Protective role of intracoronary shunt in off-pump coronary bypass operations

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ABSTRACT

الأهداف: البحث عن أي مميزات لاستخدام الصارفة في الشريان التاجي مقارنة مع العمليات التي لا تستخدم الصارفات، و ما إذا كان لها دور وقائي لعضلة القلب.

الطريقة: في هذه الدراسة الوصفية، 100 مريض خضعوا لعملية تركيب مجازة للشريان التاجي بدون استخدام مضخة القلب الاصطناعي. أجريت هذه الدراسة على مجموعة التحكم هذه في قسمين لجراحة الجهاز القلبي الوعائي وهما مستشفى الأمن الاجتماعي بأنقرة ومستشفى جامعة هاسيتيب في الفترة ما بين سبتمبر 2002م و يوليو 2006م. تم تقسيم المرضى الى مجموعتين، في المجموعة الأولى (عدد=50) أجريت لهم عملية تركيب المجازة للشريان التاجي بدون استعمال مضخة القلب الاصطناعي مع الصارفة داخل الشريان التاجي.في المجموعة الثانية (عدد= 50) لم يتم استعمال الصارفات خلال العملية، تمت دراسة مصل الكرياتين كيناس والمايوجلوبين وتروبونين تي.

النتائج: كانت هنالك زيادات ملحوظة في مستويات مصل الكرياتين كيناس في المجموعة الثانية في الساعات 6 و 12 و 24 بعد العملية. في المجموعة الثانية كانت زيادة المايوجلوبين ملحوظة إحصائيا فقط في الساعة 24 بعد العملية. كانت مستويات تروبونين تي أعلى في المجموعة الثانية في الساعات 6 و12 و24 بعد العملية.

خاتمة: هنالك بعض الأسئلة حول حماية عضلة القلب عند صيانة حقل أمان الدم أثناء عملية الشريان التاجي بدون استعمال مضخة القلب الاصطناعي. ولكن استخدام الصارفات داخل الشريان التاجي يوفر تيار تاجي قصي ويخفف من مخاطر الإصابة بنقص تروية عضلة القلب، بينما يقوم بالمحافظة على منطقة المفاغرة مريحة وخالية من الدم.

Objective: To investigate if there are any advantages in using intracoronary shunts compared to shuntless operations, in the context of whether it has a protective role for the myocardia.

Methods: This prospective study, included 100 patients who underwent off-pump coronary bypass surgery at 2 different cardiovascular surgery departments, namely, the Social Security Ankara Ihtisas Hospital, and Hacettepe University Hospital, Turkey, between September 2002 and July 2006. Patients were divided into 2 groups. In group 1 (n=50) off-pump coronary bypass operations were performed with intracoronary shunts. In group 2 (n=50) shunts were not used during off-pump. Serum creatine kinase, myoglobin, and troponin were studied.

Results: There were significant increases in serum creatine kinase levels in group 2 at postoperative 6th, 12th, and 24th hours. In group 2, the increase of myoglobin was statistically significant at only the postoperative 24th hour. Troponin levels were significantly higher in group 2 at postoperative 6th, 12th, and 24th hours.

Conclusion: There are some questions regarding myocardial protection while maintaining a bloodless secure surgical field in off-pump coronary surgery. However, use of intracoronary shunts provides distal coronary flow, and reduces the risk of myocardial ischemia, while maintaining a comfortable blood free anastomosis area.

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Although the use of cardiopulmonary bypass is common in contemporary coronary surgery, systemic and hematologic effects of extracorporeal circulation are still evident in the complication spectrum in postoperative patients. Cardiopulmonary bypass process allows the performing surgeon to operate in a motionless field, however, the necessity of using this technique for every revascularization procedure is being questioned. Off-pump coronary surgery is certainly not a new approach. The history of coronary artery bypass grafting (CABG) shows that the original cases reported by Favaloro,[1] Sabiston,[2] and Murray[3] were all performed without pump oxygenator. In 1975, Trapp and Bisarya[4] were the first to report the use of a temporary intraluminal shunt in order to facilitate the anastomosis of coronary grafts without extracorporeal circulation. Their approach was not widely accepted due to perceived complexities. Providing a bloodless secure area is extremely important for the quality of anastomosis on beating heart coronary surgery.[5] Time maintenance is a restrictive major factor during the creation of the bloodless anastomosis site. Both have a major role for the occlusion of distal coronary perfusion, which can cause unwanted temporary regional ischemia. Using intracoronary shunts provides a bloodless secure anastomosis site without temporary regional ischemia. It is a fact that intracoronary shunts can provide sufficient distal blood flow.[6] It is also very well known that snares, and clamps can cause arterial damage, and spasm.[7,8] In this study, we aim to compare 2 groups, one of which consists of subjects that had off-pump coronary bypass surgery (OPCAB) surgery by using intracoronary shunts, and the other consists of subjects that had OPCAB surgery without shunts by means of cardiac markers, such as serum creatine kinase (CK-MB), myoglobin, and troponin T. As a result, we also aim to investigate whether shuntless OPCAB surgeries cause cardiac ischemia, and if there are any differences between the 2 groups.

Methods. This case control study was prospective, randomized, and included 100 (60 men and 40 women) consecutive patients with coronary artery diseases. Operations were performed in the Social Security Ankara Ihtisas Hospital and Hacettepe University Department of Cardiovascular Surgery, Turkey between September 2002 and July 2006. The study protocol was reviewed, and approved by the Social Security Ankara Ihtisas Hospital Ethics Committee and informed consent forms were obtained from all patients.

The same team operated on the patients using the same technique. This study had 2 patient groups and OPCAB surgeries were performed in both. Patients in group 1 (n=50, 30 men and 20 women) were operated by using intracoronary shunts. Patients in group 2 (n=50, 30 men and 20 women), OPCAB operations were performed without intracoronary shunts. In group 1, the mean age was 60.20±9.06 (mean±SD, aged between 38-82 years), in group 2, the mean age was 61.18±9.15 (aged between 40-82 years). In group 1, the body weight was 81.52±11.04 kg (mean ± SD), in group 2 it was 80.70±10.97 kg. In group 1, the mean height was 170.72±7.84 cm, and in group 2, it was 170.78±8.16 cm. There were no statistically significant differences between 2 groups regarding age, gender, weight, and height. Also, there were no differences between patient characteristics with respect to smoking history, diabetes mellitus, hypercholesterolemia, hypertension, and graft number (**Table 1**). Patients were selected from a group that coronary angiography was performed on, and they were diagnosed with coronary vessels with hemodynamically significant stenosis (greater than 70% luminal narrowing) single, left anterior descending artery (LAD), or 2 vessels (left anterior descending artery-light coronary artery (RCA), or left anterior descending artery-diagonal artery). Patients with posterior vessel diseases were excluded from the study groups as some studies proved that posterior vessel off-pump bypass impairs hemodynamics of the heart by means of position of the heart.[8] Patients that required conversions during OPCAB and 3 patients whose preoperative CK-MB levels were high, were also excluded. Blood samples were collected on postoperative 6th hour, 12th hour, and 24th hour from central venous lines, and CK-MB, myoglobin, and troponin T levels were studied on venous blood samples (**Table 2**). Marker points of blood sampling (6, 12, and 24 hours) provides optimal time windows. These time intervals were chosen, as troponin T reaches its postoperative peak value in patients with the off-pump CABG technique, earlier than those with the on-pump CABG (12 hours postoperatively versus 48 hours) cardiac troponin I has been shown to be a specific marker for myocardial injury in cardiac surgery, and there is a strong concordance between maximum troponin I, troponin T and CK-MB levels. We measured troponin T, myoglobulin, and CK-MB as a marker in this study. In OPCAB surgery, these enzymes show characteristic patterns with a maximum at 24 hours after the surgery.[9,10] Operative and anesthetic technique were standard for all patients. General anesthesia was given to both groups of patients. The same general anesthetic drugs were used in all patients. Intravenous Pentothal sodium (5-7 mg/kg) was administered for induction. Anesthesia was continued with sevoflurane or isoflurane. Vecuronium bromide (0.1 mg/kg) was used as the myorelaxant drug. Cefazolin sodium and gentamicin sulphate were administered in the preoperative period for all patients. The same operative technique was used in both groups, except the case of using or not using intracoronary shunts. Standard median sternotomy incision was used for the exposure of the heart. Left internal mammaria artery harvesting, and saphenous vein graft harvesting was synchronized in 2 vessel OPCAB surgeries. The left internal mammarian artery was used as conduit in single vessel by-pass operations. The pericardium was opened vertically, and deep pericardial suture was used. The anastomosis area was stabilized with an Octopus tissue stabilizer

(Octopus II, Medtronic, Inc. Minneapolis, MN). After heparin sodium (100 IU/kg) was given arteriotomy was carried out. In group 1, intracoronary shunts were placed (Clearview intracoronary shunt Medtronic, Inc. Minneapolis MN). The shunt sizes were chosen according to the diameter of coronary arteries. In group 2, mini bulldog clamp was placed on the proximal coronary artery, and we avoided placing a clamp on the distal part of coronary artery. We used a blower to obtain a clear, and bloodless field on the anastomosis site. In both groups, 7.0 Prolene (Ethicon, Somerville, NJ) sutures were used for coronary anastomosis. Before knotting in group 1, shunts were removed in all patients, and in group 2, mini bulldogs were opened, and blood flow was observed. Then knotting was carried out. Anastomosis times and ECG's were recorded for both groups. Following bleeding control of the region, the chest was closed by standard techniques. Blood samples were drawn from central venous lines by means of a 2-syringe technique preoperatively. Central venous catheters were placed immediately before operation. Ten ml of blood was withdrawn with the first syringe and discarded, and 5 mL was obtained in the second syringe atraumatically. Blood samples were collected in commercially available tubes (Vacuette 9 ml Greiner Bio 1, USA). CK-MB, myoglobin, troponin-T levels were measured by Elecsys System (Roche Diagnostic, GmbH, D-68298 Mannheim, Germany).

Data were expressed as means ± standard deviation. A 2-tailed *P*-value less than 0.05 was considered statistically significant. Correlations between the measured laboratory indices, and clinical and demographic data were performed using the student-t test. Chi-square test was used to compare quantitative data between the groups. All statistical analyses were performed with the Statistical Package for Social Sciences (SPSS 11.5 for Windows SPSS, Chicago, IL, USA).

Results. Demographic data for patients from both group 1 and group 2 are listed in **Table 1**. Distribution of age, gender, weight, height, diabetes mellitus, hypertension, smoking, and use of drug therapy have

Table 2 - Postoperative levels of CK-MB, myoglobin, and troponin T.

Parameters	Group 1 (n=50)	Group 2 (n=50)
CK-MB (6 hours)	16.90±36.55	23.10±16.38
CK-MB (12hours)	16.18±19.03	34.02±35.23
CK-MB (24 hours)	11.01±10.58	34.96±38.71
Myoglobin (6 hours)	171.59±121.23	285.52±230.95
Myoglobin (12 hours)	195.94±144.96	323.06±221.89
Myoglobin (24 hours)	170.65±127.55	339.12±233.19
Troponin T (6 hours)	0.117±0.387	0.200±0.198
Troponin T (12 hours)	0.364±1.431	0.571±1.302
Troponin T (24 hours)	0.286±0.945	0.645±0.987

CK-MB - creatine kinase-myocardial bound, non-parametric Mann-Whitney test with 95% confidence

Table 1 - Baseline characteristics of the patients.

Characteristics	Group 1 (n=50)	Group 2 (n=50)	*P*-value
	n (%)		
Age (years) (mean±SD)	60.20±9.06	61.18±9.15	NS
Gender: M/F	30/20	30/20	NS
Weight (kg) (mean±SD)	81.52±11.04	80.70±10.97	NS
Height (cm) (mean±SD)	170.72±7.84	170.78±8.16	NS
Hypertension	24 (48)	22 (44)	NS
ACE inhibitors	28 (56)	24 (48)	NS
Beta blockers	32 (64)	35 (70)	NS
Current Smoker	20 (40)	27 (54)	NS
Left coronary disease	50 (100)	50 (100)	NS
Diabetes mellitus	16 (32)	18 (36)	NS
Hypercholesterolemia	31 (62)	29 (58)	NS
Statins	17 (34)	19 (38)	NS
CABGx1	27 (54)	30 (60)	NS
CABGx2	23 (46)	20 (40)	NS

NS - non-significant, CABG - coronary artery bypass graft, ACE - angiotension converting enzyme, M - male, F - female

Table 3 - Increasing ratio of postoperative CK-MB, myoglobin, and troponin T.

Parameters	Group 1 (n=50)	Group 2 (n=50)	*P*-value
	mean ± SD		
CK-MB (6 hours)	4.68±11.55	6.90±5.50	0.000
CK-MB (12 hours)	6.03±12.94	10.28±9.61	0.000
CK-MB (24 hours)	3.57±4.69	11.08±11.64	0.000
Myoglobin (6 hours)	9.51±7.71	12.36±10.61	0.197
Myoglobin (12 hours)	11.29±9.86	14.49±11.22	0.114
Myoglobin (24 hours)	9.86±9.01	15.76±11.86	0.010
Troponin T (6 hours)	5.15±15.1	8.01±8.59	0.016
Troponin T (12 hours)	19.17±64.33	19.28±27.10	0.008
Troponin T (24 hours)	17.03±54.05	25.18±28.58	0.000

CK-MB - creatine kinase-myocardial bound, non-parametric Mann-Whitney test with 95% confidence interval

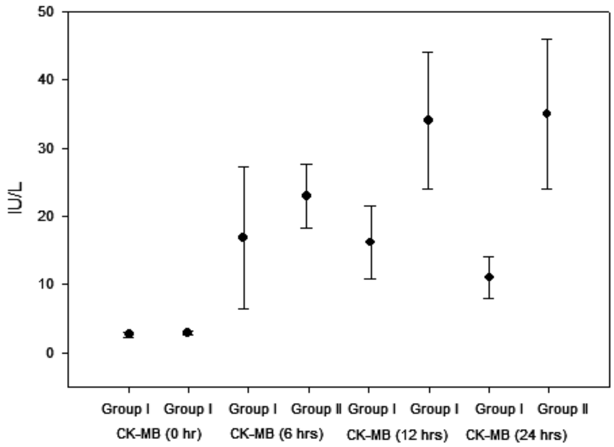

Figure 1 - Interval plot of CK_MB levels showing postoperative levels of CK-MB in group 1 and group 2 (95% confidence interval for the mean).

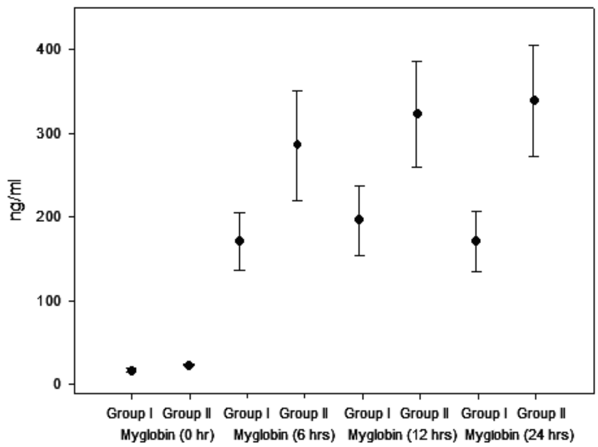

Figure 2 - Interval plot of CK-MB levels showing postoperative levels of myoglobin in group 1 and group 2 (95% confidence interval for the mean).

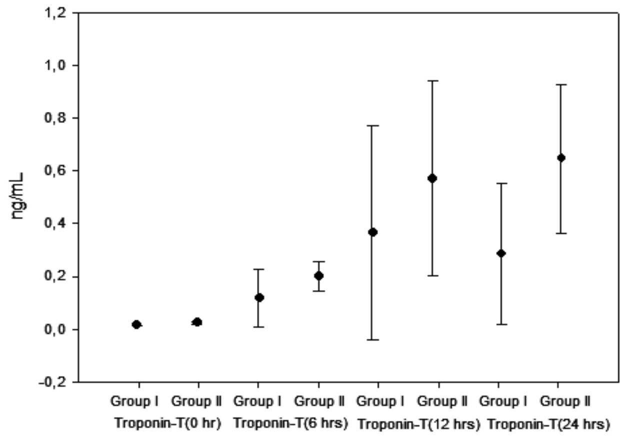

Figure 3 - Interval plot of CK_MB levels showing postoperative levels of troponin T in group 1 and group 2 (95% confidence interval for the mean).

no difference for both groups. There was no significant difference in the number of grafts, and use of left internal thoracic artery between both groups. There were also no differences in anastomosis time in the 2 groups. The same surgical team using the same technique performed all operations. There were no hospital deaths (0% mortality) and only one acute myocardial infarction occurred (2%) in group 1, 4 hours after the operation. Aorta-right coronary arterial graft occlusion was detected. **Table 2** shows levels of postoperative CK-MB, myoglobin, and troponin T. However, we consider the ratio of increase between preoperative, and postoperative levels of cardiac markers (**Table 3**). There was significant increase of CK-MB in group 2 at postoperative 6th (p<0.001), 12th (p<0.001), and 24th (p<0.001) hours. Increase of myoglobin was significant only at postoperative 24th hours (p=0.01) in group 2. In group 2, the levels of troponin T were higher at the 6th (p=0.016), 12th (p=0.008), and 24th (p<0.001) hours after operation.

Discussion. In this study, we aimed to compare 2 different techniques used in OPCAB surgeries to determine the extent of possible myocardial injury. In group 1, we maintained the surgical anastomosis site blood-free by using an intracoronary shunt, and thus allowed a distal coronary perfusion during coronary anastomosis. However, in group 2 we temporarily blocked the distal perfusion to maintain a bloodless anastomosis site by using a bulldog clamp during shuntless anastomosis. Literature on intracoronary shunt and myocardial protection in OPCAB studies is limited. Sepic et al[11] offered a publication on intracoronary shunt, and myocardial perfusion in an animal model. We found that the intracoronary shunt was capable of distal myocardial perfusion and reduced myocardial injury, however, only 6 pigs were studied, one of which was excluded. Gurbuz et al[12] conducted research on intracoronary shunt and troponin leaks in 40 patients, and reported that the intracoronary shunt reduced postoperative troponin levels significantly. However, the procedure did not reduce myocardial damage. In addition, the researchers reported that the number of patients was limited, and a study with a larger sample size would possibly provide more accurate results. Menon et al[5] reported results on an intracoronary shunt study on 35 patients. They reported that the intraluminal shunt resulted in reduced acute ischemia, and also revealed wall motion abnormalities that resulted in functions of the left ventricle to be maintained. Dapunt et al[13] compared LAD occlusion with intracoronary shunt insertion on 20 pigs, and found that revascularization by using intracoronary shunt in off-pump reduced myocardial injury. However, the study was performed on healthy pig hearts, and without coronary artery disease. The researchers reported that similar results may at least partially be expected in humans.[13] The relation between intracoronary shunt and flow measurement, endothelial dysfunction, wall damage, and insertion techniques were well documented in clinical studies.[8,13,14]

Although the OPCAB procedure itself is well known, intracoronary shunt, and myocardial protection or myocardial injury during the procedure is not well documented. In our study, we aimed to analyze myocardial injury in OPCAB, and the protective role of an intracoronary shunt in a larger population, to get more reliable results. We obtained postoperative venous blood samples in both groups, and detected CK-MB, myoglobin, troponin-T levels, 6, 12, and 24 hours following the operation to determine damage to myocytes (**Table 2**). After the myocardial cell injury, troponin levels begin to increase due to release from the myocytes. The cardiac troponin T (cTnT) levels are noticeable 3 to 12 hours after injury. The cTnT level reaches peak value on the 12th to 48th hours. Cardiac troponin T is cardiac specific, and is not increased in the serum on non-myocardial muscle injury. Analysis of cTnT has been shown to be effective in detecting minor myocardial injury in human patients.[15-17]

In our study we found that there were no differences in levels of myoglobin at postoperative 6th and 12th hours in both groups. However, serum CK-MB and troponin-T levels were higher in the patients that were operated without shunts at all marker points, and levels of myoglobin were increased 24 hours after operation in group 2 (**Table 3**). The result shows that intracoronary shunts reduce myocyte damage, and myocardial injury. The results show that intracoronary shunts have a protective role on myocardial injury in OPCAB operations, because the shunts permit distal perfusion during coronary anastomosis, and distal perfusion reduces myocardial damage. Our findings have been corroborated by other reports. In a study published by Lucchetti et al,[18] the authors found similar results to our work. They searched left ventricular wall motion score index, ejection fraction on 40 patients who underwent one vessel off-pump coronary bypass (left anterior descending-left internal mammary artery) operation with shunt, and without shunt. They reported that intracoronary shunt presumably by maintaining myocardial perfusion prevents deterioration in ventricular function. Yeatman[19] published a study on using intracoronary shunts in reducing myocardial dysfunction. The author measured heart rate, pulmonary arterial pressure, cardiac index, stroke volume, systemic vascular resistance index, and pulmonary vascular resistance index during the procedure. An inexpensive intraluminal shunt maintains coronary perfusion, prevents ischemia, reduces back bleeding, and maintains a bloodless field and molds the suture line to prevent accidental missuturing of the posterior coronary wall.[14] These advantages provide secure surgery to the surgeon. According to some studies, in some selected cases especially in high risk patients such as complicated coronary artery disease or debilitating co-morbidities and coexistence of chronic obstructive airway disease, OPCAB proffer prognostic benefits over on-pump CABG.[20-25] In the presence of co morbidities, cardiopulmonary bypass (CPB) has an additional risk for postoperative morbidity and mortality, however, OPCAB has a better clinical outcome. Off pump coronary bypass is also reported as cost-effective, and is thus favored.[26-28] Nowadays, the quality of anastomosis is the main issue on OPCAB. Maintaining a bloodless area, while also enabling continuous coronary perfusion is a dilemma. Performing vascular anastomosis on small arteries on a beating heart can be uncomfortable, and does not allow a clear view compared to cardioplegically arrested heart. This is the main difficulty in OPCAB. The beating heart with a bloody operating field is a major challenge to delicate tissue handling, and casts a shadow of uncertainty on the quality of the distal anastomosis. Also, the use of coronary snares or bulldog clamps has the potential of causing endothelial dysfunction with a predisposition to thrombosis, which can compromise the distal anastomosis. In fact, it has been suggested that OPCAB has lower patency rates.[29] However, surgeons may have to prefer OPCAB for some selected patients. However, with the application of effective target vessel stabilization and efficient visualization systems, the early and mid-term patency of OPCAB are encouraging, and comparable to on-pump CABG.[30-37] The questions that should be asked are; what is the preferable strategy in OPCAB? If OPCAB is accepted as cost-effective, and preferred since it sets free from CPB, how can we make OPCAB safe and easy? The easier way to perform OPCAB is using an intracoronary shunt or clamping the vessel. It yet remains to determine which method is safe. The past 2 decades of surgical research have been directly and mainly towards improvements in myocardial protection so that this operative strategy could be applied with minimal detriment to the myocardium.[17] Some recent studies showed that ulinastatin infusion during off-pump coronary surgery decreases cardiac troponin I (cTnI) levels, and reduced myocardial injury.[38] Some authors reported that adenosine infusion in OPCAB reduced myocardial injury, and can be used for preconditioning in order to reduce release of CK-MB and cTnI.[39] However, these methods are medical supports, and can be combined with intracoronary shunt to reduce myocardial injury in OPCAP.

In conclusion, OPCAB can be made safe and easy by using intracoronary shunt on high risk patients. Intracoronary shunt maintains a blood free anastomosis site, and offers comfort to the surgeon while distal perfusion continues. There are some studies that mention insertion of intracoronary shunts during beating heart surgery leads to severe endothelial denudation in human coronary arteries.[40] Dygert et al[41] performed research in a porcine model and published that endothelial damage was observed in the shunted region of coronary arteries in which they used intracoronary shunts. Our study did not analyze the endothelial damage, we rather aimed to research the effects of using a shunt on myocardial injury. We did not see clinical projection of regional endothelial damage. However, as we have shown in this study significant transient ischemic changes occur after clamping, and this ischemic condition may be reduced by using intracoronary shunts instead of using bulldog clamps. As a result we can say that an intracoronary shunt has a protective role in OPCAB surgery.

The main limitation of this study is the absence of post-operative coronary angiography in the follow-up period, as we could not obtain an informed consent, and permission from patients who did not experience coronary symptoms on follow-up period.

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