Evaluation of Cardiac Diseases with Computed Tomography

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Summary
Fifty-six consecutive patients with various cardiac diseases were studied with a third-generation whole body computed tomographic system. Enhancement was performed by intravenous injection of angiographic contrast medium.

Identification of the great vessels, atria and ventricles, and evaluation of abnormalities in these structures were possible by cardiac computed tomography.

For example, enlarged left ventricle in the left ventricular volume load, enlarged right ventricle in the right ventricular volume load or hypertrophied interventricular septum in idiopathic hypertrophic subaortic stenosis were revealed with a satisfactory resolution. Pericardial effusion and intracardiac thrombi were most precisely assessed by computed cardiac tomography.

Additional Indexing Words: Atrial septal defect Ebstein's anomaly Pericardial effusion Idiopathic hypertrophic subaortic stenosis Intracardiac thrombi

Computed tomography has been successfully applied to the diagnosis of diseases of various organs. However, there have been few reports of its application to the diagnosis of heart diseases. In this study, we attempted to show several possible benefits of computed tomography in the diagnoses of cardiovascular systems.

Methods
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.4)* A complete section scan was performed in 3 sec. The scale for transparency was -1000 for air, 0 for water, and +1000 for bone. In the present study, gated computed tomographic scanning to obtain "stop-action" image4) was not applied. Every computed tomogram was obtained in the position of deep inspiration. Sustained enhancement was obtained with a rapid intravenous infusion of 300 ml of Conray 30. Computed cardiac tomography was applied to 56 consecutive cardiac patients and some of the representative cases are illustrated in the results.

RESULTS

Fig. 1 indicates computed cardiac tomographic findings of a 28-year-old man without cardiovascular abnormalities. The top of each picture is the anterior of the patient and the left is the patient's right. At the level 7 cm below the sterno-clavicular angle, the left atrium, right atrium, left ventricle,

* Varian Computed Tomographic Three-second Whole Body Scanner

Fig. 1. Computed cardiac tomogram of a normal man. RV=right ventricle; LV=left ventricle; RA=right atrium; LA=left atrium; S=interventricular septum. The top of each picture is the anterior of the patient and the left is the patient's right.
and a part of the right ventricle are revealed (upper panel). The lower panel shows computed cardiac tomographic findings at the level of the right and left ventricles.

Enhancement with angiographic contrast medium was performed, and the interventricular septum was indicated as a negative shadow and chambers as positive shadows.

Fig. 2 was obtained from a 48-year-old man with aortic regurgitation.

There is an increase in the diameter of the left ventricle (LV), and the configuration of the left ventricle is more spherical than that of the normal left ventricle. Hypertrophy of the interventricular septum (S) is also shown.

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**Fig. 2.** Computed cardiac tomogram (left panel) and angiocardiogram (right panel, left anterior oblique projection) of a patient with aortic regurgitation. Ao=aorta; LV=left ventricle; RV=right ventricle; S=interventricular septum; RA=right atrium; LA=left atrium. The horizontal line indicates the tomographic plane.

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**Fig. 3.** Computed cardiac tomogram (left panel) and angiocardiogram (right panel) of a patient with atrial septal defect. RV=right ventricle; LV=left ventricle; S=interventricular septum; RA=right atrium; LA=left atrium; Ao=aorta. The horizontal line indicates the tomographic plane.
Fig. 3 is a computed cardiac tomogram (left panel) and angiocardio gram (right panel) of a 39-year-old woman with atrial septal defect (sinus venosus type).

Pulmonary arterial flow was 6.2 L/min, left to right shunt flow 3.0 L/min, and pulmonary arterial pressure was 34/9 (mean 18) mmHg. The figure is an enhanced tomogram and a marked deviation of the interventricular septum (S) toward the left ventricle (LV) as well as enlargement of the right ventricle (RV) is observed.

Fig. 4. Computed cardiac tomogram of a patient with Ebstein's anomaly. RA=right atrium; RV=right ventricle; LV=left ventricle; S=interventricular septum; RV'=atrialized right ventricle.

Fig. 5. Computed cardiac tomogram of a patient with idiopathic hypertrophic subaortic stenosis. LV=left ventricle; RV=right ventricle; S=interventricular septum.
Fig. 4 is an enhanced computed cardiac tomogram from a 43-year-old man with Ebstein's anomaly associated with a large atrial septal defect. The interventricular septum (S) is shifted to the left and the left ventricular chamber (LV) is narrowed. The right atrium (RA) is enlarged connecting with the atrialized right ventricle (RV') and small right ventricle (RV).

Fig. 5 is a computed cardiac tomogram from a 25-year-old woman who was diagnosed as having idiopathic hypertrophic subaortic stenosis. The figure is an enhanced tomogram at the level 3 cm below the aortic valve. An increase in the thickness of the interventricular septum, which measured 2.9 cm, is seen. The right and left ventricular chambers are narrowed by the hypertrophied interventricular septum.

Fig. 6 is the enhanced cardiac tomogram of a 60-year-old man with a well documented history of a 6-month-old anterolateral myocardial infarction. There is a semilunar negative shadow at the anterior portion of the enhanced left ventricular chamber (arrows), which is compatible with the angiographic findings of thrombus as indicated in the right panel.

Fig. 7 is a 68-year-old woman with mitral stenosis-regurgitation and histories of cerebral and femoral arterial thromboses. In this enhanced tomogram, a large thrombus is revealed (arrows) at the posterior wall of the left atrium.

Fig. 8 was obtained from a 66-year-old man with acute pericarditis without enhancement. The cardiac tomogram was obtained at the level 10 cm below the sterno-clavicular junction. The patient was obese, and the transparent zone (F) surrounding the heart showed a CT number of -39 which was compatible with that of the subcutaneous fat. The zone surrounding the

![Fig. 6. Computed cardiac tomogram of a patient with anterior wall myocardial infarction. There is an intraventricular thrombus (indicated by arrows), which is consistent with angiographic findings as indicated in the right panel (arrows). LV=left ventricle. The horizontal line indicates the tomographic plane.](image-url)
pericardial fat which is indicated by E, has a CT number of +20 which is lower than that of heart muscle (CT number +44) and is concluded to be a pericardial effusion (the fluid collected showed a yellowish color with a protein content of 4.5 Gm/100 ml).

**Discussion**

As indicated above, cardiac computed tomography is obviously one of
the best methods for evaluating pericardial effusion, because the distribution
of the pericardial effusion as well as the gross nature of the fluid (by the CT
number) can be evaluated. Diagnosis of the intraventricular or intraatrial
thrombi formation is of great importance, but the situation is sometimes un-
identified by conventional echocardiographic or cineangiographic methods.
A trial to detect thrombi by computed tomography might lead to more steady
detection of thrombi.

Evaluation of the chamber sizes or the interventricular septum by com-
puted tomography offers other aspects than those obtained by angiocardio-
graphy and echocardiography. However, it should be noted that the data
sampling was performed throughout the cardiac cycle for 3 sec without gating
by electrocardiograms. For this reason, the configuration of the various car-
diac structures obtained by computed tomography is net results of systolic
and diastolic findings.

Probably due to the above reasons, cardiac structures such as the mitral
valve and tendons could not be revealed with computed tomography. The
stop-action method gated with ECG is possible with the system used in the
present study, but our impression is that the quality of the computed tomo-
grams is not satisfactory due to reduced data sampling numbers for every
frame of the tomogram.

However, even without ECG gating, structures which have limited mo-
tion, such as pericardial effusion, the great vessels, atria, or thrombi might
be almost free from the effects of cardiac motion. On the other hand, in such
cardiac structures as the ventricles or interventricular septum that move rapid-
ly during systole, tomographic configuration during diastole appears to domi-
nate in composing a cardiac tomogram because silhouettes of the cardiac
structures tend to be blurred during systole by rapid motion. Actually, com-
puted cardiac tomography delineates abnormalities in the configuration of 4
chambers of the heart as indicated in Figs. 2-5; enlarged ventricles, atria,
and shifted or hypertrophied interventricular septum are revealed with a
satisfactory resolution. On the other hand, at the present time, cineangio-
graphy and echocardiography are the most adequate methods to evaluate the
structural and functional abnormalities of the heart.

However, with two-dimensional echocardiographic techniques, the whole
aspects of the ventricles or atria can not be necessarily recorded in a single
frame due to the limitation in the sector angle of the ultrasound beam, and
with cineangiography, cross-sectional findings at a certain level of the heart
are not available.

Thus, this preliminary report suggests a possibility that additional in-
formation which could not be obtained by conventional methods is available
from the computed cardiac tomography even without ECG gating.

REFERENCES