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Electron Beam Angiography for the Evaluation of Percutaneous Atrial Septal Defect Closure

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Electron beam angiography (EBA) provides excellent anatomic imaging in patients with congenital heart disease and may be useful in the assessment of atrial septal defects (ASDs). We present four patients with an ASD who were considered for percutaneous closure and underwent EBA for measurement of defect size and assessment of rim adequacy, adjacent cardiac structures, and associated congenital anomalies.

Key words: atrial septal defect; percutaneous closure; congenital heart disease

INTRODUCTION

The treatment of patients with an ostium secundum atrial septal defect (ASD) has changed significantly in the last decade. Surgical closure had been the preferred treatment for patients with left-to-right shunting since the inception of cardiopulmonary bypass. Although the operative outcomes are excellent, surgical closure carries a 5.4% 1-year rate of major complications [1]. Transcatheter closure of ostium secundum ASDs was first attempted by King et al. [2] in 1976. Since that time, numerous devices and approaches have been designed to improve both efficacy and safety [3]. Recent studies have demonstrated the efficacy, safety, and lower cost of the Amplatzer septal occluder compared to conventional surgical techniques [1,4–6]. However, procedural success is highly dependent on the preprocedural assessment of patients. Defect sizing and determination of adequate rims are essential for selecting appropriate patients for transcatheter closure. Transthoracic echocardiography (TTE) and transesophagael echocardiography (TEE) have traditionally been used for this assessment. However, echocardiography often underestimates defect size [7]. Electron beam angiography (EBA) provides excellent anatomic imaging in patients with congenital heart disease and may be useful in the assessment of ASD [8,9]. We present four patients with an ASD who were considered for percutaneous closure and underwent EBA for measurement of defect size and assessment of rim adequacy, adjacent cardiac structures, and associated congenital anomalies.

CASE STUDIES

Case 1 (Assessment of Defect Size)

A 33-year-old Hispanic female presented to the emergency room complaining of worsening dyspnea on exertion over a 6-month period. Physical examination revealed a soft midsystolic murmur at the left upper sternal border and fixed splitting of the second heart sound. Electrocardiogram (ECG) showed normal sinus rhythm with an rSr′ complex in lead V_1. TTE demonstrated a 20 mm ostium secundum ASD with mild pulmonary hypertension and left-to-right shunting. TEE showed a 22 by 27 mm ostium secundum ASD with absence of the aortic rim. EBA with three-dimensional surface reconstruction demonstrated a large 33 by 36 mm ostium secundum ASD with an absent aortic (superior) rim (Fig. 1). A 34 mm sizing balloon under TEE color Doppler imaging showed a stretched diameter of 30 mm. A 34 mm Amplatzer septal occluder device was successfully deployed.

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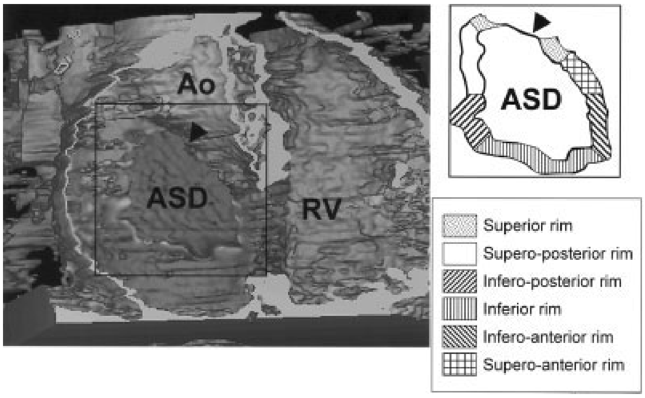

Fig. 1. Right lateral and slight caudal projection of three-dimensional EBA surface reconstruction. The free walls of the right atrium and ventricle have been removed. The ostium secundum ASD is clearly visualized. The defect abuts the base of the aorta (Ao), where a rim of septal tissue is absent [absent aortic (superior) rim; arrowhead]. The defect measures 36 mm in the vertical plane and 33 mm in the horizontal plane. RV, right ventricle.

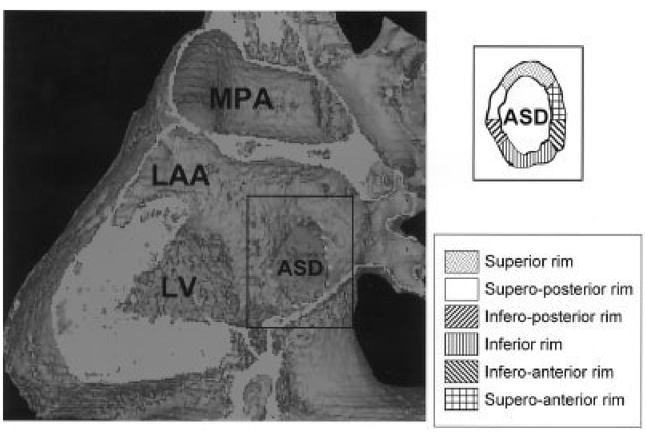

Fig. 2. Left posterolateral and slight cranial projection of three-dimensional EBA surface reconstruction. The left atrial and left ventricular free walls have been removed. The ostium secundum ASD is clearly visualized and measures 16 mm at the largest diameter with adequate rims in all directions. LAA, left atrial appendage; LV, left ventricle; MPA, main pulmonary artery.

Case 2 (Imaging of Amplatzer Device)

A 36-year-old Hispanic male was admitted with acute onset right eye ptosis and right upper and lower extremity numbness. Magnetic resonance imaging of the brain showed a small ischemic left thalamic stroke. ECG revealed normal sinus rhythm with an rSr′ pattern in lead V_1. Fixed splitting of the second heart sound was noted on physical examination. TTE with an intravenous contrast injection showed dilated right-sided chambers and a small ostium secundum ASD versus a patent foramen ovale (PFO) with bidirectional shunting. TEE demonstrated an ostium secundum ASD measuring 10 by 12 mm. EBA showed an ASD with a 16 mm vertical diameter and $\geq$ 5 mm septal rims in all quadrants (Fig. 2). At cardiac catheterization, balloon sizing of the ASD was 16 mm by both fluoroscopy and intraprocedural TEE. A 20 mm Amplatzer septal occluder was successfully deployed. Repeat EBA performed prior to discharge showed excellent visualization of the device within the atrial septum (Fig. 3).

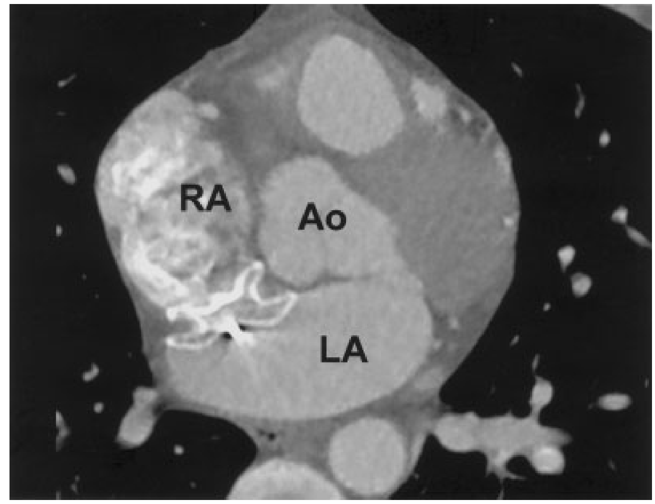

Fig. 3. Postprocedural axial EBA image of a 20 mm Amplatzer septal occluder deployed across the atrial septum. LA, left atrium; RA, right atrium; Ao, aortic root.

Case 3 (Lack of Adequate Rims)

A 20-year-old Hispanic woman was referred for evaluation of an abnormal ECG. The patient reported mild dyspnea on exertion and a history of frequent lower respiratory tract infections. Chest radiograph showed a dilated pulmonary artery and a prominent right atrial shadow. ECG revealed right atrial enlargement, right ventricular hypertrophy, right axis deviation, and an rSr′ pattern in lead V_1. TTE revealed moderate pulmonary hypertension, right-sided chamber enlargement, and a large left-to-right shunt at the atrial level. The defect was thought to measure 27–30 mm in diameter. EBA revealed a larger defect (39 mm in the widest diameter) with partially absent superior, superoanterior, inferior, and inferoposterior rims (Fig. 4). The large size of the defect and the absence of adequate septal tissue were thought to be contraindications for percutaneous closure and the patient was referred for surgical closure.

Case 4 (Associated Congenital Anomalies)

A 33-year-old Hispanic female presented with a history of worsening fatigue and palpitations. Physical examination revealed a soft midsystolic murmur over the left upper sternal border and a fixed splitting of the second heart sound. ECG revealed evidence of right atrial enlargement, right ventricular hypertrophy, and right axis deviation. TTE showed severe right-sided

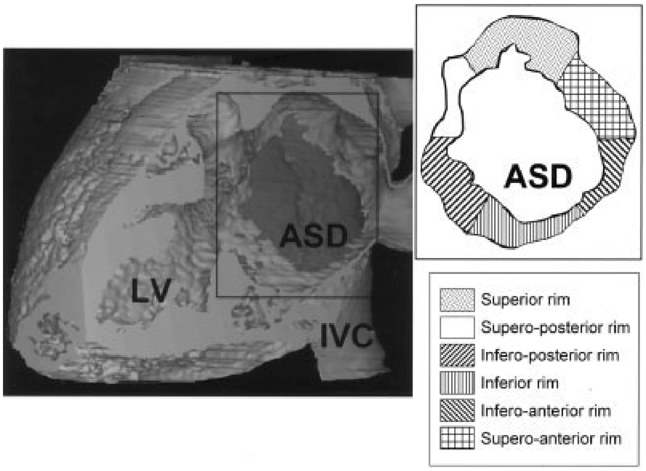

Fig. 4. Left anterior oblique view of three-dimensional EBA surface reconstruction of a patient with a large (39 mm) ostium secundum ASD. The free walls of the left ventricle and left atrium have been removed. Superior, superoanterior, inferior, and inferoposterior rims are partially absent. IVC, inferior vena cava; LV, left ventricle, ASD (atrial septal defect).

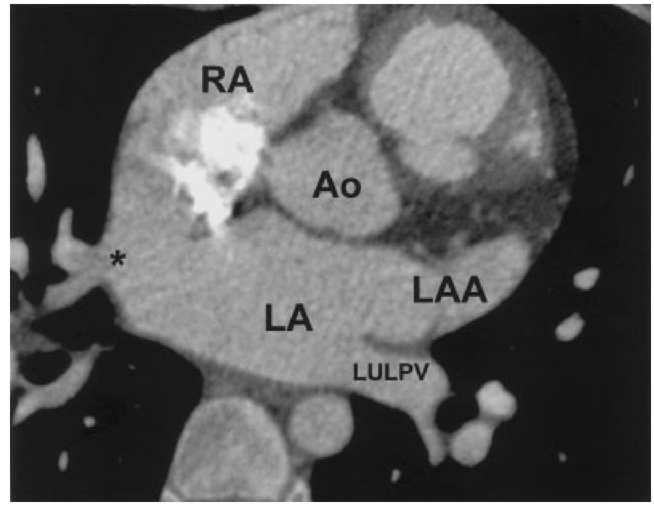

Fig. 5. Axial EBA image at the level of the anomalous right upper lobe pulmonary vein to the superior vena caval/right atrial juncture (asterisk). LAA, left atrial appendage; LULPV, left upper lobe pulmonary vein; LA, left atrium; RA, right atrium; Ao, aorta.

chamber enlargement, moderate pulmonary hypertension, and left-to-right shunting in the superior aspect of interatrial septum. The pulmonary veins were not well seen. EBA revealed a sinus venosus ASD with partial anomalous pulmonary venous return of the right upper pulmonary vein into the junction of the superior vena cava and right atrium (Fig. 5). Cardiac catheterization and angiocardiography confirmed these findings. Surgical correction with baffling of anomalous venous drainage to the left atrium and closure of the sinus venosus ASD was performed.

DISCUSSION

Percutaneous ASD closure is becoming more attractive than surgery because of faster recovery and decreased morbidity, mortality, and cost [1,4–6]. Accurate defect sizing, determination of adequate rims, and the exclusion of associated cardiac anomalies are the cornerstones to successful percutaneous defect closure [10]. TTE and TEE are widely used for this assessment. However, there is often underestimation of defect size resulting in device/defect mismatch and the need for device upsizing during the procedure [11–13]. This problem may be secondary to the detection by echocardiography of thin atrial septal membrane tissue that may not provide an adequate rim for device stabilization. Carcagni and Presbitero [7] have suggested a new echocardiographic sizing technique that includes only septal rims with $\geq$ 2.5 mm thickness in the determination of defect size and rim adequacy. Using this technique for cases 1 and 2, the defect size by TEE more closely approximated balloon sizing (case 1: TEE 30 by 32 mm, sizing balloon 34 mm; case 2: TEE 17 by 12 mm, sizing balloon 15.7 mm). Intracardiac echocardiography (ICE) has also been advocated as a method for both selection of septal occluder size and for guidance during transcatheter closure [14,15]. A series of 91 patients by Zanchetta et al. [16] found that ICE allowed accurate device sizing and optimal device placement with no ICE-related complications. EBA with three-dimensional surface reconstruction provides excellent two- and three-dimensional imaging of ASD anatomy. Moreover, as shown in case 4, EBA clearly and noninvasively identified anomalous pulmonary venous drainage that precluded percutaneous device closure. However, visualization of very thin ($<$ 2 mm) membranes is difficult with EBA. This lack of sensitivity may be of benefit when determining ASD rim adequacy for percutaneous device closure because the rims that are seen on axial and three-dimensional surface renderings may represent more adequate tissue to ensure device stability. Moreover, EBA three-dimensional defect sizing may accurately reflect the stretched defect diameter as demonstrated in cases 1 and 2. EBA appears to be accurate in assessing the defect size, but a larger series of cases is needed to address the hypotheses that EBA can be used for accurate assessment of defect size.

EBA with three-dimensional surface reconstruction may provide important anatomic information for the assessment of patients with ASD and assist in determining whether percutaneous closure is feasible and an appropriate mode of treatment.

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