Two-year assessment by exercise Thallium scintigraphy of myocardial revascularization using bilateral internal mammary and gastroepiploic arteries

Olivier Jegaden a,*, Laurence Bontemps a, Guy de Gevigney c, Christian Chatel a, Roland Itti b, Philippe Mikaeloff a

a Department of Cardio-vascular Surgery, Cardiovascular hospital, CI Bernard University, Lyon, France
b Department of Nuclear Medicine, Cardiovascular hospital, CI Bernard University, Lyon, France
c Department of Cardiology, Cardiovascular hospital, CI Bernard University, BP Lyon-Monchat, 69394 Lyon cedex 03, France

Received 3 February 1999; received in revised form 12 April 1999; accepted 28 April 1999

Abstract

Objective: To assess the blood flow supply offered to the myocardium by surgical revascularization using bilateral internal mammary (IMAs) and gastroepiploic (GEA) arteries. Methods: Two-year assessment by exercise thallium myocardial scintigraphy without medical treatment was performed in 122 patients (mean age 61 ± 9 years) who underwent coronary artery bypass grafting (CABG) with exclusive use of IMAs and GEA. Usually, the right IMA was used to bypass the left anterior descending coronary artery, and the left IMA to bypass the diagonal and the marginal arteries as a sequential graft if required. The GEA was used to bypass the right coronary artery (RCA) in 50 patients and its posterior branches in 72 patients. Results: During maximal or submaximal exercise stress testing, 119 patients (98%) were asymptomatic and 26 patients (21%) exhibited moderate ischemic ECG modifications which were correlated (P = 0.01) with incomplete revascularization and with the use of GEA to bypass the RCA. A third of patients had moderate ischemic thallium defects on exercise reversible after redistribution (anterior, 10; lateral, 2; inferior, 28). Silent residual myocardial ischemia detected by thallium scintigraphy was correlated (P < 0.001) with ECG modifications and incomplete revascularization; and inferior thallium defects were more frequent when GEA bypassed the RCA (P < 0.05). However, 26% of patients had residual ischemia despite a complete revascularization, and in at least 18% of cases for GEA and 8% for right IMA, arterial graft blood flow was insufficient at maximum exercise level and caused silent residual myocardial ischemia detected by thallium scintigraphy. Conclusions: Myocardial revascularization using bilateral IMAs and GEA offers a satisfactory myocardial perfusion in the majority of cases; however silent residual myocardial ischemia was detected in a third of patients and was related to incomplete revascularization and to insufficient blood flow supply probably due to small diameter of the arterial grafts. © 1999 Elsevier Science B.V. All rights reserved.

Keywords: Coronary artery bypass grafting; Arterial grafts; Gastroepiploic arteries; SPECT

1. Introduction

The current trend in coronary artery bypass grafting (CABG) is toward complete arterial revascularization, even in patients with three-vessel disease. The surgical technique based on the use of bilateral internal mammary (IMAs) and gastroepiploic arteries (GEA) is more and more accepted as a standard treatment in myocardial revascularization [1–4]; short and midterm results are well documented and strongly support the technique [3,5]. However, the ability of IMAs and GEA grafts to provide adequate flow at periods of peak myocardial demand was reported only in few previous studies of small size and/or with short follow-up [6–9]. The present study examined 2-year postoperatively the myocardial blood perfusion during exercise without medical treatment by thallium 201 myocardial scintigraphy in a group of 122 patients who consecutively underwent myocardial revascularization with exclusive use of both IMAs and GEA.

2. Materials and methods

A prospective study of functional results 2 years after operation was conducted in 122 patients who underwent myocardial revascularization with exclusive use of both IMAs and GEA. All patients consecutively operated from
January 1994 to June 1995 and alive 2 years postoperatively were included in this study; today they represent 19% out of our total experience with this surgical technique. This study was based on exercise stress testing and thallium 201 myocardial scintigraphy without medical treatment. The series consisted of 108 males and 14 females with a mean age of 61 ± 9 years (range 26–75 years). All patients presented with disabling angina and three-vessel disease (see Table 1); the mean left ventricular ejection fraction was 0.60 ± 0.14 (range 0.25–0.82). The surgical procedures were performed by the same surgeon according to our previous report [3] and exclusive use was made of in situ IMAS and GEA grafts: in 118 patients the right IMA was used to bypass the left anterior descending coronary artery (LAD) and the left IMA was used to bypass the diagonal arteries and/or the marginal branches of the circumflex artery, as a sequential graft in 44 patients, and in four patients the left IMA was used to bypass the LAD and the right IMA was used to bypass the diagonal and/or the marginal arteries, as a sequential graft in two patients. The GEA was used to bypass the right coronary artery (RCA) in 50 patients, the posterior descending coronary artery (PDA) in 58 patients and the posterolateral coronary artery (PLA) in 14 patients, there was no sequential GEA graft. The mean number of distal anastomoses was 3.5 ± 0.6 (range 3–6) and the rate of complete revascularization was 84% (103/122), defined as bypass of all relevant lesions, more than 70% stenosis.

Two years postoperatively, medical treatment was stopped for 2 days and perfusion/viability studies were performed using a stress technique for the early thallium imaging, followed by thallium reinjection and redistribution imaging. The stress procedure was done on a bicycle, consisting of a 2-min stage increments of 20 W. Moderate ischemic modification on ECG was defined as a less than 2-mm difference during exercise with a quick recovery at rest; a sign of severity was defined as a more than 2-mm difference during exercise or a low recovery at rest. Thallium-201 injections at maximal exercise was 111 Mbq (3 mCi) and 3 h later an additional injection of 37 Mbq (1 mCi) was reinjected. Stress SPECT were acquired starting less 15 min after completion of the stress test and 1 h after the resting reinjection. SPECT acquisitions were performed stepwise using a 180°-body-contoured-orbit and using a single head gamma camera (Sophy-camera D87) equipped with a high resolution collimator. Images were read by two independent reviewers experienced in the interpretation of myocardial perfusion studies; agreement was reached by consensus. Reviewers did not know the clinical history and details about the stress protocol. Perfusion defects were recorded on a diagram which included the three orthogonal projections; the short-axis slice was divided into 12 segments and the both long-axis slices into six segments: moderate ischemic defects were defined as a less two-segment perfusion defect, and a severe ischemic defects as a more two-segment perfusion defect.

2.1. Statistical analysis

Values of continuous variables are expressed as mean ± SD. Significant differences in discrete variables was evaluated using χ² analysis.

3. Results

In this series, 2 years postoperatively we observed no new myocardial infarction and no coronary reoperation or angioplasty were required; 120 patients were asymptomatic and two patients had non-disabling recurrent angina.

3.1. Stress testing

During exercise stress testing without medical treatment, 119 patients (98%) were asymptomatic and 26 patients (21%) exhibited moderate ischemic ECG modifications, with signs of severity in one case. Exercise test was maximal in 68 patients and sub maximal in 54 patients; mean maximal exercise level was 134 ± 33 W (range 60–220 W) and mean double product was 28 201 ± 6,609. Ischemic ECG modifications were significantly correlated with incomplete revascularization (P < 0.01), with the use of GEA to bypass the RCA (P < 0.01), and with the absence of sequential IMA graft (P < 0.05) (see Table 2).

3.2. Stress thallium scintigraphy

There was no residual ischemia in 82 patients (67%) with the same thallium images during exercise and after redistribution: 40 patients had normal images and 42 patients had gap images due to preoperative or perioperative myocardial infarction. Residual ischemia was detected in 40 patients (33%) with moderate ischemic thallium defects on exercise, reversible after redistribution: anterior, 10 (8%); lateral, two (1.6%); inferior, 28 (23%). Myocardial residual ischemia was significantly correlated with ischemic ECG modifications: 22/26 (84%) vs. 18/96 (18%) P < 0.001, and with
incomplete myocardial revascularization ($P < 0.001$) (see Table 2). Inferior ischemic thallium defects were significantly more frequent when the GEA was used to bypass the RCA: 17/50 (34%) vs. 11/72 (15%) $P < 0.05$. Overall, 26% of patients (27/103) had residual myocardial ischemia detected by thallium scintigraphy despite complete revascularization; 18% (18/103) in the inferior wall bypassed with the GEA and 8% (8/103) in the anterior wall bypassed with the right IMA.

### 4. Discussion

It was confirmed by the present study that bilateral IMAs and GEA bypass grafting are adequate to relieve angina in most patients [2,5]; 2 years postoperatively, 98% of patients were asymptomatic during maximal or submaximal exercise test performed without medical treatment. However, the primary determinant of the success of CABG is the abolition of myocardial ischemia rather than relief of angina pain. Coronary blood flow is known to increase 4-fold to 5-fold in response to an increase in myocardial demand, and concern exists about the possible inadequacy of flow through arterial grafts at periods of peak myocardial demand. In this series, silent residual ischemia was detected by stress thallium myocardial scintigraphy in a third of patients, and ischemic thallium defects were associated with ECG modifications in 55% (22/40) of cases. It was suspected that flow through arterial grafts was adequate during moderate exercise but inadequate during heavy exercise [8]. Silent residual ischemia was strongly correlated with incomplete myocardial revascularization, and these results incite to increase the rate of complete revascularization in patients with the use of IMAs as sequential grafts. However, in patients with complete revascularization silent residual ischemia remained high (26%), and was localized in the inferior wall (18%) bypassed by GEA or in the anterior wall (8%) bypassed by right IMA. These results confirm the ability of left IMA grafts to supply adequate blood flow under any physiological stress conditions [6,10], even if sequential IMA grafts were used [11]. In this series, residual ischemia related to right IMA grafts used to bypass the LAD is acceptable and was previously reported when right IMA was used to bypass the RCA [12]; an explanation offered is that a more distal segment of the right IMA was used for the anastomosis relative to the length of the left IMA graft because of the distance involved in reaching the target vessel. This finding leads to be cautious in using distal right IMA of small diameter; in such case, an alternative technique may be to bypass the LAD with the left IMA and to use the right IMA as a free graft to bypass the other left coronary arteries. Residual ischemia in the inferior wall bypassed by the GEA remains the major concern; the question is whether the GEA can supply adequate blood flow at peak myocardial demand [7,8]. In this series, in at least 18% of cases, GEA graft blood flow seems to be insufficient at the maximal exercise level and causes silent residual ischemia detectable by thallium scintigraphy, specially when it was used to bypass the RCA. In fact, there is a high variability in the GEA diameter which decreases with the length of the GEA graft, and the most effective method to obtain good flow from the GEA is to use a short graft. We think that the insufficient blood flow offers by GEA is probably related to the small diameter of the GEA in patients. This finding leads to be cautious in using GEA of small diameter, particularly to bypass a large dominant RCA; in such case, an alternative technique may be to return to vein graft after a negative exploration of GEA. The limitation of this study is the lack of angiographic controls; however, no criteria in favor of graft occlusion were observed, residual ischemia occurred at the maximal level of exercise and remained symptom-free in 98% of patients, and the excellent long-term patency of IMA and GEA is well documented [13,14]. Nevertheless, it is important to recognize that arterial grafts have some limitations in the ability to supply blood for coronary circulation.

### 5. Conclusion

Myocardial revascularization using bilateral IMAs and GEA offers a satisfactory myocardial perfusion in the majority of cases; however silent residual myocardial ischemia was detected in a third of patients and was related to incomplete revascularization and to insufficient blood flow at the maximum level of exercise in at least 18% of cases for GEA and 8% for right IMA due to the small diameter of the arterial grafts. This finding incites to be cautious when using GEA or distal right IMAs of small size, and to find alternative techniques in such situations.

### References


