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Original Article

The value of transesophageal echocardiography in transcatheter closure of atrial septal defects in the oval fossa using the Amplatzer septal occluder

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Abstract *Background:* From January, 1997, as part of an international multicentric trial, we have been closing small-to-moderate atrial septal defects within the oval fossa using the Amplatzer Septal Occluder (ASO, AGA Medical). *Methods:* All patients with defects within the oval fossa deemed potentially suitable for transcatheter closure were investigated by transesophageal echocardiography with the aim of gaining extra information that might alter the decision to use the device to close the defect. Views were obtained in transverse and longitudinal planes, permitting measurements of the diameter of the defect, and its distance from the atrioventricular valves, coronary sinus, and pulmonary veins. Additionally, we sought to identify multiple defects, and to exclude sinus venosus defects. *Results:* Of 56 patients with left-to-right shunts, 41 (73.2%) were deemed suitable for closure with the Amplatzer Septal Occluder. All underwent the procedure successfully, with no complications. This includes 5 patients with multiple small defects that were sufficiently close to the main defect to be closed with a single device. Only two of these had been detected on the transthoracic study. In the remaining 15 of 56 patients, transcatheter closure was deemed unsuitable. In 9 patients, this was due to the limitation of the size of the device available during the period of study, this representing a relative contraindication. In the remaining 6 (10.7%), transcatheter closure was not performed because multiple defects were too far apart to be closed with a single device in 3 patients, two patients were noted to have a sinus venosus defect, and another was noted to have anomalous connection of the right upper pulmonary vein to the right atrium. Excluding patients contraindicated due to the size of the defect alone, transesophageal echocardiography provided extra information in one-tenth of our patients, which altered the decision regarding management. *Conclusion:* Transesophageal echocardiography is indispensable in the evaluation of patients undergoing transcatheter closure of atrial septal defect.

Keywords: Interventional catheterization; sinus venosus defect; interatrial communications

TRANSCATHETER CLOSURE OF ATRIAL DEFECTS within the oval fossa has now been undertaken for more than two decades. The early results, especially with the new self-centering device, are encouraging, and have been shown to be safe and effective.[1–3] An accurate assessment of the septal anatomy is essential to ensure successful closure, and to prevent unnecessary complications. Although transthoracic echocardiography frequently distinguishes the defects within the oval fossa from the so-called 'primum' defect, it has been reported to be less sensitive in the demonstration of sinus venosus communications, especially in adults or bigger children.[4] Transesophageal echocardiography has been used to provide an excellent alternative window, and was found to be highly sensitive and specific for all types of interatrial communications.[4–6,7] Concomitant use of transesophageal echocardiography with fluoroscopic imaging provides information that is unique and complementary, and may improve the efficacy and safety of transcatheter closure.[8] This review was undertaken to assess the value of the technique in transcatheter closure of defects within the oval fossa using the Amplatzer Septal Occluder (ASO, AGA Medical Corp., Golden Valley, MN).

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Patients and methods

Transcatheter closure of atrial defects using the Amplatzer Septal Occluder has been performed in our institution since January 1997 as part of an international multicentric trial. The criterions for inclusion include defects within the oval fossa of less than 18 mm as judged on transthoracic echocardiography, and/or transesophageal echocardiography showing that the stretched diameter of the defect is 26 mm or less, with the defect positioned at least 6 mm from the atrioventricular valves, the right upper pulmonary veins, the coronary sinus and the superior caval vein. Transcatheter closure is contraindicated in patients with associated partially anomalous pulmonary venous connection, and in 'ostium primum' and sinus venosus defects. In our center, transcatheter closure is not performed in patients with multiple defects which are large, or else too far apart to be closed with a single device. Due to the limitation in the size of the device available during the period of study, with a range from 4 to 26 mm, transcatheter closure was not performed in patients with a stretched diameter of more than 26 mm. Six patients with right-to-left shunts, four of these with fenestrated Fontan operations, one with pulmonary atresia and intact ventricular septum subsequent to radiofrequency valvotomy and balloon dilation of the pulmonary valve, and one with Ebstein's malformation of the tricuspid valve, were excluded from analysis.

All patients with the clinical diagnosis of an interatrial communication underwent detailed transthoracic echocardiography to confirm the diagnosis and to assess the suitability for transcatheter closure. Patients with defects shown to be in the oval fossa, with a diameter of 18 mm or less, and with good surrounding rims, were subjected to transesophageal echocardiography with the aim of gaining extra information that might alter the decision to close with an Amplatzer Septal Occluder. Written consent was obtained from the patients or their guardians. All procedures were performed under general anaesthesia. Views were obtained in transverse and longitudinal planes, permitting measurements of the diameter of the defect, and the distances from the atrioventricular valves, coronary sinus, and pulmonary veins. Additionally, multiple defects were sought, along with the presence of sinus venosus defects and associated anomalous pulmonary venous connection. Patients who fulfilled the criterions were subjected to transcatheter closure using the Amplatzer Septal Occluder. The protocol includes measurement of the ratio of pulmonary to systemic flows, performance of a pulmonary arterial angiogram to demonstrate the shunts in levophase across the atrial septum to exclude anomalous venous connection; and measurement of the stretched diameter of the septal defect. The size of the device used was equal or one millimeter bigger than the stretched diameter. Transcatheter closure was done under transesophageal echocardiography as well as fluoroscopic guidance using a previously described technique.[1] Data were expressed in mean and median values.

Results

From January 1997 to March 1998, 56 patients presumed to have defects in the oval fossa underwent transesophageal echocardiography for further evaluation. Of 56 patients, 41 (73.2%) were deemed suitable for transcatheter closure using the Amplatzer Septal Occluder, and they underwent the procedure successfully with no complications (Table 1). This included 5 patients with multiple defects in whom the minor defects were close enough to the main defect to be closed with a single device. In 2 of these 5 patients, the multiple defects were detected on transthoracic echocardiography. In the remaining 15 patients in the overall group, transcatheter closure was deemed unsuitable. In 9 patients, this was because the device available during that period was too small – hence representing a relative contraindication. In the remaining 6 patients, 10.7% of the total group, transcatheter closure was not performed because of various identified contraindications. Three patients had multiple defects (Fig. 1) which were too far apart to be closed with a single device. Two had sinus venosus defects in addition to holes within the oval fossa, and another was noted to have associated anomalous connection of the right upper pulmonary vein into the right atrium. The latter was confirmed subsequently on angiography. In the 41 patients who had undergone successful procedure, complete closure was obtained in 33 (80.5%) at 24 hours, 39 (95%) at 3 months, and 100% at one year of follow-up.

Discussion

Transcatheter closure of interatrial communications is an attractive alternative mode of treatment for small-to-moderate sized defects within the oval fossa for several reasons. These include the avoidance of cardiopulmonary by-pass, absence of an ugly surgical scar, and shorter hospital stay. Since the introduction of transcatheter closure in the mid-1970s, many devices have been developed,

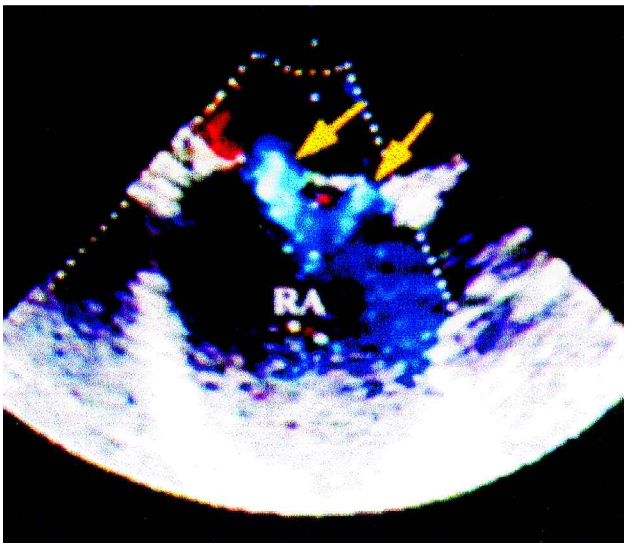

Figure 1.
Longitudinal view of the transesophageal echocardiogram showing multiple atrial septal defects (arrows) which are too far apart to be closed with a single device. RA = right atrium.

Table 1. Demographic data.

Age (median)	3 – 59 (8.5) yr
Weight (median)	11.6 – 79 (19.4) kg
Stretched diameter (mean)	4 – 26 (16.5) mm
Flouroscopic time (median)	7 – 122*(24) min
Procedure time (median)	88 – 210*(135) min

Note: *One patient had inadvertent detachment of the device from the delivery cable, which was successfully retrieved from the right atrium. A new device was subsequently implanted at the same sitting. This event accounts for the longest procedure and fluoroscopy time.

and have undergone various modifications with variable degrees of success. These include the Bard clamshell device (USCI, Billerica, MA), the buttoned device (Custom Medical Devices, Amarillo, TX), and the ASDOS device (Dr. Ing. Osypka Corp., Germany). The major drawbacks of these devices included a high incidence of residual shunts, occurring in two-fifth of those closed with the Bard clamshell device and one-fifth using the buttoned device, the complexity of the procedures, a poor centering effect, the large size of the catheters needed for delivery, and the inability to reposition the device once the right atrial disc had been deployed.[9,10,11] The new Amplatzer Septal Occluder represents a departure from previous devices. It was built to address specifically the limitations of the previous designs.

Even with such a well-designed device, careful selection of patients is essential to increase the efficacy and safety of transcatheter closure. In our group of patients, one quarter of those who appeared to be suitable for transcatheter closure were deemed unsuitable after the transesophageal echocardiographic study. In one-tenth of them, transcatheter closure was positively contraindicated. Although there are reports of safe and successful closure of multiple atrial septal defects using the Amplatzer device,[12] we did not attempt to this maneuver in our practice, as it is non-economical. Surgery is still the mainstay of treatment for sinus venosus defects, and for those in the oval fossa associated with partially anomalous pulmonary venous drainage. The diagnosis of sinus venosus defects is often difficult using transthoracic color Doppler and cross-sectional echocardiography. In adults, obese patients, and those with chest deformity, the ultrasonic beam projected from the parasternal or the subcostal regions of the anterior chest wall does not always strike the interatrial septum perpendicularly. Sometimes, echocardiographic dropouts give a false-positive appearance of the septal defect. In transesophageal echocardiography, the transducer is placed within the esophagus, which is adjacent to the posterior wall of the left atrium very close to the interatrial septum. Hence, the ultrasonic beam can be directed almost perpendicularly to the septum.[13] Kranzon et al.[4] demonstrated that transesophageal echocardiography is superior to transthoracic echocardiography in the diagnosis of the sinus venosus defect. In their study, transthoracic echocardiography failed to demonstrate the atrial septal defect in one-fifth of patients, and in three-quarters of those with sinus venosus defects that were demonstrated on transesophageal echocardiography. Anomalous venous connections associated with the sinus venosus defect were visualized by transesophageal echocardiogram in seven of the eight patients, but were not seen on transthoracic echocardiography in any patient.[4]

Transesophageal echocardiography has been widely used during transcatheter closure using various devices to ascertain the size, position and number of defects, and to ensure proper positioning of the device.[1,8,9,10,11,14] The technique provides a better appreciation of cardiac anatomy,[15] and is essential for monitoring during transcatheter closure, especially during the deployment of the device so as to avoid impingement onto vital structures, and to ensure the discs are placed properly. With the Amplatzer Septal Occluder, if there is malpositioning of device, it can be recovered into the sheath used for delivery, permitting steps to be repeated until a proper position is obtained. Transesophageal echocardiography is also used to assess residual shunting following the procedure.

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Although three-dimensional transesophageal echocardiography is superior to cross-sectional echocardiography for imaging the device, especially when abnormally placed,[14] it is not widely available. In our opinion, cross-sectional transesophageal echocardiography, coupled with simultaneous fluoroscopic imaging, are adequate to provide the information required for a successful and safe transcatheter closure of atrial defects within the oval fossa.

In conclusion, therefore, excluding patients in whom there is a relative contraindication due only to the size of the defect, transesophageal echocardiography provided extra information in one-tenth of our patients. This added data altered the management. In our opinion, the technique is indispensable in the evaluation of patients undergoing transcatheter closure of atrial septal defect.

Addendum

Subsequent to this study, AGA Medical has made bigger devices available. Our echocardiographic criterions have changed accordingly. The current largest available device is 38 mm, and the maximum diameter of the defect considered suitable for transcatheter closure is 22 mm. Transesophageal echocardiography is now even more valuable when closure is attempted using bigger devices, especially those above 28 mm.

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