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*Original Research*

# Evaluation of the radiocontrast nephropathy development due to the contrast-enhanced CT applications in emergency department

Radiocontrast nephropathy in emergency department

Gülçim Saraçoğlu[1], Sedat Yanturalı[2], Rıdvan Atilla[2], Başak Bayram[2], Pınar Yeşim Akyol[3]
[1]Emergency Department, Muğla Sıtkı Koçman University, Research and Training Hospital, Muğla
[2]Emergency Department, Dokuz Eylül University, Izmir
[3]Emergency Department, Katip Çelebi University, Atatürk Research and Training Hospital, Izmir, Turkey

**Abstract**

Aim: We aimed to determine the incidence of post-contrast acute kidney injury (PC-AKI), the demographic characteristics of patients, and the reasons that facilitate the development of PC-AKI in patients who were admitted to the emergency department and underwent computed tomography (CT) with intravascular contrast media.

Material and Methods: This study is a retrospective, cross-sectional and analytical study. Patients over the age of 18 who underwent CT with intravascular contrast media and were hospitalized for at least 48 hours were included in this study. The development of PC-AKI and the clinical and demographic characteristics of the patients were evaluated.

Results: A total of 816 patients were included in the study. Thirty-six (4.4%) patients developed PC-AKI. We found that the average length of hospital stay was 22.2 ± 41.7 days. Patients with a history of hypertension (HT) and diabetes mellitus (DM) and who had hypotension on admission to the emergency department were found to have a higher risk of developing PC-AKI ($p<0.05$ for all of them). The development of PC-AKI was significantly higher in patients receiving ACE inhibitors ($p=0.004$). When the clinical outcomes of the patients with PC-AKI were evaluated, it was observed that 47.2% (n=17) of them died. Mortality was statistically significantly higher in patients with PC-AKI than in the patients without PC-AKI ($p<0.0001$).

Discussion: PC-AKI led to an increase in the length of hospital stay of patients. The patients with PC-AKI had a higher mortality rate compared with the patients without PC-AKI.

**Keywords**

Contrast Material, Emergency Department, Nephropathy

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Corresponding Author: Pınar Yeşim Akyol, Department of Emergency Medicine, Izmir Katip Çelebi University, Atatürk Training and Research Hospital, İzmir, Turkey.
E-mail: yesimakyol@gmail.com P: +90 505 357 29 41
Corresponding Author ORCID ID: https://orcid.org/0000-0003-2477-1443

## Introduction

Post-contrast acute kidney injury (PC-AKI) is defined as an elevation of serum creatinine > 0.3 mg/dl (or > 26.5 µmol/l), or > 1.5 times baseline, within 48-72 hours of intravascular administration of a contrast agent. [1]

The development of PC-AKI depends on the physical and chemical properties of the agent used, together with the features of the patient. Because of the differences in the definition of acute renal failure (ARF) and the presence of comorbid conditions in patients, the incidence of PC-AKI in various studies ranged from 3.1% to 31%. [2] In patients with various risk factors, the incidence of PC-AKI can increase up to 50%.[3]

In this study, we aimed to determine the risk of developing PC-AKI in the emergency department (ED) and to demonstrate the risk factors for PC-AKI.

## Material and Methods

Our ED is a center that receives an average of 85,000 patients annually. In our ED, a multidetector computed tomography (MDCT) (Siemens SOMATOM Sensation 16 Slice CT Scanner) is used for CT imaging. Iopromide (Iopromide, Ultravist©; 370-100 mLflk. Bayer Schering Pharma), which is a non-ionic second-generation contrast agent, is used as an intravenous contrast agent.

This is a retrospective, cross-sectional analytical study. Ethical approval was obtained from University Ethics Committee for Non-Interventional Studies (Decision No: 2011/41-09).

*Research Method*

Patients who were admitted to our ED and who underwent CT with intravascular contrast media were investigated using the Hospital Information Management System (HIMS). Among these patients, those over 18 years of age who received contrast material and who were transferred to any hospital ward or were hospitalized for more than 48 hours in the ED were included in our study. The demographic information, clinical and laboratory data, diagnoses, clinical outcomes and prophylactic treatment were evaluated by the researchers.

Exclusion criteria were as follows: age under 18 years, having chronic kidney disease or being under regular hemodialysis (HD) program, having inaccessible data files, patients who died within 48 hours after administration of contrast material, patients whose creatinine levels were not measured before or 48-72 hours after the administration of contrast material, patients who were discharged from the ED within the first 48 hours after administration of the contrast material or who were referred to another hospital or who were left from the ED at their own request.

*Evaluation of PC-AKI*

Patients with an elevation of serum creatinine of more than > 0.3 mg/dl (or > 26.5 µmol/l), or > 1.5 times baseline, within 72 hours of intravascular administration of a contrast agent were considered "Acute Renal Failure" (ARF). Patients who had any diagnosis [prerenal, renal, postrenal] that may increase serum creatinine levels and who were treated for secondary renal failure by physicians were classified as renal insufficiency due to other causes and were not evaluated as PC-AKI. Patients with ARF who did not have prerenal, renal, and postrenal causes were considered a PC-AKI. Patients who had an infusion of sodium chloride solutions (0.9% and/or 0.45%) at a rate ≥100 m L/hour for at least 4 hours before administration of contrast material were described as receiving prophylactic treatment for PC-AKI. [1]

*Registration of data and statistical analysis*

The obtained data were recorded in data forms in the Statistical Package for Social Sciences for Windows 15.0''. The t-test was used to compare the difference between the two means. The Chi-square test was used to compare categorical variables. When the expected value was ≤5, it was evaluated using "the Fisher's Exact test". A p-value of <0.05 was considered statistically significant.

## Results

Among the 816 patients included in our study, 46.8% (n=382) were female and 53.2% (n=434) were male. The mean age of the patients was 61.0 ± 17.7 years (range: 18-115 years). Nephropathy developed in 75 (9.2%) of the 816 patients after administration of contrast material. When patients with prerenal, renal, and postrenal conditions that may lead to ARF were excluded, 36 (4.4%) developed PC-AKI.

The mean age of the 36 patients with PC-AKI was 67.9±13.2 years (range: 40-86 years); of them, 52.8% (n=19) were females and 47.2% (n=17) were males. There was no statistically significant difference between men and women in terms of the development of PC-AKI (p=0.574)

*Contrast media quantity*

The quantity of contrast material in the 36 patients who developed PC-AKI is shown in Table1. There was no relationship between the amount of contrast material and the development of PC-AKI (p=0.403, Table-1).

*Comorbid diseases*

The relationship between comorbid diseases and the development of PC-AKI is shown in Table-2.

*Drugs*

Twenty-six (3.2%) of 816 patients received ACE inhibitors

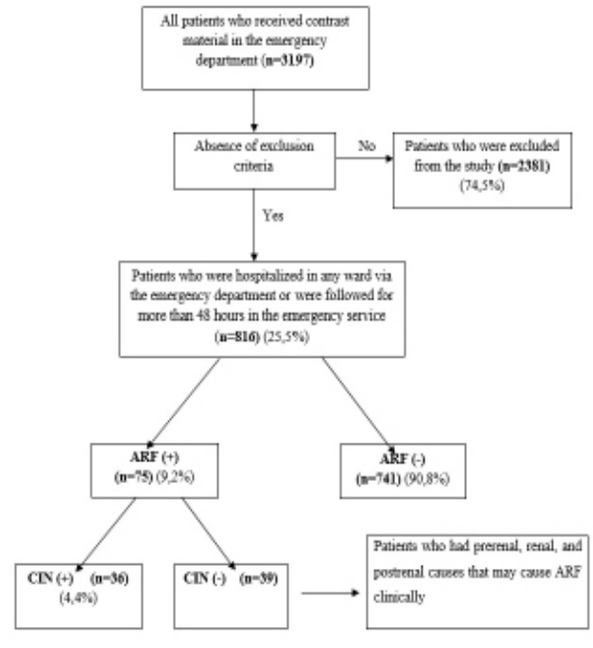


**Figure 1.** Work flow algorithm

(ACEI) in the last week. It was found that 19.2% (n=5) of them developed PC-AKI. The development of PC-AKI was higher in those treated with ACEI compared to those treated without ACEI (p=0.004).

*Prophylactic Treatment*

When the patients who received only prophylactic IV fluid were compared with the patients who did not receive prophylactic IV fluid, there was no difference between them in terms of the development of PC-AKI (p>0.05).

*Blood Pressure*

Among the 36 patients who developed PC-AKI, 63.9% (n=23) were normotensive, 13.9% (n=5) were hypotensive, and 22.2% (n=8) were hypertensive. Hypotensive patients had a higher risk of developing PC-AKI compared with normotensive patients (p=0.035). There was no difference between hypertensive patients and normotensive patients in terms of the development of PC-AKI (p=0.103).

**Table 1.** Relationship between the amount of contrast material and the development of PC-AKI

| | PC-AKI (+) | | PC-AKI (-) | | Total | |
|---|---|---|---|---|---|---|
| | Number (n) | Percentage (%) | Number (n) | Percentage (%) | Number (n) | Percentage (%) |
| ≤50 mL | 2 | 9.5 | 19 | 90.5 | 21 | 100.0 |
| 50-100 mL | 18 | 4.8 | 356 | 95.2 | 374 | 100.0 |
| ≥100 mL | 16 | 3.8 | 405 | 96.2 | 421 | 100.0 |
| Total | 36 | 4.4 | 780 | 95.6 | 816 | 100.0 |

( p=0.403)

**Table 2.** Relationship between comorbid diseases and the development of PC-AKI

| Diseases | | PC-AKI (+) n (%) | PC-AKI (-) n (%) | Total n (%) | p-value |
|---|---|---|---|---|---|
| HT | No | 537 (97.1) | 16 (2.9) | 553 (100.0) | = 0.004 |
| | Yes | 243 (92.4) | 20 (7.6) | 263 (100.0) | |
| DM | No | 675 (96.4) | 25 (3.6) | 700 (100.0) | = 0.009 |
| | Yes | 105 (90.5) | 11 (9.5) | 116 (100.0) | |
| CHF | No | 738 (96.0) | 31 (4.0) | 769 (100.0) | = 0.076 |
| | Yes | 42 (89.4) | 5 (10.6) | 47 (100.0) | |
| Malignancy | No | 664 (95.7) | 30 (4.3) | 694 (100.0) | = 0.955 |
| | Yes | 116 (95.1) | 6 (4.9) | 122 (100.0) | |
| COPD/Asthma | No | 725 (96.0) | 30 (4.0) | 755 (100.0) | = 0.069 |
| | Yes | 55 (90.2) | 6 (9.8) | 61 (100.0) | |
| CVD | No | 725 (95.8) | 32 (4.2) | 757 (100.0) | = 0.555 |
| | Yes | 55 (93.2) | 4 (6.8) | 59 (100.0) | |
| Total | | 780 (95.6) | 36 (4.4) | 816 (100.0) | |

PC-AKI: post-contrast acute kidney injury, HT: hypertension, DM: diabetes mellitus, CHF: congestive heart failure, COPD: Chronic obstructive pulmonary disease, CVD: cerebrovascular disease,

**Table 3.** Relationship between the development of PC-AKI and mortality

| | PC-AKI (+) n (%) | PC-AKI (-) n (%) | Total n (%) |
|---|---|---|---|
| Death (+) | 17(47.2) | 107 (13.7) | 124(15.2) |
| Death (-) | 19(52.8) | 673(86.3) | 692(84.8) |
| Total | 36 (100.0) | 780 (100.0) | 816 (100.0) |

(p<0.001)

*Surgical Intervention*

Among the 816 patients, 80.8% (n=659) did not undergo surgical intervention within 48 hours after administration of contrast material, whereas 19.2% (n=157) underwent surgical intervention. When the patients were compared for surgical intervention, there was no difference between them in the development of PC-AKI (p=0.2940).

*HD Necessity*

Among the 36 patients who developed PC-AKI, 94.4% (n=34) did not undergo HD, whereas 5.6% (n=2) underwent HD.

Prognosis after nephropathy

Among the 36 patients who developed PC-AKI, creatinine levels returned to baseline during follow-up in 50.0% (n=18). However, 47.2% (n=17) were clinically dead. We determined that one patient developed nephropathy with a lower creatinine clearance rate.

*Duration of hospitalization*

It was found that the average length of hospital stay was 13.9±17.6 days (range: 2-205 days). The average length of hospital stay was 22.2±41.7 days (range: 2-205 days) in the patients with PC-AKI and 13.5±15.5 days (range: 2-205 days) in the patients without PC-AKI, respectively. The average length of stay in the hospital was approximately two times higher in the patients with PC-AKI than in the patients without PC-AKI. (p<0,001)

*Clinical Outcomes*

The mortality rate was found to be higher in the patients with PC-AKI than in the patients without PC-AKI (p<0.001, Table-3).

## Discussion

Nash et al. [4] determined that PC-AKI was the third most common cause of ARF in hospitalized patients. However, the number of studies on the incidence of PC-AKI in EDs is very limited in the current literature. The majority of the studies were performed in patients who underwent percutaneous coronary intervention (PCI). Studies reported the incidence of PC-AKI changing between 2,9% and 11% [5-7]. A large, single-center study reported that contrast agent did not increase acute renal failure in contrast to what is known [8]. In our study, the incidence of PC-AKI was found to be 4.4%. Our result is lower compared to other studies. In our study, because we could not evaluate patients discharged from the ED after administration of contrast material, it is not possible to mention precisely the incidence of PC-AKI in all patients in the ED. However, monitoring of patients in hospital wards is associated with the severity of the condition leading to emergency service applications. The fact that the incidence of PC-AKI was low in these patients despite the comorbid diseases suggests that contrast-enhanced diagnostic tests can be performed safely in these patients in the ED.

Previous studies have reported that the female gender is a risk factor for the development of PC-AKI. [3,9,10] In our study, there was no statistically significant difference between the genders in terms of the development of PC-AKI.

While Bartholomew et al. [11] considered a contrast agent dose ≥ 260 mL as a high-risk factor, Mehran et al. [3] determined a contrast agent dose ≥150 mL as an independent risk factor. Marenzi et al. [12] reported that a contrast agent dose ≥ 300 mL

was an independent risk factor. However, it was reported that PC-AKI can be seen even at doses as low as 30 mL in very high-risk patients [13]. The PC-AKI Consensus Working Panel accepts that the use of contrast agent ≥100 ml increases the risk of developing PC-AKI [14]. In our study, there was no relationship between the amount of contrast material and the development of PC-AKI. In a study of 114 patients, they reported that the use of contrast agent ≤100 mL did not increase the risk of developing PC-AKI [15]. Unlike our study, only patients with serum creatinine levels <1.5mg/dl were included in this study. When the results of our study are evaluated, it can be said that there is no need to reduce the amount of contrast agent used in CT imaging in order to prevent PC-AKI in emergency services. Several studies have shown that DM increased the risk of developing PC-AKI [3,11, 12,16]. In our study, we found that the development of PC-AKI was significantly higher in diabetic patients. This result is not surprising because diabetic patients tend to develop nephropathy, take medication excessively and are at greater risk of developing secondary diseases such as HT and CAD, which may be associated with kidney diseases. Studies reported that HT was a risk factor for the development of PC-AKI [3,9,16]. We found that there was a statistically significant increase in the risk of developing PC-AKI in the patients with HT. Further studies are needed to assess whether this is due to the primary effect of HT on the kidneys or to antihypertensive drugs used by these patients. Previous studies have reported that CHF increased the risk of developing PC-AKI [3,16,17]. In our study, there was no increase in the risk of developing PC-AKI in patients with CHF. We think that this is due to the fact that, unlike many other studies, our study was performed not only on patients who underwent PCI for cardiac problems, but also on patients who were admitted to the ED and received contrast material. ACEI have been defined as a risk factor for the development of PC-AKI due to their nephrotoxic effects [18]. Similarly, we found that the development of PC-AKI was higher in those treated with ACEI.

Many treatment methods have been tried for preventing the development of PC-AKI. Studies have shown that the development of PC-AKI significantly decreased if IV fluids were given at a rate of 100-150 mL/hour during 12 hours before and after PCI. [19] In our study, there was no significant difference between patients treated with and without IV fluids.

Hypotension has been defined as a risk factor for the development of PC-AKI [3,20]. Similarly, we found that hypotension was a risk factor for the development of PC-AKI. It is not surprising that the risk of PC-AKI development increased in these patients due to the effect of hypotension on the kidneys.

Many studies have been shown that ARF after surgical intervention was most commonly seen in patients who underwent cardiovascular surgery [21]. Major surgery has been defined as a risk factor for developing postoperative ARF. The most common cause of postoperative ARF is hemodynamic instability that occurs during the surgery (hypotension) [21]. In our study, there was no difference in the development of PC-AKI between patients treated with and without surgical intervention within 48 hours after administration of contrast material. We think that this is due to the fact that the majority of previous studies have been performed on patients undergoing PCI, and cardiac surgery has been frequently made after the procedure in these patients. However, in the literature, we could not find any study comparing the incidence of PC-AKI between other surgical procedures.

The need for dialysis after PC-AKI varies according to the risk factors of the patient at the time of contrast administration, but is usually less than 1% [14]. In a study by Nikolsky et al. [22], it accounted for 3.1%. We found that 5.6% of patients with PC-AKI underwent dialysis. Studies have reported that PC-AKI was associated with prolonged hospital stay [16,20,22]. Similar to other studies, we had the same result.

Many studies have been published on the relationship between PC-AKI and short- and long-term mortality. In previous studies, mortality rates in patients with PC-AKI ranged from 7.1 to 39, and between 1.1-1.4 in patients without PC-AKI [9,16,22,23]. We found that the mortality rate was 47.2% in patients with PC-AKI and 13.7% in patients without PC-AKI, respectively. Our patient population consisted mainly of elderly patients with comorbid diseases. Even a small reduction in renal function due to contrast material in the presence of comorbid conditions may lead to higher morbidity rates.

### *Limitations*

Firstly, similar to other retrospective cross-sectional studies, information of all patients was not reached. Patients who were hospitalized for 48 hours or more after taking CT in the ED were included in the study.

### *Conclusion*

Patients who had a history of HT and DM, who received ACEI within the last 1 week and who had hypotension on admission to the ED were at a higher risk of developing PC-AKI. It was determined that only 5.6% of the patients with PC-AKI required HD and that the patients with PC-AKI had a two-fold longer length of hospital stay.

***Scientific Responsibility Statement***

*The authors declare that they are responsible for the article's scientific content including study design, data collection, analysis and interpretation, writing, some of the main line, or all of the preparation and scientific review of the contents and approval of the final version of the article.*

***Animal and human rights statement***

*All procedures performed in this study were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. No animal or human studies were carried out by the authors for this article.*

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***Conflict of interest***

*None of the authors received any type of financial support that could be considered potential conflict of interest regarding the manuscript or its submission.*

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