

Predictors of Contrast Volume in Transcatheter Aortic Valve Replacement

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Keywords

Contrast · Acute kidney injury · TAVR · Aortic valve replacement

Abstract

Background: Contrast-induced acute kidney injury (CIAKI) is a frequent and serious complication of transcatheter aortic valve replacement (TAVR). The most important procedural risk factor for CIAKI is contrast volume. **Objectives:** Because contrast volume is a modifiable factor that directly predicts CIAKI, we sought to identify predictors of increased contrast volume in TAVR patients. Identification of such predictors may allow both prediction and mitigation of CIAKI risk following TAVR. **Method:** We retrospectively analyzed data from consecutive patients not on hemodialysis who underwent successful TAVR at a single US center from 2013 to 2018. Using multivariable linear regression modelling, we assessed the relationships between contrast volumes and 49 patient and procedural factors hypothesized to be potential predictors. **Results:** In 295 patients, we identified 17 factors that independently predicted contrast volume, 10 of which contributed 90% of the complete model's r^2 value. Procedure year (suggesting a learning curve), aortic insufficiency,

radiation dose, prior AVR, and previous pacemaker placement were statistically the most significant predictors of CIAKI. TAVR device and diabetes were notably not predictors. **Conclusions:** To predict and reduce contrast use in TAVR, patients at risk for increased contrast volume may be identified using the predictors elucidated in this study. For such patients, strategies for contrast reduction and renal protection may be employed.

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Introduction

Contrast-induced acute kidney injury (CIAKI) is a frequent and serious complication of transcatheter aortic valve replacement (TAVR). By far, the most important procedural risk factor for CIAKI is a modifiable one, contrast volume: the relationship between contrast volume and CIAKI has been well documented in both coronary intervention and TAVR, especially when the contrast volume exceeds 2.7 times the patient's glomerular filtration rate (GFR) [1]. A 2015 meta-analysis reported that CIAKI complicates on the order of 20% of all TAVR procedures. CIAKI may lead to chronic kidney disease [2], with he-

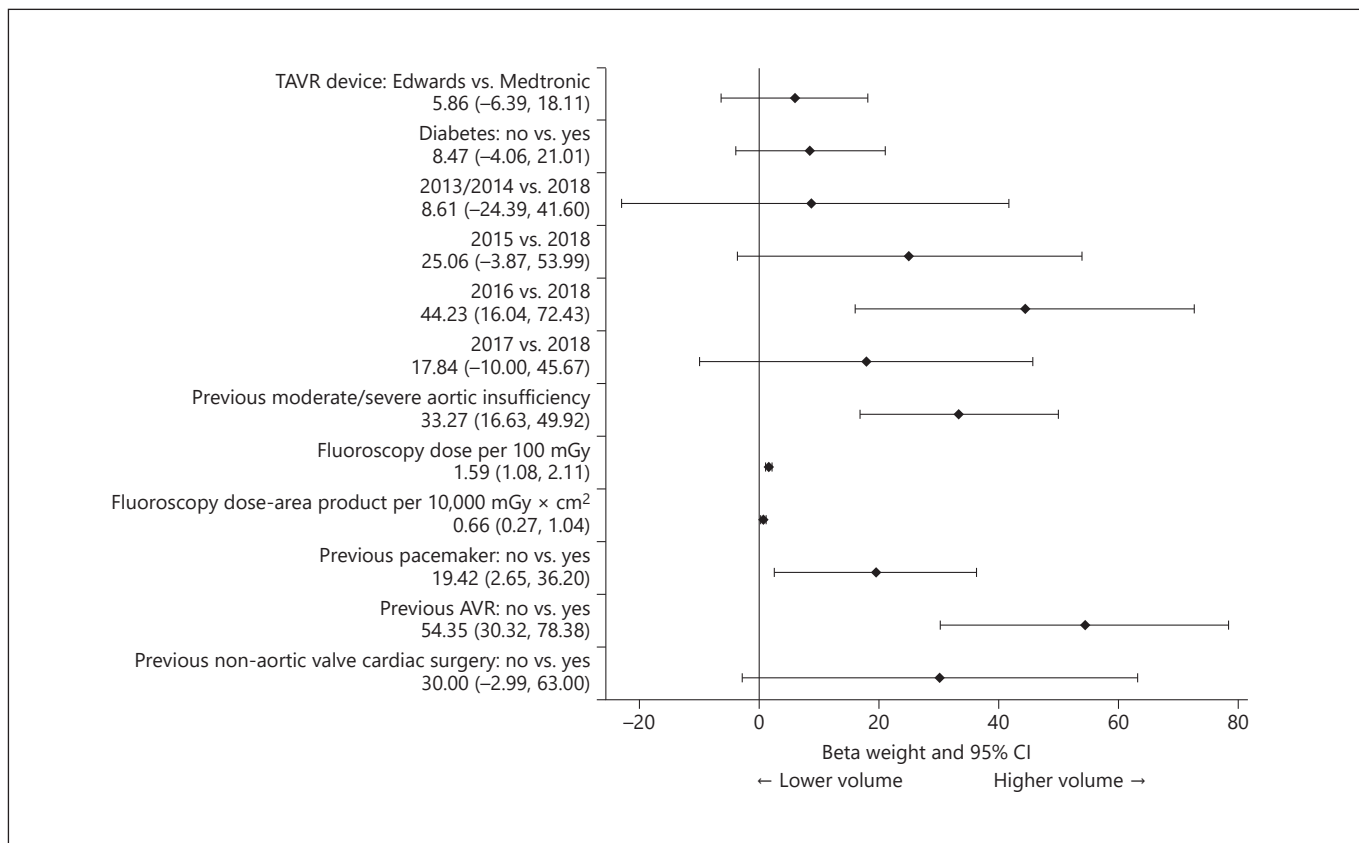


Fig. 1. Reduced model of contrast volume predictors accounting for 90% of the complete model's r^2 value (beta weights and 95% CIs). Two potentially important factors, TAVR device and diabetes, were forced into this model but emerged as non-predictors.

modialysis required in up to 10% of the cases of post-TAVR CIAKI [3]. CIAKI also predicts 4-fold higher post-TAVR mortality [4] and more than 50% increased duration of intensive care and overall hospital length of stay [5]. As contrast volume directly predicts CIAKI, identification of modifiable risk factors to reduce contrast volume may allow more accurate prediction of a patient's risk of CIAKI and will inform strategies to reduce the incidence of post-TAVR CIAKI, with its associated morbidity and mortality.

Materials and Methods

We studied consecutive patients not on hemodialysis who underwent successful TAVR without other concomitant procedures at a single US center from 2013 to 2018. The median contrast volume and percentage of patients with volume >2.7 times GFR were determined. Subsequently, 49 factors (listed in Appendix) hypothesized to affect contrast volume were analyzed, and those with $p < 0.30$ on univariate analysis were included in a multivariable linear

regression model to determine independent predictors of contrast volume. From the complete model, a reduced model of the most predictive variables was developed by backward elimination. Beta weights for the predictor variables were depicted graphically as point estimates and 95% confidence intervals (CIs).

Results

We identified a study population of 295 patients not previously on hemodialysis who underwent TAVR at a single US center from 2013 to 2018. The median contrast volume was 150 mL (interquartile range 115–185). A subset of 131 (44%) patients received volumes >2.7 times GFR. Of 17 factors that independently predicted contrast volume, 10 of the factors, depicted graphically in Figure 1, contributed 90% of the complete model's r^2 value; TAVR device and diabetes were forced into this reduced model to highlight these important factors, which emerged as non-contributors. Procedure year, prior

moderate or severe aortic insufficiency, procedural radiation dose, prior AVR, and previous pacemaker placement were statistically the most significant predictors of CIA-KI, having beta weights with 95% CIs that did not cross zero.

Discussion and Conclusion

In sum, we identified the 10 factors most strongly associated with contrast volume in TAVR, 6 of which exceeded the 95% CI threshold. Contrast reduction with successive procedure year suggests a learning curve after which contrast usage is reduced. The presence of aortic insufficiency results in contrast leaving the aortic root during diastole, requiring more contrast be injected to opacify the valve. Radiation (measured as dose or dose-area product) is required to visualize contrast, so radiation and contrast vary directly. Procedures involving patients with prior aortic valve prostheses require less contrast because the coplanar angle may be determined without injection. A previously placed pacemaker may also be used as a radiographic landmark, possibly requiring fewer contrast injections. Other variables nonsignificantly associated with contrast volume may simply be markers of procedural complexity.

Unlike most retrospective analyses, this work focused on a proven, evidence-based intervention to reduce CIA-KI: reduction of contrast volume. For the very numerous patients with known CIAKI risk factors, the predictors of high contrast volume elucidated in this study may be used to identify patients at highest risk of post-TAVR CIAKI, allowing pre-emptive modification of care including consideration of TEE-guided valve deployment or employment of contrast reduction strategies, hydration protocols, and post-procedure monitoring of renal function. Whether measures to decrease contrast volume translate into a clinical reduction in TAVR-associated CIAKI requires further study.

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Statement of Ethics

This study was approved by the University of Nebraska Medical Center (UNMC) Institutional Review Board (IRB), which waived the requirement for informed consent because only anonymized, retrospective data were used.

Disclosure Statement

The authors have no conflicts of interest to declare.

Author Contributions

A.M.G., H.D.A., and J.D.A. designed the study. A.M.G. drafted the initial manuscript. E.L. and D.K. performed and critiqued the statistical analysis and contributed to manuscript preparation and revision. G.P., D.B., Y.C., and R.J.G. collected study data and contributed to manuscript preparation and revision.

Appendix

The factors hypothesized to affect contrast volume and comprising the univariate analysis included age, gender, previous pacemaker, previous implantable cardioverter defibrillator, prior percutaneous coronary intervention, prior coronary artery bypass surgery, prior other cardiac surgery, prior aortic valve procedure, prior non-aortic valve procedure, peripheral arterial disease, hypertension, diabetes mellitus, hemodialysis, chronic lung disease, prior myocardial infarction, New York Heart Association heart failure class within 2 weeks, height, hemoglobin, albumin, predicted 1-second forced expiratory volume, weight, creatinine, right ventricular systolic pressure, left ventricular ejection fraction, aortic insufficiency, valve morphology, annular calcification, aortic valve peak velocity, aortic valve annulus size, aortic valve annular area, aortic valve mean gradient, procedure status, primary procedure indication, valve-in-valve procedure, operator reason for procedure, cardiopulmonary bypass used, valve sheath access site, valve sheath access method, valve sheath delivery size, valve manufacturer, post-procedural aortic valve gradient, post-procedure aortic valve area, radiation air kerma, radiation dose-area product, intraprocedural inotropic medications, perforation with or without tamponade, composite vascular complications (in-hospital unplanned vascular surgery/intervention, vascular access site complication requiring treatment, or major vascular complication), and procedural year.