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Renal Function Alterations Following Contrast Media Exposure: A Clinical Analysis

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Abstract **Original Research Article**

Introduction: Contrast-Induced Nephropathy (CIN) typically occurs within 24 to 72 hours after contrast media exposure, potentially leading to serious complications. The purpose of the study was to clinically analyze renal function changes following contrast media exposure and explore strategies for prevention and management. ***Aim of the study:*** The aim of the study was to clinically analyze renal function alterations following contrast media exposure. ***Methods:*** This prospective observational study included 140 patients who underwent imaging procedures with contrast media at the Department of Nephrology, Colonel Maleque Medical College, Manikganj, Bangladesh, from January 1, 2019, to December 31, 2023. Patients aged 18 years and above, with no pre-existing severe renal impairment, were included. Data on serum creatinine, risk factors such as diabetes and hypertension, and renal function outcomes were collected and analyzed using SPSS version 22.0. ***Result:*** The majority of patients (42.86%) were aged 57–61 years, with 64.29% being male. Post-contrast serum creatinine were less than 80 µmol/L in 50.00% of patients and 14.29% developed contrast-induced nephropathy (CIN). Diabetes mellitus was significantly more prevalent among CIN patients, occurring in 60.00% compared to 19.16% in non-CIN patients. Among those with CIN, 65% achieved renal function recovery within 7 days. ***Conclusion:*** Exposure to contrast media can significantly alter renal function. Incidence of contrast-induced nephropathy was 14.29%. Higher risk in patients with pre-existing conditions and favorable short-term recovery, though some may experience persistent renal dysfunction.

Keywords: Contrast-Induced Nephropathy, Acute Kidney Injury, Renal Function, Contrast Media Exposure, Clinical Outcomes.

INTRODUCTION

Renal function can be significantly impacted by iodinated radiographic contrast media, especially in patients with preexisting conditions like renal impairment or diabetes. The spectrum of this impact ranges from mild increases in serum creatinine to severe acute renal failure (ARF) with anuria [1]. Contrast-Induced Nephropathy (CIN) also referred to as contrast-induced Acute Kidney Injury (AKI). Typically manifests within 24 to 72 hours after intravascular injection of contrast media, without any other identifiable cause [2]. The incidence of Contrast-Associated Acute Kidney Injury (CA-AKI) varies, affecting 1% to 3% of patients undergoing elective percutaneous coronary intervention (PCI) [3] and rising to 10% to 16% in patients with acute coronary syndrome [4,5]. Most of the cases of CIN are reversible may lead to significant consequences, including prolonged hospitalization, increased morbidity and higher mortality rates [6,7]. Certain risk factors, such as diabetes, sepsis, anemia, hypotension, and the use of nephrotoxic agents are associated with an elevated risk of contrast-induced nephrotoxicity [8-10].

CA-AKI is a leading cause of hospital-acquired renal failure, with most cases presenting as transient impairments in renal function, which typically recover within 3 to 5 days [11]. However, in some patients, renal function fails to recover fully, leading to chronic kidney disease (CKD), in severe instances necessitating dialysis [12]. The mortality rate is particularly high in cases of AKI characterized by oliguria (urine output <400 mL/24 hrs) [13]. The clinical presentation and management of contrast-induced AKI closely resemble AKI caused by other factors, emphasizing the importance of vigilant monitoring and management [14]. Patients with preexisting AKI are more vulnerable to contrast mediated nephrotoxicity. Physicians must be more carefully in septic patients for doing diagnostic contrast imaging with the risk of further renal deterioration.

Despite advancements in preventive measures, the optimal management of patients at risk for CIN remains an ongoing challenge in clinical practice. Therefore, the aim of this study was to clinically analyze renal function alterations following contrast media exposure, focusing on identifying the extent of renal impairment and evaluating potential strategies for prevention and management.

Objectives

- The aim of the study was to clinically analyze renal function alterations before and after contrast media exposure.

METHODOLOGY & MATERIALS

The prospective observational study was conducted at the Department of Nephrology, Colonel Maleque Medical College, Manikganj, Bangladesh, from January 1, 2019, to December 31, 2023. The study involved 140 patients who underwent imaging procedures with contrast media during this period.

Inclusion Criteria:

- Adults aged 18 years and above.
- Patients who underwent imaging procedures with contrast media.

Exclusion Criteria:

- Patients with pre-existing severe renal impairment (e.g., End-Stage Renal Disease).
- Patients with known allergies to contrast media.
- Pregnant or lactating women.

Informed consent was obtained from all participants, ensuring confidentiality and voluntary participation. Baseline evaluations involved measuring serum creatinine 24 hours before contrast media administration and post-contrast evaluations conducted 48-72 hours after exposure. The contrast media used varied according to the imaging procedure and clinical requirements, adhering to standard protocols. Renal function was assessed by comparing baseline and post-contrast serum creatinine levels. Contrast-induced nephropathy (CIN) defined as an increase in serum creatinine of ≥0.3 mg/dL or ≥25% from baseline. Risk factors for CIN, including diabetes mellitus, hypertension, pre-existing chronic kidney disease (CKD) were evaluated through medical history reviews. Data were collected and analyzed using SPSS version 22.0. Paired t-tests for comparing baseline and post-contrast serum creatinine levels and chi-square tests to evaluate associations between risk factors and CIN. p-values < 0.05 considered statistically significant. The study was approved by the Institutional Review Board (IRB) of Colonel Maleque Medical College, ensuring ethical considerations with maintained patient confidentiality. Primary outcomes included changes in serum creatinine, incidence of CIN and renal function recovery within 7 days among CIN patients. Secondary outcomes assessed risk factors and long-term renal function outcomes.

RESULT

Table 1: Demographic Characteristics of the Study Patients (n=140)

Variables		No of patients	Percentage (%)
Age (in years)	37–46	10	7.14
	47–56	30	21.43
	57–61	60	42.86
	62–71	30	21.43
	72–75 years	10	7.14
Gender	Male	90	64.29
	Female	50	35.71
Pre-existing Chronic Kidney Disease (CKD)	Yes	76	54.29
	No	64	45.71

The age distribution of the patients indicated that a significant portion 60 (42.86%) were aged 57–61 years. The next largest group 30 (21.43%) were between 47–56 years old, 30 patients (21.43%) in the 62–71 years category. There were fewer patients in the 37–46 years 10 (7.14%) and 72–75 years 10 (7.14%) age groups. Gender distribution showed a male predominance with 90 (64.29%) and 50 (35.71%) females. Additionally, 76 (54.29%) patients had pre-existing chronic kidney disease (CKD), while 64 (45.71%) patients did not.

Table 2: Baseline and Post-Contrast Renal Function Parameters (n=140)

Variable		No of patients	Percentage (%)
Baseline Serum Creatinine (µmol/L)	< 70	56	40.00
	70–110	42	30.00
	> 110	42	30.00
Post-Contrast Serum Creatinine (µmol/L)	< 80	70	50.00
	80–120	49	35.00
	> 120	21	15.00

The baseline serum creatinine showed that 56 (40.00%) patients had below 70 µmol/L, indicating relatively normal renal function. Serum creatinine between 70–110 µmol/L were observed in 42 (30.00%) patients, and above 110 µmol/L were found in another 42 (30.00%) patients. Post-contrast serum creatinine were less than 80 µmol/L in 70 (50.00%) patients, suggesting a moderate effect on renal function. Between 80–120 µmol/L were recorded in 49 (35.00%) patients, while 21 (15.00%) patients had exceeding 120 µmol/L, indicating more significant renal impairment.

Table 3: Incidence of Contrast-Induced Nephropathy (CIN) Among Study Patients (n=140)

Variables	No of patients	Percentage (%)
Patients with CIN	20	14.29
Patients without CIN	120	85.71

Out of 140 patients, 20 (14.29%) developed CIN, indicating a proportion of patients who experienced kidney function deterioration post-contrast. The majority, 120 (85.71%) patients did not exhibit signs of CIN. Showing that most patients did not suffer from contrast-related renal dysfunction.

Table 4: Risk Factors Associated with Contrast-Induced Nephropathy (CIN) Compared to Non-CIN Patients

Risk Factor	Patients with CIN		Patients without CIN		P value
	(n=20)	percentage (%)	(n=120)	percentage (%)	
Diabetes Mellitus	12	60.00	23	19.16	<0.001
Hypertension	10	50.00	33	27.50	0.010
Pre-existing CKD	12	60.00	64	53.34	0.030

This table presents an analysis of common risk factors for CIN in patients with and without CIN. Diabetes mellitus was significantly more common among patients with CIN, with 12 (60.00%) having diabetes compared to 23 (19.16%) in the non-CIN group ($p < 0.001$). Hypertension was present in 10 (50.00%) CIN patients versus 33 (27.50%) in the non-CIN group ($p = 0.010$). Pre-existing chronic kidney disease (CKD) was found in 12 (60.00%) patients with CIN, compared to 64 (53.34%) in those without CIN ($p = 0.030$). IN CIN group most of the patients had both hypertensin and diabetes mellitus.

Table 5: Outcomes Based on Renal Function Recovery Following Contrast Media Exposure (n=20)

Outcome	Patients with CIN (n = 20)	Percentage (%)
Recovered Renal Function (within 7 days)	13	65.00
Persistent Renal Dysfunction	7	35.00

This table details the outcomes of renal function recovery among patients who developed contrast-induced nephropathy (CIN). Of the 20 patients with CIN 13 (65.00%) achieved recovery of renal function within 7 days, indicating a favorable short-term outcome. However, 7 (35.00%) patients experienced persistent renal dysfunction, demonstrating a less favorable outcome.

DISCUSSION

The results of this study highlight the critical issue of contrast-induced nephropathy (CIN), revealing its prevalence and impact on renal function. The data shows a diverse range of responses to contrast media, from mild, transient changes to significant renal impairment. These findings underscore the necessity of understanding the underlying risk factors, such as diabetes, hypertension, and pre-existing chronic kidney disease (CKD), which exacerbate the risk of CIN. By examining these variables, this study contributes to the ongoing discourse on effective management strategies and preventive measures to safeguard renal function in patients undergoing procedures involving contrast media.

In our study, the age distribution revealed that the largest portion of patients, 60 (42.86%), were aged between 57–61 years, with additional significant representation in the 47–56 years (21.43%) and 62–71 years (21.43%) age group population. This is similar to findings by Guevara *et al.*, [15]. Where the average patient age was 59 years, within a range of 37–75 years. We observed a male predominance, with 64.29% of our patients being male, which aligns with Guevara *et al.*,'s study reported a higher male-to-female ratio. Moreover, 54.29% of our patients had pre-existing chronic kidney disease (CKD), a finding comparable to Buckenmayer *et al.*, [16], who reported CKD present in more than half (54.3%) of their study population prior to hospital admission.

In our study, baseline serum creatinine (SCr) showed that 40% of patients had values below 70 µmol/L, indicating relatively normal renal function, while 30% had SCr between 70–110 µmol/L, and another 30% had above 110 µmol/L. Post-contrast serum creatinine revealed that 50% of patients maintained

values below 80 µmol/L, suggesting only a moderate impact on renal function, whereas 35% had between 80–120 µmol/L, and 15% exceeded 120 µmol/L, reflecting more significant renal impairment. These findings are consistent with Niemantsverdriet *et al.*, [17], who also reported that patients with elevated baseline SCr were at greater risk for renal dysfunction following contrast media exposure. This reinforces the importance of pre-contrast SCr as a crucial predictor of post-contrast renal outcomes, especially in patients with pre-existing renal impairment. Similar to larger studies on post-contrast renal dysfunction, our findings highlight the clinical importance of closely monitoring SCr before and after contrast media administration to mitigate potential risks.

In our study, 14.29% of patients developed Contrast-Induced Nephropathy (CIN), indicating that a subset of the cohort experienced kidney function deterioration following contrast media exposure. Conversely, 85.71% of patients did not show signs of CIN, suggesting that most did not suffer from contrast-related renal dysfunction. These results are consistent with the findings of Jones *et al.*, [18], who also reported that 80% of their patient population did not exhibit CIN, highlighting that a majority of patients generally remain unaffected by contrast-induced renal impairment.

In our study of risk factors associated with Contrast-Induced Nephropathy (CIN), diabetes mellitus, hypertension, and pre-existing chronic kidney disease (CKD) were identified as significant predictors. Most of the patients had both diabetes mellitus and hypertension in CIN group. Specifically, 60.00% of patients with CIN had diabetes, compared to 19.16% in those without CIN ($p < 0.001$). Hypertension was present in 50.00% of CIN patients, versus 27.50% in the non-CIN group ($p = 0.010$). Additionally, 60.00% of CIN patients had pre-existing CKD, compared to 53.34% in the non-CIN group ($p = 0.030$). These findings align with other studies that have highlighted diabetes mellitus and hypertension as significant risk factors for CIN, [19-21] reinforcing their role in increasing susceptibility to contrast-induced renal impairment. Among all our study patients, these risk factors coexisted and interacted with one another, suggesting that their combined presence may further increase the risk of developing CIN.

Our study found that 65.00% of patients with contrast-induced nephropathy (CIN) experienced recovery of renal function within 7 days, while 35.00% showed persistent renal dysfunction. This aligns closely with findings from studies like Goto *et al.*, [21], where 66% of patients recovered within a similar time frame and 34% faced ongoing renal impairment. These outcomes highlight the variability in renal recovery post-contrast media exposure and emphasize the importance of early detection and intervention for patients at risk of prolonged renal dysfunction.

These findings emphasize the importance of early identification of at-risk patients and close monitoring of renal function to minimize the adverse effects of contrast media. Continued research and preventive strategies are essential to improve outcomes for patients vulnerable to contrast-induced nephropathy.

CONCLUSION

Based on the findings of this study, incidence of contrast-induced nephropathy (CIN) is 14.29%. Early detection and proper management of CIN can recover normal renal function 65% of patients within seven days. Patients with pre-existing conditions such as diabetes mellitus, hypertension, and chronic kidney disease (CKD) were at higher risk of developing CIN. Diabetes being the most significant risk factor. However, 35% of CIN patients experienced persistent renal dysfunction. Careful monitoring and individualized risk assessment when administering contrast media, particularly in high-risk populations.

Limitations of the study

This study had several limitations:

- Small sample size may limit the generalizability of the findings.
- Single-center study might introduce bias in the results.
- The study's limited geographic scope may introduce sample bias, potentially affecting the broader applicability of the findings.

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