

Initial experience with intracardiac echocardiography guidance in transcatheter closure of interatrial communication (atrial septal defect, patent foramen ovale, fenestrated Fontan) in Saudi Arabia

Mashail Alobaidan, Tarik Moamenah, Hafeez Abdullah

The recent development of intracardiac echocardiography (ICE) has added a further dimension to the imaging modalities available to the cardiologist. Intracardiac ultrasound or echocardiography has been in existence since the 1970s with clinical use for visualization of the coronary arteries since the 1980s.^{1,2} Early ultrasound-tipped catheters used high frequency for detailed imaging of the coronary artery lumen and wall. However, these ultrasound-tipped catheters lacked good depth penetration, and color and pulse Doppler capabilities. With the introduction of lower frequency catheters, an increase in depth penetration was possible. The initial experience with the use of the catheter for guiding device closure of secundum atrial septal defect (ASD) and patent foramen ovale (PFO) has been recently described.³ We report our experience using this new modality in guiding trans-catheter closure of ASD, PFO and fenestrated Fontan.

We avoided transesophageal echocardiography (TEE) and general anesthesia (except for that needed for comparison of TEE and ICE). We assessed the feasibility and accuracy of ICE in guiding the percutaneous closure of intra-atrial communications and the success of device deployment at Prince Sultan Cardiac Center, Riyadh, Saudi Arabia.

Patients and Methods

High quality ICE imaging was obtained using a 10Fr (3.2 mm), 5.5- to 10-MHz ultrasound tipped catheter (Acuson Corporation). The advantages of this catheter include the presence of a four-way tip articulation for easy maneuverability inside the cardiac chamber and Doppler capabilities. The catheter was introduced via 10Fr sheath from the right

From the Paediatric Cardiology Department, Prince Sultan Cardiac Center, Riyadh, Saudi Arabia

*Mashail Alobaidan, MD
Paediatric Cardiology Department
Prince Sultan Cardiac Center
P.O. Box 99911
Riyadh 11625,
Saudi Arabia
Fax/Tel: +966-1-473 0049
mashaila@hotmail.com*

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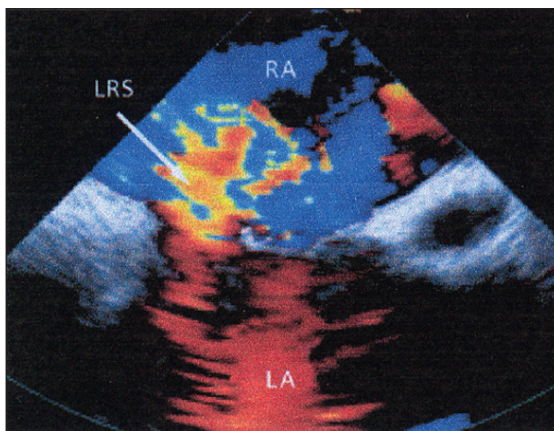


Figure 1. Atrial septal defect with characteristic left-right shunt (LA=left atrium, LRS=left-to-right shunt, RA=right atrium)..

or left femoral vein. The catheter was connected to Acuson portable machine. The catheter has a quadirectional steerable tip that houses a side-firing, multiple frequency (5-10 MHz) phased-array transducer with two-dimensional and color Doppler imaging modes. The scan plane is along the axis of the catheter with a range of tissue penetration from 2 to 120 mm. On entering the RA the transducer was rotated anteriorly to obtain an image of the tricuspid valve and right ventricle (RV) inlet. The transducer tip was then flexed posteriorly and rotated clockwise to view the aorta and atrial septum in the long axis.

Movement of the catheter cranially and caudally, afforded excellent views of the superior and inferior aspects of the atrial septum. The course of the right-sided pulmonary views could be imaged from the junction of the RA and superior venacava by rotating the catheter clockwise. A short-axis image of the aortic valve and atrial septum was achieved by further posterior flexing and rotating the transducer clockwise, such that the catheter tip was directed toward the TV. The amplatzer septal or PFO occluders were used in all patients.

Thirty-nine patients included 13 males, 26 females, 13 PFO closure, 20 ASD II (5 no device + 15 closure), 5 fenestration closure, and 1 fenestration creation. The patient ages ranged from 4 years to 51 years with a mean of 23.5 years. Body weight ranged from 17.2 kilograms to 94 kilograms with a mean of 49 kilograms.

Results

The ASD cases included 17 patients, 13 of whom were totally occluded with the device (9 with ICE alone, 4 under ICE + TEE). The device used was an Amplatzer device size between 8 and 40 mm (median 24 mm). ICE was used in sizing the ASD and post-device closure. The remaining 4 patients with ASD II failed the closure and were sent for surgical repair. There were 12 patients with PFO occluded under ICE, and we used the Amplatzer device, size 35 mm and 25 mm, cribriform occluder to close the PFO in all patients with or without aneurysm. Four patients with a fenestrated Fontan were occluded under ICE and we attempted 1 fenestration creation under ICE alone using the Amplatzer ASD device occluder size 4 to 7 mm. ICE was done before to measure the size of the fenestration and after the device was implanted to see the leak.

Discussion

As a result of the ease of implantation and the supe-

Table 1. Details of diseases in relation to devices and procedures.

No. of Patients	Disease	Device size	Procedure
12	PFO	35 PFO	ICE
2	ASD II	35 (cribriform)	ICE
3	Fenestration closure	4 mm	ICE
2	ASD II	40 mm	ICE + TEE
3	ASD II	26 mm	ICE + TEE
1	ASD II	20 mm	ICE
2	ASD II	16 mm	ICE
1	ASD II	15 mm	ICE
1	ASD II	8 mm	ICE
1	Fontan I	6 mm	ICE
1	Fontan I	7 mm	ICE
2	ASD II	25 (cribriform)	ICE
1	PFO	25 (cribriform)	ICE
1	ASD II	14 mm	ICE
5	ASD II	No device (failed)	ICE + TEE
1	Fenestration fontan	No device	ICE

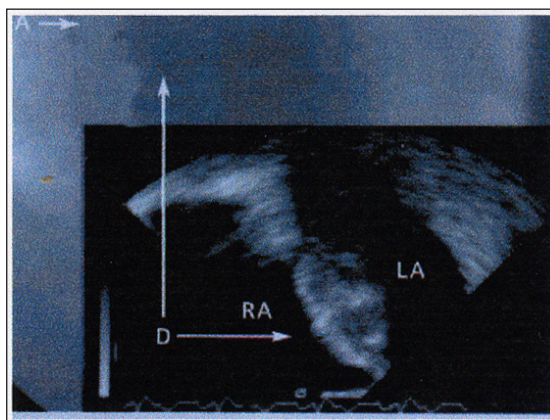


Figure 2. Split-screen imaging with simultaneous fluoroscopic and intracardiac echocardiographic image.

rior success rate of ASD closure with the Amplatzer septal occluder,^{4,5,6} the transcatheter occlusion of ASD has become widespread and has replaced the routine surgical closure in a lot of centers. The practice of transcatheter closure of ASD is usually performed under general anaesthesia guided by continuous monitoring of TEE.

To avoid the need for general anesthesia and for best assessment of the interatrial septum (IAS), ICE

Table 2. Atrial septal defect (ASD) assessment by intracardiac echocardiography (ICE) and transesophageal echocardiography (TEE).

Patient	ASD (age)	AIAS	Diameter (mm)			Device (mm)	Flouro time (min)
			ICE	TEE	Stretched		
M	12 yrs	Absent	7	-	8	8	17
F	12 yrs	Absent	24	25	24	26	15.1
F	35 yrs	Absent	38	38	40	40	23.8
F	8 yrs	Absent	14	13	158	16	22.4
F	6 ½ yrs	Present	11	-	14	15	4.7
F	12 yrs	Present	22	-	25	25(cribiform)	11.2
M	42 yrs	Absent	39	40	40	40	11.1
F	39 yrs	Present	31	33	34	35	7.1
F	4 yrs	Absent	15	-	15	16(cribiform)	9.2
M	45 yrs	Present	34	-	34	35(cribiform)	27.5
F	13 yrs	Absent	23	22	26	-	8.9
F	46 yrs.	Absent	42	39	42	-	2.4
F	11 yrs	Present	18	20	24	-	16.5
M	13 yrs	Absent	25	-	25	26	12.2
F	9 yrs	Absent	22&2	-	23 & 2	25	13.4
F	10 yrs	Absent	12	-	12.5	14	14.5
F	26 yrs	Present	37	-	38	-	
M	5 yrs	Absent	19	-	19	20	28.7
F	48 yrs	Absent	24	-	25	26	9.8
F	27 yrs	Absent	38	-	41	-	

* ASD II = atrial septal defect, AIAS = aneurysm interatrial septum

was thought to be superior to conventional TEE, and recent study results clearly demonstrate that ICE monitoring in transcatheter closure is superior to TEE.^{7,8,9}

ICE monitoring needs no general anesthesia and permits unlimited echocardiographic viewing in fully conscious and compliant patients. ICE uses a 10-MHZ transducer which provides a much higher image resolution than TEE, a fact that also helps to effectively respond to any complication.¹⁰ There is no doubt that ICE reduces the stress to the patient and reduces the fluoroscopy time as well as the full length of the procedure. For the interventional cardiologist it has great advantages. In this study we reported on the use of ICE and assess its accuracy in evaluating the IAS and the surrounding structures compared to TEE monitoring in guiding transcatheter device closure of the intratrial defect (ASD, PFO, fenestra-

tion).

Though the number of patients in which TEE was used was small, there is close agreement between TEE and ICE in their assessment of the IAS and the adequacy of the device position. ICE was found to be superior to TEE in detecting the procedural events that may affect the success of the implantation. These data favor the use of ICE to guide the routine closure of most of ASDs in adult and children without the need for TEE and general anesthesia

Initially we felt that TEE was superior in evaluating the IAS, probably because of the limited experience with the use of ICE and because we are more familiar with the use and views of the TEE. However, with time and after comparing both tools, we found it is much easier to get the views and to evaluate the atrial septal rims, except for the antero-

superior rim, and the septal flap. Device positioning and procedural events were easier with ICE rather than TEE and pulmonary veins view were much clearer with ICE than the TEE view. Device impingement in both the AV valve (tricuspid and mitral valve) is viewed in both ICE and TEE with almost the same quality.

Our study is comparable with Mullin's,⁷ Bartel's,⁸ and Michael's⁹ studies. Mullin et al recently reported successful closure of ASD under guidance with ICE and found that ICE is superior to TEE for evaluation of IAS, number of ASDs and device positioning. However Hijazi in 2001 reported on the failure of ICE to detect the malposition of the device.¹¹ Padol reported the Italian experience of using ICE and their preference for using it in an interventional procedure.¹² ICE was used recently in adults to evaluate the mitral valve (MV) and guided MV balloon valvuloplasty, as well as radiofrequency ablation by an electrophysiologist.^{13,14,15,16}

We therefore conclude that ICE is a safe tool for guiding device closure of the interatrial defect, with

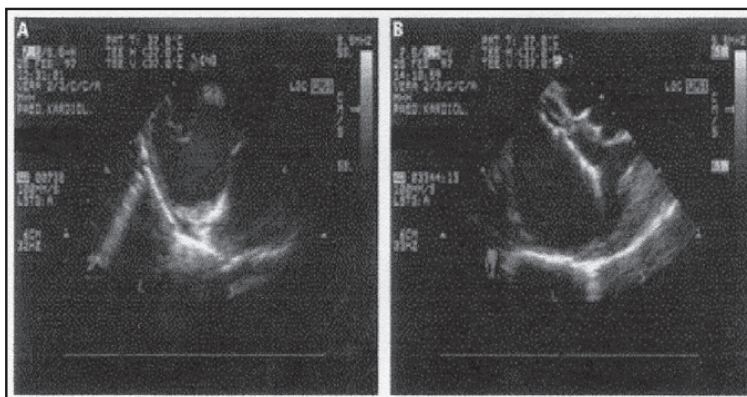


Figure 3. Intracardiac echocardiographic imaging pre- and post-Amplatze deployment.

better patient tolerance. However, we need more practice with with ICE to facilitate interpretation. We found that ICE provides adequate views and unique images of the atrial communication defect and we could measure the size of the ASD, PFO and fenestrated Fontan accurately.

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