RESEARCH LETTER

Post-contrast acute kidney injury following computed tomography: a real or overestimated threat?

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Introduction Post-contrast acute kidney injury (PC-AKI) has been studied since 1945. The greater availability of computed tomography (CT), angiography, or endovascular interventions may result in a higher occurrence of PC-AKI. However, this assumption is not confirmed by the latest reports.[1]

An accurate estimation of the incidence of PC-AKI following intravenous administration of iodinated contrast media is problematic for many reasons. First, it is difficult to establish clear nomenclature and definitions. It is currently recommended to use the term PC-AKI when AKI has developed within 48 hours of administration of the contrast medium. Contrast-induced acute kidney injury (CI-AKI) is an additional term, which denotes a disease that can be diagnosed only in the case of AKI with a proven relationship to contrast administration. Acute kidney injury should be recognized according to the Kidney Disease: Improving Global Outcomes (KDIGO) definition (an increase in serum creatinine by more than 25% or 44 μmol/l, or 0.5 mg/dl) to avoid disparity in determining the incidence of PC-AKI, which occurred in previous studies.[2] However, the definition of AKI is still debatable as reviewed recently.[3] In addition, different definitions of CI-AKI may have various prognostic stratification potentials.[4,5] Slocum et al[4] reported that the traditional definition of CI-AKI (a rise in serum creatinine ≥0.5 mg/dl) in patients undergoing percutaneous coronary interventions was superior to an increase in creatinine levels higher than or equal to 25% when identifying patients at a greater risk for adverse renal and cardiac events. Pyxaras et al[5] defined CI-AKI according to a postprocedural creatinine level increase higher than or equal to 0.3 mg/dl or according to the postprocedural (transcatheter aortic valve implantation) decrease of the creatinine clearance of at least 25%. They reported that definition of CI-AKI based on creatinine clearance had a higher prognostic accuracy compared with the definition based on absolute alterations in creatinine levels.

The remaining confounders can be divided into patient- and procedure-dependent. Patient-related risk factors are: age, comorbidities, and potentially nephrotoxic drugs.[3] Procedure-dependent risk factors include the type and amount of the contrast medium administered, the method of administration (intravenous or intra-arterial), and prevention methods used. Based on numerous studies, there is no difference in the incidence of PC-AKI following the administration of either iso-osmolar or low-osmolar contrast media.[6] On the other hand, dosing of contrast media plays a crucial role in intra-arterial administration. There is insufficient evidence to confirm the hypothesis that the intravenous dose reduction of a contrast medium, eg, in computed tomography (CT), reduces the risk of PC-AKI.[3] The role of adequate hydration as a preventive measure prior to administration of the contrast agent is emphasized.[7]

Limited or conflicting data on CI-AKI lead to fear of performing diagnostic tests using iodinated contrast media. Further consequences of these concerns are misunderstandings between clinicians and radiologists, as well as delays in diagnosis and therapy.[3] The aim of our study was to determine the incidence of acute kidney damage in patients undergoing CT with or without iodinated contrast media. Other risk factors for AKI were also considered in both study groups to confirm the association between iodinated contrast medium administration and deterioration in renal function.

Patients and methods The purpose of our study was to analyze all CT examinations performed at our Department of Nephrology, Dialysis and Internal Medicine within 3 months, from

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TABLE 1 Renal function assessed by serum creatinine levels and estimated glomerular filtration rate in patients undergoing computed tomography with and without contrast

Parameter		Before CT	1–7 d after CT	14–28 d after CT	>28 d after CT
CT with contrast	Creatinine, µmol/l	83 (42–772)	81 (48–631)	82 (42–570)	103 (46–516)
	eGFR, ml/min/1.73 m^2	68 (60–120)	73 (70–115)	77 (80–116)	58 (80–116)
CT without contrast	Creatinine, µmol/l	156 (58–767)[a]	179 (54–635)[b]	143 (64–408)	128 (35–196)
	eGFR, ml/min/1.73 m^2	52 (5–120)[a]	34 (7–120)[b]	76 (22–120)	41 (27–98)

Data are presented as median (minimum–maximum).

a P <0.05 for computed tomography with and without contrast

b P <0.01 for computed tomography with and without contrast

Abbreviations: CT, computed tomography; eGFR, estimated glomerular filtration rate

September to November 2019. In total, 188 examinations were considered, including 123 using iodinated contrast media. A total of 36 examinations performed in patients undergoing chronic or peritoneal dialysis were excluded from the analysis. The decision to perform tomography with or without contrast media was made based on clinical indications. It cannot be totally excluded that it was also affected by renal function and fear of contrast administration. We considered the number of examinations, not patients, because some patients underwent CT several times during hospitalization.

The data considered in each case can be divided into those concerning the procedure and the patient. Regarding CT, the scope of examination and the type and amount of the contrast medium used (if applicable) were analyzed. Demographic characteristics and data on comorbidities were obtained from the study patients. Renal function was assessed by measuring serum creatinine levels and glomerular filtration rate (GFR) at 4 timepoints: before CT and during 1 to 14, 15 to 28, and over 29 days after CT. The collected data were then analyzed for the incidence of CI-AKI (ie, serum creatinine levels increased by more than 25% or 0.5 mg/dl) and its possible risk factors. Estimated GFR was calculated using the Chronic Kidney Disease Epidemiology Collaboration (CKD-EPI) formula. No ethics committee approval was required for this study.

Statistical analysis Study results were presented as percentage for categorical values and mean (SD) for normally distributed variables. For nonnormally distributed variables, median and minimum–maximum values were given. Data were analyzed using the Statistica software, version 13.1 (Tulsa, Oklahoma, United States). To assess statistical significance, the t, χ^2, and Mann–Whitney tests were applied accordingly. The Kruskall–Wallis analysis of variance for repeated measurements was also used. A P value less than 0.05 was considered significant.

Results We analyzed 188 CT examinations during 3 months, of which 123 were contrast--enhanced. Iopromide (370 mg/ml) was the most commonly used contrast medium in our center—50% of all examinations were performed with this agent. Iomeprol (350 mg/ml) came second with 36% of examinations. Most CT scans were performed in a standard mode, but as many as 44.8% of contrast-enhanced CT examinations were conducted urgently. Contrast-enhanced CT scans of the abdomen, chest, both, or other body parts were performed in 28.45%, 21.14%, 38.2%, and 12.2% of the patients, respectively. Non–contrast-enhanced computed tomography of the abdomen, chest, both, or other body parts was performed in 20.7%, 20.7%, 17.2%, and 41.4% of the patients, respectively. The prevalence rates of CT with and without contrast of various body parts were similar. In both study groups (undergoing CT with or without contrast), the age of the study participants was similar, and sex distribution identical. All the above data and comorbidities together with the basic parameters of renal function in the study patients are presented in Supplementary material, *Table S1*. Of note, the study group undergoing CT with a contrast agent had a lower median serum creatinine concentration before and after the procedure compared with CT without contrast (TABLE 1). Looking at the mean serum creatinine level at follow-up, there were no significant differences between the 2 study groups. Only a month after contrast administration, the mean serum creatinine level increased, but it was due to other reasons (eg, heart failure, sepsis, and/or medications). However, interesting observations can be made when analyzing each case of CI-AKI (as defined by the KDIGO). In the study group undergoing CT with contrast, AKI occurred in 4 cases (3.25% of the study patients), whereas in the study group undergoing CT without contrast, in 2 cases (6.9%) with subsequent sepsis. This cannot be fully explained by comorbidities, because the most important risk factors for AKI occurred with similar frequency in both groups. Diabetes (25% vs 17%), cancer (23.6% vs 20.7%), and liver failure (6.5% vs 3.4%) were slightly more common in the study group undergoing contrast-enhanced CT. On the other hand, patients undergoing CT without contrast had more often chronic kidney disease, acute kidney injury, and anemia.

Discussion In our study, we did not show a significantly higher incidence of AKI after contrast-enhanced CT compared with CT without contrast. Aycock et al[8] reached similar conclusions in their meta-analysis. In addition, they showed no difference in the need for renal replacement therapy and mortality between both types of CT examination. Of note, in studies of the population at a higher risk of AKI and with worse prognosis, namely individuals from emergency departments and intensive care units, no greater occurrence of PC-AKI was noted.[9,10] Considering our findings and results of other authors mentioned above, it can be concluded that contrast-enhanced CT is relatively safe for kidney function.

Interestingly, we observed that the risk of AKI is comparable in patients undergoing CT with and without contrast. This is contrary to the common consensus and it might be stated that iodinated contrast media have a positive effect on kidney function. In the study by Haveman et al,[11] in which contrast-enhanced CT was performed in surgical patients at intensive care units, a decrease in serum creatinine levels was observed after contrast administration. This tendency was also seen after repeated contrast-enhanced CT.[12]

We do not suggest that contrast media are completely safe and free of renal complications. However, it would be worth separating intravenous and intra-arterial contrast administration procedures. Undeniably, intra-arterial iodine contrast media (first- or second-pass renal exposure) can cause PC-AKI by directly affecting the epithelial and endothelial cells, vasoconstriction, and reducing blood perfusion. The incidence of PC-AKI after intra-arterial contrast administration is low and even lower after intravenous administration.[3] Therefore, it would be reasonable to design appropriate protocols and determine preventive measures separately for each type of iodine contrast–enhanced CT.

We can only guess how many patients may have delayed or modified diagnosis, therapy, or outcomes because of fear of PC-AKI. An example would be a survey of radiologists, members of the American College of Radiology, on contrast-enhanced CT in patients with multiple myeloma or monoclonal gammopathy: as many as 36% of the participants did not consider this diagnostic tool in patients with myeloma.[13]

We compared the creatinine levels before and after CT with and without contrast to assess the prevalence of CI-AKI in the cohort of patients hospitalized during the consecutive 3 months. We found no significantly greater occurrence of AKI after contrast-enhanced CT compared with CT without contrast. According to our experience, high-risk patients (particularly with chronic kidney disease) are often admitted to the hospital for contrast-enhanced CT, because they had been denied CT on an ambulatory basis. In addition, when CT without contrast is nondiagnostic, then contrast-enhanced CT is performed, so patients are exposed to more radiation, time to diagnosis is longer, and treatment could be thus delayed as well. Moreover, hospitalized patients may also be unnecessarily exposed to hospital-acquired infections.

Conclusions The incidence of AKI is not significantly higher after contrast-enhanced CT. However, our study was conducted in a small and heterogeneous group of patients. If our findings are confirmed in a larger population, contrast-enhanced CT should not be denied, as it may turn to be a relatively safe procedure considering the development of AKI due to contrast media. Moreover, contrast-enhanced CT, if indicated, may be even life-saving, as it enables clinicians to make the proper diagnosis, provide effective treatment, and obtain favorable outcomes.

SUPPLEMENTARY MATERIAL

Supplementary material is available with the article at www.mp.pl/paim.

ARTICLE INFORMATION

CONTRIBUTION STATEMENT IC and JM conceived the study concept. IC and MK collected the data. IC and JM analyzed the data. All authors edited and approved the final version of the manuscript.

CONFLICT OF INTEREST None declared.

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