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Validation of mehran score for contrast induced nephropathy (CIN) in patients undergoing cardiac catherization in a Pakistani cohort

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ABSTRACT

OBJECTIVE: To evaluate the incidence of CIN in patients undergoing coronary catheterization and assess the predictive validity of the Mehran Risk Score (MRS) in a real-world clinical population.

METHODOLOGY: This single-center prospective study enrolled 300 adults aged 18–70 years undergoing non-emergent coronary catheterization at Aga Khan University Hospital using non-probability consecutive sampling. Data on demographics, comorbidities, and procedural variables were collected. The Mehran Risk Score was calculated for each patient. Statistical analysis was performed using SPSS version 26, employing descriptive statistics and evaluating the diagnostic performance of the Mehran Risk Score.

RESULTS: Among 300 patients (mean age 55.3±16.9 years; 62% male), 78 (26%) developed contrast-induced nephropathy. CIN patients had lower eGFR (59.3 ± 19.4 vs. 70.9 ± 12.9; p=0.0001) and higher Mehran scores (7.53±4.28 vs. 4.23±3.61; p=0.0001). Diabetes, CKD, anemia, and heart failure were significantly associated with CIN ($p < 0.01$). The Mehran Risk Score demonstrated predictive value (AUC 0.730), with 69.2% sensitivity and 73.0% specificity.

CONCLUSION: The Mehran Risk Score was found to have a useful predictive capacity in identifying patients who are at a greater risk of contrast-induced nephropathy who are undergoing non-emergent coronary catheterization. The score was consistent with the main clinical risk factors that are present in this group such as diabetes, chronic kidney disease, and anemia. It can be applied to facilitate timely stratification of risks and preventive approaches in other comparable clinical contexts, especially in resource-constrained healthcare settings.

KEYWORDS: Percutaneous Coronary Intervention, Contrast-Induced Nephropathy, Risk Assessment, Acute Kidney Injury

INTRODUCTION

Contrast-induced nephropathy (CIN) is a common iatrogenic complication in patients receiving intravascular contrast media, particularly during cardiac catheterization. Clinically, it is characterized by rise in serum creatinine of 0.3 or above within 48 to 72 hours following a cardiac catheterization, or without other likely causes [1,2]. CIN is the third most common cause of acute kidney injury in hospitalized patients and accounts for nearly 10% of all hospital-acquired AKI cases [3,4]. The entire occurrence in the general population is estimated to be 1 to 6% but increases up to 30% in patients who have risk factors, which includes chronic kidney disease (CKD), diabetes mellitus, congestive heart failure (CHF), anaemia, and advanced age [1,4–6]. CIN has been linked with a number of negative

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clinical events, such as long hospital stay, rising healthcare expenditures, renal replacement therapy, and elevated short- and long-term mortality [3,5,7].

The risk factors that can lead to CIN can be divided into non-modifiable and modifiable ones. The non-modifiable factors are CKD, diabetes, heart failure, old age, nephrotic syndrome and history of renal transplantation. The determinants that are modifiable are anaemia, hypotension, low levels of serum albumin, and taking of nephrotoxic drugs [6-8]. High contrast volume, intra-arterial contrast injection, emergency PCI, and the application of intra-aortic balloon pump are the procedural factors that contribute to the risk of CIN [6,9].

Accurate pre-procedural identification of patients at increased risk is essential for guiding preventive strategies such as hydration, minimizing contrast load, and selecting low- or iso-osmolar contrast agents. A number of predictive models have been put forward and one of the most validated predictive models is the Mehran Risk Score (MRS). The MRS takes eight parameters: hypotension, intra-aortic balloon pump, congestive heart failure, age over 75 years, anaemia, diabetes, and the volume of contrast media versus the baseline renal functions in terms of eGFR [10,11]. The MRS has its limitations, despite its wide use. It was initially designed using a Western cohort and in emergency PCI, which might restrict its use to elective cases or non-Western populations [11,12]. Also, some of the variables (volume of contrast, use of intra-aortic balloon pump) are not predicted in advance of the procedure, which decreases the usefulness of the score in pre-procedural counselling.

In recent research the possible changes or alternatives to the MRS have been investigated. Other researchers have recommended the inclusion of inflammatory markers or glycaemic status to enhance predictive accuracy especially in diabetic or other high-risk populations [2,13,14]. Nonetheless, few validation studies have been carried out among the populations in South Asia, particularly in environments of elective PCI with preventive measures that can be undertaken prior to the procedure [15].

The Mehran Risk Score has been extensively used all over the world; however, its predictive accuracy of CIN in South Asian population has not been sufficiently tested as far as patients who undergo elective coronary operations are concerned. The accuracy and clinical usefulness of the score may be affected by the regional variations in patient differences, comorbidities, and procedural practices. Timely preventive measures may be taken in anticipation of the risky individuals by available lead time before elective catheterization. The purpose of the study is to confirm the Mehran Risk Score in a Pakistani cohort experiencing non-emergent coronary catheterization, which will eventually ensure the use of context-specific risk assessment and enhanced clinical decision-making within the limited resources of the identified regions.

METHODOLOGY

This single-centre, prospective cross-sectional study was conducted in the cardiology and medicine wards of Aga Khan University Hospital, Karachi, following approval from the institutional Ethical Review Committee. Ethical principles were strictly observed, and written informed consent was obtained from all participants prior to enrolment.

The sample size of 300 adult patients aged between 18---70 years of both gender who were undergoing non-emergent coronary catheterization was recruited through a non-probability consecutive sampling method. Patients who were pregnant, had a known allergy to iodinated contrast media, had experienced catheter exposure within the seven days before, or three days after the procedure, was on maintenance dialysis, or had undergone renal transplantation were excluded.

Enrolment of the patients based on informed consent and data were collected on the structured proforma that involved the demographic features and comorbidities based on the Mehran Risk Score (MRS). The electronic medical records of the hospital were used to validate the presence of clinical information such

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as diabetes mellitus, hypertension, congestive heart failure, anaemia, and chronic kidney disease. All procedures were performed in accordance with institutional clinical guidelines. Catheterization and percutaneous coronary intervention of the left heart were performed by experienced interventional cardiologists with non -ionic and iso -osmolar contrast media. Renal prophylaxis, mostly intravenous hydration was done according to institutional guidelines and personal risk evaluation. The contrast volume that was applied was noted and intra-procedural variables such as hypotension and the application of intra-aortic balloon pumps were recorded.

Serum creatinine levels were recorded before contrast exposure and repeated within 72 hours following the procedure. A rise of at least 0.3 mg/dL from the initial value was classified as contrast-induced nephropathy (CIN). The Mehran Risk Score was determined using its eight original components, which include: age greater than 75 years, the presence of hypotension, congestive heart failure, anaemia (defined as haemoglobin <13 g/dL in men and <12 g/dL in women), diabetes mellitus, use of an intra-aortic balloon pump, the total contrast volume administered, and the baseline estimated glomerular filtration rate (eGFR).

Statistical analyses were performed using SPSS 26. Quantitative variables were expressed as mean ± SD, while qualitative variables were reported as frequencies and percentages. The diagnostic accuracy of the Mehran Risk Score was assessed using sensitivity, specificity, positive predictive value, and negative predictive value.

RESULTS

Table I presents the baseline and clinical characteristics of the 300 study participants, among whom 78 (26%) developed CIN. There was no significant difference in mean age between patients with and without CIN (56.19 ± 17.83 vs. 54.94 ± 16.59 years; p=0.573), and the mean volume of contrast administered was also comparable (72.50 ± 69.86 vs. 74.14 ± 72.87 mL; p=0.863). Patients who developed CIN had significantly lower baseline eGFR values (59.33 ± 19.40 vs. 70.89 ± 12.92 mL/min/1.73 m²; p=0.0001). Additionally, both pre- and post-procedure serum creatinine levels were markedly higher in the CIN group (pre: 1.35 ± 0.90 vs. 0.90 ± 0.21 mg/dL; post: 1.76 ± 1.15 vs. 1.05 ± 0.74 mg/dL; both p=0.0001). The mean Mehran score was also significantly elevated among patients with CIN (7.53 ± 4.28 vs. 4.23 ± 3.61; p=0.0001). Gender distribution did not differ significantly between groups (p=0.474). However, comorbid conditions—including chronic kidney disease (42.3% vs. 11.3%; p=0.0001), congestive heart failure (25.6% vs. 11.7%; p=0.003), anaemia (48.7% vs. 23.4%; p=0.0001), and diabetes mellitus (69.2% vs. 52.3%; p=0.009)—were significantly more common among CIN patients. No significant associations were found with hypotension, left heart catheterization, or percutaneous coronary intervention.

The Mehran score demonstrated predictive ability for CIN in patients undergoing cardiac catheterization, as illustrated by the ROC in **Figure I.**

Table II summarizes the ROC curve analysis for the Mehran score in predicting contrast-induced nephropathy (CIN) among the study population. The Mehran score demonstrated good discriminatory ability, with an area under the curve (AUC) of 0.730 (SE: 0.034; 95% CI: 0.663–0.797; p=0.0001), indicating a statistically significant predictive value. A threshold value of ≥ 5.50 yielded a sensitivity of 69.2% and a specificity of 73.0%. The positive predictive value was 47.3%, while the negative predictive value was substantially higher at 87.1%, suggesting strong reliability in ruling out CIN. The overall diagnostic accuracy of the Mehran score at this cutoff was 72.0%, with a positive likelihood ratio of 2.56 and a negative likelihood ratio of 0.42, further supporting its utility as a predictive tool for CIN.

Table III presents multivariable logistic regression analysis for identifying independent predictors of CIN. In the unadjusted analysis, the Mehran score showed a statistically significant association with CIN (OR:

0.816; 95% CI: 0.761–0.874; p=0.0001), while age (p=0.572) and gender (p=0.474) were not significant predictors. However, after adjusting for potential confounders, none of the evaluated variables—including age (OR: 1.001; 95% CI: 0.980–1.022; p=0.909), Mehran score (OR: 0.947; 95% CI: 0.744–1.204; p=0.656), and gender (OR: 1.378; 95% CI: 0.738–2.574; p=0.314)—retained statistical significance.

DISCUSSION

The current trial evaluated the occurrence of CIN and evaluated the predictive accuracy of the Mehran Risk Score (MRS) among non-emerging patients undergoing coronary catheterization. The prevalence of CIN in this cohort was 26% and this was in agreement with the previously reported prevalence of CIN in the population with similar clinical features [1,3,4]. The prevalence of comorbidities like diabetes mellitus, chronic kidney disease (CKD) and anaemia was larger among patients who developed CIN which is consistent with the current literature on these conditions as known risk factors [1,4–6].

Patients who developed CIN had lower baseline eGFR and higher pre- and post-procedure serum creatinine levels. The average Mehran score was also significantly more in the CIN group. These findings are in line with previous research, which illustrates the applicability of MRS elements to renal susceptibility after contrast exposure [10,11]. The analysis of the ROC resulted into a AUC of 0.73 which means that the MRS has a moderate capacity to differentiate patients who are at higher risk of CIN. This level of performance is similar to those of international studies which assess MRS in various populations [1,6,9,11].

CIN was more prevalent in patients with diabetes mellitus and CKD. These findings can be compared to research that has proposed that glycaemic state can be used to predict risk, as seen in more recent models, like the GlyMehr score, that uses pre-procedural glucose levels [2,16,17]. The reproducibility of these results with earlier studies indicates the relative significance of metabolic and renal factors in the development of CIN in particular in the regions with a high prevalence of diabetes.

Although the MRS was significantly associated with CIN in unadjusted analysis, it did not maintain statistical significance in the multivariable logistic regression model. This outcome may be related to multicollinearity, as the variables included in the MRS are also part of the regression model, which can reduce statistical independence [6,14]. The number of CIN events may also limit the ability to detect independent predictors when several variables are analysed simultaneously. For composite tools such as the MRS, ROC curve analysis is generally considered an appropriate method for evaluating predictive performance. In this study, the ROC results indicate that the MRS remains a useful tool for identifying patients at higher risk.

These findings support the use of MRS as a practical and feasible risk assessment instrument before elective coronary procedures. In settings where resource limitations may restrict access to more advanced tools, the MRS can assist clinical teams in identifying patients who may benefit from measures such as hydration, minimizing contrast volume, and avoiding nephrotoxic medications [18–21]. The associations observed with anaemia, diabetes, and CKD further support the role of optimizing correctable pre-procedural factors.

There are some limitations associated with this study. It was done in one tertiary-care centre, and this might not be as useful in the generalization of findings. The diagnosis of CIN was made through the use of serum creatinine, though other biomarkers, e.g. NGAL or cystatin C, could give earlier indication of kidney damage [8]. Other risk prediction instruments, such as the CV/GFR ratio or Intermountain Risk Score were not compared [20,21]. Multivariable modelling might also be limited by the number of CIN cases.

The strengths of the study include prospective data collection, use of a standardized CIN definition, and evaluation of the MRS in an elective, real-world South Asian population. Overall, the results support the

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applicability of the Mehran Risk Score for pre-procedural CIN risk assessment. Additional studies incorporating multicentre data, newer biomarkers, or updated risk models may further inform CIN prediction strategies [22,23].

CONCLUSION

The Mehran Risk Score was found to have a useful predictive capacity in identifying patients who are at a greater risk of contrast-induced nephropathy who are undergoing non-emergent coronary catheterization. The score was consistent with the main clinical risk factors that are present in this group such as diabetes, chronic kidney disease, and anaemia. It can be applied to facilitate timely stratification of risks and preventive approaches in other comparable clinical contexts, especially in resource-constrained healthcare settings.

Table I: Baseline and Clinical Characteristics of Study Participants (n=300)

Characteristics		**Contrast Induced Nephropathy**		**P-Value**
		Yes (n=78)	**No** (n=222)	
Age in years, Mean ± SD		56.19 ± 17.83	54.94 ± 16.59	0.573
Volume of Contrast in ml, Mean ± SD		72.50 ± 69.86	74.14 ± 72.87	0.863
eGFR mL/min/1.73 m², Mean ± SD		59.33 ± 19.40	70.89 ± 12.92	0.0001*
Pre Creatinine Level in mg/dL, Mean ± SD		1.35 ± 0.90	0.90 ± 0.21	0.0001*
Post Creatinine Level in mg/dL, Mean ± SD		1.76 ± 1.15	1.05 ± 0.74	0.0001*
Mehran Score, Mean ± SD		7.53 ± 4.28	4.23 ± 3.61	0.0001*
Gender	Male	51 (65.4)	135 (60.8)	0.474
	Female	27 (34.6)	87 (39.2)	
Chronic Kidney Disease		33 (42.3)	25 (11.3)	0.0001*
Hypotension		2 (2.6)	2 (0.9)	0.278
Congestive Heart Failure		20 (25.6)	26 (11.7)	0.003*
Anemia		38 (48.7)	52 (23.4)	0.0001*
Diabetes Mellitus		54 (69.2)	116 (52.3)	0.009*
Left Heart Catheterization		54 (69.2)	145 (65.3)	0.529
Percutaneous Coronary Intervention		22 (28.2)	77 (34.7)	0.295

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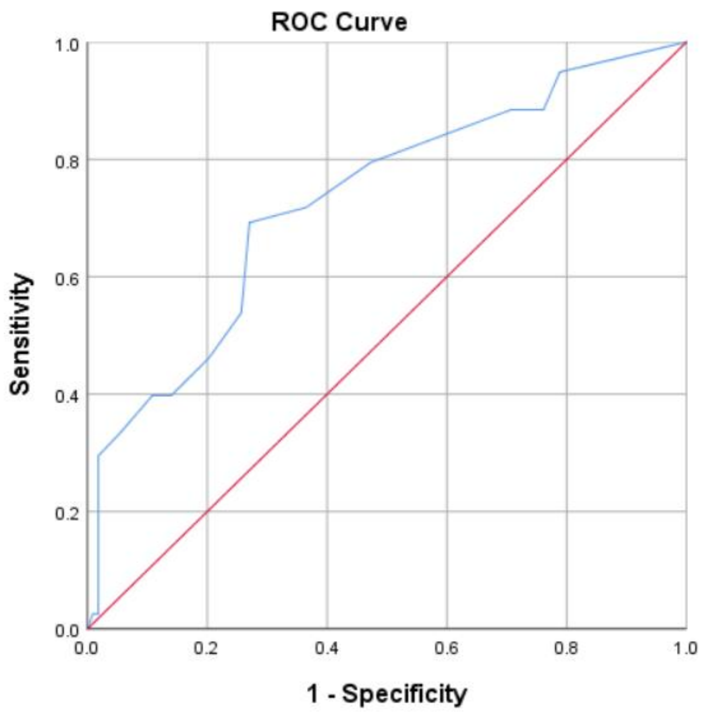

Table II: ROC Curve Analysis of Mehran Score for Predicting Contrast Induced Nephropathy (n=300)	
Area under the curve (AUC)	0.730
Std. Error	0.034
95% Confidence Interval	0.663----0.797
P-Value	0.0001
Threshold Value	≥ 5.50
Sensitivity	69.2%
Specificity	73.0%
Positive Predictive Value	47.3%
Negative Predictive Value	87.1%
Diagnostic Accuracy	72.0%
Positive Likelihood Ratio	2.56

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Negative Likelihood Ratio	0.42

Table III: Multivariable Logistic Regression Analysis for Independent Predictors of Contrast-Induced Nephropathy

Predictor	Unadjusted Odd Ratio (95% CI)	P-Value	Adjusted Odd Ratio (95% CI)	P-Value
Age (years)	0.996 (0.980 – 1.011)	0.572	1.001 (0.980 – 1.022)	0.909
Mehran Score	0.816 (0.761 – 0.874)	0.0001	0.947 (0.744 – 1.204)	0.656
Gender	1.217 (0.710 – 2.086)	0.474	1.378 (0.738 – 2.574)	0.314

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