

Patient Selection in Off-Cardiopulmonary Bypass Revascularization

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ABSTRACT

Background: The last few years have been marked by striking advances in off-pump coronary artery bypass grafting (OPCABG), thanks mainly to developments in instrumentation and technical progress in the revascularization of the posterior arteries of the heart. In 2001, OPCABG was performed on approximately 20% of patients who underwent surgical myocardial revascularization in the United States. This retrospective study aims to evaluate our experience with this procedure over the past 10 years, emphasizing the rapid and increasing progress of the method, indications, contraindications, and results.

Methods: Between August 1991 and December 2001, 2,759 patients suffering from angina pectoris underwent OPCABG. The patients' ages ranged from 13 to 93 years with a mean of 63 years \pm 12 years. The over 80-year-old group accounted for 3.5% of the patients. Males represented 58% of the patients.

Results: Intraoperative mortality in OPCABG was low. In the intraoperative period 0.4% of patients died, and the figure for the postoperative period was 2.5%. It was noted that 7.9% of the patients presented serious, nonfatal complications.

Conclusions: OPCABG is a reproducible procedure with results similar to those obtained in revascularization of the myocardium using extracorporeal circulation (ECC). We believe that over 90% of patients can be operated upon without the aid of extracorporeal circulation (ECC). In our experience, all patients are potential candidates for myocardial revascularization surgery without ECC.

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INTRODUCTION

Despite the studies of Kolessov in 1967 [Kolessov 1967] and several other isolated communications reporting on myocardial bypass surgery without extracorporeal circulation (ECC), this technique was abandoned throughout the world because of the development and popularization of the clinical use of ECC, which began to be used in myocardial revascularization with the single purpose of facilitating the operation. The 1970s were marked by huge progress in myocardial revascularization surgery performed with the aid of ECC, which achieved worldwide popularity.

Notwithstanding the great progress in the use of the ECC technique in heart surgery, reflected in decreased morbidity and mortality in most procedures and especially in myocardial revascularization surgery, it is quite clear that this method is responsible for severe and very often grave alterations in the organism. Concomitant morbid conditions may produce complications in surgery using ECC, which in itself has an enormous potential for causing multiple complications such as pulmonary insufficiency, renal insufficiency, depression of the immunological system, bleeding, and neurological, particularly neurocognitive, complications.

In 1981, Buffolo began to perform myocardial revascularization without ECC in Brazil [Buffolo 1981]. Within a few years, in Argentina, Benetti was starting to treat angina pectoris without ECC [Benetti 1985]. The revascularized vessels for these procedures were exclusively those of the anterior wall.

The revascularization of the circumflex artery and its marginal rami had always been regarded as a limiting factor for the procedure, making it inappropriate to perform a total revascularization of the myocardium. In Brazil, during the period of the resurgence of the procedure and the demonstration of its reproducibility, it was severely criticized because it was believed that the anastomoses were of inferior quality to those performed with the aid of ECC and that it was impossible to perform a complete revascularization.

In 1991, we began to explore revascularization without ECC in northeast Brazil [Lima 1993a]. Two years later, we presented our experience with myocardial revascularization of the posterior arteries without ECC, making possible a

Table 1. Patients demographics (n=849)

Data	(n)	%
Age (yr) > 70	187	22,08
Smoker	627	73,88
Hypertension	537	63,24
Hiperlipidemia	436	51,38
Diabetes	550	64,74
Previous myocardial infarction	464	54,65
Peripheral vascular disease	81	9,55
Stroke	141	16,60
Obesity	160	18,90
Dialysis	30	3,53
Pulmonary obstructive disease	158	18,64
Coronary artery disease		
1 vessel	134	15,78
2 vessels	263	30,98
3 vessels	452	53,21

complete revascularization of the myocardium [Lima 1993b]. This was achieved by placing stitches in the posterior aspect of the pericardium and pulling them to produce a temporary ectopia cordis with no hemodynamic changes. In 1977 Lobo, using this method, succeeded in performing myocardial revascularization in over 90% of his patients, thereby widening the range of surgical indication for the technique [Lobo 1997].

The past five years have been marked by a striking evolution of this procedure, due mainly to developments in instrumentation and technical advances in revascularization of the posterior arteries of the heart. In 2001, off-pump coronary artery bypass grafting (OPCABG) was performed on approximately 20% of the patients who underwent surgical myocardial revascularization in the United States. The present retrospective study is intended to evaluate our experience of this procedure over the past 10 years, highlighting the rapid and increasing evolution of the method, its indications, contraindications, and results.

MATERIALS AND METHODS

Between August 1991 and December 2001, 2,759 patients with angina pectoris underwent OPCABG. Ages ranged from 13 to 93 years with a mean of 63 years \pm 12 years. Patients over the age of 80 accounted for 3.5% of the total. The angina was classified according to the Canadian Heart Association (CHA) system: 5.5% of the patients were in Class I, 10% in Class II, 40% in Class III, and 44.5% in Class IV. The patients' demographic data is shown in Table 1 (●).

Operative Technique

The operation was performed by median sternotomy. The left inner thoracic artery was dissected and prepared and the great saphenous vein simultaneously dissected. In more recent cases, we have used the CTS platform and stabilizer (CardioThoracic Systems). An I-shaped opening of the pericardium was made and its left border fixed to the platform.

Heparinization of the patients was carried out using sodic heparin in a dose weighing 200U/kg, of body weight, and control was ensured by measuring the activated coagulation time, 300 seconds being accepted as the minimum value.

One or more sutures were then inserted into the posterior aspect of the pericardium. The anastomoses were done in the following sequence: distal anastomosis of the graft to the left anterior descending artery, followed by its diagonal ramus, then distal anastomosis of the graft in the right coronary, and finally the distal anastomosis of the graft to the circumflex artery and/or its rami. In order to construct the anastomosis, a temporary proximal snare of the coronary artery was inserted with 5-0 polypropylene anchored in bovine pericardium, followed by the incision and placement of the CTS Flo-Coil intracoronary shunt (range, 1.5 mm to 2.5 mm).

Patient Selection

In the early years of the experience, the cases were selected, particularly for patients in a serious condition and those with lesions only in the anterior arteries of the heart. In recent years, patient selection has been done in accordance with the principle that all patients with an indication for operation by conventional surgery should benefit from surgery without ECC. However, we consider a number of contraindications to be absolute: CABG surgery in combination with a valve replacement and revascularization, major arrhythmias, and cardiac insufficiency. Other contraindications regarded as relative, which are analyzed in the course of the procedure, include: intramyocardial artery, an artery less than 1.2 mm in diameter, a calcified artery, and very large ischemic hearts unable to withstand manipulation. Patients regarded as ideal candidates for heart surgery without ECC are those with at least one of the following characteristics: old age, previous stroke, previous renal insufficiency, low ejection fraction, hematological alterations, atherosclerotic plaques in the aorta and femoral artery, reoperations, and malignant diseases.

RESULTS

The use of OPCABG has increased over the years, from 3% of the coronary patients operated on in 1991, to 10% in 1993, and 72% in 1995. From 1996 to the present day the figure has never fallen below 97%. At certain times the rate has remained stable, for example when it remained at 100% for a long period (see Figure 1, ●). A total of 5,392 anastomoses have been performed, 58% using venous grafts and 42% arterial grafts. Of the arterial grafts, the left internal mammary artery (LIMA) was used in 97% of the patients, the radial artery in 2.7%, and the gastroepiploic artery in 0.3%. The number of bypasses has ranged from one to seven, with a mean of two bypasses per patient. The circumflex artery was revascularized in 35.5% of the patients.

Mortality

Intraoperative mortality has been low in OPCABG. In the intraoperative period 0.4% of the patients died, and in the postoperative period the figure was 2.5%. Overall hospital mortality was 2.9%. The causes of death were as follows:

Table 2. Mortality rate (n=2.759)

Data	(n)	%
Acute MI	27	0,98
LCOP	12	0,44
Arrhythmias	8	0,29
Stroke	8	0,29
Bleeding	7	0,25
Unknown	7	0,25
Sudden death	3	0,11
Pulmonary insufficiency	3	0,11
Sepsis	2	0,07
Acute renal failure	2	0,07
Acute aortic dissection	1	0,04
Pulmonary embolism	1	0,04
Total	81	2,95

MI = myocardial infarction; LCOP = low cardiac output

acute myocardial infarct, low cardiac output syndrome, arrhythmias, stroke, bleeding, sudden death, pulmonary insufficiency, sepsis, acute renal insufficiency, dissection of the aorta, pulmonary embolism, and unknown causes (see Table 2, ⊙). In octogenarian patients the mortality was 2.1%.

Morbidity

It was observed that 7.9% of the patients operated on presented serious, nonfatal complications. The main nonfatal complications arising from OPCABG were the following: atrial fibrillation, acute myocardial infarct, bleeding, stroke, low cardiac output syndrome, pulmonary insufficiency, operative wound infection, and renal insufficiency (see Table 3, ⊙). The use of blood has been minimized, a large percentage of the patients having been operated on without the use of blood or its components. Only 36.3% were transfused or given some blood component; thus 63.7% of patients have not been exposed to the risk of contamination by blood or its components.

DISCUSSION

The current group of patients is quite heterogeneous and includes all the patients managed by us in 10 years of experience of myocardial revascularization without ECC. The experience includes all of our early cases, with their learning curve, limitations for approaching the posterior vessels of the heart, and patients operated on with and without cardiac stabilization. It represents our overall experience with patients who are seriously ill, those whose illness is less serious, young people, and old people needing revascularization of one, two, or three arteries. The mean number of bypasses per patient was two. Although this mean appears to be low, it represents the entire experience of our unit, where there was initially a selection of patients that was influenced by the learning curve. The mean number of bypasses in the subgroup of the 180 patients most recently operated on was 2.8, which is not greatly different from that of the patients who undergo the conventional technique.

The anesthesia administered for patients operated on without ECC is similar to that for patients who underwent conventional revascularization; however, in the former, the interaction and participation of the anesthetist throughout the procedure is more demanding. The anesthetist needs to use fewer anesthetic drugs and muscle relaxants and for shorter duration in order to extubate these patients as early as possible.

The operative technique has varied over the years. Originally cardiac stabilization was done using gauze around the heart, negatively chronotropic drugs, and proximal and distal snaring of the coronary artery. More recent experience has seen the regular use of cardiac stabilizers, which permit an increased application of the method that has at times been as high as 100%. The amount of heparin currently used is small, the dosage being half that used in patients operated on with ECC. The neutralization of the protamine was done in a 1:1 ratio, but there is now a tendency to neutralize in a 1:1/2 ratio as these patients present a preserved coagulation system and may even present hypercoagulation, which may lead to unfavorable early results.

The technique for approaching the coronary used at the outset was that described by Buffolo [Buffolo 1983], in which the distal and proximal portions of the artery were occluded with 5-0 polypropylene and without the use of any kind of intracoronary perfusate. This technique has undergone changes over time, and today we use only the temporary proximal snare while we perform the arteriotomy and the placement of the intracoronary perfusate. The occlusion is done with 5-0 polypropylene anchored in bovine pericardium, and the occlusion time is minimal.

The placement of the stitch in the posterior aspect of the pericardium has also evolved over the years [Lima 1993a]. In the beginning, the stitches were placed in the left lateral pericardium and immediately afterwards another stitch would be placed in a more inferior region, thus enabling the lateral face of the heart to be exposed. With this movement the heart tended to undergo a rotation on its own axis, which is bearable up to a point, and thus it proved possible to perform anastomoses on the lateral wall of the heart in certain patients. As the stitches penetrated the left lateral pericardium, the region of the left pulmonary veins and the region between the latter and the inferior vena cava was approached, thereby achieving

Table 3. Morbidities rate (n=2.678)

Data	(n)	%
Myocardial infarction	69	2.5
Low output syndrome	35	1.3
Atrial fibrillation	46	1.7
Stroke	11	0.4
Hemorrhagic	16	0.6
Acute renal failure	21	0.8
Acute renal failure	21	0.8
Insufficiency pulmonary	6	0.2
Operative wound infection	8	0.3
Total	212	7.9

an exteriorization of the heart without compromising its hemodynamics [Lima 2000]. The large number of threads used was gradually reduced, initially to three: one in the superior left pulmonary vein, one in the inferior pulmonary vein, and one between the inferior left pulmonary vein and the inferior vena cava. More recently we have used a single stitch, between the inferior left pulmonary vein and the inferior vena cava, in the more posterior portion of the pericardium.

This is a delicate surgical maneuver and should be performed carefully, especially in patients with substantial ischemia. The placing of the heart in the correct position should be gradual and allow the heart to recover from any initial temporary instability. With the heart in ectopia cordis, the stabilizer should be positioned before any further maneuver with the coronary artery. A number of classical maneuvers of general surgery may be employed, such as turning the operating table towards the surgeon's side and adopting the Trendelenburg position. The correct procedure seems to be to start with the left anterior descending artery, followed by the right coronary and finally the circumflex and its rami, particularly in patients with intense ischemia. Revascularization of the left anterior descending artery in this group of patients improves myocardial perfusion considerably, facilitating the revascularization of the posterior arteries. It also appears to be important to do the proximal anastomoses first as a way of irrigating the myocardium at an earlier stage.

Myocardial revascularization surgery without ECC represents a change of paradigm in the treatment of coronary insufficiency. Over the past three years, a great interest worldwide in the use of this technique has fostered a substantial development of the method and an increase in its application. We regard as ideal candidates for coronary surgery without ECC patients falling into any of the following categories: advanced age, previous stroke, previous renal insufficiency, low ejection fraction, hematological alterations, atherosclerotic plaques in the aorta and femoral artery, reoperations, and those with malignant disease. If this is indeed the case, low-risk patients should also benefit from the method. Today, in our daily practice, we no longer select patients for surgery without ECC: all patients are candidates for OPCABG except those with relative and absolute contraindications: surgery combining a change of valve and revascularization, major arrhythmias, cardiac insufficiency, intramyocardial artery, artery less than 1.2 mm in diameter,

calcified artery, and very large, ischemic hearts unable to withstand manipulation.

CONCLUSION

OPCABG is a reproducible procedure, with results similar to those obtained with myocardial revascularization using ECC. We believe that it is possible to operate on over 90% of patients without the aid of ECC. In certain groups of high-risk patients, the results surpass those obtained by revascularization with ECC. The indication for the procedure has widened, due mainly to the improved techniques for exposing the posterior arteries and also to the systematic use of cardiac stabilizers. Mortality and morbidity are both low, and there is less need to use blood and its components compared with conventional surgery. The mean number of coronary artery bypasses per patient has increased in recent years as a result of better stabilization devices, and improvement of the surgical technique.

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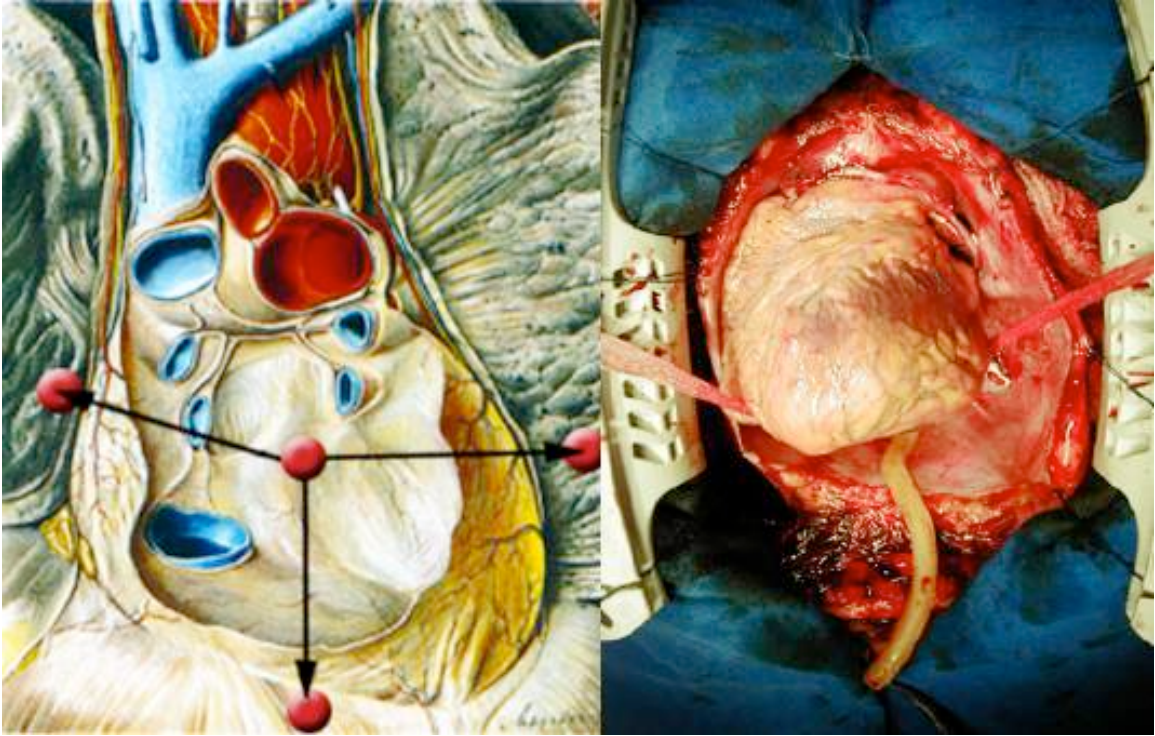


Figure 1