Additional Benefit of Three-Dimensional Transesophageal Echocardiography for Detection of Left Atrial and Left Atrial Appendage Thrombi

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Abstract

Background: Two-dimensional transesophageal echocardiography (2DTEE) is a well-established test of choice to evaluate left atrial and left atrial appendage (LA/LAA) thrombi. However, it is prone to misdiagnosis both over and underdiagnosis. Current 3-dimensional trans-esophageal echocardiography (RT3DTEE) using matrix array transducer technology might help overcome this.

Objectives: The aim of this study was to determine the feasibility of RT3DTEE for detection of LA/LAA thrombi and to compare RT3DTEE with 2DTEE in evaluation of LA/LAA thrombi

Methods: Twenty five adult patients (age 55, 44 %male) referred for 2DTEE were enrolled in the study. All cases underwent additional RT3D for detection of LA/LAA thrombi. Images of 2DTEE and RT3DTEE were reviewed offline by 3 reviewers, blinded to each other finding. The 3rd reviewer was required if the initial two reviewers had a disagreement. Correlation between 2DTEE and RT3DTEE was done by Power kappa agreement.

Results: All patients underwent 2D TEE and 3D matrix-array TEE without complication. 76% of LAA was identified as unilobed by 2DTEE and 52% by RT3DTEE, 24% was multilobed by 2DTEE and 48% by RT3DTEE. The kappa score for agreement between 2D-TEE and RT3DTEE was 0.76. There was 12% (3/25 cases) disagreement of thrombus presence by 2DTEE but not by RT3DTEE. There was 100% agreement of no thrombus detected by both techniques.

Conclusions: This study is the first to evaluate the feasibility of RT3DTEE and to compare the detection of LAA thrombus with 2DTEE. The complex structure of the LAA could be more thoroughly evaluated by RT3DTEE with good correlation with 2DTEE for thrombus detection. RT3DTEE can help decrease the incidence of over diagnosis in our study (false interpretation of pectinate muscles and spontaneous contrast echo as thrombus).

Keywords: 2-Dimensional Transesophageal Echocardiography, RT3-Dimensional Transesophageal Echocardiography.


Differences in LAA dimensions exist. These differences and the existence of multilobed appendages are important in evaluation of left atrial appendage (7-8). Owing to the complex structural features of the LAA, the diagnosis of LAA thrombus by TEE is prone to misdiagnosis, both overdiagnosis (false interpretation of prominent pectinate muscles) and underdiagnosis (occult thrombi in multilobed appendages)(9-10).

A prospective, intraoperative study to determine the ability of 2DTEE to accurately identify or exclude LA/LAA thrombi showed a false positive 2 thrombi in 14 thrombi in 14 patients (11) and a multicenter study showed exclusion of LA/LAA thrombi by 2DTEE does not preclude embolism after cardioversion of AF (12).

Echocardiographic technology has rapidly developed, with current 3-dimensional transesophageal echocardiography (RT3DTEE) developing too fast for the increased amount of information available during a transesophageal procedure. The 1 cm diameter esophageal probe utilizes a 2-dimensional, 5 MHz array at its tip with a 6.3 mm diameter aperture, including 504 active channels. The array has a periodic vernier geometry with an element pitch of 0.18 mm, built onto a multilayer flexible (MLF) interconnect circuit (13-14).

Many studies show benefit of RT3DTEE in the demonstration of the morphology, shape and contour of the structural heart very well such as mitral valve morphology, inter atrial, interventricular septum and intracardiac mass. RT3DTEE could increase the understanding of more complex structural abnormalities of the heart, LA and LAA (15-18).

Through the use of a pyramidal ultrasound beam, a new matrix array transesophageal echocardiographic probe can provide unique real-time 3-dimensional (RT3D) views of the LAA and has potential to show RT3D TEE for the visualization of LAA better than 2DTEE. This may have the potential to revolutionize the practice of TEE in the future.

RT3DTEE can provide more accurate and novel views of the LAA than 2DTEE. However, the feasibility and complimentary information of RT3DTEE compared with 2DTEE for evaluating LA and LAA thrombi has not been established. It was our aim to determine the feasibility of RT3DTEE for detection of LA/LAA thrombi and compare RT3DTEE with 2DTEE in the evaluation of LA/LAA thrombi.

**Methods**

In this feasibility test study, we included patients older than 18 years, had an indication for TEE to exclude LA/LAA thrombi and consented to enroll in the study. We excluded patients that had contraindications to TEE or had a thrombus detected by TTE before enrollment. Twenty-five consecutive patients were studied during clinically indicated TEE, which were performed according to a standard protocol. The study was approved by our Institutional Ethics Committee. Written informed consent was obtained at the time of consent for clinical TEE. Both the clinical and research portions of the transesophageal echocardiographic studies were performed using an iE33 scanner (Philips Medical Systems, Andover MA) and 3D matrix-array transesophageal echocardiographic (mTEE) probes, which can do 2DTEE and RT3DTEE in a single insertion.

**Two-Dimensional TEE and Measurements**

Standard 2D TEE was performed using the iE33 ultrasound system and the mTEE probe. The LAA was imaged. 2DTEE was performed by the standards of American society of echocardiography (4-chamber view, 2-chamber view, transgastric view and bicaval view with different degree of transducer angulations)

**Data were collected in dataset.**

**RT3D TEE and Measurements**

RT3D imaging was performed using the iE33 ultrasound system, equipped with the fully sampled matrix-array transesophageal echocardiographic (Live 3D TEE) transducer, which uses 2,500 piezoelectric elements, acquires data from a pyramidal ultrasound beam, and is capable of RT3D echocardiographic imaging. Imaging was performed at a frame rate of 8 to 10 frames/s. LAA was recorded with full volume and Live 3DTEE. Additional time required for image acquisition was recorded.

2DTEE and RT3DTEE data set were reviewed offline by 3 reviewers and blinded to each other’s finding. If 2 reviewers agreed on the findings of LA/LAA thrombi, the patient was diagnosed of having definite LA/LAA thrombi.
However, if there was disagreement on the finding from the 2 reviewers, the 3rd reviewer was required and the final decision was based on the consensus of a 23 decision.

Statistics

For correlation between 2DTEE and RT3DTEE a 2 by 2 table and power kappa agreement were used.

Results

All 25 patients (mean age, 58 ± 14 years; 56% woman) underwent RT3DTEE without complications. Table 1 lists the characteristics of the study feasibility, including comorbidities, clinical indication for TEE and cardiac rhythm at time of TEE. Fifty six percent were women; forty eight percent had rheumatic heart disease. Forty percent had percutaneous balloon mitral valvuloplasty (PBMV) and rhythm at the time of TEE showed AF in sixty four percent.

LAA was identified as multilobes by RT3DTEE more than 2DTEE. 76% of LAA was identified as unilobed by 2DTEE and 52% by RT3D-TEE, 24% was multilobed by 2DTEE and 48% by RT3DTEE (Figure 1). Additional time to acquire the RT3DTEE image was approximately 1 minute. RT3DTEE appeared to demonstrate complex structural features of LAA better than 2DTEE (Figure 2).

Table 1. Baseline characteristics and demographic data (total n = 25)

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (y), mean ± SD</td>
<td>58 ± 14</td>
</tr>
<tr>
<td>Women</td>
<td>14 (56%)</td>
</tr>
<tr>
<td><strong>Underlying disease</strong></td>
<td></td>
</tr>
<tr>
<td>Rheumatic heart disease</td>
<td>12 (48%)</td>
</tr>
<tr>
<td>Stroke</td>
<td>4 (16%)</td>
</tr>
<tr>
<td>Atrial fibrillation</td>
<td>7 (28%)</td>
</tr>
<tr>
<td>S/P MVR, AVR</td>
<td>1 (4%)</td>
</tr>
<tr>
<td>LA size (cms)</td>
<td>4.6</td>
</tr>
<tr>
<td>LAA velocities</td>
<td>30.2</td>
</tr>
<tr>
<td>Spontaneous echo contrast</td>
<td>9 (36%)</td>
</tr>
<tr>
<td>LVEF (%)</td>
<td>63.6</td>
</tr>
<tr>
<td>Warfarin</td>
<td>23 (92%)</td>
</tr>
<tr>
<td><strong>Indication for TEE</strong></td>
<td></td>
</tr>
<tr>
<td>Pre-RFA for AF or atrial flutter</td>
<td>2 (8%)</td>
</tr>
<tr>
<td>Precardioversion</td>
<td>7 (28%)</td>
</tr>
<tr>
<td>PBMV</td>
<td>10 (40%)</td>
</tr>
<tr>
<td>Intracardiac source of emboli</td>
<td>6 (24%)</td>
</tr>
<tr>
<td><strong>Rhythm at time of TEE</strong></td>
<td></td>
</tr>
<tr>
<td>Normal sinus rhythm</td>
<td>8 (32%)</td>
</tr>
<tr>
<td>AF</td>
<td>16 (64%)</td>
</tr>
<tr>
<td>Atrial flutter</td>
<td>1 (4%)</td>
</tr>
</tbody>
</table>

MVR = mitral valve replacement, AVR = aortic valve replacement, LA = left atrial, LAA = left atrial appendage, LVEF = left ventricular ejection fraction, TEE = transesophageal echocardiogram, TTE = transthoracic echocardiogram, RFA = radiofrequency ablation, AF = atrial fibrillation
Figure 1. Structural feature of LAA was detected by 2D-TEE compared with RT3D-TEE.

![2D-TEE](image1)

![RT3D-TEE](image2)

There was good correlation between 2DTEE and RT3DTEE as shown by the two by two table. The kappa score for agreement by 2D-TEE and RT3D-TEE was 0.76. Thrombi were detected 52% by 2DTEE and 40% by RT3DTEE. There was 12% (3/25 cases) disagreement of thrombus presence by 2DTEE but not by RT3DTEE. There was 100% agreement of no thrombi detected by both techniques. (Table 2)

**Discussion**

RT3DTEE for the visualization and quantitative analysis of LAA was feasible, appeared to be well tolerated, and adds much more information with minimum addition of time for the procedure and is safe. In addition, LAA was a complex structure (48% found to be multilobes), and RT3DTEE appeared to demonstrate complex structural features of LAA better than 2DTEE. More multilobes were
Table 2. Correlation between RT3D-TEE and 2D-TEE for detection LA/LAA thrombus by two by two table.

<table>
<thead>
<tr>
<th></th>
<th>3D (Positive)</th>
<th>3D (Negative)</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>2D (Positive)</td>
<td>10</td>
<td>3</td>
<td>13 (52%)</td>
</tr>
<tr>
<td>2D (Negative)</td>
<td>0</td>
<td>12</td>
<td>12 (48%)</td>
</tr>
<tr>
<td>Total</td>
<td>10</td>
<td>15</td>
<td>25</td>
</tr>
</tbody>
</table>

Kappa score for agreement = 0.76

detected in the LAA by RT3DTEE than 2DTEE. There was a good correlation with 2DTEE in the evaluation of LA and LAA thrombi. There was a 12% (3/25) disagreement of thrombi present by 2DTEE, but not RT3DTEE. When we compared imaging between 2DTEE and RT3DTEE, 2 cases of 2DTEE showed high density of spontaneous echo contrast in the LAA and suspected LAA thrombi but the RT3DTEE showed that it was pectinate muscle in the LAA. In 1 case 2DTEE showed LAA thrombus and high density of spontaneous echo contrast but RT3DTEE showed it was extracardiac structure.

This study could not demonstrate accuracy of RT3DTEE compared to 2DTEE for detection of LA/LAA thrombi. This may be due to the over detection of 2DTEE or under detection of RT3DTEE. We need further study to determine the accuracy of both techniques and RT3DTEE may be an ideal tool for future clinical application.

Future clinical application

The future development of echocardiographic technology, RT3DTEE shows good demonstration of the complex structural feature of the LAA, and may be used to help better evaluate thrombi, may provide better stratification for stroke risk, and may help decrease delayed treatment from over detection of LA/LAA thrombi.

Limitation

Our study is limited by no pathological or surgical findings to confirm the presence of LA/LAA thrombi by both techniques. Although we showed that RT3DTEE can demonstrate the LA/LAA structural feature more than 2DTEE, we cannot conclude that using RT3DTEE can demonstrate LA/LAA thrombi more than 2DTEE.

Conclusion

This study is the first to evaluate the feasibility of RT3DTEE and comparing the detection of LAA thrombus with 2DTEE. The complex structure of LAA could be more thoroughly evaluated by 3DTEE with good correlation to 2DTEE for thrombus detection. RT3DTEE can help decrease the incidence of overdiagnosis in our study (false interpretation of pectinate muscles and spontaneous contrast echo as thrombus).

Conflict of Interest

None

References


การศึกษาการใช้คลื่นเสียงอัลตร้าซาวน์สามมิติผ่านทางหลอดอาหารในการวินิจฉัยภาวะลิ่มเลือดในห้องหัวใจซ้าย

 eventData:

วิธีการวิจัย: ผู้ป่วยจำนวน 25 คนที่ต้องได้รับการตรวจวินิจฉัยภาวะลิ่มเลือดในห้องหัวใจซ้าย ได้รับการตรวจด้วยเครื่องเสียงสะท้อนความถี่สูงสองมิติและสามมิติผ่านทางหลอดอาหารโดยการใส่สายเครื่องเสียงสะท้อนความถี่สูงผ่านทางหลอดอาหารเพียง 1 ครั้ง สภาพตรวจด้วยเครื่องเสียงสะท้อนความถี่สูงได้กล่าวถึงถูกต้องและสามารถตรวจพบลิ่มเลือดที่ห้องหัวใจซ้ายได้ 100% ตรวจไม่พบลิ่มเลือดในห้องหัวใจซ้ายทั้งสองเทคนิค

ผลการวิจัย: การศึกษาในครั้งนี้เป็นการศึกษาแรกในประเทศไทยที่มีการประเมินความสะดวกของการใช้เครื่องเสียงอัลตร้าซาวน์สามมิติผ่านทางหลอดอาหารและเพื่อเปรียบเทียบการตรวจด้วยเครื่องเสียงอัลตร้าซาวน์สามมิติผ่านทางหลอดอาหารในการวินิจฉัยลิ่มเลือดในห้องหัวใจซ้ายทั้งสองเทคนิค โครงสร้างภายในห้องหัวใจซ้ายสามารถแสดงได้ชัดเจนโดยการใช้เครื่องเสียงอัลตร้าซาวน์สามมิติที่มีความละเอียดสูงกว่าเครื่องเสียงสะท้อนความถี่สูง ผู้เรียนจึงมีความเห็นว่าเครื่องเสียงอัลตร้าซาวน์สามมิติผ่านทางหลอดอาหารอาจช่วยลดการวินิจฉัยที่ผิดพลาดในการตรวจพบลิ่มเลือดในห้องหัวใจซ้ายทั้งสองเทคนิค