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Multimodality imaging evaluation before transcatheter aortic valve implantation: incidence of contrast medium-induced acute kidney injury, risk factors and prognosis

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AIM: To evaluate the incidence, risk factors, and prognostic implications of contrast medium-induced acute kidney injury (CI-AKI) in patients undergoing transcatheter aortic valve implantation (TAVI) evaluation.

MATERIALS AND METHODS: Datasets from 98 out of 207 consecutive patients referred for multidetector computed tomography (MDCT) for TAVI evaluation were eligible for evaluation and were analysed retrospectively. The incidence of CI-AKI was correlated to outcome and to potential risk factors: kidney function (estimated glomerular filtration rate [eGFR]), heart failure, diabetes, amount of contrast medium, and duration of examination period.

RESULTS: CI-AKI occurred in 67 patients (68.4%) and mainly correlated with eGFR (p=0.01) and the amount of contrast medium as a function of eGFR (p=0.04). CI-AKI occurred before TAVI in 36 (53.7%) patients of which 13 (19.4%) did not undergo TAVI. In-hospital all-cause mortality was 21.4%, and of those 21 patients, 18 (85.7%) had CI-AKI and nine (42.9%) did not undergo TAVI. One-year all-cause mortality was 39.8%, and of those 39 patients who died within 1 year, 31 (79.5%) had CI-AKI.

CONCLUSION: CI-AKI mostly occurs already before TAVI as a consequence of pre-procedural imaging, which therefore represents the main contributor for CI-AKI in relation to TAVI. Regarding the observation that some patients will ultimately have no benefit because TAVI is not performed and the poor prognosis linked to CI-AKI should encourage improvement in patient selection when referring to pre-procedural imaging.

Introduction

Transcatheter aortic valve implantation (TAVI) has emerged as the treatment of choice for patients with severe aortic stenosis considered inoperable or at high risk for

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surgery. Pre-procedural evaluation of TAVI candidates requires, among others, imaging with coronary angiography (CA) and multidetector computed tomography (MDCT). Both procedures require the use of parenteral iodinated contrast media (ICM), administered intra-arterially or intravenously, respectively.[1–3] Patients also receive ICM intra-arterially during TAVI itself. ICM carry the risk of nephrotoxicity and acute kidney injury (AKI) can occur, especially in patients with known risk factors, which is termed contrast medium-induced acute kidney injury (CI-AKI) when ICM can be assumed as the cause.[4–6] Risk factors for CI-AKI are patient-related (impaired kidney function, particularly secondary to diabetic nephropathy, congestive heart failure, and age >70 years) and procedure-related (high doses of ICM and repeated studies with ICM within a short period of time). Prophylactic strategies to avoid CI-AKI are intravenous hydration and the avoidance of procedure-related risk factors.[7] The development of CI-AKI is, among other adverse events, associated with a higher short-term and long-term mortality.[8–10] Many studies have investigated the incidence, risk factors, and prognostic implications of CI-AKI following TAVI[11–18] and clinical outcomes following TAVI, particularly with regard to renal dysfunction[19–22]; however, these studies have not specifically investigated the impact of preparatory imaging with ICM, which puts patients at risk for developing CI-AKI before TAVI. To the authors' knowledge, there has been only one study investigating the incidence and risk factors of CI-AKI following MDCT before TAVI.[23] The aim of the present study, therefore, was to evaluate the incidence, risk factors, and prognostic implications of CI-AKI in patients undergoing TAVI evaluation.

Materials and methods

Patient selection

The local ethics committee approved the protocol for this retrospective cohort study. Data from consecutive patients considered for TAVI who underwent MDCT and/or CA for pre-procedural evaluation were evaluated. Patients were excluded if they were already undergoing chronic haemodialysis or when the results of their kidney function blood tests (serum creatinine, SCr) were not consistently available before and at least every 48 hours during the evaluation period. The evaluation period started with the first contrast-enhanced examination, MDCT or CA, and ended 7 days after AKI occurred or, when AKI did not occur after the first contrast-enhanced examination, 7 days after the last contrast-enhanced examination.

Data and definitions

The following data were collected for each patient: age, gender, kidney function within a time period of 7 days before (baseline period, to assess SCr variability in the absence of ICM) and 7 days after ICM administration (evaluation period), stage of chronic kidney disease (CKD) at baseline, left ventricular ejection fraction (LVEF, from transthoracic echocardiography), diabetes, ICM volume (from MDCT and CA), and length of examination period (days between the first and the last contrast-enhanced examination). Additionally, the amount of ICM per day was calculated to assess ICM load per time. Kidney function was expressed as estimated glomerular filtration rate (eGFR) calculated from SCr using the Modification of Diet in Renal Disease (MDRD) formula: $186 \times SCr^{-1.154} \times age^{-0.203}$ ($\times 0.742$ for female patients). CKD was staged according to the Kidney Disease: Improving Global Outcomes (KDIGO) guideline.[24] Congestive heart failure was assumed when the LVEF was ≤50% as determined by echocardiography. AKI was diagnosed and staged according to the KDIGO and Valve Academic Research Consortium-2 (VARC-2) criteria[4,18,25] and was assumed to be contrast medium-induced when MDCT or CA were performed within the prior 72 hours. In brief, AKI was diagnosed when the SCr increased by ≥0.3 mg/dl within 48 hours or to ≥1.5 times baseline. The MDCT technique was as described in detail elsewhere[26] and the amount of ICM for MDCT was 100 ml in every patient, which is appropriate for MDCT angiography before TAVI[27]; for CA variable amounts of ICM were used (iopromide, 370 mg iodine/ml; Ultravist, Bayer Vital, Leverkusen, Germany). To determine in-hospital and 1-year all-cause mortality, records were reviewed or telephone interviews were conducted.

Statistical analysis

Outcome variables were defined as the presence or absence of CI-AKI, in-hospital and 1-year all-cause mortality. Categorical variables (gender, LVEF ≤ 50%, diabetes) were expressed as numbers (percentages) and continuous variables (age, eGFR, ICM, examination period) were expressed as mean (95% confidence interval [CI]). The Shapiro–Wilk test was used to test the normality of the data. Categorical variables were compared between outcome groups by using Pearson's χ^2 test or Fisher's exact test if applicable. Continuous variables were compared using the Mann–Whitney *U*-test, as tested variables were not normally distributed. Multivariate logistic regression with and without interaction effects was performed in order to identify significant independent predictors of CI-AKI. The regression model included all variables except age and gender. All statistical tests were two-sided and a *p*-value ≤0.05 was considered significant. Statistical analysis was performed with SPSS Statistics Version 21.0 (IBM Germany, Ehningen, Germany) and R Version 3.1.1 (R Foundation for Statistical Computing, Vienna, Austria).

Results

Of 207 consecutive patients referred for MDCT for TAVI evaluation, 109 patients had to be excluded because of haemodialysis (n=16) or because the eGFR was not available at baseline (n=17) or consistently during the evaluation period (n=76). The mean age of the population was 80.7 (79.3–82.1) years, and 49 (50%) of patients were male. The mean eGFR was 58.5 (53.6–63.5) ml/min/1.73m^2. LVEF

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