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ORIGINAL ARTICLE

Aortic valve surgery in patients who had undergone surgical myocardial revascularization previously†

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Abstract

OBJECTIVES: A very high percentage of patients submitted to coronary artery bypass grafting (CABG) develop symptomatic aortic disease requiring surgery upon ageing. The surgical risk of the redo procedure is controversial. We describe our recent experience with patients submitted to this surgery under such conditions.

METHODS: From July 1999 to July 2010, 51 patients (mean age, 70.3 ± 7.0 years, 86.3% male) submitted to CABG previously required aortic valve surgery (AVS). The mean interval between the surgeries was 7.1 ± 3.9 years. Twenty-one patients (41.2%) had also undergone AVS during the first surgery [12 patients (57.7%) had valve replacement and 9 patients (42.8%) had valvuloplasty]. At presentation, 51.0% were in New York Heart Association Class III/IV and the standard and logistic EuroSCOREs were 10.1 ± 2.5 and 20.9 ± 16.5%, respectively.

RESULTS: Aortic valve replacement was performed in 48 patients (94.1%). Two patients had undergone a surgery for the closure of a peri-prosthetic leak and one patient a valvuloplasty. Thirteen patients (25.5%) needed to undergo additional cardiac procedures, including root enlargement (three patients, 5.9%). Valve surgery was performed with non-dissection of the internal thoracic artery graft, when patented, and antegrade cardioplegic arrest of other territories. Hospital and 30-day mortality rate was 2% ($n = 1$). The mean duration of hospital stay was 13.0 ± 11.1 days. The most frequent complication was arrhythmias – in 25.5% of the patients, and mostly due to atrial fibrillation (19.6%). Permanent pacemaker for A-V block was required in 5.9% of the cases, stroke was documented in two cases (3.9%) and early re-intervention was observed in two cases.

CONCLUSIONS: Redo AVS performed in patients submitted to CABG previously results in mortality and morbidity rates that are much lower than what is expected, bringing clear benefits to the patients.

Keywords: Coronary artery bypass graft • Aortic valve surgery • Reoperation • Early outcomes

INTRODUCTION

A very high percentage of patients submitted to coronary artery bypass grafting (CABG) with no or minimal aortic valve gradient develop symptomatic aortic valvulopathy with hemodynamic compromise upon ageing [1]. Other patients at risk are those who had also undergone aortic valve surgery (AVS) during the first surgery and now present with recurrence of the disease. These patients, with underlying ischaemic and valvular pathology, need to undergo a reoperation, which has been reported to have a variable and controversial risk in the literature [2–9]. Many possible sources of risk have been identified, but the consensus has been observed for damage to the patent internal thoracic artery (ITA) grafts [3], haemorrhagic risk associated with the dissection of the adhesions [9, 10] and the possible myocardial injury associated with suboptimal myocardial protection [10, 11]. No ideal surgical option or myocardial protection method has been reported so far and all methods present risks. However, despite an arduous search, no specific risk factor, other than ageing, has been demonstrated to be associated with the increasing risk of reoperation [7, 8]. International risk evaluation scores, such as the EuroSCORE, estimate a substantially high mortality rate for these patients, occasionally a prohibitive risk. This is a situation that we have, however, not encountered in reality.

In this study, we aimed to evaluate the early outcomes in patients operated at our institution in this type of surgical setting during a recent 10-year period. We also aimed to characterize the population and analyse the results, pointing out our strengths and shortcomings.

MATERIALS AND METHODS

Study design, population and data collection

From July 1999 to July 2010, 3619 patients underwent an operation of the aortic valve at our institution. Of these, 51 patients (1.4%) had a history of having undergone CABG previously and

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were analysed retrospectively. Patients who had to undergo other concomitant procedures at primary or repeat operations were not excluded from the analysis.

Data were collected prospectively using a standardized written form by each involved surgeon, and validated and inputted into a computerized database by a database director and preoperative, operative and outcome variables were included.

Patient preoperative data

The preoperative characteristics of the patients are summarized in Table 1. The population studied consisted of 51 patients, 44 males (86%) and 7 females (14%), with a mean age of 70.3 ± 7.0 years (range: 54–80). The time span between CABG and AVS was 7.1 ± 3.9 years (range: 0.3–15.3 years). Only one patient had undergone the initial CABG elsewhere and one patient had undergone AVS as the third cardiac procedure. The calculated standard and logistic EuroSCOREs were 10.1 ± 2.5 and 20.9 ± 16.5%, respectively.

The mean number of grafts performed during the initial CABG was 2.2 ± 0.8 (range: 1–3). The pedicled left internal thoracic artery (LITA) was used in 44 patients (86.3%) to graft the left anterior descending artery (LAD) system. The right internal thoracic artery (RITA) was used as a free graft to the circumflex (five patients) or the right coronary (three patients) systems. Double ITA grafts were used in eight patients (15.7%). At the time of the second surgery, all the LITA grafts were patent and the overall rate of patency of the RITA grafts to the circumflex system was 88% and that to the RCA system was 74%.

Table 1: Preoperative patients' data[a]

Variable	No. (%)[b]
Mean age (years)	70.3 ± 7.0
Male	44 (86)
Body mass index (kg/m^2)	26.2 ± 2.1
Body surface area (cm^2)	175.8 ± 14.8
Time interval between CABG and AVS (years)	7.1 ± 3.9
Hypertension	38 (74.5)
Dyslipidemia	41 (80.4)
Smoking history	19 (37.3)
Peripheral vascular disease	10 (19.6)
Cerebrovascular disease	6 (11.8)
Diabetes mellitus	11 (21.6)
Previous carotid endarterectomy	5 (9.8)
COPD	5 (9.8)
Renal failure	6 (11.8)
Previous myocardial infarction	11 (21.6)
NYHA Class ≥III	45 (51.0)
Permanent atrial fibrillation	7 (13.7)
Number of previous grafts	2.2 ± 0.8
LVEF (%)	53.6 ± 18.2
Non-elective surgery	2 (3.9)
PASP (mmHg)	46.4 ± 13.2
Additive EuroSCORE	10.1 ± 2.5
Logistic EuroSCORE	20.9 ± 16.5

AVS: aortic valve surgery; COPD: chronic obstructive pulmonary disease; NYHA: New York Heart Association; LVEF: left ventricular ejection fraction; PASP: pulmonary artery systolic pressure.
[a] The definition of some of these variables are presented in Appendix A.
[b] For continuous variables, data are shown as the mean ± the standard deviation.

Twenty-one patients (41.2%) had undergone AVS during the first surgery [12 patients (57.7%) had prosthetic valve replacement and 9 (42.8%) had valvuloplasty], concomitant with mitral valvuloplasty in two patients. In the 12 patients who were submitted to prosthetic valve replacement in the first surgery, a mechanical valve was used in nine patients (75.0%) and a biological valve in three patients (25.0%). Six patients had undergone other procedures associated with CABG: mitral valvuloplasty in four patients, a pulmonary valve commissurotomy in one patient and plasty of the left coronary ostium in one patient.

In the sub-group of 30 patients who had not undergone AVS during the first surgery, the indication for the redo procedure was aortic stenosis in 18 patients (60%), with a mean gradient of 44 ± 12 mmHg and a mean valve area of 0.76 ± 0.29 cm^2. Four patients (13.3%) underwent an operation for aortic regurgitation, and eight (26.7%) for mixed disease. The aetiology of the valve disease was degenerative in 28 patients (93.3%) and rheumatic in two patients.

In the sub-group of 21 patients who had undergone AVS during the first surgery, the indication for operation was structural valve deterioration in 15 patients (71.4%) (six prosthetic and nine repair), non-structural dysfunction in two patients (paravalvular leak) and prosthetic valve endocarditis in four patients.

Technique of reoperation

The surgical approach that was followed was median resternotomy. Mediastinal and pericardial dissection was limited to the ascending aorta and the right atrium. A patent left internal thoracic artery (LITA) graft to the anterior descending territory was never dissected, controlled or clamped. Only a limited dissection of other proximal graft anastomoses was performed, just enough to avoid damage during aortic cross-clamping. All patients underwent cardiopulmonary bypass with moderate systemic hypothermia (25–28°). Cannulation was performed in the right atrium and the ascending aorta of all the patients. Decompression of the left ventricle was achieved by inserting a vent through the right superior pulmonary vein. Antegrade cold crystalloid cardioplegia was used in all the patients, injected in the aortic root or directly in the native coronary and graft ostia if aortic regurgitation was observed. If collateral backflow out of the left main ostium (from the patent LITA) obscured the operative field during AVS, pump flows were temporarily turned down for better visualization, or the ostium was occluded by placing a cardioplegia cannula. Concomitant CABG was always performed prior to AVS, in an empty beating or fibrillating heart, a technique described in detail in a previous report by our group, which had also been used in the original operation [12].

RESULTS

Operative data

The operative data are summarized in Table 2. Aortic valve replacement was performed in 48 patients (94.1%). Of these, 44 patients (86.3%) underwent replacement with a biological or mechanical prosthesis, and in four patients (7.8%), an aortic homograft was used. The type of prosthetic valve used was left to the surgeon's choice. In most cases, patients over the age of 70 years underwent aortic valve replacement with biological prostheses (n = 24; 47.1%) and patients under the age of 70 years

Table 2: Operative data

Variable	No. (%)[a]
Type of AVS	
Aortic valve replacement	
Mechanical	20 (39.2)
Biological	24 (47.1)
Aortic homograft	4 (7.8)
Paravalvular leak closure	2 (3.9)
Valvuloplasty	1 (2.0)
Size of prosthetic valve	22.6 ± 1.5 (range 20–25)
Type of surgery	
Isolated AVS	38 (74.5)
AVS + CABG	3 (5.9)
AVS + aortic root enlargement	3 (5.9)
AVS + mitral valve replacement	2 (3.9)
AVS + mitral and tricuspid valvuloplasty	2 (3.9)
AVS + mitral valvuloplasty	1 (2.0)
AVS + tricuspid valvuloplasty	1 (2.0)
AVS + ascending aorta replacement	1 (2.0)
CPB time (min)	71.9 ± 25.9
With associated procedures	90.8 ± 39.8
Without associated procedures	65.4 ± 14.9
Aortic cross-clamping time (min)	42.3 ± 13.6
With associated procedures	52.9 ± 14.7
Without associated procedures	38.7 ± 11.3
Re-entry problems	1 (2.0)

AVS: aortic valve surgery; CABG: coronary artery bypass grafting; CPB: cardiopulmonary bypass.
[a]For continuous variables, data are shown as the mean ± the standard deviation.

preferred mechanical prostheses ($n = 20$; 39.2%). In four patients with prosthetic valve endocarditis, an aortic homograft was used. Two patients were submitted to paravalvular leak closure and one patient to aortic valvuloplasty.

The majority of the patients (74.5%) were submitted to AVS alone, but 13 patients needed to undergo other procedures. Redo CABG was performed in three patients. Enlargement of the aortic annulus and root using a pericardial bovine patch was performed in three patients (3.9%). One patient had undergone ascending aorta replacement. Additional valvular procedures are listed out in Table 2.

The mean cardiopulmonary bypass and aortic cross-clamping times were 71.9 ± 25.9 and 42.3 ± 13.6 min, respectively.

One patient suffered injury of the LITA during sternal re-entry. The injury was repaired on cardiopulmonary bypass and the patient had an uneventful postoperative course.

Early outcome

The early results are summarized in Table 3 (and the definition of some of the postoperative complications are summarized in Appendix B.). The operative mortality rate was 2% ($n = 1$). One patient died 56 days after the procedure due to multi-system organ failure.

Six patients (11.8%) required inotropic support, but only one patient (2.0%) for >24 h. Mechanical support (left ventricular assistance) was used in one patient (2.0%). Eight patients (15.6%) developed acute renal failure, but none required dialysis. One patient (2.0%) had myocardial infarction (MI). It should be noted that cardiac enzymes are routinely not checked postoperatively,

Table 3: Early outcome results

Variable	No. (%)
Operative mortality	1 (2.0)
Inotropic support	6 (11.8)
Mechanical support	1 (2.0)
Myocardial infarction	1 (2.0)
Cerebrovascular accident	2 (3.9)
Acute renal failure	8 (15.6)
Respiratory failure	1 (2.0)
Reoperation for bleeding	1 (2.0)
Supraventricular arrhythmias	10 (20.0)
Prolonged postoperative duration of stay	8 (15.6)
Hospital stay (mean days)	13.0 ± 11.1

but only when hemodynamic instability, electrocardiograph changes, or new regional wall-motion abnormalities indicated that a clinically significant event may have occurred. Hence, we cannot exclude minor ischaemic events, not those that are clinically significant.

Supraventricular arrhythmias, mainly atrial fibrillation, necessitating medical and/or electrical treatment was observed in 10 patients (19.6%) and complete atrioventricular block needing permanent pacemaker implantation was observed in three patients (5.9%). One patient (2.0%) required re-exploration because of haemorrhage. Two patients (3.9%) had a stroke and one patient had respiratory failure (2.0%). A prolonged postoperative duration of hospital stay (>14 days) was observed in eight patients (15.6%). No cases of mediastinitis were observed.

The mean duration of hospital stay was 8 days (percentile 25—7 days; percentile 75—10 days; mean, 13.0 ± 11.1 days) and, as a rule, survivors were discharged to go home. No referral to aftercare institutions was made.

DISCUSSION

Since the 1980s, many articles in the literature have been debating this subject. Our interest in this subject was awakened due to the growing number of patients submitted to CABG previously who were at a high risk of facing complications in a redo aortic surgery, as predicted by the EuroSCORE risk evaluation. These patients are now being presented as the ideal candidates for transcatheter aortic valve implantation [13]. A literature search showed that the scientific community does not have a consensual answer to this question, as mortality and complication rates vary substantially; hence, we decided to evaluate our centre's experience in this setting. Other questions that should be raised are: when should the aortic valve be operated during the first surgery; and which surgery should be done [14]?

The small number of cases involved in this series, representing the experience of a single centre, is one of the shortcomings of this study that can be pointed out. However, regarding the heterogeneous characteristics of the population, when compared with those of given in other reports in the literature [4, 11, 15], the sample of this study has the advantage of adding complexity to the evaluation of the surgery, allowing a better understanding of the real patient, as ischaemic and multi-valvular pathology can occur at the same time.

This series, as patients were submitted to coronary catheterization prior to reoperation, also allowed us to evaluate the

patency of the grafts and thus infer about the patency of grafts of our total population submitted to CABG. All grafts to the LAD system (LITA) were patent, as were the 88% of grafts to the circumflex system and 74% of the grafts to the RCA system, at a mean of 7 years after CABG, findings consistent with those reported in the literature, including a significantly better patency of the arterial grafts, especially of the LITA to the LAD.

The success of this type of reoperation is demonstrated by the low incidence of surgical complications (reduced incidence of graft or heart lesions, pericardial effusion, reoperation or mediastinitis). One surgical aspect of the original procedure, not mentioned in the literature and a routine procedure implemented at our centre, is the approximation of the pericardial fat at the end of the CABG, allowing the leftward lateralization of the LITA graft and hence reducing re-entry risk. This, associated with the limited dissection of heart structures, can be responsible for the low incidence of graft lesions in the dissection. Neither femoral nor axillary artery cannulation was used at the beginning of the surgery or was needed later during the reoperation, indicating that this is a safe procedure. No preoperative co-morbidity was associated with the higher risk of complications [16].

The type of aortic valve to be implanted was decided by the surgeon in accordance with the patient's preference, age and life expectancy. A mechanical valve is generally implanted in patients up to the age of 70 years, unless the patient is of a different opinion. In our centre, patients over 75 years of age always undergo aortic valve replacement with a biological prosthesis, but a significant number of patients between 70 and 75 years of age, with a long life expectancy, opted for mechanical prostheses, as we believe this to be a better alternative. In patients with active infection involving the annulus uniformly, an aortic homograft procedure was used as a mini-root one [17].

Our strategy for myocardial protection excludes clamping of the LITA in addition to antegrade cardioplegia to the remaining coronary territories. This could potentially lead to irregular myocardial protection and possible ischaemic complications, which, however, were not observed. Similarly, Smith *et al.* [18], using a similar technique, failed to demonstrate any increase in the mortality rates, while Park *et al.* [19], from the Mayo Clinic, found increased mortality rates in cases where clamping of the ITA was pursued.

Beyond a low operative mortality rate, in this study the incidence of perioperative MI was 2.0%. Because we did not measure the biomarkers of myocardial necrosis, the rate of this event may be, by some standards, low. In an important earlier analysis of this 'non-ITA dissection' approach carried out by Byrne *et al.* [11], the incidence of perioperative MI was 9% (defining MI as new Q-wave in the electrocardiogram, creatine kinase-MB (CK-MB) ≤50 IU/l, and CK-MB/CK ratio >5% or new wall motion abnormality on echocardiography). In the more recent studies carried out by Smith *et al.* [18] and *Park et al.* [19], however, the reported incidence of MI was much lower (0.9 and 0%, respectively). In these studies, MI was defined according to the STS database criteria.

Our results are similar to those obtained using other techniques to control the LITA flow, such as supraclavicular control [20], endovascular control [21], retrograde cardioplegia [22] or beating heart [23]. Furthermore, the low mortality rate, observed with regard to our surgical procedure, can be seen as a demonstration of safety. Somehow, a balance between continuous perfusion of the LAD territory and cardioplegic protection of the remaining myocardium is achieved with this method. Two series recently reported by Redlich *et al.* and Gazzoli *et al.* [24, 25], not known to us at the beginning of our experience and at the time of the presentation of this paper at the Annual Meeting, where a similar technique was used, confirmed these findings.

We believe that the short ECC and cross-clamping times also contributed to good myocardial preservation. We have to concede, however, that the retrospective nature and the short follow-up period are important imitations of our study.

CONCLUSION

Although performing AVS after CABG is a challenging task, we have confirmed that it is feasible, resulting in mortality and complication rates that are lower than what is expected from the risk score systems that are available. We believe that this surgical approach based on a no-touch handling of the patent LITA graft and performing the procedure expeditiously is the mainstay of the success.

Conflict of interest: none declared.

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APPENDIX A.

Table A1: Definition of preoperative variables

Hypertension	Blood pressure exceeding 140/90 mmHg, a history of high blood pressure or the need of antihypertensive medications
Renal failure	Creatinine >2.0 mg/dl and no dialysis dependence
Diabetes mellitus	History of diabetes treated with oral agents or insulin
Chronic obstructive pulmonary disease	Patient requires pharmacologic therapy for the treatment of chronic pulmonary compromise or patient has a FEV1 level <75% of the predicted value
Peripheral vascular disease	Claudication either with exertion or at rest; amputation for arterial insufficiency; aorto-iliac occlusive disease reconstruction; peripheral vascular bypass surgery, angioplasty or stent; documented abdominal aorta aneurism, repair or stent or non-invasive carotid test with >75% occlusion
Cerebrovascular disease	Unresponsive coma >24 h, cerebrovascular accident (CVA), RIND or TIA
Non-elective surgery	Urgent or emergent surgery

FEV1: forced expiratory volume in the first second; RIND: reversible ischaemic neurologic deficit; TIA: transient ischemic attack.

APPENDIX B.

Table B1: Definition of postoperative complications

Operative mortality	Death from all causes, during the same hospitalization stay, regardless of the time or within 30 days of surgery
CVA	Global or focal neurological deficit lasting <24 h (transient ischaemic attack) or >24 h (reversible ischaemic neurologic deficit; stroke)
Mediastinitis	At least one of the following: (1) an organism isolated from culture of mediastinal tissue or fluid; (2) evidence of mediastinitis observed during operation; (3) one of the following conditions: chest pain, sternal instability or fever (>38°C), in combination with either purulent discharge from the mediastinum or an organism isolated from blood culture or culture of mediastinal drainage
Myocardial infarction	New Q-wave in the electrocardiogram, creatine kinase-MB (CK-MB) ≥50 IU/l, and CK-MB/CK ratio >10%
Inotropic support	Use of one or more inotropic drugs, for any length of time
Mechanical support	Use of intra-aortic balloon pumping or ventricular assistance
Acute renal failure	Postoperative creatinine serum level of ≥2.1 mg/dl plus an increase in the serum creatinine level of ≥0.9 mg/dl from preoperative to maximum postoperative values in patients who had no significant pre-existing renal disease (creatinine ≤2.0 mg/dl and no dialysis dependence)
Reoperation for bleeding	Bleeding or cardiac tamponade that required intervention after admission into the ICU
Prolonged postoperative duration of stay	Duration of stay >14 days (alive or dead)
Respiratory failure	Postoperative ventilator support for >48 h or tracheostomy or both

APPENDIX. CONFERENCE DISCUSSION

Dr D. Pagano *(Birmingham, UK)*: There are two main messages, to my mind, in your paper. It is that this is very difficult and complicated surgery, which your team does extremely well, and also that EuroSCORE is absolutely useless in predicting outcomes in these patients.

I have a question. This is a single-centre series with excellent results. How do you deal nowadays, in 2011, with patients that come to surgery for primary myocardial revascularization who have some degree of aortic valve stenosis? In which ones do you replace the valve, in which ones not, and what do you do afterwards for follow-up?

Dr Paupério: We measure the gradient intraoperatively, and if it is higher than 20 mm, we substitute the valve.

Dr Pagano: That is mean gradient?

Dr Paupério: Peak to peak.

Dr Pagano: Sorry?

Dr Paupério: We insert a needle in the left ventricle and a needle in the aorta, and if the difference is higher than 20 mm, we perform aortic valve substitution. We have to have a suspicion index before surgery by echo. If we have a gradient near 20 mmHg, we perform this manoeuvre to confirm that the gradient is significant, and then we substitute the valve.

Dr Pagano: I am a little bit at a loss here, because it is widely recognized that the best way to assess the aortic valve is by transthoracic and transoesophageal echocardiogram. So I am not quite sure how your decision-making is done intraoperatively on a beating heart with a needle through the aorta and through the left ventricular outflow tract. I am not quite sure. Can you expand a little bit more?

Dr Paupério: If we have a degree of suspicion, we have to be sure that this gradient is significant and we confirm it by using peak to peak gradient. We know that the patient is relaxed and that the gradient can be lower, but we also know that if we have to intervene in this valve later, we have a low mortality. So probably we can postpone this surgery to a later opportunity, because we know that by replacing the valve earlier, we have the risks associated with anticoagulation and, if the valve is a biological valve, with degeneration. Therefore if the gradient isn't significant, we prefer to postpone or even not to intervene.

Dr Pagano: Are there any other parameters you use apart from the gradient to decide in which patients you are going to replace the valve prophylactically?

Dr Paupério: Sorry?

Dr Pagano: Are there any other variables that you consider when you make the decision whether to replace the valve prophylactically, or do you ever replace the valve prophylactically below a 20 mmHg gradient?

Dr Paupério: When the gradient is lower than 20, we usually don't replace the valve. I don't have that data, but I don't think we usually perform aortic valve surgery in such patients. That is not the common practice in our centre.

Dr Pagano: I have no further questions.

Dr M. Antunes *(Coimbra, Portugal)*: I am the senior author of this paper and this series. Just to clarify Dr Pagano's question and Dr Paupério's answer, this series comes about because we were not as aggressive before with mild to moderate degrees of aortic valve disease. Subsequent to these results and in the last couple of years, of course, we have been more aggressive, as is everybody else, in operating prophylactically on the aortic valve. Basically the decision is made preoperatively, not intraoperatively, usually on a mean echocardiographic gradient of 20, 25, 30 mmHg, which otherwise would not be an indication for surgery, but it is an indication concomitant with grafting the coronaries. That is our current policy.

We do have this old habit of placing a needle in the left ventricle in the operating room, but that just serves, as Dr Paupério mentioned, to confirm that we indeed have a gradient. We also perform intraoperative transoesophageal echo in these patients just to confirm that the valve is sclerotic and needs replacement.

Dr B. Podesser *(St. Pölten, Austria)*: Just one comment. You said that the mean age of your population is 70 years but still you have more than 40% of mechanical valves. Have you seen a change in your policy over the period of your series? Do you use biological valves more frequently than mechanical valves today, because I think 45 to 48% mechanical is a pretty high percentage.

Dr Paupério: Usually when the patient is over 70 years, we use a biological valve and under 70 years we use a mechanical valve. But there is a group of patients between 70 and 75 years in whom the surgeon can sometimes use a mechanical valve if the patient has few co-morbidities and potentially has a higher life expectancy.

Dr Podesser: Well, the results of the biological valves are very good at the age of 65, so I think you maybe should reconsider this, because you don't have to put your patients on warfarin.

Dr S. Siminelakis *(Ioannina, Greece)*: About myocardial protection, when the LIMA is open, how do you protect the myocardium?

Dr Paupério: We never clamp the LIMA when we have a patent LIMA. In 44 patients that was the scenario. We administer cardioplegia directly in the coronary ostia and in the grafts. We think that we can obtain myocardial protection with cardioplegia, and the oxygenated blood supplied by the LIMA graft. And we perform, as could be seen, very quick surgery with short cross-clamp times.

Dr Siminelakis: So you use cold crystalloid cardioplegia and you don't clamp?

Dr Paupério: We never clamp the LIMA.

Dr Siminelakis: But the heart is warming then, in three minutes it will be warm again.

Dr Paupério: Yes, but we believe that this kind of myocardial protection is sufficient. And we can see from the results that we don't have many myocardial infarctions. The mean left ventricular ejection fraction was the same before and after the procedure.

Dr Siminelakis: It seems strange to me.

Dr T. Folliguet *(Paris, France)*: You are cooling the temperature of the body?

Dr Paupério: Yes, and we have mild hypothermia.

Dr Siminelakis: You said 28.

Dr Paupério: 25 to 28.

Dr Siminelakis: 25 is different than 28.

Dr Paupério: It depends on the procedure, because we have surgeries that include other concomitant procedures.

Dr Folliguet: Professor Antunes.

Dr Antunes: That is what he explained, but the main key message of this technique is that over time with our experience we found that we somehow, although it may be difficult to explain, we found an equilibrium between giving cardioplegia more repetitively in the coronary ostia and having the area that is supplied by the internal mammary artery undisturbed. We found that our results have improved tremendously as compared to the time when we spent a lot of effort mobilizing and clamping the internal mammary artery.

By the way, there is only one technical problem, which is that, often, if it is a good internal mammary artery and a good LAD, you have a lot of flow back through the left coronary ostium. We just place a cardioplegic cannula just to occlude it, not to give cardioplegia. It makes the operation so much simpler.

Dr Siminelakis: Retrograde cardioplegia?

Dr Antunes: Well, we don't use it in our experience for any other cases, so we have not used it in this series, but I concede that it possibly could be a solution as well.

My message of this series is exactly this: spending a lot of time controlling the patent LIMA not only gives rise to possible accidents, but also does not appear to have any favourable outcome as compared to not touching the LIMA.

Dr Siminelakis: That is very important. And the temperature goes down to 25?

Dr Antunes: We usually go to 30 degrees, somewhere around that.

Dr Folliguet: I think we can continue discussion outside, if you want, because we really have to finish. But I agree, we do the same; we don't control the LIMA and it works very well.