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Case Reports

A Novel Approach to Diagnostic Left and Right Heart Catheterization in a Patient With a Mechanical Prosthetic Tricuspid Valve

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Abstract

A 47-year-old patient was experiencing dyspnea and fatigue concerning for right ventricular hypertension and new heart failure. Because of the risks associated with catheter entrapment, prosthetic valve leaflet damage, and valve thrombosis associated with crossing a mechanical valve, a novel technique was used for diagnostic left and right heart catheterization in a patient with mechanical tricuspid valve replacement and tortuous pulmonary arteries. Using a percutaneous subxiphoid approach to avoid traversing the mechanical valve without discontinuing anticoagulation, a Volcano fractional flow reserve pressure wire (Philips Volcano) was advanced for distal measurements of pressures and saturations.

Keywords: Cardiac catheterization; tricuspid valve; heart valve prosthesis; hemodynamic monitoring, methods

Case Report

Presentation and Physical Examination

Because of the risks of catheter entrapment, prosthetic valve leaflet damage, and valve thrombosis associated with crossing a mechanical valve, diagnostic cardiac catheterization across mechanical valves is contraindicated. To assess anatomical tortuosity in patients with these valves, therefore, a novel technique for diagnostic left and right heart catheterization in a patient with a mechanical tricuspid valve (TV) and tortuous pulmonary arteries was devised. In addition, this case identifies the possible applications of epicardial puncture in diagnostic catheterizations with a Micropuncture needle (Cook Medical Inc) in an inaccessible right ventricle (RV) via the venous system.

Medical History

A 47-year-old woman presented at the clinic with concerns of worsening dyspnea on exertion and shortness of breath. Her medical history included dextrotransposition of the great arteries, ventricular septal defect, pulmonary stenosis with Rastelli repair, atrial fibrillation, a history of nonsustained ventricular tachycardia, and heart failure with reduced ejection fraction. In addition, she had undergone mechanical TV replacement in 1992 and implantable cardioverter-defibrillator (ICD) placement in 2014. Because of the patient's history of atrial and ventricular arrhythmias, she had had subjective chronic dyspnea for approximately 7 years before ICD placement. After defibrillation threshold testing, her dyspnea symptoms had significantly improved (likely because of cardioversion); she still had persistent fatigue, however, some dyspnea with exertion, and constant pressure-like chest discomfort. She reported intermittent episodes of palpitations and general feelings of lightheadedness but denied any syncopal episodes.

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The patient's vitals on presentation were stable, with a blood pressure reading of 110/50 mm Hg. Physical exam was notable for S1 mechanical click, split S2, III/VI early to midpeaking systolic murmur, and no gallops or rubs. Pertinent lab values for the patient are as follows: sodium, 138 mmol/L; potassium, 4.4 mmol/L; urea nitrogen, 18 mg/dL; creatinine, 0.5 mg/dL; hemoglobin, 11.4 g/dL; b-type natriuretic peptide, 107 ng/L; and international normalized ratio (INR) on the day of the procedure, 2.2.

Differential Diagnosis

When constructing the differential diagnosis for this patient, cardiac etiologies included left ventricular (LV) diastolic dysfunction or elevated LV end-diastolic pressure, RV hypertension, or diastolic dysfunction; coronary artery disease; TV stenosis; or atrial fibrillation. Pulmonary etiologies included pulmonary arterial hypertension or elevated pulmonary vascular resistance, obstructive sleep apnea, or other sleep apnea conditions, given that she had a body mass index of 28. Finally, overall deconditioning should be considered as a driver of her dyspnea and fatigue.

Technique

The ICD generator had reached its elective replacement index, and the patient was scheduled for a generator change and diagnostic left and right heart catheterization. The preprocedure computed tomography scan demonstrated tortuous pulmonary arteries, leading to difficulties in assessing pulmonary stenosis on transthoracic echocardiogram (TTE) (Fig. 1). Adequate images of normal mechanical TV function were obtained, so further imaging of the valve was not performed. Further evaluation was needed, however, given concern for RV hypertension and progressive heart failure symptoms. Left heart catheterization was performed using a standard retroaortic approach, with a 5F straight pigtail catheter for measuring LV pressures. Invasive coronary angiography was not performed, given the patient's age and recent computed tomographic angiography of the epicardial coronary arteries.

Limited right heart catheterization was performed to assess the superior vena cava, inferior vena cava, and right atrium. Using a Micropuncture needle with fluoroscopic but not ultrasound guidance, a subxiphoid direct RV puncture allowed access to the RV for the remainder of the prograde right heart catheterization, with advancement of a fractional flow reserve pressure wire (Philips Volcano) to the right pulmonary artery. Contrast was not needed because the RV-pulmonary artery conduit appeared radiopaque on imaging. Pressure normalization could be performed because of issues with clotting in the Micropuncture catheter as the wire was being threaded. The pressure wire remained in the RV and was used as a baseline for other pressure measurements (Fig. 2A, 2B). Pullback measurement of relative pressures was performed, with findings of mild pulmonary

Key Points

- The reader will understand the role of a technique used in a novel setting for right heart catheterization in the setting of anatomic tortuosity that precludes other traditional measurement modalities
- The reader will understand the application of epicardial puncture in diagnostic catheterization with a Micropuncture needle in an inaccessible RV via the venous system
- The reader will understand the management and monitoring of a patient without discontinuation of anticoagulation resulting from mechanical valve

Abbreviations and Acronyms

ICD	implantable cardioverter-defibrillator
INR	international normalized ratio
LV	left ventricular
RV	right ventricle
TTE	transthoracic echocardiogram
TV	tricuspid valve

Fig. 1 Preprocedure computed tomography scan of the chest without contrast shows the tortuosity of the pulmonary arteries and the stenosis from the previous pulmonary conduit placement from Rastelli repair (arrows).

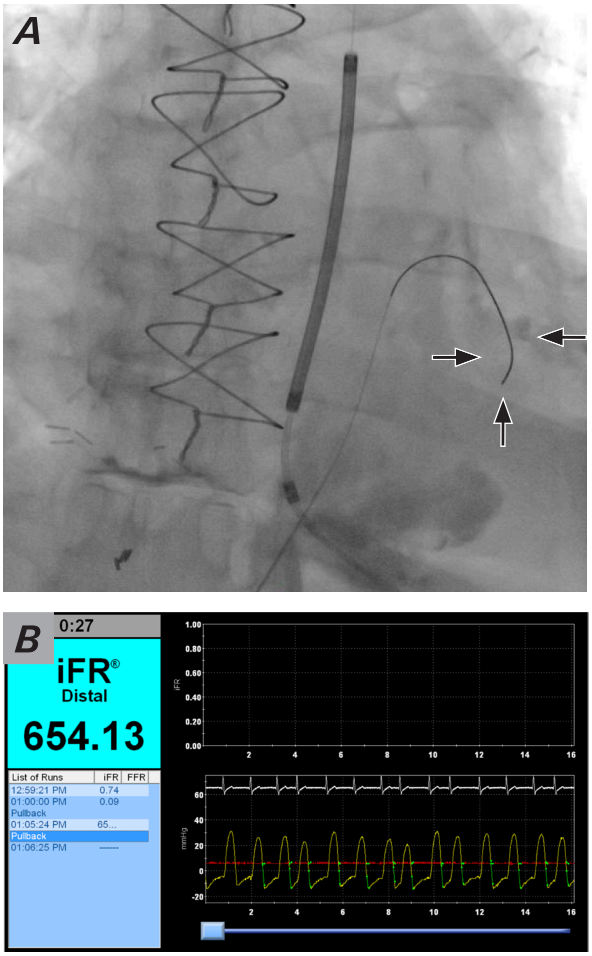

Fig. 2 Right ventricular pressure measurement. **A**) Anterior-posterior fluoroscopic image shows right ventricular access with the Philips Volcano pressure wire (arrows). **B**) Hemodynamic pressure tracings in the right ventricular body.

FFR, fractional flow reserve; iFR, instantaneous wave-free ratio.

stenosis with the following gradients: right pulmonary artery to main pulmonary artery (0 mm Hg) (Fig. 3), main pulmonary artery to RV outflow tract (4 mm Hg) (Fig. 4A-4C), and RV outflow tract to RV body (6 mm Hg). Wedge pressure could not be obtained, but an LV end-diastolic pressure of 16 mm Hg was used as a surrogate. Pulmonary vascular resistance was estimated at 2.8 Wood units (Table I).

Outcome

There was concern about puncturing the RV while the patient was on anticoagulation, with an INR 2.2 and no heparin bridge. Limited TTE did not show an effusion, however, and no significant hematoma was appreciated over the pocket. Five days after the procedure, the patient resumed warfarin, with no specific interim INR monitoring or heparin bridge.

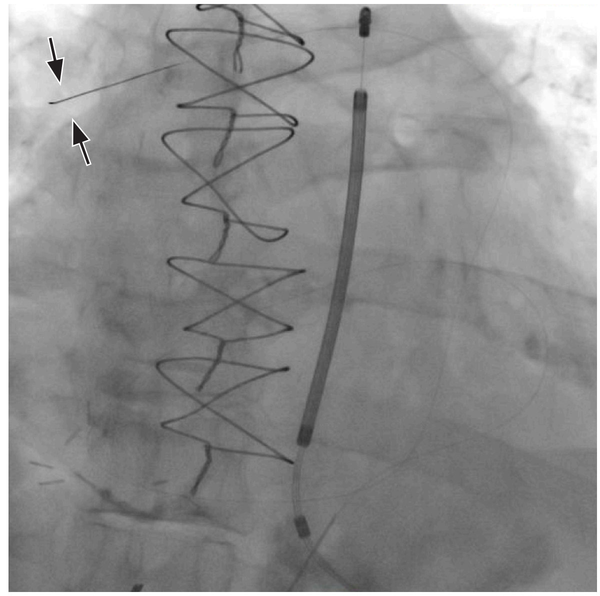

Fig. 3 Anterior-posterior fluoroscopic image shows the Philips Volcano pressure wire coming out of the right pulmonary artery (arrows).

Latest Follow-Up

Except for minimal pain from the defibrillator replacement, the patient reported no pain or bruising after the procedure and overall is doing well, from a cardiac standpoint.

Discussion

Because of the risk of valvular thrombosis, catheter entrapment, and prosthetic valve leaflet damage associated with crossing a mechanical prosthetic valve, cardiac catheterization procedures are usually contraindicated.[1-3] In specific situations, however, where noninvasive modalities do not provide adequate hemodynamic information and further assessment is necessary for indications such as heart transplant or surgical evaluation, physicians will need to explore the risks and benefits of using cardiac catheterization to take these measurements as well as the exploration of other catheterization techniques for safe evaluation. In this case, in a patient with an RV inaccessible from the venous system—although the authors often perform electrophysiology procedures via epicardial access—a similar approach with a Micro-

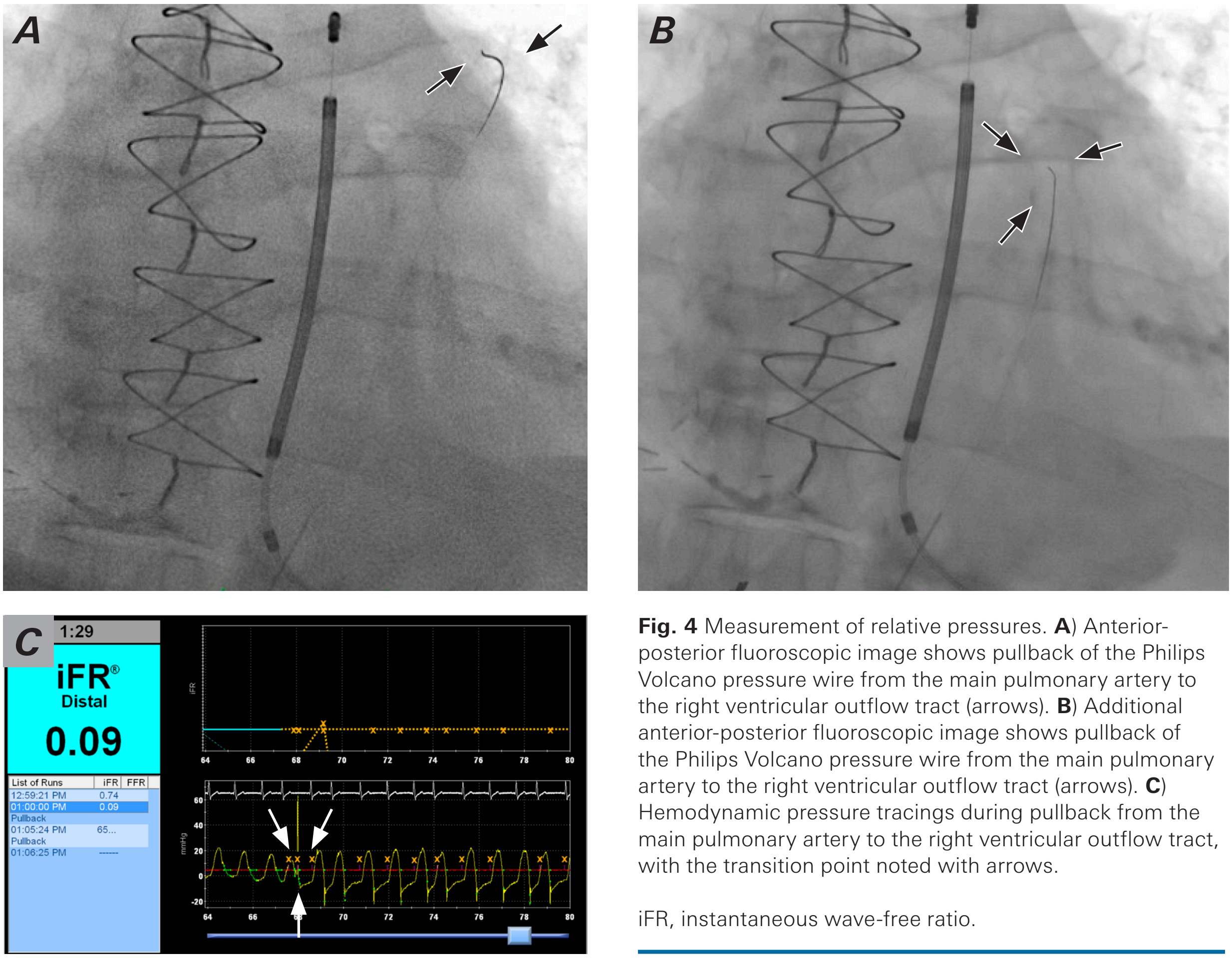

Fig. 4 Measurement of relative pressures. **A**) Anterior-posterior fluoroscopic image shows pullback of the Philips Volcano pressure wire from the main pulmonary artery to the right ventricular outflow tract (arrows). **B**) Additional anterior-posterior fluoroscopic image shows pullback of the Philips Volcano pressure wire from the main pulmonary artery to the right ventricular outflow tract (arrows). **C**) Hemodynamic pressure tracings during pullback from the main pulmonary artery to the right ventricular outflow tract, with the transition point noted with arrows.

iFR, instantaneous wave-free ratio.

TABLE I. Left and Right Heart Catheterization Pressure Measurements and Calculations

Variable	Value
Pressure, mm Hg	
Superior vena cava, mm Hg	16
Right atrium, mm Hg	16/17/16
Inferior vena cava, mm Hg	16
Right ventricular body, mm Hg	45/18
Right ventricular outflow tract, mm Hg	40/18
Left ventricle, mm Hg	91/16
Right pulmonary artery, mm Hg	38/23/30
Main pulmonary artery, mm Hg	38/23/30
Ascending aorta, mm Hg	88/47/63
Descending aorta, mm Hg	94/51/66
Left femoral artery, mm Hg	96/46/64
Cardiac index, L/min/m^2	2.8
Pulmonary vascular resistance, Wood units	2.8

puncture needle into the RV makes diagnostic catheterization achievable.

In patients with mechanical prosthetic TVs who undergo TTE for noninvasive evaluation, physicians encounter both technical limitations and difficulty making an accurate hemodynamic assessment because of abnormal transvalvular flow patterns, abnormal valve motion, paravalvular leakage, and (if patients have a prosthetic mitral valve, as well) limited visualization of the TV because it is overshadowed by the mitral valve.[4]

Although not commonly performed, percutaneous direct cardiac catheterization procedures, either through a subxiphoid or apical approach, have been conducted for further hemodynamic assessment in patients requiring left or right heart catheterization.[1,5-8] Before percutaneous approaches, a diagnostic coronary angiogram is performed to assess the locations of the epicardial coronary arteries to further minimize the risk of laceration. In this case, the risk of coronary artery injury when using a Micropuncture needle to access the RV

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was minimal, and axial imaging suggested the absence of significant coronary artery disease. In addition, although there have been case reports of percutaneous direct cardiac catheterization across prosthetic valves, significant risk of catheter entrapment, valvular thrombosis, and prosthetic valve damage remains, although the risk is higher in left-sided than right-sided procedures.[1-3,6] Even so, right heart catheterization carries the risk of pulmonary embolism from debris dislodgement of a partially thrombosed valve. In this case, the percutaneous subxiphoid puncture was performed as part of right heart catheterization to avoid the risks associated with traversing a mechanical TV.[9] Steps to increase safety, reliability, and reproducibility for direct ventricular puncture procedures could include guidance by TTE (if views permit); ventriculogram; or, as in this case, right atrium angiogram to identify the ventricular cavity and coronary angiogram to avoid coronary laceration. In addition, the pressure wire allowed for more distal pressure measurements. To improve pressure measurement accuracy, the needle or Micropuncture catheter can be connected to a transducer; afterwards, the fractional flow reserve wire would be introduced to normalize and gather more accurate pressures. Because of the patient's mechanical TV and increased risk of thrombosis, diagnostic catheterization was performed without discontinuation of anticoagulation.[9,10]

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