Renoprotective Transcatheter Aortic Valve Implantation Without Contrast Media

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Summary

The therapeutic role of transcatheter aortic valve implantation (TAVI) in high surgical risk or inoperable cases has been established. Most of the candidates for TAVI are elderly and have multiple comorbidities including chronic kidney disease. However, contrast-enhanced computed tomography and coronary angiography, both of which require iodine contrast media, are essential for pre-procedural planning. In addition, TAVI could have adverse effects on kidney function including contrast media-induced nephrotoxicity. Acute kidney injury following TAVI has been reported to be related to poor prognosis. In a case with advanced renal dysfunction, we successfully avoided post-procedural acute kidney injury by performing pre-procedural evaluation using minimal contrast and TAVI without contrast media. If anatomical conditions and experiences of the heart team are adequate, renoprotective TAVI should be a favorable therapy for patients with aortic stenosis complicated by renal dysfunction.

Key words: Transcatheter aortic valve replacement, Acute kidney injury, Chronic kidney disease, Contrast-induced nephropathy

Transcatheter aortic valve implantation (TAVI) has been confirmed as a definite therapy for aortic stenosis in patients with a high or prohibitive surgical risk, and a majority of the candidates are elderly with multiple comorbidities.1-3) Previous studies reported that 64% to 87% of patients undergoing TAVI have chronic kidney disease (CKD) [estimated glomerular filtration rate (eGFR) < 60 mL/minute].4-7) For pre-procedural planning of TAVI, contrast-enhanced computed tomography (CT) and coronary angiography are conducted, both of which require iodine contrast media. For TAVI, contrast media are usually used in several steps including the assessment of iliofemoral arteries, confirmation of perpendicular view, aortography during balloon aortic valvuloplasty, navigation of valve deployment, evaluation of perivalvular leakage, and checking complications such as aortic root rupture. CKD is a risk factor of contrast-induced nephropathy (CIN), and the quantity of contrast media used is related to the occurrence of CIN. In addition, CIN is one of the major causes of post-procedural acute kidney injury (AKI) following TAVI,7 and the prognosis of patients complicated with AKI is greatly deteriorated.8-10) We report on a patient with advanced renal dysfunction undergoing TAVI, in whom post-procedural AKI was avoided by pre-procedural evaluation using minimal contrast and TAVI without contrast media.

Case Report

The case was an 83-year-old male with symptomatic severe aortic stenosis and severe coronary stenosis with calcification in the proximal right coronary artery (RCA). He also had a history of hypertension, insulin-dependent diabetes mellitus, and severe renal dysfunction (serum creatinine: 2.86 mg/dL, eGFR: 17.3 mL/minute). According to Society of Thoracic Surgeons score, the calculated risk of mortality for isolated aortic valve replacement was 12.4%, and the risk of postoperative renal failure was 27.4%. Considering his operative risk, TAVI using minimal contrast media was selected. Echocardiography showed severe aortic stenosis due to degenerative change (aortic valve area: 0.44 cm², peak aortic valve flow: 4.8 m/sec, mean transvalvular pressure gradients: 58 mmHg). Dual-source CT using only 30 mL of contrast media provided sufficient imaging information for the aortic valve, aortic root, and arterial access (Figure 1A-E, G, H). We performed coronary angiography using 20 mL of contrast media (two injections for the left coronary artery and one injection for the RCA) using biplane cineangio-

ography at selected angles (Figure 2A). Minimal use of contrast media and hydration with normal saline preserved his renal function. His aortic valve was moderately calcified, although calcification did not extend to the left ventricular outflow tract (Figure 1A). The right and left coronary heights were adequate for TAVI (Figure 1D, E). The diameter of the iliac artery was adequate for inserting the delivery sheath (Figure 1G), and access from the iliac arteries to the ascending aorta was suitable for transfemoral approach (Figure 1B). Our multidisciplinary heart team selected the treatment modality of transfemoral TAVI using a 26-mm Edwards SAPIEN 3 valve (Edwards Lifesciences, Irvine, CA, USA) combined with PCI, using as little contrast media as possible.

Under local anesthesia with sedation, we conducted TAVI using transthoracic echocardiography guidance. A 14-french e-sheath (Edwards Lifesciences, Irvine, CA, USA) was inserted into the right common femoral artery without difficulty. A guiding catheter was engaged to the RCA, and a floppy coronary guidewire was advanced to the distal RCA. We assessed the stenotic lesion and marked its location using intravascular ultrasound (Figure 2B, C). After modification using a scoring balloon, a drug-eluting stent was deployed, guided by the calcified opaqueness on X-ray. The stent was optimally positioned, but was slightly under-expanded on ultrasound. We additionally expanded the stent using a non-compliant balloon, and achieved optimal result (Figure 2D).

An amplatz-left catheter was advanced to the ascending aorta, and a straight-wire was advanced to cross the calcified aortic valve at the perpendicular plane, at an angle calculated using pre-procedural CT (Figure 1A). A pre-shaped stiff-wire was located in the left ventricle, and balloon aortic valvuloplasty was performed using a 23-mm balloon. A 26-mm Edwards SAPIEN 3 valve was smoothly delivered to the aortic valve and was positioned using the calcified valve as landmark (Figure 1F). Under rapid ventricular pacing, the valve was deployed at the optimal position. His hemodynamics was stable, and electrocardiogram suggested no ischemic change. Perivalvular leakage was trivial, and no pericardial effusion was detected on echocardiography. The puncture site was closed using Perclose ProGlide (Abbott Vascular, Redwood City, CA, USA). No contrast media were used during PCI and TAVI. We monitored the patient for several hours in the intensive care unit, and subsequently transferred him to the general ward. His renal function was maintained at pre-procedural level, and he was discharged at postoperative day (POD) 3 without post-procedural AKI (serum creatinine: 2.37 mg/dL just after TAVI, 2.31 mg/dL on POD 1, and 2.39 mg/dL on POD 2).

Discussion

Pre-procedural evaluation using minimal contrast media and TAVI without contrast media avoided post-procedural AKI in a patient with advanced kidney dysfunction.
Most patients who undergo TAVI have chronic renal function impairment.4-7) Yamamoto, et al.5) reported advanced CKD (eGFR: <15-29 mL/minute) in 9.5% of patients who underwent TAVI. Iodine contrast media is one of the common nephrotoxic agents, and CKD is a major risk factor of CIN. Usually, TAVI requires 100-200 mL of contrast media.4-9) Post-TAVI AKI, caused mainly by CIN, correlates with adverse prognosis.5,6,8-11) Therefore, it is crucial to avoid procedural AKI when performing TAVI.

As pre-procedural evaluation for TAVI, contrast-enhanced CT and coronary angiography utilize iodine contrast media. In contrast-enhanced CT, new-generation, dual-source CT and dedicated CT protocols offer sufficient imaging data with low dose of contrast media.12-14) We used a second-generation, dual-source CT scanner (Somatom Definition Flash, Siemens Healthcare, Forchheim, Germany) with low tube current and 100 kV, which were suggested by the automatic exposure control software CareDose 4D (Siemens Healthcare). Magnetic resonance angiography (MRA) has been reported to be equivalent to contrast-enhanced CT for the calculation of aortic annulus15,16) but inferior for the assessment of aortic valve calcification and access root. Although MRA has relative good operating characteristics for the assessment of coronary artery disease,17) its use is limited in the assessment of the calcified coronary artery of patients with aortic stenosis and kidney dysfunction. Biplane cineangiography and minimal injections could minimize the amount of contrast media used in coronary angiography.

The prevalence of AKI following TAVI is 8.3%-42%5,6,8-10) and is positively correlated with baseline renal dysfunction.6) The suggested causes of AKI following TAVI includes CIN,7) thromboembolism, cholesterol embolus, systematic inflammatory response syndrome,8) and reduced renal perfusion.5,6,8-11) Patients complicated with AKI have higher all-cause and cardiovascular mortality in short and long terms.5,6,8-11) Preventive measures for AKI include periprocedural hydration with normal saline18) and minimizing the amount of contrast media used.7) Arrigo, et al.19) proposed TAVI with a single injection of contrast medium.19) In their report, five patients who were at a high risk of CIN (median eGFR, 20 mL/minute) were treated using TAVI with minimal contrast media (median dose of contrast media used, 8 mL). The single contrast injection confirmed the correct position of the pigtail catheter at the annulus. Pigtail catheter was then used as the marker for valve deployment. In their series, one of five patients developed post-procedural AKI. On the other hand, Barbanti, et al.20) reported their experience using RenalGuard System (PLC Medical Systems, Milford, MA, USA) in TAVI.20) RenalGuard System is a device that delivers intravenous fluids matched to the urine output and may be useful in selected TAVI cases. As for the effect of approach used in TAVI, transapical approach is associated with a higher incidence of AKI than transfemoral approach.6) Regarding the influence of anesthesia, general anesthesia using inhalation anesthetic may be associated with AKI.9) In the present case, we successfully performed

Figure 2. Percutaneous coronary intervention to the right coronary artery. A: Angiography of the right coronary artery. B: Lesion marking using intravascular ultrasound (IVUS). C, D: IVUS imaging of the target lesion before intervention (C) and at completion (D).
renoprotective TAVI with appropriate periprocedural hydration, transfemoral approach, local anesthesia, maintaining stable hemodynamics, and no contrast media use. Sufficient pre-procedural planning, compatible anatomy of the patient, and the experience of our heart team all contributed to the success using TAVI.

Limitations: Our success of TAVI without use of contrast media cannot be generalized to all patients. Our patient was suitable for transfemoral TAVI, and anatomical findings suggested low risk of procedural mechanical complications including annulus root rupture, coronary obstruction, and iliac artery injury. The positioning of prosthetic valve is the most important step in TAVI procedures. Uniform and moderate calcification of the aortic valve in our patient was a good landmark for valve positioning. Moreover, sufficient experience about pre-procedural planning, TAVI procedures, endpoint decisions, and complication bailouts are essential to safely perform TAVI without contrast media.

Conclusion

With an experienced heart team, pre-procedural evaluation and TAVI with minimal use of contrast media could be a therapeutic option in patients with aortic stenosis complicated by kidney dysfunction.

Acknowledgments

The authors would like to thank the other members of the TAVI team: Yuko Utanohara, MD, Keitaro Mahara, PhD, and Tatsunori Niwa, RT.

Disclosures

Conflicts of interest: Dr Tobaru is proctor of Edwards Lifesciences and Medtronic. The remaining authors report no conflict of interest regarding the content herein.

References