Functional State of Myocardium after Transmyocardial Revascularization with Nd:YAG Laser

A. I. Kozel', S. V. Evdokimov, V. P. Evdokimov, and V. L. Kovalenko

Translated from *Byulleten' Eksperimental'noi Biologii i Meditsiny*, Vol. 124, No. 8, pp. 204-206, August, 1997
Original article submitted March 5, 1997

Providing a better perfusion of the myocardium, transmyocardial revascularization with an Nd:YAG laser improves cardiac function and general condition of patients with ischemic heart disease.

Key Words: *transmyocardial laser revascularization; ischemic heart disease*

Aortocoronary bypass (ACB) and transluminal angioplasty of coronary arteries are the major techniques aimed at improving blood flow through ischemic myocardium. However, these procedures cannot be employed in patients with atherosclerotically compromised distal coronary bed. Therefore, indirect methods of myocardial revascularization are used: omentopexy [1], implantation of the thoracic artery into the muscle [9], and myocardial acupuncture [8]. These methods are aimed at revascularization of the myocardium. High-intensity laser radiation was used for creating transmyocardial channels (TMC) and attain direct perfusion of the myocardium by blood from the left ventricle [4,5]. Transmyocardial revascularization (TMR) was successfully combined with ACB [6,7].

In 1993-1995, we studied the dynamics of reparative and adaptive processes in the myocardium after irradiation with a high-intensity Nd:YAG laser. It was found that myocardial revascularization is a result of reactive changes in the microcirculatory bed in response to laser-induced damage with diffuse reorganization of blood vessels: an increase in the number of not only capillaries but also of arterioles and small arteries. After this method had been patented, it was used in the clinic of the Chelyabinsk State Institute for Laser Surgery in the treatment of patients with ischemic heart disease. Here we report the results of clinical application of TMR.

Chelyabinsk State Institute of Laser Surgery

MATERIALS AND METHODS

Functional state of the myocardium was studied in 27 patients with ischemic heart disease (23 men and 4 women aged 37-64 years) treated by TMR method during the period of April, 1995—December, 1996. Five and twenty patients had angina of exertion of III and IV functional class, respectively, and four patients had unstable angina; 18 patients had a history of myocardial infarction, and 6 patients had chronic aneurysm of the left ventricle. Aortocoronary bypass was performed in 2 patients, and cardiopericardiopexy (Thompson's operation) in 3 patients.

The indications for TMR were as follows: ineffective therapy with nitrates, β-blockers, calcium antagonists, and their combinations and distal and diffuse atherosclerotic lesions in the coronary arteries, which precluded ACB and transluminal coronary angioplasty.

Before the operation, all patients were examined by the following techniques:

1. stress-test (veloergometry according to Bruce protocol);
2. echocardiography — Doppler cardioscopy;
3. Holter (24 h) ECG monitoring;
4. digital subtractional coronary angiography and left ventriculography in two projections;
5. computer tomography of the myocardium with technetril.

The examination (except angio- and ventriculography) was repeated 3, 6, and 12 month after TMR.

0007-4888/97/0008-0802$18.00

Transmyocardial revascularization was performed in 20 patients, TMR with aneurysmectomy and Dor left ventricle plasty in 6 patients, and TMR in combination with ACB in 1 patient. Patients were operated under general anesthesia with endotracheal intubation; assisted circulation was applied in 7 patients. Left thoracotomy was used in 20 patients and middle-line sternotomy in 7 patients.

Transmyocardial channels were made with a Russian-manufactured Raduga-1 Nd:YAG laser (wavelength 1.06 μ, 25-30 W in continuous mode, exposure time 1.0-2.0 sec) with quartz monochannel light guide (diameter 400 μ). In 14 patients, II-sutures were applied onto the epicardium, a TMC was created in the middle of a suture, after which its was tightened. In 13 patients, the epicardial end of TMC was closed by pressing a finger for about 1 min (to control hemorrhage). Laser radiation was applied during diastole, and "downfall" through the myocardium indicated that a TMC channel had been created. The number of TMC in each case varied from 6 to 34. After TMR, all patients were observed in the intensive cure unit for 24-30 h. They received nitroglycerin and dobutamine for 24-48 h. Extubation was performed after 12-24 h, and thoracic drainage was removed not later than 24 h postoperation. The total volume of exudate was 250 ml. Therapy with nitrates, calcium antagonists, β-blockers, aspirin, and indirect anticoagulants was started immediately after extubation. After TMR, the patients were observed in the clinic for 10-18 days. The effectiveness of TMR was estimated by a decrease in the functional class of angina and shortening of the total time of painful and painless episodes of coronary insufficiency according to 24-h ECG monitoring (after 3, 6 and 12 months), and reduction in the myocardial perfusion "defect," as estimated by computer tomography (after 3, 6, and 12 months).

RESULTS

Preoperative veloergometry showed that in 23 patients the tolerance to physical load was quite low: 25-50 W (mean 32.5 W). Veloergometry was not performed in 4 patients with unstable angina. As evidenced by 24-h ECG monitoring, the total time of painless and painful episodes of coronary insufficiency was 72 min (40-120 min). Digital subtractional coronary angiography revealed atherosclerotic lesions in 3 large coronary arteries in 18 patients, at least in 2 arteries in 3 patients, and occlusion of one coronary artery in 6 patients. Digital subtractional ventriculography and echocardiography with Doppler cardioscopy revealed chronic aneurysm of the left ventricle in 6 patients: in 4 of them it was located in the septum and in 2 patients in the posterior wall of the ventricle; mitral regurgitation of the first degree occurred in 2 patients. In all patients, the left ventricle ejection phase was 37% (24-52%).

According to the computer tomography data, in 29 patients the mean "defect" of myocardial perfusion was 23% (14-32%).

General condition of all patients improved within 14-30 days after TMR. In 6 patients angina decreased by at least one functional class, in 21 patients not less than by two classes. In all patients, the total time of painful and painless episodes of coronary insufficiency decreased to 32 min. In 20 patients, the tolerance to physical load 3 months after TMR increased by 35 W. Computer tomography revealed a 16% (7-23%) decrease in the myocardial perfusion "defect": in 9 patients 3, 6, and 12 months after TMR, in 13 patients after 3 and 6 months, and in 2 patients after 3 months; 2 patients were not examined because they were operated less than 3 months ago.

With gradual improvement of myocardium perfusion, the patients received minimal antianginal therapy; in 7 patients it was discontinued.

Our results indicate that TMR increases myocardial perfusion, which results in the improvement of cardiac function and general condition of patients with ischemic heart disease.

REFERENCES

1. C. Beck, *Ann. Surg.*, **5**, 801-814 (1935).
2. O. H. Frazier, D. A. Cooley, K. A. Kadipasaoglu, and S. Pehlivanoglu, *Circulation*, **90**, No. 4, 640 (1994).
3. K. A. Horvath, W. J. Smith, R. G. Laurence, *et al.*, *J. Am. Coll. Cardiol.*, **25**, No. 1, 258-263 (1995).
4. M. Mirhoseini, *Lasers Surg. Med.*, No. 2, 187-198 (1982).
5. M. Mirhoseini, *Ibid.*, **6**, No. 5, 459-461 (1986).
6. M. Mirhoseini, S. Shelgikar, and M. Cayton, *Ibid.*, **8**, No. 2, 150-151 (1988).
7. M. Mirhoseini, S. Shelgikar, and M. Cayton, *J. Am. Coll. Cardiol.*, **15**, 177A (1990).
8. P. K. Sen, *J. Thorac. Cardiovasc. Surg.*, **50**, 181-189 (1965).
9. A. Vieneberg, *J. Thorac. Surg.*, **23**, 42-54 (1952).