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Acute Kidney Injury in Patients With Chronic Kidney Disease Undergoing Internal Carotid Artery Stent Implantation

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ABSTRACT

OBJECTIVES This study sought to investigate acute kidney injury (AKI) following carotid artery stenting (CAS).

BACKGROUND Few data exist on AKI following CAS.

METHODS This study evaluated 126 chronic kidney disease (CKD) patients who underwent CAS. The risk for contrast-induced AKI was defined by the Mehran score. Hemodynamic depression (i.e., periprocedural systolic blood pressure <90 mm Hg or heart rate <60 beats/min), AKI (i.e., an increase of ≥0.3 mg/dl in the serum creatinine concentration at 48 h), and 30-day major adverse events (including death, stroke, and acute myocardial infarction) were assessed.

RESULTS AKI occurred in 26 patients (21%). Although baseline kidney function and contrast volume were similar in the AKI group and the non-AKI group, the risk score was higher (10 ± 3 vs. 8 ± 3; p = 0.032), and hemodynamic depression (mostly due to hypotension) (65.5% vs. 35%; p = 0.005) was more common in the AKI group. The threshold of hemodynamic depression duration for AKI development was 2.5 min (sensitivity 54%, specificity 82%). Independent predictors of AKI were hemodynamic depression (odds ratio [OR]: 4.01; 95% confidence interval [CI]: 1.07 to 15.03; p = 0.009), risk score (OR: 1.29; 95% CI: 1.03 to 1.60; p = 0.024), and male sex (OR: 6.07; 95% CI: 1.18 to 31.08; p = 0.021). Independent predictors of 30-day major adverse events that occurred more often in the AKI group (19.5% vs. 7%; p = 0.058) were AKI (HR: 4.83; 95% CI: 1.10 to 21.24; p = 0.037) and hemodynamic depression (HR: 5.58; 95% CI: 1.10 to 28.31; p = 0.038).

CONCLUSIONS AKI in CKD patients undergoing CAS is mostly due to hemodynamic depression and is associated with a higher 30-day major adverse events rate. (J Am Coll Cardiol Intv 2015;8:1506–14) © 2015 by the American College of Cardiology Foundation.

Chronic kidney disease (CKD) has been associated with increased morbidity and mortality after coronary revascularization (1). In contrast, there are only limited and conflicting data on the impact of CKD in patients undergoing carotid revascularization (2,3). Although some data support the concept that CKD represents an independent predictor of unfavorable outcome even following carotid artery stenting (CAS) (3-6), others refute this association (2,7). A potential reason of these conflicting results is the paucity of data on post-procedural acute kidney injury (AKI). Indeed, small changes in serum creatinine (sCr) after surgery or interventional procedures are recognized as strong independent predictors for short- and long-term mortality (8). AKI following CAS may occur because of iodinated contrast media (CM) and hemodynamic depression. These 2 factors are not mutually exclusive but may act together in causing AKI. CM is a well-recognized cause of AKI. Hemodynamic depression, which occurs in 7% to 42% of patients undergoing coronary artery stenting (CAS) (9-12), might also

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have an important role in the pathogenesis of AKI (13).

In the present study on CKD patients undergoing CAS, we assessed the following: 1) the rate of AKI; 2) the role of CM and hemodynamic depression in the pathogenesis of AKI; and 3) the correlation between AKI and 30-day major adverse events (MAE)—death, stroke, and myocardial infarction.

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METHODS

PATIENT POPULATION. CKD patients (with estimated glomerular filtration rate [eGFR] ≤60 ml/min/1.73 m^2) scheduled for CAS at the Clinica Mediterranea from February 2, 2009 to September 17, 2013 were screened. Exclusion criteria were recent (≤48 h) administration of iodinated CM, dialysis, contraindication to aspirin and thienopyridines, and current enrollment in any other study. All patients who met the inclusion/exclusion criteria and signed an informed consent were included into the study. Patients were classified as symptomatic if they had experienced a recent transient ischemic attack, stroke, or transient monocular blindness ipsilateral to the study artery in the preceding 180 days before randomization. Otherwise, they were classified as asymptomatic.

STENTING TECHNIQUE. All patients were considered to be suitable for CAS, according to 2011 recommendations (14). All stenting procedures were performed according to the recommendations and without the induction of general anesthesia and/or sedation. A protection device was used in all instances. Balloon pre-dilation was performed only in case of failure of direct stenting. Self-expanding stents were used in all instances. Stents were classified according to alloy: 1) braided Elgiloy (Carotid Wallstent, Boston Scientific, Natick, Massachusetts); and 2) nitinol stents (X-Act and Acculink [Abbott Vascular Devices, Redwood City, California]; Precise [Cordis, Miami Lakes, Florida]; Crystallo Ideale [Medtronic Inc., Minneapolis, Minnesota]; Protegè (ev3, Plymouth, Minnesota); Sinus Carotid RX (Optimed, Ettlingen, Germany). Furthermore, stents were divided according to cell design: 1) closed cells: Carotid Wallstent and X-Act; 2) open cells: Precise and Protegè; and 3) hybrid: Crystallo Ideale, and Sinus Carotid RX. Balloon post-dilation was routinely performed with a 5.0-mm balloon. All patients received atropine (1.0 mg intravenously) before balloon post-dilation to minimize hemodynamic depression. Unfractionated heparin (10,000 IU) was administered intravenously at the beginning of the procedure. All patients received aspirin (100 mg/day) and clopidogrel pre-load (600 mg) 24 h before the procedure. After the procedure, clopidogrel was continued for at least 1 month, whereas aspirin was continued for life. The severity of stenosis was quantified using the NASCET (North American Symptomatic Carotid Endarterectomy Trial) criteria (15). A baseline cranial computed tomogram was obtained in all patients. Neurologic evaluations were performed every 6 h or more frequently if the patient experienced any clinical deterioration.

We measured sCr the day before the procedure and at 24 h, 48 h, and 1 week after CM administration. Additional measurements were performed in case of a deterioration of baseline renal function. We calculated eGFR by applying the Modification of Diet in Renal Disease formula (16). CKD was defined as an eGFR <60 ml/min/1.73 m^2. The risk for predicting contrast-induced AKI was calculated according to Mehran et al. (17).

Heart rate and blood pressure were assessed continuously during the procedure. After the procedure, patients were transferred to the post-interventional care unit, where heart rate and blood pressure were monitored continuously. Hemodynamic depression was defined as symptomatic or asymptomatic hypotension (systolic blood pressure <90 mm Hg) or bradycardia (heart rate <60 beats/min) at any time during or within the first 24 h after stent deployment (9,10,12,18). Treatment includes intravenous fluid boluses (≥500 ml), followed by the addition of dopamine (starting from 5 mg/kg/min). Patients who required continuous vasopressor infusion after CAS were considered to have persistent hemodynamic depression (9).

Contrast-induced AKI prophylaxis strategies were as follows: 1) in patients with eGFR 30 to 59 ml/min/1.73 m^2, hydration with sodium bicarbonate solution (154 mEq/l) plus high dose of N-acetylcysteine (NAC) (19); or 2) in patients with eGFR <30 ml/min/1.73 m^2, hydration with normal saline plus NAC controlled by the RenalGuard system (PLC Medical Systems, Franklin, Massachusetts) (19). Although the results on the use of NAC are conflicting, experimental studies demonstrated that NAC exerts its antioxidant properties preventing kidney cell death by inhibiting oxygen free radical production and thus stress kinases and apoptosis activation upon CM exposure (20). Iodixanol (Visipaque, GE Healthcare, Princeton, New Jersey) was used in all patients. In order to identify patients receiving a high-contrast load, the following weight- and creatinine-adjusted maximum contrast dose formula was used: 5 × kilograms of body

ABBREVIATIONS AND ACRONYMS

AKI = acute kidney injury
CAS = carotid artery stenting
CI = confidence interval(s)
CKD = chronic kidney disease
CM = contrast media
eGFR = estimated glomerular filtration rate
IQR = interquartile range
MAE = major adverse event(s)
NAC = N-acetylcysteine
OR = odds ratio(s)
sCr = serum creatinine