ARAŞTIRMA MAKALESİ/ORIGINAL RESEARCH

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Atan Kalp Tekniği ile Koroner Baypas; Nasıl Yapılır ve Sonuçlarımız

Coronary Bypass with Beating Heart Technique; How to Do It and Our Results

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ÖZET

GİRİŞ ve AMAÇ: Koroner revaskülarizasyon, aterosklerotik iskemik kalp hastalığının tedavisinde hayati bir role sahiptir. Koroner arter baypas greftleme (CABG) esas olarak kardiyopulmoner bypass (CPB) kullanılarak yapılırken, 1990'ların ortalarından beri kardiyopulmoner baypas (Of-pCABG) kullanılmadan yapılmaya başlandı. Of-pCABG tekniği ile yüksek riskli ve yaşlı hasta gruplarında, postoperatif inotrop ve intraaortik balon pompası kullanımında azalma, kan kaybı ve kan transfüzyonunda azalma, böbrek yetmezliği, solunum sistemi problemleri ve atriyal fibrilasyonun rsiskini azalması ile mortalite ve morbidite oranlarının da azalma görülür. Aynı zamanda postoperatif hastanede kalış süresini ve hastane maliyetlerini önemli ölçüde azalttığı da gösterilmiştir.
YÖNTEM ve GEREÇLER: 2018-2020 arasında of-pCABG tekniği ile izole koroner arter baypas yapılan 260 hastanın verileri retrospektif olarak incelenmiştir. Cerrahi sırasında kullandığımız kardiyak stabilizasyon yöntemleri ve koroner arterlerin kontrol tekniklerini paylaşmak istedik. Erken dönem sonuçlarımızı bildirdik.
BULGULAR: Hastane içi mortalite oranımız %3.0 (8 hasta) iken, serebrovasküler hastalık %2.3 (6 hasta) olarak görülmüştür. Postoperatif hemodiyaliz ihtiyacı %2.6 (7 hasta) idi. Yoğun bakım ünitesindeki ortalama kalmak 2.3 (± 0.9) gün olarak hesaplanırken, hastanede kalış süresi 9.7 (± 7.07) gündü.
TARTIŞMA ve SONUÇ: Konservatif CABG tekniğinden daha az invaziv olan of-pCABG tekniğinin, (çoklu koroner arter hastalığında, düşük EF'li hastalarda akciğer hastalığı, kronik böbrek hastalığı gibi komorbid hastalarda) tatmin edici sonuçlarla uygulanabileceğini düşünüyoruz.

Anahtar Kelimeler: koroner arter baypas, atan kalp, pompasız koroner baypas, aterosklerotik kalp hastalığı

ABSTRACT

INTRODUCTION: Coronary revascularization has a vital role in treating atherosclerotic ischemic heart disease. While coronary artery bypass grafting (CABG) is mainly performed using cardiopulmonary bypass (CPB) with cardioplegic arrest, CABG has been started to be performed without using cardiopulmonary bypass (of-pCABG) since the mid-1990s. In high-risk patient and elderly patient groups, it has been reported that with of-pCABG, a decrease in the need for postoperative inotropes and the use of intra-aortic balloon pumps, a decrease in blood loss and blood transfusion, complications such as kidney failure, respiratory system problems, and atrial fibrillation, as well as mortality and morbidity are reduced. Additionally, off-pump CABG has also been shown to reduce the postoperative length of stay and hospital costs significantly.
METHODS: Data of 260 patients with isolated coronary artery bypass with the technique of Of-PCABG between 2018 and 2020 were retrospectively examined. We wanted to share the cardiac stabilization and coronary artery control techniques we used during surgery. We have reported our early results.
RESULTS: While our in -hospital mortality rate was 3.0 %(8 patients), cerebrovascular disease was seen as 2.3 %(6 patients). The need for postoperative hemodialysis was 2.6 %(7 patients). The average stay in the intensive care unit was calculated as 2.3(±0.9) days, while the remaining time in the hospital was 9.7(±7.07) days.
DISCUSSION AND CONCLUSION: We think that the of-pCABG technique, which is less invasive than the conservative CABG technique, can be applied with satisfactory results in multi-vessel diseases, patients with low EF, and comorbid patients (such as lung disease, chronic kidney disease, or failure).

Keywords: coronary artery bypass, beating heart, of-pump coronary artery bypass, atherosclerotic heart diseases

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INTRODUCTION

Coronary artery revascularization has a vital role in treating atherosclerotic ischemic heart disease (1). Coronary artery bypass grafting (CABG) which used to be performed with cardiopulmonary bypass (CPB) and cardioplegic arrest has begun to be performed without cardiopulmonary bypass (of-pCABG) since the mid 1990s (2). Despite all the technological advances CPB still has risks of blood trauma, activation of inflammatory response, non-pulsatile flow, volume retention, coagulopathy, pulmonary dysfunction, stroke, neurocognitive changes together with air or clot embolism, complications due to cardiac arrest and aortic manipulation (3). Although there is still debate about the benefits of off-pump CABG, the advantages of the of-pCABG technique compared to traditional coronary artery bypass grafting (CABG) have been repeatedly emphasized (4). In high-risk and elderly patient groups, reduction in the need for postoperative inotropes and the use of intra-aortic balloon pumps, blood loss and blood transfusdion, complications such as kidney failure, respiratory system problems, atrial fibrillation, mortality and morbidity has been reported with of-pCABG (5,6). Additionally, of-pCABG has also been shown to reduce the postoperative length of hospital stay and hospital costs significantly (7). Therefore, interest in of-pCABG has increased in recent years. Besides these benefits, this technique also has disadvantages such as potential pitfalls, incomplete revascularization, ischemia, insufficient anastomoses during temporary target artery occlusion, and the need for special equipment (8).

MATERIAL AND METHODS

This study was conducted in accordance with the Declaration of Helsinki. Data was evaluated retrospectively after approval from the university's local ethics committee (GOKAEK-2022/08.16). In our clinic, data of 260 patients operated for isolated coronary artery bypass with of-pCABG between 2018 and 2020 were sought retrospectively. Demographic data of the patients were given in Table 1. We started an of-pCABG program by selecting favorable patients who should do very well in the perioperative period and then expanding to more challenging and high-risk cases. We did not prefer the of-pCABG technique in patients with left main coronary artery (LMCA) disease. We preferred of-pCABG, especially in patients with renal dysfunction or hemodialysis. We also performed of-pCABG operations in all emergency cases except LMCA disease.

Table 1: Demographic Data of Patients

	n (%)		
Gender (Female/Male)	70 (26.9) / 190 (73.0)		
Age (mean±SD)	64 ± 10.03		
DM	141 (54.2)		
HT	175 (67.3)		
Chronic Obstructive Lung Diseases/Asthma	118 (45.3)		
Thyroid gland diseases	Hypothyroidism	Hypertyrodism	
	3 (1.1)	28 (10.7)	
Carotid artery diseases	25 (9.6)		
Peripheral arterial diseases	29 (11.1)		
Preoperative atrial fibrilation	12 (4.6)		
Chronic renal diseases (without hemodialysis)	9 (3.4)		
Chronic renal insufficiency (with hemodialysis)	7 (2.6)		
Ejection fraction (mean±SD)	53.8 (14.0)		
Emergency/Elective operation	11 (4.2) / 249 (95.7)		
BMI (mean±SD)	24.7 (±4.26)		
EuroSCORE II	Low	Middle	High
	134 (51.5)	101 (38.8)	25 (9.6)

DM: Diabetes mellitus, HT: Hypertension, BMI: Body mass index

Continuous systemic arterial pressure (with a peripheral intra-arterial catheter) and central venous pressure (CVP) (with a venous catheter) were monitored for hemodynamic monitoring. Central nervous system (CNS) monitoring was made with continuous svO2 monitoring. We think that it is essential to evaluate possible CNS complications related to hypotension. We did not routinely use advanced monitoring methods such as pulmonary artery catheterization and transesophageal echocardiography.

All patients were pre-medicated with intravenous (iv) midazolam (0.03mg/kg) before being transferred to the operating room. Then, 5 L/min oxygen was given via a face mask, and peripheral venous access was achieved on the antecubital area using an 18-gauge catheter. Heart rate (HR) was determined by 5-channel electrocardiography (ECG), and standard peripheral oxygen saturation (SpO_2) and noninvasive blood pressure monitoring were performed. After local anesthesia with lidocaine 2% and iv fentanyl (1µg/kg), an arterial catheter was placed before anesthesia induction. After anesthesia induction using 0.05–0.1 mg/kg midazolam, 5–7 µg/kg fentanyl, 0.1 mg/kg rocuronium and 2–3 mg/kg thiopental, the patients were intubated and volume-controlled mechanical ventilation was started. Tidal volume was set at 8 ml per kilogram of predicted body weight; inspiration/expiration ratio was adjusted to 1:2, respiratory rate was adjusted to 10/minute, and fresh gas flow was set at 3 L/minute in all patients. The respiratory rate was initially started at 10/min, and was adjusted to maintain the end-tidal carbon dioxide values between 35-40 mmHg. Positive end-expiratory pressure of 5 cmH_2O was applied. Oxygen concentration was increased when SpO_2 dropped below 97 percent. Anesthesia was maintained with 40% oxygen and 60% air mixture, desflurane (0.5-1.0 MAC) inhalation and remifentanil infusion (0.2-

0.3µg/kg/min). Intraoperative additional analgesia was provided using intravenous bolus fentanyl.

Intravenous volume replacement was made at 15 to 20 mL/kg during of-p CABG to maintain hemodynamic stability during manipulation, rotation, and elevation of the heart for coronary artery grafting (9).

Surgical access was made via a median sternotomy. Mediastinal adipose tissue was dissected before the pericardium was opened. The left pericardiopleural area was suspended using silk sutures. The right pericardiopleural area and right hemithorax were opened using electrocautery. This allowed the superior vena cava and inferior vena cava to deviate freely into the right hemithorax while positioning the heart, thus preventing deterioration of venous return. A sterile abdominal sponge was placed on the parenchyma to prevent swelling of the right lung towards the mediastinum during inspiration. After harvesting the bypass grafts, 150 U/kg intravenous heparin was administered for of-p CABG.

After activated clotting time (ACT) measurement, proximal anastomoses were done under a side clamp on the ascending aorta (Image 1). The number and direction of the grafts to the target distal arteries were planned according to preoperative angiographic evaluation. Following proximal anastomoses, the distal ends of the grafts were closed with clips, and the side clamp was removed.

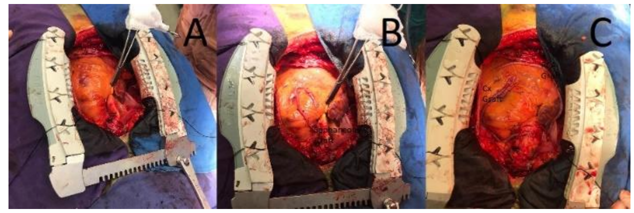

Image 1: A: Aortic side clamp, B: Proximal anastomose for Cx artery, C: Proximal anastomoses for Cx, and RCA

The left anterior descending artery (LAD) was the first artery to be revascularized in all cases. After deciding on the segment of the LAD to be anastomosed, a tissue stabilizer (*Acrobat-i Vacuum Stabilizer System, MAQUET Cardiovascular LLC,45 Barbour Bond Drive, Wayne, NU07470, USA*) was used. The segment of the LAD artery was occluded proximally and distally with the aid of bulldog clamps, and then the distal anastomosis was performed (Image 2).

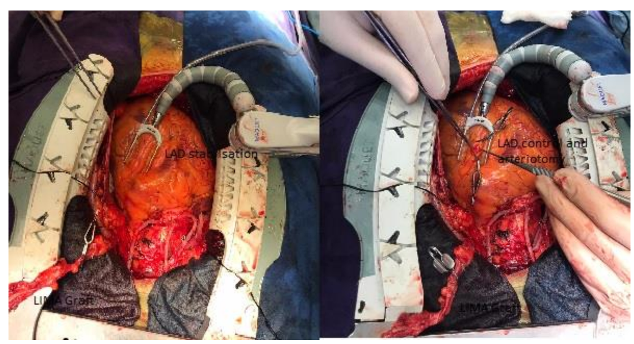

Image 2: LAD control and arteriotomy

For diagonal artery anastomosis, the heart's position was adjusted by placing gauzes (1-3 pieces) under the heart. The tissue stabilizer was placed in the appropriate segment. 6/0 prolene sutures were used to rotate and suspend the arteriotomy area proximally and distally, and control arterial bleeding. For circumflex artery (Cx) anastomosis, the Cx artery was visualized by lifting the apex of the heart towards the right hemithorax and fixing it with the Apex Holder (*Acrobat-i Vacuum Positioner System, MAQUET Cardiovascular LLC,45 Barbour Bond Drive, Wayne, NU07470, USA*). Again, the arteriotomy segment for the distal anastomosis was controlled proximally and distally by separately placed 6/0 prolene sutures. Following arteriotomy, the distal anastomosis was done in end to side fashion (Image 3).

Image 3: Cx artery control

Before the right coronary artery (RCA) anastomosis, an epicardial temporary pacemaker wire was placed to prevent possible arrhythmias. The temporary pacemaker was set to activate according to the patient's basal valve beats. Apex holder was used to position the heart appropriately. If a bypass to the distal segments (posterior descending artery (PDA) or posterolateral artery (PL)) was planned, the apex of the heart was elevated towards the right shoulder. When the anastomosis was planned for the body of the RCA, only the tissue stabilizer was used if the heart was close to its natural position. 6/0 prolenes were used for arterial control, and anastomosis was made by conventional procedure (Image 4).

Image 4: RCA control

We preferred vasoconstrictors such as nor-epinephrine since it has no chronotropic effect in the case of hypotension, which was defined as a decrease in systolic arterial pressure of more than 20% from the baseline or mean arterial pressure (MAP)<60 mmHg during cardiac manipulation. If hypertension which was defined as an increase in systolic arterial pressure of more than 20% from the baseline occurred, anesthesia was deepened, 2 µg/kg fentanyl was applied, and nitroglycerin was administered. If bradycardia which was defined as a decrease in heart rate down to <50 beats/min occurred, remifentanyl and esmolol doses were reduced, and intravenous administration of 0.01 mg/kg atropine was planned. At the end of the surgery, if necessary, heparin was neutralized with protamine. In cases of tachycardia, we preferred to use beta-blockers such as metoprolol or esmolol by infusion. During the bypass, we took care to keep the heart rate between 60-80 beats/min and systemic arterial pressure between 80-110 mmHg, especially when performing distal anastomoses. No coronary shunts were used during the distal anastomosis. After all anastomoses were completed and controlled, heparin was antagonized by appropriate dose of intravenous protamine-sulphate with ACT control. ACT was expected to fall below <200 seconds. Obtaining complete control, drains were placed in both hemithorax and mediastinum.

RESULTS

While early-term mortality was 3%, mortality after 6-month follow-up was calculated as 5.7% with 18 patients. Nearly half of the patients (138) needed at least one inotropic support in the intensive care unit. 14 (5%) patients required intraaortic balloon pump (IABP) counterpulsation in the perioperative period (10). The IABP duration ranged from one to eight days. Only one of the patients with IABP support died due to multiorgan dysfunction, and IABP could be successfully terminated in the other 13 (Table 2).

Table 2: Postoperative Complications and Result Data

	n (%)
Mortality	8 (3.0)
>6 months mortality	15 (5.7)
Cerebrovascular Diseases	6 (2.3)
Average number of grafts (mean±SD)	3.08 (±1.04)
Operation time (min) (mean±SD)	258.4 (±183.02)
Hemodialysis	7 (2.6)
Drainage (ml) (mean±SD)	879 (±506.07)
ES replacement (IU) (mean±SD)	1.5 (±1.3)
Postoperative atrial fibrillation	37 (14.2)
Inotrope usage	138 (53.0)
IABP usage	14 (5.3)
Extubation time (hours) (mean±SD)	8.4 (±6.6)
ICU stay (days) (mean±SD)	2.3 (±0.9)
Hospital stay (days) (mean±SD)	9.7 (±7.07)
Pneumonia	11 (4.2)
Revision	7 (2.6)

ES: Erythrocyte suspension, IABP: Intra-aortic balloon pump, ICU: Intensive care unit

DISCUSSION

We started of-pCABG operations in our clinic in selected patients, especially those with low EF who needed CABG with fewer grafts. However, as our experience increased, we started to perform the of-pCABG technique in all patients with isolated coronary artery disease without left main coronary artery disease, regardless of the number of grafts. After LAD bypass, the most common bypasses were Cx, RCA (PDA or trunk), and diagonal artery bypasses, respectively. The anastomosis was performed to target vessels by carefully exploring coronary arteries with an intramyocardial course. The mean operative time from the skin incision was 258.4 minutes.

There have been variable data in the literature regarding the in-hospital mortality rates of the of-pCABG technique, ranging from 1% to 7% (2, 11). In our study, the early hospital mortality rate was 3% (8 patients). Total mortality was calculated as 5.7% with 18 patients in the 6-month follow-up period. In addition to 8 patients with in-hospital mortality, mortality with various causes in 6-month follow-up period was also observed in 10 patients. The causes of early mortality in our patients were acute renal failure, sepsis, and multiorgan dysfunction. In Glance study, surprisingly, it was stated that there was no volume-outcome relationship for of-pCABG surgery. However, there was a volume-outcome relationship for mortality in on-pCABG surgeries (12). Similarly, the study of Lapar et al. showed no correlation between mortality after of-pCABG and surgeon volume-outcome; therefore, mortality after of-pCABG depended on patient risk factors rather than surgeon volume (13). As a result of our study, our clinical mortality rate is 3%, which is acceptable, and we think that mortality is due to the patients' risk factors.

An article in which randomized controlled studies were compiled stated that of-pCABG reduced bleeding and the need for allogeneic transfusion. It has been claimed that less disruption of the balance between procoagulant and anticoagulant activities was observed in patients operated with the of-pCABG technique (14). The main factors that disrupt this balance in the on-pCABG technique might be high-dose heparin administration, high contact of erythrocytes and platelets with the foreign surface due to cardiopulmonary bypass (CPB), and a long operation time. Similar to the literature, the average amount of drainage following of-pCABG operations performed in our clinic was approximately 870 mL. The mean amount of erythrocyte suspension (ES) used was 1.5 units. We think that the of-pCABG bypass technique reduces the amount of postoperative bleeding compared to conservative bypass and should be preferred in patients with high bleeding risk, such as Jehovah's Witnesses.

In different studies comparing conservative CABG and of-pCBAG techniques, it has been reported that cerebrovascular complications (CVA), renal function impairment, the risk of hemodialysis, and the risk of pneumonia were less in favor of of-pCABG (15-17).Postoperative CVA, requirement of hemodialysis, and pneumonia were observed in our series at acceptable levels (2.3%, 2.6%, 4.2%, respectively). The use of CPB causes a severe inflammatory response and immunosuppression. At the same time, the existing pulsatile flow is converted to non-pulsatile flow during CPB (18). As a result, renal flow change and immunosuppression lead to impaired renal function and susceptibility to infection in the postoperative period. Since CPB is not used with of-pCABG, renal and pulmonary complications can be said to occur less commonly. Similarly, the risk of CVA increases during CPB due to aortic manipulations, CPB lines or connections, air or thrombus embolism that may occur during pump calibration or decannulation, and the use of high-dose heparin (15). Likewise, we think that there is a lower risk of CVA due to the absence of these factors in bypass surgeries performed without CPB.

Conservative CABG with CPB may also prolong the stay in the intensive care unit (ICU) and in hospital for various reasons (19). The length of hospital stay is prolonged because of late reversal of the lung functional capacities of the patients or due to the late recovery of their physical rehabilitation. Various studies have shown that of-pCABG patients had shorter stays in the ICU and hospital (20). In our study, the average ICU stay of the patients was 2.3 days, and the total length of hospital stay was 9.7 days. The mean extubation time of our patients was found as 8.4 hours. Since CPB was not used during the operation, we think that the recovery in the postoperative lung functional capacity of the patients was faster since the lungs work functionally during the operation. Therefore, patients were extubated and physical rehabilitation began in the earlier postoperative period. Thus, the duration of stays both in the ICU and hospital were reduced.

Conclusion

While the of-pCABG, which has been increasingly used in CABG operations, was performed in selected patients in our clinic in 2018, it has become a routine technique today. We think that the of-pCABG technique, which is less invasive than the conservative CABG, can be applied with satisfactory results in multi-vessel coronary artery disease, patients with low EF, and patients with comorbidities such as lung disease, chronic kidney disease or failure.

Ethics Committee Approval: Kocaeli Ünıvercty E thical approval was obtained. Clinical Research Ethics Committee (09.02.2021/KOGOEK01.6)

Conflict of Interest: There is no conflict of interest.

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Informed Consent: This a retrospective study

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