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Original Article / Özgün Makale

Very long-term angiographic results of off-pump coronary artery bypass graft surgery

Atan kalpte koroner arter baypas greft cerrahisinin çok uzun dönem anjiyografik sonuçları

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Background: This study aims to evaluate the long-term results of angiography in patients undergoing off-pump coronary artery bypass grafting (CABG).

Methods: Between September 1993 and December 1995, a total of 162 patients who underwent off-pump CABG by the same two surgeons at a single center, followed by angiography were retrospectively analyzed.

Results: The mean time from surgery to angiography was 9.8±1.2 years (range, 7.1 to 12.6 years). The overall patency rate of the left internal mammary artery graft was 95.57% and 46.03% in saphenous vein grafts (SVG). During follow-up, 27 patients (16.67%) underwent percutaneous coronary intervention. The procedure was performed due to severe stenosis in the SVG in eight of them and due to severe lesion formation in native coronary artery in the others. Five patients underwent repeated CABG. There was no significant association between pre-, intra-, and postoperative variables and graft patency.

Conclusion: Off-pump CABG technique, in contrast to the conventional bypass, has well-known advantages such as lower transfusion of blood and blood products, shortened length of intensive care unit and hospital stay, reduced cost, and lower morbidity and mortality. Our very long-term angiographic follow-up study showed that off-pump CABG is as reliable as conventional bypass procedure with excellent outcome and patency particularly in the left anterior descending coronary artery. Therefore, off-pump CABG technique should be the primary procedure of choice in selected patients.

Keywords: Coronary artery bypass; myocardial revascularization; off-pump.

Amaç: Bu çalışmada atan kalpte koroner arter baypas greftleme (KABG) yapılan hastalarda anjiyografinin uzun dönem sonuçları değerlendirildi.

Çalışma planı: Eylül 1993 - Aralık 1995 tarihleri arasında aynı iki cerrah tarafından atan kalpte KABG yapılan ve takiben anjiyografisi çekilen toplam 162 hasta retrospektif olarak incelendi.

Bulgular: Ameliyat ile anjiyografi arasında geçen süre ortalama 9.8±1.2 yıldı (dağılım 7.1-12.6 yıl). Genel olarak greft açıklık oranı sol internal mammaryan arterde %95.57 iken, safen ven greftinde %46.03 olarak bulundu. Takip sürecinde, 27 hastaya (%16.67) perkütan koroner girişim uygulandı. Bunların sekizinde SVG'de ciddi darlık nedeniyle, diğerlerinde nativ koroner arterde yeni ciddi lezyon oluşumu nedeniyle işlem uygulandı. Beş hastaya da tekrar KABG uygulandı. Ameliyat öncesi, sırası ve sonrası değişkenler ile greft açıklığı arasında anlamlı bir ilişki saptanmadı.

Sonuç: Konvansiyonel baypasa kıyasla, atan kalpte KABG tekniği kan ve kan ürünlerinin transfüzyonunu azaltma, yoğun bakım ünitesi ve hastanede kalış süresini kısaltma, maliyeti düşürme ve morbidite ve mortaliteyi azaltma gibi iyi bilinen avantajlara sahiptir. Çok uzun dönem anjiyografik takip çalışmamızda atan kalpte KABG'nin konvansiyonel baypas işlemi kadar güvenilir olduğu ve özellikle sol ön inen koroner arterde mükemmel sonuç ve açıklık sağladığı görüldü. Bu nedenle, atan kalpte KABG tekniği, seçilmiş hastalarda öncelikli olarak tercih edilmelidir.

Anahtar sözcükler: Koroner arter baypas; miyokardiyal revaskülarizasyon; atan kalp.

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Coronary artery bypass grafting (CABG) surgery is a reliable treatment for coronary artery disease with reproducible results. However, the results of CABG, both with and without cardiopulmonary bypass (CPB), are still being debated.[1-4] Extracorporeal circulation and aortic cross-clamping can cause deleterious effects, such as the activation of immunological cascades, microembolization, and macroembolization, resulting in neurological, renal, and gastrointestinal dysfunction along with global myocardial ischemia/reperfusion injury (RI).[1] Off-pump coronary artery bypass (OPCAB) has been proposed to avoid these negative effects since it reduces the risks of postoperative morbidity, length of intensive care unit (ICU) and hospital stays, and the cost of the coronary revascularization procedure.[2-4] Because the OPCAB technique requires distal anastomosis to be performed on the beating heart, there are concerns that the long-term patency of the grafts may well be adversely affected.[1,2,5,6] The purpose of this study was to evaluate the very long-term angiographic results of OPCAB operations performed over a 10-year period at a single center.

PATIENTS AND METHODS

Five hundred and fifty-one patients who were operated by the same two surgeons between September 1993 and December 1995 at the Koşuyolu Heart and Research Hospital were evaluated in this study via preoperative and operative data that was collected from the hospital database and patient records. Each patient was contacted by telephone, and those who were eligible were invited for a control examination. In addition, informed consent was obtained from each of the patients. We were able to reach 182 patients from the telephone and address records, but we could not contact 369 others due to changes in the telephone numbers and addresses or because of incomplete records. Furthermore, 20 patients who were alive during the follow-up period of this study did not give their consent since they had had no indication of the need for cardiac catheterization since their operation. In the end, 162 patients (134 males, 28 females; mean age 53.3±9.9 years) who had control cardiac catheterizations during the follow-up period were included in the final analysis for very long-term angiographic and clinical assessments of the outcomes.

The OPCAB was performed with elastic silicone loops placed around the coronary arteries which were proximal and distal to the anastomotic site of the artery. No intracoronary shunt was used during these procedures, and only the proximal portion of the artery was occluded by a snare or bulldog clamp to achieve a bloodless field for anastomosis. The distal segment was never occluded, and further improved visualization was achieved by blowing air during the anastomosis. When a saphenous vein graft (SVG) was used, first the distal and then the proximal anastomosis was completed. Before initiating the procedure, heparin was administered to keep the activated clotting time (ACT) at between 200-250 seconds. A beta (β)-blocker was also used to keep the heart rate below 80 beats/minute. Since there was no apparent drainage, the heparin was not neutralized with protamine sulfate.

All data is presented as mean ± standard deviation (SD) or as an interquartile range. Chi-square and Fisher's exact tests were used to compare categorical variables, and the Mann-Whitney U test was used to compare continuous variables. To predict the relationship between the postoperative graft occlusion and various risk factors, a logistic regression analysis was performed, and a p value of <0.05 was considered to be statistically significant.

RESULTS

All of the study participants underwent a control angiography during the follow-up period, and the mean follow-up time from the time of the operation to this procedure was 9.8±1.2 years (range 7.1-12.6 years). The preoperative risk factors and associated conditions are listed in Table 1.

The operative data is shown in Table 2. The left internal mammary artery (LIMA) was used as the conduit of choice for the left anterior descending artery (LAD) in 158 (97.53%) of the patients while the right internal mammary artery (RIMA) was used for the right coronary artery (RCA) bypass grafting in two patients and for the LAD in one. The great SVG was used in the remaining anastomoses. One hundred and eighteen patients (72.84%) were completely revascularized, and two (1.23%) underwent an endarterectomy to the RCA.

The peri- and postoperative morbidities are listed in Table 3. Perioperative myocardial infarction (MI) was detected in eight of the patients (4.94%). One of these had occluded LIMA and SVG grafts in the control angiography, and three had a patent LIMA but occluded SVG grafts. The grafts were patent in the remaining four patients.

Very long-term cardiac mortality occurred at a rate of 4.8% in three patients. One patient with chronic renal failure was lost due to acute MI following dialysis nine years after the original surgery, another

Table 1. Preoperative variables

	n	%	Mean±SD
Age			53.28±9.91
Male	134	82.7	
Body mass index (kg/m^2)			26.89±3.63
Diabetes mellitus	42	25.93	
Hypertension	111	68.52	
Hyperlipidemia	57	35.19	
Smoker	112	69.14	
Family history	66	40.74	
Chronic obstructive pulmonary disease	18	11.11	
Extracardiac arteriopathy	4	2.47	
Chronic renal failure	1	0.62	
Left ventricular dysfunction	23	14.2	
Previous myocardial infarction	77	47.53	
Unstable angina pectoris	41	25.31	

SD: Standart deviation.

died because of decompensated congestive heart failure during the postoperative ninth, and the third patient was reoperated on because of graft occlusion in the ninth year of follow-up and did not survive the surgery.

The LIMA graft was patent in 151 patients (95.57%) while two of the RIMA grafts were in this same condition (66.67%). In addition, one of the RIMA grafts on which RCA was performed was occluded. We also determined that the patency of the SVG was lower (46.03%), and we observed superior patency of the bypass grafts when they were performed on the LAD (Table 4).

We also divided the patients into three groups according whether there was patency in all, some, or none of the bypassed grafts. In addition, we examined the effects of the preoperative and postoperative variables (Table 5) and found no significant differences between these groups with regard to any of the preoperative variables. However, postoperative atrial fibrillation was significantly higher in the patients with non-patent grafts (p=0.0001), and the length of hospital stay was also significantly longer in those patients (p=0.043). The logistic regression analysis determined that none of the variables were associated with graft occlusion.

Percutaneous coronary intervention (PCI) was necessary in 27 patients (16.67%) during the follow-up period, and eight of these had significant stenosis in the SVG (4.94%). The remaining subjects had a new onset of significant lesions in the native coronary arteries. Furthermore, one patient with occluded LIMA and SVG grafts and four with LIMA occlusion underwent reoperations.

Table 2. Operative variables

	n	%
Number of bypassed vessels in each patient		
1 vessel	108	66.67
2 vessels	45	27.78
3 vessels	9	5.56
Target vessels		
Left anterior descending artery	162	100
Diagonal	24	14.8
Circumflex high lateral branch	4	2.47
Circumflex posterolateral branch	1	0.62
Right coronary artery	26	16.05
Right coronary posterior descending artery	7	4.32

DISCUSSION

Avoiding the morbidities associated with CPB, for example aortic cannulation and clamping, hypothermia, cardiac arrest, systemic hemodilution, and impaired

Table 3. Peri- and postoperative variables

	n	%
Inotrope	9	5.56
Intraaortic balloon pump	3	1.85
Reoperation for bleeding	3	1.85
Pulmonary complications	3	1.85
Stroke	1	0.62
Peroperative myocardial infarction	8	4.94

Table 4. The patency of the bypass grafts in relation to the target vessels

Target vessels	LIMA			RIMA			SVG		
	n	Patent	%	n	Patent	%	n	Patent	%
Left anterior descending artery	158	151	95.57	1	1	100	3	3	100
Diagonal	–	–	–	–	–	–	24	12	50
Circumflex high lateral branch	–	–	–	–	–	–	4	1	25
Circumflex posterolateral branch	–	–	–	–	–	–	1	1	100
Right coronary artery	–	–	–	2	1	50	24	10	41.67
Right coronary posterior descending artery	–	–	–	–	–	–	7	2	28.57
Total	158	151	95.57	3	2	66.67	63	29	46.03

LIMA: Left internal mammary artery; RIMA: Right internal mammary artery; SVG: Saphenous vein graft.

hemostasis, has become possible via the introduction of the OPCAB procedure. It is well known that this technique is associated with less systemic inflammation, reduced transfusion requirements, the preservation of renal function, better myocardial function, and reduced atrial fibrillation as well as a decrease in pulmonary dysfunction, reduced costs, and less mortality.[1,7-9] Despite the aforementioned advantages, only 15-20% of the CABG operations are conducted using the OPCAB technique.[2,7,10,11]

A recent report by Filardo et al.,[12] which compared the long-term survival between off-pump and on-pump CABG patients (over 12 years of follow-up) stated that the OPCAB group was at an increased risk of death (18%) independent of their preoperative severity. Additionally, the authors suggested that the lower complete revascularization rate in these patients might have caused this difference. In multivessel disease, on-pump CABG is frequently the technique of choice, but for patients needing less bypass vessels, OPCAB is still sometimes preferred to achieve the goal of complete revascularization. In our patient group, complete revascularization was achieved in 118 (72.84%) of the patients and long-term cardiac mortality was seen in 4.8%. In the mortality group, complete revascularization occurred in 66.67% of the patients while in 27.16%, it was incomplete. However, there was no association between the late outcome (angina recurrence, MI, or death) and incomplete revascularization.

The clopidogrel after surgery for coronary artery disease (CASCADE) randomized controlled trial

Table 5. An analysis of the pre- and postoperative variables within the patency groups

	None patency				Totally				Some patency				
	n	%	Mean	Range	n	%	Mean	Range	n	%	Mean	Range	*p*
Age (year)			55.5	(45.75-57.75)			55	(44.75-61)			50.5	(45-60)	0.930
Gender													
Female	2	33.3			23	17.7			3	11.5			0.428
Male	4	66.7			107	82.3			23	88.5			
Body mass index			30.84	(27.06-33.11)			26.88	(24.63-28.89)			26.56	(23.35-29.96)	0.053
Mean follow-up time (years)			8.6	(7.9-10.4)			9.8	(9-10.8)			10.2	(8.9-10.7)	0.307
Left ventricular dysfunction	0	0			17	13.08			6	23.08			0.245
Previous MI	3	50			57	43.85			17	65.38			0.132
Diabetes mellitus	2	33.3			31	23.85			9	34.62			0.476
Hypertension	4	66.7			84	64.62			23	88.46			0.057
Hyperlipidemia	2	33.3			44	33.85			11	42.31			0.708
Chronic obstructive pulmonary disease	0	0			17	13.08			1	3.85			0.266
Smoker	3	50			89	68.46			20	76.92			0.407
Family history	3	50			55	42.31			8	30.77			0.493
Chronic renal failure	0	0			1	0.77			0	0			0.884
Extracardiac arteriopathy	0	0			3	2.31			1	3.85			0.831
Inotrope	1	16.67			5	3.85			3	11.54			0.142
Intraaortic baloon pump	0	0			3	2.31			0	0			0.686
Perioperative MI	1	16.67			4	3.08			3	11.54			0.077
Reoperation	4	66.67			0	0			1	3.85			0.0001
Percutaneous coronary intervention	2	33.3			15	11.54			10	38.46			0.002

SD: Standard deviation; MI: Myocardial infarction.

showed that the statin therapy used to achieve LDL levels of less than 100 mg/dL was independently associated with improved graft patency.[13] Omeroglu et al. investigated the mid-term angiographic results of OPCAB at our institution, and they also stated that graft type and hyperlipidemia were significant risk factors for graft occlusion.[5] In contrast to these findings, neither hyperlipidemia nor statin therapy had any effect on graft patency in our patients. Furthermore, there were some variables other than hyperlipidemia that were quite different between the patients with patent anastomoses and those with occluded anastomoses (e.g., diabetes). However, because of the small sample size in our study, it is likely that these differences were not statistically significant.

The primary concern regarding the use of OPCAB has been the patency of the bypassed grafts due to the technically challenging requirement for the anastomoses to be performed on a beating heart. In our study, the LIMA patency was 95.57% but the SVG patency was lower at 46.03%. In long-term follow-up studies, the LIMA and SVG patencies of on-pump CABG patients were between 80 and 94% and 45 and 75%, respectively.[14-18] The main limitation of this study was its retrospective design and small sample size. In addition, we lacked a second comparison group with on-pump CABG patients because there were no digital patient records at that time; therefore, establishing a propensity-matched group was not possible. Despite these limitations, our study was able to provide the very long-term angiographic results of OPCABG operations, and even though there was a very long follow-up period in our study, the patencies of the LIMA-LAD and LAD-targeted grafts (95.57% and 100%) were still comparable to the findings of short- and mid-term control studies.[5,19-23]

Conclusion

No definitive conclusions regarding can be drawn from previously mentioned large clinical trials and studies regarding the superiority of either strategy or selection criteria of patients on the outcomes of on-pump and off-pump CABG since no randomized, double-blinded, prospectively designed trial is available.[24] This technique may be technically challenging, but it offers superior patient comfort along with reduced costs and less morbidity. The superior very long-term patency rates of the LIMA-LAD grafts and LAD-targeted grafts in our patient group should garner special attention since the hybrid revascularization procedures are becoming more popular.[25,26] In this study, the angiographic controls revealed the superior patency of the LAD-targeted grafts (95.57-100%) over a time period of up to 10 years. In suitable patients, the handling of coronary arteries other than the LAD with PCI while performing an LAD bypass with OPCAB may prove to be a good alternative procedure that can provide favorable outcomes.

Declaration of conflicting interests

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