Diagnosis of Noninfective Cardiac Mass Lesions by Two-Dimensional Echocardiography

Comparison of the Transthoracic and Transesophageal Approaches

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This study was conducted in 46 patients with cardiac thrombi, 15 patients with atrial myxomas, and 32 patients with other cardiac or paracardiac tumors. Diagnoses were subsequently proven by surgery, autopsy, computed tomography, magnetic resonance imaging, or angiography in all patients. All patients underwent precordial and transesophageal two-dimensional echocardiography to assess the various mass detection rates. Atrial myxomas and predominantly left-sided cardiac tumors were identified by both echocardiographic techniques with comparable detection rates. Left ventricular apical thrombi were detected more frequently by precordial echocardiography. In contrast, transesophageal echocardiography was superior in visualizing left atrial appendage thrombi, small and flat thrombi in the left atrial cavity, thrombi and tumors in the superior vena cava, and masses attached to the right heart and the descending thoracic aorta. These data indicate that transesophageal echocardiography leads to a clinically relevant improvement of the diagnostic potential in patients in whom cardiac masses are suspected or have to be excluded in order to ensure the safety of clinical procedures. (Circulation 1991;83:70–78)

Since the initial demonstration of an atrial myxoma with ultrasonography by Effert and Domanig in 1959,1 the value of echocardiography for diagnosing cardiac and paracardiac masses is well established.2–12 This is particularly true for the two-dimensional technique that provides tomographic, anatomic imaging and allows the visualization of most cardiac and paracardiac regions. In some patients, however, the precordial echocardiographic approach may result in an insufficient image quality because of emphysema, obesity, or chest deformities, and, thus, no reliable diagnosis can be made. During recent years, it has been shown that transesophageal echocardiography using the unobstructed view from the esophagus to the heart provides an optimal imaging quality of most cardiac structures in practically all patients.13–16 In addition, the close proximity of the esophagus to the heart allows the use of higher transducer frequencies that increase image resolution. Moreover, transesophageal imaging permits the routine visualization of certain cardiac regions that often cannot be visualized from the precordial views, such as the left atrial appendage and the superior vena cava.15,16

The present study was undertaken to compare the diagnostic accuracy of transthoracic with that of transesophageal echocardiography for detecting cardiac and paracardiac masses.

Methods

Patients

For inclusion into this study, patients had to meet the following selection criteria: 1) presence of an intracardiac or paracardiac tumor or thrombus proven by surgery, autopsy, or other commonly accepted diagnostic procedure, such as computed tomography, magnetic resonance imaging, or angiography; 2) all patients had to be studied by precordial and by transesophageal echocardiography.
According to these selection criteria, we included 93 consecutive patients (39 men, 54 women) who were between 20 and 82 years of age. Diagnoses of these patients are listed in Table 1 and were proven by surgery (n = 67), autopsy (n = 2), computed tomography (n = 29), magnetic resonance imaging (n = 7), or angiography (n = 15).

**Echocardiographic Examination**

All patients were studied by conventional transthoracic echocardiography with 2.25- or 3.5-MHz phased-array transducers and standard techniques including multiple right and left parasternal, apical, and subxiphoidal views. Within 24 hours after the precordial examination, all patients underwent transesophageal echocardiographic investigation. Transesophageal studies were performed with 3.5- or 5.0-MHz phased-array transducers mounted at the tip of a modified gastroscope (Diasysonic Echoscope, Disonics Cardio/Imaging Inc., Salt Lake City; model 21362A, Hewlett-Packard Co., Andover, Mass.). Patients were studied in a left lateral decubitus position after 4 hours or more fasting and application of a local pharyngeal anesthesia (1% lidocaine spray) as the only premedication. An antibiotic prophylaxis was not performed in this study because most of the examinations were performed before the development of this still-controversial procedure. Before the examination, patients had given informed consent, and all transesophageal studies were performed without complications.

**Results**

**Left and Right Atrial Myxomas**

All 15 myxomas in the left (n = 13) and right atria (n = 2) were correctly diagnosed by both the transthoracic and transesophageal approaches. In addition, the transesophageal echocardiogram revealed echoluent areas within the tumor in two patients, which were not detected on the precordial image (Figure 1). All 15 myxomas originated from the interatrial septum as proven by surgery; the point of attachment to the septum was clearly visualized on the transthoracic echocardiogram in 12 patients and on the transesophageal echocardiogram in all 15 patients (Figure 1).

**Thrombi**

The detection rates for intracardiac and extracardiac thrombi are listed in Table 2. Whereas three patients with a right atrial thrombus were correctly diagnosed by transthoracic and transesophageal echocardiography, eight (31%) of 26 thrombi within the left atrial cavity were not detected on the precordial echocardiograms; failure of the precordial technique was due to an insufficient imaging quality created by emphysema and mitral prosthesis-induced shadowing in one patient each, by a flat mural thrombus in three patients, and by thrombi less than 10 mm in diameter in three patients. A

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**Table 1. Diagnosis and Localization of Intracardiac and Paracardiac Masses in 93 Patients**

<table>
<thead>
<tr>
<th>Localization</th>
<th>Diagnosis</th>
<th>Patients (n)</th>
</tr>
</thead>
<tbody>
<tr>
<td>LA</td>
<td>Cavity</td>
<td>22</td>
</tr>
<tr>
<td></td>
<td>Appendage</td>
<td>9</td>
</tr>
<tr>
<td></td>
<td>Cavity and appendage</td>
<td>3</td>
</tr>
<tr>
<td>LA and RA</td>
<td>Isolated</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Straddling IAS</td>
<td>2</td>
</tr>
<tr>
<td>RA</td>
<td>Isolated</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>And SVC</td>
<td>1</td>
</tr>
<tr>
<td>SVC</td>
<td>Isolated</td>
<td>2</td>
</tr>
<tr>
<td>LV</td>
<td>Apical</td>
<td>5</td>
</tr>
</tbody>
</table>

**Tumors**

Right paracardial
- And penetration PA | Bronchial carcinoma | 1 |
- And penetration RA | Fibrosarcoma | 1 |
- And penetration RA, RV | Rhabdomyosarcoma | 1 |
- And penetration PA, RA, RV | Bronchial carcinoma | 1 |
- And penetration RA, RV | Calcified hematoma | 1 |
- And penetration PA, RA, RV | Malignant histiocytoma | 1 |
- And penetration PA, RA, RV | Lipoma | 1 |
- And penetration PA, RA, RV | Malignant thymoma | 1 |
- And penetration PA, RA, RV | Metastasis of melanocarcinoma | 1 |
- And penetration PA, RA, RV | Malignant lymphoma | 1 |

RA
- And IVC | Uteromyosarcoma | 1 |
- And IVC | Leiomyoma | 1 |
- And IVC | Leiomyosarcoma | 1 |
- And IVC | Renal cell carcinoma | 3 |
- And IVC/SVC | Renal cell carcinoma | 1 |
- And IVC/SVC | Myxoma | 2 |
- And IVC/SVC | Rhabdomyosarcoma | 1 |

LA
- And penetration RV | Rhabdomyosarcoma | 1 |
- And penetration RV | Myxoma | 13 |

Left paracardial
- And anterior mediast. | Teratoma with pseudocyst | 1 |
- And infiltration LV | Myofibroma | 1 |
- And infiltration LV | Malignant thymoma | 1 |
- And infiltration LV | Lipoma | 1 |
- LV | Rhabdomyosarcoma | 1 |
- Descending aorta | Malignant histiocytoma | 1 |

**Cysts**

Right pericardial | Pericardial cyst | 4 |
Left pericardial | Pericardial cyst | 2 |
Posterior LA | Bronchogenic cyst | 1 |

<table>
<thead>
<tr>
<th>Localization</th>
<th>Diagnosis</th>
<th>Patients (n)</th>
</tr>
</thead>
<tbody>
<tr>
<td>LA, left atrium; RA, right atrium; IAS, interatrial septum; SVC, superior vena cava; LV, left ventricle; PA, pulmonary artery; RV, right ventricle; IVC, inferior vena cava.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The typical example of a left atrial thrombus that was not detected by the precordial examination is shown in Figure 2. In two instances, the transesophageal
Figure 1. Transesophageal echocardiograms of left atrial myxoma subsequently proven by surgery. Imaging from the esophagus identifies additional morphological details such as echolucent areas representing cysts (left, arrow) that were not detected on the precordial image. In addition, the point of attachment at the interatrial septum (arrow) can clearly be demonstrated (right). LA/RA, left and right atrium; LV/RV, left and right ventricle.

Echocardiogram identified a long thrombus straddling the interatrial septum through a patent foramen ovale (one instance) and a small atrial septal defect (one instance) (Figure 3), which was subsequently confirmed by surgery; in these two instances, the precordial and subxiphoid views had suggested isolated masses within both atria.

Twelve patients had thrombi within the left atrial appendage proven by surgery (in three instances associated with a separate thrombus in the left atrial cavity); all thrombi were visible on the transesophageal echocardiogram (Figure 4) but were not visible on the precordial echocardiogram. Three patients showed a thrombus in the superior vena cava.

Table 2. Detection of 51 Cardiac Thrombi in 46 Patients by Transthoracic and Transesophageal Echocardiography

<table>
<thead>
<tr>
<th>Localization</th>
<th>RA</th>
<th>LA</th>
<th>IAS</th>
<th>LAA</th>
<th>SVC</th>
<th>LV</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Echocardiography</td>
<td>n</td>
<td>%</td>
<td>n</td>
<td>%</td>
<td>n</td>
<td>%</td>
<td>n</td>
</tr>
<tr>
<td>Transthoracic</td>
<td>3</td>
<td>100</td>
<td>18</td>
<td>69</td>
<td>2</td>
<td>100</td>
<td>0</td>
</tr>
<tr>
<td>Transesophageal</td>
<td>3</td>
<td>100</td>
<td>26</td>
<td>100</td>
<td>2</td>
<td>100</td>
<td>12</td>
</tr>
</tbody>
</table>

RA, right atrium; LA, left atrium; IAS, overriding thrombus lodged in patent foramen ovale (1) or small atrial septal defect (1); LAA, left atrial appendage; SVC, superior vena cava; LV, left ventricle.

Figure 2. Transesophageal echocardiogram demonstrating a flat mural thrombus within the left atrial cavity (arrows) that was not visualized by the precordial approach. Presence of the thrombus was confirmed by subsequent surgery. LA/LV, left atrium and ventricle; AO, aortic root.
cava attached to intravenous catheters or to a pacemaker wire. Only the thrombus attached to the latter could be identified by transthoracic echocardiography in the area where the thrombus prolapsed into the right atrium; the part of the thrombus within the superior vena cava was undetected in all three patients by the transthoracic approach. In contrast, the transesophageal image clearly identified the thrombus within the superior vena cava in all three patients (Figure 5).

Five patients after myocardial infarction showed a mural thrombus within the left ventricle. All thrombi were localized in the apical area and were visualized by the precordial examination in the four-chamber view. The transesophageal technique, however, detected an apical mobile thrombus in only one patient, although a transesophageal modified four-chamber view and the transgastric short-axis plane were applied.

Intracardiac and Paracardiac Tumors (Without Myxomas)

Table 3 summarizes the findings of intracardiac and paracardiac tumors by the transthoracic and transesophageal approaches. In one patient who had a mass within the right atrium and inferior and superior venae cavae, only the transesophageal view demonstrated the involvement of the superior vena cava (Figure 5); in the remaining seven patients, right atrial tumors with or without involvement of the inferior vena cava were detected by both techniques. Whereas all six left-sided pericardial or paracardiac tumors were correctly identified by both techniques, only nine of 14 right-sided pericardial or paracardiac tumors were correctly identified by transthoracic echocardiography. The five tumors that were missed by the conventional approach but that were correctly identified by the transesophageal view (Figure 6)
were localized behind the sternum and lateral to the right ventricle \((n=3)\), in the corner between the diaphragm and the heart \((n=1)\), or could not be differentiated from a pericardial effusion by the precordial view \((n=1)\). Intracardiac tumors (invading from the inferior vena cava in six patients) also could be visualized by both techniques. In one patient, the tumor infiltration of the right ventricular wall could not be visualized by either technique. In another patient, the tumor penetration into the pulmonary artery could be visualized only by transesophageal echocardiography (Figure 7). Also, in one patient with obstruction of the thoracic descending aorta by malignant histiocytoma, only the transesophageal technique demonstrated the tumor mass (Figure 8).

**Discussion**

The sensitivity of two-dimensional echocardiography for detecting intracardiac and paracardiac masses depends on the tumor size, acoustic properties, and location of the particular mass.

**Cardiac Thrombi**

Concerning the echocardiographic detection of left ventricular mural thrombi, a sensitivity of 90% or more has been reported. Accordingly, all five thrombi localized in the apical region of the left ventricle were detected by precordial echocardiography in the present study. Transesophageal echocardiography is clearly inferior in detecting apical left ventricular thrombi compared with the conventional transthoracic approach. Thus, only one of the five corresponding thrombi could be unequivocally visualized from the esophagus. This is because the apical region of the heart is localized in the far field when imaged with high-frequency transducers from the esophagus; furthermore, an ideal image plane

**FIGURE 5.** Transesophageal echocardiograms demonstrating thrombotic material attached to an intravenous catheter (top) and a malignant tumor (bottom left) in the superior vena cava (arrows) and the corresponding diagram (bottom right). LA, left atrium; AO/AO ASC, ascending aorta; SVC/VCS, superior vena cava.
through the apical region is difficult to obtain as long as esophageal probes with only one image plane are used. On the other hand, the precordial apical view with its multiple planes provides a clear image quality of the cardiac apex in most patients.

For the transthoracic echocardiographic detection of left atrial thrombi, a sensitivity between 38% and 61% has been reported.\(^6,18-20\) Although this sensitivity range is remarkably low, two-dimensional echocardiography is usually considered the method of choice for detecting left atrial thrombi. Previous studies show that small and flat atrial thrombi and thrombi obscured by the shadowing of prosthetic valves are usually undetected by precordial echocardiography.\(^6,18,20,21\) This was confirmed in the present study: all eight thrombi within the left atrial cavity undetected by precordial echocardiography were either small, flat mural masses or were found in a patient with mitral valve prosthesis. In these cases, the diagnostic potential of echocardiography can be markedly improved when the transesophageal approach is used. The same is true for the detection of thrombi limited to the left atrial appendage as reported previously.\(^22-24\) All 12 instances of thrombotic material within the left atrial appendage were undetected on the precordial echocardiogram but were clearly identified on the transesophageal echocardiogram. Whereas the atrial appendage can be visualized by precordial echocardiography only in rare instances when a modified parasternal short-axis view is applied,\(^25\) the cavity of the appendage becomes visible in practically all transesophageal echocardiograms.\(^22-24\) This fact is of particular importance when potential cardiac sources of thrombi have to be

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**TABLE 3. Detection of Intracardiac and Paracardiac Masses (Tumors or Cysts) by Transthoracic and Transesophageal Echocardiography in 32 Patients**

<table>
<thead>
<tr>
<th>Mass localization</th>
<th>Patients (n)</th>
<th>Transthoracic</th>
<th>Transesophageal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Right atrium</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>And IVC</td>
<td>6</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>And IVC/SVC</td>
<td>1</td>
<td>1*</td>
<td>1</td>
</tr>
<tr>
<td>Left paracardial</td>
<td>5</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>And penetration left heart</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Right paracardial</td>
<td>11</td>
<td>6</td>
<td>11</td>
</tr>
<tr>
<td>And penetration right heart</td>
<td>3</td>
<td>3†</td>
<td>3</td>
</tr>
<tr>
<td>Left ventricle</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Posterior left atrium</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Left atrium and right ventricle</td>
<td>1</td>
<td>1‡</td>
<td>1‡</td>
</tr>
<tr>
<td>Descending aorta</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Total (patients)</td>
<td>32</td>
<td>26</td>
<td>32</td>
</tr>
<tr>
<td>n</td>
<td>32</td>
<td>81</td>
<td>100</td>
</tr>
</tbody>
</table>

ICV, inferior vena cava; SVC, superior vena cava.
*Part of the tumor in SVC not seen.
†Invasion of the pulmonary artery in one patient not seen.
‡Right ventricular involvement not seen.

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**FIGURE 6. Transesophageal echocardiogram (left) and corresponding diagram (right) demonstrating a cystic tumor mass (bronchial carcinoma) predominantly localized on the right heart that was not clearly seen on the precordial views. LA/RA, left and right atrium.**
excluded in patients with arterial embolic events as well as before performing mitral valvuloplasty, in which the safety of the procedure is directly influenced by the presence or absence of thrombotic material within the left atrium and the appendage area.

Because transesophageal echocardiography allows a clear visualization of the atrial septum in the area of the fossa ovalis, a thrombus lodged in a patent foramen ovale or small atrial septal defect could be identified in two patients. Although this condition is a rare finding, it elucidates the potential risk of paradoxical embolism associated during any type of Valsalva maneuver in patients with a noncompetent atrial septum.

Right heart thrombi are a relatively rare finding, and in the present series, they could be identified by both echocardiographic techniques in all patients. This, however, is only true as long as thrombi are localized within the right atrium or ventricle. When thrombus involves the superior vena cava, the precordial approach usually fails to demonstrate its presence, whereas transesophageal echocardiography can reliably detect this mass as documented in our study. This is of clinical relevance in patients with pacemakers and long-standing intravenous lines who are under intensive care or who are receiving long-term chemotherapy. In addition, transesophageal echocardiography seems also to be a promising approach in the diagnosis of central pulmonary artery emboli.

Cardiac Tumors

The diagnosis of atrial myxomas by transthoracic M-mode and, in particular, two-dimensional echocardiography is well established. In the present study, all right and left atrial myxomas were equally detected by both techniques. Transesophageal echocardiography, however, was slightly superior to precordial echocardiography in identifying the tumor attachment point and in identifying additional morphological details such as cysts. In selected patients,
this superior ability to provide additional information on morphological details may be of clinical relevance with regard to the echocardiographic differentiation of myxomas from thrombi.37,38

Cardiac and paracardiac tumors (other than myxomas) could be echocardiographically evaluated in 32 patients in this study. Although in most patients both echocardiographic approaches led to a correct mass detection, the transesophageal technique was superior in identifying masses localized anterior to the heart or that had invaded the superior vena cava, pulmonary artery, or descending thoracic aorta. This is in good agreement with a recent report on 12 patients with paracardiac tumors, in which transthoracic echocardiography failed to identify masses in six patients.39 Although the transesophageal technique seems to have high sensitivity for detecting intracardiac and paracardiac tumors, this technique cannot displace other diagnostic techniques such as computed tomography or magnetic resonance imaging.11 This is because echocardiographic information concerning tumor extent and tissue characterization is often limited. In addition, primary tumors of the heart are less frequent than metastatic masses, leading to the necessity of excluding tumor manifestations more distant from the heart. Transesophageal echocardiography, however, seems to be superior to the precordial technique as an initial screening procedure for cardiac tumors, at least for the particular tumor localizations mentioned above.

Limitations and Clinical Implications

This study has certain limitations as well as clinical implications. Patients with cardiac masses due to infective endocarditis were not included in this series because detection of these types of masses has been addressed previously.14,40 In addition, the transesophageal echocardiographic results may have been influenced by the findings obtained by the preceding precordial approach; this bias, however, seems to be unavoidable because we believe that the transesophageal examination should not be performed without an earlier conventional study. Moreover, because only patients with proven cardiac masses were included in this study, conclusions are not possible concerning the specificity of the echocardiographic findings. Despite these limitations, our results clearly document that transesophageal echocardiography is the method of choice for detecting masses localized within the left atrial appendage and the superior vena cava. This is of particular clinical importance for patients with otherwise unexplained arterial embolism, for those scheduled for mitral valvuloplasty, and for those who have undergone short- or long-term instrumentation of the vena cava. The superior diagnostic potential of the transesophageal technique described for atrial appendage masses also holds true for small and flat thrombi within the atrial cavity. Cardiac tumors, in particular those lesions localized around the right heart, were more accessible when imaged from the esophagus; consequently, the transesophageal approach should be used in patients in whom a paracardiac tumor is suspected but in whom precordial echocardiographic findings have been negative.

References


**KEY WORDS** • cardiac tumor • echocardiography • cardiac thrombus
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