

Total Myocardial Revascularization Without Cardiopulmonary Bypass: A Reality

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ABSTRACT

Objective: From January 1995 to June 1999 our surgical team at ICORP, Fortaleza, Ceará, Brazil, performed coronary artery surgery without cardiopulmonary bypass as a routine procedure. A total of 897 operations were performed during this period, 91.8 % (824) of them without cardiopulmonary bypass. The purpose of the present study is to evaluate the results of these 824 patients with regard to duration of hospitalization, age, sex, number of grafts, reoperations performed, morbidity and mortality. All patients underwent previous coronary arteriography.

Methods: With patients admitted in the hospital for elective or emergency myocardial revascularization, all the coronary arteries were bypassed, possibly without cardiopulmonary bypass, including the marginal branches of the circumflex artery. Basic statistical analysis has been performed over the above-mentioned variables.

Results: The patients' ages ranged from 35 to 88 years, with a mean age of 61.2. The average duration of hospitalization was seven days. In all, 1,738 grafts were implanted, the number in individual patients varying from one to four (average of 2.1 per patient). The incidence of procedure-related complications was 3.15% (26 patients). Twenty-three patients (2.8%) died in the early postoperative period.

Conclusions: Considering the data obtained from this study, we conclude that the procedure can be used in the vast majority of patients undergoing coronary artery surgery (compared to the similar studies of patients operated on with cardiopulmonary bypass).

INTRODUCTION

The methods used for myocardial revascularization (MR) have evolved rapidly over the last few years. All over the

world, new procedures are being developed and presented, aimed not only at reducing postoperative morbidity and mortality, hospital stay, and the high costs of these procedures, but also at improving the patients' quality of life.

A number of studies have shown that MR without the use of cardiopulmonary bypass (CBP) can be performed with a low surgical risk and excellent results. This is basically due to improvements in surgical and anesthetic equipment, good postoperative aftercare and in particular, to the enhancement of the technical skills of the surgical teams. This method is not, however, really a novelty. Alexis Carrel [Carrel 1910] experimentally performed a bypass in dogs from the descending aorta to the left coronary artery using a homologous carotid artery. In 1946, Vineberg [Vineberg 1954] introduced the implantation of the left internal mammary artery (LIMA) into the cardiac muscle without CBP using a left thoracotomy. Kolessov [Kolessov 1967] in 1966 in Russia, by means of a wide left thoracotomy through the fifth intercostal space, performed the LIMA implantation directly into the anterior descending (AD) artery in several patients with good results, also without CBP. Ankeney [Ankeney 1975] published a trial study of 200 MRs without CBP. In our area, Buffolo et al. [Buffolo 1983, Buffolo 1985, Buffolo 1994] and Lobo Filho et al. [Lobo Filho 1997, Lobo Filho 1999] in Brazil and Benneti et al. [Benneti 1991] in Argentina published large series of patients operated on with this method, presenting good results.

It is a well-known fact that the serious changes, mainly at the level of the cell, resulting from the flow of blood through nonendothelized surfaces such as those present in the CPB circuits, trigger off systemic nonspecific inflammatory response [Kirklin 1983, Blauth 1988, Butler 1993]. Our technique has the advantage of eliminating CPB, thereby avoiding all its adverse effects, and is recommended especially in high risk patients suffering from other organic diseases (i.e., chronic renal insufficiency, lung disease, a history of strokes), MR surgery in the acute phase of the infarct, reoperation, and those over seventy [Buffolo 1994].

MATERIALS AND METHODS

Between January 1995 and June 1999, our team attempted to systematize MR surgery without CPB, during which time 897 patients were presented for MR. The patients understood

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Table 1. Comparison of semestral evolution of number of operations with and without CPB

	1st semester 1995	2nd semester 1995	1st semester 1996	2nd semester 1996	1st semester 1997	2nd semester 1997
Without CPB	37 (55%)	86 (82%)	103 (97%)	107 (99%)	98 (98%)	97 (96%)
With CPB	30 (45%)	18 (18%)	3 (3%)	1 (1%)	2 (2%)	4 (4%)
Total	67	104	106	108	100	101

	1st semester 1998	2nd semester 1998	1st semester 1999
Without CPB	80 (90%)	113 (97%)	104 (96.3%)
With CPB	07 (10%)	03 (3%)	4 (3.7%)
Total	87	116	108

and were presented with the alternative forms, the risks related to the procedure, and agreed upon the procedure. Of these, 824 (91.8%) were operated on without CPB (Table 1, ●). An analysis of this group showed that age ranged from 35 to 88 years. Sixty-four percent (526) of the patients were male. Of these 824 patients, 79 (9.6%) underwent MR surgery by means of a small left anterolateral thoracotomy [Vacek 1992, Loop 1996] through the fourth intercostal space. The other 745 (90.4%) patients underwent a median sternotomy aimed at revascularizing, when necessary, all the arteries of the heart, including the marginal branches of the circumflex artery. The details of the technique are described below.

Following ECG and the monitoring of the central venous pressure and blood pressure, the patient is anesthetized. The thorax is then opened by sternotomy or left thoracotomy, eventually exposing the heart by fixing the pericardium to the drapes. The great saphenous vein is removed by scaled incisions, starting at the thigh. The radial artery used is, in the vast majority of cases, that of the left forearm, since the patients are predominantly right-handed and have also been submitted to cardiac catheterization through the right arm. If the LIMA is used, the artery is totally dissected from its origin to the seventh intercostal space, ligation of all its branches being affected by means of a metal clip. Anticoagulation is then carried out through the endovenous administration of heparin at a dosage of 2 mg/kg of body weight. This anticoagulation is maintained by applying half of the original starting dose of heparin for every subsequent hour.

We emphasize that both the perfusionist and all the equipment for the immediate creation of the extracorporeal circulation circuit are in place at the disposal of the surgical team. Once the grafts have been correctly prepared, the coronary arteries to be revascularized are dissected. The interruption of the blood flow to the coronary region where the anastomoses is to be performed is achieved by passing a 4-0 or 5-0 polypropylene suture in a figure eight, with tourniquets, proximal and distal to the site of the anastomosis.

Between the tourniquets and the coronary, a small segment (1 cm) of Folley's probe number 10 is interposed in order to protect the bed of the coronary artery. The artery is incised longitudinally and the anastomosis performed with the graft by means of a continuous suture, using a single 8-0 polypropylene suture to the LIMA and a 7-0 suture to the saphenous or radial artery.

After the anastomosis has been completed, testing is performed with dilators and with the bloodstream itself to evaluate its permeability. When the LIMA is used, the tissue that has been dissected along with its extremity is fixed onto the epicardium. The saphenous or radial arteries are preferentially anastomosed in the ascending aorta with a 5-0 or 6-0 continuous polypropylene suture. When a highly calcified or previously much manipulated aorta is encountered, they are anastomosed in the form of a Y with the LIMA. The anticoagulation is interrupted and an intravenous injection of 1.0 mg protamine hydrochloride is given for every mg of heparin. The procedure is then completed with the partial approximation of the thymic tissue, a rigorous review of the hemostasis, drainage and closure of the thorax. Epicardiac electrodes of a temporary pacemaker are not routinely employed.

In order to better expose the posterior arteries, thereby greatly facilitating the anastomoses (in accordance with the personal communication of Dr. Ricardo Lima), three 3-0 catgut sutures are inserted into the postero-inferior region of the pericardium, between the left superior pulmonary vein and the inferior vena cava. These sutures, when subjected to traction, cause the mediastinum to veer to the left, causing the heart to be pulled out with the sutures without encountering hemodynamic disturbances.

RESULTS

A total of 1,738 bypasses were carried out on these 824 patients, an average of 2.1 bypasses per patient. The LIMA was used in 694 bypasses (40%) and the radial artery in 15 (0.8%). From the total bypasses, the saphenous vein was used in 59.2% of the cases. The number of bypasses per patient ranged from 1 to 4. Of the 824 patients, 79% (9.6%) underwent MR by means of a small left anterolateral thoracotomy, performing a single LIMA bypass to the anterior descending branch of the left coronary.

Regarding the number of bypasses per patient, our main concern is not the implantation of an excessive number of bypasses. Rather, our concern is the insertion of bypasses that in our opinion can truly benefit the patient after careful analysis of the coronaries anatomy, the patient's clinical status, and transoperative conditions. Keeping in mind our department operates within an emergency heart hospital, a considerable number of patients require only a single

Table 2. The number of revascularized coronary arteries in 824 patients without CPB

	N	%
Anterior descending	770	44.3
Right coronary	317	18.2
Marginal branch	310	17.9
Diagonal branch	255	14.7
Posterior descending	38	2.2
Posterior ventricular	09	0.5
Diagonalis	39	2.2
Total	1738	100

bypass, whether as the result of an unsuccessful angioplasty or because of the technical impossibility of carrying out such a procedure.

Excluding the 194 patients who received a single bypass, either in an emergency situation or because they were submitted to a left minithoracotomy, the average number of bypasses per patient rose to 2.4. The most frequently revascularized arteries were the anterior AD artery and the right coronary artery (Table 2, ②). The age of patients ranged from 35 to 88 years, with an average of 61.2 years. The duration of hospital stay was from 4 to 24 days, with an average of 7.1 days. It should be noted, however, that 79% of the patients were discharged between postoperative days 5 and 8 (Figure 1, ③). The only patient who remained hospitalized for 24 days after surgery suffered from chronic renal insufficiency and required hemodialysis three times a week. The complications encountered in the immediate postoperative period were stroke, dehiscence of the sternum, postoperative infarct, and bleeding (Table 3, ④). The hospital mortality rate observed in this group was 2.7 %, the causes of which are shown in Table 4 (⑤).

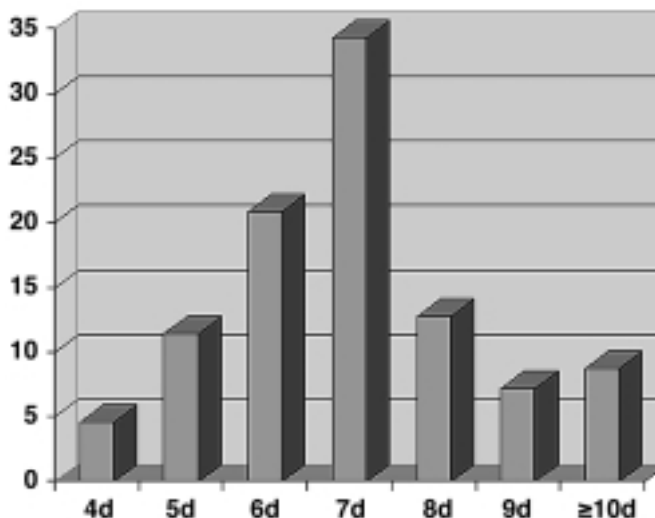


Figure 1. Variation of duration of hospital sojourn

Table 3. Principal complications (morbidity) in the immediate postoperative period

Complications	N	%
Stroke	7	0.84
Dehiscence of sternum	2	0.24
Postoperative infarct	8	0.97
Bleeding	9	1.10
Total	26	3.15

DISCUSSION

Over the last few years, the treatment of coronary insufficiency has undergone marked evolutionary changes. The development of cardiorenal pharmacology, a greater epidemiological control of the coronary risk factors, the notable development of angioplastic methods, and the changes in living habits of the female population have all led to a modification in the profile of the coronary patient, causing cardiologists to adopt a new therapeutic vision from both philosophical and medical standpoints [Vacek 1992, Westaby 1995, Benetti 1996, Bitti 1996, Loop 1996, Lytle 1996, Ruygrok 1996, Wenger 1996].

There is a growing tendency for the patients referred for surgical treatment to be increasingly older individuals and more serious cases, not to mention the reoperations, it is fair to say that we are now in the decade of reinterventions [Jones 1991].

An indirect influence, but one with considerable repercussions in the general context, is the financial aspect, which now plays a major role within the overall social situation. Effective and safe methods costing less than the classical procedures have become more and more necessary.

Special conditions, such as the need to perform MR as a matter of urgency, mainly after the failure of angioplastic procedures or in the event of an acute myocardial infarct following thrombolytic medication, make it essential for the surgical team to act with the utmost rapidity. They seek not only to salvage the ischemic myocardium, but also to make the technique as nonaggressive as possible in view of the seriousness of such patients.

Despite the recognition of the importance CPB has played and continues to play in the progress of heart surgery, it is common knowledge, as a result of research carried out in a

Table 4. Causes of death in immediate postoperative period

Causes	N	%
Unknown	5	0.60
Bleeding	5	0.60
Cardiogenic shock	5	0.60
Arrhythmia	4	0.48
Pulmonary embolism	1	0.12
Stroke	1	0.12
Sudden death	2	0.24
Total	23	2.8

number of centers, that the use of these devices causes grave systemic damage [Kirklin 1983, Blauth 1988, Butler 1993], which is sometimes irreversible and catastrophic, especially in high risk patients.

Following this reasoning, in 1995 we drew up a department protocol for performing MR surgery without the use of extracorporeal circulation, initially approaching only the anterior arteries of the heart in most severely compromised patients. With the increasing refinement and familiarity with the method, as well as good results achieved, we started to revascularize the posterior arteries of the heart, progressively extending the technique to other types of patients with the result that today 91.8 % of MR operations are performed without the use of CPB (Table 1, 2).

In relation to anastomoses patency, studies have shown that the percentage of graft permeability are comparable to those of other methods [Buffolo 1994]. The author believes that the extremely low incidence of infarction in the immediate postoperative period, the substantial clinical improvement displayed by the patients, most of whom are suffering from angina prior to surgery, the nontraumatic manner in which the anastomoses are performed, and the tests carried out when they are completed, all give us enormous confidence regarding the permeability of this graft.

In order to demonstrate the efficiency of the anastomoses, in June 1999, we performed 79 MRs by means of left anterolateral minithoracotomy, using as a graft exclusively the LIMA to the DA without CPB. In the last 46 consecutive cases, the quality of LIMA anastomosis was evaluated, showing an excellent patency in 95.6% (44) of all cases. Keeping in mind this type of anastomosis requires great technical skill, we believe that grafts to other arteries of the heart performed without CPB would show similar degree of patency. We also believe that in specific or emergency cases, mainly after a single LIMA bypass to the AD artery (the "gold standard"), angioplastic methods may succeed in completing the revascularization of the myocardium.

In conclusion, while it may be too soon to say that MR surgery should be performed without CPB, it is not too soon to state that it may systematically be performed in this way.

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