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Original Article / Özgün Makale

A prospective study on indication of intracoronary shunt during off-pump coronary bypass grafting surgery for single-vessel disease

Tek damar hastalığı için atan kalpte koroner baypas greft cerrahisinde intrakoroner şant endikasyonu üzerine prospektif bir çalışma

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ABSTRACT

Background: This study aims to investigate whether usage of intracoronary shunt is beneficial in off-pump coronary artery bypass grafting surgery in patients with left anterior descending artery lesion with or without retrograde flow in the vessel.

Methods: A total of 80 patients (54 males, 26 females; mean age 61.9 years; range 36 to 82 years) treated with off-pump coronary artery bypass grafting surgery in our clinic between April 2007 and March 2014 were enrolled. While half of the patients had angiographically demonstrated occluded (100%) left anterior descending artery disease, the other half had stenotic left anterior descending artery disease (70-99%). These patients were randomized into four groups according to the degree of obstruction and use of intracoronary shunt. Groups were compared in terms of duration of anastomosis and serum levels of troponin I, creatinine kinase, and creatinine kinase myocardial bundle.

Results: Postoperative levels of creatinine kinase myocardial bundle and troponin were significantly lower in the groups in which intracoronary shunt was used. On the contrary, there was no difference in terms of preoperative levels of creatinine kinase myocardial bundle and troponin and pre- and postoperative levels of creatinine kinase in groups with or without shunt usage.

Conclusion: Intracoronary shunt may be advised especially in critically ill patients with anatomical challenges. Further clinical trials are necessary to clarify the indications of intracoronary shunts in off-pump coronary artery bypass grafting surgery.

Keywords: Coronary bypass surgery; myocardial injury; off-pump coronary artery bypass grafting surgery; shunt.

ÖZ

Amaç: Bu çalışmada damarda retrograd akım olan ve olmayan sol ön inen arter lezyonu olan hastalarda atan kalpte koroner arter baypas cerrahisi sırasında intrakoroner şant kullanımının faydalı olup olmadığı araştırıldı.

Çalışma planı: Nisan 2007 - Mart 2014 tarihleri arasında kliniğimizde atan kalpte koroner arter baypas cerrahisi ile tedavi edilen toplam 80 hasta (54 erkek, 26 kadın; ort. yaş 61.9 yıl; dağılım 36-82 yıl) çalışmaya dahil edildi. Hastaların yarısında anjiyografik olarak gösterilmiş tıkalı (%100) sol ön inen arter hastalığı varken diğer yarısında tam tıkalı olmayan (%70-99) sol ön inen arter hastalığı vardı. Bu hastalar tıkanıklık derecesi ve intrakoroner şant kullanımına göre dört gruba randomize edildi. Gruplar; anastomoz süresi, troponin I, kreatinin kinaz ve kreatinin kinaz miyokardiyal izoenzimi serum düzeyleri açısından karşılaştırıldı.

Bulgular: İntrakoroner şant kullanılan gruplarda ameliyat sonrası kreatinin kinaz miyokardiyal izoenzimi ve troponin düzeyleri anlamlı derecede düşük idi. Buna karşın, şant kullanılan ve kullanılmayan gruplarda ameliyat öncesi kreatinin kinaz miyokardiyal izoenzimi, troponin düzeyleri ve ameliyat öncesi ve sonrası kreatinin kinaz düzeyleri açısından farklılık yoktu.

Sonuç: İntrakoroner şant özellikle anatomik zorlukları ve kritik hastalığı olan hastalarda önerilebilir. Atan kalpte koroner arter baypas greft cerrahisinde intrakoroner şantların endikasyonlarını ortaya koyacak ileri klinik çalışmalara ihtiyaç vardır.

Anahtar sözcükler: Koroner baypas cerrahisi; miyokardiyal yaralanma; atan kalpte koroner arter baypas greft cerrahisi; şant.

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There is a growing concern in beating-heart coronary surgery to refrain from morbidity caused by cardiopulmonary bypass (CPB) surgery.[1] Prompt progress in surgical techniques and availability of cardiac stabilizing retractors has let off-pump coronary artery bypass grafting (OPCABG) to turn out to be an established procedure. OPCABG surgery has several advantages when compared with the conventional techniques such as shorter hospital stay, shorter need of ventilatory support, less blood loss and decreased need of blood transfusion, decreased inflammatory response, and low risk of complications in the postoperative period. Also, reduced cost is a recently emphasized advantage of OPCABG surgery.[2,3]

Dry surgical field is one of the main necessities while performing coronary anastomosis. Manual compression of the vessel or the use of shunts during surgery are the most preferred methods to achieve that requisite. Intracoronary shunting is a more beneficial method in retaining perfusion while maintaining a dry and a relative bloodless field during OPCABG when compared with the traditional technique.[4] Additional benefits of intracoronary shunting are prevention of interrupted blood flow, subsequent ischemia and its consequences such as arrhythmia, ST segment depression, and left ventricle perfusion defects. However, it must be kept in mind that there is a risk also for a shunt to damage the vessel leading to thrombosis or subsequent stenosis.[5]

Even though many statements have been reported about the effects of shunts, there is no consensus about their indications. This vagueness lead surgeons to act according to their own clinical experience. Therefore, in this study, we aimed to investigate whether usage of intracoronary shunt is beneficial in OPCABG surgery in patients with left anterior descending (LAD) artery lesion with or without retrograde flow in the vessel.

PATIENTS AND METHODS

This prospective study was performed in the cardiovascular surgery department of Medical Faculty of Recep Tayyip Erdogan University after the approval of the institutional review board (2012/49). Informed consent was obtained from the patients before the operation. The study included 80 patients (54 males, 26 females; mean age 61.9 years; range 36 to 82 years) who underwent OPCABG surgery performed by the same surgical team in our institution between April 2007 and March 2014. Of the 80 patients, 40 had angiographically demonstrated isolated occluded (100%) LAD lesion, while the other 40 had isolated stenotic (70-99%) LAD lesion. These patients were randomized into four groups consistent of 20 patients each as follows:

- Group 1 (n=20): Stenosis in LAD (70-99%) treated with intracoronary shunt,
- Group 2 (n=20): Stenosis in LAD (70-99%) treated without intracoronary shunt,
- Group 3 (n=20): Complete occlusion in LAD (100%) with retrograde filling treated with intracoronary shunt,
- Group 4 (n=20): Complete occlusion in LAD (100%) with retrograde filling treated without intracoronary shunt.

The exclusion criteria include multivessel disease, severe left ventricular dysfunction (ejection fraction <20%, documented with echocardiogram), reoperative intervention, emergency operation, elevated cardiac enzymes, and history of recent myocardial infarction (MI).

A standard anesthetic technique was used for all patients and all procedures were performed through a median sternotomy. Left internal mammary artery (LIMA) was harvested before the pericardiotomy. Systemic hypothermia was avoided by adjusting the room temperature of operating theatre. Partial anticoagulation was accomplished with 1 mg/kg body weight of heparin until a target activated clotting time of 250-350 seconds was achieved. Heart rate, systemic arterial pressure, central venous pressure, pulmonary arterial pressure, and pulmonary capillary wedge pressure were continuously monitored. All patients in both groups had LIMA-LAD coronary artery bypass grafting via OPCAB technique. Following the exposure and stabilization of the LAD, preparations were made for the coronary arteriotomy. Cardiac stabilizers were used during the distal anastomosis. 8-0 polypropylene suture (Ethicon, Somerville, NJ, USA) was utilized for the anastomosis. After arteriotomy, a soft silicone subcoronary snare was placed 0.5 cm proximal to the intended target site to obtain a bloodless anastomotic field and the vessel was occluded throughout the anastomosis in patients for whom intracoronary shunt was not used. The LAD was declamped after the last suture of the anastomosis. In the shunt group, a Clearview intracoronary shunt (Medtronic Inc., Minneapolis, MN, USA) was inserted into the coronary artery after opening the LAD artery. Shunt size was estimated by examination of the external appearance of the vessel before opening the coronary. Shunts were inserted under direct vision and the proximal end was inserted first. The shunt was removed just before

Table 1. Presentation and comparison of demographics in four groups

	Group 1 (n=20)			Group 2 (n=20)			Group 3 (n=20)			Group 4 (n=20)			
	n	%	Mean±SD	n	%	Mean±SD	n	%	Mean±SD	n	%	Mean±SD	*p*
Mean age (years)			62.6±9.7			63.4±6.8			61.0±10.1			60.7±10.5	0.927*
Female	6	30.0		6	30.0		8	40.0		6	30.0		0.952
COPD	4	20.0		2	10.0		2	10.0		4	20.0	0.853	
Diabetes mellitus	6	30.0		6	30.0		4	20.0		6	30.0	0.945	
Hypertension	8	40.0		6	30.0		8	40.0		6	30.0	0.932	

SD: Standard deviation; * Wilcoxon signed Ranks test; COPD: Chronic obstructive pulmonary disease.

knotting the last suture. A Clearview carbon dioxide blower device (Medtronic Inc., Minneapolis, MN, USA) with a saline aerosol aided in visibility. Heparin was not neutralized by protamine sulfate at the end of the operation.

Two samples of serum creatinine phosphokinase (CK), creatinine phosphokinase myocardial bundle (CK-MB), and troponin I were measured half an hour before the operation and 24 hours after the operation. Serum CK and CK-MB levels were studied by enzymatic immunoassay (AU640e® Chemistry Immuno Analyzer, Olympus America Inc., Melville, NY, USA). Troponin I levels were assessed by electrochemiluminescence in immunoassay analysis (Modular Analytics E 170, Roche Diagnostics, Basel, Switzerland). Normal values of the cardiac markers were 0.00-0.04 ng/mL for cardiac troponin I, 30-200 IU/L for CK, and 0-25 IU/L for CK-MB. Increased CK-MB levels >100 IU/L was considered as diagnostic for MI. All patients underwent electrocardiography assessment with regard to the development of new Q-waves, loss of R-wave progression, a new ST elevation (>2 mm), and T-wave changes on each day after surgery. Echocardiography (ECHO) was performed in all patients before and 24 hours after the surgical intervention.

Statistical analysis

Data were analyzed using Statistical Package for Social Sciences for Windows version 16.0 software program (SPSS Inc., Chicago, IL, USA). The confidence interval and level of significance were set at 95% and $p<0.05$, respectively. Qualitative data was compared using chi-square and Fisher's exact tests, while quantitative data was evaluated with Kruskal-Wallis and Mann-Whitney U tests.

RESULTS

No statistically significant difference was observed between groups in terms of age, gender, and the frequency of comorbidities (Table 1). Postoperative levels of CK-MB and troponin were significantly lower in the groups with intracoronary shunt (p=0.021 and p=0.001, respectively). In contrast, the groups with or without shunt displayed no difference in terms of preoperative levels of CK-MB (p=0.985), troponin (p=0.988), and both pre- (p=0.981) and postoperative levels of CK (p=0.198) (Table 2).

When groups were compared, a significant difference was noted between groups 1 and 4 with respect to the duration of anastomosis (p=0.041).

Table 2. Comparison of pre- and postoperative values of parameters in four groups

	Patients with shunts		Patients without shunts		
	Group 1 (n=20) (LAD, stenosed)	Group 3 (n=20) (LAD, occluded)	Group 2 (n=20) (LAD, stenosed)	Group 4 (n=20) (LAD, occluded)	
	Mean±SD	Mean±SD	Mean±SD	Mean±SD	*p**
Mean anastomosis time (min)	7.7±1.0	7.5±1.0	6.8±0.7	6.7±0.5	0.059
Mean preoperative CK (IU/L)	77.8±25.9	76.6±35.6	74.6±23.4	79.8±35.0	0.981
Mean postoperative CK (IU/L)	725.3±282.0	718.8±154.1	835.7±92.5	792.4±107.6	0.198
Mean preoperative CK-MB (IU/L)	17.2±5.2	17.7±2.7	17.4±4.9	17.2±3.6	0.985
Mean postoperative CK-MB (IU/L)	37.2±10.6	36.1±6.1	44.8±8.6	39.2±4.2	0.021
Mean preoperative troponin I (ng/mL)	0.0±0.0	0.0±0.0	0.0±0.0	0.0±0.1	0.988
Mean postoperative troponin I (ng/mL)	0.3±0.1	0.2±0.1	0.6±0.2	0.4±0.2	0.001

LAD: Left anterior descending; SD: Standard deviation; * Wilcoxon signed Ranks test; CK: Creatinine phosphokinase; MB: Myocardial bundle.

Table 3. Comparison of four groups with regard to alteration of parameters pre- and postoperatively

	Group 1 vs group 2	Group 1 vs group 4	Group 2 vs group 3	Group 3 vs group 4
	p	*p*	*p*	*p*
Mean anastomosis time (min)	0.063	0.041	0.064	0.075
Mean preoperative CK (IU/L)	0.649	1.000	1.000	1.000
Mean postoperative CK (IU/L)	0.096	0.257	0.059	0.257
Mean preoperative CK-MB (IU/L)	0.849	0.849	0.879	0.849
Mean postoperative CK-MB (IU/L)	0.015	0.075	0.022	0.138
Mean preoperative troponin I (ng/mL)	0.597	0.880	0.910	0.970
Mean postoperative troponin I (ng/mL)	0.001	0.406	0.001	0.174

CK: Creatinine phosphokinase; MB: Myocardial bundle.

Similarly, postoperative levels of CK-MB and troponin I displayed a significant difference not only between groups 1 and 2 (p=0.015 and p=0.001, respectively), but also between groups 2 and 3 (p=0.022 and p=0.001, respectively) (Table 3). No difference was observed in any parameters between groups 1 and 3, and between groups 2 and 4.

DISCUSSION

The present study aimed to investigate whether intracoronary shunting is beneficial in OPCABG surgery with special reference to the presence or absence of retrograde flow in the vessel. Postoperative levels of CK-MB and troponin were found to be significantly lower in the groups with intracoronary shunt. On the contrary, the groups with or without shunt displayed no difference in terms of preoperative levels of CK-MB, troponin, and both pre- and postoperative levels of CK.

Since its description by Kolesov in the 1960s, OPCABG has become a more reasonable decision for CPB.[6] However, the operating surgeon may still come upon hemodynamic instabilities resulting in ischemia of the myocardium during surgery. An intracoronary shunt may avoid these consequences by decreasing the necessity for emergency initiation of surgery, and supporting the operating surgeon to perform an enhanced coronary anastomosis.[7] Manipulation of coronary arteries with hemostatic devices during OPCABG bears the risk of endothelial injury with subsequent coronary artery stenosis, and collateral damage such as septal MI, septal branch right ventricular fistula, and distal embolization of atheromatous debris.[8,9] Previous studies analyzing the effects of hemostatic devices on coronary endothelial function and morphology have been performed in animal coronary arteries.

Bleier et al.[10] stated that cardiac troponins may be representing the release of proteins from non-structurally bound cytosolic pools instead of real MI. Sadony et al.[11] revealed that cardiac troponin I serum level measured at the 24th hour has a sensitivity of 100% and a specificity of 97%. Furthermore, Gurbuz et al.[12] and Bozok et al.[13] determined that troponin I levels in patients without coronary shunts were significantly higher than patients with shunts. They highlighted that this elevation may be interpreted as a reversible injury rather than a frank myocardial necrosis, so they advise the usage of shunt in patients prone to transient ischemia. Emmiler et al.[14] compared shunt group with shuntless on the basis of cardiac enzymes and echocardiographic evaluation. Their findings were consistent with the results of Gurbuz et al.[12] and Bozok et al.[13] In both studies, the coronary lesions did not exhibit retrograde filling.[12,13] In our study, we included patients having retrograde filling of LAD and both groups had no difference in terms of troponin I levels. This data correspond also with CK-MB levels. In the present study, postoperative CK-MB and troponin levels were found to be significantly lower in groups with intracoronary shunt.

Hemodynamic collapse necessitating conversion to CPB did not occur in the present study. However, this study is not adequately designed to answer whether coronary shunting could avoid CPB surgery.[15] Various authors have shown that coronary shunting throughout LAD grafting can avoid myocardial wall motion aberrations, and others documented reversal of hemodynamic instability by coronary shunting.[16,17] Furthermore, many researchers claimed that coronary shunting might decrease troponin release.[12,13] In the present study, ECHO was performed in all patients before and 24 hours after the surgical intervention. Echocardiography assessments revealed no abnormality in myocardial wall motion between groups. It must be

noted that only totally occluded LAD grafting was assessed in our study.

In anesthetized patients, blood pressure required to prevent ischemia may be low and this may be related not only to the shunt, but also to the proximal intracoronary pressure, and collateral circulation.[18] Coronary shunting may prevent ischemia in antegradely perfused LADs during grafting. Ischemia in LAD area can be observed by measuring the strain in interventricular septum.[19] It must be kept in mind that we only included patients with LAD disease. None of the patients with occluded LAD developed ischemia which may be due to well-established collaterals, or the lack of stress which may delay the competence of collateral blood supply.

The current study possesses several limitations. The major limitation is the relatively small sample size, which limits the interpretation of significant conclusions on the indications of intracoronary shunts. Second, the samples could not be considered representative of patients that had undergone OPCABG surgery because the subject population was only obtained from one center, resulting in possible sampling bias. Third limitation is the lack of angiography, which is considered the gold standard for assessment of evaluating the graft patency. Limitations of control arteriography are its costs, risks in clinically stable patients of 0.7-4.0%, and the possible disruption of baseline hemodynamics by contrast injection.[20] The cardiac markers measured repetitively would possibly give a reasonable evaluation of the release. However, Sadony et al.[11] stated that a cardiac troponin I value at 24 hours had a sensitivity of 100% and a specificity of 97% for discrimination of patients with or without MI. The enzyme differences observed in this study may be statistically significant but not clinically significant. Finally, the anastomosis was limited to the LAD, where it is easily performed particularly when other coronary arteries were patent. Despite the limitations, this study provided additional information on the use of intracoronary shunts and their beneficial effect on myocardium.

All in all, no ischemia occurred in totally occluded LAD lesions in our series. There is no consensus concerning the benefits of shunts in constituting anastomosis. It is a must to avoid endothelial damage in every kind of surgery. Shunts potentially extenuate endothelium and may cause intimal hyperplasia and stenosis. Our results support that there is no need to use intracoronary shunts in OPCABG. During OPCABG surgery, the anastomoses must be performed either with respect to the status of collaterals or the degree of occlusion. No matter whether shunt is used or not, either the vessel with the most developed collateral network or the vessel that is most obstructed must be selected initially for performance of anastomosis.

In conclusion, we think that intracoronary shunts are advisable especially in critically ill patients with anatomical challenges. Further prospective, randomized, clinical studies are needed to unveil the indications of shunts in off-pump coronary artery bypass grafting surgery.

Declaration of conflicting interests

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