Influence of intracoronary shunt on myocardial damage: a prospective randomized study

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Received 20 March 2008; received in revised form 18 July 2008; accepted 4 August 2008; Available online 9 September 2008

Abstract

Objective: We aimed to evaluate whether surgical intracoronary shunt protects myocardium in patients with moderate left ventricular dysfunction (ML VD).

Methods: Thirty-nine patients consisted the shunt group and 43 patients consisted the shuntless group. Troponin I, CK, and CK-MB were measured preoperatively, and at 6 and 24 h postoperatively. Cardiac enzymes, rate of postoperative atrial fibrillation (AF) and third month ejection fraction (EF) were compared between the groups. Results: There were no significant differences between the groups for preoperative troponin I, CK, and CK-MB, and postoperative CK levels (at 6 and 24 h). Postoperative troponin I and CK-MB levels were significantly lower in the shunt group (p < 0.001). Although preoperative EF of the patients were not significantly different between groups, the third month EF were significantly increased in both groups, and this increment was significantly higher in the shunt group than the shuntless group. One patient (2.3%) died in the shuntless group whereas there was no death in the shunt group. Conclusion: Intracoronary shunt has protective effects on myocardium in patients with moderate left ventricular dysfunction.

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Keywords: Off-pump; Myocardial protection; Shunts

1. Introduction

Coronary artery bypass grafting (CABG) has a greater positive impact on survival and quality of life than medical therapy in patients with left ventricular dysfunction (MLVD). Off-pump coronary artery bypass (OPCAB) has several advantages over on-pump CABG (ONCAB) regarding mortality, morbidity, and cost-effectiveness [3,4]. This procedure is becoming increasingly popular throughout the world [5–8]. Beside the fact that coronary surgery procedure is usually delayed to later ages due to advances in interventional cardiology, the proportion of higher-risk patients who require complex surgical procedures is likely to increase in the near future [9]. Intracoronary shunts have been used in OPCAB surgery since 1975. The occlusion of the coronary artery, which is necessary to control blood flow during distal anastomosis procedures, can cause temporary regional ischemia. Therefore, intracoronary shunts have been introduced into practice for limiting the regional ischemia and making a bloodless distal anastomosis [10,11]. However, Hangler et al. [12] suggested that intracoronary shunts may be used in selective cases in which critical ischemia or technical difficulties arise as a result of anastomotic conditions during anastomosis, and routine shunt insertion into coronary arteries during beating heart revascularization may be avoided. The use of the Octopus tissue stabilizer has proven to be a safe and versatile means to stabilize the heart during OPCAB procedures, especially in LVD [13]. In the current study, we hypothesized that intracoronary shunt use may reduce the myocardial damage in moderate left ventricular dysfunction (MLVD) patients, when compared to shuntless anastomosis in OPCAB surgery on the basis of cardiac markers and postoperative ejection fraction (EF) and atrial fibrillation (AF).

2. Material and methods

The study was approved by the local ethics committee. Ninety patients, who had undergone OPCAB surgery, were included in the study. Patients were randomized according to tables of random numbers to (1) shunt, or (2) shuntless group. Both groups were planned to include 45 patients. Patients who had stable angina with multivessel coronary artery lesion (angiographic evidence of >70% luminal diameter narrowing) and MLVD undergoing CABG surgery with OPCAB were enrolled in our study. The exclusion criteria were: age over 75 years, severe left ventricular dysfunction (SLVD)
(EF < 30%), and normal ventricular function (EF > 50%), reoperation, emergency operation, preoperative elevated cardiac enzymes, intracavitary procedures, or recent (in the last three months) myocardial infarction (MI). Cardiac enzymes were measured preoperatively, and at 6 and 24 h postoperatively in all patients. The occurrence rate of postoperative AF and third month EF ratio were evaluated in all operated patients. Three patients in the shunt group and one patient in the shuntless group did not apply for third month echocardiography control, one patient in shunt group underwent reoperation and two patients in the shunt group underwent aneurysmmorrhaphy. One patient died in shuntless group. In total, six patients in the shunt group and two patients in the shuntless group were removed from the study. The shunt group consisted of 39 patients and the shuntless group consisted of 43 patients. All operations were performed by the same team.

3. Anesthesia protocol

All patients were premedicated (midazolam, 0.05 mg/kg IV) and received their usual cardiac drug regimen, except aspirin, diuretics, angiotensin-converting enzyme inhibitors, and angiotensin II receptor blockers, which were withdrawn at least 24 h before surgery. In the operating theater, cannulae were inserted in a peripheral vein, the radial artery, and the right jugular vein. Standard monitoring included pulse oximetry, leads II and V5 of the ECG for heart rate and automated ST-segment trend analysis, continuous measurements of arterial and central venous pressures, nasopharyngeal temperature, and end-tidal capnography. A balanced anesthetic technique included fentanyl (bolus of 1–2 μg/kg followed by intermittent bolus of 1–2 μg/kg/h), etomidate (bolus of 0.2–0.3 mg/kg), esmeron (bolus of 1 mg/kg and intermittent bolus of 0.3 mg/kg/h) and inhaled sevofluorane (2–3% in the prebypass period and 1–1.5% in the bypass period), and ventilation was modified with each patient to reach partial arterial oxygen pressure above 150 mmHg and partial arterial carbon dioxide pressure above 45 mmHg.

4. Surgical technique

A median sternotomy was performed in all patients. The left internal mammarian artery, radial artery, and saphenous vein were harvested using standard techniques. By adjusting the operating room, hypothermia was avoided. Partial anticoagulation was accomplished with 1–2 mg/kg body weight of heparin until a target activated clotting time (ACT) of 250 s was achieved. All patients in both groups had multivessel coronary artery bypass grafting using the OPCAB technique. In both groups, Octopus 4 (Medtronic Inc., Minneapolis, MN, USA) was used as cardiac stabilizer. In order to obtain a bloodless anastomotic field in the shunt group after arteriotomy we did the following: after opening distal artery, intracoronary shunts (Clearview intracoronary shunt, Medtronic Inc., USA) were inserted into the coronary artery for each anastomosis which were 1.5, 2.0 or 2.5 mm in size according to the coronary artery lumens and shunts were removed after the last suture just before tying. In the shuntless group, the vessels were occluded with vascu-statt II (Saint Paul, Minnesota, USA) after arteriotomy. Polypropylene 8-0 suture was used for LIMA-LAD anastomosis. Polypropylene 7-0 suture was used for other distal anastomoses. The period of each distal anastomosis was noted in both groups. Heparin was not neutralized by protamine sulfate at the end of the operation. The thorax was closed in a standard method.

5. Postoperative MI follow-up

All patients underwent ECG assessment regarding to the development of new Q-waves, loss of R-wave progression, or a new ST elevation (>2 mm), and T-wave changes on each day after surgery. In addition, the patients were evaluated according to >5% increase in serum creatine kinase-myocardial band isoenzyme (CK-MB)/CK ratio. Inotropic support was defined as a requirement of inotrope administration for more than 30 min.

Serum CK and CK-MB levels were determined in Roche/Hitachi Automated Clinical Chemistry Analyzer, Modular P-800 using commercial Roche kits that were supplied by Roche Diagnostics GmbH (Mannheim, Germany). Expected values for healthy people: men: 39–308 U/l, women: 26–192 U/l for CK, and 7–25 U/l for CK-MB. For myocardial infarction diagnosis was made using the combination of CK and CK-MB activity: CKM<sub>men</sub> > 190 U/l, CK<sub>women</sub> > 190 U/l and CK-MB > 24 U/l. cTnI plasma concentrations were measured by commercial Pathfast<sup>™</sup> cTnI kits (Pathfast<sup>™</sup> cTnI, Compact immuno-analyzer, Mitsubishi Kagaku liftron, Inc., Tokyo, Japan) using method of chemiluminescent enzyme immunoassay (CLEIA). Normal values of cTnI were 0.00–0.02 ng/ml.

6. Statistical analysis

Statistical analysis was done with SPSS 13.0 statistical software program (SPSS Inc., Chicago, IL, USA). Descriptive analysis was made. The difference between the groups for nominal data was analyzed by χ² test. In evaluation of continuous variables, Student’s t-test and Mann–Whitney U-test were used, repeated measures were compared by paired t-test and Bonferroni correction. All p values less than 0.05 were considered to be statistically significant.

7. Results

Both groups were similar with respect to sex, age, and presence of hypertension (HT), diabetes mellitus (DM) and chronic obstructive pulmonary disease (COPD). The preoperative troponin I, CK, CK-MB, postoperative 6 and 24 h CK levels, and preoperative EF of the groups were not significantly different (p > 0.05) (Table 1). There was no significant difference in mean distal anastomoses between the groups; however, the sum of distal anastomoses periods was significantly higher in the shunt group than the shuntless group (Table 2). Six and 24 h CK-MB levels, 6 and 24 h troponin I levels were significantly lower in the shunt group.
(p < 0.001). Postoperative EF was significantly higher in the shunt group (p < 0.05). Postoperative AF incidence was higher in shuntless group but the difference was not statistically significant. Length of intensive care unit stay was significantly longer in shunt group; however, there was no difference for hospital stay between the groups. The pre- and postoperative EF ratio of the components were shown in Table 3.

The increased enzyme markers were thought not to be due to the thrombosis of the graft. Although it was not confirmed by angiography, there were no ECG abnormalities, severe CK-MB elevation, or hemodynamic deterioration after the operation. The postoperative echocardiographies also did not reveal hemodynamic deterioration. In one of 82 patients who had pathological ECG record, the clinical situation was associated with perioperative MI. As there was a finding that was related to graft failure, he was reoperated and the RCA graft was reanastomosed. In the shuntless group, a patient died after requiring more than 48 h of mechanical ventilation. In this patient, the preoperative EF was 30%; the patient was lost because of chronic renal failure in the 7th postoperative day.

**8. Discussion**

Our study results confirmed the primary hypothesis that OPCAB surgery using intracoronary shunts reduced the myocardial damage during anastomoses. It successfully demonstrated that the patients who underwent off-pump CABG with shunt had less troponin I and CK-MB levels after surgery. CABG continues to decline along with the advances in interventional cardiology, although the proportion of higher-risk patients requiring complex surgical procedures will likely continue to increase in the near future [9]. OPCAB surgery using the intracoronary shunt reduces the myocardial damage during the anastomosis [14]. This system has the double advantage of drying the anastomatic site (hemostatic effect) while allowing an effective distal coronary perfusion (myocardial protection), which may sometimes be necessary in OPCAB surgery [15]. Lucchetti et al. [16] reported that intracoronary shunts are beneficial during OPCAB in patients with isolated left anterior descending (LAD) coronary artery lesion. They showed that intracoronary shunts prevented impairment in left ventricular function during construction of coronary anastomoses. Therefore, they advised the use of intracoronary shunts in patients with unstable angina and left ventricular dysfunction. Bleier et al. [17] speculated that some of the troponin probably represented protein release from non-structurally bound cytosolic pools rather than true myocardial necrosis. Sadony et al. [18] stated that a cardiac troponin I value at 24 h had a sensitivity of 100% and a specificity of 97%. Troponin I elevation represents a reversible myocardial damage not an irreversible necrosis [18,19]. Gürbüz et al. [20] reported that intracoronary shunt reduced the postoperative troponin I levels significantly, so it may be indicated in patients who are thought to be susceptible to transient ischemia. Although in their study, CK-MB levels were not statistically significant, they were high enough to attract attention and this study only included LAD-LIMA anastomosis. Our study successfully demonstrated that the patients who underwent off-pump CABG with shunt had less troponin I and CK-MB levels, increased postoperative EF and a decreased rate of AF after surgery. We thought that the cause of this result was multivessel coronary bypass. Hemodynamic findings and ECG findings were similar in both groups. Hangler et al. [12] reported that the insertion of intracoronary shunts during beating heart surgery leads to severe endothelial denudation in human coronary arteries and therefore they recommend using intracoronary shunts selectively in patients with critical ischemia or in patients

<table>
<thead>
<tr>
<th>Table 1</th>
<th>Preoperative patients data</th>
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<tbody>
<tr>
<td></td>
<td>Shunt group, n (39)</td>
</tr>
<tr>
<td>Age</td>
<td>64.01 ± 8.97</td>
</tr>
<tr>
<td>Female, n (%)</td>
<td>11 (28)</td>
</tr>
<tr>
<td>Previous myocardial infarction, n (%)</td>
<td>16 (41)</td>
</tr>
<tr>
<td>Previous cerebrovascular accident, n (%)</td>
<td>4 (10)</td>
</tr>
<tr>
<td>COPD, n (%)</td>
<td>4 (10)</td>
</tr>
<tr>
<td>Diabetes mellitus, n (%)</td>
<td>14 (36)</td>
</tr>
<tr>
<td>Hypertension, n (%)</td>
<td>17 (44)</td>
</tr>
<tr>
<td>Previous cardiac operation, n (%)</td>
<td>1 (3)</td>
</tr>
<tr>
<td>Ejection fraction, n (%)</td>
<td>39.61 ± 5.7</td>
</tr>
<tr>
<td>Previous PCI, n (%)</td>
<td>21 (54)</td>
</tr>
<tr>
<td>Preoperative CK</td>
<td>83.5 ± 71.7</td>
</tr>
<tr>
<td>Preoperative CK-MB</td>
<td>21.9 ± 11.3</td>
</tr>
<tr>
<td>Preoperative troponin I</td>
<td>0.0174 ± 0.0118</td>
</tr>
<tr>
<td>CCI</td>
<td>1.27 ± 1.02</td>
</tr>
</tbody>
</table>

Abbreviations: COPD, chronic obstructive pulmonary disease; IABP, intra-aortic balloon pump CK, creatinine phosphokinase; CK-MB, creatinine phosphokinase myocardial bundle; MICSS, mean intracoronary shunt size; CCI, coronary collateral index.

<table>
<thead>
<tr>
<th>Table 2</th>
<th>Operative patients data</th>
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<tbody>
<tr>
<td></td>
<td>Shunt group</td>
</tr>
<tr>
<td>Anastomoses distal</td>
<td>2.77 ± 0.74</td>
</tr>
<tr>
<td>One vessel, n (%)</td>
<td>3 (8)</td>
</tr>
<tr>
<td>Two vessels, n (%)</td>
<td>13 (33)</td>
</tr>
<tr>
<td>Three vessels, n (%)</td>
<td>19 (49)</td>
</tr>
<tr>
<td>Four vessels, n (%)</td>
<td>4 (10)</td>
</tr>
<tr>
<td>Intraoperative blood loss</td>
<td>374.8 ± 76</td>
</tr>
<tr>
<td>TDDA (min)</td>
<td>27.1 ± 9.45</td>
</tr>
<tr>
<td>IABP, n (%)</td>
<td>1 (3)</td>
</tr>
</tbody>
</table>

TDDA, total duration of distal anastomosis; IABP, intra-aortic balloon pump.
with technical difficulties as a result of anatomic conditions. Whether the endothelial injury yielded early or late thrombosis of the coronary artery is unclear.

Although the duration of anastomosis in shunt group in our study was increased, the myocardial damage was decreased which was confirmed by lower troponin I and CK-MB levels. These patients frequently have atherosclerotic disease, systemic arterial hypertension, and DM. In the current study, there were no significant differences between these risk factors among groups. However, we considered that the shunt use after OPCAB might have preventive effects on AF rate because of the lower incidence of AF in shunt group. Nevertheless, further studies with larger series are needed to decipher our consideration. In our study, postoperative EF ratio was significantly higher in shunt group, although preoperative EF rate was not significantly different. This finding strengthens the idea of the protective effect of shunt use on myocardium. Some techniques have been introduced to overcome the technical difficulties. However, whether the endothelial injury yielded early or late thrombosis of the coronary artery is unclear. Demaria et al. [23] reported that in an experimental swine model intracoronary shunts are associated with different disadvantages, depending on the mismatch to the target coronary artery. And they say that whatever their size, shunts are not the ideal device for safely obtaining a satisfactory hemostasis. This results support our clinical attitude of the selective use of intracoronary shunts.

In conclusion, intracoronary shunts have protective effects on myocardium, such as increasing postoperative EF and decreasing AF incidence. They can be used in OPCAB surgery especially in MLVD patients.

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