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Right and left ventricular dysfunction in patients with dilated cardiomyopathy: A study with equilibrium radionuclide ventriculography

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Summary

Right and left ventricular function was evaluated in 28 patients with dilated cardiomyopathy to determine whether both ventricular functions were equally impaired in each patient. The ejection fractions of both ventricles were measured using equilibrium radionuclide ventriculography.

In 13 patients the left ventricular ejection fraction (LVEF) was lower than the right ventricular ejection fraction (RVEF) by 6% or more, their mean values being 24±8% (mean±SD) and 37±7%, respectively (group 1). The difference between the LVEF and RVEF was less than 6% in nine patients; LVEF 29±8% and RVEF 30±7% (group 2). In six patients the RVEF was lower than the LVEF by 6% or more, and their mean values were 21±6% and 37±10%, respectively (group 3). The frequency of ventricular tachycardia, which was determined by the Holter ECG, was significantly higher in group 3 (100%, 6/6) than in the others (group 1+2; 41%, 9/22), $p<0.05$. The NYHA functional class correlated well with the LVEF, but not with the RVEF. It was concluded that the left and right ventricular functions are not necessarily equally impaired in patients with dilated cardiomyopathy, and that the difference may correlate with their clinical features.

Key words

Dilated cardiomyopathy | Radionuclide ventriculography | Right and left ventricular function | Ventricular tachycardia

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Introduction

Dilated cardiomyopathy is generally considered to be accompanied by both left and right ventricular dysfunction[1~3]. However, in most studies only left ventricular function has been analyzed, with less attention paid to the right ventricle[4~6], possibly due to the difficulties in assessing right ventricular function.

This is a report of our analysis of the right and left ventricular functions in patients with dilated cardiomyopathy using radionuclide ventriculography[7,8], and a comparison of each ventricular dysfunction with the respective clinical features of patient.

Materials and methods

Twenty-eight consecutive patients with dilated cardiomyopathy who were admitted to Kyushu University Hospital or Matsuyama Red Cross Hospital between 1980 and 1983 were the subjects of this study. There were 25 men and three women, whose ages ranged from 19 to 71 years, with a mean of 47 ± 15 years. Dilated cardiomyopathy was defined as idiopathic dilatation and dysfunction of either ventricle as determined by contrast ventriculography, echocardiography and/or radionuclide ventriculography. Each patient had a decreased ejection fraction of either ventricle of up to 40% according to radionuclide ventriculography. Normal right and left ventricular ejection fractions measured by this method were 52 ± 1 and 68 ± 2%, respectively (n=10, mean±SD).

1. Radionuclide technique

After the injection of 15 mCi Tc-99m human serum albumin into an antecubital vein, multiple gated equilibrium radionuclide ventriculography was performed using a gamma camera (PHO/Gamma LFOV Searle) and a converging hole collimeter. With the patient supine, the gamma camera was positioned for a 30–50 degree left anterior oblique projection and a 5 to 10 degree craniocaudal angle tilt to separate the ventricles and the atria. An energy of 140 KeV was selected with a 20% window. Using a commercially available program for nuclear cardiology (Shimadzu Scintipac 1200), gated images were collected for 10 minutes with a nuclear medicine computer having a 64×64 matrix. For each patient, a frame rate of 40 msec/frame or less was used[9]. A multi-buffer system was used to exclude the unwanted beats by more than 10% difference in R-R intervals in patients with arrhythmias. Three-point temporal and 9-point spatial smoothings were performed. A fixed region of interest was drawn on a diastolic image of a composite cardiac cycle using a "joy-stick," taking care to exclude the atria and pulmonary artery. For background, an end-systolic image region of interest was drawn for each ventricle. The computer program permitted the operator to observe the motion of each cardiac chamber in cine-mode and aided the operator in determining the end-diastolic region of interest. The ejection fraction of each ventricle was determined by the computer from the time activity curve.

2. Validation of radionuclide data

To validate the radionuclide data, the left ventricular ejection fraction obtained from radionuclide ventriculography was compared with that obtained by contrast ventriculography. There was a good correlation between the two methods; $r=0.96$, $y=-6.30+1.05x$, $SEE=4.4$, $n=22$ (**Fig. 1**). The right ventricular ejection fraction as calculated using equilibrium radionuclide ventriculography was compared with results obtained from the first pass method, and there was a good correlation between them, $r=0.93$, $y=-8.80+1.2x$, $SEE=5.1$, $n=18$. Inter and intraobserver variability was examined in 14 randomly-selected cases, and there was a good reproducibility as shown in **Table 1**.

3. Holter ECG monitoring

For all patients with dilated cardiomyopathy, 24 hour Holter ECG monitoring was performed using a magnetic tape system (Avionics model 445B). Two channels of the ECG were recorded for 2 to 4 days for each patient. Play-back analysis of the Holter ECG tape was performed by a Dynamic Electrocardioscanner (Avionics model 660A). The incidence of ventricular tachycardia, defined as three or more consecutive

Table 1. Inter- and intera-observer variability of radionuclide data (n=14)

	Inter-observer variability		Intra-observer variability	
	RVEF	LVEF	RVEF	LVEF
Correlation coefficient	0.93	0.98	0.99	0.99
Correlation equation	y=−0.27+1.02x	y=0.70+0.99x	y=−0.75+1.00x	y=0.95+0.99x
Standard error of estimate	3.4	2.3	1.3	1.7

RVEF=right ventricular ejection fraction; LVEF=left ventricular ejection fraction.

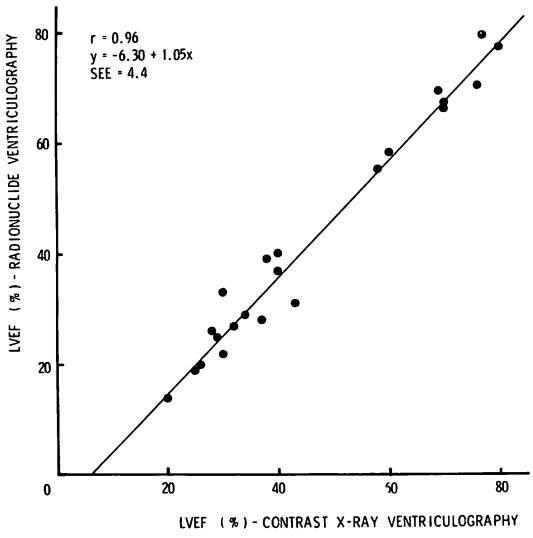

Fig. 1. Correlation of left ventricular ejection fraction (LVEF) **obtained by radionuclide ventriculography and contrast X-ray ventriculography in 22 patients.**

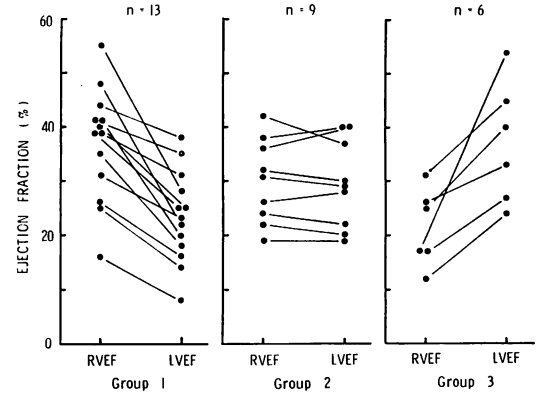

Fig. 2. Right and left ventricular ejection fraction in patients with dilated cardiomyopathy.

Note that the decrease in right and left ventricular ejection fraction is not necessarily the same in each patient.

RVEF=right ventricular ejection fraction; LVEF=left ventricular ejection fraction.

For the explanation of groups 1 to 3, see text.

ventricular contractions, was analyzed.

4. Statistical analysis

Statistical analysis was performed using the Student's t-test for unpaired data, and p values less than 0.05 were considered significant. All values were expressed as means±SD.

Results

As shown in **Fig. 2**, 13 of 28 patients had lower left ventricular ejection fractions (LVEF) than right ventricular ejection fractions (RVEF) by 6% or more (24±8% for LVEF and 37±10% for RVEF). Left and right ventricular ejection fractions were similar in nine patients, i.e., the difference in ejection fractions for the two ventricles was less than 6% (LVEF, 29±8%, RVEF, 30±7%). The remaining six patients had more severely reduced RVEF than LVEF, by 6% or more (LVEF, 37±10% and RVEF, 21±6%). Most patients had dysfunction of both ventricles, while a few patients had only right or left ventricular dysfunction (**Fig. 2**).

Table 2 shows the various symptoms in three groups of patients with dilated cardiomyopathy. Exertional dyspnea was most frequent in patients with marked left ventricular dysfunction (group 1) and in those with dysfunction of both ventricles to the same degree (group 2). In patients with marked right ventricular dysfunction

Table 2. Symptoms of patients with dilated cardiomyopathy

Symptoms	Group 1 (n=13)	Group 2 (n=9)	Group 3 (n=6)	Total (n=28)
Exertional dyspnea	10	6	1	17
Palpitation	3	6	3	12
Orthopnea and/or nocturnal dyspnea	6	2	1	9
Fatigue	5	2	2	9
Edema	2	2	1	5
Chest oppression	1	1	2	4
Abdominal symptom	0	1	0	1

Group 1: Patients in whom the left ventricular ejection fraction is lower than the right.

Group 2: Patients in whom both ventricular ejection fractions decrease equally.

Group 3: Patients in whom the right ventricular ejection fraction is lower than the left.

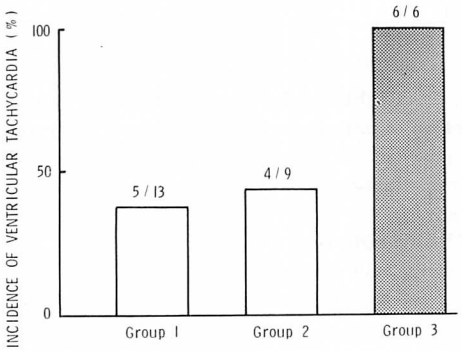

Fig. 3. Frequency of ventricular tachycardia in in three groups of patients with dilated cardiomyopathy.

The frequency of ventricular tachycardia is significantly higher in group 3 than in the groups 1 puls 2 ($p<0.05$). For the explanation of group 1 to 3, see text.

(group 3), exertional dyspnea was uncommon, but palpitation was relatively common. Orthopnea and/or nocturnal dyspnea was more frequent in group 1 than in group 3.

The incidence of ventricular tachycardia was compared for three groups. As shown in **Fig. 3**, the incidence was much higher in group 3 (100%) than in group 1 (38%) or group 2 (44%), and the difference was statistically significant ($p<0.05$).

Table 3. Right and left ventricular ejection fraction in patients with and without ventricular tachycardia

	Right ventricular ejection fraction (%)	Left ventricular ejection fraction (%)
With ventricular tachycardia	28±9*	31±11
Without ventricular tachycardia	36±10	26±8**

Values are mean±SD.

* $p<0.05$, ** $p<0.025$ compared with right ventricular ejection fraction without ventricular tachycardia.

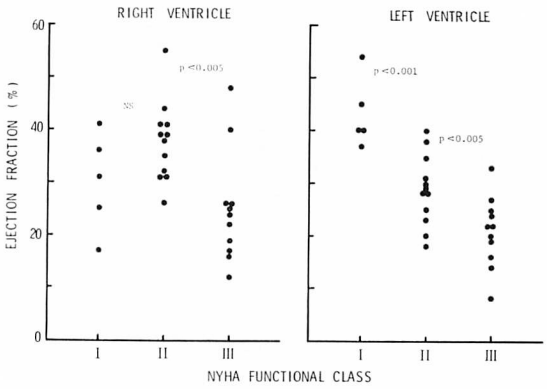

Fig. 4. Functional class of the New York Heart Association (NYHA) **and ejection fraction of the right and left ventricle.**

Note that the left ventricular ejection fraction correlates well with the functional classes.

Table 3 shows the right and left ventricular ejection fractions of patients with and without ventricular tachycardia. The left ventricular ejection fractions were similar for the two groups, while the right ventricular ejection fractions were less in patients with ventricular tachycardia ($p<0.05$). In patients without ventricular tachycardia the right ventricular ejection fractions were greater than the left ($p<0.025$), however, in patients with ventricular tachycardia

right and left ventricular ejection fractions were similar.

Fig. 4 shows the ejection fractions of the right and left ventricles of patients having different functional classes of New York Heart Association. As shown in the left panel, advances in functional class were not necessarily associated with decreases in the right ventricular ejection fractions. However, the left ventricular ejection fractions correlated well with the functional classes, suggesting that the left ventriclar function may be a more dominant factor than the right ventricular function in determining the functional classes.

Discussion

Validation of data

Radionuclide ventriculography is a reliable, non-invasive method for evaluating the right and the left ventricular ejection fractions[1,8]. The validity of our results of radionuclide ventriculography was evaluated by various methods. The left ventricular ejection fraction obtained by radionuclide ventriculography correlated well with that by contrast ventriculography. The right ventricular ejection fraction measured by the equilibrium method correlated well with those by the first pass method. Inter- and intra-observer variability and reproducibility were acceptable. These results indicate that the radionuclide data in the present study are reliable.

Comparison of ejection fractions of the right and left ventricles

It is generally considered that dysfunctions of both ventricles develop in patients with dilated cardiomyopathy[1~3]. However, no studies have evaluated in detail both the right and left ventricular ejection fractions using radionuclide ventriculography. The results of the present study revealed that the degrees of right and left ventricular dysfunction are not equal in all patients with dilated cardiomyopathy. Instead, 13 of 28 patients had lower left ventricular ejection fractions greater than 6% than right ventricular ejection fractions (group 1). A difference of greater than 6% was selected because the variation of reproducibility of the ejection fraction of either ventricle was less than 6% in our study. The mean difference in the ejection fractions of the right and left ventricles was $13 \pm 7\%$ in this group. Additional six patients had higher left ventricular ejection fractions than right (group 3), and the remaining nine patients had nearly equal right and left ventricular functions (group 2). Thus, the degrees of right and left ventricular dysfunction seemed to differ with each patient having dilated cardiomyopathy. The underlying mechanism for this awaits clarification.

Symptoms of dilated cardiomyopathy

Exertional dyspnea was the most common symptom in patients with dilated cardiomyopathy and it developed more frequently in those with marked left ventricular dysfunction (group 1) than in those with marked right ventricular dysfunction (group 3). Orthopnea or nocturnal dyspnea which can indicate congestive left ventricular failure, was uncommon in patients with prominent right ventricular dysfunction. These results indicate that dysfunction of right or left ventricle in a patient may relate to his symptoms.

The functional classes of the New York Heart Association were compared with the ejection fractions of the right or left ventricle. Left ventricular dysfunction correlated well with impaired functional class but the decrease in the right ventricular ejection fraction was not necessarily associated with impaired functional classes. Some patients with marked right ventricular dysfunction and nearly normal left ventricular function were asymptomatic except for occasional palpitation not associated with exertion. These results indicate that left ventricular function play a major role in determining functional classes of the New York Heart Association.

Incidence of ventricular tachycardia

In patients with dilated cardiomyopathy, arrhythmias are one of the most serious complications, and they may cause sudden death. The incidence of ventricular tachycardia in this study was 54% in the 28 patients. When the right and left ventricular ejection fractions were compared for patients with and without ven-

tricular tachycaria, no significant difference was observed in the left ventricular ejection fractions. Indeed, the right ventricular ejection fraction was less in patients with ventricular tachycardia. Furthermore, when the right and left ventricular ejection fractions were compared, the incidence of ventricular tachycardia was significantly higher in patients with dominant right ventricular dysfunction. Such patients may have arrhythmogenic right ventricular dysplasia[10,11]. In this study, all but one patient had decreased left ventricular ejection fractions and this may not be in agreement with the recent reports by Fontaine et al[10], and Manyari et al[12] who described mild left ventricular dysfunction in patients with arrhythmogenic right ventricular dysplasia and postulated that this disease was a specific form of dilated cardiomyopathy. The results of the present study also showed that some patients with dilated cardiomyopathy had more prominent right ventricular dysfunction than left, and they all developed ventricular tachycardia. Furthermore, one of our patients had an episode of ventricular tachycardia and marked dilatation and a decreased ejection fraction of the right ventricle, but a normal left ventricular function[13]. He was diagnosed as having arrhythmogenic right ventricular dysplasia at that time. He developed left ventricular dysfunction during a three year observation period and finally exhibited a typical form of dilated cardiomyopathy. These results may indicate that arrhythmogenic right ventricular dysplasia may be a specific form of dilated cardiomyopathy. In other words, some patients with dilated cardiomyopathy may develop right ventricular dysfunction initially, then left ventricular dysfunction later.

The present study clarified that right and left ventricular functions were not equally compromised in all patients with dilated cardiomyopathy. This may result from the different pathogenesis of cardiomyopathy of both the ventricles, and further study of these discrepant characteristics may provide clues for exploring the etiologic mechanisms of dilated cardiomyopathy.

拡張型心筋症における左右心室の駆出率と臨床像との対比：平衡時心プールシンチ法による検討

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拡張型心筋症 28 例について，左右心室駆出率の低下度を平衡時心プールシンチ法を用いて検討した．13 例では左室駆出率 (LVEF) が右室駆出率 (RVEF) よりも 6% 以上低下しており，それぞれの平均値は LVEF；24±8% (mean±SD), RVEF；37±7% であった(第 1 群)．左右両心室の駆出率が 6% 未満の差違に留ったものは 9 例であった (LVEF；29±8%, RVEF；30±7%, 第 2 群)．残り 6 例では RVEF が LVEF よりも 6% 以上低下していた (RVEF；21±6%, LVEF；37±10%, 第 3 群)．ホルター心電図を用いて検討した心室性頻拍の出現率は，第 3 群で他の 2 群に比し，有意に高頻度であった(第 3 群の 6 例全例；100%, 第 1 群＋第 2 群の 22 例中 9 例；41%)．NYHA の旧心機能分類は LVEF の低下度と関連があり，RVEF とは関連がなかった．拡張型心筋症における左右それぞれの心室機能は必ずしも同程度に低下しないことがわかり，また，こうした低下度の左右差と臨床像との関連が示唆された．

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