Feasibility of the utilisation of the right internal thoracic artery in the transverse sinus in off pump coronary revascularisation: early angiographic results

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Abstract

Objective: The objective of this study was to analyze the feasibility of beating heart coronary surgery and to angiographically assess complete revascularisations with routine use of the two internal thoracic arteries (ITA), with the right ITA pedicled and placed through the transverse sinus. The authors report the results of their initial experience of coronary surgery without CPB, which began in December 1998.

Methods: From December 1998 to October 1999, 50 patients underwent non-urgent beating heart coronary revascularisation via a median sternotomy with the 2 ITA. Stabilization of the anastomotic site was ensured by the Octopus stabilizer 1 then 2. A troponin Ic assay was systematically performed in the initial postoperative period. With the patient’s consent, postoperative angiography was performed before discharge.

Results: The mean number of anastomoses was 2.5 ± 0.6 per patient (range: 2–4). Distal anastomoses by arterial grafts were performed in 87% of cases. In one case, the right ITA could not be kept pedicled and tunnelled in the transverse sinus and a Y graft onto the left ITA had to be performed. Left anterior descending-diagonal sequential bypass with the left ITA was performed in seven patients (14%). There was no operative mortality. One patient developed postoperative myocardial infarction. Follow-up angiography was performed in 42 cases (84%), with 104 anastomoses reviewed (85%). The patency rate for all anastomoses was 98.1%, with 90.4% of excellent results. The patency rate of the right ITA was 100%, with 90.5% of excellent results.

Conclusions: Beating heart coronary surgery allows revascularisation of all coronary territories. This technique is not an obstacle to the use of the pedicled right ITA tunnelled in the transverse sinus. It is not associated with an increased postoperative morbidity and mortality, and the early follow-up angiographic results are excellent. © 2001 Elsevier Science B.V. All rights reserved.

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1. Introduction

There has been a rapid growth of beating heart coronary surgery over recent years, with a constant increase in the number of patients operated by this technique. However, despite the demonstrated benefit of using two internal thoracic arteries (ITA) on long term results [1], reports on off-pump coronary surgery with the use of the two ITA remains rare, especially with the right ITA pedicled and tunnelled through the transverse sinus. We report our initial series of patients undergoing non-urgent beating heart coronary surgery in order to evaluate the feasibility of the utilisation of the right ITA kept pedicled and tunnelled through the transverse sinus assessed with angiographic analysis.

2. Materials and methods

From December 1998 to October 1999, 50 patients underwent non-urgent isolated coronary surgery with the two ITA via median sternotomy with the off-pump technique. All operations were performed by the same operator. The objective in this series was to perform revascularisation of the circumflex artery or marginal branches with the right ITA kept pedicled. The mean age was 63.3 ± 8.9 years. Twenty patients (40%) had three-vessel-disease. Among the 30 other patients with two-vessel-disease, six of them had previously undergone a percutaneous transluminal coronary angioplasty (PTCA) of the right coronary artery 2 months
before surgery. These six patients underwent angiographic control the day before surgery to assess the result of PTCA, which was excellent for these six patients. The other patient characteristics are presented in Table 1.

2.1. Coronary revascularisation

Our coronary revascularisation strategy has been described previously [2]. The objective in this series was to perform complete revascularisations and to use the ITA as much as possible to revascularize the left coronary arteries by preserving the two ITA pedicled. Revascularisation generally consisted of implantation of the left ITA onto the LAD, possibly associated with sequential revascularisation of a diagonal artery; the right ITA, tunneled in the transverse sinus of the pericardium, was implanted onto a bisecting branch, a marginal branch of the circumflex, or the circumflex artery, and exceptionally onto a first diagonal. Diagonal arteries were revascularized whenever possible by sequential revascularisation by the left ITA when the LAD was revascularized. When another graft had to be implanted onto branches of the circumflex artery, a vein graft was used. The right coronary artery was only revascularized by saphenous vein grafts, which is our usual policy [2]. No arterial grafts other than the ITA were used.

2.2. Operative technique

Anesthesia was induced with sufentanil, propofol and rocuronium and maintained with the same drugs delivered by infusion pumps. A continuous flow Swan–Ganz catheter was used to demonstrate any haemodynamic changes during mobilization of the heart and coronary clamping. Blood pressure was continuously monitored by a radial catheter. Plasma expansion was performed right from the start of the operation by infusion of 500–1000 ml of hydroxyethyl-starch. Inotropic support with dopamine (3–6 μg/kg/min) or bolus neosynephrine was administered in the case of hypotension not responding to plasma expansion. Heparinization was performed at the beginning of ITA harvesting (200 IU/kg) to achieve an activated partial thromboplastin time greater than 300 s. A cell saver was systematically used and collected volumes greater than 600 ml were processed. Particular care was taken to maintain the patient at normothermia by a hot water undermattress and a forced-air warming blanket (Bair Hugger®).

After exploration of the coronary arteries, the revascularisation strategy was decided and the decision to perform surgery without CPB was confirmed. The two ITA were then harvested without opening the pleura. A saphenous vein graft was harvested at the same time, when necessary. Exposure of the different coronary arteries were achieved with pericardial traction sutures. Immobilization of the anastomotic site was maintained by an Octopus® 1 then 2 (Medtronic®) stabilizer. Preconditioning was not performed routinely. Coronary artery clamping was only performed proximally, by placing a crimped silicone-coated stay suture. After arteriotomy, exposure of the anastomotic site was ensured by an oxygen–water blower-mister (Medtronic®). An intracoronary shunt was never used. All sutures were performed with polypropylene 7-0 or 8-0 suture material.

2.3. Postoperative period

After leaving the operating room, the patients were transferred to the intensive care unit. A troponin Ic assay was systematically performed. In this series, we did not wish to modify the length of stay in the intensive care unit, which is usually 1 or 2 days. With the patient’s consent, postoperative angiography was performed before discharge. This examination was systematically performed in the case of elevation of Troponin Ic greater than 5.0 at the 6th or 12th postoperative hour. For practical reasons related to this examination technique, we did not try to decrease the length of hospital stay. Transfer to a cardiovascular rehabilitation centre was proposed to all patients after discharge from hospital.

3. Results

3.1. Details of revascularisation

During the period of study, the planned beating heart revascularisation had to be performed with CPB in 1 case, due to the intramyocardial course of the LAD. Three patients developed ventricular fibrillation related to gas embolism due to the blower-mister. These cases of ventricular fibrillation were reduced by electric shock with immediate return of stable haemodynamics and continuation of the beating heart operation. The mean number of distal anastomoses was 2.5 ± 0.6. Distal anastomoses by arterial grafts represented 87% of all anastomoses. Revascularisation was performed exclusively by arterial grafts in 74% of patients, and revascularisation of left coronary
arteries was performed exclusively by arterial grafts in 94% of cases. The frequency of sequential grafts was 14%; this rate was similar for patients operated with CPB (usually 20%). Operative details are presented in Table 2. In one case, the pedicle of the right ITA, implanted onto the circumflex artery, could not be preserved and a Y implantation onto the left ITA had to be performed. Characteristics of the utilization of the two ITA are listed in Table 3.

3.2. Postoperative data

There was no operative mortality in this series. One patient developed a postoperative myocardial infarction (2%). One postoperative cerebrovascular accident occurred in a patient operated by three coronary bypass grafts using two pedicled internal thoracic arteries with no associated procedure on the ascending aorta. A case of mediastinitis was observed in a diabetic patient. Three haemorrhagic complications were noted: haemothorax: one patient; postoperative bleeding requiring surgical revision: two patients. Three patients (6%) required packed cell transfusion.

3.3. Postoperative angiography

Postoperative angiography was performed in 42 patients (84%), and a total of 104 anastomoses (85%) were reviewed. Angiographies were analysed according to Fitzgibbon’s classification [3]. The patency rate was 98.1% (102 grade A or B anastomoses) (grade A). Excellent results (grade A) were obtained in 90.4% (94/104) of cases. The patency rate was 100%, with 85% of grade A anastomoses (11/13). Detailed analysis of the grade B or O anastomoses showed that eight (80%) were observed in patients operated during the first half of the series. Only two grade B anastomoses were identified in the last 25 patients reviewed. In all patients with occlusion or stenosis observed at angiographic control, the exercise test at one month was negative, and no additional revascularization was performed.

4. Discussion

Most recent publications on coronary revascularisation surgery without CPB demonstrate the growing use of this technique, as the BH/CPB ratio is regularly increasing. However, analysis of these series shows that beating heart surgery has led to various types of changes of the surgical revascularisation strategy. Firstly, this attitude has led to the conduct of incomplete revascularisations, with absence of revascularisation of the lateral wall by grafting of the occluded (grade O); no myocardial infarction was observed in the two patients with occluded grafts. No image of kinking or stretching of the grafts were observed in this series. The patency rate of the 41 cases of right ITA tunnelsed in the transverse sinus of the pericardium was 100%, with 90.2% of grade A anastomoses (37/41). In these four cases, the stenosis was located at the heel of the anastomosis. In three cases, the stenoses were evaluated between 70 and 80%. In the last case, the stenosis was over 90% with a low flow in the RITA, resulting in a non-functional graft. The single case of Y implantation of the right ITA onto the left ITA was also reviewed and showed an excellent result (grade A). Review of 35 distal anastomoses of the left ITA, excluding sequential grafts, showed a patency rate of 94.3% (two occlusions). In one case, the occlusion was located in the middle of the LITA, the anastomosis being patent. All patent anastomoses were in grade A. Follow-up angiography was performed in all of the seven patients with diagonal-LAD sequential revascularisation by the left ITA. Analysis of these 14 anastomoses revealed all grafts patent with two grade B. In these two cases, these poor results were situated on the distal anastomosis (left ITA anastomosed end-to-side onto the LAD). Saphenous vein grafts were reviewed in 81% of cases (13/16). The patency rate was 100%, with 85% of grade A anastomoses (11/13). Detailed analysis of the grade B or O anastomoses showed that eight (80%) were observed in patients operated during the first half of the series. Only two grade B anastomoses were identified in the last 25 patients reviewed. In all patients with occlusion or stenosis observed at angiographic control, the exercise test at one month was negative, and no additional revascularization was performed.

Table 2
Operative details

| Number of distal anastomoses | 2 30 (60%) | 3 17 (34%) | 4 3 (6%) |
|-----------------------------|------------|------------|---------|
| Distal anastomoses with arterial grafts | 107 (87%) | 7 (14%) |

* LAD, left anterior descending.

Table 3
Conduit arrangements

| Grafted vessels           | Left ITA | Right ITA | Saphenous vein graft | Total |
|---------------------------|----------|-----------|----------------------|-------|
| Left anterior descending  | 49       | 1         | 1                    | 51    |
| Distal circumflex artery  | –        | 14        | 3                    | 17    |
| Marginal branch of circumflex | 1       | 33        | –                    | 34    |
| Diagonal artery           | 7        | 3         | –                    | 10    |
| Right coronary artery     | –        | –         | 12                   | 12    |
| Posterior descending artery | –       | –         | 1                    | 1     |
| Total                     | 57       | 50        | 16                   | 123   |

* ITA, internal thoracic artery.
circumflex artery and its branches, as some teams have adopted the objective to avoid the use of CPB to a maximum [4,5]. Another consequence of the difficulty of exposure of the lateral wall has been the exclusion of patients requiring revascularisation of the circumflex artery from beating heart surgery [6–8]. Lastly, this can lead to a reduction of the number of anastomoses by arterial grafts, which remains low in the majority of published series. In particular, very few publications have reported the use of two ITA pedicles in beating heart surgery [9], and none have reported the use of the right ITA tunnelled in the transverse sinus. Once again, this has led to changes in the revascularisation strategy [10], as some teams have abandoned the use of the right ITA tunnelled in the transverse sinus to revascularize the circumflex artery [7]. Our experience is very different, and in this series of 50 patients, in which the circumflex artery (or one of its branches) or a retroventricular artery was revascularized in all cases, poor exposure never prevented beating heart grafting of these arteries. The opposition between beating heart surgery and pedicled right ITA tunnelled in the transverse sinus does not appear to be justified and we have always used the right ITA in this way with excellent results (100% of early patency). This is now an essential point for the development of beating heart coronary surgery. The most recent studies on the use of these two arterial grafts have demonstrated the superiority of their long-term results, both in terms of survival that the subsequent risk of reoperation or angioplasty, and probably long-term recurrence of angina [1,11].

The reproducibility of exposure of the lateral wall therefore allows beating heart revascularisation to be performed in a greater number of patients and the number of conversions to CPB surgery during the procedure is consequently very low [9]. The quality of revascularisation achieved with the off-pump technique is confirmed by clinical and angiographic results. The postoperative myocardial infarction rate and the operative mortality remain low, as reported in other series [7–9,12]. These good results of revascularisation without CPB are even better in the context of patients operated in a critical situation. Similar findings have been reported in elderly patients, in whom the results of beating heart surgery appear to be superior to those of conventional CPB surgery [13,14]. The good results of this operative technique on early graft patency are confirmed by postoperative angiography. The value of the present study is to demonstrate maintenance of these good results when revascularisation is extended to the lateral wall, even when using a pedicled right ITA tunnelled in the transverse sinus. Furthermore, the grade B anastomoses detected on these postoperative angiographies are not predictive of the longer term results, as several studies have demonstrated the possibility of regression of these lesions on subsequent angiographic follow-up [9,15,16]. Finally, these follow-up examinations demonstrate the existence of a learning curve, as more than 80% of the abnormalities detected on postoperative angiography concerned the first half of this series of examinations. This phenomenon has been observed by many teams [4,7,9,10,16], and simply corresponds to a general rule for the acquisition of any new surgical technique.

The principle limitation of this study is that it is not a randomised analysis BH vs CPB. We preferred assessing the results of this particular aspect of the off-pump coronary surgery from the beginning of our experience. During the period of study, other patients were operated on with CPB, and concurrently, the ratio BH/CPB increased. Since the end of the study, 115 additional patients were operated on with the two pedicled ITA with the off-pump technique. At the present time, 96% of the patients undergo CABG without CPB in elective surgery.

In conclusion, beating heart coronary surgery is not an obstacle to the routine use of the pedicled right ITA tunnelled in the transverse sinus, and more generally to the use of both ITA, the value of which has now been clearly established. This is reflected by the low mortality and morbidity rates observed, and by the postoperative angiography results. These particularly encouraging results suggest that beating heart coronary surgery will continue to become more widely used.

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