Anatomical basis for acquired intracardiac shunt postaortic valve replacement: Doppler echocardiographic diagnosis

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Abstract

We report a case of postoperative intracardiac shunts across the membranous septum detected by Doppler echocardiography and discuss the anatomical basis for the development of such a complication.

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Iatrogenic intracardiac shunts are uncommon and have been recognized after aortic and mitral valve surgery. The early detection and treatment of such a complication can prevent subsequent adverse hemodynamic effects and long-term sequelae. We report a case of intracardiac shunts from the left ventricle outflow tract (LVOT) across the membranous septum into the right atrium (RA), right ventricle (RV) and left atrium (LA) following a redo aortic valve replacement. The lesion was detected by transthoracic Doppler echocardiography (TTDE).

Case report

An 82-year-old male who had undergone a coronary artery bypass and tissue aortic valve replacement in 1997, followed by mitral valve annuloplasty in 1998, was treated for uncomplicated infective endocardities (IE) in February 2000 with prolonged antibiotic course and in June 2002 he was evaluated for exertional shortness of breath. He denied orthopnea, nocturnal dyspnea, or fevers. Physical examination of this afebrile elderly patient was unremarkable except for a 3/6 ejection systolic murmur over the aortic area radiating to the carotids and a holodiastolic murmur along the right sternal border. There was no peripheral stigma of IE. Laboratory results were normal. ECG revealed sinus rhythm, first-degree heart block and an old inferior infarct. Transthoracic echocardiogram showed moderately enlarged left ventricle with decreased systolic function, EF 35%. The aortic tissue valve was thickened, with decreased cusp excursion and without obvious vegetation or flail. Color flow Doppler demonstrated severe prosthetic regurgitation. The degree of regurgitation has increased from moderate to severe compared to previous examination. The estimated pulmonary systolic pressure was 61 mmHg. The patient underwent aortic valve replacement with a 23
Carpenteer Edwards tissue valve, and the postoperative course was uneventful. Transthoracic echocardiogram performed prior to discharge showed improved LV function with an EF of 50%, and normal function of the aortic tissue prosthesis. However, there was a highly turbulent color flow jet from the LVOT across the membranous septum into the RA and RV straddling the septal leaflet of the tricuspid valve on the parasternal short-axis view (Fig. 1). The peak velocity of the jet, from the LVOT to RA, was 6 m/s (Fig. 2). In the apical four-chamber view another jet was seen entering the LA from the LVOT just beneath the aortic prosthesis (Fig. 3). The RV was not enlarged and the Doppler estimated RV systolic pressure was 46 mmHg. The calculated shunt fraction was not significant (QP/QS ratio of 1.2). The patient was discharged with instruction for early follow up.

Discussion

The congenital form of LV to RA communication accounts for less than 1% of all congenital heart disease and was first classified by Gerbode et al. Acquired communications are recognized as a complication of IE, myocardial infarction and cardiac trauma and albeit far less frequently, as complication of aortic or mitral valve surgery. Jackson et al. reviewed a series of 310 patients with aortic valve replacement and found two cases of postoperative iatrogenic shunts. Both patients developed heart failure, one at 6 months and the other at 1 year and were found to have intracardiac shunts on cardiac catheterization. Similar observation of a membranous defect following aortic valve replacement have been reported at autopsy.

The membranous portion of the ventricular septum is intricately related to aortic, mitral, and tricuspid valves in addition to RA, right and left ventricles. The thin membranous septum, which is about 3 mm in thickness, lies posterior to the aortic root (non-coronary cusp), and to the left ventricular outflow tract. The septal leaflet of the tricuspid valve straddle the right side of the membranous septum dividing it into two portions, superior atroventricular and inferior inter-ventricular portions. The atroventricular portion is between the RA and left ventricular outflow tract (LVOT) and the inter-ventricular portion is between the two-ventricle (Fig. 1). The membranous septum separates the aortic root and the LVOT on one side and the RA and RV on the other

![Figure 1](A) Parasternal short-axis view showing two jets straddling the septal leaflet of the tricuspid valve (TV), one into the RA and one into the RV. (B) Cross-sectional anatomy of the membranous septum (MS) denoted by the two asterisks at the level of the LVOT where it is divided into superior atroventricular (AV) and inferior inter-ventricular (IV) portions.
Figure 2  (A) Color flow Doppler from the apical four-chamber view showing an eccentric jet from the LVOT into RA directed toward the right atrial free wall. (B) CW Doppler demonstrates a peak velocity of the LVOT–RA systolic shunt to be 6 m/s.

Figure 3  (A) Color flow Doppler from the apical four-chamber view showing the two shunts into the LA (arrowhead) and into the RA (arrow). (B) Anatomy of the membranous septum (between the two asterisks) divided by the septal leaflet of the tricuspid valve into superior atrioventricular (AV) and inferior inter-ventricular (IV) portions.
side. This anatomical arrangement explains the developmental course of fistula communication from the LVOT to either RV or RA or from the aortic root to the RV. Additionally, the membranous part of the ventricular septum lies posterior to the posteromedial commissure of the mitral valve adjoining the LA. During aortic or mitral valve surgery, aggressive debridement of calcific aortic or mitral valve annuli, and in some cases, inclusion of the septum in the suture line, may result in injury causing ischemic necrosis and gradual weakening of the septum and formation of fistulae.\textsuperscript{6,11–14}

The clinical presentation may vary based on the magnitude of the shunt. Large shunts are associated with failure of hemodynamic improvement immediately after aortic or mitral valve surgery.\textsuperscript{1} Small shunts, as in our case, are initially asymptomatic and the associated murmur may be the only clue. Progressive enlargement of the defect with the resultant increase in shunt may lead to heart failure weeks or months after surgery.\textsuperscript{6} With the wide application of intraoperative echocardiography these defects can be diagnosed promptly. While the communication into RA or LA can be detected easily, the communicating into anteriorly located RV can be at times difficult to image due to the intervening aortic prosthesis. The two-dimensional echocardiogram may show the fistulous tract if it is large, whereas color Doppler will invariably show the left to right shunt and the spectral Doppler can estimate the systolic gradient. The color Doppler jet from the LVOT to RA should be differentiated from an eccentric tricuspid regurgitation jet. The tricuspid regurgitation usually has a lower peak velocity unless there is severe pulmonary hypertension, whereas the shunt from LVOT to RA will usually be higher and directed toward the right atrial free wall. The hemodynamic consequences of significant shunts are readily determined by the surface echocardiography and include the assessment of RV size and function. Determination of shunt fraction and pulmonary artery pressure will quantify the hemodynamic burden on the pulmonary circulation. Obtaining this information from an echo obviates the need for cardiac catheterization indicated in early case reports.\textsuperscript{2,6,13}

Surgical trauma to membranous septal tissue, already weakened from previous valve operations and previous IE, rendered our patient susceptible for developing this complication. Since the patient had no symptoms and the shunt was not significant, conservative management with bacterial endocarditis prophylaxis and frequent clinical and echocardiographic monitoring was decided.

References