Original Research Article

Contrast-induced acute renal injury: multi-factor analysis to establish risks and associations

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ABSTRACT

Background: Contrast-induced acute kidney Injury (CIAKI) also called nephropathy is one of the recurrent complications with very high mortality and morbidity rate amongst the patients undergoing percutaneous coronary intervention (PCI). The purpose of this research was to validate the incidence, risk factors, and correlation of various comorbidities with CIAKI.

Methods: The study was conducted on 308 patients who had undergone PCI procedures. All patients were recruited following all ethical guidelines. All patients were treated as per the hospital protocol. All patients were followed up for 7 days post PCI. Out of 308 patients, 35 developed CIAKI while remaining was classified as control for post-hoc analysis comparison. Evaluation of the patients was done using Mehran’s risk score, ODD analysis and RADHIKa method.

Results: The incidence of CIAKI was found in 35 (11.37%) out of 308 patients. No patients required dialysis within 1 week of the procedure. The use of the ionization optimized contrast medium (IOCM) is linked with the reduction of +CIAKI. The obvious relationship between the volume of contrast media, MRS, and CIAKI was reestablished. Post-hoc analysis of CIAKI and non-CIAKI revealed that the CIAKI is closely linked with heart failure as a risk factor. Congestive heart failure (CHF) increases the risk of CIAKI and that results in an increased risk of heart failure.

Conclusion: In conclusion, the pre-existing multiple co-morbidities, volume, and ionization value of the contrast media were found to be directly associated with CIAKI.

Keywords: Contrast-induced nephropathy, Contrast-induced acute kidney injury, Renal injury, Serum creatinine, Angiography, PCI

INTRODUCTION

Contrast-induced acute kidney injury (CIAKI) that is also known as Contrast-induced nephropathy (CINp) is an acute kidney injury group condition that continues to exasperate cardiologists for its adverse impact on prognosis post-Percutaneous coronary intervention (PCI). Mostly CIAKI is self-limiting with maximum levels of Serum creatinine (SCr) that are achieved in 3-5 days and gradually returning to baseline levels within 7-10 days.¹,² Furthermore, the other causes of transient rises in SCr are associated with longer hospital ward and intensive care unit stays. Myocardial infarction (MI), stroke, Heart failure (HF), rehospitalization, and death after coronary angiography, PCI, and angiography followed by cardiac surgery.³
In general, CIAKI is defined as an absolute increase in SCr 0.3 mg/dl after PCI or fall in urine output less than 0.5 ml/kg/hour for more than 6 hours. However, there is significant disparity and ambiguity in the definitions of CIAKI. Hence, beyond definitions, kidney disease improving global outcomes (KDIGO) consensus classifications are clinically pragmatic tools accepted widely for defining CIAKI. This classification and staging include increase in SCr by >0.5 mg/dl (44 pmol/l) within 48 hours; increase in SCr >25%×baseline (known or presumed to be within 7 days pre-procedure), after excluding other factors that may cause nephropathies, such as nephrotoxins, hypotension, urinary obstruction, or atheromatous emboli; urine volume <0.5 ml/kg/h for 6 hours;

Among various risk factors of CIAKI a major independent risk factor is pre-existent chronic kidney disease (CKD), a condition that arises when estimated glomerular filtration rate (eGFR) remains below 60 ml/min/1.73 m² for more than 3 months. This is also supported by an analysis of 985,737 PCI patients. However, besides CKD, there are other risk factors involved in the development of CIAKI. Hence, Mehran’s risk score is an important consideration in CIAKI studies. Mehran’s risk score is calculated on the basis of - age, systemic hypertension, diabetes mellitus, anemia, congestive heart failure, contrast media volume, eGFR, and use of intra-aortic balloon pump during PCI.

The pathophysiology of CIAKI is yet to be completely explored. There are several aspects into consideration including hemodynamic perturbations, tubular epithelial cytotoxicity chemical (nitric oxide/prostaglandins) mediated vasomotor changes, low partial oxygen pressure at the outer renal medulla, metabolic demand, etc. (23,24,25). The pathophysiology indicates the association of the iodine content of the contrast media (CM) with the mentioned considerations. Hence, there is innovation in the CM compositions to reduce CIAKI incidence. The occurrence of CIAKI is as high as 23-30% in the patients undergoing transcatheter cardiac procedures like PCI. Studies have off-late indicated a variety of opinions about the incidence of CIAKI, against the consideration of limiting angiographic procedures in patients with chronic kidney disease (CKD).

The described study was conducted on a total of 308 consecutive patients in a super-specialty center in South India, with the following objectives: to assess the incidence of contrast-induced CIAKI patients undergoing PCI; to assess the efficacy of reno-protective measures in the prevention of CIAKI; and to evaluate the risk factors in the development of CIAKI and to validate the Mehran risk score (MRS) for the prediction of both CIAKI and clinical outcomes.

The study was also focused on observing the adverse clinical events during hospitalization including major bleeding, requiring more than one unit of blood transfusion, acute pulmonary edema, acute renal failure requiring emergency hemofiltration or hemodialysis, cardiogenic shock, revascularization, tachyarrhythmias and bradyarrhythmia, cardiac death, re-infarction, and stroke.

**METHODS**

The study included 308 consecutive ST-elevated MI (STEMI) undergoing PCI including all types of acute MI that occurred from December 2017 till December 2018 at Lisie Hospital, Kochi. The patients with CKD, patients on maintenance hemodialysis, CAPD Patients with renal transplantation, patients with infection, and history of collagen vascular disease, chronic peritoneal, or hemodialytic treatment were excluded.

All patients were given physiologic (0.9%) saline intravenously. Left ventricular dysfunction or overt heart failure, the hydration rate was 0.5 ml/kg/h and for other patients were 1 ml/kg/h for 12 hours after contrast exposure. The concomitant therapy included fractionated intravenous heparin (100 IU/kg) after cannulation for and sodium bicarbonate beta-blockers, ACE inhibitors, (abciximab), diuretics, intra-aortic balloon pump or inotropic drugs support, etc. as indicated. Echocardiography within 12 h from hospital admission and SCr estimation at admission or just before PCI, thereafter every day for three days, and at 1-week post-discharge was done for all patients. Evaluation of all
patients included clinical parameters and Mehran risk score, corresponding with SCr evaluation time. Creatinine clearance was calculated using the Cockcroft- Gault formula. The study was approved by the Ethics Committee at Lisie Hospital, Kochi. The data was analyzed using minitab software and Microsoft excel.

RESULTS

The study was conducted in 308 subjects, fulfilling inclusion and exclusion criteria. Among them, 32 patients had prior PCI and 5 patients had prior CABG. All subjects that were screened to participate in the study passed the complete eligibility criteria, all patients underwent PCT as indicated. The patients were observed for 7 days for CIAKI. Out of 308 patients, 35 developed and the remaining patients were classified as a control for post-hoc data analysis comparison (Figure 1).

Baseline analysis

Demographics

The cohort of 308 MI patients had advanced age with a mean age of 61.09 years, the majority were males (76.3%) and a significant proportion had diabetes (52.6%), and systemic hypertension (46.11%). Ten (3.25%) patients had a history of renal disease (Table 1).

The disease presentation included effort angina (38%), STEMI (28%), and non-STEMI (37%). Thirty-five (11.37%) patients presented with heart failure (Table 1).

Procedural characteristics

Most of the patients were treated for the single-vessel disease, with one stent implanted. The mean per-patient target vessel treated was 1.4 and the mean stent per patient was 1.41, which represents a typical population with MI treated with PCI. A small subset of population underwent staged procedure (n=21, 6.82%), Rescue PCI (n=9, 2.93%) or required use of IABP during (PCI) 5 (1.63%); (Table 1).

In all, 119 (38.64%) were given iso osmolar CM (IOCM) and 189 (61.36%) low osmolar CM (LOCM). The mean volume of CM used was 178.09 ml. Only 8 patients had CM injected over 350 ml. however, the dose was still below MCD (Table 1).

Table 1: Demographics, disease presentation and medical history.

| Parameter                               | Presentation | Observation |
|-----------------------------------------|--------------|-------------|
| Sample size                             | N 308        |             |
| Age                                     | Mean ± SD    | 61.0 ±10.01 |
| Sex (males)                             | N (%)        | 235 (76.3)  |
| Comorbidty                              |              |             |
| Diabetes mellitus                       | 162 (52.6)   |             |
| Systemic hypertension                   | 142 (46.11)  |             |
| Dyslipidaemia                           | 58 (18.84)   |             |
| Chronic obstructive pulmonary disease   | 17 (5.52)    |             |
| Peripheral vascular disease             | 13 (4.23)    |             |
| Smoking                                 | 16 (5.2)     |             |
| Hypotension                             | 7 (2.28)     |             |
| Anemia                                  | 8 (2.6)      |             |
| Medical history                         |              |             |
| Myeloma                                 | 0 (0)        |             |
| Proteinuria                             | 3 (0.98)     |             |
| Use of medications                      | 1 (0.33)     |             |
| Renal disease                           | 10 (3.25)    |             |
| Prior PCI                               | 32 (10.39)   |             |
| Prior CABG                              | 5 (1.63)     |             |
| Clinical presentation                   |              |             |
| Effort angina                           | 119 (38.64)  |             |
| Angina at rest                          | 23 (7.47)    |             |
| STEMI                                   | 116 (37.68)  |             |
| Anterior wall MI                        | 47 (15.26)   |             |
| Inferior wall MI                        | 38 (12.34)   |             |
| Posterior wall MI                       | 22 (7.15)    |             |
| Right ventricle MI                      | 5 (1.63)     |             |
| Lateral wall MI                         | 4 (1.3)      |             |
| Parameter                                  | Presentation | Observation |
|-------------------------------------------|--------------|-------------|
| NSTEMI                                    |              | 114 (37.02) |
| CHF                                       |              | 35 (11.37)  |
| Ejection fraction (EF) < 40               |              | 36 (11.69)  |
| **Metrics**                               |              |             |
| EF                                        | Mean (±SD)   | 52.24 ± 9.57|
| Baseline eGFR                             |              | 76.49 ± 22.11|
| Baseline mehran risk score (MRS)          |              | 5.04 ± 3.64 |
| Number of vessels treated per patient     | N (%)        | 1.4 ± 0.62  |
| 1                                         |              | 203 (65.91) |
| 2                                         |              | 86 (27.92)  |
| 3                                         |              | 17 (5.52)   |
| 4                                         |              | 1 (0.32)    |
| Number of stent used                      | N (%)        | 1.41 ± 0.68 |
| 1                                         |              | 204 (66.89) |
| 2                                         |              | 80 (26.23)  |
| 3                                         |              | 19 (6.23)   |
| 4                                         |              | 2 (0.66)    |
| **Total**                                 | N            | 434         |
| **Procedure type**                        |              |             |
| **Exposure type**                         |              |             |
| Primary                                   | N (%)        | 75 (24.36)  |
| Index                                     |              | 3 (0.98)    |
| Staged                                    |              | 21 (6.82)   |
| **Decision type**                         |              |             |
| Elective                                  | N (%)        | 216 (70.13) |
| Ad hoc                                    |              | 3 (0.98)    |
| Rescue PCI                                |              | 9 (2.93)    |
| Use of IABP during (PCI)                  |              | 5 (1.63)    |
| **Route of procedure**                    |              |             |
| Radial                                    |              | 288 (93.51) |
| Femoral                                   |              | 19 (6.17)   |
| Radial + Femoral                          |              | 1 (0.32)    |
| **Contrast Type**                         |              |             |
| Visipaque (iodixanol) iso-osmolality      |              | 119 (38.64) |
| ContraPaque (iohexol) low-osmolality      |              | 13 (4.22)   |
| PAMIMAGE (iopamidol) low-osmolality       | N (%)        | 176 (57.14) |
| Iso-Osmolar CM                            |              | 119 (38.64) |
| Low-Osmolar CM                            |              | 189 (61.36) |
| Volume of contrast                        |              | 178.09 ± 76.87 |
| Patients with contrast volume > 350       |              | 8 (2.60)    |
| Patients with contrast volume > MCD       |              | 0 (0)       |
| **Event**                                 |              |             |
| PCI procedural success                     | N (%)        | 292 (94.81) |
| **Cardiac events**                        |              |             |
| Composite Events – MACE, MACCE            |              | 4 (1.3)     |
| Death                                     |              | 2 (0.65)    |
| Re-infrac/myocardial infraction           |              | 1 (0.33)    |
| Target vessel revascularization           | N (%)        | 1 (0.33)    |
| Stroke                                    |              | 0 (0)       |
| Heart failure                             |              | 23 (7.47)   |
| Bleeding                                  |              | 3 (0.98)    |
| **Renal events**                          |              |             |
| Occurrence of CI-AKI                      | N (%)        | 35 (11.37)  |
| Renal replacement therapy                 |              | 0 (0)       |
### Table 2: Analysis of renal function before and after PCI.

| Renal function          | Pre-procedure | 24 hours post-procedure | 48 hours post-procedure | 1 week post-procedure | Pre-post correlation value |
|-------------------------|---------------|-------------------------|-------------------------|-----------------------|---------------------------|
| Creatinine              | 1.06±0.26     | 0.99±0.27               | 1.03±0.27               | 1.39±5.83             | -0.005                    |
| Urine Output            | 1745.25±499.29| 1961.18±630.87          | 2022.64±621.4           |                       | 0.338                     |

### Table 3: RADHIKα analysis of CIAKI and no-CIAKI – part 1.

| CKAKI | n-CKAKI | Ψ       |
|-------|---------|---------|
| N     | 35      | 273     | -      |
| Age   | 57.89±7.9 | 61.5±10.18 | 0.94   |
| Sex (males) | 30 (85.72%) | 205 (75.1%) | 1.15   |
| Diabetes mellitus | 17 (48.58%) | 145 (53.12%) | 0.91   |
| Systemic hypertension | 21 (60%) | 121 (44.33%) | 1.40   |
| Dyslipidaemia | 7 (20%) | 51 (18.69%) | 1.10   |
| Chronic obstructive pulmonary disease | 1 (2.86%) | 16 (5.87%) | -2.46   |
| Peripheral vascular disease | 2 (5.72%) | 11 (4.03%) | -0.74   |
| Smoking | 5 (14.29%) | 11 (4.03%) | -9.58   |
| History myeloma | 0 (0%) | 0 (0%) | 1.00   |
| History proteinuria | 0 (0%) | 3 (1.1%) | 1.28   |
| History penile Disease | 2 (5.72%) | 8 (2.94%) | -0.35   |
| eGFR | 70.68±21.35 | 77.24±22.09 | 0.92   |
| Prior PCI | 3 (8.58%) | 29 (10.63%) | 0.64   |
| Prior CABG | 1 (2.95%) | 4 (1.47%) | 0.58   |
| Chronic heart failure | 10 (28.58%) | 25 (9.16%) | 5.67   |
| Left ventricular ejection fraction | 46.18±12.22 | 53.02±8.88 | -0.87   |
| Hypotension | 4 (11.43%) | 3 (1.1%) | -1.65   |
| Anemia | 0 (0%) | 8 (2.94%) | -2.43   |
| NPO pre-procedure | 35 (100%) | 273 (100%) | -1.00   |
| Intravenous sodium chloride pre-procedure | 35 (100%) | 271 (99.27%) | -1.01   |
| Intravenous sodium bicarbonate pre-procedure | 3 (8.58%) | 6 (2.2%) | 1.28   |
| NAC pre-procedure | 13 (37.15%) | 68 (24.91%) | -1.61   |
| Ascorbic acid pre-procedure | 7 (20%) | 32 (11.73%) | -2.23   |
| Osmolality of contrast medium | 17 (48.58%) | 102 (37.37%) | -1.35   |
| Volume of contrast medium | 197.15±102.78 | 175.65±72.52 | 1.12   |
| Use of intra-aortic balloon pump during PCI | 2 (5.72%) | 3 (1.1%) | -0.18   |
| LAD infract related artery | 22 (62.86%) | 152 (55.68%) | 1.14   |
| Number of treated vessels | 1.35±0.59 | 1.41±0.62 | 0.96   |
| Primary | 12 (34.29%) | 63 (23.08%) | 1.62   |
| Index | 0 (0%) | 3 (1.1%) | -1.28   |
| Staged | 2 (5.72%) | 19 (6.96%) | -0.37   |
| Elective | 19 (54.29%) | 197 (72.17%) | -0.73   |
| Ad hoc | 0 (0%) | 3 (1.1%) | -1.28   |
| Rescue PCI | 4 (11.43%) | 5 (1.84%) | -2.03   |
| Number of stent used | 1.29±0.57 | 1.43±0.69 | 0.90   |
| Completeness of revascularizations | 32 (91.43%) | 260 (95.24%) | 0.96   |
| Intravenous sodium chloride post-procedure | 35 (100%) | 273 (100%) | -1.00   |
| Intravenous sodium bicarbonate post-procedure | 0 (0%) | 4 (1.47%) | -1.42   |
| NAC post-procedure | 19 (54.29%) | 59 (21.62%) | -2.97   |
| Total MRS | 6.35±5.21 | 4.87±3.35 | -1.31   |
| RADHIKα Ratio | -0.26 | 0.218874 |
Table 4: RADHIKα analysis for expectancy of outcomes of CIAKI / no-CIAKI.

| Event                               | CIAKI       | n-CIAKI      | ψi  | ψi * ψR | CI range   | Outcome                  |
|-------------------------------------|-------------|--------------|------|---------|------------|--------------------------|
|                                     | N | % | N | % | | LCI | UCI |                   |
| Occurrence of CIAKI                | 35 | 1.000 | 0 | 0.000 | -19 | 5.02 | 4.80 | 5.24 | Worse |
| Renal replacement therapy          | 0 | 0.000 | 0 | 0.000 | 1  | -0.26 | -0.48 | -0.05 | Improved |
| mortality                          | 0 | 0.000 | 2 | 0.007 | 1  | -0.31 | -0.53 | -0.09 | Improved |
| Re-infract/myocardial infraction   | 0 | 0.000 | 1 | 0.004 | 1  | -0.29 | -0.50 | -0.07 | Improved |
| TVR (Target vessel revascularization) | 0 | 0.000 | 1 | 0.004 | 1  | -0.29 | -0.50 | -0.07 | Improved |
| Heart failure                      | 11 | 0.314 | 12 | 0.044 | -44 | 11.64 | 11.43 | 11.86 | Worse |
| Stroke                             | 0 | 0.000 | 0 | 0.000 | 1  | -0.26 | -0.48 | -0.05 | Improved |
| Bleeding                           | 1 | 0.029 | 2 | 0.007 | 1  | -0.13 | -0.35 | 0.09  | Improved |

Table 5: RADHIKα analysis for propensity-matched incidence expectancy.

| Event                               | LCI | Expected (ψi x ψR) | UCI | Observed (ψi) |
|-------------------------------------|-----|--------------------|-----|---------------|
| Occurrence of CIAKI                | 4.80| 5.02               | 5.2417 | -19           |
| Renal replacement therapy          | -0.48| -0.26             | -0.0455 | 1             |
| mortality                          | -0.53| -0.31             | -0.0914 | 1             |
| Re-infract/myocardial infraction   | -0.50| -0.29             | -0.0666 | 1             |
| TVR                                | -0.50| -0.29             | -0.0666 | 1             |
| Heart failure                      | 11.43| 11.64             | 11.864 | -44           |
| Stroke                             | -0.48| -0.26             | -0.0455 | 1             |
| Bleeding                           | -0.35| -0.13             | 0.0861 | 1             |
| t = 0.17, p=0.35                   |     |                   |       |               |

Figure 2: Interval plot analysis for various risk factors and occurrence of CIAKI.

_Procedural outcomes and adverse events_

The procedural success rate was 94.81%. CIAKI, the primary endpoint of this study occurred in 35 (11.37%) patients, of which no patient required renal replacement therapy including dialysis, within 72 hours of the procedure. The composite Major adverse cardiac events (MACE), Major adverse cardiac and cerebrovascular events (MACCE) were 1.3%, as there was no stroke. The MACE was contributed by deaths 2 (0.65%); MI 1 (0.35%)
and TVR 1 (0.33%). Additionally, there were 23 (7.47%) events of HF and 3 (0.98%) events of major bleeding (Table 1).

The analysis of correlation of occurrence of CIAKAI and various factors demonstrated a strong factorial relationship between the amount of contrast and LAD procedure. Higher age, diabetes, systemic hypertension, COPD, smoking, CKD, eGFR, Prior revascularization (PCI/CABG), Cardiac failure, ventricular dysfunction, and IABP, hypotension, and anemia demonstrated relationship with the occurrence of CIAKI. There was a direct relationship between types of PCI. The procedures which are commonly associated with the repetition of PCI within a short time or with high contrast (rescue PCI, PAMI) had a higher incidence of CIAKI. However, better planned or low contrast requiring PCI procedures (index+staged, adhoc after angiography, elective PCI) had a significantly low incidence of CIAKI (p<0.001; T=17.53, paired t-tests). The obvious relationship between the volume of contrast media, MRS, and CIAKI was reestablished (p<0.001, T=40.58, paired t-test) (Figure 2).

![Figure 3: ODDS analysis for various risk factors of CIAKI.](image)

![Figure 4: Probability distribution relationship of CIAKI with various prophylactic measures.](image)

**Comparative analysis of CIAKI occurrence and non-occurrence**

For binary comparison of effect of the risk factors on CIAKI occurrence, ODDS analysis was performed for the top 12 risk factors viz. age, volume of contrast, eGFR, EF, DM, SHT, smoking, prior PCI, prior CABG, CHF, hypotension, and anemia. The analysis revealed similar results (Figure 3).

The key aspects to prevent renal injury included hydration, electrolyte, and maintenance of adequate blood pressure. This was achieved by the infusion of NPO, intravenous saline normal or hyperbaric saline, intravenous sodium bicarbonate, NAC, and ascorbic acid were administered pre-operative, intraoperative, and post-operative as prophylaxis. The Probability plot of the relationship of these measures with occurrence/non-occurrence of CIAKI reveals that in absence of IV sodium chloride (IV saline),
the probability of occurrence of the CIAKI is significantly and higher (p<0.005). The presence of intravenous injection of sodium bicarbonate directly correlates with the absence of CIAKI. Other preventive measures had indistinctive probability distributions. However, all the probability distributions are statistically significant (p<0.005) (Figure 4).

![Histogram of Occurrence of CI-AKI by Osmolality](image1)

**Figure 5: IOCM versus LOCM - CIAKI incidence.**

![Image2](image2)

**Figure 6: RADHIKA analysis of clinical outcomes.**

The incidence of CIAKI in 189 patients of LOCM exposure was 18 (9.52%) while in 119 patients of IOCM exposure patients were 17 (14.29%) revealing a significant difference in the incidence of CIAKI in LOCM and IOCM groups. (p=0.116, fisher's exact test); (figure 5). As there was enough evidence to compare the CIAKI occurrence with non-occurrence in the group, the post hoc analysis was undertaken.

**Analysis of renal function indicators**

The pre-procedure SCr was 1.06±0.26 for all patients. The SCr at 24, 48 hours and 1 week post-procedure was 0.99±0.27, 1.03±0.27 and 1.39±5.83 respectively. The correlation analysis revealed Pearson r-value as -0.005 meaning that there was a very week correlation and it was a negative correlation. The urine output procedure was 1745.25±499.29, at 24 hours post-procedure, urine output was 1961.18±630.87, and 48 hours post-procedure was 2022.64±621.4, there was a poor to moderate correlation with value 0.338 as per Pearson correlation analysis (Table 2). As there was no significant relationship between pre-procedure and post-procedure SCr, the analysis of SCr in the CIAKI group versus non-CIAKI group was not performed.

**Post hoc analysis for the cause to effect correlation**

The CIAKI occurred in 35 (11.37%) patients. The post-hoc relative propensity of these two groups was determined with virtual equalization by RADHIKA method. The data shows $\psi_R=-0.26$ which inferred that the test group (in this study the post hoc CIAKI occurrence group) was a relatively higher risk for CIAKI occurrence (Table 3). The range for equal-propensity was from −0.05 to −0.48.

The actual outcome of the study demonstrated that the Results of the CKAKI subgroup as expected. Additionally, in this group, the other composite device endpoints were also as per the prediction. The stroke outcomes were deemed improved outcome, where both groups had no
event are statistically illustrated value for both the arms; which are used for extrapolation if required.

Propensity-equivalency analysis with RADHIKA Method revealed that there was a marginal improvement in the CIAKI group with downhill expectancy in the incidence of renal replacement therapy, mortality. Re-infract/myocardial infarction, TVR, Stroke, and Bleeding, while the occurrence of CIAKI and Heart failure was more than expected in the CIAKI group, despite match propensity stratification of risk (Table 4, 5, Figure 6). However, due to the small sample size in one of the arms, the significance is limited (p=0.35)

DISCUSSION

CM increases blood viscosity and osmolality leading to reduced microcirculation, impaired erythrocyte-plasticity, and microvascular thrombosis and cytotoxicity. The effect is assumed to be directly proportional to the agent’s viscosity, osmolality, ionic values, etc. Hence, the trends have changed from using classical ionic ‘hyperosmolar’ solutions to less non-ionic, low-osmolar’ (LLCM) or IOCM solutions. However, reducing osmolality results in increased viscosity, which could have a countering set-off effect on the achieved nephrotoxicity. This effect can accelerate the similar effect of terminal vessels affecting conditions like diabetes and hypertension (iohexol cooperative study). Administration of high volumes (>350 colors >4 ml per kilogram) of CM or frequent administration within 72 hours is associated with a high risk of CKAKI increased risk as demonstrated by in a study that included 1213 patients.

A clinical study of 891 patients demonstrated an association of CIAKI with clinical presentation and imaging type. In particular, the association of STEMI undergoing PCI is associated with a high risk of CIAKI. This study was able to establish a similar relationship of CIAKI with STEMI (r<0.005) and higher contrast volume (r<0.005). Furthermore, the risk of CIAKI is found to be more prominent in the case of diabetes (ODDS=0.3466) and hypertension (ODDS=1.585). The presence of periprocedural hemodynamic instability requiring the use of inotropetic agents or intra-arterial balloon pump (IABP) therapy is particularly associated with high-risk (12). In this study, there were 5 (1.63%) IABP patients, of which 2 (40%) had CIAKI (no statistical significance).

Furthermore, CKD has an obvious association of renal ischemia due to compromised microvascular and macrovascular circulation. National cardiovascular data registry has demonstrated significant deterioration of kidney function after angiographic procedures.

Furthermore, in line with a few previous studies, procedural factors such as the total volume of CM (>350 mL or >4 mL/kg) and previous CM exposure within 72 hours are directly related to the development of CIAKI (32). Hence, in CKD patients, the maximum safe volume of contrast is basis a ratio of the volume of CM to creatinine clearance (V:CrC1) not exceeding 3.7:1.

Post-hoc analysis of comparison in a cohort of the clinical study is a known method used for the establishment of correlations or subset strengths. However, statistically, this analysis may be used for indicative reasons only. In this study, the RADHIKa method was used for equated propensity analysis of the incidence of various events. The risk of heart failure was observed to be increased unexpectedly, while CIKAI was the criteria for post-hoc analysis. All other conditions were marginally better or as expected in both groups.

CONCLUSION

This 308 patients study demonstrated that the incidence of CIAKI was 11.37%. The pre-existing co-morbidities, volume, and ionization-type of the CM, MRS is directly associated with CIAKI. The binary and equated propensity analysis of CIAKI and no-CIAKI subsets revealed that the IOCM is associated with a low incidence of CIAKI and cardiac failure is closely associated with CIAKI both as a risk factor as well as comorbidity or complication.

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