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Original Research Article

Predictors and Consequenses of Contrast Induced Nephropathy in Northeast Nigeria: A Call for Caution in Iodinated Contrast Procedures

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Abstract: Contrast-induced nephropathy (CIN) remains a significant clinical concern worldwide, recognized as the third leading cause of acute kidney injury (AKI) in developed countries. Defined as an acute increase in serum creatinine greater than 0.5 mg/dL above baseline or a 25% rise within 48 to 72 hours following contrast media (CM) administration, CIN's prevalence and patterns vary across different settings. The advent of novel kidney biomarkers, such as serum cystatin C, has enhanced the detection of contrast-related AKI, yet limited data exist from regions like Northeast Nigeria. This study aimed to evaluate the predictors, clinical patterns, and short-term renal outcomes of CIN using both serum cystatin C and creatinine among patients undergoing contrast procedures at the University of Maiduguri Teaching Hospital (UMTH). ***Methods*:** A prospective cohort study was conducted involving 150 consenting adult patients (aged ≥18 years) referred for contrast-enhanced investigations at UMTH. Sociodemographic data were collected, and blood samples analyzed for serum cystatin C and creatinine levels. Estimated glomerular filtration rate (eGFR) was calculated using CKD-EPI equations. CIN was diagnosed based on established criteria, and the prevalence, risk factors, and outcomes were assessed. Statistical significance was set at $p<0.05$. ***Results*:** The prevalence of CIN was 30% (45 patients) when assessed via serum creatinine at 48 hours, and 49.3% (74 patients) using serum cystatin C at 24 hours. Significant predictors of CIN included advancing age (OR=1.346, P=0.009), higher contrast volume (OR=2.037, P=0.001), elevated baseline serum creatinine (OR=1.601, P=0.006), and reduced baseline eGFR (OR=1.767, P=0.003). The diagnostic performance of cystatin C demonstrated sensitivities of 53.3% at 24 hours, increasing to 68% at 48 hours, but it was not more sensitive or specific than serum creatinine. Among patients with CIN, 73.3% experienced complete renal recovery within two weeks, while 27% had persistent renal dysfunction, with some requiring dialysis or being lost to follow-up. Notably, some patients with persistent dysfunction recovered renal function within three months, although a small proportion remained on dialysis. ***Conclusion*:** The study highlights a high prevalence of CIN at UMTH, emphasizing the need for caution during iodinated contrast procedures. Key predictors include age, contrast volume, baseline renal function, and serum cystatin C levels. The findings underscore the importance of risk stratification and vigilant monitoring to prevent adverse renal outcomes. Further efforts are warranted to develop preventive strategies and promote safer contrast use in this region.

Keywords: Contrast-Induced Nephropathy, Acute Kidney Injury, Cystatin C, Creatinine, Predictors, Renal Outcomes.

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INTRODUCTION

Contrast-induced nephropathy (CIN) is a significant clinical concern characterized by an acute elevation of serum creatinine greater than 0.5 mg/dL above baseline or an increase of serum creatinine exceeding 25% within 48 to 72 hours following the administration of contrast media (CM) [1]. Although serum creatinine remains the standard diagnostic marker for CIN, it has notable limitations, as it typically does not rise immediately after contrast exposure, potentially delaying early detection of renal injury. In this context, cystatin C has emerged as a promising alternative biomarker due to its stability and ability to reflect renal function more reliably, often indicating renal impairment as early as 24 hours post-exposure [2].

Globally, CIN has become the third leading cause of hospital-acquired acute renal failure (ARF), particularly in developed countries, where it accounts for approximately 12% of such cases [3]. Despite the advent of lower-toxicity contrast agents, the risk of CIN persists, especially among patients with pre-existing renal insufficiency, diabetes mellitus, or those exposed to nephrotoxic agents. While many cases of CIN are benign, its development significantly increases morbidity and mortality, potentially leading to dialysis, prolonged hospitalization, and permanent kidney damage [4].

In Nigeria, the increasing utilization of radiological imaging and contrast media—ranging from low-osmolar to high-osmolar agents—raises concerns about a corresponding rise in CIN incidence and associated adverse outcomes [5]. Previous studies, such as one conducted by Okoye *et al*., in Benin, reported a notably high incidence of CIN at 35.9%, highlighting the need for localized data on prevalence and risk factors. Notably, not all patients exposed to contrast media develop CIN, suggesting that individual susceptibility factors may influence outcomes [6].

This study aims to determine the predictors and consequences of CIN in patients undergoing contrast procedures in Maiduguri, Nigeria. Targeting strategies to prevent CIN and mitigate its impact on patient health in our setting.

METHODOLOGY

This study was a prospective observational study of a cohort of patients referred for contrast imaging studies who met the inclusion criteria in UMTH. Ethical approval for the study was sought and obtained from UMTH Health Research Ethics Committee. Informed written consent was obtained from each patient and subjects made to append their signatures/thumb print on the consent form. Strict confidentiality was maintained throughout the course of this research. Investigations required for the study were carried out at no cost to the subjects. Subjects were allowed to opt out of the study without any consequence. Those who required interventions were referred to the nephrology clinic.

Sample Size Determination

The sample size was determined using the formula n =z2pq/d2.

Where:
n = the desired sample size (when population is greater than 10,000)
z = the standard normal deviate, set at 1.96 which corresponds to the 95 percent confidence level.
p = the proportion in the target population estimated to have CIN, which is 11% or 0.1117
q = 1- p
d = degree of accuracy desired, usually set at 0.05.
Substituting:
n = (1.96)2(0.11) (1-0.11)/(0.05)2 = 150.4
n = 150.4

Study Subjects

With an estimated attrition rate of 10% (lost to follow-up) and the estimated sample size of 150, the sample size of 160 out of the 165 subjects were recruited to increase the statistical power and factor-in attrition.

Inclusion Criteria for Study Subjects

- All patients undergoing contrast studies in Radiology Department of UMTH.
- Age >18 years who consented.

Exclusion Criteria for Study Subjects

- Age <18 years
- Failure to obtain consent from subjects/refusal of subjects to participate in the study
- Subjects with documented end stage renal disease or on maintenance haemodialysis
- Patients in any shock state or severe debilitation
- Subjects who have uncontrolled hyperthyroidism/ thyroid malignancies
- Subjects in heart failure New York Heart Association class III and IV
- Exposure to contrast in the last 24-48hours
- Nursing/pregnant subjects.
- History of hypersensitivity to contrast in the past
- Post renal transplant recipient

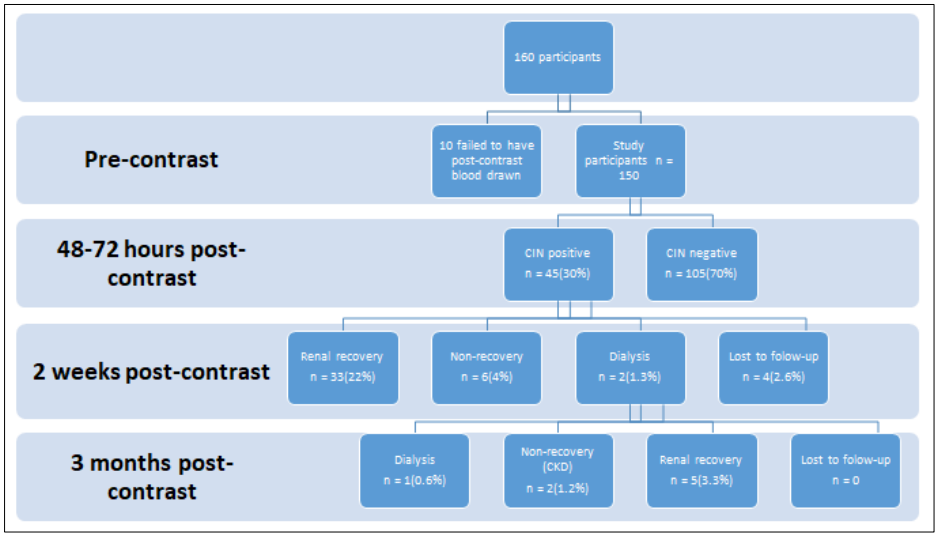
Sampling Technique

Consecutive patients who met the inclusion criteria were enrolled as they presented to the radiology department for imaging requiring the use of CM. One hundred and sixty subjects were enrolled for the study. Of these subjects, we posited that some may develop CIN, while others will not. Analysis was done comparing those who developed CIN with those who did not. All subjects who developed AKI (defined as serum creatinine elevation of 25% above baseline or absolute rise of 44.2µmol/l within 48 or 72 hours or rise in cystatin

C of 10% from baseline) were compared with subjects who were subjected to CM and did not develop CIN. Also, of those who developed AKI, those who had early elevation of cystatin C were also compared to those who did not.

Characteristics of Participants

A total of 160 subjects who satisfied the inclusion criteria were enrolled into the study. These subjects presented to the Radiology Department for various radiological investigations requiring the use of CM.



Sociodemographic Characteristics

The mean age of the study population was 49.20 ± 15.44 years, with a range of 23 to 75 years. The age group 50-59 years accounted for the highest percentage of subjects at 33.3% (50 subjects) while that of 60-69 years accounted for 20.7% (31 subjects) of the study subjects. Only 6 subjects in the age-range of 18-29 years were enrolled in the study.

Ninety-two (61.3%) subjects were male while 58 (38.7%) were female, with a male to female ratio of 1.58:1.

Most of the study subjects had tertiary education 67(44.6%), 22 subjects (14.7%) had secondary education, 40 subjects (26.7%) had no formal education, while 22 (14.7%) and 21 (14%) subjects had secondary and Islamic education respectively.

Subjects of Kanuri ethnicity accounted for the majority of participants (32.0% of the study subjects). Babur is the second majority (15.3) then followed by Hausa/Fulani (11.3%), Marghi (18%) and Shuwa (6%). Yoruba and Igbo constituted the least participants at 6% each. Other minority tribes accounted for 20% of the study subjects, including Igala, Tiv, Idoma, Nupe, Jaba, Egbira, and others.

The majority of the subjects were married accounting for 74.7% of the study subjects, 12% were widowed, 10.7% single and 2% separated. (Table 1)

Table 1: Socio-demographic Characteristics of Study Participants

Variable	Number of subjects (%)	Mean age ± SD (years)
Sex		
Male	92(61.3)	55.5 ± 10.7
Female	58 (38.7)	45.5 ± 13.3
Age Group (years)		
18-29	9(6.0)	
30-39	22 (14.7)	
40-49	27 (18.0)	
50-59	50(33.3)	
60-69	31(20.7)	
70-79	11(7.3)	
Marital Status		
Single	16 (10.7)	
Married	112 (74.7)	
Separated/Divorced	3 (2.0)	
Widowed	19 (12.7)	

Ethnicity		
Kanuri Babur Marghi Shuwa	48 (32.0) 23(15.3) 18 (12.0) 9(6.0)	
Hausa/Fulani	17(11.3)	
Igbo Yoruba	6 (4.0) 6 (4.0)	
Others	20 (13.3)	
Educational Status		
None Secondary Tertiary	40 (26.7) 22(14.7) 67(44.6)	
Islamic	21 (14.0)	

Independent Predictors of CIN

The independent predictors for the development of CIN after exposure to CM included the following: advancing age (p=0.019), high volume of contrast (p=0.001), high creatinine at baseline (p=0.006), and low eGFR at baseline (p=0.003) (table 2).

Table 2: Independent predictors for CIN

Risk factor	P Value	OR	CI (95%)
Advancing Age	0.009	1.346	1.006 – 2.990
High Volume of contrast	0.001	2.037	1.015 – 9.060
High Creatinine at baseline	0.006	1.601	1.043 – 6.010
Low eGFR at baseline	0.003	1.767	1.510– 7.980
Cystatin C at baseline	0.002	1.052	1.012- 1.053

Abbreviations: OR (odds ratio), eGFR (estimated glomerular filtration rate), CI (confidence interval)

Consequences of CIN

Forty-five subjects developed CIN after exposure to CM. Of these, 33 had serum creatinine value return to baseline, 6 subjects had non recovery of renal function, two subjects were on haemodialysis. Four subjects were lost to follow up.

At three months post exposure to ICAs, one subject was still having twice weekly haemodialysis, five out of the six subjects (who had non-renal recovery at 2 weeks post-contrast) (Table 3) had their serum creatinine return to baseline. Two of the subjects had persistent renal non-recovery but had not commenced renal replacement therapy. (Table 4)

Table 3: Consequence at 2 weeks post-CIN

Category of outcome	Number of subjects (%)
Renal recovery	33(73.3)
Non-recovery	6(13.3)
Renal replacement Lost to follow-up	2(4.6) 4(8.8)
Death	0(0.0)
Total	45(100)

Abbreviation: CIN (contrast induced nephropathy)

Table 4: Consequence at 3 Months Post-CIN

Category of outcome	Number of subjects(%)
Renal recovery	38(84.4)
Non-recovery	2(4.4)
Renal replacement Lost to follow up	1(2.2) 4(8.8)
Death	0(0.0)
Total	45(100)

Abbreviation: CIN (contrast induced nephropathy)

DISCUSSIONS

This is a prospective study carried out at the University of Maiduguri Teaching Hospital, aimed at determining the predictors and consequences of CIN at 2 weeks and 3 months. This study applied multiple regression statistics to identify independent risk factors

associated with CIN. The univariate variables assessed are age, volume of contrast administered, serum creatinine at baseline and eGFR at baseline as co-founding risk factors. Volume of contrast is found to be most predictive of CIN with OR:1.037; 95%CI: 1.015-1,060 and P=0.001 and this was followed by eGFR with OR:1.067; 95%CI:0.910-0.980 and P= 0.003, serum creatinine at baseline with OR:1.085; 95%CI: 0.942-0.990 and P= 0.006, Cystatin C at base line was equally a significant risk factor with OR of 1.052; 95%CI: 1.012-1.053 and P=0.002 and finally age was a strong predictive risk factor for CIN in this study with OR:1.006; 95% CI: 0.896-0.990 and P= 0.009. These findings are similar to the results from the study by Okoye *et al*., [6], where eGFR <60ml/min/1.73m2, age ≥55years and baseline serum creatinine value >1.5µmol/l significantly predicted the development of CIN. Thus, eGFR, age and high baseline level of serum creatinine were independent predictors of CIN. Evola *et al*., [45], showed that age and eGFR were independent predictors for development of CIN among Italian patients. The mean age of the group that developed contrast induced nephropathy was higher than the group that did not, also, a significant number of study subjects with baseline chronic renal insufficiency (defined by eGFR <60ml/min/1.73m2) developed nephropathy. Although the study was carried out on patients undergoing percutaneous coronary intervention and not contrast enhanced imaging studies, their results are similar to those obtained in this study. Banda *et al*., [54], also demonstrated age as significant independent risk factor for the development of CIN. Sany *et al*., [50], in a study among type II diabetics in Egypt showed that the risk of CIN was inversely proportional to the eGFR. The estimated glomerular filtration rate of <60ml/min/1.73m2 was independently associated with the development of CIN. In a similar study by Kashif *et al*., [54], involving patients undergoing non-emergent cardiac catheterization, low eGFR was found to be an independent predictor for CIN. A study among hospitalized Israeli patients undergoing contrast enhanced imaging studies by Shema *et al*., [52], found that increasing age and renal insufficiency (defined as serum creatinine ≥1.2mg/dl) were associated with higher incidence of CIN, similar findings were observed in this study. The short-term renal outcome defined as normalisation of Scr or persisting of renal dysfunction was determined by following up patients with CIN for two weeks. When variables were entered into multinomial logistic regression analysis, none of them was found to predict the outcome of CIN. Banda *et al*., [54], showed that there is a three-fold risk of death in anaemic patients who developed CIN. In a study by Kim *et al*., [39], eGFR <30ml/min/1.73m2 was shown to increase the risk of renal replacement therapy in subjects with CIN. Wi *et al*., [56], looked at the one-month outcome of patients who developed CIN after percutaneous coronary intervention and compared characteristics of those that recovered and those that did not. Hypertension was more common in patients who had persistent renal dysfunction and these patients had higher mortality and dialysis rates.50In this study, none of the variables had predictive power to determine the short-term outcome of CIN, this may be related to the small number of subjects that were studied for outcome.

This prospective study was conducted at the University of Maiduguri Teaching Hospital to assess the prevalence, determinants, and consequences of contrast-induced nephropathy (CIN) at two weeks and three months post-exposure. The research employed multiple regression analysis to identify independent risk factors associated with CIN. The univariate variables examined included age, contrast volume administered, baseline serum creatinine, and baseline estimated glomerular filtration rate (eGFR), which were considered potential confounders.

The findings indicated that the volume of contrast administered was the most significant predictor of CIN, with an odds ratio (OR) of 1.037 (95% confidence interval [CI]: 1.015–1.060; P=0.001). Following this, eGFR was also a significant factor, with an OR of 1.067 (95% CI: 0.910–0.980; P=0.003). Baseline serum creatinine was another important predictor, with an OR of 1.085 (95% CI: 0.942–0.990; P=0.006). Additionally, baseline cystatin C levels were significantly associated with CIN, with an OR of 1.052 (95% CI: 1.012–1.053; P=0.002). Age was also identified as a strong predictive factor, with an OR of 1.006 (95% CI: 0.896–0.990; P=0.009).

These results align with previous studies, such as those by Okoye *et al*., [6], which found that eGFR below 60 ml/min/1.73 m², age 55 years or older, and baseline serum creatinine above 1.5 µmol/l significantly predicted CIN development. Similarly, Evola *et al*., [44]. reported that age and eGFR were independent predictors among Italian patients undergoing contrast procedures, noting that patients with baseline chronic renal insufficiency and higher age were more prone to nephropathy. Although their study focused on patients undergoing percutaneous coronary interventions rather than contrast-enhanced imaging, the findings are comparable.

Other studies, such as Banda *et al*., [54], also identified age as an independent risk factor for CIN. Research by Sany *et al*., among type II diabetics in Egypt demonstrated that lower eGFR was associated with increased CIN risk, with eGFR below 60 ml/min/1.73 m² being an independent predictor. Kashif *et al*., [51]. Found similar results in patients undergoing cardiac catheterization, where reduced eGFR increased CIN risk. Shema *et al*., [52]. In Israel observed that older age and renal insufficiency (serum creatinine ≥1.2 mg/dl) correlated with higher CIN incidence, consistent with this study's findings.

Regarding short-term renal outcomes, defined as normalization of serum creatinine or persistent renal dysfunction over two weeks, the analysis did not identify any variables as predictors of outcome. This may be due to the limited sample size. Banda *et al*., [54]. Reported a threefold increased risk of death among anemic patients who developed CIN. Kim *et al*., [45]. Found that an eGFR below 30 ml/min/1.73 m² increased the likelihood of requiring renal replacement therapy in CIN patients. Wi *et al*., [56]. Examined one-month outcomes post-percutaneous coronary intervention, noting that hypertension was more common among patients with persistent renal dysfunction, who also experienced higher mortality and dialysis rates. In this study, none of the variables studied predicted short-term CIN outcomes, possibly due to the small number of subjects evaluated for this purpose.

The study further demonstrated that a significant majority of participants who developed contrast-induced nephropathy (CIN)—approximately 84.4%—experienced complete renal recovery within the study period. In contrast, a small proportion of individuals (6.6%) showed persistent renal dysfunction beyond the three-month follow-up mark. According to the Kidney Disease Outcomes Quality Initiative (KDOQI) guidelines, this duration of kidney impairment meets the criteria for a diagnosis of chronic kidney disease (CKD), indicating a potential progression from acute kidney injury to a chronic condition. These findings underscore the importance of long-term monitoring in patients who do not exhibit timely renal recovery following CIN.

CONCLUSION

The following conclusions could be deduced from this study: The development of CIN in the studied individuals is enhanced by these major risk factors: advancing age, volume of contrast administered, high baseline serum creatinine, Cystatin C at baseline and a low eGFR at baseline. This study also revealed that majority (84.4%) of subjects who developed CIN had full recovery and minority (6.6%) who did not have renal recovery required follow up beyond three months of the study period suggesting the development of chronic kidney disease (CKD) by KDOQI definition of CKD.

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