

Total myocardium revascularization without extracorporeal circulation: five-year experience

Revascularização total do miocárdio sem circulação extracorpórea: cinco anos de experiência

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Abstract

Objective: To evaluate the immediate postoperative results of off-pump myocardium revascularization surgery by analyzing complications and mortality.

Method: A total of 1440 patients were submitted to off-pump myocardium revascularization. The surgical technique consisted in proximal occlusion of the approached artery, the application of the LIMA graft in the posterior pericardial deflection and stabilization of the target artery with a suction stabilizer. The distal anastomoses were performed first.

Results: Among the patients evaluated, 924 were male and 516 were female, with a mean age of 63.12 ± 8.76 years. The ejection fraction was normal in 749 patients, 740 (51.4%) patients had suffered previous myocardial infarction and 687 (47.6%) patients were in functional class III or IV. The mean EuroSCORE was 4.93 ± 3.32 . The mean number of distal anastomoses was 3.12 ± 1.23 per patient. A total of 1173 (81.5%) patients remained less than 12 hours on mechanical ventilation and among these, 888 (61.7%) remained for less than six hours. The stay in the ICU was of one night for 330 (22.8%) patients, for two nights for 930 (64.6%) patients and

182 (12.4%) patients remained for three or more nights. In regards to complications, three (0.2%) patients presented with renal insufficiency, six (0.4%) patients suffered strokes, nineteen (1.3%) patients were reoperated for bleeding, nineteen (1.3%) patients had mediastinitis, eighteen (1.25%) patients suffered severe myocardial infarction and 212 (14.7%) presented atrial fibrillation. There were 50 (3.5%) deaths, 29 (2.5%) of them being among the 1148 patients operated electively, 9 (4.7%) among 190 patients submitted to coronary re-operation and 12 (11.7%) among 102 patients undergoing emergency operations.

Conclusion: With the evolution of biomedical technological, all the vessels of the heart are now approached. These data suggest that the operation for myocardial revascularization is safe and efficient. It can be applied to all patients who need coronary surgery, with low rates of complication and mortality.

Descriptors: Myocardial revascularization, methods. Extracorporeal circulation. Coronary artery bypass.

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Resumo

Objetivo: Avaliar os resultados imediatos da operação para revascularização do miocárdio sem circulação extracorpórea, analisando-se complicações e mortalidade.

Método: Foram submetidos à operação para revascularização do miocárdio sem circulação extracorpórea 1440 pacientes. A técnica operatória consistiu em oclusão proximal da artéria abordada, aplicação do ponto de LIMA na deflexão pericárdica posterior e estabilização da artéria alvo com estabilizador de sucção. As anastomoses distais foram feitas inicialmente.

Resultados: Entre os pacientes avaliados, 924 eram ao sexo masculino, com idade média de 63,12±8,76 anos. A fração de ejeção era normal em 749 pacientes. Setecentos e quarenta (51,4%) pacientes tinham antecedente de infarto do miocárdio. Seiscentos e oitenta e sete (47,6%) pacientes encontravam-se em classe funcional III ou IV. O EuroSCORE médio foi de 4,93±3,32. A média de anastomoses distais foi de 3,12±1,23 por paciente. Mil cento e setenta e três (81,5%) pacientes permaneceram menos de 12 horas em ventilação mecânica, sendo que destes, 888 (61,7%) permaneceram menos de 6

horas entubados. A permanência em UTI foi de uma noite em 330 (22,8%) pacientes e de duas noites em 930 (64,6%). Cento e oitenta e dois (12,4%) pacientes permaneceram três ou mais noites na UTI. Quanto às complicações, três (0,2%) pacientes apresentaram insuficiência renal, seis (0,4%) tiveram acidente vascular cerebral, 19 (1,3%) foram reoperados por sangramento, 19 (1,3%) tiveram mediastinite, 18 (1,25%) infarto agudo do miocárdio e 212 (14,7%) apresentaram fibrilação atrial. Houve 50 (3,5%) óbitos, sendo 29 (2,5%) entre 1148 pacientes operados eletivamente, nove (4,7%) entre 190 pacientes submetidos a reoperação coronariana e 12 (11,7%) entre 102 pacientes operados em caráter de emergência.

Conclusão: Com a evolução da tecnologia biomédica, todos os vasos do coração passaram a ser abordados. Estes dados sugerem que a operação para revascularização do miocárdio é segura e eficaz, podendo ser aplicada em todos os pacientes que necessitem de cirurgia coronariana com baixos índices de complicações e mortalidade.

Descritores: Revascularização miocárdica, métodos. Circulação extracorpórea. Ponte de artéria coronária.

INTRODUCTION

The use of cardiopulmonary bypass in patients submitted to coronary artery surgeries is commonly associated with an increase in morbidity in the postoperative period due to the systemic inflammatory reaction it causes [1].

Numerous articles published over the last few years associated cardiopulmonary bypasses with a series of complications observed in patients who underwent coronary artery bypass grafting (CABG) [2-4]. After the pioneering works of BUFFOLO et al. [5] and BENETTI [6], off-pump CABG became of interest world-wide, with investigations carried out by many centers [7-12]. These studies have been published in Brazil and overseas and demonstrate the efficiency and safety of this type of surgery, which is becoming more and more popular among cardiovascular surgeons, clinical cardiologists and intensivists.

In the current study, we present a retrospective analysis of the first 1440 patients who underwent off-pump CABG over the last five years in our institution.

In 1999, the year in which this program was initiated, a little more than 50% of the coronary patients were submitted to off-pump surgery. With the experience gained, this number increased to 100% last year, showing that all patients that

need CABG surgery can benefit from the off-pump technique.

METHOD

From January 1999 to January 2004, 1440 patients, with a mean age of 63.12 ± 8.76 years (varying from 28 to 94 years) were submitted to off-pump CABG. From this total, 924 were male and 516 were female with 183 patients being over 75 years old.

From September 2001, all patients had their personal data stored on the database of the Society of Thoracic Surgeons [13] and the risk index was calculated according to the score developed by the European Association for Cardiothoracic Surgery, the EuroSCORE [14-15]. The patients operated on before this date had their data collected by analyzing their hospital records.

All patients were submitted to medium thoracotomy. The anesthesia and the graft harvesting techniques have been previously described [16]. After graft harvesting, the patient was heparinized using 2.5 mg/kg. Afterwards an Ethibond 2-0 suture was fixed in the central portion of an 80-cm by 3-cm strip which was applied to the posterior pericardium, between the inferior cava vena and left inferior pulmonary

vein [16]. By moving this strip, all the regions of the heart were accessible and little hemodynamic variation was caused. The surgery table was used in the Trendelenburg and left lateral positions. At this stage, the central venous pressure was maintained above 15 mmHg.

The distal anastomoses were normally performed first, starting when possible, with the right coronary artery and its branches, followed by the marginal branches of the circumflex artery, the diagonalis, the diagonal branches, and finally, the anterior descending branch. In cases in which one area appeared to be more ischemic than others, this region was revascularized first. The approached artery was temporally occluded in its proximal portion using a 4-0 prolene suture fixed to a small silicon strip. The area in which the work was performed was fixed using a suction stabilizer (Octopus System, Medtronic Corporation). The distal anastomosis was then performed using a continuous 7-0 prolene suture. When finished, the systolic pressure was maintained at 100 mmHg and the proximal anastomosis was performed with a continuous 6-0 prolene suture. On partial aortic declamping, 2 mg/kg of heparin were reverted using protamine sulfate (initial dose of heparinization was 2.5 mg/kg) and the surgery was completed. Over the last six months, whenever possible, the patient was awoken and extubated in the surgery room.

In respect to the coronary disease risk factors, 350 of the patients were diabetic, 572 had dyslipidemia, 921 were smokers and 1197 suffered from hypertension. In 208 patients, no coronary artery risk factors were detected.

The 538 of the patients were in functional class II, 215 patients were in class I, 401 in class III and 286 in class IV. Seven hundred and forty patients had suffered previous myocardial infarctions, with 115 suffering infarctions within the ten-day period prior to surgery. The ejection fraction was more than 50% in 749 patients, between 30% and 50% in 511 patients and less than 30% in 180 patients.

In respect to the associated diseases (Table 1), six patients used pacemakers, 23 had chronic renal insufficiency, 15 suffered from gastrointestinal disease, 27 had chronic atrial

fibrillation, 44 peripheral vascular arterial disease, 45 had previously suffered strokes and 68 suffered severe chronic obstructive pulmonary disease.

Coronary cineangiography revealed disease of a single vessel in 73 patients, two-vessel disease in 384 and three or more vessels involved in 983 patients. The injury of the left coronary trunk was seen in 132 patients.

One hundred and sixty-seven patients had previously been submitted to myocardium revascularization, while 347 patients had undergone angioplasty.

In the immediate postoperative period, 303 patients were using endovenous nitroglycerin to control angina, 52 used vasoactive drugs because of hypotension and 21 patients needed intra-aortic balloons before starting the surgery. One hundred and two patients were submitted to emergency surgery.

The average EuroSCORE was 4.93 ± 3.32 , ranging from 0 to 18 points.

RESULTS

The total number of distal anastomoses was 4993, with a mean of 3.12 ± 1.23 per patient, varying from one to seven anastomoses. The left internal thoracic artery was utilized in 1185 patients and only arterial grafts were utilized in 293 cases.

The time of mechanic ventilation ranged from 0 to 288 hours. One hundred and nineteen patients were extubated inside the surgery room and 1173 patients remained less than 12 hours on mechanic ventilation, with 890 remaining intubated for a period of less than 6 hours. The ICU stay was less than two nights for 1260 patients, with 330 of them remaining only one night in the unit.

In respect to the complications observed in the postoperative period (Table 2), three patients evolved with acute renal insufficiency, six patients presented strokes, 19 patients required reoperation because of bleeding, 19 patients developed mediastinitis, 18 patients presented with acute myocardial infarction and 212 developed atrial fibrillation. Seven patients operated at the beginning of the

Table 1. Associated diseases.

Total atrioventricular block	6	0.4%
Renal insufficiency	23	1.6%
Gastrointestinal disease	15	1.0%
Atrial fibrillation	27	1.8%
Peripheral vascular arterial disease	44	3.0%
Stroke	45	3.0%
Chronic obstructive pulmonary disease	68	4.7%

Table 2. Post-operative complication.

Renal insufficiency	3	0.2%
Stroke	6	0.4%
Early reoperation	7	0.5%
Reoperation due to bleeding	19	1.3%
Mediastinitis	19	1.3%
Myocardial infarction	18	1.3%
Atrial fibrillation	212	14.7%

series needed to be reoperated in a period of less than twelve months after the first operation.

A total number of 50 (3.5%) patients died, with 29 (2.5%) deaths occurring among the 1148 patients submitted to elective surgery, nine (4.7%) deaths among 190 patients who were submitted to coronary reoperation and 12 (11.7%) among 102 patients operated as an emergency. The Table 3 shows the main causes of death.

Table 3. Causes of death.

Renal insufficiency	2	0.1%
Stroke	2	0.1%
metabolic causes	4	0.2%
Pulmonary thromboembolism	4	0.2%
Bleeding	6	0.4%
Mediastinitis	9	0.6%
Unknown cause	9	0.5%
Cardiogenic shock	14	1.0%

COMMENTS

On-pump CABG is considered the Gold Standard procedure due to its excellent results and its reproducibility in different cardiac centers. In spite of the optimum results over 15 years of follow up [17], numerous publications have demonstrated deleterious effects of cardiopulmonary bypass [1-4].

Over the last few years, after improvements in the stabilization techniques and in the approach to the heart [18], interest in off-pump CABG has increased immensely as can be seen by works presented by different centers [7-12]. Brazilian surgeons greatly influenced this increased interest, initially with BUFFOLO et al. [5] and after, with LIMA [18] and RIVETTI & GANDRA [19].

CABG on the beating heart is associated with a reduction in cerebral microemboli and inflammatory response and with a better renal protection [1,20,21]. Better results compared to the conventional technique have been presented in subgroups of patients with higher surgical risk, including patients with significant ventricular dysfunction [22] and patients submitted to coronary artery reoperations [23].

In our series, we analyzed the immediate results of the first 1440 patients operated on without the use of cardiopulmonary bypass in our institution. In this group, some patients were selected for the off-pump surgery only during the first two years. In the last two years practically all patients were submitted to off-pump surgery. In the last year, the only patient operated on using cardiopulmonary

bypass was being submitted to a third coronary surgery and during the thoracotomy the right ventricle was severely injured and so cardiopulmonary bypass was established to satisfactorily repair the problem. All the other patients were submitted to off-pump surgery, proving that nowadays all heart vessels can be adequately approached using this technique.

The incidence of complications in patients operated on using off-pump CABG was low in our series, for example, the rate of renal insufficiency was 0.2% and strokes was 0.4%. Other complications such as mediastinitis and myocardium infarction were also infrequent, with the prevalence of infarction improving in the later cases.

Another important factor to be considered, early reoperation (as the quality of anastomosis is always questioned in respect to off-pump CABG), also presented a low incidence (0.51%) and all cases were patients from the start of this study.

The second question asked by critics of off-pump CABG is about the low number of distal anastomoses per patient. In our total series, the mean number of distal anastomosis per patient was 3.12 ± 1.23 with this number increasing in 3.22 in the last twelve months, showing that the off-pump surgery allows total CABG.

CONCLUSION

The great advances in the biomedical industry in the area of less-invasive surgeries have made revascularization of all myocardial vessels possible. In one initial phase of the experiment, the occurrence of arrhythmia and hemodynamic instability is expected even during the preparation of anastomoses in the anterior wall, which, with experience, rarely happens even when three or four grafts into the lateral and posterior heart walls are necessary. Studies suggest a great benefit of off-pump surgeries compared to conventional surgeries [24-26], which are already giving good results over the medium term [27-29]. With the greater advances in interventionist cardiology, the heart surgeon is put under great pressure to use less invasive surgery and provide excellent results, which, we believe, start with off-pump surgeries. The data of the present series show that off-pump CABG operations are safe and efficient, presenting a low rate of complications and mortality, allowing good quality of anastomoses, as well as allowing total CABG. Currently, it is the method of choice in our institution for coronary artery surgeries.

BIBLIOGRAPHIC REFERENCES

1. Matata BM, Sosnowski AW, Galinanes M. Coronary artery bypass graft surgery off-pump on the beating heart abolishes inflammation and oxidative stress. *Artif Organ*. 1999;23:662-3.
2. Kirklin JK. Prospects for understanding and eliminating the deleterious effects of cardiopulmonary bypass. *Ann Thorac Surg*. 1991;51(4):529-31.
3. Brasil LA, Gomes WJ, Salomão R, Buffolo E. Inflammatory response after myocardial revascularization with or without cardiopulmonary bypass. *Ann Thorac Surg*. 1998;66(1):56-9.
4. Ascione R, Lloyd CT, Lotto AA, Pitsis AA, Angelini GD. Inflammatory response after coronary revascularization with or without cardiopulmonary bypass. *Ann Thorac Surg*. 2000;69(4):1198-204.
5. Buffolo E, Andrade JCS, Branco JN, Teles CA, Aguiar LF, Gomes WJ. Coronary artery bypass grafting without cardiopulmonary bypass. *Ann Thorac Surg*. 1996;61(1):63-6.
6. Benetti FJ. Direct coronary surgery with saphenous vein bypass without either cardiopulmonary bypass or cardiac arrest. *J Cardiovasc Surg*. 1985;26(3):217-22.
7. Mack MJ. Beating heart surgery for coronary revascularization: is it the most important development since the introduction of the heart-lung machine? *Ann Thorac Surg*. 2000;70(5):1774-8.
8. Milani RM, Brofman PRS, Moutinho JA. Morbidity and mortality impact in the myocardial revascularization without extracorporeal circulation. In: 12th World Congress on Cardiothoracic Surgery. Luzern, Switzerland;2002.
9. Moshkovitz Y, Lusky A, Mohr R. Coronary artery bypass without cardiopulmonary bypass: analysis of short-term and mid-term outcome in 220 patients. *J Thorac Cardiovasc Surg*. 1995;110(4 Pt 1):979-87.
10. Patel NC, Grayson AD, Jackson M, Au J, Yonan N, Hasan R et al. The effect off-pump coronary artery bypass surgery on in-hospital mortality and morbidity. *Eur J Cardiothorac Surg*. 2002;22(2):255-60.
11. Pinheiro BB, Fagundes WV, Ramos MC, Azevedo VLB, Silva JM. Revascularização do miocárdio sem circulação extracorpórea em pacientes multiarteriais: experiência de 250 casos. *Rev Bras Cir Cardiovasc*. 2002;17(3):242-7.
12. Lobo Filho JG, Leitão MCA, Lobo Filho HG, Soares JPH, Magalhães GA, Leão Filho CSC et al. Cirurgia de revascularização coronariana esquerda sem CEC e sem manuseio da aorta em pacientes acima de 75 anos: Análise das mortalidades imediata e a médio prazo e das complicações neurológicas no pós-operatório imediato. *Rev Bras Cir Cardiovasc*. 2002;17(3):208-14.
13. Clark RE. The STS Cardiac Surgery National Database: an update. *Ann Thorac Surg*. 1995;59(6):1376-81.
14. Roques F, Nashef SA, Michel P, Gauducheau E, de Vincentiis C, Baudet E et al. Risk factors and outcome in European cardiac surgery: analysis of the EuroSCORE multinational database of 19030 patients. *Eur J Cardiothorac Surg*. 1999;15(6):816-23.
15. Nashef SA, Roques F, Michel P, Gauducheau E, Lemeshow S, Salamon R. European System for Cardiac Operative Risk Evaluation (EuroSCORE). *Eur J Cardiothorac Surg*. 1999;16(1):9-13.
16. Milani RM. Análise dos resultados imediatos da operação para revascularização do miocárdio sem pinçamento total da aorta [Tese de mestrado]. Curitiba:Universidade Federal do Paraná, 2000.
17. Fiore AC, Naunhein KS, McBride LR, Peigh PS, Pennington DG, Kaiser GC et al. Fifteen-year follow-up for double internal thoracic artery grafts. *Eur J Cardiothorac Surg*. 1991;5(5):248-52.
18. Lima RC. Padronização técnica de revascularização miocárdica da artéria circunflexa e seus ramos sem circulação extracorpórea [Tese de doutorado]. São Paulo: Universidade Federal de São Paulo. Escola Paulista de Medicina, 1999.
19. Rivetti LA, Gandra SM. Initial experience using an intraluminal shunt during revascularization of the beating heart. *Ann Thorac Surg*. 1997;63(6):1742-7.
20. Bowles BJ, Lee JD, Dang CR, Taoka SN, Johnson EW, Lau EM et al. Coronary artery bypass performed without the use of cardiopulmonary bypass is associated with reduced cerebral microemboli and improved clinical results. *Chest*. 2001;119(1):25-30.
21. Tang AT, Knott J, Nanson J, Hsu J, Haw MP, Ohri SK. A prospective randomized study to evaluate the renoprotective action of beating heart coronary surgery in low risk patients. *Eur J Cardiothorac Surg*. 2002;22(1):118-23.
22. Eryilmaz S, Corapcioglu T, Eren NT, Yazicioglu L, Kaya K, Akalin H. Off-pump coronary artery bypass surgery in the left ventricular dysfunction. *Eur J Cardiothorac Surg*. 2002;21(1):36-40.
23. Stamou SC, Pfister AJ, Dangas G, Dullum MK, Boyce SW, Bafi AS et al. Beating heart versus conventional single-vessel reoperative coronary artery bypass. *Ann Thorac Surg*. 2000;69(5):1383-7.
24. Racz MJ, Hannan EL, Isom OW, Subramanian VA, Jones RH, Gold JP et al. A comparison of short and long-term outcomes after off-pump and on-pump coronary artery bypass graft surgery with sternotomy. *J Am Coll Cardiol*. 2004;43(4):557-64.

25. Gerola LR, Buffolo E, Jazbik W, Botelho B, Bosco J, Brasil LA et al. Off-pump versus on-pump myocardial revascularization in low-risk patients with one or two vessel disease: perioperative results in a multicenter randomized controlled trial. *Ann Thorac Surg*. 2004;77(2):569-73.
26. Mack MJ, Pfister A, Bachand D, Emery R, Magee MJ, Connolly M et al. Comparison of coronary bypass surgery with and without cardiopulmonary bypass in patients with multivessel disease. *J Thorac Cardiovasc Surg*. 2004;127(1):167-73.
27. Reston JT, Tregear SJ, Turkelson CM. Meta-analysis of short-term and mid-term outcomes following off-pump coronary artery bypass grafting. *Ann Thorac Surg*. 2003;76(5):1510-5.
28. Lima RC, Escobar MAS, Lobo Filho JG, Diniz R, Saraiva A, Césio A et al. Resultados cirúrgicos na revascularização do miocárdio sem circulação extracorpórea: análise de 3410 pacientes. *Rev Bras Cir Cardiovasc*. 2003;18(3):261-7.
29. Aguiar LF, Andrade JCS, Branco JN, Palma JH, Teles CA, Gerola LR et al. Revascularização do miocárdio sem circulação extracorpórea: resultados da experiência de 18 anos de sua utilização. *Rev Bras Cir Cardiovasc*. 2001;16(1):1-6.