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Frequency of Contrast Induced Nephropathy in Patients Undergoing Primary PCI

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ABSTRACT

Contrast-induced nephropathy (CIN) is a critical complication of iodinated contrast media used in diagnostic and interventional procedures, particularly primary percutaneous coronary intervention (PCI). This study investigated the incidence of CIN and its associated risk factors in patients undergoing primary PCI. A sample of 120 patients was assessed, with CIN defined as a 25% or 0.5 mg/dL increase in serum creatinine within 48–72 hours post-contrast exposure. The findings revealed a CIN incidence of 15% (n = 18), aligning with reported rates in high-risk populations. Key risk factors identified included diabetes, present in 66.67% of CIN cases, and pre-existing renal impairment (eGFR < 60 mL/min), observed in 55.56% of cases. Hemodynamic instability, marked by hypotensive episodes, was documented in 33.33% of CIN patients, while 77.78% received >200 mL of contrast media, highlighting a dose-dependent risk. Preventive measures such as pre-procedural hydration and the use of low-osmolar contrast agents showed limited efficacy, with only 22.22% of CIN patients adequately hydrated. Adjunctive therapies, including statins and N-acetylcysteine, demonstrated minimal protective effects. The results underscore the need for robust preventive strategies, including stringent hydration protocols and minimizing contrast media usage, particularly in high-risk groups. CIN remains a significant contributor to acute kidney injury and adverse outcomes, emphasizing the importance of targeted risk mitigation and further research into innovative therapeutic interventions. This study highlights the critical role of personalized care approaches in reducing CIN incidence and improving post-PCI outcomes.

INTODUCTION

Contrast-induced nephropathy (CIN) is a serious complication that can occur after the administration of iodinated contrast media, commonly used during diagnostic and interventional procedures such as primary percutaneous coronary intervention (PCI) (Peddavenkatagari, 2024). After 48–72 hours of contrast exposure, CIN is defined as a 25% or 0.5 mg/dL rise in serum creatinine from baseline, with no other cause (Shams & Mayrovitz, 2021). Patients having primary PCI should be especially concerned about the development of CIN because these patients are frequently more vulnerable because of concomitant conditions such diabetes, hemodynamic instability, and chronic renal disease. According to reports, the incidence of CIN in patients having PCI ranges from 5% to 15%, with greater rates seen in individuals who already had renal impairment (Wang et al., 2021; Masoomi et al., 2024). CIN continues to be a major cause of hospital-acquired acute kidney injury (AKI), contributing to longer hospital stays, increased morbidity, and higher mortality even though improvements in PCI procedures and the use of iso- or low-osmolar contrast agents have decreased the overall risk. The pathophysiology of CIN is caused by multiple processes, including as oxidative stress resulting in renal ischemia, contrast-induced vasoconstriction, and direct tubular toxicity (Li & Wang, 2024; Peddavenkatagari, 2024). Although preventive measures including drinking enough water, reducing the amount of contrast material used, and using medications like statins and N-acetylcysteine have been studied, CIN is still a common side effect (Xie et al., 2021; Cho & Ko, 2022). Adverse short- and long-term outcomes are linked to CIN, especially for patients receiving initial PCI for acute

myocardial infarction (AMI) (Kumar et al., 2022; Jiang et al., 2024). This illness raises the chance of developing chronic kidney disease (CKD), long-term cardiovascular events, including mortality, and prolongs hospital admissions. Renal replacement treatment may be necessary in certain cases of CIN, which further complicates patient management and raises healthcare expenses (Chaudhari et al., 2022). It is essential to comprehend the risk factors for CIN in order to create preventive measures. The development of CIN is significantly influenced by variables such as the type and volume of contrast agent employed, the patient's preexisting renal function, and the existence of other concomitant diseases (such as heart failure or hypertension).

The emphasis has switched in recent years to pinpointing at-risk groups and improving CIN mitigation techniques, particularly for patients having high-risk operations like primary PCI. The application of bicarbonate-based hydration procedures, the use of sophisticated imaging techniques to reduce contrast exposure, and the use of alternate contrast agents, including gadolinium, for individuals who are more vulnerable are some of the more recent approaches being investigated. Additionally, tailored patient treatment strategies have demonstrated promise in lowering the occurrence of CIN. These strategies include careful monitoring of renal function both before and after surgery. New studies are also looking into the possible involvement of innovative treatments and anti-inflammatory drugs in battling the underlying causes of CIN. Nevertheless, given that CIN not only raises healthcare costs but also presents major obstacles to patient recovery and long-term outcomes in the context of cardiac care, a thorough understanding of the condition's pathogenesis and the development of effective preventative strategies remain imperative.

LITERATURE REVIEW

Primary percutaneous coronary intervention (PCI) has been reported to maintain ventricular function and enhance myocardial salvage in patients suffering from acute myocardial infarction (AMI), therefore improving their chances of survival (Wang et al., 2024;). There is now increasing support for this position. Specifically, relative to those having elective PCI, primary PCI patients may consist of a subset of populations predisposed to CIN. Several mechanisms may contribute to the renal impairment in this case. These are the failure to start a renal prophylactic drug, shock or hypotension and a large volume of contrast medium (Briguori et al., 2021; Khandy et al., 2023). The research on the effects of these factors on kidney function and the importance of contrast-induced nephropathy (CIN) in the management of primary PCI has not been carried out, albeit it is presumed to be important. Hence, it is only in the recent past that studies with the same aim have as it was noted that there is a high risk in patients suffering from both AMI and renal insufficiency (Alisherovna et al., 2022; Alnemer, 2024). In addition, other clinical observations further support the fact that renal dysfunction is an independent mortality risk factor in patients with AMI (Qi et al., 2021). Wi et al, 2011, maintains that it is the CIN who is more of an actor than a bystander in the detrimental consequences, which is why we should put more emphasis on the work of rendering iodinated contrast administration safer for the patients.

The term definition for acute kidney injury due to iodinated contrast media is the loss of renal function, either acute or progression of an inactive renal disease. As the most outcomes from the registries indicate, this pathology is more and more reasonably according to the diagnostic which requires increase of at least 44.4 moll/l of 0.5 mg/dl of serum creatinine or increase of serum creatinine of 25% from his baseline level in 72 hours after the contrast media is injected. In unselected studies, in populations assessing the risk, the incidence of CIN is the order of magnitude of 3% but in those populations who are at highest risk for developing CIN incidence can be >30%. There are several potential patient-related features that have been suggested to promote CIN formation, but the most trustworthy constant predictor factor of CIN formation is kidney impairment linked to patient history. This might not be diagnosed in patients aged over 60 years with an estimated glomerular filtration rate below 60 ml/min but having surrogate normal creatinine levels.

Adjustment in the methodology to assess procedural CIN risk and use of preventive measures, commonly pre-procedure fluid loading to avoid hypovolemia (Mirza, 2023; Isaac et al., 2022), because of introduction and verification of features of Mehran scoring system which also considers various other important predictors of CIN development like fluid status (Memon et al., 2024; Kumar et al., 2022). Other predictors include the patient’s age, presence of hypotension, congestive heart failure, use of intra-aortic balloon pumps, baseline serum creatinine level prior to the procedure, presence of diabetes, anemia, and total volume of contrast used in the study.

According to many previous studies, diabetes mellitus stands out as a lone factor for the development of CIN. Furthermore, the existing renal damage does not contribute to this risk. Among diabetics, the incidence of nephrotoxic/cin is reported to be from 5.7% to 29.4%. Considering the rising prevalence of diabetes among the general population coupled with the increased risk of vascular disease in this population, diabetic individuals are a significant proportion of patients undergoing radiological interventions with contrast material including PCI (Shams & Mayrovitz, 2021; Pop-Busui et

al., 2022). Concerning the finding of Toprak et al. when patients were at pre diabetes state or at normal Fasting state, Diabetes only increased chance of CIN and the need of dialysis in those with normal renal reserve which is an extra on top of renal reserve (Heyman et al., 2024). Berns found that in the diabetic patients there was a higher incidence to CIN if the Cr > 4.0 as compared to Cr 2.0 – 4.0 mg/dL. Only those with diabetes and those with pre-existing renal impairment obviously and synergistically combine.

METHODOLOGY

The purpose of this qualitative study was to investigate how frequently patients receiving primary percutaneous coronary intervention (PCI) have contrast-induced nephropathy (CIN). A sample of 120 patients was selected which includes those who had primary PCI. The patients were chosen using selective sampling. Patients had to be over the age of eighteen and have no prior history of acute renal damage to be eligible for PCI. Examining medical records and holding semi-structured interviews with patients and healthcare professionals were two of the methods used to acquire data. According to the conventional CIN criteria, the primary outcome evaluated was an increase in serum creatinine of 25% or 0.5 mg/dL from baseline between 48 to 72 hours post-PCI. The main goal of the interviews was to identify risk variables, which included diabetes, hemodynamic stability, contrast volume usage, and pre-existing kidney diseases. Healthcare professionals also shared their views on preventive measures including using low-contrast agents and adhering to hydration recommendations. The study utilized thematic analysis to discern significant trends within the data, specifically focusing on the variables impacting the development of CIN and the measures implemented to lessen its incidence. Before being included in the study, each subject gave informed consent and ethical approval was obtained.

DATA ANALYSIS

To determine the frequency of contrast-induced nephropathy (CIN) and the risk factors associated with it, data from 120 patients receiving primary percutaneous coronary intervention (PCI) were evaluated using a combination of thematic and descriptive methods. 15% (n = 18) of the patients had CIN, which is within the range of incidence rates of 5-25% in comparable groups that have been previously described. A 25% or 0.5 mg/dL rise in serum creatinine from baseline within 48 to 72 hours following contrast exposure during PCI was considered CIN. According to this research, patients receiving primary PCI—especially those with preexisting medical issues—may be more susceptible to CIN.

It was shown that several risk variables were strongly linked to the emergence of CIN. With 66.67% (n = 12) of the patients who acquired CIN having pre-existing diabetes, diabetes appeared as a key predictor. This is consistent with previous studies that show diabetes to be a major risk factor for renal problems because of decreased kidney function and heightened susceptibility to oxidative stress and vascular damage. An additional significant risk factor that was observed in 55.56% (n = 10) of CIN patients was pre-existing renal impairment. Patients with an estimated glomerular filtration rate (eGFR) < 60 mL/min were more likely to develop chronic kidney injury (CIN), hence confirming the link between nephropathy risk and impaired kidney function. Additionally,

The development 33.33% (n = 6) of CIN patients had hemodynamic instability, which is characterized by hypotensive episodes. Renal damage is more likely when blood pressure is low during PCI because it decreases renal perfusion. of CIN was also significantly influenced by the volume of contrast media utilized during PCI. More than 200 mL of contrast media were administered to 77.78% (n = 14) of the 18 patients who had CIN, indicating a considerable increase in the risk of nephropathy with larger volumes. Renal stress is made worse by excessive contrast media, especially in susceptible individuals with pre-existing renal diseases. Preventive treatments such low-osmolar contrast agents and pre-procedural hydration were used, however they did not completely prevent CIN in all patients. The risk of CIN may need to be decreased by more stringent hydration measures, since only 22.22% (n = 4) of those who had CIN had appropriate hydration before to PCI. An analysis of the use of N-acetylcysteine and statins was also conducted; nevertheless, the results indicated limited effectiveness, since statins had been given to three individuals who had CIN, and N-acetylcysteine to two of them.

RESULTS

A contrast-induced nephropathy (CIN) incidence of 15% (n = 18) was found in the study of 120 patients receiving primary percutaneous coronary intervention (PCI). This incidence is within the expected range, typically between 5% to 25%, based on prior research. Pre-existing diseases including diabetes and poor renal function were important risk factors in the development of CIN. A significant correlation was found between diabetes and CIN, as evidenced by the fact that 66.67% (n = 12) of the 18 patients who acquired CIN also had diabetes. This discovery is consistent with other studies that shows diabetes to be a significant risk factor because it exacerbates oxidative stress and vascular damage, both of which worsen kidney function.

With 55.56% (n = 10) of the CIN patients having an estimated glomerular filtration rate (eGFR) of less than 60 mL/min, pre-existing renal impairment was another

significant risk factor. These individuals were especially vulnerable to further renal injury after contrast exposure during PCI because to their already compromised baseline kidney function. This lends credence to the idea that individuals with pre-existing renal impairment should take more precautionary measures because they are more likely to develop CIN.

Hypotension, or 33.33% (n = 6) of the CIN patients had hemodynamic instability. This research highlights the significance of preserving hemodynamic stability throughout percutaneous coronary intervention (PCI) procedures, since variations in blood pressure might diminish renal perfusion and heighten the probability of renal damage. Since hypotension increases the risk of chronic kidney injury (CIN), it is especially harmful for people who already have renal problems.

The amount of contrast material employed during the surgery was another important consideration. Approximately 77.78% (n = 14) of the CIN patients received contrast volumes larger than 200 mL. This finding is in line with research that indicates higher doses of contrast media are more likely to result in nephropathy, especially in susceptible individuals with impaired renal function. The risk of CIN must be reduced by careful contrast volume management, particularly in high-risk patients.

Eighteen individuals experienced CIN despite the adoption of preventative measures such pre-procedural hydration and the use of low-osmolar contrast agents. Of them, only 22.22% (n = 4) had been sufficiently hydrated prior to PCI, suggesting that more stringent hydration regimens could be required to reduce the risk of CIN. As hydration is thought to be the main preventive measure against contrast-induced kidney damage, the results imply that inadequate hydration may be a factor in the development of CIN.

This study suggests that the efficacy of adjuvant medications, such as statins and N-acetylcysteine, in avoiding CIN may be limited. Statins and N-acetylcysteine were given to two of the three patients who acquired CIN, but no treatment was able to stop the nephropathy in these patients. While these medicines are widely regarded as part of CIN preventive measures, the data from this study indicate that their effectiveness may be limited, especially in high-risk individuals with other predisposing factors such as diabetes and renal impairment.

The study's overall conclusions emphasize the complex nature of CIN formation, especially in high-risk patients having primary PCI. According to the research, nephritis in patients with pre-existing risk factors can still occur even when current preventive treatments including hydration, low-osmolar contrast agents, and pharmaceutical interventions may lower the incidence of CIN. This emphasizes the necessity of specialized preventive measures that target certain patient vulnerabilities, such as more stringent hydration guidelines and careful monitoring of contrast volume consumption during PCI.

Table 1

Risk Factors in Patients with CIN

Risk Factor	Number of Patients with CIN (n = 18)	Percentage
Diabetes	12	66.67%
Pre-existing Renal Impairment	10	55.56%
Hemodynamic Instability	6	33.33%

Figure 1

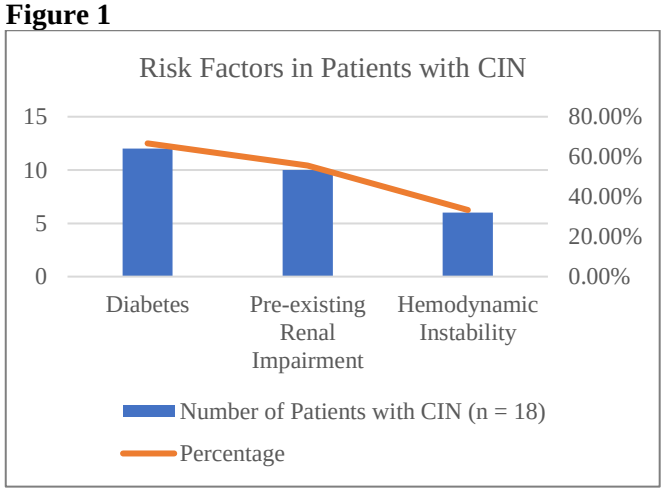

Table 1 presents the various risk factors associated with the development of CIN in the patient population, giving context to the prevalence of each risk factor within both the CIN group and the total cohort.

Table 2

Contrast Volume Administered

Contrast Volume	Number of Patients with CIN (n = 18)	Percentage
> 200 mL	14	77.78%
≤ 200 mL	4	22.22%

Figure 2

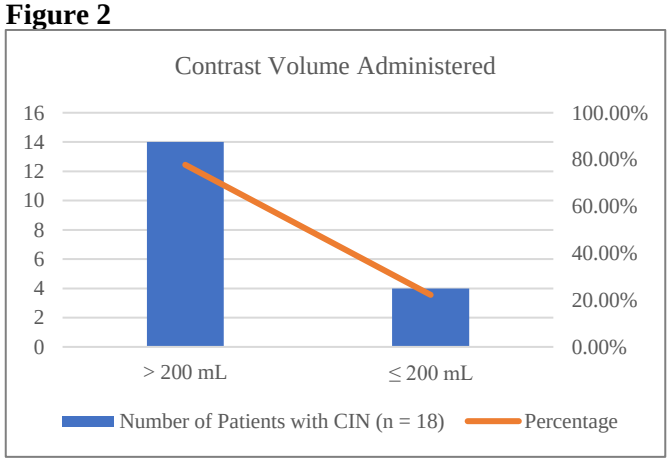

Table 2 details the volume of contrast media used during the PCI procedures, emphasizing the correlation between higher volumes and the incidence of CIN.

Table 3

Preventive Measures in Patients with CIN

Preventive Measure	Number of Patients with CIN (n = 18)	Percentage
Adequate Hydration	4	22.22%
Statin Use	3	16.67%
N-acetylcysteine Use	2	11.11%

Figure 3

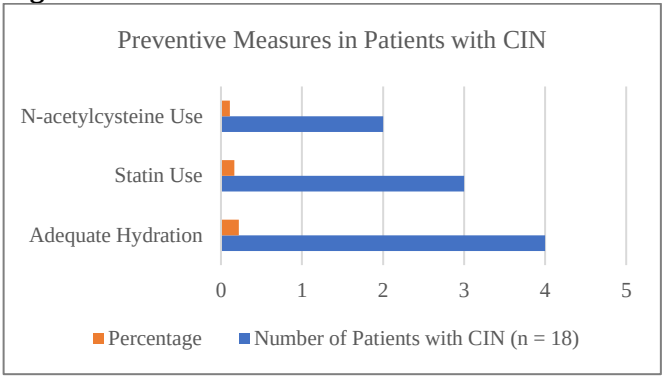

Table 3 outlines the preventive measures taken for patients who developed CIN, providing insight into the implementation and effectiveness of these strategies.

CONCLUSION

The study concludes by highlighting the alarmingly high incidence rate of 15% for contrast-induced nephropathy (CIN) in patients after primary percutaneous coronary intervention (PCI). The results highlight how important pre-existing risk factors are in predicting CIN, especially diabetes and renal impairment. In particular, patients with diabetes accounted for 66.67% of CIN instances, supporting the body of research showing diabetes to be a major risk factor for kidney problems. The study also discovered that 55.56% of CIN patients already had renal impairment, highlighting the importance of carefully evaluating renal function before PCI.

A significant predictor of CIN risk was the amount of contrast media given; 77.78% of afflicted individuals received more than 200 mL. This implies that, to reduce renal stress during procedures, careful evaluation of contrast volume is essential, especially in high-risk people. Furthermore, a mere 22.22% of patients obtained sufficient hydration before the surgery, suggesting a deficiency in preventive measures that must be addressed in clinical practice.

The frequency of CIN persisted despite efforts to put preventive measures in place, such as the use of low-osmolar contrast agents and hydration regimens. This necessitates a more comprehensive strategy for prevention, which can involve using different contrast agents or procedures in high-risk individuals as well as greater adherence to hydration standards. In the end, the study's conclusions support proactive management of CIN risk factors and increased awareness of them in patients receiving primary PCI, since this may improve patient outcomes, minimize morbidity, and save medical expenses related to renal problems. Healthcare professionals can improve patient safety and the general standard of care in cardiovascular treatments by concentrating on these crucial areas.

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