

# Total arterial myocardial revascularization: analysis of initial experience

Shahzad Gull Raja, MRCS; Zulfiqar Haider, FRCS; Haider Zaman, FRCS (CTh); Mukhtar Ahmed, FRCS

*From the Department of Cardiac Surgery, Mayo Hospital, Lahore, Pakistan*

*Correspondence to:  
Dr. Shahzad G. Raja MRCS  
Department of Paediatric  
Cardiothoracic Surgery  
Alder Hey Children's Hospital  
Eaton Road, Liverpool  
L12 2AP  
United Kingdom  
Email: drrajashahzad@hotmail.com*

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**BACKGROUND:** Total arterial myocardial revascularization is an attempt to overcome the problems of late vein graft atherosclerosis, occlusion and need for coronary re-operations. Despite increasing evidence of efficacy, the use of arterial conduits has not been accepted as a primary practice in most of the centers in Pakistan for various reasons. We analyze our initial experience to assess the feasibility of total arterial revascularization as a primary strategy in patients requiring first time coronary artery bypass grafting.

**METHODS:** Two hundred patients undergoing first time CABG at our institution, from January 2000 to April 2001, were studied. Group 1 consisted of 100 patients undergoing total arterial revascularization (using bilateral internal thoracic and radial arteries) and Group 2 consisted of 100 patients undergoing conventional CABG (using one internal thoracic artery and supplemental veins). Thirty-day mortality and early morbidity with particular reference to re-sternotomy for bleeding, cerebrovascular accidents, renal failure, and sternal dehiscence were the main outcome measures.

**RESULTS:** Patients in Group 1 were younger ( $56.2 \pm 10.4$  vs.  $60.3 \pm 9.8$  years;  $P < 0.001$ ), had lower Parsonnet scores ( $4.8 \pm 0.4$  vs.  $9.6 \pm 1.8$ ;  $P < 0.001$ ), and had better left ventricular function. Both groups received a similar number of grafts. The percentage of patients undergoing total arterial revascularization rose from 20% in the first three months to over 65% in the three later three-month periods. Overall 30-day mortality was 1.5%, one patient (1%) in Group 1 and two patients (2%) in Group 2. There was a similar incidence of postoperative complications and length of median postoperative stay in both groups.

**CONCLUSION:** Total arterial revascularization can be adopted as a primary strategy in most patients undergoing CABG with no increase in mortality or morbidity.

The clinical and prognostic benefits of coronary artery bypass grafting (CABG) for certain anatomical patterns of coronary artery disease are well accepted.<sup>1</sup> Most patients undergoing CABG require three or four bypass grafts and the "standard" operation uses a single internal mammary artery (IMA) to the left anterior descending coronary artery,<sup>2,3</sup> and supplemental vein grafts to the other coronary vessels.

The long-term patency of vein grafts in the coronary circulation has been poor. Ten years after CABG three quarters of vein conduits are blocked or severely diseased,<sup>4</sup> whereas more than 90% of ITA (internal thoracic artery) grafts are patent and disease free. Vein graft failure leads to reduced survival, recurrent angina, late myocardial infarction, and the need for further intervention,<sup>5</sup> so that by 10 to 15 years after the initial operation up to 40% of patients may require a redo CABG at increased risk and cost.<sup>6-8</sup> Aspirin and lipid lowering agents improve vein graft patency rates over the medium term,<sup>9,10</sup> but it is not known if they will significantly improve long term patency rates.

Myocardial revascularization using only IMA grafts has developed in an incremental manner from using in-situ LIMA (left internal mammary artery) as a single graft to the LAD (left anterior descending) artery, to the use of bilateral free or sequential IMAs, and now recently, to the use of preconstructed composite grafts (free RIMA grafts that

are attached to the side of an in-situ LIMA).<sup>11-13</sup> The revival of use of the RA (radial artery) as a graft has offered another easily accessible source of arterial conduits.<sup>14</sup>

Concern that myocardial revascularization based entirely on arterial grafts may not be able to support the myocardium in the short term<sup>15</sup>, particularly in the presence of critical coronary stenoses, cardiomegaly, or left ventricular hypertrophy, and thus lead to hypoperfusion and increased mortality has delayed the adoption of this technique in most centers in Pakistan. There might be a higher morbidity from longer operation times and from possible local ischemic complications (sternum and hand) from bilateral IMA and RA harvesting. The aim of this study was to evaluate our initial experience with total arterial myocardial revascularization to establish its safety and efficacy in the perioperative and early postoperative periods.

## Methods

We studied the first 100 patients undergoing first-time CABG at the department of cardiac surgery, Mayo Hospital, Lahore, Pakistan from 1 January 2000 to 30 April 2001, who had total arterial myocardial revascularization. Patients with total arterial revascularization (Group 1) were compared with 100 patients who had conventional CABG using single LIMA and vein grafts (Group 2) during the same period. All patients were assessed at a follow-up clinic at 6 weeks. In particular, mortality at 30 days and postoperative complications, including excessive bleeding requiring reoperation, cerebrovascular accidents, impairment of renal function, and sternal wound breakdown were assessed.

A policy of total arterial revascularization was begun in January 2000 after the publication of the Cleveland Clinic study reporting that two ITA grafts offered significant clinical and survival advantages over one ITA graft in patients undergoing CABG.<sup>8</sup> That report did not address the concept of total arterial revascularization as it used arterial as well as vein grafts.

Initially we refrained from doing total arterial revascularization if there was: (1) significantly impaired ventricular function (ejection fraction <30%) because of the likelihood of requiring inotropes (which predispose to arterial graft spasm) and a limited life expectancy; (2) obese insulin dependent diabetics (but not diabetics with a normal body mass index), because of increased risk of

sternal problems with bilateral IMA grafts; or (3) an abnormal Allen test as a contraindication to the use of the radial artery.

*Harvesting of conduits.* Patients undergoing total arterial revascularization had all grafts performed using a combination of the left IMA, right IMA, and the radial artery. The IMA conduits were harvested with a skeletonized rather than a pedicled technique to decrease the risk of sternal devascularisation.<sup>16</sup> The IMAs were treated topically with papaverine to prevent spasm and the radial artery irrigated internally and externally with 100 mg phenoxybenzamine in 50 ml of blood.<sup>17</sup>

*Cardiopulmonary bypass.* All operations were performed with cardiopulmonary bypass using a Cobe CML membrane oxygenator (Cobe Cardiovascular Inc, Arvada) and a roller pump producing non-pulsatile flow. Cardiopulmonary bypass was achieved using a pump flow rate of 2.4 L/m<sup>2</sup>/min at normothermia with the temperature allowed to drift to 34°C. All anastomoses were constructed during a single cross clamp period with one liter of St Thomas's cold (4°C) crystalloid cardioplegia administered every 20 minutes as necessary.

*Graft distribution.* Various distributions of the grafts were used based on the principle of placing both IMA grafts to the left sided coronary vessels. This included the use of the left IMA to the left anterior descending coronary artery and the right IMA to the obtuse marginal artery via the transverse sinus with the radial artery placed to the posterior descending artery. In some cases the left IMA was placed to the obtuse marginal artery and the right IMA to the left anterior descending coronary artery. The proximal anastomosis ("top ends") of the radial artery were initially placed on the aorta but in the last 25 cases as composite grafts to the right IMA or left IMA in a "T" or "Y" fashion.

Conventional CABG was performed using the left IMA to the left anterior descending coronary artery and supplemental vein grafts as necessary. Proximal venous anastomoses were placed on the aorta.

Data were entered in a local database (Access, Microsoft). Analysis was performed using the Statistica software package (version 5.5, Tulsa, Oklahoma, USA). Normally distributed data are presented as the mean and standard deviation and comparisons are with the non-paired t test. Categorical data were compared with a Chi-square

test. A *P* value of <0.05 was considered as the conventional level of statistical significance.

## Results

Over a period of 16 months from January 2000 until the end of April 2001, of 200 patients undergoing first time CABG at our institution, 100 underwent total arterial revascularization (Group 1) and 100 had conventional CABG (Group 2). The proportion of patients receiving total arterial revascularization increased from 20% of patients in the first three month period of the study to 44% in the second three month period and more than 65% of the cases over the three latest three month periods. This reflected a combination of growing confidence with the technique.

**Preoperative data.** Patients in Group 2 were older, more were females, and more had a higher Parsonnet score than in Group 1 (Table 1). Poor ventricular function (ejection fraction <30%) was present in 25 patients in Group 2 and in 6 patients in Group 1. The proportion of urgent patients (those with unstable angina requiring surgery on that admission) was similar in both groups.

**Intraoperative data.** Each group received the same number of grafts with Group 1 receiving  $3.1 \pm 0.8$  grafts and Group 2 having  $3.2 \pm 0.7$  grafts.

**Postoperative data.** Thirty-day mortality consisted of three patients (1.5%), one in Group 1 and two in Group 2. The Group 1 patient who died was a 63-year-old male with chronic obstructive pulmonary disease (COPD) and borderline renal function who had undergone urgent bilateral ITA grafting for a tight left main stem stenosis. He had difficulty in weaning off the ventilator. He was extubated on day 6 but struggled with breathing and suffered cardiac arrest before he could be reventilated. Attempts at resuscitation failed. The family declined postmortem examination so patency of grafts could not be documented. Two patients died in Group 2. One was a 68-year-old woman who suffered an extensive anterolateral myocardial infarction and underwent emergency CABG. She died 12 hours after surgery from low cardiac output despite inotropic support and an intra-aortic balloon pump. Postmortem examination confirmed massive infarct involving the whole of the lateral and anterior wall of the left ventricle. Both the IMA and single vein graft were patent. The other patient in Group 2 was a 70-year-old smoking, diabetic male with COPD who underwent urgent CABG for unstable angina

**Table 1.** Preoperative characteristics of patients undergoing a first-time coronary artery bypass graft (CABG) by total arterial revascularization (Group 1) or a conventional CABG (Group 2).

	Group 1 (n=100)	Group 2 (n=100)	<i>P</i> value
Age (years)	56.2±10.4	60.3±9.8	<0.001
Male (n)	67	56	0.04
BMI	27.4±3.4	27.6±3.7	0.3
Urgent operation	56	59	0.6
Ejection fraction <30%	6	25	0.01
Smoking	22	25	0.8
Hypertension	36	39	0.7
Diabetes	21	24	0.8
COPD	11	15	0.6
Creatinine >150 mmol/L	4	6	0.9
Parsonnet score	4.8±0.4	9.6±1.8	<0.001

**Table 2.** Postoperative data in patients undergoing a first-time coronary artery bypass graft (CABG) by total arterial revascularization (Group 1) or a conventional CABG (Group 2).

	Group 1 (n=100)	Group 2 (n=100)	<i>P</i> value
CVA	1	0	0.9
Atrial fibrillation	21	23	0.6
Renal impairment	8	10	0.5
Haemofiltration	4	3	0.8
Re-exploration for bleeding	2	3	0.4
Sternal dehiscence	2	1	0.7
ICU stay (days)	1	1	0.8
Hospital stay (days)	6	6	0.8
Mortality	1	2	0.7

with one IMA and two vein grafts. He developed fulminant *Pseudomonas* chest infection and died of multi-organ failure on the tenth postoperative day. Postmortem examination showed no recent infarct and that all three grafts were patent. Table 2 gives the incidence of postoperative outcomes.

Follow-up angiography performed in the first 30 cases in Group 1 showed 100% patency of all the grafts at 6 weeks follow-up. Refusals of patients

to undergo follow-up angiography along with the costs of repeating angiography were the main reasons for limited angiographic assessment.

## Discussion

The aim of this study was to analyze our initial experience and assess the feasibility of total arterial revascularization as a primary strategy for CABG in a typical tertiary referral center in Pakistan. We did not intend to compare total arterial revascularization and conventional CABG. Specifically, we report our results to address persistent concerns that a strategy of total arterial revascularization might increase perioperative mortality and morbidity. To the best of our knowledge no similar strategy or study has been reported from Pakistan.

Even in the absence of randomized trials of arterial revascularization versus conventional CABG, there is evidence of clinical and survival benefit with bilateral IMA grafting. In May 1999 the Cleveland clinic group reported that bilateral IMA grafts improved 10 to 15 year survival and markedly reduced the need for reoperation.<sup>8</sup> These benefits were also present in patients of advanced age, and in those with diabetes or significantly impaired ventricular function.<sup>8</sup> In contrast, Sergeant and colleagues reported no survival benefit of bilateral IMA grafting.<sup>18</sup> One possible explanation for this, however, is that of their database of 9600 patients, only about 100 with bilateral IMA grafts have been followed up to 10 years. In their early experience the second IMA graft was frequently used for the anatomically less important diagonal coronary artery.<sup>18</sup>

The most important finding in our study is that total arterial revascularization can be performed in most patients undergoing CABG in a typical Pakistani population with an acceptably low mortality and morbidity. While these were not our highest risk patients, they were not a specially selected low risk group. Their mean age was 60 years but 15% were over 70 years, 40% were urgent patients, and approximately one third had diabetes.

It is also apparent that with increasing surgical experience the proportion of patients who are suitable candidates for total arterial revascularization also increases. In our own practice the number trebled from 20% in the earlier part of the study to almost 65% of patients in the latter periods (and is currently over 70%). Indeed, our only persisting contraindication to the use of arterial grafts is in

patients with severely impaired left ventricular function who have a more limited life expectancy and who are likely to need an intra-aortic balloon and/or significant inotropic support after surgery.

The incidence of sternal dehiscence, the most feared complication of the use of both ITA, was similar in both groups. We would emphasize that harvesting ITA conduits in a skeletonized rather than pedicled fashion significantly reduces the risk of sternal devascularization by preserving ITA collaterals to the chest wall.<sup>19</sup> We do not consider diabetes a contraindication to the use of skeletonized ITA grafts unless the patient is also obese. Approximately one third of our patients were diabetic and recent evidence from the BARI trial suggests that such patients have most to gain from the use of bilateral ITA grafts.<sup>20</sup>

Another surgical consideration is the increased length of operating time required to perform total arterial revascularization. In the authors' hands this increased total surgical operating time from around one hour and 55 minutes in Group 2 patients to around two hours and 40 minutes in Group 1 patients. The increase in operative time was necessary for harvesting the grafts and not cardiopulmonary bypass times, which were  $72 \pm 12$  minutes for Group 1 patients and  $68 \pm 15$  minutes for Group 2 patients.

Total arterial revascularization offers further advantages over conventional CABG. The use of in situ or composite bilateral ITA grafts (with an additional radial artery) eliminates the need to perform "top ends" on the aorta. It is manipulation of the aorta by cannulation, or with a cross clamp or side-biting clamp, which is a major cause of stroke after CABG. Furthermore total arterial revascularization is particularly suitable for patients without an adequate saphenous vein, and eliminates the frequently underestimated morbidity associated with harvesting vein from the legs. Finally, total arterial revascularization is compatible with, and may indeed facilitate, the rapidly increasing techniques of CABG without cardiopulmonary bypass (off-pump or OPCAB).<sup>21</sup>

The most obvious weaknesses of our study are the lack of angiographic and long term clinical follow up. However, we must point out that neither was the primary aim of this study.

Total arterial revascularization is a feasible primary strategy in most patients presenting for first time CABG and can be performed with low mortality and morbidity.

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