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E-Challenge

Taking a New Path: Intracardiac Shunt Calculation to Aid in Decision-Making With Annular Rupture After Transcatheter Aortic Valve Replacement Deployment

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AN 87-YEAR OLD male presented with worsening dyspnea on exertion, angina, and new onset atrial tachyarrhythmias. On subsequent workup, severe aortic stenosis was found. Given the patient's age, frailty, and severe medical comorbidities, he was deemed to have prohibitive surgical risk and was referred for transcatheter aortic valve replacement (TAVR).

A preoperative transthoracic echocardiogram (TTE) showed mildly reduced left ventricular systolic function with an ejection fraction of 45% to 50%, severe aortic stenosis with a mean pressure gradient of 43 mmHg, peak velocity of 4.2 m/sec, an aortic valve area calculated at 0.7 cm^2, and mild aortic and mitral insufficiency.

Per institutional protocol, a planning computerized tomography (CT) of the chest with TAVR gating was performed 2 weeks before the procedure. The scan showed the following distances: 29 mm annular diameter, 31 × 33 mm annular biplane diameter, and 35 mm sinus of Valsalva with mild effacement. There was moderate aortic valve calcification with calcific fusion of the left and right coronary cusps. Severe coronary calcification and moderate aortic root calcification were present with an Agatston score of 453 (Fig 1).

The TAVR was performed with the patient under general endotracheal anesthesia with transesophageal echocardiography (TEE) monitoring. A Sapien 3 26 mm bioprosthetic valve (Edwards Lifesciences Inc, Irvine, CA) was planned via a left-sided transfemoral approach. Intraoperative TEE confirmed the TTE findings, and no unexpected pathology was encountered.

After an uneventful deployment of the valve, TEE demonstrated a small aortic annulus rupture resulting in continuous shunting between the right sinus of Valsalva and the right ventricular outflow tract (RVOT), creating a left-to-right fistula with continuous flow (Video 1 and Fig 2). Numerous views were required to clearly assess the location of the aorto-RVOT fistula and any effect on other structures (Video 2 and Fig 3).

Clinical Challenge

What is the best approach to evaluate the severity of the complication?

Clinical Course

After extensive conversation with the cardiothoracic surgery and interventional cardiology teams on how to address the new

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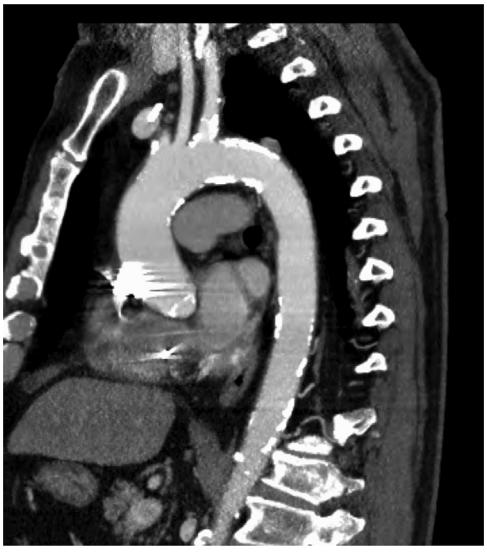

Fig 1. Sagittal plane of computed tomographic angiogram of ascending aorta and aortic arch demonstrating severe coronary calcification and moderate and focal root and arch calcification.

aorto-RVOT fistula, it was determined that quantification of the left-to-right shunt severity was required to best determine the next course of action. Even though a Doppler spectral profile could not be obtained along the fistula tract, it was clear from the images that the rupture was supra-annular (see Videos 1 and 2). Unfortunately, adequate pulmonary artery views could not be obtained via TEE for echocardiographic determination of the pulmonary and systemic stroke volumes (Qp:Qs) ratio.

The anesthesiology team therefore decided to perform a right heart catheterization (RHC) to obtain the requisite regional oxygen regional saturations to calculate the degree of intracardiac shunt (Equation).

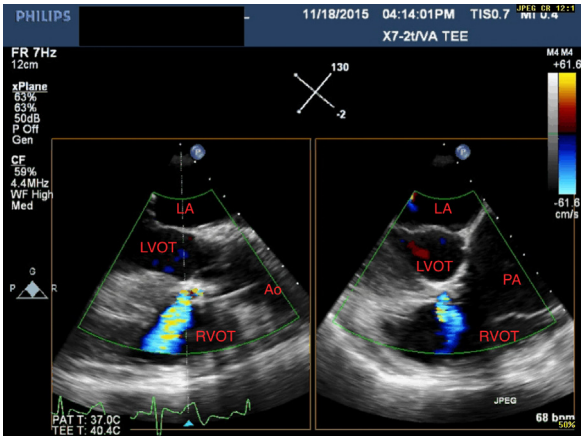

Fig 2. Still, labeled image of transesophageal echocardiographic orthogonal biplane of midesophageal aortic valve long-axis view showing continuous flow from the aortic root into the right ventricular outflow tract. Ao, aorta; LA, left atrium; LVOT, left ventricular outflow tract; PA, pulmonary artery; RVOT, right ventricular outflow tract.

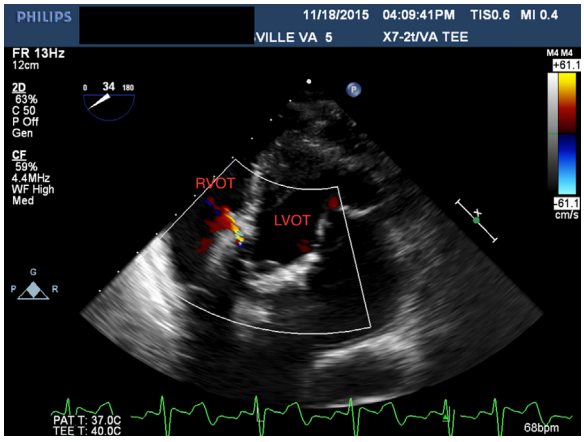

Fig 3. Still, labeled image of transesophageal echocardiographic deep transgastric long-axis view showing communication between the sinus of Valsalva and the right ventricular outflow tract. LVOT, left ventricular outflow tract; RVOT, right ventricular outflow tract.

Equation: Intracardiac Shunt

The following formula was used to determine the severity of the intracardiac shunt: Qp:Qs = (Ao – MV)/(LA – PA), where Ao is aortic saturation, MV is mixed venous saturation, LA is left atrial saturation, and PA is pulmonary artery saturation.

A pulmonary artery catheter was introduced through the preexisting right internal jugular central line, and using fluoroscopic guidance, the requisite saturations were obtained in traditional RHC fashion (Table 1). Given the presence of the aorto-RVOT fistula, the mixed venous saturation was measured using differential saturations from the superior and inferior vena cavae. This resulted in a calculated Qp:Qs value of 1.5, denoting a hemodynamically significant left-to-right shunt. Transcatheter closure of the aorto-RVOT fistula was discussed; however, the anatomy was not believed to be favorable to closure with available devices. Other than the fistula, the TEE examination remained unchanged from pre-TAVR deployment. The mean pressure gradient across the valve was calculated at 10 mmHg, with trivial perivalvular leak.

The patient's condition remained hemodynamically stable during this time, and he did not require vasoactive medications for support. The pulmonary artery pressures remained unchanged with a mean of 20 to 25 mmHg and a pulmonary

Table 1
Right Heart Catheterization Oxygen Saturation Results (%)

Ao	100
SVC	68.6
IVC	76.2
MV	70.5
LA	100
PA	80.7

Abbreviations: Ao, aorta; IVC, inferior vena cava; LA, left atrium; MV, mixed venous (MV = [3SVC + IVC]/4); PA, pulmonary artery; SVC, superior vena cava.

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