

TREADMILL STRESS TESTING IN EVALUATION OF AORTOCORONARY BYPASS SURGERY

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Abstract

Graded exercise treadmill tests were performed on 34 patients who had saphenous vein bypass surgery for coronary artery disease. A group of 21 patients with stable angina underwent both pre- and post-operative exercise stress testing. Thirteen patients with unstable angina were given only the postoperative tests.

A marked improvement was noted in (1) symptoms of chest pain—82% of patients had no chest pain on postoperative stress testing—, (2) ECG abnormalities produced by the exercise—75% of patients had normal exercise ECG postoperatively—, (3) functional capacity (Met-level)—from 4.1 ± 1.5 in stable angina group preoperatively to 7.5 ± 2.4 in the same group ($p < 0.001$) and 7.2 ± 2.5 in unstable angina group postoperatively—and (4) Cardiac reserve (double product)—from $20.0 \pm 4.7 \times 10^3$ in stable angina group preoperatively to $27.5 \pm 5.4 \times 10^3$ in the same group ($p < 0.001$) and $27.8 \pm 5.8 \times 10^3$ in unstable angina group postoperatively.

INTRODUCTION

The aortocoronary-vein bypass procedure for the treatment of ischemic heart disease has become to be widely accepted. Though this operation is reported to yield a relief of angina in a high percentage of patients¹⁻⁴, it is difficult to evaluate the effect of myocardial revascularization. Thus, it seems that objective means of evaluation are necessary for the vein bypass procedure. The purpose of this study is to obtain an objective information as well

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as subjective response to the aortocoronary bypass surgery by comparing the results of pre- and post-operative treadmill tests.

MATERIALS AND METHODS

The subjects of our study were 34 cases, 30 males and 4 females, in the age ranging from 38 years to 69 years old. Forty-four percent of the patients studied were in the 5th decade and 35% in the 4th decade. They were divided into two groups: a stable angina group and an unstable angina group. The stable angina group was consisted of 21 cases (67%) and the unstable angina group 13 cases (28%). The stable angina group underwent both pre- and post-operative stress testings. The unstable angina group had only postoperative stress test. Unstable angina was defined as (1) stable angina with a recent spontaneous increase in severity; (2) angina at rest; or (3) acute coronary insufficiency with no evidence of acute complete myocardial infarction by serial ECG's and serum enzyme determination⁵.

Postoperative stress tests were performed 2 to 4 months after the surgery. Preoperative exercise tests were made on 21 patients with stable angina. The patients were subjected to the exercises according to the protocol of modified Bruce and Hornsten method using the graded multistage treadmill test.⁶⁻⁸ The exercise was continued for 3 minutes at each treadmill stage; Stage I: 2.0 mph; 3.0% grade; Stage II: 2.8 mph, 6% grade; Stage III: 3.3 mph 9% grade; Stage IV: 3.3 mph, 12% grade; Stage V: 3.3 mph, 15% grade and so on. A positive ECG finding was defined as a segmental ST depression of 0.1 mV or over lasting more than 0.08 sec. in any of modified leads.

The double product, which is the systolic blood pressure and heart rate and reflects the cardiac reserve, was measured in each patient. Met-level, which is metabolic equivalent and reflects functional cardiac capacity, was also calculated in each patient. One Met was equal to the resting energy expenditure where oxygen consumption was approximately 3.5 ml per Kg. body weight per minute⁹. Coronary angiography utilizing the Sones technique in multiple views^{10,11} and aortocoronary bypass operation with saphenous vein graft^{12,13} were performed on all 34 patients.

RESULTS

Table 1 displays the results of angiographic study and types of bypass operation in the two groups of patients. In stable angina group five patients (24%) had single vessel disease and the other hand, only one patient (8%) had single vessel disease in unstable angina group. Seventeen patients (81%) in stable angina and 11 patients (85%) in unstable angina group had complete

TABLE 1. Angiographic findings and types of bypass operation in a group of patients with stable and unstable angina

Stable angina-21 (62%)	SVD-5	C-5
		I-0
	DVD-6	C-5
		I-1
	TVD-10	C-7
		I-3
Unstable angina-13 (38%)	SVD-1	C-1
		I-0
	DVD-3	C-2
		I-1
	TVD-9	C-8
		I-1
SVD=single vessel disease DVD=double vessel disease TVD=triple vessel disease C=complete bypass operation (bypassed all significant obstructions) I=incomplete bypass operation (bypassed not all significant obstructions)		

operation, meaning all significant obstructions were bypassed. One patient with double vessel disease and three patients with triple vessel disease in stable angina group had incomplete operation, meaning some significant obstruction couldn't be bypassed. In the unstable angina group incomplete operation was performed on one patient with double vessel disease and one patient with triple vessel disease. Left main trunk lesion alone or with right coronary artery disease was included in triple vessel disease.^{14 15)} The results of pre- and post-operative treadmill test in stable angina group are shown in Table 2. Postoperatively a marked improvement was noted objectively as well as subjectively—the number of patients with positive ST change and chest pain decreased while the double product and Met-level increased.

Figure 1 displays the double product and Met-level of each patient in the stable angina group which was divided into five subgroups: 1) single vessel disease with complete operation (Δ); 2) double vessel disease (DVD) with complete operation (X); 3) DVD with incomplete operation (X'); 4) triple vessels disease (TVD) with complete operation (\circ) and 5) TVD with incomplete operation (\bullet). A significant improvement was noted postoperatively ($p < 0.001$). In the unstable angina group a marked improvement was also noted on postoperative treadmill test (Table 3). Table 4 displays the summary of pre- and post-operative treadmill test in the two groups. Preoperatively all the 34 patients had chest pain and 21 patients with stable angina had positive ECG finding. Postoperatively 28 patients out of 34 (82%) had no chest pain

TABLE 2.
Pre- and post-operative treadmill test in stable angina group

	SVD		DVD			
	C		C		I	
	Pre	Post	Pre	Post	Pre	Post
Number of patients with chest pain	5	0	5	0	1	1
Number of patients with positive ST change	5	1	5	0	1	0
Double product ($\times 10^3$)	18.6 ± 6.0	25.6 ± 3.7	21.2 ± 6.1	27.8 ± 6.7	26.7	26.6
Met-level	3.3 ± 1.1	8.1 ± 2.7	4.7 ± 1.1	8.5 ± 2.3	3.0	5.0

	TVD			
	C		I	
	Pre	Post	Pre	Post
Number of patients with chest pain	7	1	3	1
Number of patients with positive ST change	7	3	3	1
Double product ($\times 10^3$)	19.3 ± 2.3	27.0 ± 6.0	20.0 ± 4.6	30.3 ± 6.2
Met-level	3.9 ± 0.9	6.7 ± 2.2	5.3 ± 3.2	7.7 ± 2.8

SVD, DVD, TVD > same in Table 1
C, I,
Post=Postoperative test

Pre=Preoperative test
 \pm =one standard deviation

TABLE 3.
Postoperative treadmill test in unstable angina group

	SVD	DVD		TVD	
	C	C	I	C	I
Number of patients with chest pain	0	1	0	1	1
Number of patients with positive ST change	1	1	0	2	0
Double product ($\times 10^3$)	36.0	32.5 ± 6.5	32.3	25.5 ± 5.2	25.0
Met-level	9.0	7.3 ± 0.4	9.0	6.8 ± 3.2	7.0

SVD, DVD, TVD > same in Table 1
C, I
 \pm =one standard deviation

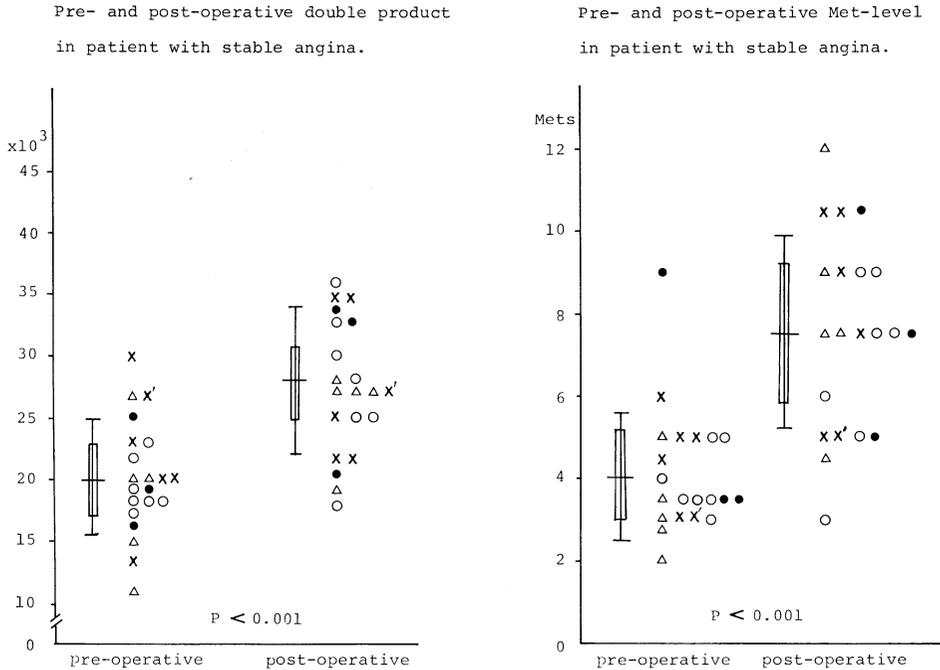


Fig. 1.

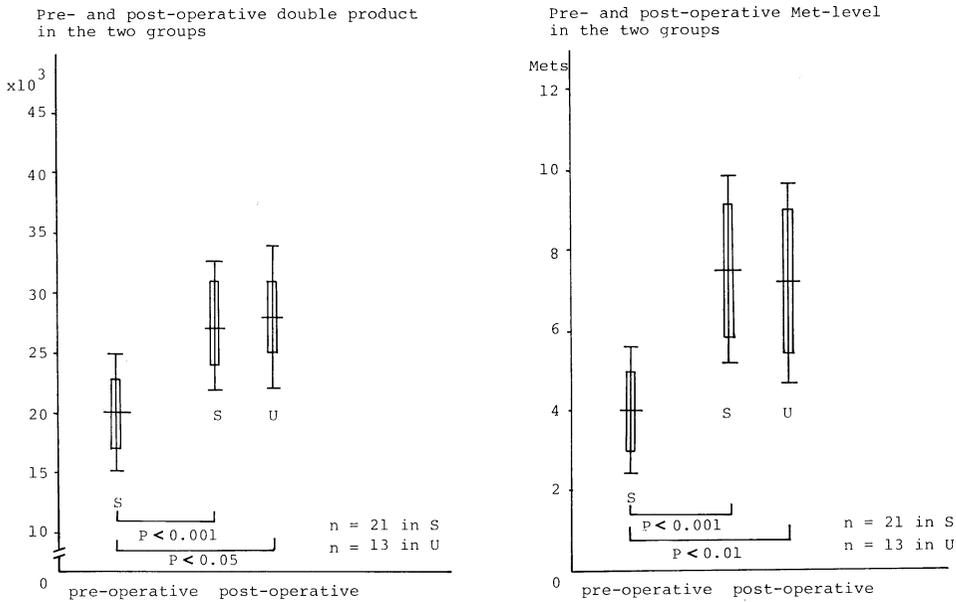
- △ SVD with complete ope.
- × DVD with complete ope.
- ×' DVD with incomplete ope.
- TVD with complete ope.
- TVD with incomplete ope.

and 15 patients out of 20 (75%) with stable angina had normal exercise ECG. Four patients with unstable angina had chest pain on postoperative treadmill test. Postoperative improvement of chest pain and ECG change were less in triple vessel disease in both the stable and unstable angina. Met-level was slightly decreased with increase in the severity of disease although no significant difference was noted between the two groups when compared with the post-operative Met-level in the similar severity of the disease. In the single, double or triple vessel disease the postoperative Met-level was almost identical in the two groups. No correlation was found between the average of the double product and the severity of the disease. The patients with unstable angina did well postoperative treadmill test as well as those with stable angina. The postoperative double product and Met-level were improved at the same level in both groups (Figure 2).

TABLE 4.
Summary of pre- and post-operative treadmill test in the two groups

		SVD		DVD		TVD	
		stable	unstable	stable	unstable	stable	unstable
Number of patients with chest pain	pre	5	1	6	3	10	9
	post	0	0	0	1	2	3
Number of patients with positive ECG change	pre	5	—	5	—	10	—
	post	1	1	0	1	4	2
Double product ($\times 10^3$)	pre	18.6 ± 6.0	—	20.0 ± 6.4	—	20.2 ± 3.5	—
	post	25.6 ± 3.7	36.0	27.7 ± 6.0	32.4 ± 4.6	28.3 ± 5.9	25.4 ± 4.8
Met-level	pre	3.3 ± 1.1	—	4.4 ± 1.2	—	4.3 ± 1.8	—
	post	8.1 ± 2.7	9.0	7.9 ± 2.5	7.8 ± 1.0	7.0 ± 2.3	6.8 ± 2.9

SVD, DVD, TVD: same in Table 1
pre, post: same in Table 2
 \pm = one standard deviation
— = no treadmill test was performed



DISCUSSION

The graded multistage exercise treadmill test is the method widely used and well standardized, which can be safely applied to patients with severe coronary artery disease by a cardiologist.¹⁶⁻¹⁹⁾ This test can be done on an out-patient basis in the clinic or office and allows both the physician and patient to evaluate performance both subjectively and objectively during the exercise. There were no significant side effects during the treadmill stress testing in our study of 34 patients, even in preoperative triple vessel disease group. Because of the multiplicity of factors involved such as placebo effect,²⁰⁻²²⁾ perioperative MI²³⁻²⁵⁾ and denervation of ischemic areas,^{4,26)} the evaluation of the effect of myocardial revascularization was difficult.

Postoperative improvement should be supported not only by a subjective symptomatic improvement but also by an objective improvement of cardiac reserve and functional aerobic capacity. In our observations, the multistage maximal treadmill tests before and after surgery have demonstrated objective as well as subjective data that aortocoronary vein bypass graft can improve functional capacity in all subgroups of patients regardless of single, double or triple vessel disease in either the stable or unstable angina group.

The significant correlation between treadmill test and coronary flow results as well as grafts patency has been demonstrated in several studies.^{27,28)} In our data only four patients (17%) showed ischemic changes on the electrocardiogram during the treadmill test without developing angina although some reports demonstrated a large proportion of the surgically treated patients, showing ischemic ST depression without angina.^{29,30)} None of our 34 patients had the evidence of perioperative myocardial infarction. These observations suggest that increased coronary blood flow is the most important contributing factor to the postoperative improvement of angina in our patient. It seems that additional factors such as trauma to nerves and possibly other non-specific factors related to surgery couldn't play a major role in the relief of angina in these 28 patients. A long term follow-up of these 34 patients with treadmill testing is needed to fully assess ultimate prognosis and bypass patency in each subgroup of patients. The efficacy of surgery on life expectancy and prevention of fatal acute myocardial infarction in patients with stable angina³¹⁾ as well as unstable angina and/or left main artery disease remains debated issue.^{32,33)} It is clear, however, from this and other studies that cardiac surgery is the only effective means available at the present time for changing myocardial reserve capacity.^{27,34,35)} This appears to result in a marked improvement in functional capacity and symptomatic chest pain. These benefits have helped many patients lead more productive lives.

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