Imaging-Guided Transcatheter Aortic Valve Replacement and Percutaneous Coronary Intervention in Decompensated Severe Aortic Stenosis with Acute Renal Impairment

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ABSTRACT

An 82-year-old woman with severe aortic valve stenosis (AS) and a significant proximal right coronary artery (RCA) stenosis presented with decompensated heart failure and acute kidney injury. She was treated with intravascular ultrasound (IVUS)-guided percutaneous coronary intervention (PCI) and trans-oesophageal echocardiography (TOE)-guided transcatheter aortic valve replacement (TAVR).

Keywords: Aortic valve stenosis; Transcatheter aortic valve replacement; Pneumonia; Acute kidney injury

Key Summary Points

Decompensated heart failure in case of severe AS is challenging and requires urgent treatment particularly when complicated with renal impairment.

Understanding the pathophysiology is a cornerstone for proper management. Our patient developed acute cardiorenal syndrome with a vicious circle of worsening renal function then improper diuresis to worsening heart failure, so we had to interrupt this circle by treating the precipitating factor which was severe AS.

Despite absence of evidence, TAVR still plays an important role in complicated cases of severe AS with acute heart failure.

IVUS-guided PCI is a known approach that helps to overcome the problem of contrast medium in patients with renal impairment.

We can rely on TOE and fluoroscopy during TAVR, but this requires good understanding of the anatomy of the aortic root.

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CASE History of Present Illness

An 82-year-old women, with a history of arterial hypertension and severe aortic valve stenosis (AS), was planned for transcatheter aortic valve replacement (TAVR) but postponed because of contrast-induced acute kidney injury (AKI) after coronary angiography and computed tomography (CT) [(creatinine 5.3 mg/dL (0.47 mmol/L)]. She presented before the planned appointment with progressive dyspnoea for 3 days before admission.

On admission, the patient was alert with cough, expectoration and dyspnoea NYHA III, blood pressure 130/100 mmHg, heart rate 81 bpm, temperature 36.7 °C.

The patient had been admitted to the intensive care unit and received heart failure and antibiotic treatment. Her clinical condition deteriorated with progressive dyspnoea, worsening kidney function with anuria and pulmonary oedema and finally required haemodialysis.

Investigations

Laboratory
Total leucocyte count 13.1 x 10^3/μL, CRP 12.88 mg/dL (122.7 nmol/L), pro-BNP 7073 pg/mL (836.3 pmol/L), creatinine 1.37 mg/dL (0.12 mmol/L) progressed to 3.55 mg/dL (0.31 mmol/L), blood culture was negative.

Chest X-ray
On admission chest X-ray showed consolidation in the basal left lung and mild pleural effusion (Fig. 1a). X-ray 3 days later showed increasing lung congestion with bilateral pleural effusion (Fig. 1b), so pleurocentesis was performed; 1450 mL pleural fluid was drained and proved to be transudate after analysis.

Echocardiography
Left ventricular ejection fraction 65%, no wall motion abnormalities, aortic valve was heavily calcified with mean pressure gradient of
65 mmHg and aortic valve area (AVA) was 0.43 cm², stroke volume index (SVi) was 33 mL/beat/m². Trans-oesophageal echocardiography (TOE) showed AVA of 0.9 cm² with mild aortic insufficiency and degenerative mild mitral regurgitation.

**CT Aortography**

CT aortography (in a previous admission) showed aortic annulus diameter of 19 × 25 mm, perimeter was 70 mm and area 37 mm² (Fig. 2a), distance of coronary ostia from the annulus (right coronary artery (RCA) 9 mm, left main coronary artery (LM) 8 mm) (Fig. 2b, c). Calcium score was 3936 Agatston units (AU), right external iliac artery minimal diameter was 7 mm and the left was 8 mm while right common femoral minimal diameter was 4 mm and the left was 8 mm.

**Coronary Angiography**

Coronary angiography (in a previous admission) showed a significant stenosis in the RCA with angiographically normal left coronary artery (LCA) (Figs. 3 and 4).

**Management**

Under antibiotics, infection parameters decreased and blood culture was negative; nevertheless the patient was in pulmonary oedema and anuria. In this high-risk patient (STS score 10.03% and EuroSCORE II 15.38%) with drug-resistant cardiorenal syndrome, the heart team
decided to perform intravascular ultrasound (IVUS)-guided percutaneous coronary intervention (PCI) on the RCA then TOE-guided TAVR to avoid contrast. The decision to perform PCI for RCA was only dependent on the angiographic assessment (about 80%) and we could not perform non-invasive tests because the patient was decompensated; additionally the physiological assessment (FFR or iFR) is still doubtful in the presence of severe AS [1]. For fear of LM occlusion after TAVR—low ostium position—the decision was to advance a stent into the left anterior descending coronary artery (LAD), in parking position, without inflation.

A written informed consent was obtained from the patient for using and publishing her data with all measurements and rights of data protection according to the local ethics committee approved guidelines (Helsinki Declaration of 1964, as revised in 2013).

**Procedure**

The procedure was performed under elective intubation and deep sedation. The left common femoral artery was punctured under fluoroscopic guidance and selected to be the access for TAVR (depending on the measurements from the CT) while the right femoral access was chosen as a secondary access and for RCA PCI. A Judkin right (JR) 4.0 6F guiding catheter engaged the RCA. Without use of contrast media, a guide wire was advanced into the RCA (Video 1), followed by an IVUS pullback. During continuous pullback the distal and the proximal landing zones for the stent were documented by fluoroscopy as well as IVUS showed that the minimal lumen area (MLA) was 3.4 mm², minimal diameter was 1.7 mm and the area stenosis was 79%. After the size and length of the lesion were obtained (Fig. 5a), a drug-eluting stent (3.0 × 28 mm; DES) was implanted under fluoroscopic orientation followed by post dilation using a 3.5 × 15 mm non-compliant balloon. The result was controlled fluoroscopically with clear-stent and with IVUS (Fig. 5b). The stent was well expanded without evidence of edge dissections. A Judkin left (JL) 4.0 6F guiding catheter was used to engage the LM and 4.0 × 15 mm DES was advanced into LAD without inflation; then the guiding catheter was disengaged into the aorta, leaving the guide wire with the DES parked in the LAD. A pigtail catheter was advanced to the non-coronary

**Fig. 3** Coronary angiogram of the RCA showing angiographically significant proximal RCA stenosis

**Fig. 4** Coronary angiogram for the left coronary artery (LCA) showing angiographically normal LCA
cusp to guide the annulus level. With TOE and fluoroscopic guidance, a 26-mm balloon expandable Edwards Sapien 3 Ultra (Edwards Lifescience, Irvine, CA, USA) trans-catheter valve was implanted (Figs. 6 and 7 and Video 2). After TAVR, peak-to-peak gradient was 2 mmHg, aortic regurgitation index was 28, and TOE showed good TAVR position with no insufficiency. The LAD stent shaft was jailed between aortic wall and valve with resistance during extraction attempt (Video 3). For fear of stent-loss, a bailout implantation in the LM was necessary (Fig. 5c) confirming the results with 5 mL contrast (Fig. 5d). The patient was extubated in the catheter laboratory and transferred to the intensive care unit.

Video 1: Fluoroscopy-guided RCA engagement. Engagement with JR4 and passage of the guide wire without contrast injection into distal RCA (MP4 3085 KB)

Video 2: TAVR implantation. Edwards Sapien 3 Ultra valve deployment and disengaged JL from left main trunk with the stent in parking position in middle LAD (MP4 11695 KB)

Video 3: Difficult withdrawal of the stent. Jailing of the stent shaft between TAVR device and
Follow-Up Post-TAVR

On the second post-TAVR day, haemodialysis could be stopped. Creatinine improved to 1.91 mg/dL (0.17 mmol/L). Echocardiography revealed a well-seated prosthesis in the aortic position with a mean gradient of 17 mmHg and no para-valvular regurgitation; AVA was 1.33 cm². The patient was discharged 1 week after TAVR in a stable condition.

**DISCUSSION**

Our case sheds light on two important points: (1) the role of TAVR in acute heart failure, (2) the growing role of imaging-guided TAVR (fluoroscopy-TOE guidance) and PCI (IVUS guidance) particularly in case of renal impairment.

AS is the third most frequent cardiac disease after coronary artery disease and arterial hypertension, and is associated with a high incidence of adverse outcomes [2]. Moreover, it is frequently associated with abnormalities of the arterial system like cerebral, renal and coronary arteries [3].
The prognosis of patients with severe AS complicated by decompensated heart failure is poor, with high rates of mortality. In addition, management of heart failure complicating severe AS is particularly challenging because patients easily develop severe congestion or acute decline in cardiac output [4]. We assume this is the pathophysiology that occurred in our patient, renal hypoperfusion and subsequently renal impairment with anuria and increasing congestion. The patient entered in a vicious circle that we had to interrupt.

Several studies have confirmed that AKI is a strong predictor for short- and long-term mortality after TAVR [5]. However, in our case, AKI improved after TAVR and this could be explained by the normalization of cardiac output and body fluid redistribution after TAVR.

When one performs a TAVR without contrast, the main technical challenges relate to how to optimally position the valve prior to deployment. There are many described techniques e.g. angiographic, 3D TOE, and 2D TOE guided. In our case, fluoroscopy and TOE-guided TAVR was performed with the help of pig-tail catheter in the non-coronary cusp to guide the exact annulus position. Bagur et al. showed that TOE-guided TAVR was associated with similar midterm results as angiography-guided TAVR and significant reduction of contrast media [6].

For intravascular imaging, we used IVUS as it is the imaging modality of choice in patients

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**Fig. 7** TOE during TAVR procedure. a Adjustment of the valve position in three-chamber view, b during valve inflation, c after valve implantation showing good leaflet excursion, d colour flow Doppler (CFD) showing no significant aortic insufficiency
with advanced kidney disease because it does not require blood clearance by contrast injection as compared to optical coherence tomography.

CONCLUSION

Severe AS complicated by acute cardiorenal syndrome is a challenging situation. Fluoroscopy and TOE-guided TAVR in association with an IVUS-guided PCI may be a feasible solution for those patients.

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Compliance with Ethics Guidelines. A written informed consent was obtained from the patient for using and publishing her data with all measurements and rights of data protection according to the local ethics committee approved guidelines (Helsinki Declaration of 1964, as revised in 2013).

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Authors’ Contributions. Karim Elbasha: data collection, writing and considering the concept and design. Gert Richardt: concept and drafting. Rayyan Hemetsberger: reviewing and drafting the data. Abdelhakim Allali: concept and design as well as drafting the case.

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