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Contrast Induced Nephropathy Risk Prediction Assessment: Usefulness among Africans Undergoing Intravenous Contrast Procedures

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Authors' contributions

This work was carried out in collaboration between all authors. Author OO designed the study, performed the statistical analysis, wrote the protocol, and wrote the first draft of the manuscript. Authors EO and LO edited the manuscript. Author EU managed the data presentation. All authors read and approved the final manuscript.

Original Research Article

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ABSTRACT

Aims: To validate the CIN predictive risk score developed by Mehran et al in the study population.
Study Design: This is a hospital-based prospective observational study.
Place and Duration of Study: Department of Medicine and Department of Radiology, University of Benin Teaching Hospital, Edo State, Nigeria. September 2009 to March 2010.
Methodology: One hundred and forty-two (142) out of 180 patients undergoing intravenous contrast procedures completed the study. They were recruited consecutively over a 6-month period. Data on their sociodemographic characteristics and health status were collated. A modified version of Mehran's CIN risk prediction chart was included in the questionnaire. Venous blood and urine were collected for serum creatinine and biochemical estimations before contrast exposure and up to 72 hours post-exposure.
Results: The frequency of CIN was 35.9%. Majority of the patients studied had low risk

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scores. Although CIN (+) patients had higher total risk scores when compared to CIN (-) patients, it did not reach statistical significance (P=.600). Baseline renal insufficiency, anaemia and age >55 years were significant risk factors for CIN and predictive of CIN in univariate but not multivariate analysis.

Conclusion: The CIN predictive score by Mehran et al. did not sufficiently identify patients at risk for CIN in the population studied.

Keywords: Contrast-induced nephropathy; prediction score; risk factors.

ABBREVIATIONS

ARF	-	*Acute renal failure*
BMI	-	*Body mass index*
CCF	-	*Congestive cardiac failure*
CIN	-	*Contrast-induced nephropathy*
CIN(+)	-	*Contrast-induced nephropathy present*
CIN(-)	-	*Contrast-induced nephropathy absent*
CM	-	*Contrast media*
CT	-	*Computerised tomography*
EDTA	-	*Ethylene diaminetetraacetic acid*
ESRD	-	*End stage renal disease*
ESUR	-	*European Society of Urogenital Radiology.*
GFR	-	*Glomerular filtration rate*
HTN	-	*Hypertension*
IVU	-	*Intravenous urography*
JNC	-	*Joint national committee*
OR	-	*Odds ratio*
PCV	-	*Packed cell volume*
SD	-	*Standard deviation*
UBTH	-	*University of Benin Teaching Hospital*
WC	-	*Waist Circumference*
WHR	-	*Waist hip ratio*

1. INTRODUCTION

1.1 Frequency of Contrast Induced-Nephropathy (CIN)

The contrast media guidelines of the European Society of Urogenital Radiology (ESUR) defines CIN as impairment in renal function (an increase in serum creatinine by > 25% or 44.2μmol/L) within 3 days after intravascular administration of contrast medium, without an alternative aetiology [1]. However, the most commonly used definition in clinical trials is an increase in serum creatinine of 0.5 mg/dL (44.2μmol/L), or a 25% increase from the baseline value, assessed at 48 hours after the procedure [2].

The frequency of CIN is said to have decreased over the past decade from a general incidence of about 15% to 7% [3] owing to a greater awareness of the problem, better risk prevention measures and improved iodinated contrast media with less toxicity [4]. Although the incidence of CIN is low in patients with normal renal function, its prevalence can be much higher in several patient subsets e.g. diabetics, patients with existing renal insufficiency [2,5-

7]. The rate of CIN reported in studies that included patients with pre-existing renal dysfunction or diabetes mellitus in whom a standard hydration protocol was not administered is between 12% and 26% [2,8-11]. Lodhia et al. reported an incidence of 25% among patients with decompensated liver cirrhosis [7]. In patients with multiple risk markers, the incidence of CIN can rise to 50% or more [12].

Majority of existing data on CIN are from cardiac patients who receive intra-arterial contrast during interventional cardiology procedures. However, more recently, a study by Mitchell et al reported an incidence of 11% among outpatients receiving intravenous contrast during contrast enhanced CT [13]. This is the first prospective study reporting the incidence of CIN after contrast enhanced CT in an outpatient setting.

There is some evidence supporting a higher risk of CIN after intra-arterial compared with intravenous administration [14]. The heterogeneity between studies precludes direct comparisons [2] and since the route of administration of contrast is procedure-specific, there are no trials comparing routes of administration [2].It has been suggested that the renal effects of atheroemboli dislodged during arterial catheterization may contribute to the apparently higher incidence of CIN after arterial administration of CM [2].

1.2 Risk Factors for CIN

Risk factors for contrast-induced nephropathy (CIN) are related to patient characteristics and the contrast media used [1]. Large studies have also shown consistently that the risk of CIN increases with the number of risk markers. The most important patient specific risk factors are pre-existing renal insufficiency and diabetes [2,8,15,16].

Other risk factors are classified into modifiable and non-modifiable. The non-modifiable risk factors include: older age, advanced congestive cardiac failure (CCF), low left ventricular ejection fraction, acute myocardial Infarction, cardiogenic shock, vascular disease (cerebral, coronary, renal or peripheral), hyperthyroidism, multiple myeloma and renal transplant. The modifiable ones are: volume of contrast, hypotension, anaemia and blood loss, dehydration, low serum albumin level(<35g/l), use of drugs such as angiotensin converting enzyme (ACE) inhibitors, diuretics, non-steriodal anti-imflammatory drugs(NSAIDS), nephrotoxic antibiotics, use of intra aortic balloon pump (IABP) and sepsis [2,4,15,16].

A study reported that if baseline plasma creatinine level is ≤ 1.2mg/dl, the risk of CIN is only 2%; in patients with values of creatinine in the range of 1.4-1.9 mg/dl, the risk of CIN compared with that of the previous group increase fivefold (10.4%) 15. As for patients with serum creatinine level ≥2.0mg/dl, more than half of them (62%) subsequently developed CIN.

Okoye et al. [17] reported a higher frequency of CIN among patients aged >55 years, anaemic patients and those with baseline renal insufficiency.

The CIN Consensus Working Panel agreed that renal dysfunction is the most important risk marker for CIN and that from a practical perspective; renal dysfunction (with diabetes) is the most important factor to consider in predicting the risk of CIN [1].

1.3 Risk Prediction of CIN

Apart from the unfavorable combination of diabetes and renal insufficiency, the presence of two or more other risk factors of CIN also has additive influence on the rates of CIN [3]. The presence of multiple CIN risk factors in the same patient or high-risk clinical scenarios can create a very high risk for CIN (~50%) and acute renal failure (~15%) requiring dialysis after contrast exposure [4].

Mehran et al.[18]developed a simple scoring method to assess the cumulative risk of several variables on renal function. The study included 8,357 patients undergoing Percutaneous coronary interventions (PCI) who were recruited from a prospective interventional cardiology data base over 6 years. These patients were all prehydrated with normal saline however the volumes used were uniform in all patients and so some patients may still have been dehydrated as is obtained in patients with CVD. The overall incidence of CIN was 13.9%. A total of 18 variables were significantly associated with development of CIN; they included age >75years, female gender, hypertension, hyperlipidaemia, diabetes, peripheral vascular disease, previous stroke, CKD (serum creatinine>1.5mg/dl), advanced congestive cardiac failure, acute coronary syndrome at presentation and several angiographic and/ or procedural characteristics (multivessel disease, hypotension, IABP use, contrast media type and contrast volume >150mls).

Eight variables that were the strongest independent predictors of CIN (i.e. hypotension, IABP, CCF, CKD, diabetes, age>75 years, anaemia and volume of contrast) were assigned a weighted integer; the sum of the integers was a total risk score for each patient. The occurrence of CIN was found to be 7.5% and 57.3% for a low (≤5) and high (≤16) risk score respectively.

This assessment tool uses readily available information and is easily incorporated into routine clinical practice in the evaluation of patients who might undergo procedures involving contrast media. Unfortunately this scoring is specific for patients undergoing PCI. It could be adopted for patients undergoing other intravenous contrast procedures e.g. CT scan, however 2 variables i.e. use of IABP and variation in contrast volume have to be ignored, as was done in this study.

The aim of this study therefore, was to attempt to validate the CIN risk prediction score amongst African patients undergoing contrast CT and intra venous Urography.

2. MATERIALS AND METHODS

2.1Study Area

The study was conducted at the University of Benin Teaching Hospital (UBTH), a tertiary hospital in the South-South region of Nigeria, serving as the main referral hospital in Edo, Delta, Kogi, and Ondo states.

2.2 Study Population

The study population consisted of inpatients and outpatients aged 18years and above, who were referred to the UBTH Radiology Department for contrast-enhanced computer

tomography or intravenous urography (IVU). A total of 180 consenting subjects who met the inclusion criteria were recruited consecutively and studied.

2.3 Study Design

It was a prospective observational study spanning a period of 6 months, September 2009 to March 2010. Ethical clearance was obtained from the Ethics and Research committee of the hospital for the study.

2.4 Methodology

After obtaining informed consent from eligible patients or their relatives, information on their socio-demographic characteristics, clinical history, blood pressure (mmHg) and anthropometric measurements were collated. The CIN risk assessment sheet (Chart 1) was used to assign risk scores to the patients.

Chart 1. Mehran's CIN risk assessment score sheet

RISK ASSESSMENT SHEET

Risk Factor (Integer score)	PT.SCORE
• hypotension (5)	……..
• use of intra-aortic balloon pump (5)	…NA…….
• congestive cardiac failure (5)	……..
• serumcreatinine> 1.5mg/dl (4)	……..
• age>75years (4)	……..
• anaemia (3)	……..
• diabetes mellitus (3)	……..
• volume of contrast medium (1 per 100ml used)	…NA……..
• TOTAL SCORE (25)	……

NA= not applicable in this study

Venous blood was collected by venepuncture (before, 24, 48 and 72 hours after exposure to contrast) into lithium heparin bottles for serum electrolyte, urea and creatinine estimation. Creatinine estimation was done using the modified Jaffe's method [19]. Haematocrit readings were obtained using microhaematocrit reader (Hawksley micro-haematocrit reader).

Eighty milliliters of iopamidol, a low osmolar non-ionic iodinated CM was used for all patients who had CT scans while 50mls of diatrizoate (urograffin), a high osmolar CM was used for IVU.

2.4.1 Clinical definitions and criteria

The following definitions and criteriawere used to evaluate the physical and biochemical parameters

- CIN was regarded as elevation of serum creatinine by ≥25%, 24-72hrs after exposure to contrast.

- Hypertension(HTN) – reported history of HTN, HTN medication usage or repeated blood pressure reading of ≥ 140/90 mmHg as measured with a mercury sphygmomanometer, according to JNC VII guidelines [20].
- Hypotension – repeated systolic blood pressure reading of < 100mmHg.
- Cardiac failure was defined as self-report of diagnosis of CCF by a doctor or other health personnel.
- Diabetes was defined as self-report of diagnosis by a doctor or other health personnel, or use of oral glucose lowering agent/insulin.
- Obesity was regarded as BMI > 30kg/m^2, waist circumference > 102cm in males and 88cm in females (WHR > 0.7 in females and > 0.9 in males).
- Anaemia was regarded as PCV< 30% [21].
- Renal insufficiency was regarded as baseline serum creatinine of ≥ 1.5mg/dl or GFR<60mls/min.
- Abnormal serum urea was defined as serum urea concentration > 40mg/dl.

2.5 Data Analysis

Data entry and management were performed using SPSS statistical software package version 16 (SPSS, inc., Chicago, IL). The socio-demographic characteristics, health status and biochemical measurements (serum electrolytes, urea, creatinine, haematocrit) of the study population are presented as tables. Data are presented as mean ± SD for continuous variables and as frequency and percentages for categorical variables. The main statistical analysis involved the estimation of the incidence of CIN for the study population; the incidence rates of CIN according to age, sex and risk factors such as hypotension, anaemia, diabetes mellitus, renal impairment and hypoalbuminaemia were analysed and the association between CIN risk assessment scores and the presence of CIN. For nominal data, the Chi-square test was used to determine the difference between groups while for numerical data the Student t-test was used. All p value <.05 was regarded as significant and marked with asterix within tables for ease of recognition.

3. RESULTS

One hundred and eighty patients were recruited for the study, however blood samples for more than one day was obtained in 142 patients. Thirteen out of the outpatients recruited did not turn up for follow up sample collection; the remaining 25 who were inpatients were either discharged within the 24 hour period, refused further sampling or had died from non-renal causes.

Age of subjects ranged between 18-85years (Table 1). There were more males than females with a sex ratio of 1:1.6 (F: M).

Of the 142 patients who completed the study, 17 (12%) were outpatients while 125(88.0%) were inpatients /emergency patients. One hundred and thirty three patients were referred for CT scan while only 9 had IVU. Fig. 1 shows the indications for CTscan.

Frequency of CIN among patients studied was 35.9%.One of the 9(11.1%) patients who had IVU and 50 out of 133 (37.5%) who had CT scan developed CIN (p=0.150†). Out of the 17 outpatients 3(17.6%) developed CIN, while 48 of 125 (38.4%) inpatients had CIN (p=0.160).

Serum creatinine levels of subjects ranged between 0.30mg- 4.60mg/dl, with mean of 0.88±0.46mg/dl. The frequency of CIN increased significantly with increasing baseline serum creatinine levels (Table 2).

Table 1. Sociodemographic Characteristics of the 142 patients studied

Characteristics	n(%) or mean ± SD
Mean Age(yr)	49.2 ± 18.1
Male Sex	87(61.3)
Female Sex	55(38.7)
Marital Status	
Single	33(23.2)
Married	95(66.9)
Divorced	2(1.4)
Widowed	12(8.5)
Occupation	
Skilled	25(17.6)
Semi Skilled	24(16.9)
Unskilled	52(36.6)
Students	18(12.7)
Others	23(16.2)

Others = retired, housewife, unemployed

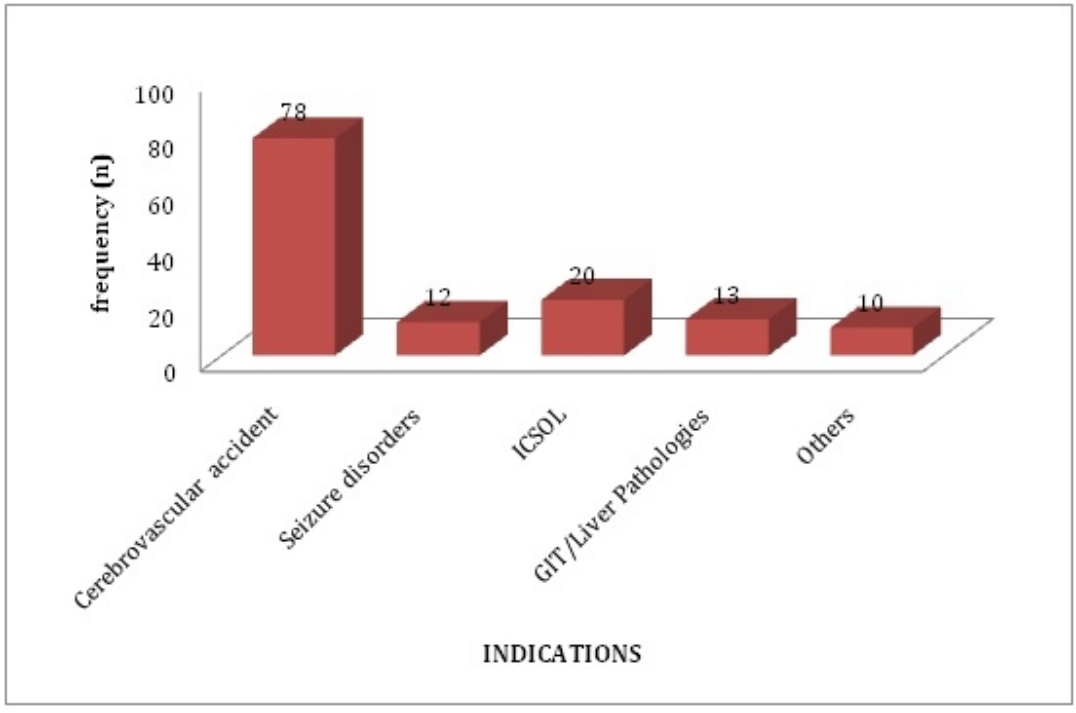

Fig. 1. Indications for contrast CT scan

ICSOL- intracranial space-occupying lesion, GIT- gastrointestinal, OTHERS- dizziness, lung carcinoma, toxoplasmosis, hydrocephalus, uterine fibroid

Table 2. Distribution of baseline serum creatinine concentrations

Serum creatinine(mg/dl)	ALL n(%)	CIN(+)n(%)	CIN(-) n(%)
0.30 - 0.89	81 (100.0)	24 (29.6)	57 (62.6)
0.90 - 1.49	53 (100.0)	21 (39.6)	32 (35.2)
1.50 - 2.09	6 (100.0)	4 (66.6)	2 (2.2)
>2.10	2 (100.0)	2 (100.0)	0 (0.0)
TOTAL	142 (100.0)	51 (35.9)	91 (64.1)

X^2= 8.174;DF=3, p=.043.

There was no significant association between anthropometric measurements of patients and developing CIN (Table 3).

Table 3. Comparison of anthropometric indices for CIN (+) and CIN (-) patients

Parameters	ALL Mean ± SD	CIN(+) Mean ± SD	CIN(-) Mean ±SD	Mean Difference 95% CI	P value
BMI (kg/m^2) n = 102	26.40 ± 2.69	26.23 ± 2.37	26.49 ± 2.86	-0.3(-1.1,2.2)	.576
Weight (kg) n = 102	74.76 ± 8.49	74.27 ± 7.41	75.04 ± 9.05	-0.7(-3.7,0.7)	.606
WC(cm)	79.18 ± 12.95	79.10 ± 10.4	78.9 ± 15.0	0.2 (-4.5, 4.9)	.934
WHR	0.87 ± 0.04	0.88 ± 0.04	0.87 ± 0.04	0.0(-0.0,0.0)	.346

CI-Confidence Interval; CIN-Contrast Induced Nephropathy; SD-Standard Deviation; WC-Waist Circumference; WHR - Waist Hip ratio.

Majority of the patients studied had low CIN risk assessment scores (≤5). 11.8% of patients who developed CIN had high scores in the range of 6-10, compared to 8.8% of those who did not develop CIN. This difference was however not statistically significant (Table 4).

Table 4. Association between the Total CIN Risk assessment scores of patients and CIN

CIN Scores	Total n(%)	CIN + n(%)	CIN(-) n(%)
≤ 5	128 (90.1)	45 (88.2)	83 (91.2)
6-10	13 (9.2)	6 (11.8)	7 (7.7)
11-16	1 (0.7)	0 (0.0)	1 (1.1)
Total	142 (100.0)	51 (100.0)	91 (100.0)

df = 2, P value = .600†. CIN - Contrast Induced Nephropathy.

There were a significantly higher proportion of patients with serum creatinine≥ 1.5mg/dl developing CIN compared to those with values < 1.5mg/dl (p=0.025). Similarly patients with GFR< 60ml/min, anaemic and patients aged >55yrs had significantly increased risk of CIN (p=.028, 0.021 and .028 respectively, Table 5).

Table 5. The Association between presumptive risk factors and CIN

Risk factors	Total	CIN(+) n(%)	CIN(-) n(%)	P Value or Fishers exact
Female Sex	55 (100.0)	20 (36.3)	35 (63.7)	.929
Male Sex	87 (100.0)	31 (35.6)	56 (64.4)	
Age <55yrs	84 (100.0)	24 (28.6)	60 (71.4)	.028*
>55yrs	58 (100.0)	27 (46.5)	31 (53.5)	
SBP > 100mmHg	135 (100.0)	48 (35.5)	87 (64.5)	.702†
< 100mmHg	7 (100.0)	3 (42.8)	4 (57.2)	
Anaemia	25 (100.0)	14 (54.5)	11 (45.5)	.021*
No Anaemia	117(100.0)	37 (32.5)	80 (67.5)	
Diabetes	10 (100.0)	5 (50.0)	5 (50.0)	.499 †
No Diabetes	132 (100.0)	46 (34.8)	86 (65.2)	
Creatinine≥ 1.5mg/dl	8 (100.0)	6 (75.0)	2 (25.0)	.025*†
< 1.5 mg/dl	134 (100.0)	45 (33.5)	89 (66.5)	
GFR < 60ml/min	12 (100.0)	8 (66.7)	4 (33.3)	
GFR ≥ 60ml/min	130 (100.0)	43 (33.1)	87 (66.9)	.028*†
Serum albumin<3.5g/dl	70 (100.0)	28 (40.0)	42 (60.0)	.317
Serum albumin>3.5g/dl	72 (100.0)	23 (31.9)	49 (68.1)	
Serum urea >40mg/dl	50 (100.0)	23 (46.0)	27 (54.0)	.065
Serum urea<40mg/dl	92 (100.0)	28 (30.4)	64 (69.6)	

† = Fishers exact test

Baseline creatinine, GFR<60ml/min, anaemia and age ≥55yrs were predictive of CIN in univariate analysis but not in multivariate analysis (Table 6).

Table 6. Predictors of CIN

Risk factors	OR	CI(95%)	P	OR	CI(95%)	P
GFR<60ml/min	4.05	1.15-14.19	.029	0.52	0.12-2.30	.39
Cr ≥ 1.5mg/dl	5.90	1.15-30.50	.033	4.13	0.67-25.4	.126
PCV≥30%	2.75	1.14-6.64	.024	0.92	0.31-2.71	.884
Age≥55yr	2.18	1.08-4.37	.029	0.49	0.24-1.03	.060

GFR= glomerular filtration rate; OR= odds ratio; CI= confidence interval; Cr= creatinine; PCV= packed cell volume.

4. DISCUSSION

This study has shown that the simple risk score for prediction of CIN does not sufficiently identify patients at risk for CIN in our black study population. Though a higher proportion of CIN (+) patients had high total risk scores when compared to CIN (-) patients, it did not reach statistical significance.

This finding was not surprising, since this study also showed that though there was a higher occurrence of CIN among patients who had some of the traditional risk factors; these factors did not sufficiently predict CIN. Age above 55yr, anaemia and renal insufficiency were significantly associated with CIN risk but diabetes, hypotension amongst others were not.

Most studies have shown that diabetes is a predictor of CIN and it remains significant as an independent predictor in most but not all, multivariate analyses [2,12,22-25]. It is still unclear if the risk of CIN is significantly increased in patients with diabetes who do not have renal impairment. Results of studies are conflicting [5]. Among diabetics, the incidence of CIN varies from 5.7-29.4% [26,27]. The duration of diabetes and the presence of diabetic complications have been reported to increase the risk of CIN [28]. The most appropriate characterization of diabetes with respect to CIN is that it acts as a risk multiplier [2]. That is in the setting of a reduced estimated GFR <60ml/min, diabetes amplifies the risk for CIN and complicates the postprocedure management with respect to glycaemic control and management of other comorbidities.

The definitions of some of the risk factors in the Mehran's score were adjusted for this study for example the cut-off haematocrit for anaemia was reduced to 30% becauseanaemia is quite prevalent in our region of the world and so a lower haematocrit level will more reliably define anaemia. Cut-off age was reduced to 55yr rather than 75yr since life expectancy is 47yr in Nigeria and other studies have shown that age greater than 55yr is a risk for CIN; this study confirms that age above 55yr is indeed a risk for CIN in our population.

It is important to also recall that the CIN risk score was originally developed among patients undergoing percutaneous coronary interventions [18] and may differ characteristically from patients undergoing CT scan or other intravenous contrast procedures. Intra-arterial rather than intravenous contrast is used for coronary interventions and the volume of contrast as well as method of injection also differs. Some of the variables in the score chart such as variation in contrast volume and use of IABP were not applicable in this study and so were not scored, however these are important risk factors for patients undergoing coronary artery interventions.

The limitation of this study was not testing the Mehran's prediction score exclusively on the subset of patients (9) who had IVU. It is generally accepted that use of High osmolar contrast media as is done in this subset is associated with a higher risk of CIN. However, this study did not show a significant difference in the frequency of CIN between the IVU group versus the CTscan group. An explanation for this observation may be that patients referred for IVU were more stable outpatients and their baseline creatinine is requested as a pre-requisite for the procedure.

5. CONCLUSION

Contrast induced nephropathy is common in the study population and the risk is more in patients who have some of the traditional risk factors. However, these factors do not sufficiently predict CIN.

Generally there is a paucity of data on CIN among patients undergoing CT scan and other intravenous contrast procedures. The use of contrast-enhancing procedures especially CT scan, is increasing in developing countries. Most of these patients are referred for the procedure as emergency cases and often times may not be adequately prepared. It is needful for more research aimed at identifying significant risk factors and developing a simple risk assessment tailored to our peculiar patients undergoing these procedures. Meanwhile simple practices such as renal function assessment and adequate hydration before all contrast procedures must be encouraged.

CONSENT

All authors declare that 'written informed consent was obtained from the patient (or other approved parties) for publication of this manuscript.

ETHICAL APPROVAL

All authors hereby declare that all experiments have been examined and approved by the appropriate ethics committee and have therefore been performed in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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