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Complete Myocardial Revascularization Using Arterial Grafts

Dr. Dallan

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Luiz Alberto Dallan, MD, PhD, Sérgio Almeida de Oliveira, MD, PhD, Luiz A. Lisboa, MD, Fernando Platania, MD, Fabio B. Jatene, MD, PhD, José Carlos R. Iglézias, MD, PhD, Carlos Abreu Filho, MD, Richard Cabral, MD, Adib D. Jatene, MD, PhD

Heart Institute, Hospital das Clínicas, Medical School, University of São Paulo, São Paulo, SP, Brazil

ABSTRACT

Background: Complete arterial revascularization is important in younger patients to reduce the likelihood of future reoperation. We assessed the short-term outcome of a strategy to provide complete arterial revascularization in a cohort of young patients.

Methods: Three hundred and eighty-five patients underwent myocardial revascularization using artery grafts alone and were followed up for 30 months. One hundred fourteen patients (29.6%) had single-vessel disease, 118 (30.6%) had two-vessel disease, and 153 (39.7%) had three or more obstructed coronary arteries. Eight of the patients had undergone previous surgical revascularization. The left internal thoracic artery (LITA) was routinely used for the left anterior descending branch (LAD). In 103 patients (28.1%), the in situ right internal thoracic artery (RITA) was used for revascularization of the right coronary artery (RCA) and its branches. The RITA was sometimes used as a free graft from the aorta or as an artificial "Y" from the LITA to the diagonal and marginal branches. Other arterial conduits included the radial artery (RA) in 215 patients (55.8%), the right gastroepiploic artery (RGEA) in 24 patients (6.3%), and the inferior epigastric artery (IEA) in four patients (1.1%).

Results: In patients having lesions in three or more arteries, the mean number of distal anastomoses was 3.2 per patient. There were no intraoperative deaths. Hospital mortality was 1.8% (n = 7). Of the fatal cases, two were redos and two underwent combined procedures (one for left ventricular aneurysm and one for double valve replacement), while only three of the fatal cases underwent revascularization as a primary and isolated procedure.

Conclusions: Complete arterial reconstruction carries an acceptably low operative mortality and excellent short-term follow-up. This strategy is particularly important for young patients to reduce the probability of future reoperation.

INTRODUCTION

Direct myocardial revascularization has also undergone several technical changes since it was first introduced. In 1968, René Favarolo and the Cleveland Clinic surgeons popularized the use of the greater saphenous vein as a bridge between the ascending aorta and the obstructed coronary arteries [Favarolo 1968]. Initially proposed for the treatment of right coronary stenosis, saphenous vein grafts (SVGs) proved to be very versatile and quickly were adapted for revascularization of all regions of the heart, with good initial results.

Saphenous vein grafts were considered optimal vascular conduits for coronary artery bypass since they were easy to remove and prepare and could be used for multiple grafts. However, the weaknesses of the saphenous vein as a conduit were exposed over a period of 10 to 12 years after its initial use. The main weaknesses are: (1) accelerated progression of intimal hyperplasia and atherosclerosis, and (2) persistent incidence of lower extremity wound complications due to saphenous harvesting.

After the 1970s, the internal thoracic artery (ITA) was favored as an excellent alternative to saphenous veins for myocardial revascularization. Initially, it was mostly used in patients without adequate saphenous veins, or in patients with single-vessel disease. Loop et al. reported the use of

Address correspondence and reprint requests to: Luís Alberto Dallan, Divisão Cirúrgica, Av. Dr. Enéas de Carvalho Aguiar 44, Cerqueira César, São Paulo – SP, Brazil, Cep: 05403-000, Phone: 55-11-3069-5014, Fax: 55-11- 3069-5415, Email: dcidallan@incor.usp.br

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Figure 1. Angiography of a saphenous graft for left anterior descending branch (LAD) of the left coronary artery after 12 years. Despite being patent, the graft shows a critical block (see arrow).

this graft in 175 consecutive patients with a mortality of 0.6% [Loop 1973]. Subsequent data from the Cleveland Clinic indicated the importance of the left internal thoracic artery (LITA) to left anterior descending (LAD) anastomosis in preventing late cardiac events and reoperation.

Excellent long-term patency of the LITA-LAD anastomosis began to convince other surgical programs to incorporate internal thoracic arteries into their procedures. Initial reticence was based on concerns about perceived difficulties with its dissection, fragility, vascular spasm, and limitations in the initial flow rates. However, with broadening experience and improved surgical techniques, these concerns were gradually dispelled. Publications from such renowned centers as the Cleveland Clinic [Loop 1986], and others, proved the efficacy of ITA grafts for the long-term survival of patients, especially compared to long-term survival rates when using saphenous vein conduits alone. The influence of these studies led to the LITA surpassing the saphenous vein as the conduit of choice for myocardial revascularization.

Long-term angiographic patency of LITA-LAD grafts has been well documented. These data encouraged surgeons to use other arteries of similar diameter and wall characteristics as potential long-term coronary grafts, and in most cases with promising results. Among the newer and popular choices are the right gastroepiploic artery (RGEA), the inferior epigastric artery (IEA), and the radial artery (RA).

This study is aimed at evaluating the early clinical course of patients undergoing myocardial revascularization exclusively with arterial grafts.

MATERIALS AND METHODS

From July 1995 to December 1997 (30 months), 385 patients received full myocardial revascularization without venous grafts. Eighty-one percent of the patients were male. The mean age of the patient group was 58.6 years (range 36-78 years). Eight patients had undergone previous revascularization ("redo"), 114 (29.6%) had single-vessel disease, 118 (30.6%) had two-vessel disease, and 153 (39.7%) had lesions in three or more coronary arteries.

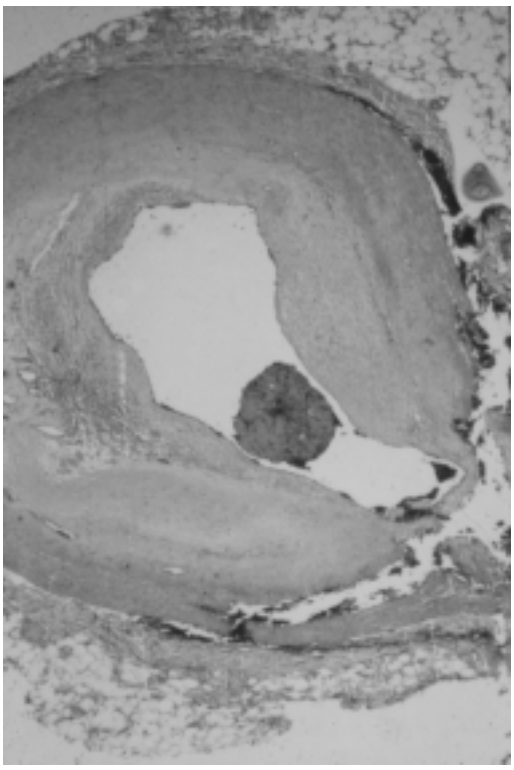

Figure 2. Histological section of the saphenous vein used in myocardial revascularization. Significant hypertrophy may be observed in the media, combined with atherosclerosis and luminal thrombosis.

The LITA was routinely used for the LAD. The right internal thoracic artery (RITA) was used in situ for the main right coronary artery (RCA), the diagonal branches of the LAD, or the left marginal branches. Proximal anastomosis of the RA was preferably used in an artificial "Y" from the LITA, and was subsequently anastomosed to the branches of the lateral wall of the heart. The RGEA was used in situ for the right coronary branches.

RESULTS

The LITA was used in 374 patients (97.1%), and the RITA in 108 patients (29.1%). The RA was used in 215 patients (55.8%), the RGEA in 24 patients (6.3%), and the IEA in four patients (1.1%). Overall, 809 arterial grafts were used in this group of patients, with 839 coronary anastomoses. In patients with lesions in three or more obstructed arteries, the mean number of revascularized coronary targets was 3.2 per patient.

There were no intraoperative deaths. Hospital mortality was 1.8% (n = 7). Of the fatal cases, two were redo's, two

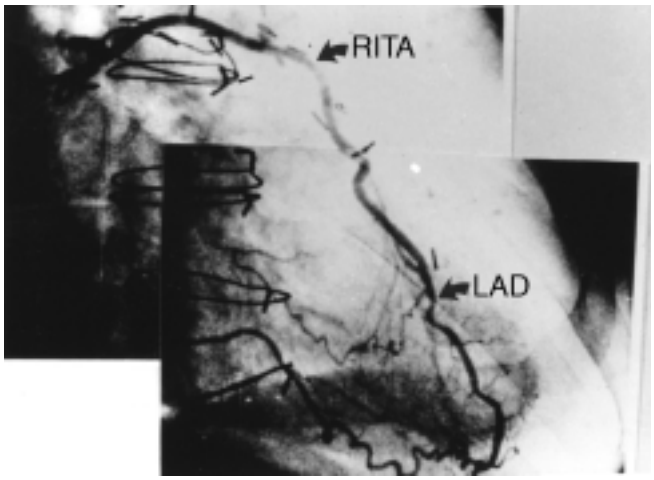

Figure 3. Angiography of the right internal thoracic artery (RITA) used as a free graft between the aorta and the anterior descending branch after seven years).

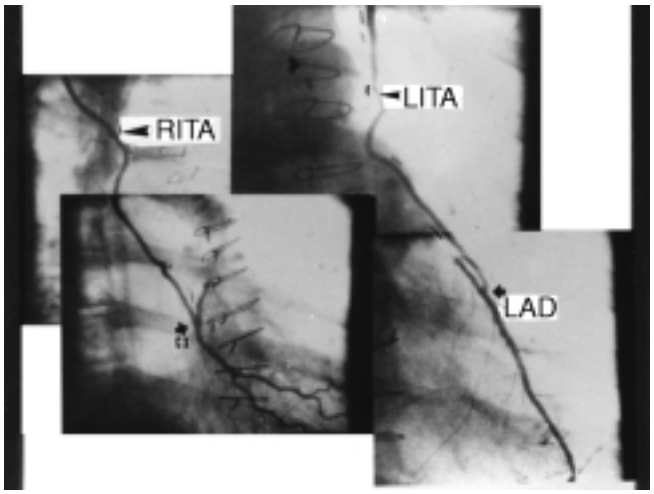

Figure 4. Angiography of both internal thoracic arteries used in situ in the same patient. The right internal thoracic artery (RITA) was anastomosed by retro-aortic route at the circumflex artery (CX). The left internal thoracic artery (LITA) was anastomosed to the LAD (see arrow).

had combined procedures (one for left ventricular aneurysm and one for double valve replacement), and three had undergone revascularization as a primary and isolated procedure. Only three of the seven fatalities died from low cardiac output syndrome.

DISCUSSION

Saphenous vein grafts often degenerate over time (Figure 1, ◎). The anatomicopathologic changes observed in their structure, however, are different than those observed in the coronary arteries. Studies of veins obtained from reoperations or necropsies show that, some months after the initial surgery, most of these grafts reveal some degree of hyperplasia of the intimal layer. Although this hyperplasia is not responsible for graft occlusion, it is likely a cause for the development of late venous atherosclerosis [Lytle 1994].

Venous grafts assessed after three years frequently display lipid infiltration into the media. The atherosclerotic process tends to be progressive and may, especially after the fifth postoperative year, develop stenosis with clinical symptoms. Venous atherosclerosis, as opposed to sclerosis of the coronary artery, tends to be circumferential, diffuse, and extremely friable (Figure 2, ◎).

The development of atherosclerosis in venous grafts is more frequent and rapid in patients with diabetes, hypercholesterolemia (>300 mg/dl) and hypertriglyceridemia (>180 mg/dl) [Lytle 1991]. Unfortunately, even patients with normal serum lipids are at risk of developing graft atherosclerosis. However, there is evidence that postoperative treatment with diet and drugs that decrease serum lipids may attenuate graft occlusion.

Angiographic studies carried out by Lytle et al. [Lytle 1991] evaluating 646 patent saphenous grafts observed that after 5 to 12 postoperative years, 19% of the grafts developed atherosclerotic stenosis and 26% were totally occluded. Even though the saphenous vein is considered an excellent graft for elderly or hemodynamically unstable patients, the evidence reported above has led to the choice of internal thoracic artery grafts over venous grafts in younger patients.

Kolessov [Kolessov 1967] pioneered the use of the ITA graft in six patients. In five of them the ITA was anastomosed into the anterior descending branch and in the remaining patient into the circumflex artery, with one fatality. However, the surgical planning was based only on clinical data and electrocardiograms, and most of these patients were operated upon without hemodynamic studies.

Green et al. [Green 1968] based on an experimental study in 42 dogs, operated on two patients whose ITAs were anastomosed to the anterior interventricular branch. The authors of the Green article used a microscope with 16X power to perform the anastomosis. According to the authors, at least 120 to 160 hours of laboratory training were required to master the surgical technique using an operative microscope. For this reason, in 1970 Favaloro et al. started to perform the anastomosis without a microscope, using instead 3.5X optical magnifying lenses [Favarolo 1968]. This technical simplification facilitated the use of ITA grafts by other centers and permitted their use for additional targets, such as the diagonal and circumflex arteries.

The advantage of myocardial revascularization using only arterial grafts is based on the superior long-term survival of these grafts compared to the saphenous vein. Evidence is based on the low mortality and morbidity observed in selected groups of patients, especially young ones, operated upon in the late 1970s and early 1980s. The follow-up of patients using the internal thoracic artery

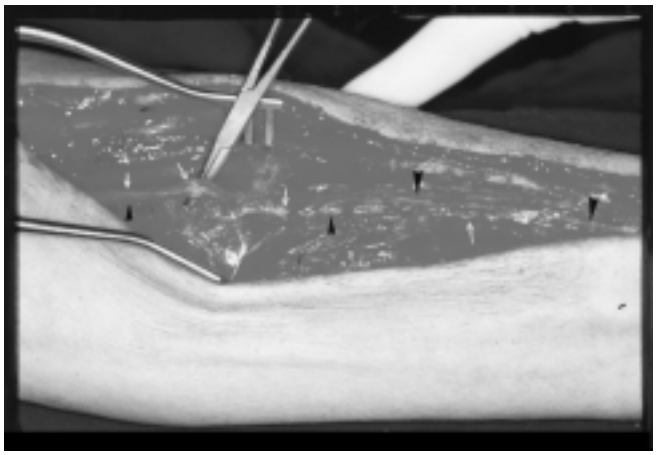

Figure 5 Radial artery (RA) of the left arm (see arrows), with posterior ligature of the collateral branches.

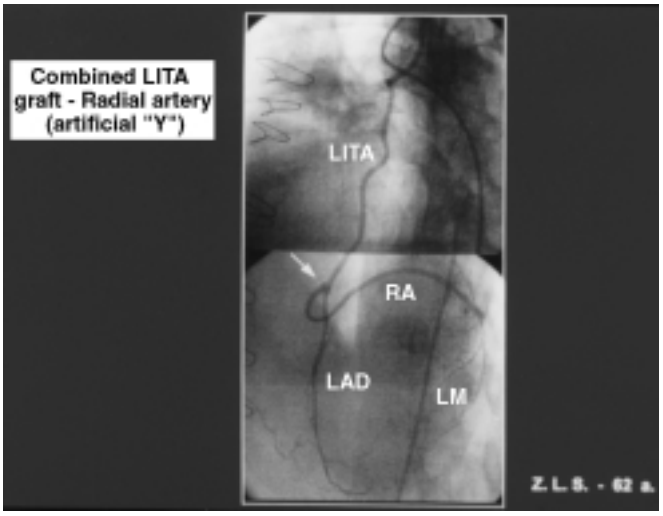

Figure 7. Postoperative angiography, showing a combined graft between the left internal thoracic artery (LITA) and the radial artery (RA), revascularizing LAD, and the left marginal artery (LM) of the left coronary artery.

showed that the ITA maintained its patency in a large number of patients throughout the years, suggesting that they are resistant to atherosclerosis. Moreover, ITA grafts provided a higher late survival rate and lower reoperation rates when compared to venous grafts alone.

This evidence and the experience acquired in the last two decades has led us to expand our use of multiple arterial grafts. In our current series, the LITA was used in 97.1% of the patients, mostly for the LAD. The RITA was used in 29.1% of the patients in this study, especially for the RCA or its branches. Harvesting the RITA as a skeletonized graft will allow it to become elongated enough to reach the beginning of the RCA branches along the diaphragmatic wall. It was also used by the retro-aortic route for the circumflex artery branches (Figure 4, ◎), as suggested by Puig et al. [Puig 1984]. The in situ anastomosis of the RITA to the LAD, although possible, may lead to problems in a future reoperation since it crosses the anterior mediastinum just under the sternum.

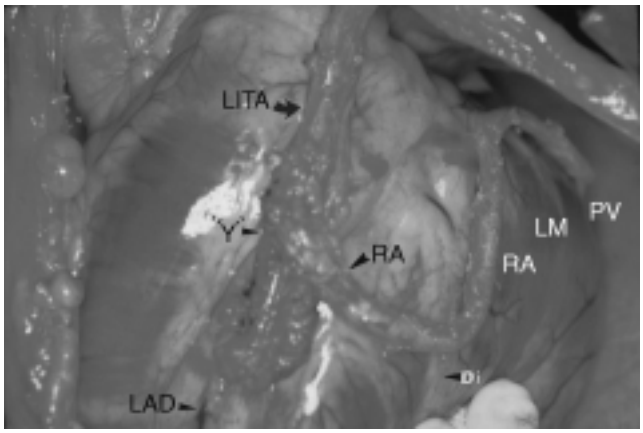

Figure 6. Anastomoses of the proximal pedicle of the radial artery (RA) directly into the left internal thoracic artery (LITA) ("Y"), which was in turn anastomosed to the LAD. The RA was then anastomosed to the diagonal (Di), left marginal (LM), and posterior ventricular (PV) arteries of the left coronary artery.

The disadvantages of the ITA graft are few. It rarely develops atherosclerosis and its diameter is usually appropriately matched to the diameter of the target coronary artery. Length limitations may be overcome by using it as a free graft (Figure 3, ◎). With increasing experience, we have noted fewer contraindications to its use. Currently, elderly patients can receive at least one of these arteries. However, we have avoided the use of both thoracic arteries in insulin-dependent diabetic patients to reduce the probability of sternal wound infection. We have also avoided ITA grafts in cases of subclavian artery stenosis, in acute myocardial infarction, and in cases of mild stenosis of the arteries to be revascularized in order to avoid problems with competitive flow.

The radial artery has been used as an important alternative in myocardial revascularization, especially in combination with the ITA, in order to achieve complete arterial reconstruction (Figure 5, ◎). Evidence of radial artery spasm, confirmed by early postoperative angiography, which disappears after 6 to 12 months suggests that RA grafts experience decreased vascular tone over time. We believe that administration of calcium-channel blockers is mandatory in the early postoperative period after RA grafts.

The radial artery was initially used as a free graft from the aorta to less important branches of the left coronary artery. Soon, however, it was used for the revascularization of all coronary branches. Its diameter, usually close to 3 mm, allows for the performance of several sequential anastomoses without concern for luminal narrowing. This, combined with the hypothesis of greater spasm when undergoing direct aortic pressure, has led most surgeons to anastomose the proximal RA to the LITA [Dallan 1996]. In our

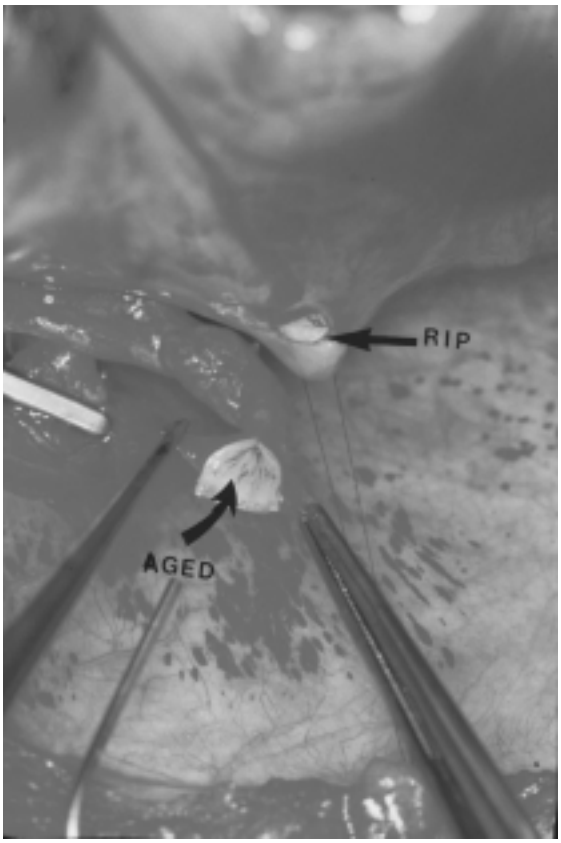

Figure 8: Preparation for anastomosis between the right gastroepiploic artery (RGEA) and posterior interventricular branch (PIB) of the right coronary artery. The excellent caliber of the RGEA, superior than the caliber of the coronary artery is shown in this figure.

series, the RA was used in 215 patients (55.8%). In approximately 35% of these patients, the RA was anastomosed end-to-side to the LITA, making an artificial "Y". This technique permits revascularization of all the major left coronary vessels using just the LITA and an RA segment (Figure 7, ◎).

The same technique is possible with the inferior epigastric artery. Initially used from the aorta to the diagonal coronary branches, the IEA has been combined with other arterial grafts, especially the LITA. The IEA has been shown to be extremely beneficial as an extension for the LITA during minithoracotomies. When the LITA is too short to reach the LAD, 3 to 4 cm of the IEA can be harvested using an infraumbilical abdominal incision and attached to the LITA.

Since 1984, the right gastroepiploic artery has been used in situ or as a free graft. A large clinical experience with the RGEA was obtained in Japan, especially through studies carried out by Suma et al. [Suma 1993], who observed a graft patency rate of 96% in early postoperative studies and 95% after two years of follow-up.

In most cases, the RGEA pedicle easily reaches the distal LAD or the inferior and lateral branches of the cardiac wall. We prefer to anastomose the RGEA to the right coronary trunk or into the posterior interventricular branch (Figure 8, ◎). In 24 patients (6.3%), the RGEA was used in situ for the RCA and its branches.

CONCLUSION

We conclude that complete myocardial revascularization may be carried out using arterial grafts alone with low morbidity and mortality rates in a selected group of young patients. The favorable long-term clinical results observed with the use of arterial grafts, especially with the ITA, has led us to choose them over venous grafts.

REFERENCES

1. Dallan LA, Oliveira SA, Jatene FB, Corso R, Iglesias JCR, Prates N, Souza JM, Verginelli G, Jatene AD. Artéria radial na ampliação do uso de enxertos arteriais para revascularização do miocárdio: considerações anatômicas e tática cirúrgica. Rev Bras Cir Cardiovasc 11(2):75-81, 1996.
2. Favaloro RG. Saphenous vein autograft replacement of severe segmental coronary artery occlusion: operative technique. Ann Thorac Surg 5(4):334-9, 1968.
3. Green GE, Stertzer SH, Reppert EH. Coronary arterial bypass grafts. Ann Thorac Surg 5(5):443-50, 1968.
4. Kolessov VI. Mammary artery-coronary artery anastomosis as method of treatment for angina pectoris. J Thorac Cardiovasc Surg 54(4):535-44, 1967.
5. Loop FD, Lytle BW, Cosgrove DM, Stewart RW, Goormastic M, Williams GW, Golding LA, Gill CC, Taylor PC, Sheldon WC, et al. Influence of the internal mammary-artery graft on 10-year survival and other cardiac events. N Engl J Med 314(1):1-6, 1986.
6. Loop FD, Spampinato N, Siegel W, Effler DB. Internal mammary artery grafts without optical assistance: clinical and angiographic analysis of 175 consecutive cases. Circulation 48(1 Suppl):III162-7, 1973.
7. Lytle BW. The clinical impact of atherosclerotic saphenous vein to coronary artery bypass grafts. Semin Thorac Cardiovasc Surg 6(2):81-6, 1994.
8. Lytle BW, Loop FD, Cosgrove DM, Ratliff NB, Easley K, Taylor PC. Long-term (5 to 12 years) serial studies of internal mammary artery and saphenous vein coronary bypass grafts. J Thorac Cardiovasc Surg 89(2):248-58, 1985.
9. Puig LB, Franca Neto L, Rati M, Ramires JA, da Luz PL, Pileggi F, Jatene AD. A technique of anastomosis of the right internal mammary artery to the circumflex artery and its branches. Ann Thorac Surg 38(5):533-4, 1984.
10. Suma H, Wanibuchi Y, Terada Y, Fukuda S, Takayama T, Furuta S. The right gastroepiploic artery graft: clinical and angiographic midterm results in 200 patients. J Thorac Cardiovasc Surg 105(4):615-23, 1993.