 26 CIN cases required dialysis. Two sessions of hemodialysis were needed in these patients, but both recovered from CIN eventually.

Several risk models have been developed to predict CIN following PCI.[27–29] Mehran risk score is one such score, which includes multiple clinical and procedural parameters such as hypotension, use of intraaortic balloon pump, and contrast volume. Though robust and validated, the Mehran score requires data that may not always be readily available before the procedure. Other models, like the age, creatinine, ejection fraction (ACEF) score and the National Cardiovascular Data Registry (NCDR) risk score (age, diabetes, anemia, CHF, renal function, contrast volume), also incorporate laboratory and echocardiographic findings, which may not be feasible to calculate quickly in all clinical settings. In contrast, the $CHA_2DS_2$-VASc score is simple, bedside-friendly, and composed entirely of clinical variables that are routinely available, particularly in settings where rapid and simple risk stratification is needed.

The confounding factors were controlled in the study. Due to the limited sample size and the observational nature of the study, multivariate regression was not conducted. However, the results provide valuable initial evidence supporting the predictive role of $CHA_2DS_2$-VASc score in this population. Although a statistically significant association was observed between the $CHA_2DS_2$-VASc score and CIN, causality cannot be firmly established. The study was conducted at a single center with a modest sample size of 182 patients, which may limit generalizability. Nevertheless, the findings provide important preliminary evidence suggesting the potential utility of the $CHA_2DS_2$-VASc score as a simple and effective tool to stratify CIN risk in patients undergoing PCI.

The significant association between higher $CHA_2DS_2$-VASc scores and CIN observed in this study highlights the potential of this scoring system beyond its traditional use in atrial fibrillation. The ease of calculating the score and the availability of its components at the bedside make it a practical option for early risk stratification in the Indian clinical setting, particularly where access to more sophisticated predictive tools may be limited. While our results are consistent with findings from studies conducted in other countries, they also reflect local demographic and clinical characteristics that may influence CIN risk. Further research involving larger populations and multivariate modeling is required to establish the independent predictive value of the score.

## Conclusion

According to this study, in patients with ACS undergoing PCI, $CHA_2DS_2$-VASc score of more

than two is independently correlated with the incidence of CIN. To predict CIN risk, $CHA_2DS_2$-VASc score is an innovative and inexpensive scoring system.

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