

Composite Bilateral Internal Thoracic Artery Grafts via Standard Sternotomy for Lateral Wall Revascularization in Conscious Patients

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ABSTRACT

Background. A new technique has been developed that permits complete arterial revascularization of the lateral wall of the heart using in situ bilateral internal thoracic artery grafts in awake patients. This technique, performed without cardiopulmonary bypass or mechanical ventilation, creates the least invasive revascularization method for the lateral wall of the heart yet described.

Methods. In 4 patients, double or triple vessel coronary artery bypass grafting was performed without general anesthesia. A high thoracic epidural anesthesia was started 1 hour before surgery. Bilateral internal thoracic arteries were harvested and all anastomoses were performed with the off-pump technique via standard median sternotomy. Circumflex branches were anastomosed with the left internal thoracic artery via a heart positioner.

Results. All patients remained awake throughout the whole procedure. There was no perioperative myocardial infarction or mortality. Pneumothorax was observed in only 1 patient and did not hinder the procedure. There were no hemodynamic changes during lateral wall revascularization. Two patients required unexpected coronary endarterectomy during circumflex and right coronary artery anastomoses.

Conclusions. Complete arterial revascularization via median sternotomy using in situ bilateral internal thoracic artery grafts without general anesthesia is a feasible and safe procedure for multivessel disease. This approach allows for complete coronary artery revascularization in patients with contraindications for general anesthesia with or without cardiopulmonary bypass.

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INTRODUCTION

Cardiac surgeons have tried to minimize the operative trauma of cardiac operations, especially coronary artery bypass grafting (CABG), since modern cardiac surgery was started in the 1950s. The first step was to avoid extracorporeal circulation and to perform coronary revascularization with off-pump techniques, which have been used during the last 2 decades [Benetti 1991; Buffolo 1996]. The second step was to minimize surgical incisions and to avoid median sternotomy, which was popularized in the last decade, and our clinic performed different types of this approach [Isik 1997; Kırılı 1998; Gürbüz 2000]. Advances in off-pump surgical technology and adoption of creative techniques rendered revascularization of the circumflex system through standard median sternotomy possible [Baumgartner 1999], which was the third step. Early- and mid-term angiographic outcomes were comparable with conventional techniques [Kırılı 1999; Ömeroglu 2000]. The techniques of off-pump CABG are constantly undergoing refinement and many areas of potential benefit are vigorously explored [Ngaage 2003]. These procedures are more useful in high-risk patients [Güler 2001; Kırılı 2002], whereas off-pump revascularization techniques do not have any negative effect on the myocardium [Kırılı 2003]. The last step was to prefer only arterial grafts for off-pump coronary artery revascularization in patients with multivessel disease [Hirose 2002]; after that it was reported that bilateral internal thoracic artery (ITA) grafts had better rates of late survival and more freedom from cardiac events than a single ITA graft [Lytle 1999].

Whereas the main progress in cardiac surgery was the avoidance of cardiopulmonary bypass (CPB) in the 20th century, the new millennium allows us to avoid general anesthesia and mechanical ventilation during cardiac operations. A new strategy to reduce the invasiveness of cardiac surgery has recently been described [Karagöz 2000]. In recent years, limited centers have reported their clinical experience and several techniques with CABG in awake patients [Zenati 2001; Vanek 2001; Aybek 2003].

This new strategy prevents the side effects of CPB and does not require mechanical ventilation or general anesthesia. The present report describes my performance of the first lateral wall revascularization using in situ bilateral ITA grafts via complete median sternotomy in conscious patients without endotracheal general anesthesia.

PATIENTS AND METHODS

In October 2003, 12 conscious patients underwent CABG with high thoracic epidural anesthesia at Kosuyolu Heart and Research Hospital, Istanbul, Turkey. This study was approved by the Ethics Committee of the hospital, and written informed consent was obtained from all participants. Patients were fully informed about the pros and cons of the surgical approach, including that this technique is new and long-term results are not yet available, and a written informed consent was obtained. Four of the patients included in this study were operated on without endotracheal general anesthesia and they received CABG to construct extension grafts between the in situ right ITA and the left anterior descending (LAD) artery, and the left ITA and the circumflex (Cx) arteries. The last patient received a radial artery (RA) as the third arterial graft between the aorta and the right coronary artery (RCA). Patient selection criteria included the absence of recent antithrombotic (<1 week) or fibrinolytic therapy (<2 days), presence of significant (>70%) stenosis, good-caliber target vessels (>1 mm), the presence of 2 inflow grafts (bilateral ITAs), and patient cooperation. Severe left ventricular dysfunction, severe pulmonary disease, or any other variable that could present potential comorbidity did not affect patient selection. Demographic data and preoperative status of patients are described in Table 1. Patients continued to take their usual medications until the morning of surgery, except aspirin, which was stopped 1 week before surgery. No patient was given beta-blockers or specific antiplatelet therapy preoperatively.

Epidural Anesthesia

High thoracic epidural anesthesia was used for these operations. No muscle-paralyzing agent or general anesthetic agent was used. Throughout the operation, patients spontaneously breathed nasal oxygen (4 L/min). The objective of this approach was to achieve somatosensory and motor block at the T1 to T8 level, and motor block of the

intercostal muscles while preserving diaphragmatic respiration. One hour before the operation, the patient was premedicated with 0.07 mg/kg midazolam and was placed in a sitting position, and then a 16-gauge flexible-tip catheter (Perifix Soft 505; B. Braun, Melsungen, Germany) was inserted through a Tuohy needle at the T1 to T2 interspace, employing the median approach and the loss-of-resistance technique. The catheter was directed cephalad and advanced 3 to 4 cm in the epidural space. The block level was tested after epidural administration of a test dose of 5 mL lidocaine as a bolus. Fifteen minutes later, the level of the block was tested by assessing both temperature and pin prick discrimination. Loss of temperature discrimination was deemed necessary to continue the operation with epidural anesthesia. Additional bolus doses of epidural anesthesia solution were administered as needed to achieve motor block of the intercostal muscles. Motor block of the intercostal muscles was assessed visually by monitoring the loss of intercostal movement. Sensory block level was maintained at the C6 to T8 level. An epidural anesthesia solution was used for continuous epidural anesthesia, consisting of bupivacaine hydrochloride, lidocaine, fentanyl, and bicarbonate. At least 60 minutes elapsed between epidural catheter insertion and heparinization. The operating room was kept warm and only warm intravenous fluids were used.

The patient was draped in a manner that would give free and unrestricted access for the anesthesiologist to manipulate the head and neck of the patient, in case an urgent tracheal intubation should be necessary. Monitoring of the patient included only continuous electrocardiogram (lead DII), direct arterial pressure, central venous pressure, and pulse oximetry. Local anesthetic ointments were used before placement of epidural and invasive catheters. In all operations, 5000 IU of heparin was used for anticoagulation, which was not reversed with protamine at the termination of the operation. Cardiopulmonary bypass was not used.

Surgical Technique

The heart was exposed through a median sternotomy. Careful dissection of bilateral ITAs was necessary to avoid pneumothorax in the spontaneously breathing patient. For 3-vessel CABG, an additional RA graft was dissected with the adjunct of local anesthesia in the last patient. All operations' procedures are shown in Table 2. The sternum was spread with the retractor (Genzyme OPCAB system; Genzyme Biosurgery, Cambridge, MA). Two thirds of the pericardium were first opened in the midline, and then a right and left oblique pericardiectomy was performed down to the diaphragm (reverse Y-shape). We never entered the pleura on either side. The left pericardium and accompanying fat pad on the lateral side of the pulmonary artery were divided to allow room for the left ITA to arrive into the left pericardial space [Mansuroglu 2004]. This latter maneuver helps keep the ventilated left lung out of the surgeon's field of view during the anastomosis and provides some additional working room. This maneuver keeps the left ITA free of tension after closing the sternum and obtains the shortest way to arrive at the Cx branches without any kinking or tension caused by the pericardium.

Table 1. Patients' Demographics Data*

Patient demographics	
Age, y	56 ± 9.4
Sex, M:F	4:0
Weight, kg	74 ± 3.5
Height, cm	169 ± 4.7
BSA, m ²	1.83 ± 0.06
Left ventricle ejection fraction, %	54.2 ± 9.7
Cardiothoracic ratio, %	48.3 ± 4.1
Mean preoperative NYHA, class	2.1 ± 0.75
Previous myocardial infarction	2
Left main disease	1
Chronic obstructive lung disease	1
Renal disease	1
Peripheral vascular disease	1

*BSA indicates body surface area; NYHA, New York Heart Association.

Table 2. Operation Procedures*

First Anastomosis	Second Anastomosis	Third Anastomosis
RITA-LAD	LITA-CxOM ₃	
RITA-LAD	LITA-CxOM ₂	
RITA-LAD	LITA-CxOM ₃	
RITA-LAD	LITA-CxOM ₃	Ao-RCPD (radial artery)

*RITA indicates right internal thoracic artery; LAD, left anterior descending artery; LITA, left internal thoracic artery; CxOM, obtuse marginal branch of circumflex artery; Ao, aorta; RCPD, right coronary posterior descending artery.

The right ITA was used for the LAD anastomosis and performed first. A metal horseshoe stabilizer (Genzyme Biosurgery) and soft silicone elastomer tapes were used to stabilize and occlude the LAD. Anastomosis was performed with the standard beating heart bypass technique using a blower system to clear the anastomosis site. We preferred not to use intraluminal shunts.

The left ITA was anastomosed to the Cx branches. Placing the patient in a mild Trendelenburg position facilitates rotation of the heart as well as increases venous filling to maintain cardiac output [Hart 2003]. Moderate right lateral decubitus positioning at 30 degrees allowed for gravity-assisted rotation of the heart rightward. Exposure of the posterolateral wall was then accomplished by pulling up the Genzyme immobilizer heart manipulation device (Genzyme Biosurgery), which held fast the left ventricle apex via the negative vacuum. The apex of the heart was rotated toward the patient's right and placed outside of the pericardial cavity near the right arm of the sternal retractor. As with the LAD anastomosis metal horseshoe stabilizer (Genzyme Biosurgery) and soft silicone elastomer tapes were used to stabilize and occlude the branch. Anastomosis was performed with the standard beating heart bypass technique using a blower system to clear the anastomosis site, and we preferred not to use intraluminal shunts.

The last nonpedicled graft (RA) was anastomosed to the right coronary posterior descending (RCPD) artery with the same technique used in the last patient. Exposure of the inferior wall was then accomplished by pulling up the Genzyme immobilizer heart manipulation device. The apex of the heart was rotated toward the patient's left shoulder and placed outside of the pericardial cavity near the left arm of the sternal retractor. Again, a metal horseshoe stabilizer (Genzyme Biosurgery) and soft silicone elastomer tapes were used to stabilize and occlude the RCPD artery, and anastomosis was performed with the standard beating heart bypass technique using a blower system to clear the anastomosis site. We preferred not to use intraluminal shunts.

RESULTS

Operative Data

There was no operative mortality or morbidity. Operative time ranged from 180 to 235 minutes (mean, 211 ± 23.2 minutes) after the beginning of epidural anesthesia. Two patients

required unexpected coronary endarterectomy during Cx anastomosis (1 cm open and 1 cm closed) or RCPD anastomosis (1 cm open and 3 cm closed). Both arteries were grafted as long segments (1 cm) with arterial grafts. We did not observe any myocardial ischemia and/or arrhythmia during endarterectomy. The distal soft silicone elastomer tape was loosened to perform distal endarterectomy. Mean chest tube drainage was 517.5 ± 160.7 mL (range, 400-750 mL), but no patient received any blood products. The stay in the intensive care unit was 15.7 ± 1.7 hours, and the length of hospitalization was 7 days for all patients.

Hemodynamic Status

No patient was converted to CPB and global cardioplegic arrest. Lateral or inferior wall exposure was accomplished with acceptable hemodynamic performance (Table 3). There were no intraoperative electrocardiographic changes. The rhythm was sinus during the whole procedure in all patients. During the postoperative period, we did not observe any myocardial ischemia or arrhythmia on the electrocardiographs. There were no significant increases in cardiac enzymes 6 and 12 hours after surgery (CK [150 IU/L] 97 ± 17 IU/L and 176 ± 26 IU/L, and CK-MB [<25 IU/L] 18 ± 2.3 IU/L and 23 ± 3.6 IU/L, respectively). Renal function was not negatively affected by the procedure and the creatinine level did not rise more than 1.2 mg/dL in any patient.

Respiratory Problems

During surgery, we provided patients with oxygen face masks, thus maintaining oxygen saturation levels consistently over 90%, as measured by pulse oximetry. Intra- and postoperative blood gas values are given in Table 4. In 2 patients the pleura was opened. In the first patient, the right pleural defect was a small hole and it was repaired primarily after catheter aspiration of the air in the pleural space was carried out. In the second patient, the left pleura was opened widely, and the lung was allowed to collapse. But the patient did not have any respiratory distress during the procedure.

DISCUSSION

High thoracic epidural block yields cardiac sympathectomy, which has distinct advantages in patients with ischemic heart disease. The sympathetic nerve fibers from T1 to T5 innervate the myocardium and coronary vasculature and play a critical role in determining coronary blood flow and distribution. Perioperative sympathectomy improves myocardial oxygen supply-demand indices because of bradycardia and coronary vasodilatation. Secondly, ITA dilatation provides excellent graft flow.

Table 3. Hemodynamic Parameters

Value	Heart Rate, r/min	Systemic Arterial Pressure, mmHg	Central Vein Pressure, mmHg
Intraoperative	63.7 ± 7.4	124 ± 11.6	14 ± 4.5
Postoperative	84.5 ± 6.7	113.5 ± 8.6	7.4 ± 3.8

Table 4. Intraoperative and First Postoperative Arterial Blood Gas Results

	O ₂ -Saturation, %	pCO ₂ , mmHg
Intraoperative	97.8 ± 1.7	51.1 ± 8.6
Postoperative	98.4 ± 0.8	40.9 ± 7.4

Blockage of the cardiac accelerator fibers may be responsible for the decreased prevalence of postoperative supraventricular tachycardias and other types of cardiac dysrhythmias observed in patients managed with epidural blockage. Moreover, epidural anesthesia provokes a fibrinolytic state that might counterbalance the procoagulant state observed after beating-heart surgery [Mariani 1999]. Reducing the inflammatory cascade with epidural anesthesia increases the clear advantage of off-pump surgery compared to CBP. Another advantage of sensory block of the chest is superb pain control, which makes the immediate postoperative period virtually painless.

This new surgical strategy has some risks [Mangano 2003]. The major drawback of high thoracic epidural anesthesia is the risk of epidural hematoma formation. This complication can be avoided by strict adherence to such principles as a minimum time delay of 60 minutes between epidural puncture and heparinization and willingness to postpone surgical intervention for at least 24 hours if a bloody tap occurs [Paiste 2001]. Second, occurrence of pneumothorax during surgical operation is a dreaded complication because this surgical strategy involves operating on patients who are on spontaneous respiration. When the pleural cavity is opened, it must be repaired sufficiently after aspirating the air in the pleural cavity or it must be opened widely to prevent tension pneumothorax. In fact, maintenance of patient response is very important during epidural anesthesia to monitor the patients for the development of Horner syndrome and for maintenance of diaphragmatic respiration to prevent accumulation of carbon dioxide. But we did not observe anxiety or lack of cooperation in any of our patients during the whole procedure.

Avoidance of general anesthesia and positive pressure ventilation for complete arterial revascularization of the lateral or inferior wall coronary artery extends the spectrum of less invasive operative procedures, especially in high-risk patients. Significant complications following CABG surgery are often associated with pre-existing pulmonary disease or reduced general health status. These factors often require prolonged postoperative ventilatory support and a prolonged intensive care unit stay. However, spontaneous breathing maintains physiologic intrapulmonary pressures and therefore positively affects pulmonary circulation [Schachner 2003] and the risk of postoperative pulmonary failure and the complications of long-term ventilation may be reduced with avoidance of general anesthesia and endotracheal intubation.

Awake CABG via complete sternotomy, which is an alternative method for the lateral or inferior wall of the heart, has not been described. The published series in the English literature describe several techniques for complete revascularization in conscious patients, but they do not include the lateral wall revascularization [Zenati 2001; Vanek 2001; Aybek 2003; Karagöz 2003]. Complete sternotomy provides ideal access to

all coronary branches of the Cx and RCA, enabling the surgeon to perform complete arterial revascularization. In this series of patients, double or triple bypass grafting was performed using arterial grafts while the patients were conscious. Using arterial grafts in coronary revascularization provides better long-term results than venous conduits because of their excellent patency rates. Using bilateral ITA grafts is the most beneficial procedure for complete arterial revascularization for double vessel disease, whereas the RA and/or right gastroepiploic artery can be added for triple or more vessel disease. There is no contraindication to prefer bilateral ITA grafts in all age groups. Exposure and local coronary stabilization play a key role in off-pump complete revascularization [Gersak 2003], and the suction type of the heart positioner is an essential element of lateral and inferior wall revascularization. Any kind of these instruments can be used in this kind of operations. Although lateral wall access produces more hemodynamic alterations during Cx anastomosis [Hart 2003], we have not observed any problems during lateral and inferior wall revascularization.

In my experience, total arterial myocardial revascularization with composite grafts represents the best option for off-pump surgery for the following reasons: avoidance of aortic manipulation, preference of small coronary arteriotomy, and making arterial grafts extremely useful in smaller and more diseased native coronary vessels. The routine use of total arterial myocardial revascularization with composite grafts is a technique that may be too technically demanding for off-pump operations by surgeons using conventional conduits, and previous experience with composite arterial conduits may be important with the on-pump technique. The author has performed off-pump CABG since 1997 and total arterial complete revascularization using off-pump techniques through median sternotomy for 1 year. After this experience, I have started using composite arterial grafts for CABG on conscious patients.

The ability to perform off-pump coronary surgery in awake patients through a median sternotomy essentially makes it feasible to perform any off-pump surgery during epidural anesthesia. The majority of the presented series in the literature are anterior wall revascularizations. Lateral or inferior wall revascularization is feasible with newly developed stabilizers and apical positioners. This strategy is a new option to offer the benefits of CABG to patients with multivessel disease who are deemed inoperable with regard to general anesthetic considerations. This early report shows the feasibility and safety of CABG through median sternotomy in a small group of conscious patients having lateral and inferior wall ischemia. After our newly developed coronary bypass surgical technique, there are no limits to awake CABG procedures for revascularizing all coronary arteries and we think that utopia has become a reality with this technique: full arterial complete revascularization without CPB, a mechanic ventilator, or general anesthesia.

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