Aortic Regurgitation During Systole: Color Flow Mapping and Doppler Interrogation Following the Damus-Kaye-Stansel Procedure

Randall Michael Giuffre, Norman N. Musewe, Jeffrey F. Smallhorn, and Robert M. Freedom

Division of Cardiology, Department of Pediatrics, Hospital for Sick Children, Toronto, Canada

SUMMARY. Echocardiographic evidence of systolic aortic regurgitation following a Damus-Kaye-Stansel procedure for palliation of complex double-outlet right ventricle is presented. This procedure directs left ventricular output to the aorta through a proximal main pulmonary artery-aortic anastomosis and utilizes a valved conduit between the right ventricle and distal pulmonary artery. Postoperative Doppler and color flow echocardiographic findings revealed systolic and diastolic regurgitation from the native aorta to the right ventricle. Aortic valve closure at the time of the original Damus-Kaye-Stansel procedure would eliminate regurgitant flow and circumvent subsequent closure of this valve due to increased systolic aortic regurgitation.

KEY WORDS: Systolic aortic regurgitation — Damus-Kaye-Stansel procedure

Aortic regurgitation is a diastolic event with reflux of blood from the aortic root to the left ventricle. The recent advent of color flow Doppler has allowed more precise evaluation of small regurgitant jets, thus, enabling accurate interrogation of these jets by conventional pulsed or continuous wave Doppler for the derivation of hemodynamic data.

Systolic aortic regurgitation was found in two patients following a Damus-Kaye-Stansel procedure performed for palliation of complex double-outlet right ventricle. In this procedure left ventricular output is directed to the aorta through a proximal main pulmonary artery—ascending aortic anastomosis, and a valved conduit is interposed between the right ventricle and distal pulmonary artery [2, 6]. This report describes the unique Doppler and color flow echocardiographic findings of systolic aortic regurgitation in this setting.

Case Reports

Case 1

The first patient was a term male infant with a birth weight of 3.95 kg. Cardiac catheterization and echocardiography on the second day of life revealed a diagnosis of double-outlet right ventricle of the Taussig-Bing type, complicated by aortic coarctation. Following aortic arch repair utilizing a left subclavian flap aortoplasty and placement of a pulmonary artery band on day 2 of life, a Damus-Kaye-Stansel operation was carried out at the age of 8 months. The aortic valve was not oversewn.

One year after surgery, a loud systolic ejection murmur, grade 3/6, was audible along the upper sternal border in the otherwise clinically well child. The postoperative catheter study demonstrated full saturation in the aorta and the absence of a pressure gradient between the left ventricle and ascending aorta. The right ventricular pressure was 80% of systemic pressure due to the severe diffuse conduit narrowing. Biplane ascending aortography revealed a competent aortic valve, and a jet of regurgitation through the left (pulmonary) semilunar valve into the left ventricle.

Case 2

The second patient was a 3-week-old term female infant with a birth weight of 4.40 kg. At catheterization the findings were those of double-outlet right ventricle complicated by coarctation of the aorta. Initial surgery consisted of a resection of the coarctation with a left subclavian flap and placement of a pulmonary artery band. At 6 years of age, a Damus-Kaye-Stansel repair, using a 20-mm pulmonary homograft, was performed. The postoperative course was uneventful.

Results

The immediate postoperative echocardiogram in both patients revealed mild pulmonary regurgitation and no evidence of a gradient across either outflow
Fig. 1. Parasternal long axis view demonstrating real-time color flow. The central regurgitant turbulent jet is indicated by the arrow in the second frame. This turbulent Doppler flow into the right ventricle (outlined by the arrow) is confirmed by M-mode in the bottom frame. Note the flow occurs in both the systole and diastole. ao, aorta; rv, right ventricle; ra, right atrium.

Fig. 2. Continuous wave Doppler study demonstrates flow across the native aortic outflow tract. The transducer is located at the apex, and flow from the main pulmonary artery is directed away from the transducer out the ascending aorta (B). Blood flow from the main pulmonary artery retrograde into the aortic root and right ventricle is shown, resulting in systolic aortic regurgitation (A). In addition, systolic and diastolic aortic regurgitation is shown with peak flow occurring in early diastole (C). Ao, aorta; RV, right ventricle; CW, continuous wave; MPA, main pulmonary artery; Con, conduit; LV, left ventricle.

tract. At follow-up (4 months postoperatively) in the first patient, Doppler echocardiography revealed a 40 mmHg gradient across the conduit. Color flow mapping (Fig. 1) demonstrated the presence of both systolic and diastolic regurgitant flow across the native aortic valve.

In the second patient, the echocardiogram at 17-months postoperative follow-up demonstrated no significant pressure gradient across the conduit. There was color flow evidence of systolic and diastolic regurgitation from the native aorta into the right ventricle. Doppler interrogation across the aortic valve confirmed both systolic and diastolic regurgitation, and no left semilunar (native pulmonary) valve regurgitation (Fig. 2).

Discussion

The mechanisms responsible for systolic aortic regurgitation are intimately related to the unique anatomy and physiology of the Damus-Kaye-Stansel procedure. The hemodynamic situation allowing for aortic regurgitation as a systolic event must be very uncommon. In the Damus-Kaye-Stansel postoperative setting, the aortic valve insufficiency may be related to the aortic root distortion as the main pulmonary artery-aortic root anastomosis is in close proximity to the aortic valve. In addition, the low pressure right ventricle may allow prolapse of the aortic valve leaflets. This valve distortion may act as the mechanism allowing the systolic aortic regurgitation seen in these patients, as the presence or absence of a gradient across the homograft conduit did not influence the observed systolic regurgitation. The presence of systolic aortic regurgitation may also allow an estimate of right ventricular pressure during the postoperative follow-up of patients.

The Damus-Kaye-Stansel procedure has a definitive role in certain patients with the Taussig-Bing form of transposition of the great arteries with coronary artery anatomy unsuitable for transfer [1].