Value of Mehran risk score in assessing the risk of contrast-induced acute kidney injury in patients who underwent percutaneous coronary intervention

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Abstract

Objectives: In patients who underwent Percutaneous coronary intervention (PCI), contrast-induced acute kidney injury (CI-AKI), which is defined as a blood creatinine increase by ≥ 0.5 mg/dl (44.2 μmol/l) or ≥ 25% of the initial creatinine value within 48 hours after intervention, is one of the severe complications of the procedure. We conducted this study to assess the Mehran risk score in patients who underwent PCI; the prognostic value of the Mehran risk score in the risk of CI-AKI; and to follow up the kidney function after three months and six months. **Materials and methods:** We analyzed 217 patients who underwent PCI from 01/2020 to 03/2021 at Hue University of Medicine and Pharmacy Hospital. We calculated the Mehran risk score, investigated the characteristics related to CI-AKI, and followed up on kidney function after three and six months. **Results:** Patients with CI-AKI had an average Mehran risk score of 10.92 ± 6.05, significantly higher than patients without CI-AKI with 3.87 ± 3.71. In the multivariate regression analysis, Hypotension, Age > 75, and Diabetes were independently associated with CI-AKI. The cut-off value for risk of CI-AKI of Mehran risk score was > 10, with a sensitivity of 66.7% and a specificity of 88.3%. The kidney function improved significantly in patients with CI-AKI after three months of follow-up. There were three patients with EFGR < 60 ml/min/1.73 m^2, and these results were maintained for six months of follow-up. **Conclusions:** Mehran risk score had prognostic value in assessing CI-AKI in patients who underwent PCI. Hypotension, age > 75, and diabetes are independent risk factors for CI-AKI.

Keywords: *Coronary artery disease, Mehran risk score, Percutaneous coronary intervention, CI-AKI, Prognosis.*

1. INTRODUCTION

Coronary artery disease (CAD) is one of the most common cardiovascular diseases with a high mortality rate, up to 37% in Southeast Asian countries, and occupies 54% of mortality among cardiovascular diseases [1]. Currently, percutaneous coronary interventions (PCI) are increasingly widely used to treat patients with CAD, with the number of procedures reaching more than 2 million in the United States each year [2]. Despite applying advanced techniques, reducing the amount of contrast used in the procedure, and having strategies to prevent CI-AKI, there is still a prevalence of about 3.3- 14.5% of patients with CI-AKI after the procedure [3-5]. CI-AKI is defined as an increase in blood creatinine ≥ 0.5 mg/dl (44.2 μmol/l) or ≥ 25% of the initial creatinine value within 48 hours [6-7]. Some studies also show that CAD patients with CI-AKI have a higher rate of major adverse cardiovascular events (MACE) than those without CI-AKI [4]. Many risk factors which are associated with the risk of CI-AKI, such as age, hypotension, heart failure, diabetes, anemia, and chronic renal failure, and several scores have been established to assess the risk of CI-AKI such as the Mehran score, modified Mehran score, or the ratio between contrast amount and glomerular filtration rate [6], [8-11].

Therefore, CI-AKI is still a crucial issue that needs to be assessed in patients undergoing PCI, facilitating the prediction and prevention of this complication. For the above reasons, we conducted a study on the topic ***"Value of Mehran risk score in assessing the risk of Contrast-induced Acute Kidney Injury in patients who underwent percutaneous coronary intervention"*** with the following objectives:

- Evaluate some baseline characteristics and the Mehran risk score in patients who underwent percutaneous coronary intervention.
- Assess the value of the Mehran risk score in predicting the risk of contrast-induced acute kidney injury in patients who underwent percutaneous coronary intervention and monitor renal function after 3 months and 6 months.

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2. MATERIALS AND METHODS

2.1. Study population

The study included all patients with CAD who underwent PCI and received in-patient treatment and outpatient follow-up at the Hue University of Medicine and Pharmacy Hospital from January 2020 to March 2021.

2.1.1. Inclusion criteria

- All patients with CAD who underwent PCI.
- Patients were tested for blood Creatinine before and within 48 hours after the procedure.
- Patients diagnosed with CI-AKI were followed up for blood creatinine after 3 and 6 months.
- Patients agree to participate in the study.

2.1.2. Exclusion criteria

- Patients who had the indications for hemodialysis before the procedure.
- The patients had active bleeding.
- Patients with kidney injury due to other causes.
- The patients did not agree to participate in the study.

2.2. Study method

2.2.1. Study design: cross-sectional, with short-term follow-up

2.2.2. Sample size and Sampling method: the sample size is 217. Patients were enrolled conveniently, including those who underwent PCI.

2.2.3. Location: Cardiology Center, Hue University of Medicine and Pharmacy Hospital

2.2.4. Specific Research Methods:

- All patients were asked about their medical history and had a clinical examination
- Laboratory tests: total blood count, hematocrit, lipid profile, blood creatinine, Echocardiography.
- The estimated glomerular filtration rate (eGFR) was calculated using the MDRD equation.
- PCI was performed under the guidance of the GE OEC 9900 DSA machine manufactured in the United States.
- Patients were guideline-directed medical treatment according to the Vietnam National Heart Association guidelines before and after intervention.
- Calculate the Mehran risk score.
- Blood creatinine was tested within 48 hours after intervention.
- Patients with CI-AKI were followed up for blood creatinine tests after 3 and 6 months.

2.2.5. Main criteria in the study:

- CI-AKI: blood creatinine increased by $\geq$ 0.5 mg/dl (44.2 μmol/l) or $\geq$ 25% of the initial creatinine value within 48 hours after intervention [6].
- Reduced kidney function: eGFR <60ml/min/1.73m2.
- Mehran risk score calculation:

Risk Factors	Defination	Interger Score
Hypotension	Systolic blood pressure < 80 mm Hg for at least 1 hour, requiring inotropic medications, or intra-aortic balloon pump (IABP) within 24 h	5
Intra-aortic balloon pump (IABP)		5
Congentive Heart Failure	NYHA class III/IV Heart failure and/or history of acute pulmonary edema	5
Age > 75 years		4
Anemia	Baseline hematocrit < 39% for men and < 36% for women	3
Diabetes		3
Contrast media volume		1 for each 100ml
Estimated glomerular filtration rate (ml/min/1.73 m^2)	Calculated using the MDRD equation	2 for 40 - 60 4 for 20 - 40 6 for < 20

- The Mehran risk score is calculated by the sum of the component factors and is classified into Low (< 5), Medium (6- 10), High (11 - 15), and Very High (> 16) risk categories [6].

2.2.6. Statistical Analysis: Medical history and baseline characteristics were recorded in the research form. We utilized the SPSS 26.0 statistical software to analyze the data using medical statistical algorithms. The statistical tests with a p-value < 0.05 are considered statistically significant.

3. RESULTS

Through a study of 217 patients who underwent PCI at the Hue University of Medicine and Pharmacy Hospital from January 2020 to March 2021, we obtained the following results:

3.1. Baseline characteristics and Mehran risk score

Table 1. Baseline characteristics.

Characterstics	CI-AKI (n = 12)	No CI-AKI (n = 205)	*p*
Age	72.42 ± 9.15	64.86 ± 9.73	**0.009**
Male	83.3% (10)	76.1% (156)	0.566
BMI (kg/m^2)	24.26 ± 4.05	25.03 ± 3.09	0.409
Hypertension	75.0% (9)	70.7% (145)	0.752
Diabetes	41.7% (5)	23.9% (49)	0.167
Current Smoking	16.7% (2)	23.9% (49)	0.397
History of PCI	16.7% (2)	15.61% (32)	0.629
Diagnosis at admission			
ST elevation myocardial infarction	16.7% (2)	7.8% (16)	0.279
Non- ST elevation myocardial infarction	33.3% (4)	12.2% (25)	**0.036**
Unstable angina	33.3% (4)	51.7% (106)	0.216
Stable angina	16.7% (2)	28.3% (58)	0.381
Laboratory tests			
Hemoglobin (10^3/μl)	13.81 ± 3.69	13.96 ± 2.76	0.271
Hematocrit (%)	42.31 ± 0.20	44.87 ± 0.18	0.158
Creatinine (μmol/l)	85.75 ± 22.98	77.79 ± 18.56	0.156
eGFR (ml/min/1.73 m^2)	76.94 ± 20.11	86.32 ± 21.56	0.143
Reduce kidney function	25.0% (3)	8.8% (18)	0.065
Echocardiography			
Mean EF	56.68 ± 11.93	60.48 ± 11.13	0.252
EF < 50%	33.3% (4)	10.7% (22)	**0.019**

The table showed that of the total number of patients in the study group, only 12 patients (5.53%) had CI-AKI. Patients with CI-AKI were older than those who didn't have CI-AKI. Also, most of the patients were hospitalized because of acute coronary syndrome. Regarding the laboratory tests, there were no significant differences between the two groups. Patients with CI-AKI had a higher proportion of patients with EF < 50% than the group without CI-AKI.

Table 2. PCI-related characteristics.

Characteristics	CI-AKI (n = 12)	No CI-AKI (n = 205)	*p*
Emergency procedure	41.7% (5)	19.5% (40)	0.066
Multivessel lesions	75.0% (9)	72.2% (148)	0.679
Contrast media volume (ml)	139.17 ± 36.55	129.71 ± 40.78	0.433
Contrast media volume > 150 ml	33.3% (4)	30.7% (63)	0.850
Mehran risk score	10.92 ± 6.05	3.87 ± 3.71	**< 0.001**

In the patient group with CI-AKI, the percentage of emergency procedures tended to be higher than in the group without CI-AKI (41.7% vs. 19.5%) with p = 0.066. The Mehran risk score in patients with CI-AKI was higher, with 10.92 ± 6.05, compared to 3.87 ± 3.71 in patients without CI-AKI, p < 0.001.

Table 3. Mehran risk score-related characteristics.

Charactersistics	Low (n = 154)	Moderate (n = 40)	High (n = 19)	Very high (n = 4)	*p*
Hypotension	0.6% (1)	22.5% (9)	21.1% (4)	75.0% (3)	**< 0.001**
IABP	0% (0)	0% (0)	0% (0)	0% (0)	N/A
Congestive Heart failure	1.9% (3)	32.5% (13)	63.2% (12)	100.0% (4)	**< 0.001**
Age > 75 years	2.6% (4)	35.0% (14)	78.9% (15)	50.0% (2)	**< 0.001**
Anemia	3.9% (6)	22.5% (9)	57.9% (11)	100.0% (4)	**< 0.001**
Diabetes	18.8% (29)	35.0% (14)	52.6% (10)	50.0% (2)	**0.003**
Contrast volume >150ml	30.5% (47)	40.0% (16)	15.8% (3)	25.0% (1)	0.301
eGFR < 60 ml/min/1.73 m^2	1.3% (2)	30.0% (12)	21.1% (4)	75.0% (3)	**< 0.001**
CI-AKI	2.6% (4)	7.5% (3)	15.8% (3)	50.0% (2)	**< 0.001**

Most of the Mehran risk score components were found to be higher in patients with high or very high Mehran risk scores. However, the percentage of patients with > 150 ml contrast volume was not significantly different between the two groups.

3.2. Mehran risk score in assessing the risk of CI-AKI

Table 4. Multivariate regression analysis of risk factors of CI-AKI

Risk factors	Odd Ratio	95% Confidence Interval	*p*
Hypotension	6.32	1.86- 33.02	**0.001**
Congestive Heart failure	3.32	0.69- 16.09	0.136
Age > 75 years	7.18	1.71- 30.18	**0.007**
Anemia	0.46	0.075- 2.85	0.406
Diabetes	8.75	1.65- 46.27	**0.011**
Emergency procedure	3.25	0.48- 21.81	0.225
Contrast volume > 150 ml	0.858	0.179- 4.12	0.848

Among the risk factors, Hypotension, Age > 75 years, and Diabetes are the independent risk factors of CI-AKI, with the OR being 6.32, 7.18, and 8.75, respectively (p < 0.05).

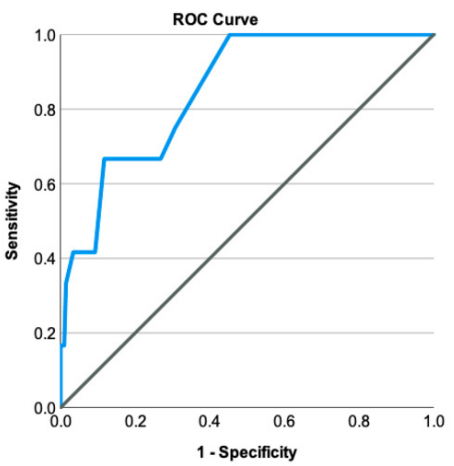

Figure 1. ROC Curve of Mehran risk score in predicting CI-AKI.

This figure showed that the area under the curve (AUC) was 0.851(95% CI: 0.758- 0.943) with p < 0.001. The cut-off point > 10 had the highest value of predicting CI-AKI, with a sensitivity of 66.7% and a specificity of 88.3%.

Table 5. The change in renal function after 3- and 6-month follow-up in patients with CI-AKI.

Charactertictisc	After 48 hours (n = 12)	After 3 months (n = 12)	After 6 months (n = 12)	*p1*	*p2*
Creatinine (μmol/l)	114.92 ± 28.29	93.70 ± 22.10	91.05 ± 22.98	< 0.001	0.273
eGFR (ml/min/1.73 m^2)	55.24 ± 14.72	70.02 ± 18.29	71.42 ± 16.94	< 0.001	0.365
eGFR < 60 (ml/min/1.73 m^2)	58.3% (7)	25.0% (3)	25.0% (3)	0.014	1.000
eGFR < 40 (ml/min/1.73 m^2)	16.7% (2)	0.0% (0)	0.0% (0)	0.135	1.000

*p1: compared after 48 hours and after 3 months; p2: compared after 3 months and 6 months

Among the patients who had CI-AKI, after 3 months of follow-up, the kidney function improved. There were only 25% of patients still had eGFR < 60 ml/min/1.73 m^2. The kidney function was maintained the same after 6 months compared to after 3 months. There were no patients who needed hemodialysis.

4. DISCUSSIONS

4.1. Baseline characteristics and Mehran risk score

In our study, among 217 patients who underwent PCI, CI-AKI occurred in 12 patients, accounting for 5.53%. This result is relatively consistent with domestic and international studies, such as the study of Bui Xuan Nghia et al. 6.79% [12], as well as other studies in the world showing rates of about 3.3 to 14.5% [3]. Most patients were admitted to the hospital because of acute coronary syndrome, of which the most common was unstable angina at 50.69% and ST-elevation myocardial infarction at about 8.29%. This result is similar to other studies showing that most patients undergoing PCI had acute coronary syndrome [4-5], [8]. Regarding the laboratory test, the proportion of patients with EF < 50% was lower in the group of patients with CI-AKI compared to those without CI-CKI with p = 0.019. This result is similar to the study of Bui Xuan Nghia et al. [12]. However, some other studies showed that the characteristics of anemia, renal function, and heart failure were statistically significantly lower than the group of patients without CI-AKI [4-6]; this may be due to differences in population selection.

Regarding the characteristics of PCI procedures, about 20.7% of the procedures were performed as emergency procedures. A study by Hitinder Gurm et al. [8] showed that the rate of emergency intervention was about 25%. A study by Bui Xuan Nghia et al. [12] showed that the rate of emergency coronary intervention and elective procedures was comparable. Coronary angiography results showed that 72.35% of patients had multi-vessel coronary artery lesions. A study by Jin Wi et al. showed that the rate of multi-vessel lesions was more than 60%, and this rate increased gradually according to the Mehran risk score [5]. However, according to other studies, the rate of multivessel coronary intervention was about 30% [4, 6, 11]. In our study, there was no statistically significant difference between the average contrast volume and the rate of patients using > 150 ml of contrast during the procedure between the two groups. This result is similar to the study of Bui Xuan Nghia et al. [12]. However, according to some other studies, the amount of contrast used in the group of patients with CI-AKI was higher than that in the group without CI-AKI [4-5]. In our study, when we performed the procedures on patients with a high risk of CI-AKI, we tried to use as little contrast as possible. Hence, the amount of contrast used during the procedure is not much different between the patients with or without CI-AKI.

Regarding the Mehran risk score characteristics, patients with CI-AKI had a higher average Mehran scale score, 10.92 ± 6.05, compared to 3.87 ± 3.71 in the group of patients without CI-AKI, with p < 0.001. Regarding the patient grouping according to the Mehran score, most patients had low (70.97%) and medium risk (18.43%); high risk accounted for 8.76%, and very high risk accounted for 1.84%. In the group of patients with very high Mehran risk scores, the proportion of patients with CI-AKI accounted for up to 50%. Other studies also indicated that in the group of patients with high Mehran risk scores, the proportion of patients with CI-AKI was high [5-6, 12]. Among the components of the Mehran score, Hypotension, Congestive heart failure, Old age, Anemia, or Diabetes were all found to be higher in the group of patients with a high Mehran risk score with P < 0.001.

4.2. Mehran Risk Score in assessing the risk of CI-AKI

In our study, when analyzing multivariate regression analysis of risk factors for CI-AKI, Hypotension, Age >

75, and Diabetes were independent factors with p < 0.05. Other studies have shown that intra-procedural hypotension is an independent risk of CI-AKI [4-6], [11-12]. The mechanism of this phenomenon is quite complicated; contrast causes the release of endothelin and adenosine, combined with prolonged constriction of the renal artery due to an imbalance between nitrous oxide, adenosine, endothelin, prostaglandin and ROS [7, 13]. Hypotension further aggravates renal ischemia, increasing the risk of acute kidney injury [3]. Increasing age and diabetes are factors that affect renal function, reducing the filtering ability of the kidney, so they are also independent risk factors for CI-AKI. Initial studies on the Mehran score showed that the proportion of patients using contrast >150ml was 14.6%, and high contrast volume was an independent risk factor for CI-AKI. However, according to our study or the study of Bui Xuan Nghia, this difference was not statistically significant [12]. This is explained by the fact that for patients at high risk of CI-AKI, we limit the amount of contrast used in the procedure to limit the risk of CI-AKI.

41.7% of patients with CI-AKI experienced emergency intervention, which tended to be higher than the rate of emergency intervention in patients without CI-AKI, with p = 0.066. This result is similar to the study of Bui Xuan Nghia [12]. Still, the study by Daisuke Abe showed that performing emergency procedures has a higher risk of causing CI-AKI [14]. In patients with acute coronary syndrome, especially patients with ST-elevation myocardial infarction related to right coronary artery occlusion or left main, cardiac function is suddenly distorted, and the risk of causing hypotension and heart failure is high. Hence, the rate of CI-AKI is higher. Because of the small study population, this difference was not statistically significant.

When using the ROC curve to evaluate the prognostic value of the Mehran risk score, the area under the ROC curve was 0.851, p < 0.001, with a cutoff point > 10. This result demonstrated that patients with a Mehran score > 10 should be given more attention in prevention and treatment measures for CI-AKI. This result was similar to the study of Bui Xuan Nghia [12], with an area under the ROC curve of 0.747 and a cutoff point > 10. Mehran's initial study also showed that the group of patients with Mehran > 11 had a CI-AKI rate of 26.1%, and in patients with Mehran ³16, this rate was up to 57.3% [6]. Through this result, preventive measures for CI-AKI should be implemented when performing PCI in patients with a high to very high Mehran score. Prophylactic measures for CI-AKI have been proven effective through large studies, including providing adequate fluid for patients before the procedure, using statins before the procedure, using low osmolar contrast during the procedure, limiting the amount of contrast, combining the use of intracoronary imaging methods, and using hemodynamic support when there is prolonged hypotension [3, [7, 15].

In our study, within 48 hours after intervention, 5.53% (12) of patients had CI-AKI, including seven patients with reduced eGFR (< 60 ml/min/1.73 m^2) and two patients with eGFR < 40 ml/ min/1.73 m^2. However, after 3 months of follow-up, the average eGFR increased from 55.24 ± 14.72 (ml/min/1.73 m^2) to 70.02 ± 18.29 (ml/min/1.73 m^2) and remained stable at 6 months. After 3 months of follow-up, only three patients had eGFR < 60 ml/min/1.73 m^2, and no patients had eGFR < 40 ml/min/1.73 m^2 and required hemodialysis. Some other studies showed that in the group of patients with high and very high Mehran scores, the rate of patients requiring hemodialysis was 3-5% [11] and could be up to more than 10%, according to Mehran et al. [6]. Additionally, a high Mehran risk score is also an independent predictor of major adverse cardiovascular events. Patients with a high or very high Mehran score have a statistically significant higher rate of major cardiovascular events and mortality [4, 5, 7, 11].

5. CONCLUSION

A study of 217 patients who underwent PCI at the Hue University of Medicine and Pharmacy Hospital revealed that the incidence of CI-AKI was 5.53%. Independent risk factors for CI-AKI included hypotension, age > 75, and diabetes. A Mehran risk score greater than 10 was determined to be the cutoff value for predicting CI-AKI. Therefore, the Mehran risk score should be applied in clinical practice to assess CI-AKI risk and guide appropriate prevention and treatment strategies.

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