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Exercise body surface mapping in patients with left ventricular hypertrophy: Comparison with stress thallium scans (SPECT)

Hidenori YOSHIDA*
Hidenori HAGIWARA
Keiko IHARA
Teruo SHIRAKI
Hiroshi YAMANARI
Katashi MATSUBARA*
Daiji SAITO
Takao TSUJI
Shoichi HARAOKA*

Summary

To evaluate exercise-induced myocardial ischemia in patients with electrocardiographic evidence of left ventricular hypertrophy (LVH), including ST·T changes, body surface maps (QRST area maps) were recorded using 87 lead points before and after exercise. The patterns of the subtraction QRST area maps (S-maps) were compared with the findings of stress thallium (Tl) scans in 31 patients with hypertrophic cardiomyopathy and in five with essential hypertension.

All 18 patients whose S-maps revealed changes less than $-40\ \mu$VS or only an increase over the anterior chest region showed no positive findings on the stress Tl scans. However, there were clearly positive findings on stress Tl scans in eight (89%) of nine patients whose S-maps revealed changes greater than $-40\ \mu$VS over a wide precordial region or in six (67%) of nine patients whose S-maps revealed increases over the anterior chest region and had accompanying changes greater than $-40\ \mu$VS somewhere over the precordial region. These results suggested that exercise QRST area maps could differentiate exercise-induced myocardial ischemia from LVH with ST·T changes.

Key words

Body surface mapping　Left ventrcular hypertrophy　Stress thallium scan (SPECT)　Hypertrophic cardiomyopathy　Myocardial ischemia

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岡山大学医学部　臨床検査医学
*同　第一内科
岡山市鹿田町 2-5-1 (〒700)

*Department of Laboratory Medicine and the First Departmentof Internal Medicine, Okayama University Medical School, Shikata-cho 2-5-1, Okayama 700

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Purpose

The clinical usefulness of exercise QRST area maps in evaluating exercise-induced myocardial ischemia in patients with ECG evidence of left ventricular hypertrophy (LVH) with ST-T changes was evaluated. Using 87 lead points, body surface maps were recorded before and after exercise. The procedures used for recording and constructing maps were those of the method of Yamada, et al[1]. Subtraction area QRST maps (S-maps) were obtained by subtracting pre-exercise map data from those of post-exercise maps. S-map patterns were compared and evaluated with findings obtained from stress thallium scans (SPECT).

Subjects and Methods

The study subjects consisted of 31 patients with hypertrophic cardiomyopathy (HCM) diagnosed by echocardiography and cardiac catheterization, and five patients with essential hypertension (EH) with ECG findings of LVH and ST-T changes (**Table 1**). Exercise tests were performed on a bicycle ergometer in the supine position (**Fig. 1**). Exercise endpoints included; development of severe dyspnea, palpitation or angina; decreased blood pressure; ST-segment depression or elevation exceeding 2.0 mm; and complicating severe ventricular ectopy. Body surface maps were recorded directly before and three min following exercise, and S-maps were then prepared. SPECT was performed within one to two weeks after recording the exercise maps by injecting 4 mCi ^{201}thallium (^{201}Tl) at the exercise end-points, then exercise was continued for one min. After terminating the exercise, multiple view myocardial scintigrams were obtained with a ZLC-7500 single head γ camera (Siemens) 10 min, and again, four hours after the injection of ^{201}Tl. At each interval, SPECT imaging was performed in the short-axis, long-axis and four-chamber views. We judged the stress thallium scan as positive only when clearly reversible defects were observed. S-map patterns were evaluated by comparing them with SPECT findings.

Table 1. Subjects

	Cases	Male	Female	Age
HNCM	18	14	4	56.7±9.7
HOCM	6	4	2	63.0±7.6
APH	7	5	2	57.7±6.0
EH	5	4	1	53.6±8.1
Total	36	27	9	57.5±8.7

HNCM=hypertrophic nonobstructive cardiomyopathy; HOCM=hypertrophic obstructive cardiomyopathy; APH=apical hypertrophy; EH=essential hypertension.

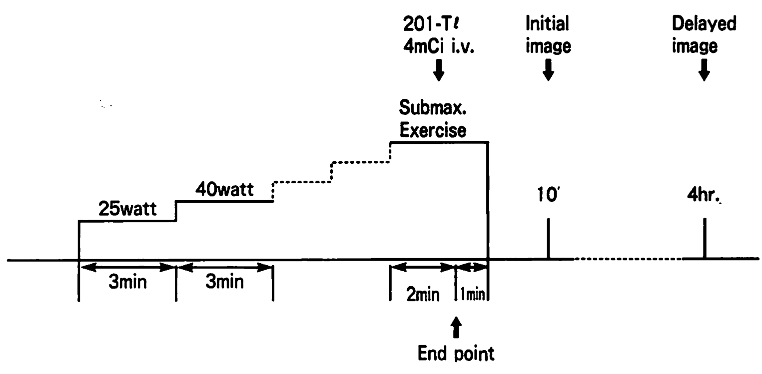

Fig. 1. Method of exercise tests with a bicycle ergometer.

Results

S-maps patterns were classified in four types (**Fig. 6**). A typical example of an exercise 12-lead ECG and a QRST area map of a patient with hypertrophic nonobstructive cardiomyopathy (HNCM), classified as Type 1, is shown in **Fig. 2**. Following exercise, the 12-lead ECG showed ST depression in leads II, aVF, and V_3 to V_6, and the S-map showed negative changes greater than $-40\,\mu$VS in the precordial leads. Examples of SPECT scintigrams of this patients are shown in **Fig. 3**. Clearly reversible defects in the anterior and posterior myocardial wall regions were observed.

Fig. 4 shows examples of the exercise 12-lead ECG and the QRST area map of a patient with apical hypertrophic cardiomyopathy (APH), classified as Type 2. The 12-lead ECG at rest showed giant negative T waves in the precordial leads. Voltages of these negative T waves decreased following exercise. The S-map for this patient showed an increase in the positive area in the precordial leads. No significant findings were observed in the stress thallium scan, as shown in **Fig. 5**. These four S-map patterns are summarized in **Fig. 6**.

In one of the eight Type 2 patients (cases with S-maps showing an increase only in the area of precordial leads) and in all 10 Type 4 patients (cases with the S-maps showing small changes less than $-40\,\mu$VS), no significant positive results were obtained from SPECT. Positive results were obtained from SPECT

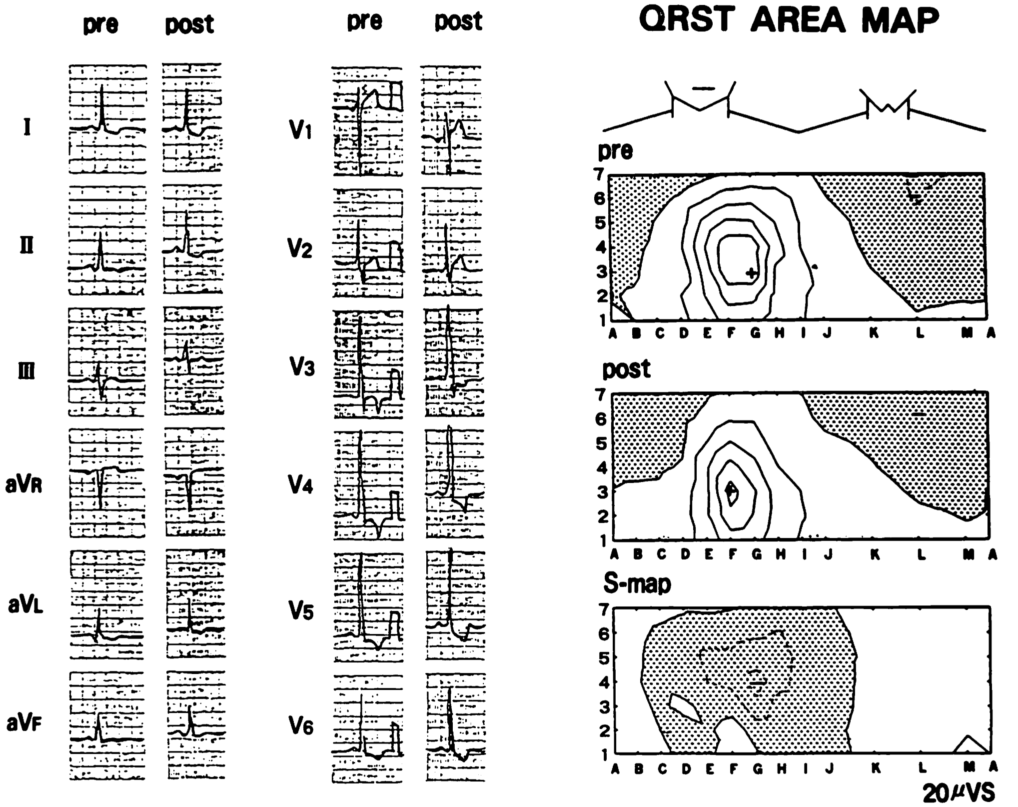

Fig. 2. Exercise 12-lead ECG and QRST area maps of a patient with HNCM classified as Type 1.

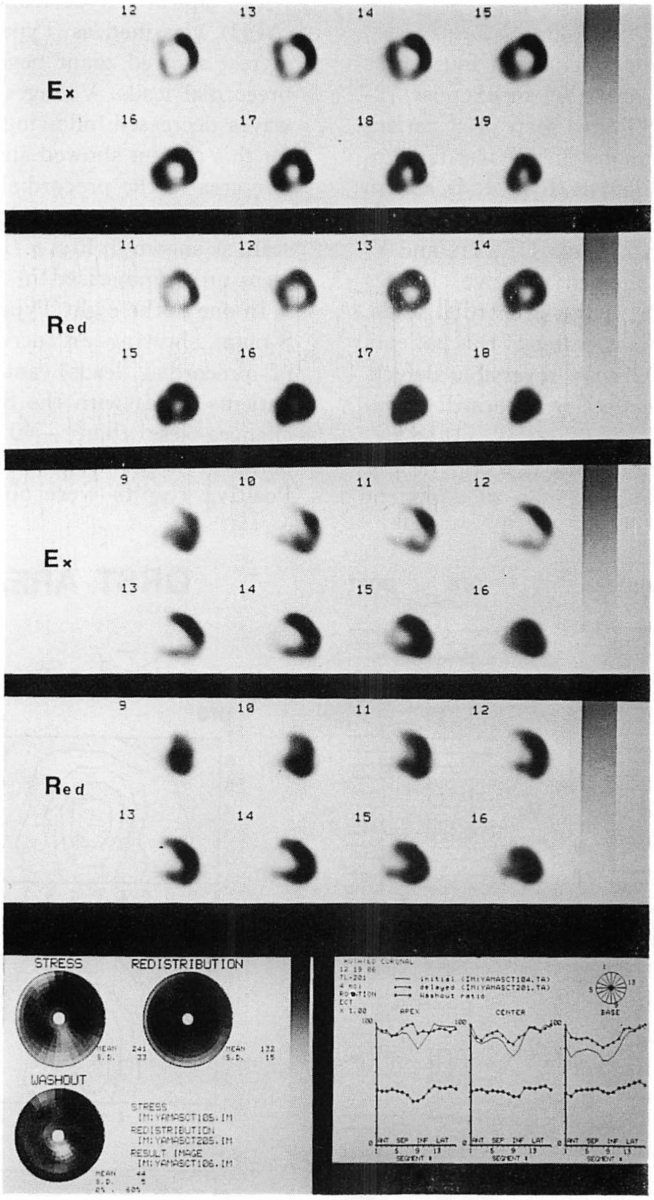

Fig. 3. Stress thallium scan (SPECT) **of the patients in Fig. 2.**

in eight (89%) of the nine Type 1 patients (cases with S-maps showing large negative changes greater than $-40\,\mu$VS from the precordial leads) and in six (67%) of the nine Type 3 patients (cases with S-maps showing an increase in the positive area from the precordial leads plus simultaneous negative changes greater than $-40\,\mu$VS from the remaining leads).

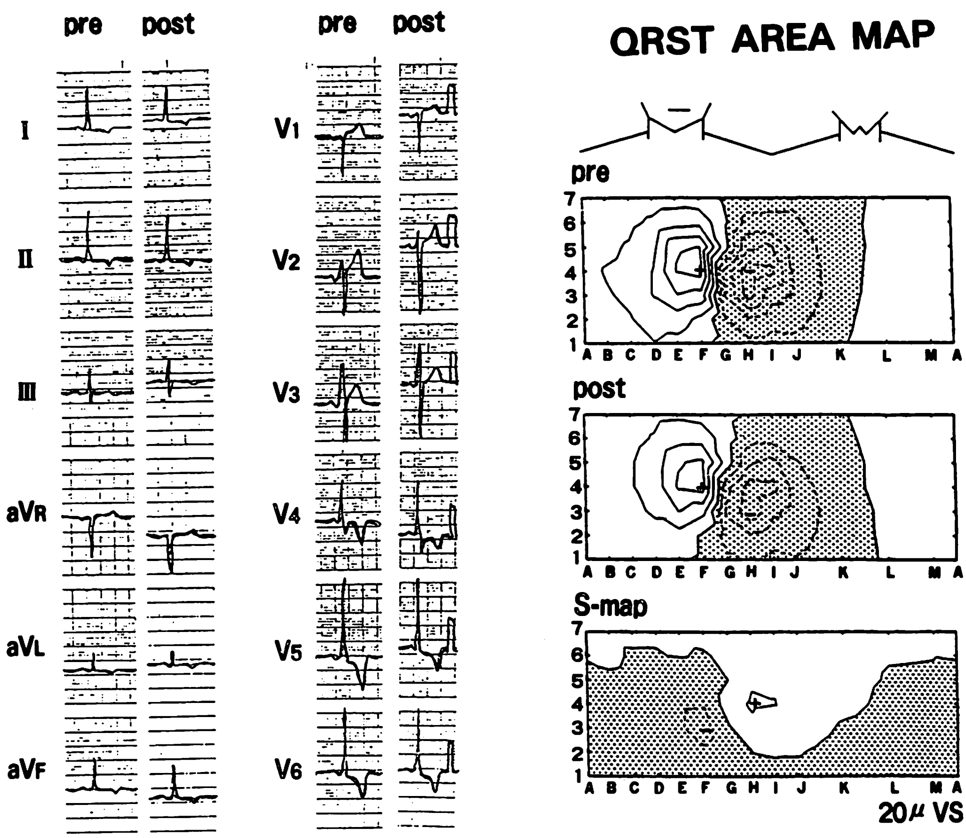

Fig. 4. Exercise 12-lead ECG and QRST area maps of patients with APH classified as Type 4.

Discussion

Many patients, especially those with HCM, whose ECGs demonstrate LVH with ST-T abnormalities, show exercise-induced ST-T changes[2,3] and frequently it is very difficult to evaluate the true exercise-induced myocardial ischemia in these patients. Recently some investigators have reported that the exercise thallium-201 myocardial scans of patients with HCM revealed a significant persistent defect or reversible defect despite the absence of clear stenosis of the major coronary arteries[4,5]. Mechanisms advocated as responsible for this are multiple; for example, ischemia caused by so-called "small vessels disease"[6], systolic narrowing of the intramural coronary arteries due to markedly thickened myocardium, coronary spasm and an increase in left ventricular end-diastolic pressure. An excessive oxygen demand by the hypertrophied heart exceeding the capacity of the coronary circulation may be responsible [2,3]. Thus, patients with HCM may have some associated coronary perfusion abnormalities.

As Abildskov[7,8] reported, QRST isointegral area maps allow the evaluation of abnormalities of ventricular recovery properties independent of ventricular activation sequence abnormalities. QRST area maps are also very useful for evaluating exercise-induced ischemic changes combined with ventricular activation abnormalities such as left ventricular hypertrophy. In the present study, clearly reversible perfusion

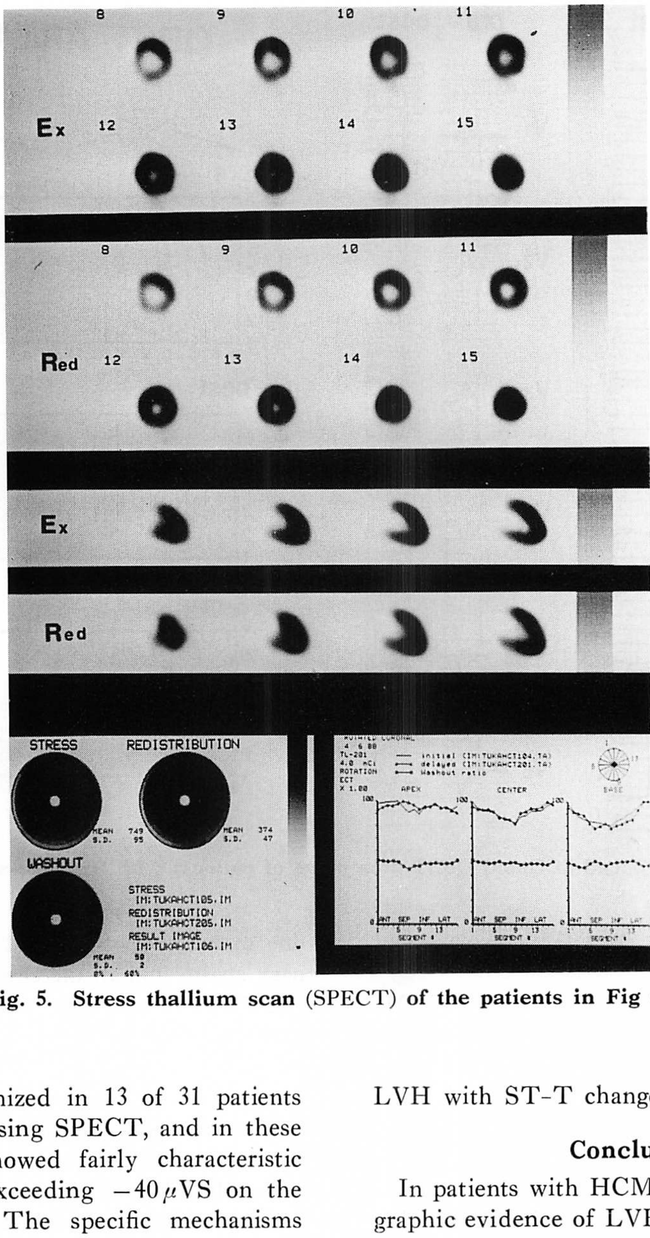

Fig. 5. Stress thallium scan (SPECT) **of the patients in Fig 4.**

defects were recognized in 13 of 31 patients with HCM (42%) using SPECT, and in these patients S-maps showed fairly characteristic negative changes exceeding $-40\mu VS$ on the precordial surface. The specific mechanisms responsible for ischemic changes in patients with LVH, especially those with HCM, were not clearly identified during the present study. However, it was suggested that exercise QRST area maps may be useful for identifying exercise-induced myocardial ischemia in patients having electrocardiographic evidence of LVH with ST-T changes.

Conclusion

In patients with HCM having electrocardiographic evidence of LVH with ST-T changes, exercise QRST area maps can assist in identifying exercise-induced myocardial ischemia.

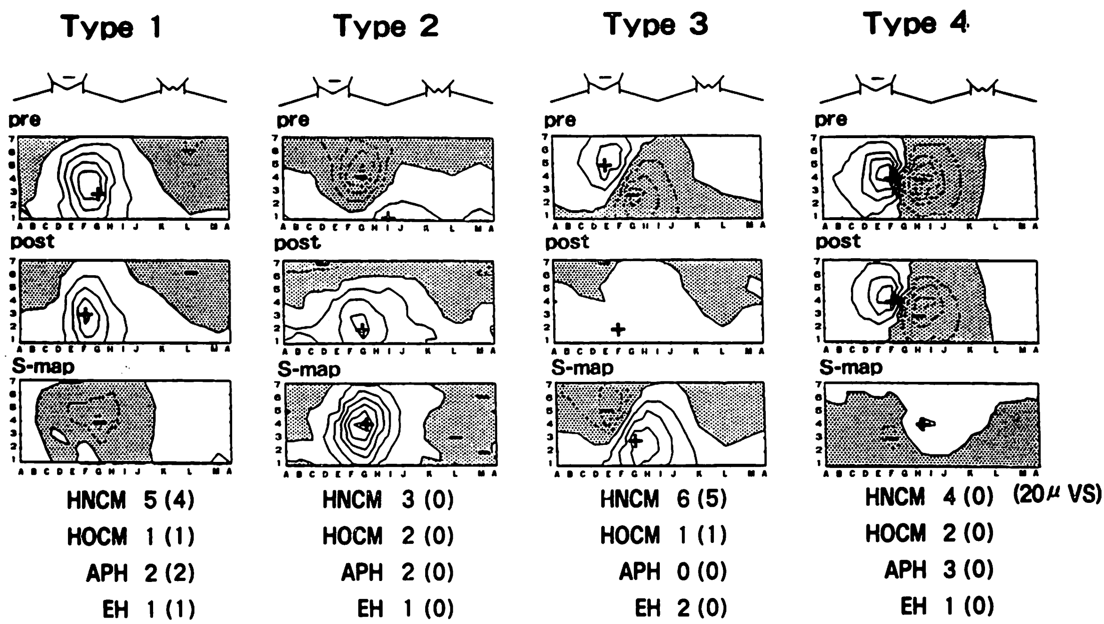

Fig. 6. Typical patterns of S-maps in exercise QRST area maps and the numbers of patients of each Type who had positive stress thallium scans (SPECT).

The figures in parentheses show the numbers of patients who had positive stress thallium scans (SPECT). Shaded area shows the area of negative value and white area shows the area of positive value. S-map means the subtraction map obtained by subtracting data of pre-exercise maps from those of post-exercise maps.

要　　約

左室肥大例における運動負荷電位図および負荷 ^{201}Tl 心筋シンチグラム (SPECT) の対比検討

岡山大学医学部　臨床検査医学
*同　第一内科
吉田英紀*，萩原秀紀，井原敬子，
白木照夫，山成　洋，松原　堅*，
斎藤大治，辻　孝夫，原岡昭一*

左室肥大心電図に ST・T 変化を伴う心肥大と虚血性心疾患の鑑別を目的として，運動負荷心電図により，脱分極の変化に影響されず，再分極の異常を把握し易いとされる QRST area map (以下 map) の有用性を，^{201}Tl 負荷心筋シンチ (SPECT) (以下シンチ) の所見と対比検討した．症例はかかる心電図を有し，心カテや心エコー図検査などで肥大型心筋症 (HCM) と診断された 31 例(非閉塞型 HNCM 18 例，閉塞型 HOCM 6 例，心尖部肥大型 APH 7 例)と，高血圧症 (EH) 5 例，および対照とした労作性狭心症 5 例である．それらの例にエルゴメーター多段階運動負荷を行い，その前後で体表面 87 誘導点を用いて map を記録し，同様の負荷量で記録したシンチの所見と比較検討した．

1. 負荷後から負荷前の map を差引いて求めた差の map のパターン上，左前胸部を中心に，少なくとも $-40\,\mu$VS 以上の広い範囲で負荷後陰性部分が広がるものは，HNCM 5 例，HOCM 1 例，APH 2 例，EH 1 例，および狭心症全 5 例で認められ，これらの例における負荷シンチ陽性率は 89% であった．

一方，負荷後の map の変化が $-40\,\mu$VS 未満

か，もしくは単なる増大を認めただけのものは，全例負荷シンチ所見も陰性であり，負荷後前胸部で陽性部分が増大しても，同時に他の部で -40μVS 以上の陰性領域が出現した例では，負荷シンチの陽性率は 67% であった．以上より負荷 map の差のパターンから虚血の有無の鑑別が可能であった．

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