Quantitative Evaluation of Treadmill Test Induced ST-T Changes Using Body Surface Mapping

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Using the ST difference map after the treadmill exercise test, the 26 patients with coronary artery disease were studied. 1) The extent and the speed of complete recovery of ST depression or negative area were well correlated with the severity of coronary artery disease. 2) ST elevation or positive area was correlated with regional asynnergies. 3) ST elevation area disclosed regional defect of $^{201}$TI scintigam at rest, while ST depression area could disclose it infrequently.

As a noninvasive method to determine the location, extent and grade of myocardial ischemia, body surface isopotential mapping is expected to have some advantages over the conventional 12 lead electrocardiogram because of its greater number of lead points. Recently, owing to the marked progress in engineering, it became possible to record all electrocardiograms simultaneously to obtain the map in a short time, and to follow the rapid ST-T changes after the test.

To make a quantitative diagnosis of myocardial ischemia, the ST changes following the treadmill test were studied using the body surface mapping technique, and they were compared with the results obtained by coronary angiograms, left ventriculograms and $^{201}$TI scintigrams.

METHODS

The subjects consisted of 26 male patients with ischemic heart disease, aged 37 to 70 years, mean 55.4 years: 14 patients with myocardial infarction, 5 myocardial infarction complicated with angina pectoris, and 7 angina pectoris.

All cases were examined by coronary angiography, 23 by left ventriculography and 22 by $^{201}$TI scintigraphy.

Before and after the treadmill exercise test, the body surface isopotential map was recorded using the HPM-5100 type mapper made by Chunichi Denshi Co. ST changes following the exercise test were further analysed, and compared with the above mentioned examination data. The treadmill exercise test was performed according to the Sheffield protocol.

Computer Processing of the Data

The 87 electrocardiograms for the map were memorized into a cassette tape in the mapper. This map data could be recorded 90 seconds or less after the exercise test, and thereafter at intervals of 210 seconds. The ST changes at a point 60 msec after the J point were analysed, and 0.1 mV or more changes of ST level were considered to be significant. The changes of ST level at respective lead points, obtained by subtracting the pre-exercise ST level from the post-exercise one, were recorded with 0.1 mV increment of isopotential line, and the ST difference map was obtained. Furthermore, the extent of the area showing more than 0.1 mV ST deviation was computed.

Key Words:
ST difference map
Treadmill test
$^{201}$TI scintigram

RESULTS AND DISCUSSION

The left part of Fig. 1 shows ST difference map in a patient who had 75% stenosis at 3 segments (6, 7 and 9) of LAD, and 99% and 75% stenosis at 2 segments (1 and 2) of RCA, respectively. The ST difference map 90 seconds after the exercise test revealed ST depression or negative area over the anterior, apical, septal, lateral and inferior regions, equal to 898 cm² of the area size of the map. Five minutes after the exercise test, ST depression area remained 393 cm².

The right part of Fig. 1 demonstrates ST difference map of a patient with 75% stenosis of segment 6 of LAD and 100% occlusion of seg-

T.S. 47yrs. male myocardial infarction

ST difference MAP

ANT, APEX, LAT; ST elevation

Left Ventriculogram

Anterolateral, Apical; Aneurysmal

Fig. 2. ST elevation area on the ST difference map corresponded with aneurysmal regions on left ventriculograms in a patient.

regions, equal to 278 cm², and disappeared 5 minutes later. These 2 cases both had two vessel disease with LAD and RCA lesions, although they differed in the severity of coronary artery disease.

The extent and the speed of disappearance process of the ST depression area on the ST difference map were proportional to the severity of the coronary artery disease.

As shown in Fig. 2, ST elevation or positive area on the ST difference map appeared at anterior, apical and lateral regions, and left ventriculogram revealed the presence of aneurysmal wall motion at the same region. Three of 4 cases with aneurysmal wall motion confirmed by left ventriculogram, showed marked ST elevation area on the ST difference map corresponding with the aneurysmal region. The relation between ST changes and left ventriculogram findings were analysed. The contraction state of left ventricle were divided into normal, reduced, none, dyskinetic, and aneurysmal according to the classification of the American Heart Association. A score of 0 to 4 was given to the above mentioned contraction states, respectively. The sum of the respective scores in the 7 segments of left ventriculogram was used as the parameter of left ventricular contraction abnormalities, i.e., asynery index. The asynery index in 23 cases was compared with the results of ST difference maps, which were classified into 4 groups: ST

![Graph showing relationship between ST change and LV contractility](image)

**Fig.3.** A relation between ST deviation on the ST difference map and asynery index obtained by left ventriculograms was demonstrated.

![Graph showing relationship between ST difference MAP and ²⁰¹TI scintigram](image)

**Fig.4.** A relation between ST deviation on the ST difference map and image defective areas in ²⁰¹TI scintigrams were shown.

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elevation, ST elevation and depression, ST depression and normal groups. The ST elevation group had higher asynergy index, while ST depression group lower asynergy index (Fig. 3). A close relation was proved between ST elevation and LV contraction abnormalities.

A relation between ST difference map and $^{201}$TI scintigram was studied in 22 patients. In this analysis, the left ventricle was divided into 6 parts: anterior, apical, septal, lateral, inferior, and posterior regions. Defective or decreased myocardial images in $^{201}$TI scintigram were found in 14 of 15 regions (93%), which showed significant ST elevations on the ST difference map, and in all 7 regions which occupied central parts or maxima of the ST elevation areas on the ST difference map (Fig. 4). On the other hand, defective myocardial images were present only in 2 of 33 ST depression areas (7%), and completely absent in the 11 ST depression areas which occupied central parts or minima of the ST depression areas.

These results suggested that the ST elevation areas after the exercise test had marked regional ischemia or fibrosis at rest enough to give $^{201}$TI defective images, while the ST depression areas after the exercise test had no significant ischemia at rest.

REFERENCES