Interobserver variability in the detection of spontaneous echo contrast, left atrial thrombi, and left atrial appendage thrombi by transoesophageal echocardiography

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Abstract

Objective—To assess the interobserver variability between two observers from different echocardiographic laboratories. Design—Two observers reviewed video recordings blinded to the other’s diagnosis. In part I (n = 88), they determined interobserver variability for spontaneous echo contrast, left atrial thrombi, and appendage thrombi. No diagnostic criteria for thrombi were defined. In part II (n = 85), diagnostic criteria for thrombi were defined.

Results—Part I: Both observers agreed in diagnosing spontaneous echo contrast in 97%, left atrial thrombi in 90%, left atrial appendage thrombi in 94%. Part II: With predefined criteria no disagreement occurred in diagnosing left atrial thrombi. In the diagnosis of left atrial appendage thrombi both observers agreed in 89%. The mean diameters of the 10 thrombi on which the observers agreed were greater than of the nine appendage thrombi on which they disagreed.

Conclusions—Interobserver variability in the diagnosis of spontaneous echo contrast is low. Defined criteria decrease interobserver variability for left atrial and appendage thrombi, although one third of the thrombi diagnosed by one observer were not confirmed by the other. Interobserver variability is high in the assessment of small structures (<15 mm) within the left atrial appendage.

Keywords: thrombus; left atrial echocardiography; transoesophageal thrombus; detection of spontaneous echo contrast

Transoesophageal echocardiography (TOE) is superior to transthoracic echocardiography in diagnosing spontaneous echo contrast and left atrial and appendage thrombi. These TOE findings are associated with arterial embolism, especially in patients with atrial fibrillation. Since there is no gold standard for the diagnosis of spontaneous echo contrast, and the diagnosis of left atrial and appendage thrombi can only be confirmed by surgery or necropsy, diagnostic criteria and the assessment of interobserver variability are important. So far studies of interobserver variability have only been performed between different observers of the same echocardiographic laboratory. The present study was performed to assess the interobserver variability between two observers from different echocardiographic laboratories in two cities. Both observers diagnosed spontaneous echo contrast and left atrial and appendage thrombi by reviewing video recordings of TOE examinations.

Methods

PATIENTS

For the study, 173 consecutive patients were included (90 female, 83 male, mean age 65 years, range 26–91 years). They were investigated during a 10 month period (between May 1989 and February 1990) in one echocardiographic laboratory. Indications for TOE are listed in table 1. A moderate to severe mitral stenosis was present in nine patients (5%).

INSTRUMENTATION

The echocardiographic equipment used consisted of an Aloka 870 scanner; a 5 MHz monoplane probe was used in the first 38 patients and a 5 MHz biplane probe was used in the following 135 patients. During TOE, special care was taken to visualise the whole cavity of the left atrium and left atrial appendage from different planes, with the tip of the probe slightly flexed. Gain settings were adjusted as required to distinguish spontaneous echo contrast from echoes due to excessive gain. All transoesophageal studies were performed by one investigator (MS) from one echocardiographic laboratory. The complete TOE examinations were recorded on VHS videotapes.

Table 1 Indication for transoesophageal echocardiography

<table>
<thead>
<tr>
<th>Indication</th>
<th>Patients</th>
</tr>
</thead>
<tbody>
<tr>
<td>Embolic event</td>
<td>17</td>
</tr>
<tr>
<td>Atrial fibrillation</td>
<td>51</td>
</tr>
<tr>
<td>Endocarditis</td>
<td>73</td>
</tr>
<tr>
<td>Acute dissection</td>
<td>13</td>
</tr>
<tr>
<td>Valvular heart disease</td>
<td>6</td>
</tr>
<tr>
<td>Prosthetic valve dysfunction</td>
<td>14</td>
</tr>
<tr>
<td>Inadequate transsesthorasic study</td>
<td>2</td>
</tr>
<tr>
<td>Suspected shunt lesion</td>
<td>6</td>
</tr>
<tr>
<td>Total</td>
<td>173</td>
</tr>
</tbody>
</table>
ASSESSMENT OF INTEROBSERVER VARIABILITY

Two observers (GK = observer A, CS = observer B) from two different echocardiographic laboratories in two cities reviewed the video recordings in the time between May and July 1990. Both observers were blinded to the initial TOE diagnosis as well as to the other observer's diagnosis. Both observers had ample experience in transthoracic and transoesophageal echocardiography at the time of the study.

PART I OF THE STUDY

Both observers expected a high variability in the diagnosis of spontaneous echo contrast. Therefore an interim analysis was planned. The first 88 patients comprised the sample of part I of the study. Part I assessed the interobserver variability in diagnosing spontaneous echo contrast and left atrial and appendage thrombi. Spontaneous contrast was defined as fog-like echo clouds with a distinct motion pattern, repeatedly present in at least some parts of the left atrium or its appendage. Both observers used a grading scale to describe the phenomenon: grade 1 = echo clouds seen intermittently in parts of the left atrium and the left atrial appendage; grade 2 = echo clouds seen continuously in parts of the left atrium and the left atrial appendage; grade 3 = echo clouds seen continuously in the whole left atrium and the left atrial appendage.

For thrombus no common diagnostic criteria were defined in part I. This was done because the diagnosis was expected to be easy in view of the well defined criteria for a left ventricular thrombus. Each observer had only to decide whether there was evidence of "definite", "probable", or "no" thrombus within the left atrium and the left atrial appendage on a video recording. After an analysis of the results of part I, the two observers reviewed the video recordings of the controversial cases together.

PART II OF THE STUDY

As a result of the reviewing process, common diagnostic criteria for left atrial and appendage thrombi were defined. The criteria were defined by modifying commonly used transthoracic criteria: clear borders, distinct echogenicity, independent mobility, longest diameter >10 mm, demonstrable in >1 plane. At least three criteria were required for the diagnosis of a "definite" thrombus. A structure showing only two criteria was assessed as "probable" thrombus. Additionally, the longest diameters of probable or definite thrombi were measured.

In part II both observers reviewed the video recordings of the next 85 patients and applied the now defined diagnostic criteria. The interobserver variability of spontaneous echo contrast was not evaluated because of the results of part I.

There were no significant differences in age, gender distribution, and indication for TOE between the patients in part I and part II of the study.

STATISTICS

Agreement between the two observers was estimated using the $\kappa$ measure of concordance. To calculate the $\kappa$ a macro was built within the SAS® software environment (SAS Institute Inc.). A $\kappa$ ranging from 0-21 to 0-40 was classified as "fair", from 0-41 to 0-60 as "moderate", from 0-61 to 0-80 as "good", and >0-80 as "very good". To compare groups we used the Wilcoxon two sample test for continuous and ordinal parameters and the $\chi^2$ test for nominal variables.

Results

PART I

Diagnosis of spontaneous echo contrast (Table 2)

Observer A diagnosed spontaneous echo contrast in 28 cases (32%), assessing it as grade 1 in 13 cases, grade 2 in seven cases, and grade 3 in eight cases. Observer B diagnosed spontaneous contrast in 25 cases (28%), assessing it as grade 1 in 12 cases, grade 2 in 10 cases, and grade 3 in three cases. Both observers showed a good agreement ($\kappa = 0-65$). They agreed on the diagnosis and gradation in 73 cases (83%) and disagreed on the gradation in 15 cases (17%). Observer A had a tendency to diagnose higher grades. Regarding the overall presence or absence of spontaneous echo contrast, both observers showed a very good agreement ($\kappa = 0-92$). In only three cases did observer A make the diagnosis but not observer B.

Diagnosis of thrombi

Observer A diagnosed 17 thrombi (19%), two definite and 15 probable, within either the left atrium or the left atrial appendage. Observer B diagnosed 15 thrombi (17%), six definite and nine probable, within either the left atrium or the left atrial appendage. Both observers showed a moderate agreement ($\kappa = 0-45$).

Left atrial thrombi

Observer A diagnosed 11 thrombi (13%), all described as probable, whereas observer B diagnosed six thrombi (7%), five of them probable and one definite. Both observers showed a moderate agreement ($\kappa = 0-42$). They agreed in 79 cases (90%): in 75 cases on the absence and in four cases on the presence of a probable or definite thrombus. In nine cases (10%) they disagreed: observer A diagnosed seven probable thrombi which were not confirmed by observer B; observer B diagnosed two probable thrombi which were not confirmed by observer A.

<table>
<thead>
<tr>
<th>Table 2</th>
<th>Diagnosis of spontaneous echo contrast by transoesophageal echocardiography by two observers in 88 patients (part I)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Observer A</td>
<td>Total</td>
</tr>
<tr>
<td>Observer B: Total</td>
<td>88</td>
</tr>
<tr>
<td>Observer B: Absent</td>
<td>63</td>
</tr>
<tr>
<td>Grade 1</td>
<td>12</td>
</tr>
<tr>
<td>Grade 2</td>
<td>10</td>
</tr>
<tr>
<td>Grade 3</td>
<td>3</td>
</tr>
</tbody>
</table>
Figure 1 Left atrial thrombus. Both observers agreed on the diagnosis. LA, left atrium; MV, mitral valve; LV, left ventricle; RA, right atrium; RV, right ventricle.

Figure 2 "Controversial" left atrial appendage thrombus. Observer A diagnosed a probable thrombus and observer B a definite one.

Left atrial appendage thrombi
Observer A diagnosed six thrombi (7%), two definite and four probable, within the left atrial appendage. Observer B diagnosed nine thrombi (10%), five definite and four probable. Both observers showed a good agreement ($\kappa = 0.65$). They agreed in 83 cases (94%), in 78 cases on the absence of thrombi, in three cases on the presence of probable thrombi, and in two cases on the presence of definite thrombi. In five cases they disagreed: observer A diagnosed one probable thrombus that was not confirmed by observer B; observer B diagnosed one probable thrombus and three definite thrombi that were not confirmed by observer A. There was a tendency of observer B to diagnose more left atrial appendage thrombi.

Monoplane versus biplane probes
Agreement between the two observers was fair to moderate in 38 cases that were investigated by monoplane probes ($\kappa = 0.36$ for left atrial thrombi, $\kappa = 0.48$ for left atrial appendage thrombi). Agreement was good in the 50 cases that were investigated by the biplane probe ($\kappa = 0.63$ for both left atrial and appendage thrombi).

**PART II**

**Diagnosis of thrombi**
Observer A diagnosed 15 thrombi (18%), 11 definite and four probable within either the left atrium or the left atrial appendage. Observer B diagnosed 18 thrombi (21%), 15 definite and three probable within either the left atrium or the left atrial appendage. Both observers showed a good agreement ($\kappa = 0.68$).

Left atrial thrombi
Both observers diagnosed a definite left atrial thrombus in four cases (fig 1). They agreed on the absence of a left atrial thrombus in 81 cases (95%). There was no case of disagreement ($\kappa = 1$).

Left atrial appendage thrombi (table 3)
Observer A diagnosed 11 left atrial appendage thrombi (13%), four probable and seven definite. Observer B found 14 thrombi (17%), three probable and 11 definite. Both observers showed a good agreement ($\kappa = 0.77$). They agreed in the diagnosis of thrombi in 76 cases (89%) and disagreed in nine cases (11%) (fig 2). There was still the tendency of observer B to diagnose more left atrial appendage thrombi.

As expected, the mean diameter of the six left atrial appendage thrombi on which the observers agreed was greater than the diameter of the thrombi on which the observers disagreed: 21 mm versus 13 mm ($P = 0.07$) for observer A; 19 mm versus 11 mm ($P = 0.01$) for observer B.

### Table 3 Diagnosis of left atrial appendage thrombus by two observers in 85 patients (part II)

<table>
<thead>
<tr>
<th>Observer</th>
<th>Total</th>
<th>No</th>
<th>Probable</th>
<th>Definite</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Observer B: Total</td>
<td>85</td>
<td>74</td>
<td>4</td>
<td>7</td>
</tr>
<tr>
<td>No</td>
<td>71</td>
<td>70</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>Probable</td>
<td>3</td>
<td>3</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Definite</td>
<td>11</td>
<td>4</td>
<td>6</td>
<td></td>
</tr>
</tbody>
</table>

Discussion
As TOE is frequently used in multicentre trials, assessment of interobserver variability between different echocardiographic laboratories becomes important. So far, studies of interobserver variability in diagnosing spontaneous echo contrast and thrombi have only been performed between different observers from the same echocardiographic laboratory. This is the first study on interobserver variability between two different echocardiographic laboratories using this technique.

There should be no difference between interobserver variability studies within a single centre and between separate centres. However, since the field of TOE is relatively
Interobserver variability in TOE assessment of thrombi

new and the diagnosis of spontaneous echo contrast sometimes seems arbitrary, we decided to look for interobserver variability between different echocardiographic laboratories.

We have restricted our analysis to a review of the video recordings. The study cannot answer the question of how both observers would have established a diagnosis when performing a TOE examination in the same patient. That would have included a complete TOE re-examination of the patient and was not carried out for reasons of ethics.

It is known that the diagnosis of spontaneous echo contrast is dependent on transducer frequency, gain setting, and echocardiographic equipment. A good agreement between two observers in the diagnosis of spontaneous echo contrast has already been shown within the same echocardiographic laboratory. We found a good agreement between the two observers in grading spontaneous echo contrast. However, the clinical relevance of the phenomenon is unknown.

Agreement between the two observers was very good regarding the overall presence or absence of spontaneous echo contrast, so we restricted the assessment of interobserver variability to part I of the study.

Both observers expected a high agreement in the diagnosis of left atrial and appendage thrombi. That expectation was supported by well defined transthoracic criteria for left ventricular and atrial thrombi and by six anatomically controlled TOE studies in patients with mitral stenosis undergoing surgery. These studies showed an excellent sensitivity and specificity.

Therefore no common criteria for thrombi were defined for part II of the study.

Interobserver variability in diagnosing left atrial and appendage thrombi was unexpectedly high in part I of the study. The 14 controversial cases were reviewed together by both observers. They found out that the diagnostic criteria in published reports were not sufficient for our patients. The criteria were obtained from patients with severe mitral stenosis requiring surgery, in whom the left atrium and appendage were large and easy to explore. The situation was quite different in our patients whose left atrial appendages were narrow, tortuous, and heavily trabeculated.

Only 5% of our patients had mitral stenosis.

For part II, we defined common diagnostic criteria for modifying transthoracic criteria.

Application of defined diagnostic criteria decreased interobserver variability in the diagnosis of left atrial thrombi. The fact that the same defined diagnostic criteria were applied to left atrial appendage thrombi helped to decrease interobserver variability, although nine controversial cases remained. One third (5 of 15) left atrial appendage thrombi diagnosed by one observer were not confirmed by the other observer (table 3). The controversial thrombi in the left atrial appendage were smaller than the thrombi on which both observers agreed. The controversial thrombi were differently interpreted as trabeculae or small thrombi. Since our diagnostic criteria were not anatomically controlled, we do not know which observer made the correct diagnosis in these patients. We must conclude that there is disagreement in interpretation despite the echocardiographic experience of the two observers.

Interobserver variability was high in patients who were investigated by a monoplane probe. But even the use of biplane probes and common diagnostic criteria in part II of the study resulted in nine controversial cases.

From our findings we conclude that interobserver variability in the diagnosis of spontaneous echo contrast is low when defined diagnostic criteria are applied. Defined criteria decrease interobserver variability for left atrial and appendage thrombi, although one third of the left atrial appendage thrombi diagnosed by one observer were not confirmed by the other. Interobserver variability is high in the assessment of small structures (<15 mm) within the left atrial appendage.

There is a need for clinically controlled studies on thrombi in the left atrial appendage in patients without mitral stenosis. There is also a need for improved and generally accepted diagnostic criteria for thrombi in the left atrium and appendage.

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