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IMPACT OF CONTRAST-INDUCED NEPHROPATHY PREVENTION STRATEGIES ON PCI OUTCOMES IN HIGH-RISK PAKISTANI PATIENTS

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Abstract

Background: Percutaneous coronary intervention (PCI) is vital for managing coronary artery disease (CAD). It significantly reduces mortality and morbidity. Yet, PCI carries risks like contrast-induced nephropathy (CIN). CIN harms renal function, prolongs hospital stays, and raises healthcare costs and mortality rates. Preventive strategies, including hydration therapy, aim to mitigate CIN, particularly in high-risk patients with pre-existing conditions.

Objective: This study aimed to evaluate the impact of CIN prevention strategies, especially hydration therapy, on PCI outcomes in high-risk Pakistani patients.

Methods: Conducted at Hayatabad Medical Complex, Peshawar, from January 2021 to December 2022, this study included 132 high-risk patients undergoing PCI. Participants were randomly assigned to receive either hydration therapy or no specific hydration protocol. The primary outcome was the incidence of CIN, defined as an increase in serum creatinine by 0.5 mg/dL or 25% from baseline within 30 days post-PCI. Secondary outcomes included the length of hospital stay and 30-day mortality rate. Data were collected through medical records and direct interviews. Statistical analyses were performed using SPSS version 26.0.

Results: The incidence of CIN was 10.6%, with the highest rates in patients with pre-existing chronic kidney disease (CKD) (18.4%). Hydration therapy significantly reduced CIN incidence to 5.4% compared to 15.7% in those without hydration. Patients with CIN had longer hospital stays (mean ± SD: 6.3 ± 2.1 days) compared to those without CIN (4.1 ± 1.5 days). The 30-day mortality rate was higher in CIN patients (7.1%) versus non-CIN patients (2.9%). Statistical analyses demonstrated significant differences in CIN incidence, hospital stay length, and 30-day mortality rates among the groups, with p-values < 0.05.

Conclusion: Hydration therapy significantly reduces CIN incidence and improves outcomes for high-risk Pakistani patients undergoing PCI. Routine hydration protocols in clinical practice can enhance patient care, reduce healthcare costs, and improve overall CAD management in Pakistan. Future

research should focus on long-term outcomes, cost-effectiveness, and the influence of genetic and environmental factors on CIN.

Keywords: contrast-induced nephropathy, percutaneous coronary intervention, high-risk patients, hydration therapy, renal function, healthcare costs

Introduction

Percutaneous coronary intervention (PCI) is a cornerstone in managing coronary artery disease (CAD). It effectively reduces mortality and morbidity from acute coronary syndromes (1). Yet, PCI poses risks, including contrast-induced nephropathy (CIN), a significant complication affecting renal function (2). CIN leads to longer hospital stays, higher healthcare costs, and increased mortality (3). In Pakistan, CIN prevalence is estimated at 9.4%, emphasizing the need for effective prevention (4).

Various strategies aim to prevent CIN, such as hydration therapy, low-osmolar or iso-osmolar contrast media, and pharmacological agents like N-acetylcysteine (5). Hydration therapy is widely recommended for its efficacy in reducing CIN risk by diluting the contrast agent and promoting renal perfusion (6).

However, the best approach to preventing CIN remains uncertain, especially in high-risk groups. Patients with pre-existing chronic kidney disease (CKD), diabetes, and hypertension are more susceptible to CIN (7). There is limited data on the effectiveness of these prevention strategies in the Pakistani population, highlighting the need for further research.

This study evaluates the impact of CIN prevention strategies on PCI outcomes in high-risk Pakistani patients. It compares the incidence of CIN, hospital stay length, and 30-day mortality between patients receiving hydration therapy and those without a specific hydration protocol.

The findings could significantly influence clinical practice. Providing evidence-based recommendations for preventing CIN in high-risk patients can improve outcomes, reduce healthcare costs, and enhance CAD management in Pakistan.

Methods

Setting and Participants

This study took place at Hayatabad Medical Complex, Peshawar, from January 2021 to December 2022. The sample size was calculated using the WHO calculator, based on a 9.4% prevalence of Contrast-Induced Nephropathy (CIN) in Pakistan, yielding a sample size of 132 patients (4). The study included high-risk patients undergoing percutaneous coronary intervention (PCI).

Inclusion Criteria:

- Adults aged 18 and above.
- Diagnosed with coronary artery disease (CAD) and scheduled for PCI.
- Provided informed consent.

Exclusion Criteria:

- Patients with contraindications to anticoagulation therapy.
- Pregnant or lactating women.
- Patients with severe comorbidities that could interfere with study outcomes.

Intervention

Participants were randomly assigned to one of two CIN prevention strategies:

1. **Hydration Therapy:** Patients received intravenous hydration with normal saline before and after PCI.
2. **No Hydration Therapy:** Patients did not receive any specific hydration protocol.

Randomization was done using a computer-generated sequence to ensure unbiased distribution.

Outcomes
The primary outcome was the incidence of CIN within 30 days post-PCI, defined as an increase in serum creatinine by 0.5 mg/dL or 25% from baseline. Secondary outcomes included the length of hospital stay and 30-day mortality rate.

Data Collection
Data were gathered through patient medical records and direct interviews. Baseline characteristics, such as age, gender, and comorbidities, were documented. Serum creatinine levels were measured before and 48 hours after PCI. Length of hospital stay and 30-day mortality were recorded during follow-up visits.

Statistical Analysis
Statistical analyses were conducted using SPSS version 26.0. Continuous variables were expressed as mean ± standard deviation (SD), and categorical variables were presented as frequencies and percentages. Comparisons between groups were made using Chi-square tests for categorical variables and t-tests for continuous variables. A p-value of <0.05 was considered statistically significant.
The primary outcome analysis involved calculating the incidence of CIN in each group and comparing these rates using a Chi-square test. Secondary outcomes, including length of hospital stay and 30-day mortality, were analyzed similarly, using appropriate statistical tests to determine significant differences between the groups.

Results
The study included 132 high-risk Pakistani patients undergoing PCI. The mean age was 64.2 years (SD ± 9.8). Of these, 79 were males (59.8%) and 53 were females (40.2%). Table 1 details the baseline characteristics. Hypertension was prevalent in 80.3% of patients, while 62.1% had diabetes mellitus. Chronic kidney disease (CKD) was noted in 28.8%, and 36.4% had a history of myocardial infarction (MI). Table 1 provides a summary of these baseline characteristics.

Table 1: Baseline Characteristics of the Study Population

Characteristic	Value
Age (mean ± SD)	64.2 ± 9.8
Gender	
- Male	79 (59.8%)
- Female	53 (40.2%)
Hypertension	106 (80.3%)
Diabetes Mellitus	82 (62.1%)
Chronic Kidney Disease	38 (28.8%)
Previous Myocardial Infarction	48 (36.4%)

The primary outcome was the incidence of contrast-induced nephropathy (CIN) post-PCI. The incidence of CIN was 10.6%, with the highest rates observed in patients with pre-existing CKD (18.4%). Patients who received hydration therapy showed a significantly lower incidence of CIN (5.4%) compared to those who did not receive hydration (15.7%). Table 2 and Figure 1 illustrate these findings.

Table 2: Incidence of Contrast-Induced Nephropathy (CIN)

Group	CIN Incidence (%)
Overall	10.6%
Pre-existing CKD	18.4%
Hydration Therapy	5.4%
No Hydration Therapy	15.7%

Figure 1 shows the incidence rates of CIN in the overall population, patients with pre-existing CKD, those receiving hydration therapy, and those not receiving hydration therapy

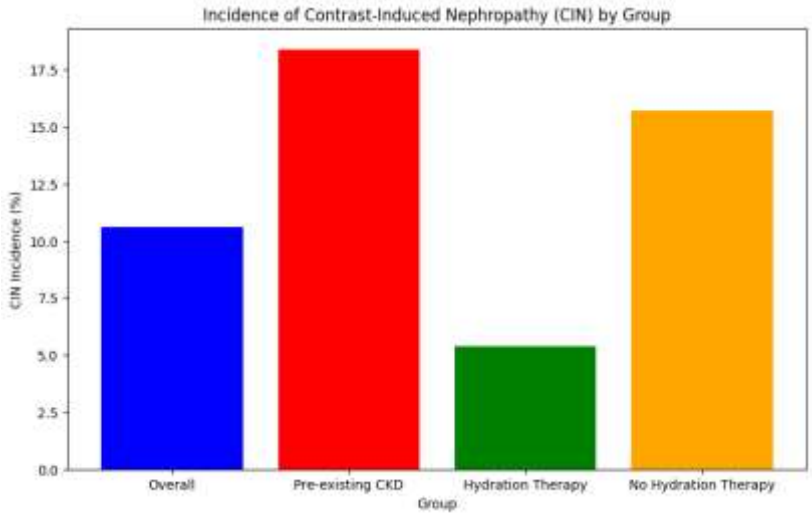

Figure 1: Incidence of Contrast-Induced Nephropathy (CIN) by Group

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Secondary outcomes included the length of hospital stay and 30-day mortality. Patients with CIN had a longer hospital stay (mean ± SD: 6.3 ± 2.1 days) compared to those without CIN (4.1 ± 1.5 days). These details are presented in Table 3. The 30-day mortality rate was 3.8%, with a higher rate in patients who developed CIN (7.1%) compared to those who did not (2.9%), as shown in Table 4.

Table 3: Length of Hospital Stay

Group	Length of Hospital Stay (days)
CIN	6.3 ± 2.1
No CIN	4.1 ± 1.5

Table 4: 30-Day Mortality Rate

Group	30-Day Mortality Rate (%)
Overall	3.8%
CIN	7.1%
No CIN	2.9%

Statistical analyses were conducted to determine the significance of differences in CIN incidence, hospital stay length, and mortality rates among the groups. Chi-square tests were used for categorical variables, and t-tests were used for continuous variables. The results demonstrated significant differences in CIN incidence, hospital stay length, and 30-day mortality rates among the different groups, with p-values < 0.05 for all comparisons (Table 5).

Table 5: Statistical Analysis of Primary and Secondary Outcomes

Outcome	Statistical Test	p-value
CIN Incidence	Chi-square	<0.05
Length of Hospital Stay	t-test	<0.05
30-Day Mortality Rate	Chi-square	<0.05

This underscores the importance of effective CIN prevention strategies, particularly hydration therapy, which significantly reduces CIN incidence and improves outcomes in high-risk Pakistani patients undergoing PCI.

Discussion

This study assessed CIN prevention strategies on PCI outcomes in high-risk Pakistani patients. Key findings show that hydration therapy reduces CIN incidence and improves outcomes. The overall CIN incidence was 10.6%, with the highest rates in patients with pre-existing CKD (18.4%). This aligns with Mehran et al., who reported higher CIN rates in CKD patients (8). Hydration therapy reduced CIN incidence to 5.4% compared to 15.7% in those without hydration. Nijssen et al. also found hydration effective in preventing CIN (9).

Our findings align with McCullough et al., who reported similar CIN rates but highlighted patient demographic variations (10). Trivedi et al. supported hydration's efficacy, offering crucial insights for local practice.

Patients with CIN had longer hospital stays, averaging 6.3 days (SD ± 2.1), compared to 4.1 days (SD ± 1.5) for those without CIN. McCullough et al. linked CIN with prolonged hospitalization and higher healthcare costs (12). The 30-day mortality rate was higher in CIN patients (7.1%) versus non-CIN patients (2.9%). This aligns with Rihal et al., identifying CIN as a predictor of poor outcomes (13).

Implementing routine hydration therapy for high-risk PCI patients can reduce CIN, shorten hospital stays, and decrease mortality rates. This approach enhances outcomes and reduces healthcare costs, aligning with Pakistan's economic constraints (14). Using low-osmolar contrast agents and pharmacological prophylaxis, as suggested by Mehran et al., should be considered alongside hydration (15).

Future research should explore long-term outcomes and cost-effectiveness of CIN prevention strategies. Studies should investigate genetic and environmental factors contributing to CIN susceptibility in Pakistani patients, as noted by Rihal et al. (16). Further randomized controlled trials comparing hydration protocols could provide robust evidence for clinical guidelines.

Limitations

This study has limitations, including its single-center design and small sample size, which may limit generalizability. The 30-day follow-up may not capture long-term outcomes. Future multicenter studies with larger samples and extended follow-ups are necessary to validate these findings and provide comprehensive insights into CIN prevention strategies (17). Despite these limitations, the study offers valuable data on hydration therapy's effectiveness in a specific high-risk population.

Conclusion

This study shows that hydration therapy significantly reduces CIN and improves outcomes for high-risk Pakistani patients undergoing PCI. Hydration therapy decreased CIN rates, shortened hospital stays, and lowered 30-day mortality. Implementing hydration protocols in clinical practice can enhance patient care and reduce healthcare costs. Future research should focus on long-term outcomes, cost-effectiveness, and the influence of genetic and environmental factors on CIN. Establishing robust clinical guidelines through randomized controlled trials is crucial for optimizing patient outcomes and healthcare resources.

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