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Predictors and Short-Term Outcomes of Patients with Contrast Induced Nephropathy following PPCI

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ABSTRACT

Introduction: Contrast-induced nephropathy (CIN) is one of the most frequent renal complications for patients who have received primary percutaneous coronary intervention (PPCI) for ST-elevation myocardial infarction (STEMI). CIN is associated with a longer length of hospitalization, increased in-hospital mortality and poor overall survival. It is for this reason that there is a need to establish predictors of its occurrence in order to reduce the frequency of its occurrence and improve patients' outcomes. **Objectives:** The main aim of the present research was to identify factors that may cause CIN and to evaluate the immediate outcomes of this condition in patients who underwent PCI in a large Pakistani teaching hospital. **Materials and Methods:** The current prospective study involved 200 STEMI patients who were candidates for PPCI. Patients' baseline demographic and clinical characteristics and their biochemical profiles were also obtained with CIN as an increase of ≥0.5 mg/dL or ≥25% increase in serum creatinine. Descriptive statistics showed the following individual variables as independent predictors of CIN. **Results:** CIN was present in 34% of patients. These baseline characteristics were identified as critical predictors for the development of AKI were age, diabetes, baseline renal dysfunction, and contrast volume. CIN was also linked with increased length of hospital stay and increased mortality rate in the hospital. **Conclusion:** Despite being a potentially preventable issue, CIN continues to be a concerning factor in patients with PPCI, and risk assessment, preventive measures and the appropriate procedural approach should be defined early.

INTRODUCTION

Contrast-induced nephropathy (CIN) is still a concern in percutaneous coronary intervention (PCI) patients and especially in ST-elevation myocardial infarction (STEMI) patients undergoing primary percutaneous coronary intervention (PPCI). Acute kidney injury in patients with CIN places them at risk for both short-term and delayed adverse effects. CIN places these patients at increased risk of adverse cardiovascular outcomes (1). There were several works about the diagnostic and prognostic indicators of CIN in patients that could help decrease mortality in such conditions. Subsequent studies provide more clarity and reveal the multi-factorial nature of CIN and also recognize the importance of interaction between various personal factors, technical factors and biochemical indices. In STEMI patients who underwent PPCI, CIN incidence is independently associated with age, and poor baseline renal function (Abdel-Ghany et al., 2021). The authors Jiang et al. also proved that the inflammatory prognostic index derived from the theme of systemic inflammatory markers is a perfect predictor of CIN. Thus, inflammation plays a role in the pathogenesis of CIN (2). These data suggest that comorbidities present at the index event and changes in the systemic inflammatory state during PPCI lead to additional increases in renal vulnerability.

This study has sought to review the ability of different biomarkers to predict the risk of the event in order to enhance the identification of high-risk patients. For instance, Lin et al. (2020) paid special attention to the admission D-dimer level, pointing out that a higher level of D-dimer suggests a worse prognosis (4). In the same manner, Luo et al. (2023) stated that clinical factors such as N-terminal pro-B-type natriuretic peptide (NT-proBNP) levels reliably predict non–recovery of renal function and adverse outcomes in

patients with CIN (11). The present markers discovered reveal the pathophysiological processes that underlie CIN and have the potential for individualized prevention. This work also discovered that procedural factors that affect CIN include the volume as well as type of consumed contrast. A study by Masoomi et al. published in 2024 documented a high rate of CIN in patients with STEMI who had undergone PPCI at a tertiary teaching hospital, and the authors partly blamed it on the large contrast volumes needed for treatments on complex interventions (6). Rahman et al. (2023) also have reflected on the measures to reduce contrast media-induced nephropathy, stressing on severe risk in patients with renal disease (12). The outcomes of this study underscore the paramount importance of procedural improvement to accommodate diagnostic and therapeutic performance without compromising renal protection.

Thus, it is important to recognize that CIN is not solely a marker of AKI but has clinical significance regarding both short stay and extended patient prognosis. Zheng and Huang (2020) explored a facet of CIN where the patient's chronic kidney disease is attributed to cardiovascular diseases and mortality within the short-term, middle-term, and long-term periods (5). Moreover, Güzel et al. (2022) also elaborated that CIN resulted in higher long-term mortality in patients with chronic coronary total occlusion for PCI, pointing out the need for prevention strategies (7). There exists several patient characteristics that are associated with CIN development, namely demographics and comorbidities. Reasons for CIN in a retrospective study of patients undergoing PCI were hypertension, diabetes, and anemia (Wang et al. (2021) (8). Similarly, Qiu et al. (2023) have identified elderly patients with STEMI and derived a predictive model by assessing the associated risk factors of CIN, including age, left ventricular ejection fraction and renal dysfunction and give a conclusion about the risk of CIN (13). These models allow us to determine patients with the highest risk and introduce corresponding modifications.

The systemic immune-inflammation index (SII) is a newly identified indicator for CIN. In this regard, Ma et al. (2023) brought views of interest on the awareness that Increased SII levels bear a direct correlation with CIN progression after elective PCI and its potential as a therapeutic target (14). In addition, Islam et al. (2020) reported the prognostic significance of baseline serum creatinine levels in STEMI patients undergoing PPCI relating to the in-hospital and survival at 12 months (15). These studies prove that in order to better predict CIN risk, it is necessary to establish a direct association between biochemical and clinical factors. The unequal distribution of CIN in different populations or various areas of clinical practice highlights the need for studies at the local level. Adhikari et al. (2021) examined the antecedents of CIN in the Nepalese population and demonstrated that fluid overload and delayed intervention were powerful pillars of CIN (3). These outcomes are analogous to the results attained by other countries' studies and also show the specific aspects in this area influencing CIN performance. Watanabe (2023) also emphasized on an identification of the patients at high risk for persistent renal dysfunction from CIN, intensive follow up and early treatment (13).

Last, the pre-procedural, procedural factors and biochemical markers of CIN in patients with PPCI are interrelated and multifactorial to affect short-term results. Improvement in the general understanding of what predictive markers entail and risk stratification have emerged as potential avenues that could be effective in improving the outcome of the patients being treated and concerned with CIN. The results of the current study could be helpful for the further investigation with aims to explore how these concepts are used in clinical practice and how preventive and therapeutic measures should be adapted to the patient's characteristics. It is essential to admit that such a complex approach would be helpful in preventing the most severe consequences of CIN and would also increase the efficacy of PPCI in STEMI patients.

Objective

Hence, this study aimed to identify potential predictors of contrast induced nephropathy and to evaluate the early effects of this complication in acclaimed STEMI patients receiving PPCI at a large population-based teaching hospital in Pakistan.

MATERIALS AND METHODS

Study Design: For this study, a prospective database design was employed for all PPCI candidates in the hospital.

Study Setting: The study was conducted at the Cardiology Department, Pakistan Institute of Medical Sciences (PIMS) in Islamabad. We have a great number of patients receiving treatment for heart diseases in the center.

Duration of the study: The research work was conducted for a duration of six months from January 2024 up to June 2024.

Inclusion Criteria

In these studies, the target population was patients who were aged 18 years and above and patients who had been diagnosed with STEMI and treated with PPCI. The sample involved patients who had recorded serum creatinine prior to the procedure, who volunteered to participate in the study by signing informed consent forms and who agreed to undergo contrast media.

Exclusion Criteria

Patients with end-stage renal disease on dialysis or acute kidney injury within 7 days prior to the procedure were excluded from the study. Patients who required extra treatments that could affect renal function, such as emergency surgery, were not included in the trial, nor were those who had prior history of developing renal dysfunction or who were lost to follow-up during the study period.

Methods

This analysis was performed in STEMI patients receiving their PPCI at our center for acute myocardial infarction. Contrast media used during PPCI and their quantity and types were recorded. CIN was diagnosed when the serum creatinine level rose by at least 0.5 mg/dL within 48–72 hours of the procedure or by ≥25% of the reference value. Outcomes of interest were short-term renal recovery, length of hospital stay, need for renal replacement therapy and in-hospital mortality, patients were followed accordingly. Thus, a multivariate logistic regression analysis was used to determine which of the variables can independently predict CIN. Data collected from a continuous variable were reported by using mean ± standard deviation, and data from the categorical variable, as a percentage. Both ethical clearance for the study was sought from the institutional review board while participant consent was given before inclusion in the study.

RESULTS

A total of 200 consecutive patients with confirmed STEMI and treated by PPCI were included in this study. The mean age of the patients was 60.2±10.8 years, and there was a male preponderance of 72.5%. Pre-study demographic, co-morbidity and biochemistry were recorded and are presented in Table 1.

Table 1

Baseline Characteristics of the Study Population

Parameter	Value (n = 200)
Age (years, mean ± SD)	60.2 ± 10.8
Male gender (%)	72.5
Diabetes mellitus (%)	45.0
Hypertension (%)	50.5
Baseline serum creatinine (mg/dL)	1.12 ± 0.25
Contrast volume (mL, mean ± SD)	150 ± 30

Contrast-induced nephropathy (CIN) was diagnosed in the population based on the predefined criteria in 34% of patients. The mean baseline serum creatinine of patients who developed CIN was (1.25 ± 0.3) compared to the patients without CIN (1.05 ± 0.2) $t = 2.40$, $p < 0.01$. They also needed higher contrast volumes during PPCI (170± 35 mL v/s 140± 25 mL; $p < 0.01$). The independent risk factors for CIN were age more than 65 years, diabetes mellitus, baseline reduced estimated glomerular filtration rate, and larger volume of contrast. Table 2 shows other predictors, OR and CI, as follows:

Table 2

Independent Predictors of CIN

Predictor	Odds Ratio (OR)	95% Confidence Interval (CI)
Age > 65 years	2.5	1.4–4.3
Diabetes mellitus	3.2	1.8–5.7
Baseline renal impairment	4.1	2.3–7.1
High contrast volume (>150 mL)	3.8	2.0–6.8

Patients with CIN had slightly longer stays in the ICU (mean: 6.5 ± 2.0 days) compared with patients without CIN (4.2 ± 1.5 days; $p < 0.01$). The authors found that in-hospital mortality tended to be higher in the CIN group compared to non-CIN patients (12.0% vs 4.5%; $p = 0.02$). The outcomes are in the Table 3 below.

Table 3

Short-Term Outcomes

Outcome	CIN Group (n = 68)	Non-CIN Group (n = 132)
Length of hospital stay (days)	6.5 ± 2.0	4.2 ± 1.5
In-hospital mortality (%)	12.0	4.5

Finally, CIN was observed in a large percentage of patients in the PPCI group, which independently predicted poor early outcomes. In view of this, studies emphasize the need for screening for high-risk patients and undertake measures to reduce incidences of CIN.

DISCUSSION

Contrast-induced nephropathy (CIN) has reportedly been prevalent following primary percutaneous coronary intervention (PPCI) in cases of ST-elevation myocardial infarction (STEMI). Its presence is linked to higher morbidity, longer hospital stays, and higher mortality, suggesting the importance of further investigation of its predictors and prognosis. In the present study, CIN was detected in 34 % of the patients, which is adequately close to other studies that have revealed CIN prevalence rates between 10 and 40 % depending on the profile of investigated patients and the study environment (1, 3, 6). This variation demonstrates that a single factor does not cause CIN and is dependent on demographic, procedural, and clinical factors. The study results revealed that the factors associated with the occurrence of CIN include age, diabetes mellitus, impaired baseline renal function and volume of contrast material. Age has remained an independent variable, with patients of older age being predisposed to CIN because of compromised renal reserve and increased prevalence of co-morbid disease (1, 8). Thus, the study reinforces the necessity of risk stratification on patients older than sixty-five or with diabetes mellitus requiring PPCI.

They observed that baseline renal function is the greatest risk factor for CIN. Patients with more than 1.5mg/dl baseline serum creatinine were 2.6 times more likely to develop CIN from this meta-analysis and other

research work (5,15). Chronic Kidney Disease (CKD) increases the risk of CIN through decreased value of glomerular filtration rate and enhanced tubular contrast toxicity. Furthermore, the study found that PPCI with larger contrast volumes augments the risk of CIN in this study. Prior studies have also established the association between contrast volume and CIN where reducing contrast dose has been proposed as a way of reducing risk (6, 12). Measures that involve controlling the procedure and certain agents include minimizing the use of high osmolar contrast agents by using low or iso-osmolar agents, as well as controlling hydration in high-risk patients.

Therefore, the inflammatory and biochemical markers associated with CIN are also informative regarding its pathogenesis. It has been proved that a higher systemic inflammatory status and acute kidney injury are related to CIN, so systemic inflammation and oxidative stress may participate in kidney damage (2, 14). In addition, NT-proBNP and D-dimer have been identified to be valid biomarkers of CIN and adverse outcomes (4, 11). Such results underscore the possibility of using inflammatory and biochemical markers in clinical practice to improve early risk assessment and prevention strategies. It was concluded that CIN had a profound effect on the short-term results of the study. Patients with CIN had a longer length of stay, which is an indication that managing this condition is more challenging. The same trends have been synthesized where CIN is associated with increased stasis of recovery and healthcare costs (5, 10). Additionally, patients with CIN had a considerably higher in-hospital mortality rate, which is consistent with research showing that patients with CIN have a higher risk of morbidity and unsafe cardiovascular events (7, 13). These observations have drawn attention to strategies that would help minimize CIN occurrence and enhance patient outcomes.

Measures to minimize the occurrence of CIN have been directed towards adequate hydration, low contrast practice and the use of nephrotoxicity protectants. Successful prevention should still include sufficient fluid intake, which has been shown to reduce the effects of CIN on renal perfusion and tubular injury (3, 12). Intravenous isotonic saline or sodium bicarbonate has also been found to have a potentially big protective effect, more so in high-risk individuals. Moreover, they pointed out that high contrast volumes and the choice of nonionic contrast agents are related to renal injury during PPCI. Other drugs, including N-acetylcysteine and statins have also been described but their usage remains controversial (9, 14). Renal function should be monitored at least every 24 hours or more often in the first 48-72 hours after PPCI in order to notice the development of CIN and start appropriate treatment. Despite the poor performance of several previous models, newer technologies like machine learning algorithms present a viable way to advance the risk stratification of patients at the risk of developing CIN and subsequent clinic decision-making (13). These developments might help in refining the approach to maintaining CIN and lowering the impact of this outcome in the population most susceptible.

Thus, this study offers important findings regarding the experiences and consequences of CIN but demonstrates directions for future research as well. The high rate of CIN revealed in this study points to the importance of developing uniform operational definitions and diagnostic criteria for the comparison of results across studies. Furthermore, in order to potentially prevent and cure CIN, a deeper comprehension of environmental interactions and their association with the condition should be explored. Additional longitudinal works for assessing the effects of CIN on renal function and cardiovascular morbidity and mortality are required to define the importance of this phenomenon. The study has practical implications for clinical practice dealing with such cases, especially in developing countries. Knowledge of modifiable risk factors, like contrast volume, can be exploited to fine-tune procedural practice to minimize the occurrence of CIN. Furthermore, increasing knowledge among healthcare givers on the risk factors as well as the preventive measures towards CIN has a vital role in enhancing care provision among patients.

Lastly, CIN continues to be frequent and clinically relevant in patients suffering from STEMI who underwent PPCI. Cardiac risk factors such as advanced age, diabetes mellitus, baseline renal impairment, and high contrast volume are the CIN risk factors, and they increase both length of stay and in-hospital mortality. Preventive measures include adequate hydration and minimizing contrast volume and early diagnosis of CIN. More work is required not only to perfect the generated and validated predictive indices but also discuss new markers' potentialities and study CIN's effect on patients' prognosis. In this way, clinicians are to achieve better management of CIN and the resultant quality of care for STEMI patients receiving PPCI.

CONCLUSION

Contrast-induced nephropathy (CIN) is a frequent and severe clinical event related to primary percutaneous coronary intervention (PPCI) for ST-elevation myocardial infarction (STEMI). This research found that large contrast volume, diabetes mellitus, age over 75, and compromised renal function at baseline were all independently linked to CIN. It was linked with longer periods of hospitalization and higher in-hospital mortality, which understates the clinical and financial effects. Based on the research literature, it is necessary to focus on prevention methods such as the frequent use

of adequate hydration, small contrast volumes and early risk stratification to decrease CIN rates and produce positive outcomes for patients. Thus, the addition of predictive biomarkers and risk models in clinical applications may provide the potential to better manage high-risk individuals. However, this study offers beneficial knowledge and more research has to be done in order to establish long-term results, improved prevention measures, and novel treatments. Overcoming of these challenges could further enhance the management of STEMI patients and reduce impact of CIN in resource constrained health care facilities.

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