En Face View of Atrial Septal Defect by Two-Dimensional Transthoracic Echocardiography: Comparison to Real-Time Three-Dimensional Transesophageal Echocardiography

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Background: It is generally believed that three-dimensional (3D) echocardiography can provide unique en face views of atrial septal defects (ASDs), whereas conventional two-dimensional (2D) transthoracic echocardiography (TTE) cannot. The purpose of this study was to develop a special 2D TTE–based en face view of ASDs.

Methods: En face views of ASDs on 2D TTE were obtained in 415 consecutive adult patients and compared with the results of real-time 3D transesophageal echocardiography in 25 of these patients.

Results: Acceptable en face views of ASDs on 2D TTE were obtained in 80% of patients, in whom secundum ASDs could be adequately imaged in more standard 2D imaging planes. The ability to visualize en face views of ASDs on 2D TTE was inversely related to their sizes ($P < .05$). The differences in the major and minor dimensions of ASDs between 2D TTE and real-time 3D transesophageal echocardiography were not statistically significant ($P > .05$). Conventional 2D transthoracic echocardiographic views significantly underestimated ASD size with superior-inferior directional major axis.

Conclusion: Two-dimensional TTE can provide en face views of ASDs and their spatial orientations with respect to neighboring structures. This method may provide incremental information to 3D echocardiography in patients with ASDs. (J Am Soc Echocardiogr 2010;23:714-21.)

Keywords: Atrial septal defect, En face view, Transthoracic echocardiography, Real-time 3D transesophageal echocardiography

Real-time three-dimensional (RT3D) transesophageal echocardiography (TEE) is a recently developed technique that is increasingly used in echocardiography laboratories.[1-4] Generally, atrial septal defects (ASDs) have complex shapes that are not well characterized on two-dimensional (2D) transthoracic echocardiography (TTE),[4] whereas three-dimensional (3D) echocardiography provides unique en face views of ASDs.[5-7] However, unlike conventional 2D transthoracic echocardiographic views, the special 2D transthoracic echocardiographic imaging technique may provide en face views of ASDs and their spatial orientations with respect to neighboring structures. This study was designed to evaluate the feasibility and advantages of en face views of secundum ASDs obtained using 2D TTE and compared with findings on RT3D TEE as a reference.

METHODS

Study Patients

In this prospective study, 415 consecutive adult patients (120 male, 295 female; age range, 14-75 years; mean age, 35 years) with ostium secundum ASDs and significant left-to-right shunts were referred to our institution from August 2006 to September 2009. Patients with poor transthoracic echocardiographic images and ≥2 ASDs were excluded. All patients had adequate 2D transthoracic echocardiographic images for evaluating ASDs. After we acquired RT3D transesophageal echocardiographic capabilities in May 2009, 25 patients (8 men, 17 women; age range, 20-61 years; mean age, 40 years) were also evaluated using RT3D TEE as well as 2D TTE. Patients were stratified by New York Heart Association functional classification. Written informed consent was obtained from all patients. The study was approved by our institutional review board.

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Abbreviations
2D = Two-dimensional
3D = Three-dimensional
ASD = Atrial septal defect
RT3D = Real-time three-dimensional
TEE = Transesophageal echocardiography
TTE = Transthoracic echocardiography

En Face Views of ASDs on 2D TTE

Patients with ASDs were diagnosed using TTE. Echocardiographic images were obtained in all subjects in a steep left lateral decubitus position, with the patient's left arm extended over the head, by an experienced sonographer using an Acuson Sequoia C256 (Siemens Medical Solutions, Mountain View, CA) echocardiographic imaging system equipped with a 2.0-MHz to 3.5-MHz transducer. An electrocardiogram was recorded and displayed simultaneously on the image. There were two methods to image en face views of ASDs on 2D TTE.

First, the ASD was shown in the parasternal or apical 4-chamber view. Because all patients had enlarged right ventricles, the apical area was essentially showing the right ventricle, and the view became a nonstandard 4-chamber view. We adjusted the transducer position with slight movement and rotation and angulation to make the ultrasonic beam parallel to the interatrial septum (Figure 1A). The image index marker was at approximately 1 o'clock. The majority of patients did not require repositioning. Keeping the atrial septum and ASD in the region of interest, the transducer was rotated counterclockwise approximately 45° to 60°, such that the direction of the ultrasound beam remained similar to that of the aforementioned nonstandard 4-chamber view, and the image index marker was at approximately 11 o'clock. The interatrial septal plane and en face view of the ASD could be obtained (Figure 1B). Minor adjustment may be required to achieve the view, because the region of interest may depart from the interatrial septal plane during transducer rotation.

Second, the transducer was placed in the parasternal and apical area. A 4-vessel (ie, pulmonary artery, aorta, and superior and inferior vena cava; Figure 2A) or 3-vessel (ie, pulmonary artery, aorta, and superior vena cava) view of the heart can be obtained by rotating the transducer approximately 45° to 60° counterclockwise from the apical 4-chamber view with 20° angulation toward the right side of patient and slight tilting anteriorly. The ultrasound beam was directed approximately toward the patient's right shoulder, and the image index marker was at approximately 11 o'clock. If the transducer was slightly angulated toward the patient's left lateral side from the 4-vessel or 3-vessel view, the en face view of the ASD and the interatrial septal plane could also be shown (Figure 2B). When patient had an enlarged right ventricle, it was easier to show the 4-vessel or 3-vessel view of the heart. To avoid instrument artifacts and echo dropout, en face views of ASDs must be confirmed using color flow mapping (Figure 2C). We used a dynamic range of approximately 70 dB and tissue harmonic wave mode. With respect to the optimal image, slight tilting or angulation of the transducer may be necessary. Because the atrial septum may not be a plane, and also because there are individual variations in the position of the heart within the thorax, the transducer position may vary among subjects. All echocardiographic data were stored digitally on magneto-optical discs for online and subsequent analysis.

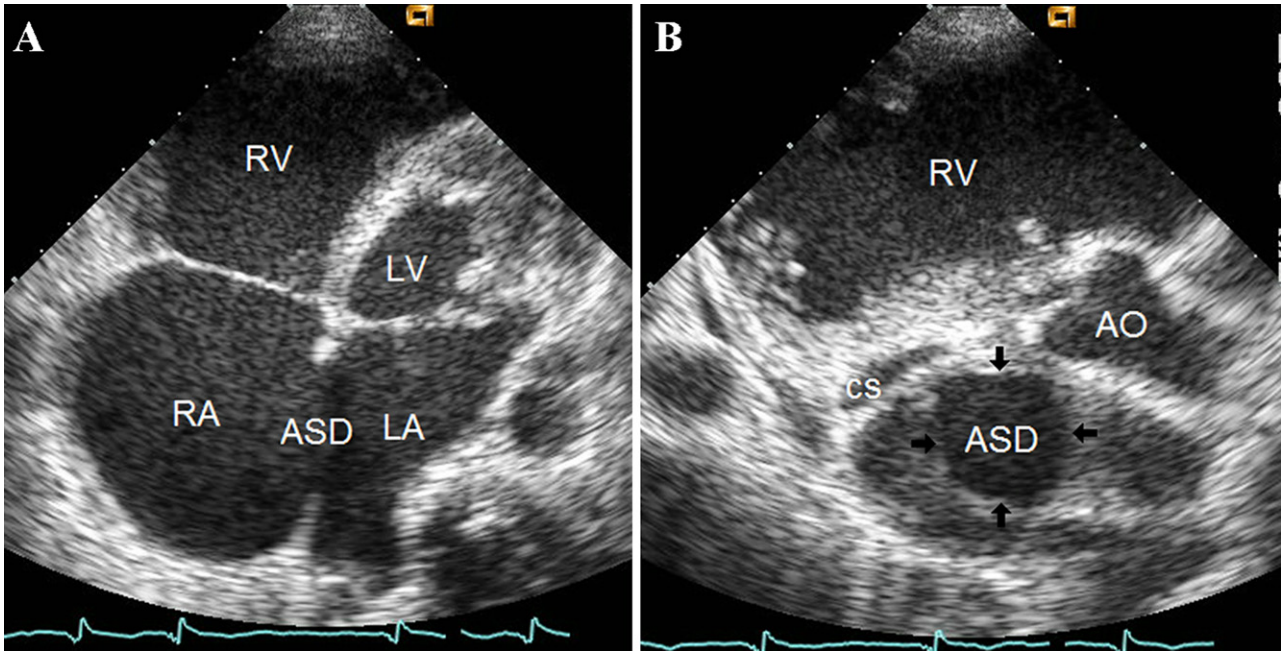

Figure 1 The 2D TTE en face view of ASK. Atrial septal defect was shown in conventional view **(A)** and en face view with continuous clear rim of defect **(B)**. *AO*, Aorta; *cs*, coronary sinus; *LA*, left atrium; *LV*, left ventricle; *RA*, right atrium; *RV*, right ventricle.

Image Quality

The image quality of TTE depicting en face views of ASDs was evaluated subjectively by two independent experienced cardiac echocardiographers offline using a 4-point grading scale: excellent, good, moderate, or poor. An excellent image was an en face view