Minimally invasive coronary artery bypass grafting via a small thoracotomy versus off-pump: a case-matched study§,*

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Abstract

Objective: The minimally invasive coronary artery bypass grafting (MICS CABG) operation performed via a small thoracotomy has not previously been examined in a direct comparison to sternotomy off-pump coronary artery bypass grafting (OPCAB).

Methods: We matched, according to age, gender, left ventricular function, and median number of distal anastomoses, 150 patients who underwent MICS CABG via small left thoracotomy, and 150 patients who received sternotomy OPCAB. All operations were performed by the same surgeon.

Results: There was no perioperative mortality (0/300). In the MICS CABG group, pump assistance was used in 28/150 (19%) patients, and conversion to sternotomy occurred in 10/150 (6.7%) patients. In the OPCAB group, conversion to on-pump occurred in 3/150 (2.0%) patients. There were four (2.7%) reoperations for bleeding and one (0.7%) for anastomotic revision in each group. The median hospital length of stay was 5 days for MICS CABG (average 5.4), and 6 days for OPCAB (average 7.2) (P = 0.02). New-onset atrial fibrillation occurred in 35 (23%) MICS CABG patients and in 42 (28%) OPCAB patients (P = 0.3). No wound infection occurred with MICS CABG versus six (4.0%) with OPCAB (P = 0.03). A self-limiting left pleural effusion developed in 22 (15%) MICS CABG patients and in six (4.0%) OPCAB patients (P = 0.002). The median time to return to full physical activity was 12 days in MICS CABG patients versus >5 weeks in OPCAB patients (P < 0.001).

Conclusions: MICS CABG is a valuable alternative for patients in need of multivessel CABG. The operation appears at least as safe as OPCAB, and associated with shorter hospital length of stay, less wound infections, and faster postoperative recovery than OPCAB.

Keywords: Coronary artery bypass grafting; Minimally invasive approaches; Off-pump coronary artery bypass surgery

1. Introduction

Since its development by Drs Rene Favaloro and Donald Effler in 1967, coronary artery bypass grafting (CABG) has become one of the most important surgical procedures in the history of medicine [1]. By revolutionizing the natural history and quality of life of patients with ischemic heart disease, arguably, no other operation has prolonged more lives and provided more symptom relief. Conversely, the invasiveness of CABG remains considerable and has not appreciably diminished in over 40 years. Minimally invasive surgical alternatives have been proposed, but none has gained widespread acceptance, or successfully allowed for the routine avoidance of sternotomy while maintaining direct vision and manipulations, to treat a wide array of patients with multivessel coronary artery disease.

Recently, we reported on 450 initial consecutive patients who underwent minimally invasive coronary artery bypass grafting (MICS CABG) via a small thoracotomy approach, which preserves the anatomic configuration and principles of CABG, including the performance of handsewn proximal anastomoses onto the ascending aorta, does not require special infrastructure, and avoids sternotomy [2]. In that series, we indicated that MICS CABG was feasible and had excellent procedural and short-term outcomes.

In the present study, we aimed to compare the outcomes of MICS CABG with that of off-pump coronary artery bypass grafting (OPCAB) performed via a sternotomy [3]. To this end, we used a case-matched study design, where we compared 150 patients who underwent MICS CABG with 150 patients who underwent OPCAB.

2. Methods

2.1. Patient population

Between 2005 and 2010, 150 patients with coronary artery disease (CAD) referred for CABG underwent MICS CABG
performed by a single surgeon (M.R.) at the University of Ottawa Heart Institute (UOHI). This constitutes the initial and consecutive series of MICS CABG procedures at this institution; as this was the initial experience with this operation, patients were generally selected on the basis of being good candidates for a minimally invasive approach, often requiring a limited number of distal anastomoses.

During the same period, the same surgeon performed 312 consecutive OPCAB procedures. The 150 MICS CABG patients were matched to 150 low-risk OPCAB patients, randomly selected from the 312 patients from the same surgeon and period. Matching took place according to age, gender, left ventricular function, and median number of distal anastomoses.

2.2. Preoperative evaluation

The indications for MICS CABG and conventional OPCAB with sternotomy have been previously described [2—4]. OPCAB has been the subject of numerous publications. Similar to OPCAB, MICS CABG can be performed in most patients in need of coronary revascularization, with the exception of patients with severe hemodynamic compromise, severe pectus excavatum, or severe pulmonary disease, as tolerance of single-lung ventilation greatly facilitates the conduct of the operation. Relative contra-indications to MICS CABG include hemodynamically significant left subclavian stenosis; hemodialysis arteriovenous fistula on the patient’s left side; redo surgery; morbid obesity; severe left ventricular dysfunction; need for right coronary artery graft with no posterior descending or left ventricular branch target; need for circumflex coronary artery graft with no adequate marginal branch target; and the absence of femoral pulses bilaterally. If the use of a radial artery is contemplated, the ulnar pulse and Allen test must be compatible with its safe use [1].

2.3. Operative procedure

The conduct of the MICS CABG and OPCAB operations have been described previously [2—5]. All patients undergoing OPCAB received intravenous heparin to maintain the activated clotting time above 250 s between the termination of conduit harvest and the completion of all anastomoses. The MICS CABG operation used the same anticoagulation parameters, unless cardiopulmonary bypass was used, where a minimum activated clotting time of 480 s was maintained.

For MICS CABG, the patient was intubated with a double-lumen endotracheal tube or with a regular endotracheal tube and a left bronchial blocker, in order to selectively deflate the left lung. The patient was positioned in a 15–30° right lateral decubitus position, with the right arm extended to allow harvest of the radial artery, if applicable. The left 5th intercostal space was incised over 4–6 cm, starting at the mid-clavicular line and extended laterally (Fig. 1). A Thoratrak™ (Medtronic, Minneapolis, MN, USA) rib spreader was inserted, and the pericardium was incised anterolaterally. The targets were identified. The left internal thoracic artery was taken down from a lateral approach, under direct vision. Prior to 2007, proximal anastomoses were performed from the left internal thoracic artery in a T-graft configuration, using 8/0 polypropylene. From 2007 onward, all proximal anastomoses were handsewn onto the ascending aorta after the application of a side-biting clamp, using a technique of aortic exposure described elsewhere (Fig. 1) [1,2]. For distal anastomoses, a Starfish™ NS apical positioner and an Octopus™ NS (Medtronic, Minneapolis, MN, USA) were used. If exposure was poor, or if the patient did not tolerate progressive mobilization of the apex despite hemodynamic support including low-dose vaspressors, the heart was brought back into its resting position, and preparations for femoral arterial and venous cardiopulmonary bypass (without aortic cross-clamping), by using a direct cut-down approach, were undertaken. In such cases, the remainder of the revascularization was carried out under cardiopulmonary bypass support, after which weaning took place using dual-lung ventilation.

No sequential grafting was performed in this series, in either the MICS CABG or the OPCAB group. All distal coronary anastomoses were performed by using running 7/0 polypropylene.

2.4. Postoperative management and follow-up

Patients were started on daily enteric-coated acetylsalicylic acid 81 mg and clopidogrel 75 mg on the day of operation [6], unless they received cardiopulmonary bypass.
in which case enteric-coated acetylsalicylic acid 325 mg without clopidogrel was used. Unless contraindicated, antihypertensives were resumed on the first postoperative day. Patients with a radial artery graft were prescribed dihydropyridine calcium channel blockers for 6 months.

Patients were followed up for a minimum of 90 days after discharge from the hospital. Death was defined as mortality occurring within 30 days of operation. Stroke was defined as a permanent new focal neurological deficit occurring either intra- or postoperatively. Respiratory insufficiency was defined as a cumulative requirement for intubation and ventilation of 72 h or more, at any time during the postoperative stay. New-onset renal failure was defined as the need for temporary or permanent renal dialysis of any type. Transfusion rates were determined by the proportion of patients who received at least one transfusion of any blood product. Sternal wound infection was defined as drainage of purulent material from the wound and was recorded up to 12 months postoperatively. Return to full physical activity postoperatively was defined as: (1) the ability to walk 30 min or more per day and (2) the ability to use the upper torso and arms without restriction for activities of daily living.

2.5. Statistical methods

Matching between the MICS CABG and OPCAB groups was performed in 1:1 fashion, by using Microsoft Excel 2007 and Stata 10.1 (Stata, College Station, TX, USA). For each patient in the MICS CABG group, one patient was randomly selected from the 312 contemporary OPCAB patients of the same surgeon, on the basis of corresponding age, gender, and left ventricular function (dichotomized as left ventricular ejection fraction of 50% or more, or of less than 50%). To obtain the same median number of grafts performed, the OPCAB matching cohort was resampled until the median number of grafts was equal between the MICS CABG and the OPCAB groups, while preserving the other three matching characteristics. Matching on the same median number of grafts had to be used because no contemporary OPCAB cohort from the same surgeon was available that allowed 1:1 matching based on the actual number of grafts.

All results are reported according to the intent-to-treat principle. Continuous data are expressed as means ± SD, and discrete data as numbers (percentage). Comparisons of normally distributed continuous and categorical data were performed by using a Student’s unpaired t-test and a Fisher’s exact test, respectively. Comparisons of continuous non-normally distributed data were performed with a Wilcoxon rank-sum test. All tests were two-tailed. Analyses were performed in Stata 10.1.

3. Results

3.1. Patient characteristics

The preoperative characteristics of the MICS CABG and OPCAB patients are shown in Table 1. The patients ranged in age from 37 to 90 years (mean, 60.8 years), of which 246 were male. The most common indication for operation was stable angina. There was no significant difference between the MICS CABG and OPCAB patients with respect to age, gender, body habitus, clinical presentation, and prevalence of left ventricular dysfunction, diabetes, hypertension, or prior coronary revascularization.

3.2. Procedural characteristics and postoperative outcomes

Table 2 displays the procedural outcomes of the matched MICS CABG and OPCAB groups. While the median number of grafts, a matching characteristic, was equal between the MICS CABG and OPCAB groups, the mean number of grafts was higher with OPCAB, as a result of a larger proportion of patients in the MICS CABG group having received single-vessel revascularization. Complete revascularization, that is, of each major myocardial territory subtended by a coronary artery of 1.5 mm or more in diameter with stenosis ≥70%, was achieved in all patients. Of these, five MICS CABG patients and five OPCAB patients had hybrid revascularization during the same hospital stay, with percutaneous coronary intervention (PCI) performed either before (N = 9) or after operation (N = 1, in the MICS CABG group).

There was a 6.7% rate of conversion to sternotomy with MICS CABG. Cardiopulmonary bypass using direct femoral venous and arterial cannulation was employed in 28 MICS CABG patients, with no resultant vascular or groin complication. In the MICS CABG group, there was no statistically significant difference in mortality and hospital length of stay according to whether cardiopulmonary bypass was used or not; however, the median number of grafts was higher (median 2.5 vs 2; P < 0.001; Wilcoxon rank-sum) in MICS CABG patients in whom cardiopulmonary bypass was used. The rates of return to the operating room were identical between MICS CABG and OPCAB groups; however, there

| Table 1. Preoperative patient characteristics (N = 300). |
|-----------------|-----------------|-----------------|
|                 | MICS CABG (N = 150) | OPCAB (N = 150) |
| Age, years      | 60.1 ± 9.1      | 60.4 ± 8.5      |
| (range 37—82)   | (range 42—90)   |                |
| Men/women, n    | 123/27          | 123/27          |
| Height, cm      | 171.8 ± 9.4     | 170.6 ± 8.3     |
| (range 147—195) | (range 152—188) |                |
| Weight, kg      | 80.0 ± 15.4     | 82.4 ± 15.7     |
| (range 37—140)  | (range 52—172)  |                |
| Clinical presentation, n |                 |                 |
| No angina       | 4 (2.7%)         | 8 (5.3%)        |
| Stable angina   | 124 (82.7%)      | 121 (80.1%)     |
| Unstable angina | 19 (12.7%)       | 10 (6.7%)       |
| Acute myocardial infarction | 3 (2.0%) | 11 (7.3%) |
| Left ventricular dysfunction, n | 31 (20.7%) | 31 (20.7%) |
| Diabetes mellitus, n | 43 (28.7%) | 46 (30.3%) |
| Hypertension, n  | 122 (81.3%)      | 126 (84.0%)     |
| Prior PCI, n     | 25 (16.7%)       | 31 (20.7%)      |
| Prior CABG, n    | 3 (2.0%)         | 2 (1.3%)        |
| Preop HgB level, g/l | 140.8 ± 14.7 | 139.2 ± 16.8    |

CABG, coronary artery bypass grafting; Hgb, plasma hemoglobin; MICS CABG, minimally invasive coronary artery bypass grafting; OPCAB, off-pump coronary artery bypass grafting; PCI, percutaneous coronary intervention; Preop, preoperative.

a Matching characteristics from which the OPCAB sub-cohort was selected from a larger cohort (another matching characteristic is median number of grafts; please see Table 2).

b Defined as preoperative left ventricular ejection fraction of 49% or less.
overall was a significantly lower transfusion rate with MICS CABG ($P = 0.01$). No difference was observed in the rates of other in-hospital complications, including atrial fibrillation ($P = 0.3$). Significantly more MICS CABG patients developed a pleural effusion ($P = 0.002$), always on the left side, than the OPCAB patients; however, no patient required thoracentesis or tube thoracostomy.

On average, MICS CABG patients went home postoperatively 1 day earlier than OPCAB patients ($P = 0.02$), and experienced significantly less wound infections, both in overall numbers and in regard to deep tissue infections requiring intravenous antibiotics ($P = 0.03$) (Fig. 2).

One striking difference between the two groups was the time to return to full physical activity. In the MICS CABG group, this occurred at a median of only 12 days, while in the OPCAB patients return to full activity took place at a median of 36 days ($P < 0.001$).

4. Discussion

In 2009, we reported on the feasibility and safety of the MICS CABG operation in a report that also represented, to our knowledge, the largest series to date of a non-sternotomy multivessel CABG operation [2]. In that article, we had noted excellent MICS CABG procedural outcomes and freedom from complications, including revascularization, major morbidity, and wound infection. Nevertheless, it remained unclear as to whether MICS CABG was really as safe or at all beneficial compared with OPCAB, which arguably represents, in expert hands, the current gold standard in advanced coronary artery surgery. In an attempt to resolve this equipoise, we carried out the present case-matched study, comparing MICS CABG to OPCAB, by selecting matched and mainly low-risk OPCAB patients whose main characteristics closely correspond to that of our initial, consecutive MICS CABG population. The main finding of the present report is that MICS CABG is not
only safe and feasible from inception, but also associated with recovery advantages consisting of lower transfusion rates, wound infection, and a marked postoperative physical recovery advantage when compared with OPCAB. Although incisional pain was not specifically addressed in the prospective evaluation of MICS CABG and OPCAB patients reported in this study, faster return to full physical activity in the MICS CABG group implies at least adequate and possibly superior pain control in these patients, compared with those who received OPCAB.

Several factors could have adversely affected the outcomes of MICS CABG in this comparison. While OPCAB is routine, the MICS CABG series presented herein is an initial and consecutive one, performed by a single surgeon; it, therefore, encompasses the technical learning curve issues that any new operation may entail. Further, MICS CABG is a technically challenging operation, and possible attempts at selecting lower-risk patients for this procedure during its inception and development were addressed by matching the MICS CABG group to a similarly low-risk OPCAB population. Despite the above considerations, MICS CABG proved in this study to be safe and even beneficial when compared with OPCAB. This suggests that the MICS CABG operation can be implemented and developed safely and efficaciously, without the occurrence of a dangerous learning curve with respect to morbidity and mortality. The main observed drawback of MICS CABG was the development of a self-limiting left pleural effusion in a sizable proportion of patients.

In this study, a greater rate of cardiopulmonary bypass use and of conversion (to sternotomy) was noted in the MICS CABG group compared with the OPCAB group. This is due to the inherent anatomic restriction brought by the intact sternum (when MICS CABG is compared with OPCAB), which prevents against massively retracting the heart anteromedially for posterolateral wall exposure. However, the use of cardiopulmonary bypass during MICS CABG is typically semi-elective [4], and takes place when good exposure of the vessel to be grafted (usually a posterolateral circumflex branch) proves difficult or associated with hemodynamic instability during positioning of the heart, which is solved by aborting the attempt, resting down the heart, and preparing for femoral cardiopulmonary bypass. In the authors’ experience, the use of cardiopulmonary bypass is arguably felt to be superior to conversion to sternotomy, which takes place if hemodynamic instability occurs and does not immediately resolve (2.7% of MICS CABG patients in this study). Notably, the aorta is never cross-clamped with MICS CABG, even if cardiopulmonary bypass assistance is elected.

There were no complications or clinical drawbacks of cardiopulmonary bypass or femoral cannulation in this series. Although conversions to sternotomy did occur, they also did not appear to lead to major morbidity or mortality, and were well below the '100% sternotomy rate' of OPCAB. Of note is that poor exposure in itself, which led to conversion to sternotomy in four patients at the initial part of the series, is no longer an indication for sternotomy in our practice, but rather an indication for the use of cardiopulmonary bypass support.

The MICS CABG operation is important, in our opinion, because the thoracic invasiveness of CABG had not decreased since the CABG operation was introduced more than 40 years ago [5,7]. With the exception of a few specialized centers performing total endoscopic coronary artery bypass in very selected patients [8—10], no other operation had completely eliminated the sternotomy and decreased the invasiveness of CABG, while preserving the key principles of complete revascularization and the wide applicability for multivessel or diffuse CAD. Of note is that the MICS CABG operation is quite different from a minimally invasive direct coronary artery bypass (MIDCAB) operation, by itself associated with excellent results but restricted to the performance of a single left internal thoracic artery to left anterior descending (LITA-LAD) graft [11—14].

4.1. Limitations

This report is observational and bias in the selection of patients is likely, especially in the earlier part of the experience. Matching also took place based on the median number of grafts, rather than their actual 1:1 linkage, as there was no contemporary OPCAB cohort available from the same surgeon that would have permitted 1:1 matching based on the actual number of grafts. This limitation resulted from the development and routine availability of MICS CABG during the study period, its common request by patients, and its particularly easy applicability when a patient requires two grafts or less. As a result, the median number of grafts between groups was similar, but not the mean or the distribution of the grafts performed. It remains possible that these differences alone could explain some of the changes in transfusion, wound infection, and postoperative recovery observed with MICS CABG compared with OPCAB in this study. Furthermore, as this is a single-center experience and considering that the most commonly reported median number of grafts performed with OPCAB is usually three, it cannot be stated that MICS CABG is as safe as OPCAB ‘in general’.

Another unknown aspect about MICS is the durability of the procedure. Although mid-term follow-up is ongoing, long-term patency remains to be systematically investigated and reported. Consequently, no inference can yet be made regarding the late durability of this revascularization procedure. On the other hand, MICS CABG allows for a graft configuration that is anatomically similar to conventional CABG, and chronic phase results could be equivalent, provided all technical aspects of the minimally invasive procedure are mastered. Finally, MICS CABG remains a new technique in need of external validation, and its results might not be generalizable to all centers.

5. Conclusions

MICS CABG is a valuable alternative for patients in need of multivessel CABG. Despite the patient selection that occurs, our data indicate that the MICS CABG operation is not only as safe as OPCAB but also associated with shorter hospital length of stay, lower transfusion rates, better freedom from wound infection, and much faster postoperative physical recovery. Graft patency and long-term results, however, remain in need of future investigation.
Appendix A. Conference discussion

**Dr K. Kirali** (Istanbul, Turkey): To minimize the invasiveness of coronary artery bypass surgery, cardiac surgeons have tried developing new techniques. We achieved avoidance of CPB and median sternotomy. Standard OPCAB has gained widespread acceptance for multivessel CABG around the world, whereas minimally invasive procedures have not. I have some questions:

First, in your series, only 2% of OPCAB patients needed extraanatomic circulation. Then how can you explain the greater incidence of pulmonary insufficiency and deep sternal infection after conventional OPCAB technique?

**Dr Lapierre**

And the second, in all types of OPCAB procedures, we discharge patients before the sixth postoperative day and advise them to walk for a minimum of 30 minutes every day. But what is the reason for your OPCAB patients taking longer than 5 weeks to return to full physical activity?

**Dr Subramanian**

The answer to your first question is that both patients were diabetic, we used BITA in both, and they were also obese, so that’s the reason for the sternal infection.

And as for the second question, why return to physical activity is longer in the OPCAB group, the reason most likely is that we advise against too much activity until 8 weeks. But, the patients are limiting themselves. According to the questionnaires, with the thoracotomy they are back to activity sooner and are not limited as much.

**Dr V. Subramanian** (New York, NY, USA): I have to rise up to comment or ask a question, because I seem to have started the momentum for minimally invasive coronary bypass surgery back in 1994, and then around 2004 multivessel small thoracotomy, same-day surgery. I have some reservations.

One, I think you ought to be very careful about when you report the data. You have about 6.7% conversion rate, so how did you treat them? Do you place them in the OPCAB group? How would that affect full return to activity and length of stay and other factors?

The second point is a very high incidence (19%) of CPB. Can you tell us whether this is emergency CPB use, or elective, what vessels, and what are the reasons for conversion?

The third comment would be that we performed MVST CABG. We have abandoned that mainly because our graft patency was suboptimal, when you look at a 6-month or 12-month period, especially in the lateral wall.

**Dr Lapierre**

First, any conversion was conversion to standard OPCAB. It was not in an emergency; the use of cardiopulmonary bypass was really elective. So we tried, for the MICS CABG, to mobilize the heart. And with a low dose of a vaspressor, we cannot keep the pressure. If we have evidence that the patient will become hemodynamically unstable, we go on pump and we do the surgery with pump support beating heart.

**Dr Subramanian**

Did you place the converted patients in the OPCAB group or the minithoracotomy?

**Dr Lapierre**

They are always converted to OPCAB group. We never go on pump to convert from the MICS.

**Dr Subramanian**

But the analysis is done as if intent to treat analysis with the MIDCAB.

**Dr Lapierre**

Exactly.

**Dr Subramanian**

So you kept in that group or the OPCAB group?

**Dr Lapierre**

No, we kept them in the MIDCAB group.

**Dr S. Jain** (New Delhi, India): I just wanted to know, are you able to put a graft on the right main coronary artery through this approach? Because we find it is very difficult to put the graft on the right main coronary artery.

**Dr Lapierre**

I agree with you. We didn’t experiment with it. When we tried to mobilize the heart, usually it’s very easy to see the proximal PDA vessel, but not the right vessel, not the right coronary.

**Dr D. Taggart** (Oxford, United Kingdom): What was the median or mean operating time for the two procedures? Is there much of a difference in the operating room?

**Dr Lapierre**

At first when we started with the MICS, I would say we could barely do a first case within 7, 8 hours. So it was very long. The learning curve is pretty steep. So until you reach about 10—15 cases, you’re not going to do two cases. Now, after more than 150 cases, we can regularly do two cases a day with the MIDCAB approach.

**Dr Taggart**

So what would be the median time for one of your minimally invasive procedures? Tell me numbers. Give me numbers.

**Dr Lapierre**

I would say 4 hours skin to skin.

**Dr Taggart**

And for your off-pump?

**Dr Lapierre**

It would be about, I would say, 3 hours.

**Dr Taggart**

So not an enormous difference.

The other thing I have to say is, unfortunately, in your presentation, the data you showed on your slides, it was all so small I couldn’t see anything. So it was very difficult. Unfortunately, I couldn’t get the full benefit of your presentation.

**Dr B. Alsoufi** (Riyadh, Saudi Arabia): Regarding the 19% who required cardiopulmonary bypass compared to off-pump, obviously your group is very efficient doing the off-pump, but still you have to convert quite a bit. What did you learn during this initial experience: is it a certain vessel, or a certain position of the heart that is not well tolerated and that is why you’re able to do same vessel with off-pump through a sternotomy but not...
Dr Lapierre: The most difficult vessel to do is a vessel which is very lateral. We were discussing it this morning with the presentation at Medtronic. And the problem is that when you don’t open the sternum, you don’t have as much space to tilt the heart. So it’s very difficult to have access to this particular territory, and then the patient becomes quite unstable. So we’ve learned that we must use vasopressors, we must refrain from filling up the heart too much. Because often when the pressure goes down, the first reflex that some anesthetists will have is to shove some volume in, the heart dilates, and then it’s even more complicated. So that’s about what we have learned.

Dr Taggart: Could I ask you as well, was there a differential use of two internal mammary arteries in these groups? I don’t know if it was in your presentation, but could you tell me that.

Dr Lapierre: Of course, with MICS CABG we never use the right internal mammary artery.

Dr Taggart: Does that concern you?

Dr Lapierre: It was a bit concerning actually. We had this discussion a couple of weeks ago with my colleague, why not use the internal right artery? But at that point we should do a second thoracotomy. And my colleague was a bit turned off by the idea of two incisions. But this is a great point.

Dr Taggart: Because I have to make one comment to the audience here. A whole lot of off-pump people were very unhappy with the ROOBY trial because it didn’t show benefits for off-pump surgery. That may simply reflect the fact that what we know from the literature is that in low-risk patients there is not a great deal to be gained by off-pump surgery.

But for me, I think for most patients coming to my operating room, it’s far more important they leave with two patent internal mammary arteries than whether they had on- or off-pump surgery. And I’m saying that as someone who does 90% off pump. So it’s just a comment.

Dr Subramanian: I think we shouldn’t be carried away. I think the original operation was devised as a LIMA to LAD. And we tried to extend it and we gave up. Because fundamentally I think the arterial graft and the LAD are the important elements. As you said, David, an arterial graft to the left side, another additional arterial graft to circumflex is also important. So that’s why we tried composite grafting. But the anastomotic milieu is very, very hard today. We haven’t done the anastomotic connectors. But I think it becomes an inferior operation when you do multivessel small thoracotomy. You can do it. I don’t think it’s a good operation in its quality. It’s a great operation to do, but I’m not sure what the eventual value is going to be, so that’s the problem.

Dr Jain: I personally feel this operation is very good. (Inaudible.)