CLINICAL STUDY

Value of echocardiography in results evaluation of transcatheter atrial septal defect closure in adults

Simkova I, Kozlovsky M, Riecansky I, Fridrich V

Slovak Postgraduate Medical Academy, Div. Cardiology, Department of Cardiology, Slovak Institute of Cardiovascular Diseases, Bratislava, Slovakia. **simkova@susch.sk**

Abstract

Transcatheter closure of secundum atrial septal defect using Amplatzer occluder is accepted treatment modality. Transthoracic (TTE) and transoesophageal (TEE) echocardiography provides indispensable informations in the selection of eligible atrial septal defects, evaluates the exact size, location and morphology of the defect. In the closure procedure assistance of TEE enables precise determination of device size, correct placement of the device and immediate and follow-up closure results assessment. The present prospective study was performed in order to investigate the value of both approaches — TTE and TEE in the intermediate-term follow-up. Before, during transcatheter defect closure and in the follow-up echocardiography studies [TTE and TEE] were performed in 33 adult patients with secundum atrial septal defect with fulfiled TEE criteria. Correct placement of the device without interference with surrounding structures under TEE monitoring was possible in all patients. Immediate complete closure was achieved in 49 % of patients, after 3 months in 94 %. TEE findings corresponded well with TTE. In the follow-up echocardiographic signs of right ventricle overload retreated. Results indicate that TEE provides valued data for the selection and closure procedure. TTE is a sufficient reliable approach for results evaluation in intermediate follow-up. Echocardiography plays crucial role in the safety and efficacy assessment of transcatheter treatment of secundum atrial septal defect. ***(Fig. 4, Ref. 16.)***

Key words: echocardiography, secundum atrial septal defect, Amplatzer occluder.

Secundum atrial septal defect [ASD] has been closed surgically since before the development of cardiopulmonary bypass and has been rutinely operated upon safety for 5 decades. However, surgical correction of ASD does require sternotomy and cardiopulmonary bypass, therefore can be associated with numerous possible complications (Šimková et al., 1990, 1997). Furthermore there is limited, but significant, hospital stay and convalescence time.These drawbacks have inspired the invention of various techniques and devices to close small to moderate-size ASD by catheter. The history of catheter closure began at the end of 70th, although vigorous expansion reached in the last ten years. In the evolution period various methods and devices (*Bard clamshell-device*:USCI Billerica, MA, *buttoned devices*, *Das-Angel Wings-device*: Microvena Corporation, White Bear Lake, Minn, *ASDOS-device*:Osypka GmbH,Germany) were tried, signated by series of disappointments and problems, e.g. device arm fractures, residual shunts, ante- and retrograde approach needed, redeployment problems, embolisation .... (Block, 1997; O'Laughlin, 1997). The follow-up results with the self-expanding and self-centering nitinol prosthesis called *Amplatzer septal occluder* [ASO] (AGA Medical Corporation, Golden Valley, Minn) seem to fulfil the promises of an effective and safe closure system (Mašura et al., 1997). Application of this method requires in all phases the assistance and guidance of echocardiography. In the process of patient selection for transcatheter closure two-dimensional transthoracic (TTE) as well as transoesophageal (TEE) echocardiography provide informations playing crucial role. They are: location, size, morphology, number and hemodynamic relevance of ASD, sufficient tissue rims surrounding the defect. Furthermore TEE assistance during the closure procedure itself (detection of correct placement of the device without interference with atrioventricular valves, sinus coronarius and pulmonary veins) assures comfortable accomplishment of the procedure. The excellent echo appearance of ASO allows continual echocardiographic long-term follow-up of closure results.

Slovak Postgraduate Academy of Medicine, Div. Cardiology, Bratislava, Slovakia

Address for correspondence: I. Simkova, MD, PhD, Dep. Cardiology, Slovak Institute of Cardiovascular Diseases, Pod Krasnou horkou 1, SK-833 48 Bratislava 37, Slovakia.
Phone: 0903.448 663

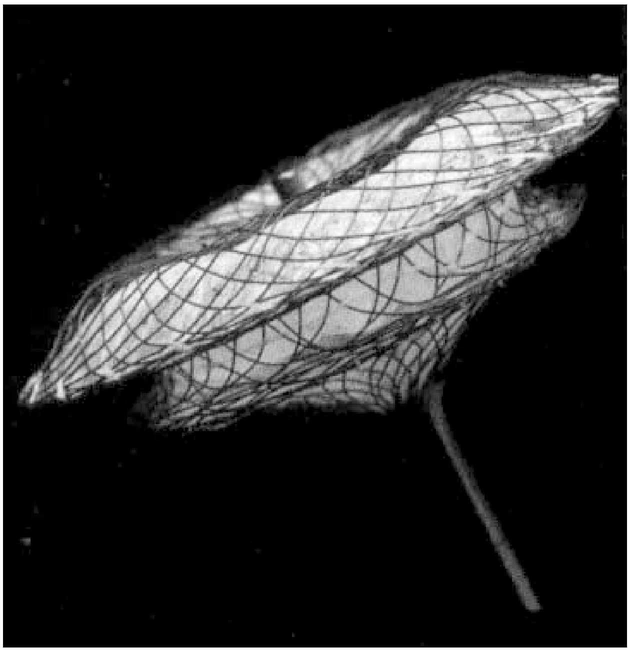

Fig. 1. Amplatzer septal occluder.

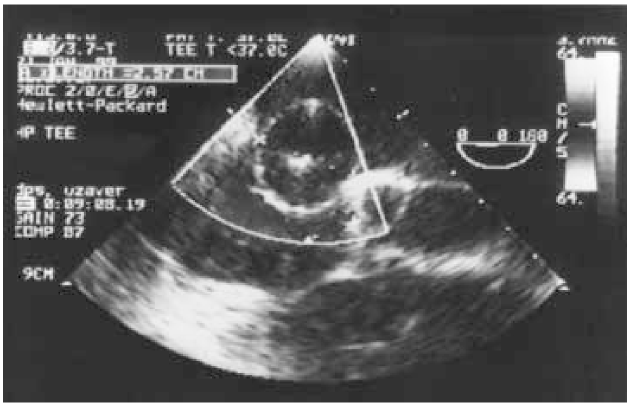

Fig. 2. Sizing procedure: detection of balloon-stretched diameter (TEE approach).

Therefore, the aims of this prospective study was to investigate the value of both echocardiographic approaches — TTE and TEE in the intermediate-term follow-up:

— in the selection of eligible ASD for transcatheter closure,
— in the closure procedure itself: selection of correct device size, device placement and detection of interference with surrounding structures and of possible complications,
— in evaluation of closure efficiency of ASO immediately after ASD closure and in the follow-up.

Material and methods

The study population consisted of 33 (M/F = 10/23) patients [pts] with mean age 36±15 years with significant left to right shunt (Qp:Qs = 1.9±0.7) due to secundum ASD.

The ASO (Fig. 1) consists of basket-type weave of nitinol wire, that expands to form 2 facing disks with waist in between. The prosthesis has been filled with polyester fibers to enhance fibrogenicity and effectiveness of closure. The device diameter is determined by the diameter of the waist. The device is collapsed and loaded into a delivery catheter attached to the positioning wire by a small screw mechanism. The advantage of this device is, that the operator has the ability to retrieve and reposition the device prior to its release.

Prior to the closure two-dimensional echocardiographic (TTE and TEE) examination using Hewlett Packard Sonos 2000 echocardiograph with multiplane TEE probe was performed to determine, if the ASD is suitable for transvenous correction. Morphology, location, size and number of ASD was clearly demonstrated. The size of eligible ASD is expressly determined by the largest ASO size of 38 mm. The presence of adequate superior and inferior rims (>5 mm) were regarded as crucial for successful closure unlike of superior and anterior rim, which can be absent. The size of right ventricle (RV) was measured, motion of interventricular septum (IVS), tricuspid regurgitation [TR] and pulmonary hypertension was assessed.

The closure of ASD was performed under guidance of TEE: (1) sizing procedure aimed on detection of balloon-streched diameter of ASD (Fig. 2), therefore on selection of correct device size. The stretched diameter is defined as the largest balloon that passed through the ASD at cathetrisation, (2) correct placement of ASO (Fig. 3), (3) detection of misplacement of ASO, monitoring of recapture of ASO to the delivery sheat and correct redeployment, (4) possible interference with surrounding structures, (5) evaluation of immediate closure effectiveness: trivial residual shunt (TS = color jet ϕ <1 mm), small shunt (SS = color jet ϕ 1—2 mm), moderate shunt (MS = color jet ϕ >2 mm) (Boutin et al., 1993).

Echocardiographic examination in the follow-up used rutinely the transthoracic approach (Fig. 4). By the by evaluation of location of ASO, closure efficacy, RV size, IVS motion, TR was measured. In order to investigate the usefulness and necessity of TEE in the follow-up, both approaches — TTE as well as TEE — were obligatory applicated in 15 pts after 1 and 3 months. Otherwise TEE was used in all pts with residual shunts, in unclear cases or in pts with low quality of TTE imaging.

Pts were examined one week prior to and after the closing procedure on the 1st day, after 1 and 3 months and then yearly. Preprocedural echocardiographic findings were compared with periprocedural measurements as well as immediate closure results with results in the follow-up (12—18 months).

Results

(1) The median ASD diameter by TEE was 17mm (16.9±3.6 mm), the median ASD ballon-stretched diameter was 20 mm (20.1±5.1 mm). *(2)* TEE monitoring confirmed correct placement of ASO in the first procedure in all pts. *(3)* In 6 % (2 pts) TEE revealed deployment attempt of second disc in the left atrium, disc was recaptured and correctly placed under TEE guidance in the right atrium. *(4)* Neither interference with atrioventricular valves,

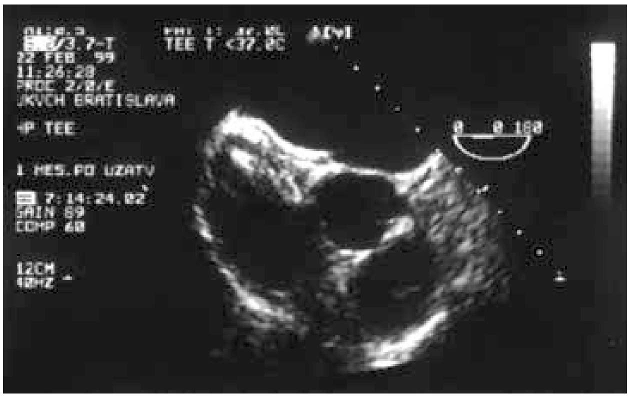

Fig. 3. Correct placement of Amplatzer septal occluder (TEE approach).

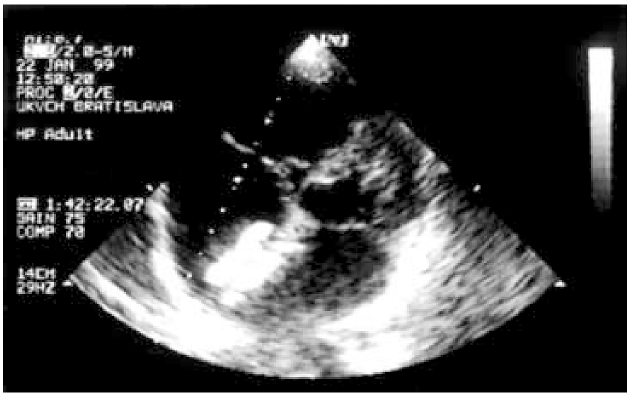

Fig. 4. Correct placement of Amplatzer septal occluder (TTE approach).

pulmonary veins nor complications were detected. *(5)* TEE using colour Doppler enabled assessment of immediate closure results as follows: complete closure of ASD in 16 pts (49 %), TS in 7 pts (21 %), SS in 8 pts (24 %) and MS in 2 pts (6 %). In the follow-up residual shunts disappeared up to 3 months except for two pts (6 %), where SS remained also after 12 months. Complete closure after 12 months was 94 %. The comparison of both echocardiographic approaches in 15 pts revealed very comparable results. Small and moderate shunts were detected by both methods, trivial were overlooked by TTE. After 3 and 12 months remained 2 small shunts were visible also by TTE. In one patient we revealed after 3 months one more opened small ASD (ϕ 1—2 mm) located above the device. The ASD didn't reach hemodynamic relevance. This small ASD was overlooked prior to closure.

TTE evaluation demonstrated regression of RV overload. RV size changed significantly (40 mm vs 34 mm, $p<0.001$), paradoxal motion of IVS disappeared.

Discussion

The complexity of the anatomy and topography of the left and right sides of the atrial septum as well as of the fossa ovalis defects given by echocardiography particularly transoesophageal provide warranty concerning correct device selection, device placement and closure efficacy assessment.

Reports of device closure of single secundum ASD indicate encouraging prospects for both reduced mortality, morbidity and costs. The incidence of residual shunts and complications remains high in preliminary reports (Justo et al., 1995; O'Laughlin, 1997). However the recent studies with newer generation of devices promise to provide a safe and effective substitute for surgery (O'Laughlin, 1997; Mašura et al., 1997; Thanopoulos et al., 1998; Cao et al., 2000), because of higher closure rates and fewer complication rates. The most important in this treatment modality is the process of patient selection and choice of the device.

The selection of patients based on echocardiography is probably the most important step in the whole process. Only careful interrogation of the atrial septum preferable by two-dimensional multiplane TEE can confirm the valid indication for catheter closure. In our study group in all cases the device could be placed correctly and we had no complications with necessity of following surgical correction. The results are comparable with studies using ASO (Mašura et al., 1997; Thanopoulos et al., 1998; Cao et al., 2000). More sophisticated approach is three-dimensional TEE not in common use allowing better spatial relationship between intracardiac structures, in the main in case of multiple defects. This technique clearly demonstrates the shape, size and distance between defects (Cao et al., 2000).

The device has to fulfil criteria to become widespread used: complete closure efficacy, reponibility, easy implantation and costeffectiveness. Amplatzer septal occluder seems to meet such requirements (Mašura et al., 1997; Cao et al., 2000). In case of ASO both two important aspects — safety and closure efficacy — are assured by periprocedural TEE monitoring (Ewert et al., 1999; Cao et al., 2000). Multiplane TEE evaluated the exact size of the defect and the relatioship to the surrounding structures. Furthermore TEE was invaluable in guiding the precise measurement of the balloon stretched diameter. However in present study similarly to others (Mašura et al., 1997; Pfeiffer et al., 1998) the TEE measurements demonstrated shorter diameters of the defect than balloon sizing. The explanation is, that balloon sizing resulted in oversized ASD diameters because of deformation of as ASD as balloon and stretching septal tissue. This procedure serves to careful and exact selection of device size and so to minimizing the degree of residual shunts.

Excellent echocardiographic appearance of ASO insures safely deployment and correct placement of both discs. In our study population in 2 cases (6 %) the TEE guidance of redeployment of second disc was necessary. Similar low incidence of redeployment necessity due to misplacement of both discs in the left atrium was reported in larger study group (Gavora et al., 1998). The TEE guidance can avoid this complication. The ability of reposition of ASO up to the moment of release of the screw is very important advantage of this device.

The immediate closure rate evaluated by TEE with colour Doppler was 49 %, very similar to study of Mašura et al. (1997) (57 %). However within 3 months complete closure increased to 94 %, an usual rate for ASO (Mašura et al., 1998; Berger et al., 1999; Cao et al., 2000), however unusual for other devices (Lloyd et al., 1994; O'Laughlin, 1997; Zamora et al., 1998). Althogh in time in studies with other devices residual shunts became smaller or dissappeared too (Lloyd et al., 1994; O'Laughlin, 1997; Block, 1997). The immediate success rate of closure is due to the closure mechanism of ASO, e.g. the defect is blocked by the connecting waist. The comparative manner of shunts echocardiographic interrogation showed comparable results, the differences were found only in evaluation of trivial shunts in the early follow-up period (up to 1 month). In the mean follow-up period of 14 months no complications were detected. In one case very small second defect, hemodynamic irrelevant, was overlooked. In this patient similarly as in the whole group all signs of right ventricle overload continuously followed by echocardiography disappeared. This is one more echocardiographic confirmation of high efficacy of ASO in the ASD corection.

One more advantage of TEE guidance and assistance during the closure procedure is shorter fluoroscopic time.

The transcatheter closure of ASD is nowadays accepted as a safe and effective treatment modality. Due to above mentioned facts however it is possible only under assistance of echocardiography. In the process of selection of eligible defects TTE and TEE play crucial role, the closure procedure shoud be performed by TEE guidance and follow-up of closure results by monitoring of TTE. TTE seems to be a reliable method in evaluation of follow-up results, however in patients with low quality of TTE imaging or unclear cases TEE is necessary complementary method.

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