Evaluation of Valvular Heart Diseases with Computed Tomography

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Forty-two patients with valvular heart diseases were studied with a third-generation computed tomographic system. The cardiac chambers (the atria and ventricles) were evaluated semiquantitatively, and valvular calcification was easily detected with computed tomography. Computed tomography was most valuable in revealing left atrial thrombi which were not identified by other diagnostic procedures in some cases.

Although computed tomography has been applied successfully to the diagnosis of diseases of various organs, there have been few reports of its application to the diagnosis of heart diseases.1−3 The present study was undertaken to assess structural abnormalities of valvular heart diseases with a third-generation whole-body computed tomographic system.

MATERIALS AND METHODS
Forty-two patients with valvular heart diseases (9 with mitral stenosis, 8 with mitral regurgitation, 11 with mitral stenosis-regurgitation and 7 each with aortic stenosis-regurgitation and combined valvular diseases) were studied. Six subjects with normal circulation were also studied as a control group.

Fig. 1. Computed tomograms of a patient with mitral regurgitation and bilateral heart failure (upper panel) and a patient with aortic regurgitation (lower panel). RA = right atrium; RV = right ventricle; LV = left ventricle; S = interventricular septum; Ao = descending aorta; E = pleural effusion

Key Words:
Computed tomography
Valvular heart diseases
Left atrial thrombus

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A computed tomographic whole-body scanner which utilized a continuously rotating gantry and pulsed anode with X radiation collimated to form a thin fan shaped beam was used\(^1\) (Varian Computed Tomographic Three-Second Whole Body Scanner). In the present study, gated computed tomographic scanning to obtain “stop-action” image\(^2\) was not applied to protect the quality of the image.

Every computed tomogram was obtained in the position of deep inspiration.

Sustained enhancement was obtained with a rapid intravenous infusion of 100–200 ml of 60% meglumine iothalamate. The tomographic slices of the heart were obtained at an interval of 1 cm thickness.

![Fig. 2](image1.png) Computed tomogram from a patient with mitral regurgitation. Angiographic contrast medium is passing through the left atrium. LA = left atrium; LV = left ventricle; RA = right atrium; RV = right ventricle; Ao = aorta

![Fig. 3](image2.png) Computed tomogram of a patient with mitral stenosis-regurgitation at the level of the mitral valve (upper panel) and a patient with aortic stenosis-regurgitation at the level of the aortic valve (lower panel). The arrows indicate the mitral (upper panel) and aortic (lower panel) valves.

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### TABLE I DIMENSIONS OF THE CARDIAC CHAMBERS MEASURED WITH COMPUTED TOMOGRAPHY

<table>
<thead>
<tr>
<th>No. of cases</th>
<th>Right atrium</th>
<th>Left atrium</th>
<th>Left ventricle</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>long axis</td>
<td>short axis</td>
<td>long axis</td>
</tr>
<tr>
<td>1. Normal</td>
<td>6</td>
<td>5.0 ± 0.8</td>
<td>3.0 ± 1.0</td>
</tr>
<tr>
<td>2. Mitral stenosis</td>
<td>9</td>
<td>6.2 ± 1.1</td>
<td>4.0 ± 0.9</td>
</tr>
<tr>
<td>3. Mitral regurgitation</td>
<td>8</td>
<td>6.9 ± 1.8</td>
<td>4.2 ± 1.0</td>
</tr>
<tr>
<td>4. Mitral stenosis-regurgitation</td>
<td>11</td>
<td>7.0 ± 1.0</td>
<td>4.5 ± 0.9</td>
</tr>
<tr>
<td>5. Aortic stenosis-regurgitation</td>
<td>7</td>
<td>6.5 ± 1.2</td>
<td>3.3 ± 1.1</td>
</tr>
<tr>
<td>6. Combined valvular diseases</td>
<td>7</td>
<td>7.0 ± 1.5</td>
<td>4.5 ± 0.5</td>
</tr>
</tbody>
</table>

*(in cm, mean ± SD)*

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Fig. 4. Computed tomographic (upper panel) and two-dimensional echocardiographic (lower panel) findings of a left atrial thrombus (indicated by arrows, Case 6). LA = left atrium; LV = left ventricle; RV = right ventricle; S = interventricular septum; Ao = aorta

Fig. 5. Cardiac computed tomographic findings of Case 3. The left atrial thrombus is indicated by an arrow. LA = left atrium; RA = right atrium; RV = right ventricle; Ao = aorta

Fig. 6. Thrombus removed by cardiac surgery in the case shown in Fig. 5. LA = left atrium

RESULTS

Figure 1 indicates computed tomograms from a patient with mitral regurgitation (upper panel) and a patient with aortic regurgitation (lower panel).

Enlarged right and left ventricles and right atrium are revealed.

Figure 2 indicates the computed tomogram of another patient with mitral regurgitation at a level slightly lower than that indicated in Fig. 1. The passage of the contrast medium in the left atrium is delineated.

The largest values of the long and short axes of the cardiac chambers of the heart were measured for each group of patients, as shown in Table I. The right ventricle was not measured because the chamber was revealed only partly by computed tomography.

Figure 3 is the non-enhanced computed tomogram of a patient with mitral stenosis-regurgitation (upper panel) and aortic stenosis-regurgitation (lower panel). The arrows indicate calcifi-
### Table II: Clinical and Laboratory Findings of Patients

<table>
<thead>
<tr>
<th>Case No.</th>
<th>Age</th>
<th>Diagnosis</th>
<th>AF</th>
<th>Systemic thrombosis</th>
<th>LA measured by CT</th>
<th>CT No. of thrombi</th>
<th>CT No. of thrombi detected by angiogram</th>
<th>CT No. of thrombi detected by echocardiogram</th>
<th>Operative or autopsy findings of thrombi</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. 45F</td>
<td>MSR</td>
<td>TR (+)</td>
<td>(-)</td>
<td>(-)</td>
<td>9.5 x 6.1 cm</td>
<td>1.3 x 1.6 cm</td>
<td>+68</td>
<td>(-)</td>
<td>(--)</td>
</tr>
<tr>
<td>2. 47F</td>
<td>MSR</td>
<td>ASR (+)</td>
<td>(+)</td>
<td>(+)</td>
<td>11.3 x 7.0 cm</td>
<td>2.0 x 2.3 cm</td>
<td>+42</td>
<td>(+)</td>
<td>(+)</td>
</tr>
<tr>
<td>3. 59F</td>
<td>MS</td>
<td>(+)</td>
<td>(+)</td>
<td>(+)</td>
<td>10.7 x 5.0 cm</td>
<td>1.2 x 1.6 cm</td>
<td>+43</td>
<td>(+)</td>
<td>(--)</td>
</tr>
<tr>
<td>4. 68F</td>
<td>MSR</td>
<td>(+)</td>
<td>(+)</td>
<td>(+)</td>
<td>14.3 x 7.6 cm</td>
<td>7.5 x 1.7 cm</td>
<td>(--)</td>
<td>(+)</td>
<td>(+)</td>
</tr>
<tr>
<td>5. 46M</td>
<td>MS</td>
<td>(+)</td>
<td>(+)</td>
<td>(+)</td>
<td>11.3 x 6.2 cm</td>
<td>3.2 x 1.9 cm</td>
<td>(--)</td>
<td>(--)</td>
<td>(+)</td>
</tr>
<tr>
<td>6. 45M</td>
<td>MSR, ASR, TR</td>
<td>(+)</td>
<td>(+)</td>
<td>(+)</td>
<td>13.7 x 7.6 cm</td>
<td>6.1 x 2.1 cm</td>
<td>+35</td>
<td>(--)</td>
<td>(--)</td>
</tr>
<tr>
<td>7. 61F</td>
<td>MS</td>
<td>(+)</td>
<td>(+)</td>
<td>(+)</td>
<td>11.1 x 5.9 cm</td>
<td>2.6 x 2.3 cm</td>
<td>+38</td>
<td>(--)</td>
<td>(--)</td>
</tr>
<tr>
<td>8. 63F</td>
<td>MSR</td>
<td>(+)</td>
<td>(+)</td>
<td>(+)</td>
<td>11.1 x 6.1 cm</td>
<td>3.6 x 2.1 cm</td>
<td>(--)</td>
<td>(--)</td>
<td>(--)</td>
</tr>
</tbody>
</table>

AF = atrial fibrillation, ASR = aortic stenosis-regurgitation, CT = computed tomography, CT No = CT number, LA = left atrium, MS = mitral stenosis, MSR = mitral stenosis-regurgitation, TR = tricuspid regurgitation, * = located at left atrial appendage, — = not measured

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**Discussion**

A gross evaluation of the sizes of the cardiac chambers by computed tomography was attempted as shown in Table I. It should be noted that the data shown was performed without gating out the cardiac cycle for 3.6 sec. Without gating out the cardiac cycle, the ventricles in all patients were not identified structurally. However, the left atrial appendage and mitral valve, and the left atrium were not identified structurally in 2 of the 8 studied patients. Table II shows the summary of the patients with left atrial thrombi. A small filling defect with left atrial thrombi was revealed by left atrial appendage. Figure 6 is the thrombus excised by surgery or echocardiography in one of the 4 patients and was not identified by echocardiography in 2 of them.

Figure 5 is the computed tomogram of a patient (with left atrial thrombi detected by computed tomography, aortic stenosis-regurgitation, and valve calcification (CT panel) indicate a large thrombus (measured as 6.1 x 2.1 cm) attached to the posterior wall of the left atrium. This was confirmed by the two-dimensional echocardiogram shown in the lower left panel. The compared tomographic findings (upper panel) with the surrounding cardiac tissue (CT panel). There were 14 cases with mitral (upper panel) and aortic (lower panel) valves. There were 14 cases with mitral valve calcification detected by computed tomography. The CT number of the area with mitral valve calcification detected by computed tomography was 140.5 ± 5.4.
rapid motion. Still, the estimation of the cardiac chamber size with computed tomography should be limited to semiquantitative analysis. On the other hand, as entire aspects of the atria are not easily assessed echocardiographically or occasionally cineangiographically, computed tomographic evaluation of these chambers might be helpful in understanding the abnormalities in these structures.

Calcification of the valves is easily identified by a sharp increase in the density of the area or by measuring the CT values; the situation can also be estimated echocardiographically, but with less certainty. The presence of left atrial thrombi is of significant importance, regardless of the size of the thrombi, due to the possibility of systemic embolization. Successful echocardiographic detection of a thrombus with a diameter as small as 1.5 cm has been reported.

However, in our experience 2 surgically confirmed left atrial thrombi (both were small thrombi located at the left atrial appendage, Cases 1 and 3 in Table II) were not correctly evaluated echocardiographically. Cineangiographic methods also have been associated with inaccuracy in detecting left atrial thrombi and one of the surgically confirmed thrombi were overlooked by the procedure. Computed tomography has the advantage of offering uniform slices of the left atrium in an attempt to detect thrombi in unknown areas of this chamber. In Cases 5, 6 and 7, possible left atrial thrombi detected by computed tomography were consistent with those detected echocardiographically, although they were not confirmed by surgery or autopsy. In Case 8, however, the apparent small left atrial thrombus was not identified by either cineangiography or echocardiography, and the possibility of false positive findings cannot be excluded. Occasionally, pericardial fat located near the left atrial appendage simulates a thrombus, but the lower CT numbers (minus values) of the area excluded the possibility of a thrombus, which has CT values from +35 to +68.

In conclusion, our experience suggests that computed tomography is useful in evaluating cardiac chamber size semiquantitatively, in identification of valvular calcification and especially in detecting left atrial thrombi of patients with valvular heart diseases.

REFERENCES


Jpn. Circulation Journal Vol. 46, April 1982