Surgical Myocardial Revascularization: Off-Pump Use of Bilateral Internal Thoracic Artery Grafting

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Summary

Background: Advances in surgical myocardial revascularization (MR) have introduced additional benefits with the off-pump (OP) technique and the use of bilateral internal thoracic artery (ITA) grafting. Off-pump surgical MR has been associated with improved immediate outcomes and reduced incidence of perioperative complications, and the use of bilateral ITA grafts provides increased survival and decreased cardiovascular events in the long term.

Objective: To present the initial experience with the combined use of these advances in surgical MR.

Methods: A total of 35 consecutive patients undergoing off-pump MR with bilateral ITA grafting were studied; the left ITA was directed toward the anterior descending artery and the right ITA was anastomosed to the circumflex artery branches. The predominant comorbidities were previous myocardial infarction in 71.4% of the patients, diabetes mellitus in 34.2%, and renal failure in 14.2%.

Results: No patients presented electrocardiographic changes or enzyme elevation in the postoperative period. The number of bypasses per patient ranged from two to four (median of three bypasses/patient). Postoperative hospital stay ranged from three to 12 days (mean of 4.7 + 1.7 days). No cases of sternal dehiscence or infection were observed, but one patient suffered a stroke on the fourth postoperative day and died. Late follow-up lasted from four to 48 months. No late deaths occurred, 31 patients are asymptomatic, and three have residual angina.

Conclusions: The combination of these technical advances in surgical myocardial revascularization proved efficient and able to contribute to improved benefits in the long term. (Arq Bras Cardiol 2008;90(1):18-23)

Key words: Myocardial revascularization; thoracic arteries; extracorporeal circulation.

Introduction

Coronary artery bypass grafting (CABG) is the most efficient therapeutic method for the treatment of coronary artery disease in certain subgroups of patients, particularly those at a higher risk[1]. Advances in surgical MR have introduced additional benefits, such as the off-pump technique and the use of bilateral internal thoracic artery (ITA) grafting.

Off-pump coronary artery bypass surgery (OPCAB) has been associated with improved immediate outcomes and reduced incidence of perioperative complications[2-4]. Furthermore, observational studies conducted in the past decade demonstrated that the bilateral use of ITA grafting provides patients with additional benefits, thus improving long-term outcomes. Increased survival and decreased risk of cardiovascular events are observed in comparison with single ITA and saphenous vein grafting[5,6]. These benefits are verified when bilateral ITA grafts are directed toward the left coronary artery system, and are demonstrated even in patients at a higher risk, as is the case of diabetics, elderly patients, and those with left ventricular dysfunction[5-8]. Additionally, the introduction of the skeletonized ITA harvesting enabled a wider use of both ITA grafts by reducing the risks of infectious complications and sternal dehiscence[9,10].

Therefore the combination of these techniques may provide additional advantages in the surgical treatment by reducing perioperative mortality and improving late outcomes.

The initial experience with the combined use of these advances in surgical MR is presented.

Methods

Patients - In this series, 35 patients consecutively undergoing off-pump surgical MR using bilateral ITA grafting were studied; the left ITA was directed toward the anterior descending artery (AD), and the right ITA was passed behind the aorta through the transverse sinus, and anastomosed to the circumflex artery (Cx) branches. The case series comprises 28 male patients and seven female patients, with age ranging from 41 to 76 years (mean of 56.0 ± 8.6 years). The associated comorbidities were previous myocardial infarction in 25 patients (71.4%), diabetes mellitus in 12 (34.2%), renal failure in five (14.2%) – of which two were undergoing chronic hemodialysis, peripheral arterial disease

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in three (8.5%), and liver cirrhosis, Chagas disease and AIDS in one patient each (2.8%).

Ejection fraction, as measured by echocardiography (Teichholz method), ranged from 42% to 73% (mean of 62.5 ± 9.4%). All patients are being followed-up on an outpatient basis. The study protocol was approved by the Institutional Ethics Committee.

Technique - The surgical technique used has been previously described[11]. In summary, plasma expansion is performed with crystalloid solutions and synthetic colloids in the beginning of the operation in order to optimize the preload and provide hemodynamic stability during heart displacement to expose the coronary arteries and perform the anastomoses. Inotropic support, when necessary, is achieved with the temporary use of dobutamine administered via infusion pumps. Heparin was used for anticoagulation, at a dose to keep activated clotting time above 250 seconds.

The operations were performed via median sternotomy and both ITAs were dissected in the skeletonized fashion using a meticulous technique for clipping and sectioning of the arterial branches from their origin up to the bifurcation. In all cases, the left ITA was used for grafting the left anterior descending (LAD) artery, and the right ITA was passed behind the aorta through the transverse sinus and anastomosed to the marginal artery (Figure 1).

As an operative strategy, the left ITA is always initially anastomosed to the LAD, and next is revascularized the posterior descending artery. This sequence is followed because the heart displacement necessary to obtain exposure of these two arteries is small and hemodinamically well tolerated. These two revascularized arteries and subsequent adequate perfusion of the anterior and inferior heart walls enable, in the sequence, a medial heart displacement to expose the lateral wall and anastomosis of the right ITA to the marginal artery. Whenever possible diagonal arteries were revascularized with sequential left ITA or saphenous vein grafts (Figure 1). For posterior descending artery revascularization, saphenous vein or right gastroepiploic artery grafts were used. Closed plication of a left ventricular apical aneurysm was simultaneously performed in one patient.

Exposure and stabilization of the coronary arteries are obtained with the help of an Octopus®3 suction stabilizer (Medtronic, Inc.), use of a single Lima stitch, and sometimes use of the Starfish® positioner (Medtronic, Inc.) fixed to the OctoBase® retractor (Medtronic, Inc.). More recently, in the second half of these series, an autotransfusion system was used for intraoperative blood retrieval.

Results

In the intraoperative period the heart displacement maneuvers for anastomosis construction was well tolerated by all patients, with six of them requiring temporary inotropic support with dobutamine for the performance of the anastomosis with the marginal artery. No patient presented postoperative electrographic changes or enzyme elevation; likewise, no patient required mediastinal reexploration for bleeding. The number of bypasses per patient ranged from two to four, with a median of three bypasses per patient. Left ITA was used for sequential revascularization of the AD and diagonal in seven patients. The right gastroepiploic artery was used for revascularization of the posterior descending artery in four cases, and segments of reversed saphenous vein were used in the remaining cases. No sternal dehiscense or

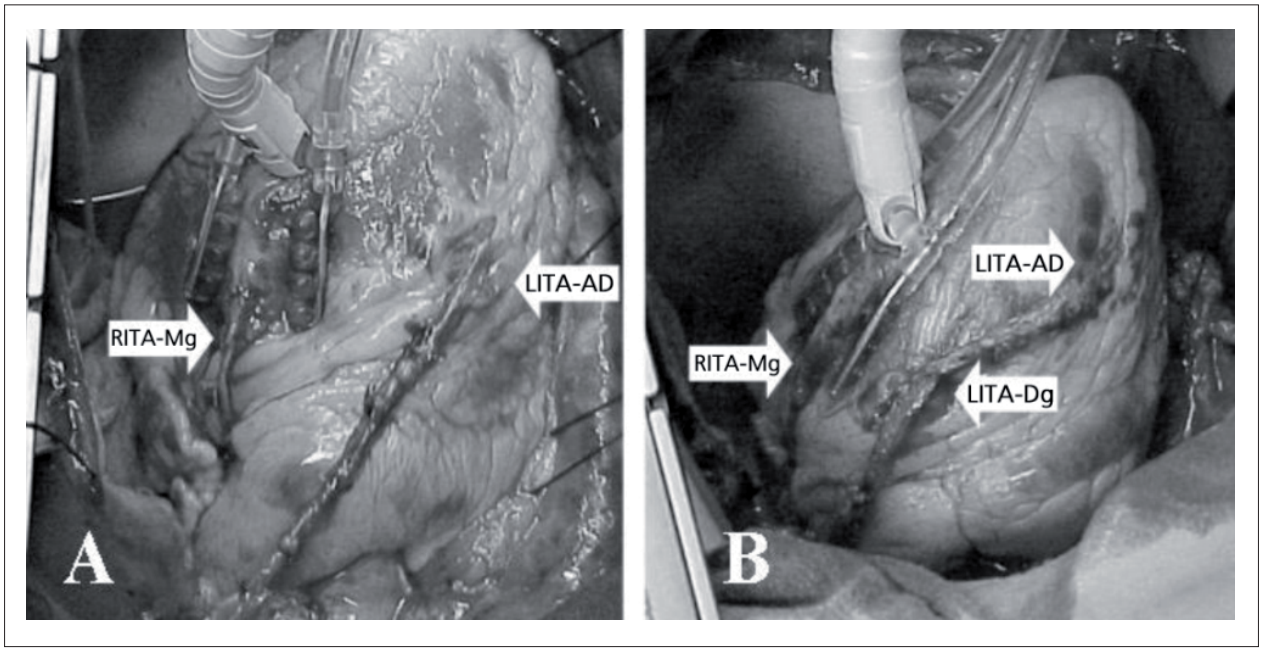

Fig. 1 - A - Image showing anastomosis of the left internal thoracic artery with the anterior descending coronary artery, and anastomosis of the right internal thoracic artery with the marginal artery B - The left internal thoracic artery was used to revascularize the anterior descending coronary artery and its diagonal branch sequentially; LITA - left internal thoracic artery, DA - anterior descending coronary artery, RITA - right internal thoracic artery, Mg - marginal artery, Dg - diagonal branch.

infection, nor significant postoperative complications were observed, except for one patient who suffered a stroke in the fourth postoperative day, and progressed with cerebral infarction and death on the twenty first postoperative day. Two patients had superficial wound infection in the site from which the saphenous vein was harvested.

Postoperative hospital stay ranged from three to 12 days, with a mean of 4.7 ± 1.7 days. The postoperative follow-up lasted from four to 48 months (mean of 19.2 ± 14.3 months), and was completed in all patients. In the follow-up period, all patients are alive. Thirty one of them are asymptomatic, and three remain with angina (two with class II angina, and one with class III angina, according to the classification of the Canadian Cardiovascular Society – CCS). One patient underwent angioplasty due to the progression of the coronary disease in a non-revascularized artery, and remains in class III (CCS). Five patients underwent postoperative coronary angiography, two at the cardiologist's discretion and three because of chest discomfort. In the repeat angiographic study, the bilateral ITA grafts were patent in all cases (Figure 2).

Discussion

Current scientific evidence corroborates that surgical MR is the most efficient method for the treatment of coronary artery disease in patients at a higher risk for cardiovascular events[1]. Longer survival with improved relief of anginal symptoms - therefore an improved quality of life - is observed.

Undoubtedly, the major contributions for surgical MR in the past decades were the introduction of the off-pump technique and the demonstration of long-term outcomes with the use of bilateral ITA.

The use of cardiopulmonary bypass (CPB) is associated with a complex systemic inflammatory response and neurological changes that significantly contribute to the occurrence of perioperative complications. Recent studies have shown that off-pump surgical MR is safe and efficient, providing a reduction of immediate (perioperative) complications when compared to the on-pump technique[12-15]. In addition to avoiding CPB, there is also the advantage of not using total aortic clamping for infusion of cardioplegia. Since the 1990's, a significant change was observed in the demographics of patients referred for surgical MR, related, to a great extent, to the advanced age of this group of patients. As a consequence, neurological complications now account for a significant number of postoperative morbidities. Total aortic clamping has been deemed responsible for a great part of the neurological complications observed in the postoperative period of off-pump surgeries as a result of embolization of atheromatous debris[16].

Recent series demonstrate that off-pump MR significantly improves mortality and morbidity in all subgroups, especially in patients with higher operative risk factors[12-19]. Furthermore, hospital stay is reduced, with lower use of hospital resources and consequent lower costs when compared to the conventional technique[17-18].

Recently, a randomized controlled study comparing on-pump to off-pump MR demonstrated that patients undergoing the off-pump technique showed better clinical outcomes (lower need for blood transfusion and shorter duration of mechanical ventilation), shorter hospital stay and better cognitive function, with no difference in relation to graft patency[19].

The use of bilateral ITA grafting may give patients additional benefits, by providing longer survival and lower incidence of cardiovascular events when compared to single ITA grafting. This significant increase in survival occurs when both ITA grafts are grafted to the arteries of the left coronary system, that is, the left ITA is anastomosed to the LAD and the right ITA is anastomosed to the Cx branches (marginal arteries). The effect of the use of bilateral ITA grafting is a mean 15% increase in survival in 20 years[5,6].

These benefits also extend to patients at a higher risk, such

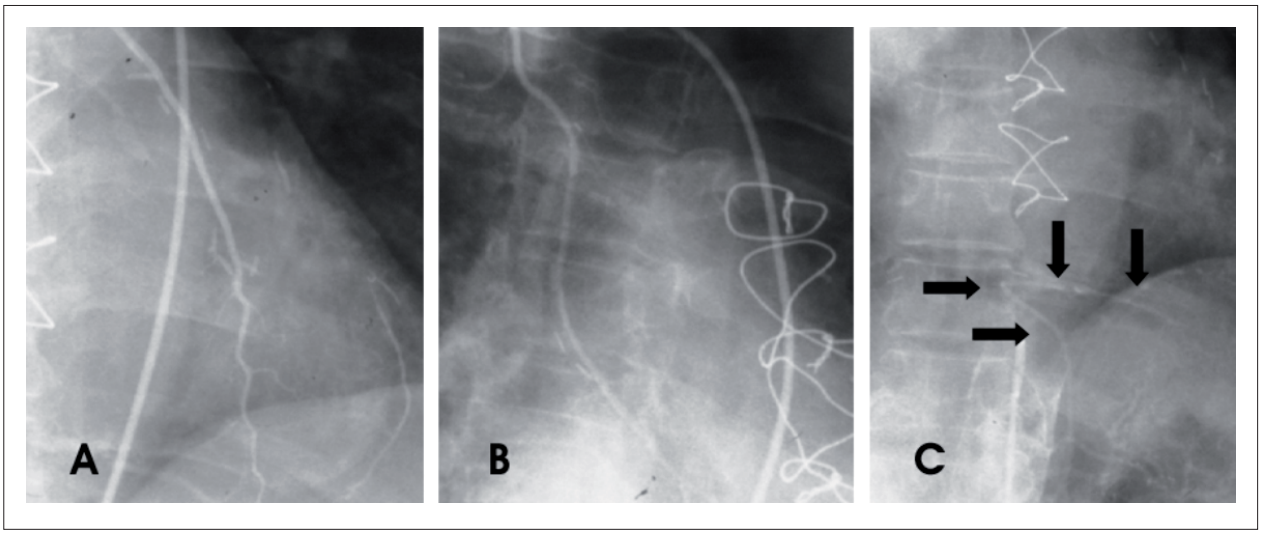

Fig. 2 - Postoperative angiographic study showing the left internal thoracic artery anastomosed to the anterior descending coronary artery (A), right internal thoracic artery anastomosed to the marginal artery (B), and right gastroepiploic artery used to revascularize the posterior descending artery (arrows) (C)

as diabetics, elderly patients and those with left ventricular dysfunction[5-8]. Particularly in diabetics, the use of bilateral ITAs has shown improved long-term survival and reduced need for further revascularization procedures[20,21]. In our case series, diabetics accounted for one third of the patients operated on.

More recently, large studies have confirmed that right ITA grafting through the transverse sinus and anastomosed to the Cx branches has an excellent long-term angiographic patency when compared to that of left ITA for the AD[22]. The technique of utilization of right ITA directed through the transverse sinus to revascularize the marginal artery was proposed by Puig et al[23] in the early 1980's.

Shah et al[24] studied the late patency of bilateral ITA grafts in a series of 1434 patients. With a mean 80-month follow-up, the authors demonstrated that 96.3% of the left ITA grafts and 90% of the right ITA anastomosed to the marginal artery were patent[24]. In the same experience, with a mean 99-month follow-up, 61% of the saphenous vein grafts were patent[25].

The ITA endothelial properties have been demonstrated to contribute to these improved outcomes. ITA grafts promote a nitric oxide release higher than those of the radial artery and saphenous vein grafts[26]. This makes the ITA an "live conduit" able to dilate (caliber adaptation) and, consequently, to increase blood flow in response to the coronary bed demand and to the myocardial area supplied. Furthermore, the increased production of nitric oxide by the ITA endothelium is able to reduce and prevent the atherosclerotic process in the distal bed of the coronary artery that was revascularized with this graft[27].

Skeletonized ITA harvesting, as was used in this series, provides additional advantages. The conventional pedicled dissection, in which the ITA is harvested with endothoracic fascia, muscle, vein, and periadventitial tissues, reduces the sternal blood supply and may be the cause of postoperative complications. There is also a reduction in the blood supply of the intercostal muscles and phrenic nerve, thus resulting in a more significant postoperative respiratory dysfunction[28,29].

The skeletonization harvesting involves meticulous ITA dissection, with minimum damage to adjacent tissues and preservation of vascular trunks that account for the sternal blood supply[30-32] (Figure 3). As a consequence, less sternal complications (infection and dehiscense), improved preservation of the respiratory function and a lower incidence of postoperative pain and dysesthesia have been demonstrated. This enables a wider use of this technique in patients at a higher risk, such as diabetics and patients with chronic renal failure, without causing increased additional risk of sternal complications[9,10,30]. Another advantage of the skeletonization technique is that ITA grafts show a higher blood flow with greater length, thus permitting revascularization of more coronary arteries using the sequential technique, as shown in Figure 1[10].

In this operative technique, the order of revascularization is also a determinant factor for surgical success. The first artery to be revascularized has always been the AD, followed by the posterior descending or diagonal artery, and, finally, the Cx branches. This is necessary because during heart displacement for exposure of the lateral wall and visualization of the marginal artery the other heart segments need to be revascularized, to compensate the drop in cardiac output caused by the heart displacement.

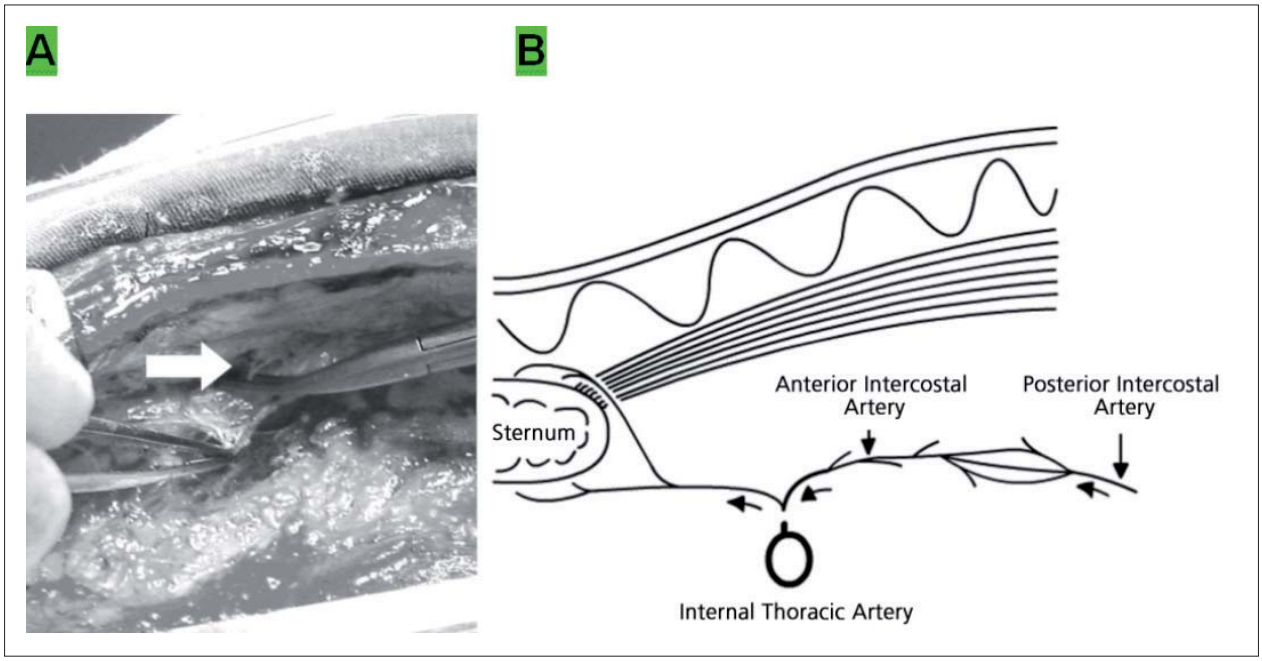

Fig. 3 - A - Careful clip ligation adjacent to the arterial truncus originating from the left internal thoracic artery and dividing into the anterior intercostal artery and sternal branch. Preservation of this trunk allows sternal blood flow to be maintained after internal thoracic artery harvesting. B - Schematic drawing showing the connection of the anterior intercostal artery with the posterior intercostal artery, which originates in the aorta and maintains continued sternal bone vascularization after internal thoracic artery harvesting.

Another important factor for the technical quality of this procedure is the use of stabilizers. In this case, we used the Octopus®3 suction stabilizer (Medtronic, Inc.), which enables the immobilization of the coronary artery and performance of better quality anastomoses. Recently, the use of the Starfish® positioning system (Medtronic, Inc.) has enabled medial heart displacement, with apparent reduction of the hemodynamic changes.

The right gastroepiploic artery has been used to revascularize the right coronary artery branches, mainly the posterior descending artery, because of the anatomic position of its structures. This makes it possible to revascularize the three coronary arteries using only arterial grafts. Hirose et al[33] studied the angiographic patency of the right gastroepiploic artery and showed results of 98.7%, 91.1% and 84.4% at one, three and five years of follow-up, respectively.

An easy-to-use, low-cost intraoperative blood retrieval system developed in our service has allowed the retrieval of almost all the blood during surgeries, thus dramatically reducing the need for homologous blood transfusion in the second half of the series of patients operated on. Blood transfusion during surgical MR has been associated with a significant reduction in the long-term survival[34].

This initial case series demonstrates that, in selected patients, the off-pump MR strategy using the right ITA anastomosed to the marginal artery is possible and technically successful. Furthermore, the additional use of the right gastroepiploic artery to revascularize the posterior descending artery enables the performance of off-pump MR using only arterial grafts. In theory, this MR strategy is close to the optimal quality model, because of its clinical benefits translated into the superiority of the arterial grafts over venous grafts and its use without the need for ECC.

Conclusion

In conclusion, these technical advances used in combination during surgical myocardial revascularization have proven effective and may contribute for improved benefits in the long term.

Potential Conflict of Interest

No potential conflict of interest relevant to this article was reported.

Sources of Funding

There were no external funding sources for this study.

Study Association

This study is not associated with any graduation program.

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