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ORIGINAL ARTICLE

Transcatheter Closure of Secundum Atrial Septal Defects: Results in Patients with Large and Extreme Defects

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Background Transcatheter closure of moderate sized atrial septal defects (ASD) has been demonstrated to be safe and effective. However, the feasibility of transcatheter closure of very large defects is less clear, particularly when an aortic rim of septal tissue is absent.

Methods The study included patients referred for transcatheter ASD closure with maximal ASD diameter ≥20 mm at pre-procedural transoesophageal echocardiography. Patients were grouped according to presence of moderately large (20–29 mm), very large (30–39 mm), or extremely large (≥40 mm) ASD size. Procedural success was defined by successful device deployment and absence of complications.

Results Forty-two patients (median age 40 years, range 12–85 years, 76% female) were included in the study. The mean maximal ASD diameter was 29.0 ± 7.4 mm. Twenty-three patients had moderately large ASDs (23.0 ± 2.8 mm); 13 had very large ASDs (33.1 ± 2.9 mm) and six had extremely large ASDs (41.3 ± 1.6 mm). The aortic rim was absent in 22 patients, and present in 20 patients (4.7 ± 2.9 mm). Transcatheter defect closure was successful in 36 of 42 patients (86%). Procedural success was 100% in the moderately large ASD group, 92% in the very large group but only 17% (one out of six) in the extremely large group. If patients with ASD ≥40 mm were excluded ($n = 6$), the overall success rate was 97%. A single complication (device dislodgement) occurred in a patient with a 42 mm defect and a deficient postero-inferior rim. The presence or absence of an aortic rim of septum did not influence procedural success.

Conclusion The vast majority (97%) of large ASDs in the range 20–39 mm can be successfully closed percutaneously with a low or zero complication rate. However, procedural success is poor when attempting closure of extreme defects (≥40 mm), regardless of whether an aortic rim of septal tissue or present or absent.

Keywords Atrial septal defect • Transcatheter closure • Structural heart disease • Congenital heart disease • Percutaneous intervention

Introduction

Secundum atrial septal defects (ASD) have been closed percutaneously using a transcatheter approach for nearly 40 years [1]. Although surgical and transcatheter closure success rates are comparable, the transcatheter approach, where feasible is now the preferred technique as it is associated with shorter hospitalisation and lower morbidity [2–4]. Previous studies have demonstrated that transcatheter closure of moderate sized ASDs is safe and effective [5,6]. However, the feasibility of a transcatheter approach for very large defects (>30 mm diameter) is less clear, particularly when a rim of septal tissue at the aortic root is absent and when the postero-inferior rim is deficient (<5 mm). Whilst the European and Canadian congenital heart disease guidelines recommend transcatheter closure for ASDs measuring less than 38 mm

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diameter, US guidelines do not specify a maximal ASD size that is suitable for transcatheter closure [7–9]. Indeed few studies have compared success rates and safety for transcatheter closure of moderately large, very large and extremely large ASDs on an intention to treat basis. We therefore report results from a series of patients with moderately large (20–29 mm), very large (30–39 mm) and extremely large (≥40 mm) ASDs who underwent attempted transcatheter closure at a single interventional cardiology centre.

Methods

Patients

The study population consisted of 42 consecutive patients referred to a single large interventional cardiology service for transcatheter closure of a single large ASD, defined as maximal ASD diameter of ≥20 mm but <40 mm on the pre-procedural transoesophageal echocardiogram (TOE). All study patients had demonstrated right heart dilatation and colour Doppler evidence of left to right inter-atrial shunting on pre-procedural transthoracic echocardiography (TTE). Follow up was performed by the referring physician.

Peri-procedural Transthoracic Echocardiography

All patients underwent TTE prior to the ASD closure procedure. Right ventricular size and function was assessed as per ASE guidelines from para-sternal, apical and sub-costal views [10]. The right ventricle (RV) was categorised as being mildly, moderately or severely dilated. If tricuspid regurgitation was present, RV systolic pressure was estimated using the Bernoulli equation in combination with right atrial pressure that was estimated from the inferior vena cava size and respiratory variation. All patients had a complete TTE study on the day following the ASD closure procedure.

Transoesophageal Echocardiography

TOE examination was performed with Philips echocardiography machines (5500 or iE33) utilising a multiplane two-dimensional or three-dimensional probe. TOE studies were either performed in the lead up to the procedure or in the cardiac catheterisation laboratory immediately prior to the procedure. Standard mid-oesophageal views were acquired at 0°, 45°, 90°, and 135° to assess the maximum ASD diameter. All procedures also involved further sizing of the defects with an Amplatzer sizing balloon, which provided a maximal "stretched diameter''. The largest diameter obtained at either study was recorded as ASD size.

The anatomical characteristics of ASDs were carefully assessed by a cardiologist experienced in the performance of TOE to document the presence of an aneurysmal septum (defined as total excursion greater than 10 mm) and the presence or absence of a rim of septal tissue at the aortic root, as assessed in the mid-oesophageal short axis (45°) view.

Procedural Success and Follow-up

Transcatheter closure was performed using previously described techniques [11]. Procedural success was defined as successful delivery of the closure device with no peri-procedural complications, satisfactory appearance of the occluder device at the post-procedure TTE (day one) with no pericardial effusion, and patient discharged from hospital day one post-procedure with no additional medical attention required. Procedural complications were defined as bleeding requiring transfusion, advanced heart block requiring cardiac pacing, or abnormalities on the post-procedure TTE including pericardial effusion, new or worsening mitral valve dysfunction due to device interference with the anterior mitral valve leaflet, device migration or embolisation, or aortic root perforation. Clinical follow up visits were used to assess late complications occurring post-discharge.

Statistical Analysis

Descriptive statistics described population mean, median, and standard deviation. ASDs were further analysed according to size [moderately large (20–29 mm), very large (30–39 mm) and extremely large (≥40 mm)] defined as the largest diameter obtained at either the pre-procedural TOE or the intra-procedural TOE during balloon sizing of the defect ("stretched diameter''), and the presence or absence of an aortic rim of septal tissue. Group comparisons were made with the student *t*-test. A p value < 0.05 was considered statistically significant.

Results

Patient Characteristics

Baseline characteristics of the 42 patients with large ASD are presented in Table 1. The majority of patients were female (76%) with a mean age of 40 ± 18 years. The population was relatively healthy with only four out of the 42 patients having co-morbidities (hypertension). All patients had normal left ventricular size and ejection fraction. Right ventricular size was at least mildly dilated in all patients with 19% of patients having a severely dilated RV. Right ventricular systolic function was normal in 40% of patients; only one of the 42 patients had severely reduced RV ejection fraction.

ASD Characteristics

ASD characteristics are presented in Table 2. As expected, ASD diameter at the initial TOE was smaller than the "stretched diameter'' obtained following intra-procedural balloon inflation (23.7 ± 7.6 mm versus 29.0 ± 7.4 mm, $p < 0.001$.) Thirteen patients had very large (30–39 mm diameter) ASD and six patients had extremely large ASDs (diameter ≥40 mm). Twenty-two of the 42 patients (52%) had no aortic rim with the remaining 20 subjects having an average aortic rim of 4.7 ± 2.9 mm. Patients with absent aortic rim had larger defects then patients with aortic rim present (30.6 ± 6.8 mm versus 27.2 ± 7.7 mm, $p < 0.05$). Aortic rim dimension decreased as ASD size increased (Table 2). Atrial septum