Transnasal transesophageal echocardiography in the detection of left atrial thrombus

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Summary
Background: The widespread use of transesophageal echocardiography (TEE) is limited by disadvantages, including patient intolerance and increased medical costs. We aimed to investigate the feasibility and safety of transnasal TEE in the detection of possible embolic sources in patients with atrial fibrillation (AF) and/or stroke, using an ultrathin TEE probe.

Methods: Sixty-two patients with AF and/or stroke underwent transnasal TEE without conscious sedation. The presence or the absence of the following parameters was evaluated: left atrial (LA) thrombus; LA spontaneous echocardiographic contrast; intraatrial shunts; and aortic plaque.

Results: The insertion of a TEE probe was successful in 52 (84%) patients. TEE found LA thrombus in 10 (19%) patients and other embolic sources in 4 (8%) patients. Two (4%) patients had mild epistaxis.

Conclusions: This study demonstrated that the use of transnasal TEE was feasible and safe in the detection of LA thrombus in patients with AF and/or stroke.

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Introduction

The major complication of atrial fibrillation (AF) is thromboembolism. The left atrium (LA), especially its appendage, is the presumed site of thrombus formation and a source of arterial thromboembolism. Previous studies suggested that up to 20% of all strokes have been attributed to a cardioembolic source, and patients with AF had a four- to five-fold increased risk of stroke [1—3]. Transesophageal echocardiography (TEE) has clear advantages over transthoracic echocardiography (TTE) and other imaging modalities in the detection of possible embolic sources, particularly in the investigation of the LA appendage [4—8]. Importantly, their diagnosis may have major therapeutic implications. However, because of its disadvantages, including patient intolerance and increased medical costs, controversy exists in routinely performing TEE in patients with AF and/or stroke [9—11].

Instrumentation

TEE examination was performed with a Prosound SSD-α 10 (Aloka Co, Ltd, Tokyo, Japan), equipped with an ultrathin probe, UST-52110S (Aloka Co, Ltd) (Fig. 1). This monoplane probe has single frequency imaging (5.0 MHz) as well as pulse-wave Doppler and color Doppler capabilities. The tip size of the phased array transducer was 6.0 mm wide, 5.3 mm thick, and 13.4 mm long. The probe shaft was 4.8 mm in diameter, and the probe was 70 cm in length. The probe was equipped with an anteflexion and retroflexion angulation control via a knob on the handle. This probe was originally released for TEE examination via a transoral approach in pediatric patients in whom standard size probes could not be used.

Methods

Study population

This study population consisted of 62 patients (36 males, mean age 71 ± 11 years) who had electrocardiographically documented AF (n = 49, 79%) or a history of stroke diagnosed by magnetic resonance imaging (n = 9, 15%), or both (n = 4, 6%). All patients were referred to the laboratory for a clinically indicated TEE examination because of normal results on their TTE examination for possible intracardiac sources of embolism. The patients were excluded if they had (1) congenital disease, (2) a history of nasopharyngeal trauma or surgery, or (3) allergy to lidocaine. This study was approved by the ethics committee of the Osaka Ekisaikai Hospital. Written informed consent for participation was obtained in all patients. We informed that the alternative was a standard transoral TEE if they chose not to participate in the study, if they did not tolerate the examination, or if imaging capabilities were inadequate to answer the referral questions in clinical practice.
Transnasal transesophageal echocardiography was judged using four ranks, from well tolerated to mild, moderate, or severe discomfort. Tolerance during the probe insertion was evaluated in two separate phases, passage of nasal cavity and esophagus, respectively. It was judged by three ranks of no pain, discomfort without pain, and discomfort with pain.

**TEE assessment**

The presence or the absence of thrombus in the LA and its appendage was evaluated in the present study. Spontaneous echocardiographic contrast in the atrium, intraatrial shunts, atrial septal aneurysm, and aortic plaque were also assessed as possible sources of embolism. Thrombus was diagnosed as an echo dense mass with independent motion relative to the chamber wall. Spontaneous echocardiographic contrast was defined as dynamic "smoke-like" echoes in the atrium. Gain settings were adjusted to minimize gray-noise artifact when assessing for spontaneous echocardiographic contrast. The LA appendage flow velocity was obtained by the pulsed Doppler method with the sample volume placed 1 cm distal from the mouth of the LA appendage. Five consecutive cardiac cycles were recorded and averaged. Intraatrial shunts, atrial septal aneurysm, and aortic plaque were evaluated by color Doppler method. The operator indicated the success or failure of the procedure, the reason for failure, and the adverse effects of the TEE examination.

**Statistical analysis**

Values were expressed as mean ± SD. Comparisons between the two groups for the parametric data were made with an unpaired t test. Differences were considered significant at \( P < 0.05 \).

**Results**

**Insertion of TEE probe through nasal cavity**

The insertion of the TEE probe was successfully completed in 52 (84%) of 62 patients. Failed insertion was caused by anatomical reasons (failure to pass the probe through the nasal cavity) in 8 (13%) patients and patient intolerance (pain) in 2 (3%) patients. These 10 patients did not have epistaxis. No examinations were failed due to inability to pass the probe into the esophagus. The clinical characteristics of patients with success or failure of the probe insertion are summarized in Table 1. There were no significant differences in patient characteristics.

![Figure 1](image)

**Figure 1** Frontal (A) and lateral (B) views of the ultrathin (UST-52110S, left) and conventional (UST-5293S, right) transesophageal echocardiography probes are shown for comparison. The tip sizes of the transducers were 6.0 and 14.6 mm wide, 5.3 and 11.8 mm thick, 13.4 and 24 mm long, and the shaft diameters were 4.8 and 9.0 mm, respectively.
Table 1 Characteristics of patients with success or failure of the insertion of transesophageal echocardiography probe.

<table>
<thead>
<tr>
<th></th>
<th>Success (n = 52)</th>
<th>Failure (n = 10)</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>71 ± 10</td>
<td>64 ± 14</td>
<td>0.1</td>
</tr>
<tr>
<td>Gender, male (n, %)</td>
<td>27 (61%)</td>
<td>5 (63%)</td>
<td>0.6</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>59.0 ± 14.3</td>
<td>63.9 ± 13.3</td>
<td>0.4</td>
</tr>
<tr>
<td>Height (m)</td>
<td>160.0 ± 9.5</td>
<td>165.6 ± 8.3</td>
<td>0.1</td>
</tr>
<tr>
<td>Body surface area (m²)</td>
<td>1.6 ± 0.2</td>
<td>1.7 ± 0.2</td>
<td>0.2</td>
</tr>
<tr>
<td>History of inflammatory disease in nasopharynx (n, %)</td>
<td>4 (9%)</td>
<td>3 (38%)</td>
<td>0.3</td>
</tr>
<tr>
<td>Underlying etiology</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AF (n, %)</td>
<td>36 (82%)</td>
<td>8 (100%)</td>
<td>0.2</td>
</tr>
<tr>
<td>Stroke (n, %)</td>
<td>10 (23%)</td>
<td>0 (0%)</td>
<td>0.2</td>
</tr>
<tr>
<td>Medication</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Warfarin (n, %)</td>
<td>25 (57%)</td>
<td>4 (50%)</td>
<td>0.5</td>
</tr>
<tr>
<td>Aspirin (n, %)</td>
<td>14 (53%)</td>
<td>4 (50%)</td>
<td>0.3</td>
</tr>
</tbody>
</table>

AF, atrial fibrillation.

Echocardiographic findings

Among 52 patients, transnasal TEE found at least one potential intracardiac source of embolism in 14 (27%) patients; LA appendage thrombus with spontaneous echocardiographic contrast in 7 patients and without spontaneous echocardiographic contrast in 3 patients, spontaneous echocardiographic contrast without the thrombus in 2 patients, patent foramen ovale in 1 patient, and mobile aortic plaque in 1 patient. Fig. 2 shows an example of thrombus in the LA appendage. LA appendage flow velocity was measured in 48 (92%) patients. Patients with LA thrombus and/or spontaneous echocardiographic contrast had lower LA appendage flow velocity than the remaining patients (12.7 ± 5.3 cm/s vs 33.4 ± 18.8 cm/s, P < 0.001).

Tolerance and safety of transnasal TEE

The questionnaire regarding tolerance was completed by 50 (96%) of 52 patients. Twenty-nine (58%) patients answered "well tolerated" for topical anesthesia (Fig. 3). "No pain/discomfort" was reported by 36 (72%) and 42 (84%) patients for the insertion into nasal cavity and esophagus, respectively (Fig. 3).

In 52 patients, the oral administration of warfarin was observed in 29 (56%) patients, and aspirin in 18 (35%) patients. Two (4%) patients

Figure 2  (A) Transesophageal echocardiography image focusing on the left atrium (LA) appendage in patients with atrial fibrillation (AF). A mobile thrombus was detected in the appendage (arrows). (B) Pulse-wave Doppler image measured at the outlet of the appendage, showing low LA appendage emptying and filling Doppler signals.
had mild epistaxis after the procedure. This epistaxis stopped spontaneously within 3 min. These patients had warfarin therapy without aspirin at the time of procedure, where the values of prothrombin time—international normalized ratio were 1.45 and 1.85 s, respectively. No significant hemodynamic or mechanical complications were noted during procedure or follow-up. Also, there were no complications for topical anesthesia with the use of vasoconstrictor.

Discussion

This study demonstrated that transnasal TEE without conscious sedation was feasible (85%) and safe in the detection of LA thrombus in patients with AF and/or stroke.

The advantages of TEE over TTE and other imaging modalities for detecting possible embolic sources have been clearly described, particularly in the investigation of the LA appendage [4,5]. Nevertheless, whether TEE should be performed in all patients with AF and/or stroke remains a matter of debate [9—11]. The guideline also concluded that the use of TEE in a patient with stroke who had a normal TTE and no history of AF in the detection of embolic sources was uncertain [17]. One problem of current TEE technique is the large size of the probe, which causes discomfort during entry into the esophagus, requiring moderate levels of conscious sedation. Close monitoring during and after the procedure, as well as specialized nursing care, are therefore needed. These efforts result in patient intolerance as well as increasing medical costs; direct costs of intravenous access and medications, indirect costs associated with the need for a second nurse/technician during the procedure, and direct non-health costs for time-loss from work for both patient and patient’s escort. Also, conscious sedation may cause drug-induced respiratory depression, airway obstruction, hypotension, or arrhythmia in up to 0.5% to 2.0% of the procedures [18,19]. To overcome these limitations, there is a need for safe and feasible TEE techniques, even without conscious sedation.

The transnasal approach without conscious sedation is widely used for various gastrointestinal conditions in the esophagogastroduodenoscopy, especially in Asian and European countries [20,21]. The transnasal approach has less gagging, but the patient experiences more pain on insertion of the endoscope, as compared with the transoral approach. Therefore, sufficient nasal anesthesia and a small size of endoscope are vital for transnasal esophagogastroduodenoscopy. Previous studies demonstrated that the feasibility and the tolerance of transnasal esophagogastroduodenoscopy without conscious sedation were related to the endoscope diameter [22,23]. Murata et al. who used a 5.9 mm endoscope reported that the transnasal approach was well tolerated and considerably reduced patient discomfort as compared with the transoral approach [24]. In the field of TEE, Spencer et al. demonstrated that transnasal intubation of a TEE probe was feasible and safe in patients with various heart diseases [15,16]. However, their patients required conscious sedation during the procedure due to the relatively large TEE probe (7.3 mm wide and 6.0 mm thick). In the present study, the use of an ultrathin probe (6.0 mm wide and 5.3 mm thick) allowed for a transnasal approach using topical anesthesia. Approximately 80% of patients answered “no pain/discomfort” for the probe insertion passing through the nasal cavity and esophagus with sufficient topical anesthesia only without conscious sedation. In addition, the cost—effectiveness of an unsedated procedure was clearly described in the esophagogastroduodenoscopy. The cost of a conventional sedated procedure was reduced by 35—60% in the unsedated procedure [12,25]. As a consequence, we believe that transnasal TEE without conscious sedation using an ultrathin probe is safe, feasible and cost—effective, which would enhance the use of
TEE in clinical practice, similar to the esopha-
gastroduodenoscopy. The widespread use of TEE would help to clarify the effectiveness of TEE in the management and the outcome among the patients with and without TEE examination in AF and/or stroke.

Study limitations

There were several limitations to this study. First, there were no significant differences in patient characteristics between patients with success or failure of the insertion of TEE probe. It might be explained by the small number of patients. In addition, only 1 patient had patent foramen ovale, and 1 patient had mobile aortic plaque. Therefore, further studies with a larger number of patients should be necessary.

Second, validation against the standard technique was not performed. The feasibility and safety of the transnasal approach should be compared with those of routine transoral TEE performance in future investigations. Two patients taking war-
farin had epistaxis (nasal bleeding). This bleeding may be an issue in the wide use of TEE in clinical practice. In addition, criteria of tolerance ranking were subjective and semi-quantitative in the present study. Also, we cannot eliminate the possibility of the underestimation of the presence of thrombus. This thin probe potentially has poor contact with the esophageal wall in an adult subject. However, the prevalence of LA thrombus of 19% in our study was similar to that reported in previous investigations [26,27]. A future miniature omni-
plane probe with better image quality should be developed.

Third, the transnasal unsedated approach required familiarity with nasal and pharyngeal anatomies and expertise with transnasal intubation and nasopharyngeal advancement of the probe. The supervision or structured training provided by expert endoscopists might be needed with the initial attempts.

Finally, the cost of intravenous access and medications was 500–1500 yen per sedated TEE examination in Japan, depending on the sedative agents. Such direct medical cost was dispensable in the unsedated procedure. However, the 12-Fr and 16-Fr plastic conduits were necessary only for the transnasal approach. This cost should be evaluated without excluding patients unable to complete transnasal TEE. Also, cost-effectiveness associated with indirect and direct non-health costs was not assessed in this study. Further investigation might be necessary to clarify this point.

Conclusion

This study demonstrated that transnasal TEE without conscious sedation was safe and feasible (84%) in the detection of LA thrombus in patients with AF and/or stroke, using an ultrathin TEE probe. This approach has the potential to enhance the use of TEE in clinical practice, providing reduced procedure-related costs with similar or better patient tolerance.

References

[4] DePace NL, Soulen RL, Kotler MN, Mintz GS. Two dimen-
[8] de Bruijn SF, Agema WR, Lammers GJ, van der Wall EE, Wolterbeek R, Holman ER, Bollen EL, Bax JJ. Trans-
[10] Manning WJ, Douglas PS. Transesophageal echocardiogra-
[12] Garcia RT, Cello J, Nguyen MH, Rogers SJ, Rodas A, Trinh HN, Stollman NH, Schluex G, McQuaid KR. Unsedated ultrathin EGD is well accepted when compared with con-
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