Summary

Intracardiac echocardiography (ICE) serves as an adjunct to fluoroscopy for electrophysiological procedures by identifying critical anatomic landmarks and confirming catheter-endocardial contact. In the present study, we investigated the usefulness of ICE for radiofrequency catheter ablation. ICE was utilized to guide transseptal puncture in 19 patients undergoing radiofrequency catheter ablation. The fossa ovalis, which was one critical anatomic landmark, had an average vertical diameter of 18.5 ± 6.9 mm and an average horizontal diameter of 10.0 ± 2.4 mm, as measured by ICE and fluoroscopy. Although there was only a small shift of the puncture site in the horizontal direction, the puncture site shifted towards the upper edge of the fossa ovalis for 17 patients (89%). Furthermore, we could verify that the distance between the apex of the tent-shape formed by the pressure of the puncture needle in the fossa ovalis and the left atrial wall opposing it was sufficient to carry out the procedure safely. Confirming the puncture site using ICE is useful in carrying out transseptal left heart catheterization safely. (Jpn Heart J 2003; 44: 673-680)

Key words: Intracardiac echocardiography, Fossa ovalis, Transseptal catheterization

Over the past few years, atrial septal puncture through the fossa ovalis has become important for radiofrequency catheter ablation in many patients with left-sided accessory pathway and atrial fibrillation.¹⁻³ This procedure has been performed under transthoracic ultrasound and/or right atrial contrast radiography guidance. However, the complication rate for this procedure was reported to be 2% to 6%.²⁻⁵ The major reason for this is our inability to identify the fossa ovalis. Recently, the utility of intracardiac echocardiography (ICE) in clearly visualizing
intra- and extracardiac structures was reported.\textsuperscript{1,6} ICE serves as an adjunct to fluoroscopy for electrophysiological procedures by identifying critical anatomic landmarks, confirming catheter-endocardial contact, visualizing radiofrequency lesions, and monitoring thrombus formation.\textsuperscript{7-12} In the present study, we measured the horizontal and vertical diameters of the fossa ovalis and investigated the locations of safe puncture sites for radiofrequency catheter ablation with ICE.

\textbf{METHODS}

\textbf{Patient population:} The subjects were 19 patients requiring left heart catheterization for ablation of a left-sided accessory pathway ($n = 14, 74\%$), atrial fibrillation ($n = 3, 16\%$), and atrial tachycardia originating from the left atrium ($n = 2, 10\%$). The mean age was 48.6 years, and 10 patients were males. None of the patients had structural heart disease.

\textbf{Electrophysiological procedure:} Informed consent was obtained from each patient before electrophysiological study. Intravascular sheaths were placed in three femoral veins and in a median cubital vein. Through these sheaths multipolar electrode catheters were advanced to the high right atrium, the His bundle, the right ventricular apex, and into the coronary sinus for programmed electrical stimulation and recording. Programmed stimulation induced tachycardia in each patient, and diagnostic maneuvers confirmed the mechanism of the tachycardia and the necessity of a transseptal puncture.

\textbf{Transseptal puncture:} Two electrode catheters were removed and two venous sheaths were replaced with an 8.5-French sheath for ICE (model 5662, EP Technologies, San Jose, CA, USA) and an 8-French transseptal sheath (model 406840, Daig Corp., Minnetonka, MN, USA). A 9-French, 9-MHz intracardiac ultrasound transducer catheter (model 9900, EP Technologies, Mountain View, San Jose, CA, USA) was placed in the right atrium. The distal tip of the catheter was flushed with 3 to 10 mL of sterile water, and the catheter was connected to an ultrasound console (model 15006, Boston Scientific Corp., Sunnyvale, CA, USA). The images were displayed on a monitor and recorded on a videotape. The ICE catheter was positioned along the intraatrial septum to provide the optimal view of the fossa ovalis. Before transseptal puncture, ICE imaged the upper and lower edges of the fossa ovalis (Figures 1A -D).

The transseptal dilator was loaded with a Brockenbrough needle (USCI Angiographics Systems, Tewksbury, MA, USA), the tip of which was advanced to within 2 to 4 cm from the distal end of the dilator.\textsuperscript{13-15} The dilator and the needle were rotated toward the intraatrial septum and slowly withdrawn under fluoroscopic guidance while assessing the characteristic “jump” as the dilator passed over the aortic knob and fell onto the fossa ovalis. The dilator was manipulated
until the tip was in close contact with the fossa ovalis. With continued advancement of the dilator, ICE showed the characteristic tenting of the fossa (Daoud, et al., Figure 2). We positioned the dilator to the center of the fossa ovalis. The needle was then advanced. The sudden collapse of the tented fossa confirmed that the transseptal puncture was successful and we halted the advancement of the needle.

The advancement of the dilator and the sheath into the left atrium was monitored by ICE. The dilator and the needle were removed while suction was maintained through a 20 mL syringe placed on the sheath sideport. After successful transseptal puncture, an electrode catheter was placed through the sheath and 3000 units of heparin was administered intravenously followed by an additional 1000 units for one hour. During these procedures, continuous ultrasound images were recorded by the ICE catheter.

Figure 1. We defined the vertical diameter of the fossa ovalis as follows: the distance between the upper edge of the fossa ovalis (arrow in A) and the lower edge of the fossa ovalis (arrow in B) in the fluoroscopy. The ICE catheter was positioned along the intraatrial septum to provide an optimal view of the fossa ovalis. Before transseptal puncture, ICE imaged the upper (C) and lower (D) edges of the fossa ovalis.
Intracardiac measurements: When the ICE was pulled from the cranial to caudal direction, we could easily identify both the upper and lower edges of the fossa ovalis by the abrupt change in thickness of the septal wall.

We measured the maximum horizontal diameter of the fossa ovalis using ICE. We defined the vertical diameter of the fossa ovalis as follows: the distance between the tip of the ICE at the upper edge of the fossa ovalis and the tip of the ICE at the lower edge of the fossa ovalis in the fluoroscopy. The distance between the maximum point of tenting of the fossa and the left atrial wall was also measured.

Statistical analysis: All composite data are expressed as the mean ± standard deviation (SD). Data were analyzed by paired Student’s t test. A P value of < 0.05 was considered significant.
RESULTS

Fossa ovalis size: The mean vertical diameter of the fossa ovalis was $18.5 \pm 6.9$ mm (10.0-31.0 mm) and the mean horizontal diameter of the fossa ovalis was $10.0 \pm 2.4$ mm (4.8-14.2 mm). The vertical diameter was significantly longer compared with the horizontal diameter. The distance between the maximum point of tenting of the fossa and the left atrial wall was $12.5 \pm 4.1$ mm (6.0-23.8 mm).

Transseptal puncture: Transseptal puncture was achieved through the fossa ovalis in each patient and required a single attempt in all patients with no complications. Although we tried to puncture at the center of the fossa ovalis in all patients, the puncture site was the center in only 2 patients (11%) and was shifted to the upper edge of the fossa ovalis in 17 patients (89%) (Figure 3). On the other hand, the shift of the puncture site in the horizontal direction was only slight in all patients.

Figure 3. A schematic drawing showing the distribution within the fossa ovalis of the actual puncture sites in this study (patients). Although we tried to puncture at the center of the fossa ovalis in all patients, the puncture site was at the center in only 2 patients (11%); it was shifted to the upper edge of the fossa ovalis in 17 patients (89%).
DISCUSSION

The major findings of this study were that ICE clearly identified the fossa ovalis and that the puncture site tended to shift to its upper edge, which was the actual site in our study for left heart catheterization.

The complication rate with transseptal puncture for left heart catheterization guided by fluoroscopy was reported to be 2% to 6% in previous studies. Because ICE provided information on not only the intracardiac structures but also the adjacent extracardiac structures, ICE could be used as the sole imaging modality and safety guide for transseptal catheterization. In fact, ICE-guided transseptal left heart catheterization for radiofrequency catheter ablation did not lead to complications in recent and present studies.

Daoud, et al showed that the mean horizontal diameter of the fossa ovalis was 13.4 \( \pm \) 4.3 mm and that the distance from the maximum point of tenting of the fossa ovalis to the left atrial wall was 11.9 \( \pm \) 5.8 mm as measured by ICE in 53 patients. However, only the horizontal diameters of the fossa ovalis were measured in that report. The fact that the actual puncture site shifted towards the upper edge of the fossa ovalis but not sideways suggests that the vertical diameter was more important than the horizontal diameter for a safe procedure. In fact, the transseptal needle did insert itself into the upper edge due to the unidirectional sliding motion in 17 of the 19 patients. In atrial septum puncture, the suitable point is of course the safe center of the fossa ovalis rather than its upper edge. However, the tip of the needle seldom touched the target point vertically because of the unfavorable angle of the sheath. As a result, when the pushing force was applied to the needle, the tip slipped cranially to be trapped at the upper edge of the fossa ovalis, before finally being inserted into the wall.

In previous studies, the surface area but not the vertical diameter of the fossa ovalis was measured in autopsy patients. However, our observation draws attention to the unwanted sliding of the needle during the puncture, thus demonstrating the importance of the measurement of the vertical diameter. The ICE, which allows direct visualization of the edges, is therefore a useful guiding tool in this procedure.

Furthermore, Gonzalez, et al studied the locations of successful puncture sites in the atrial septum by fluoroscopy in 96 patients in which transseptal catheter ablation was performed. They reported that there were considerable variations in puncture sites among patients using a fluoroscopy-guided method. This means that careful attention is necessary in transseptal puncture in order to prevent unwanted complications.

When the needle perforated through the septal wall, the tenting shape formed by the septum disappeared but the tip of the needle did not move appre-
cially. Therefore, it is possible to puncture safely if there is sufficient distance between the top of the tent and the atrial free wall just before the perforation. Actually, we were able to perform a puncture even when this distance was as short as 6 mm.

If the fossa ovalis can be observed directly using ICE, it will be possible to carry out transseptal punctures more safely. Therefore, it is important to confirm the following ICE findings; 1) the aorta is not visualized completely at the position of the upper edge of the fossa ovalis, and 2) the distance between the apex of tenting of the fossa ovalis and the left atrial free wall is sufficiently long to carry out transseptal puncture safely.

**Limitations:** Because we measured the vertical diameter of the fossa ovalis by fluoroscopy, it might not be as accurate as the horizontal diameter of the fossa ovalis measured by ICE. In this study, we performed transseptal puncture using ICE in patients with structurally normal hearts. It is not clear whether this technique is applicable to patients with an obvious structural abnormality. Accordingly, a larger randomized study, including subjects with structural abnormalities, is required to confirm the safety of ICE-guided transseptal left heart catheterization for radiofrequency catheter ablation.

**REFERENCES**


