Technical Aspects and Initial Experience in Off-Pump Coronary Artery Bypass Grafting

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Background: Since “off-pump” coronary artery bypass grafting (OPCAB) has been refined, we try an effort to avoid the adverse effects of cardiopulmonary bypass (CPB) and perform OPCAB in Chinese patients. Methods: Between July 1999 and March 2001, 150 OPCAB were performed through a median sternotomy, using the Octopus II (Medtronic, MI) and deep pericardial suture-traction for stabilization to enable access to all territories of the heart. Emergent cases with cardiogenic shock under inotropics or intra-aortic balloon pump support were excluded. Results: An average of 3.0 ± 0.7 (range 1-6) grafts/patient were done. Complete revascularization was performed in 94.7% of cases. Operative mortality was 2%. There were two cases of conversion to cardiopulmonary bypass, and the utility of internal mammary artery (IMA) was 82.7%. The mean postoperative endotracheal intubation time was 6.8 ± 4.9 hours, length of ICU stay was 1.5 ± 0.7 days. Postoperative length of stay was 9.0 ± 2.8 days. No case of sternal wound infection or acute renal failure occurred in this group of patients. Conclusions: With progressive experience, proper technique, and mechanical stabilization, OPCAB may be used as a safe and effective procedure of myocardial revascularization in Chinese patients.

Key words: coronary artery bypass grafting, off-pump

INTRODUCTION

After the adoption of CPB and cardioplegic arrest for cardiac surgery, specific adverse effects of CPB have been reported1. To eliminate or minimize CPB associated morbidities and mortalities has become current focus. Recently, Calafiore2, Benetti3 and Subramanian4 and associates report that OPCAB grafting is a safe and effective method of myocardial revascularization in patients with single or multi-vessel coronary artery disease (CAD). With more experiences, OPCAB has become a standard procedure in the Western countries, but it is still a new technique in Taiwan. So we tried an effort to perform OPCAB in CAD patients to avoid the adverse effects of CPB. This study reviews the clinical experience in the 150 OPCAB cases in our hospital. Preoperative characteristics and postoperative morbidities and mortalities are recorded.

MATERIALS AND METHODS

From July 1999 through March 2001, OPCAB was performed in 150 patients at Tri-Service General Hospital (TSGH) by a single surgeon (C.S. Tsai). Initially, only patients with single- or two-vessel coronary disease were considered. After the first 7 patients, however, all patients regardless of anatomy were included. The cases with cardiogenic shock under inotropics (dopamine ≥3μg/kg/min or combined dobutamine) or intra-aortic balloon pump (IABP) support were excluded. Other emergency cases such as left main CAD, unstable angina pectoris or coronary angiogram related complications without inotropics or IABP support were still included.

The surgical procedure was performed under closed-circuit general anesthesia, and the continuous cardiac output was monitored (Abbott, IL) in all patients. The operating room was warmed and the body temperature of the patient was maintained.

Control of heart rate was usually not necessary unless it exceeded 110/min of sinus rhythm or 100/min of atrial fibrillation; intermittent intravenous esmolol was injected if necessary. Diluted ephedrine, dopamine and nitroglycerine solutions were routinely prepared, as required to normalize hemodynamics. In patients with impaired left ventricle function (ejection fraction [EF] less than 40%) or
with left main CAD, a guide wire was inserted into femoral artery before sternotomy for possible emergent IABP support. Heparin (200 units/kg) was administered before division of the internal mammary artery.

Sometimes, transient drop of blood pressure occurred when the heart was manipulated to evaluate all territories and possible anastomosis sites of revascularization, especially in the cases with impaired left ventricular function. If the hemodynamic response to a large dose of dopamine infusion or bolus of ephedrine injection was inadequate, then an IABP was inserted. Four deep pericardial silk sutures with traction and change of the patient’s position were used to expose the entire heart. The Octopus II Flexible Tissue-Stabilizer System (Medtronic, MI) was used to immobilize the target artery, and changed the position of stabilizer and the direction of traction to facilitate the immobilization.

After dissection of the target artery, proximal arterial occlusion was achieved by a single encircling silicone loop (Scanlan, MN). A heparinized humidified sterile blower (Medtronic, MI) was used to clear the field of blood. The temporary epicardial pacing wire was sutured before right coronary territory revascularization.

In general, bypasses were first performed on the left anterior descending (LAD) and diagonal coronary arteries, then on the right coronary artery (RCA), posterior-descending artery (PDA), or posterior lateral (PL) artery. The obtuse marginal (ObM) or left circumflex (LCx) coronary artery was bypassed finally. If LAD was the most patent artery with good collateralizing circulation to other coronary arteries, then the occluded or highly stenotic artery was first bypassed. In highly stenotic cases, early reperfusion was achieved through the combined devices of the 7-Fr. aortic root cannulation (Medtronic, MI), 4-way cardioplegia delivery set (Baxter, UT), and vessel cannulae (Medtronic, MI).

After distal anastomoses were completed, the aorta was side clamped to achieve proximal anastomoses. The hemodynamics should be observed for a few seconds especially in small-aorta cases.

The continuous cardiac output monitor could display patient’s left ventricular function and body temperature. After completion of each distal anastomosis, if the cardiac index was less than 1.5 L/min/m² or the systolic blood pressure was less than 90 mmHg, then we would release the stabilizer and retraction sutures temporarily. When the cardiac index was increased, then the procedure was resumed.

During the procedure of myocardial revascularization, the anesthesiologist controlled the depth of anesthesia, fluids, inotropic agents and patient’s position. Early infusion with dopamine or ephedrine was indicated to prevent occurrence of severe cardiac collapse. Fluid infusion was infrequently given unless the wedge pressure was low. In the cases with preliminary intra-operative IABP support, the IABP was weaning during wound closure if the cardiac index greater than 2.5 L/min/m², and it was removed in ICU with normal activated clotting time.

RESULTS

Results are expressed as mean ± standard deviation. Our criteria for a perioperative myocardial infarction is defined as follows: (1) the development and persistence of Q-wave on postoperative electrocardiogram; (2) poor R-wave progression in postoperative precordial leads; (3) an absolute creatine kinase-MB level greater than 50 IU/L with new left ventricular abnormal wall motion.

Table 1 shows the preoperative characteristics and major risk factors of patients. Complete revascularization was attained in 94.7% of cases. The average postoperative length of endotracheal intubation was 6.8 ± 4.9 hours, length of ICU stay was 1.5 ± 0.7 days, postoperative length
of hospital stay was 9.0 ± 2.8 days. Table 2 summarizes the coronary territory distribution of grafts. An average of 3.0 ± 0.7 (range 1 to 6) grafts per patient were performed. About 74.7% of operations involved revascularization of three or more vessels. The posterior wall had at least one ObM or LCx graft in 67.3% of cases.

There were 23 cases with preoperative impaired left ventricular function (EF < 40%), 16 cases received preliminary intra-operative IABP support, and 87.5% of these achieved complete revascularization. The IABP was removed immediately when patients arrived in ICU with stable hemodynamics. Table 3 shows the operative data of the IABP support patients.

There were two patients who required conversion to CPB: one redo patient with severe adhesion of posterior wall, and the other suffered from perioperative myocardial infarction. Both patients recovered well and are still being followed up regularly. Operative mortality was defined as death that occurred during the same hospitalization or less than 30 days after surgery. The operative mortality was 2% (3 patients). One patient was attributed to impaired left ventricular systolic function (EF = 30%), heavily calcified ascending aorta and diffusely atheromatous coronary vessels with incomplete revascularization. Another was attributed to chronic obstructive pulmonary disease with carbon dioxide narcosis and respiratory inhibition. And the third was due to diffusely atheromatous coronary vessels also, and was complicated with perioperative myocardial infarction and cardiogenic shock. All mortalities and cases with conversion to CPB occurred among the first one-third of patients treated.

The instances of postoperative complication are shown in Table 4. One patient had an old CVA that was complicated by a transient postoperative CVA, but this patient recovered well before discharge. One patient received re-sternotomy for checking bleeder over the LIMA bed. Routine postoperative coronary angiogram to determine graft patency was not performed because of insurance limitations and patient’s noncompliance; angiograms were performed when cardiac events (arrhythmia, angina, and heart failure) occurred. Four patients complained of progressive exertional dyspnea and received coronary angiogram: two revealed grafts patent, one had a proximal anastomosis stenosis and which was treated through percutaneous transluminal coronary angioplasty. The last one showed grafts patent but with insignificant stenosis in the ungrafted circumflex coronary artery.
DISCUSSION

We report our early experience with performing OPCAB in Taiwan. In our opinion, OPCAB continues to be an evolving procedure. As compared with Western series\textsuperscript{2-11}, our patients were older. In addition, we had an acceptable average number of grafts, percentage of total revascularization, mortality and morbidity. Since life expectancy has been increasing steadily, the number of elderly patients with CAD also is increasing gradually. From our experience, OPCAB is a valid alternative to conventional CABG for older patients with frequent co-morbidity\textsuperscript{12}.

Because of improvements in the mechanical stabilizer and in the placing of retraction sutures, all coronary territories now can be accessed and treated. The ability to change the direction of retraction and to position the stabilizer is important during this procedure\textsuperscript{5,13}. Maintenance of a normal hemodynamics is also a key point of OPCAB because low blood pressure will aggravate coronary hypoperfusion and initiate a vicious circle. Early intervention with inotropics gets effectively and most of the inotropics can be tapered off before wound closure. But OPCAB is still contraindicated in the patients with preoperative unstable hemodynamics, because on CPB and to unload the failing heart is the first priority.

OPCAB is more difficult to perform in patients with impaired left ventricular function. In such patients, they usually have large heart and poor hemodynamic compliance during cardiac manipulation. From our experience, intra-operative IABP support and early reperfusion are useful adjunctive techniques\textsuperscript{14}. The IABP provides immediate and persistent mechanical support and its effects will not be altered by metabolic or circulatory factors.

The continuous cardiac output monitor can provide accurate information of left ventricular function and body temperature. It shows the hemodynamic that whether we can proceed with the next procedure or not and it also provides accurate monitoring in ICU.

There are two mortalities associating with diffusely atheromatous coronary lesions. In such patients, their coronary arteries become more fragile and less elastic, and that takes more time to perform OPCAB. At present, OPCAB is still somewhat limited in such cases\textsuperscript{7}. But co-morbidities with diabetes, peripheral artery disease, renal insufficiency and CVA are so frequent in such patients. To avoid the adverse effects of CPB, the OPCAB techniques and indications need to be further studied and refined.

Our experience of OPCAB in redo patients is rare. Due to adhesion and poor visualization of the coronary artery, OPCAB is relatively contraindicated\textsuperscript{7}. But OPCAB in redo patients with ObM or LCx lesions can be performed via left thoracotomy, and it is also performed in selective single-vessel disease\textsuperscript{15,16}. We think it depends on the grafting territory and intra-operative evaluation.

Although this early experience of a small number of patients precluded meaningful statistical analysis, the results presented here suggest that OPCAB grafting is a safe and effective procedure of coronary revascularization in the Oriental with good short-term results and minimal morbidity. It must be emphasized that despite these good results, more studies of long-term graft patency are needed to support this technique.

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REFERENCES

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