

Hybrid Coronary Revascularization in Beating Heart Coronary Artery Bypass; The Results and Review of The Literature

Tuğra Gençpınar¹, Çağatay Bilen¹, Berke Özkan¹, Ebru Özpelit², Hasan Hepağuşlar³, Kıvanç Metin¹, Hüdai Çatalyürek¹

¹) Dokuz Eylul University, Department of Cardiovascular Surgery, Izmir, Turkey

²) Dokuz Eylul University, Department of Cardiology, Izmir, Turkey

³) Dokuz Eylul University, Department of Anesthesiology and Reanimation, Izmir, Turkey

Abstract

Background: The aim of this study is to evaluate demographic, clinical and laboratory features and outcomes of the hybrid cases undergoing beating heart coronary artery bypass grafting.

Methods: January 2011 - 2015 in the isolated beating heart coronary bypass performed (n = 54). The cases were retrospectively analyzed with demographic characteristics and used hybrid approaches. After off-pump coronary artery bypass surgery (OPCAB), the cases were followed for following hybrid coronary revascularization (HCR) with multi-vessel coronary artery disease (MVCAD).

Results: Fifty-four consecutive patients underwent elective HCR (n = 7) or OPCAB (n = 47). The cases consisting of 12 female (22.2%), 42 male (77.7%) were found. 54 cases with an average age of 62.51 years (min: 41, max: 86) (13.279 SD) have been observed. There was no any complication in HCR group. Stroke in 2 case (3.7%), hypoxic ischemic encephalopathy (right internal lacunar infarct) and transient ischemic attack (TIA) in two cases (3.7%) were detected. Inpatients mortality ratio was 7.4% with multiple organ failure.

Conclusion: HCR is associated with successful results. We believe that OPCAB should be preferred in selected cases with potential high risk morbidity.

Keywords: Artery, cardiopulmonary bypass, hybrid coronary artery revascularization.

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Introduction

Coronary artery bypass graft (CABG) is a superior management approach for severe coronary artery disease.⁽¹⁻³⁾ The left internal thoracic artery is considered to be the best conduit for CABG.⁽²⁻⁴⁾ However, preferred standard coronary artery bypass grafting technique remains controversial between off pump and on pump or hybrid coronary revascularization.

In this sense, beating heart surgery for cardiac surgeons is a growing number of treatment options. Assigning anastomosis during cardiac surgery quality is improved even more with the technological developments in this area. Shortened length of hospital stay, decreased respiratory period and decreased pulmonary complications, less bleeding and blood transfusion, decreased inflammatory response, decreased arrhythmias, decreased neurological complications and decreased mortality with cost-effective management are very important. Recent studies show us that the off pump approach is less associated with the postoperative stroke. Also, the off pump patients had less perioperative death and lower incidences of all morbidities as present reports.⁽¹⁻⁴⁾

Panoulas et al.⁽⁶⁾ have demonstrated that the excellent patency rates of drug-eluting stents associated with HCR survival benefits. In the study of Harskamp et al.⁽⁷⁾ they detected that among diabetic patients with percutaneous coronary intervention (PCI) of non-left anterior descending vessels are safety and efficacy.

However, limited literature was available about following hybrid coronary revascularization after OPCAB. The present study aimed at evaluating the results of HCR at mid-term follow up.

1. Patients

We have retrospectively collected the outcome data on all patients undergoing a beating heart CABG (n: 54). In the time period, from January 2011 through January 2015, 54 cases (42 males and 12 females) had been included in the study criterias. Perioperative follow-up period was determined as 7 days. We received data for all patients undergone a primary isolated OPCAB. Mean age of the cases is 62.51 years (min: 41, max: 86) (13.279 SD).

2. Exclusion Criteria

Patients with reoperative CABG, under 18 years old, operated peripheral vascular disease or muscle disease, trauma, shock, malnutrition, pregnancy, liver diseases, dialysis dependent renal failure and neoplasias were excluded.

Materials and Methods

This study was prepared through the application of the guidelines of “The Declaration of Helsinki”. This retrospective study was conducted with the approval of the Ethics Committee for Clinic Research on 07 April 2015 with the protocol number 2079-GOA/2015. The cases were followed for 1 month in the study. 54 patients observed undergoing OPCAB between January 2011 and 2015. The primary outcomes were the risk factors including advanced age, sex, smoking status, hypertension, hyperlipidemia, carotid disease, diabetes mellitus, prior cardiac events, chronic obstructive pulmonary disease, peripheral vascular disease, body mass index, neurological events, HbA1c levels, and serum creatinine levels. The secondary outcomes were of preoperative New York Heart Association (NYHA) heart failure functional class, Euroscore II functional status, and left ventricular ejection fraction. Other outcome measures were perioperative death (in hospital) and intensive care unit vital follow up. In all calculations and statistical analyses, “Statistical Package for Social Sciences” (SPSS-Chicago, IL, USA) 16 and Software Excel (Microsoft-USA) programs were used.

Surgery

We preferred with the table in trendelenburg position. Standard full sternotomy was performed. The patients were kept under control for blood pressure. Standard doses (1-1.5 mg/kg) of systemic heparin had been applied. The target ‘Activated Clotting Time’ (ACT) was greater than 300-350 seconds. Left internal mammary artery (LIMA) was prepared as long as possible. Surgical loops (Design for Vision *3.5, US) were used during dissection and the operation. The grafts were harvested with scissors and hemoclips used for bleeding. The grafts were protected inside of ‘Perlingalit’ (1.0 mmol/L) mixed with heparinized blood. Also,

heparinized blood was injected intraluminally into the saphenous vein grafts (SVG) after harvesting. SVG was commonly used for the obtuse marginal branches and/or the posterior descending coronary artery. SVG in patients with advanced age group (over 80) was used as autograft and supported by literature.⁽⁵⁻⁶⁾ For an excellent exposure, an additional deep pericardial retraction suture was used. Also, the table was raised and rotated towards the right. This position would allow us to displace the heart to the right and apex it anteriorly. Right pleural space was opened to help for the right incision. These maneuvers had allowed us to move the heart towards the right pleural space easily. We had used the stabilizers that devices work by attachment (suction). Silastic® tape or silk suture had passed around the target vessel for proximal occlusion. Intracoronary shunts were used as recommended. A CO2 blower (Novatech aspirateur microvac® 2 x 70 mm) had been used with saline irrigation to prevent damage to the coronary endothelium. The anastomosis was performed in a traditional CABG with routine approaches. Proximal anastomoses had been performed after the distal anastomoses to protect the stabilization. Heparin reversal had not been carried out except for mandatory cases (3 case had bleeding status). We had not used to placed temporary pacing wires except in 4 unstable case. Intra-aortic balloon counter-pulsation (IABP) was introduced in four case at the end of the operation. We avoided from renal dysfunction with blood pressure regulation. Routine perioperative operation room and intensive care unit (ICU) vital follow up was performed.

Results

Demographic data and comorbidities are analyzed in **Table-1**. A total of 54 patients with MVCAD included the study.

7 patients were treated with HCR. PCI was possible without diffuse stenosis and severe calcification. PCI was performed before and after the operation with MVCAD. All cases were performed electively. Only one case had unsuccessful PCI on the right posterior descending coronary artery.

Most of the procedural characteristics were similar in the OPCAB and HCR groups. Comorbidities relat-

ed to the patient group were the diabetes mellitus in 6 cases (11.1%) (Insulin dependent-HbA1c median ratio 7.58) and the hypertension in 5 cases (9.25%). Smoking was observed in 26 patients (48.1%). Chronic Obstructive Pulmonary Disease was observed in 5 cases (9.25%). Alcohol use was not found. The average body mass index was found to be 28.21±5.1. There were 5 cases (9.2%) with atrial fibrillation. One of them had neurological events like transient ischemic attack (TIA). History of myocard infarction was found in 14 cases (25.9%). Prolonged ventilatory use (≥24 hours), reoperation for bleeding, sternal wound infection, or mediastinitis had not been put forth. No patients had required a mechanical circulatory support or dialysis. In both groups, no outcomes of perioperative myocardial infarction were observed. Also, there was no evident doubt requiring the distal anastomosis. There was no need for early repeat revascularization (following 7 days). In addition, cardiac arrest and multi-organ dysfunction were performed in four OPCAB cases during ICU following up. Inpatients mortality ratio was 7.4% with multiple organ failure in the OPCAB group. The early postoperative mortality rate was 0% (no mortality or complication during HCR). In the 1st postoperative month, functional capacity improved dramatically: the number of patients in New York Heart Association functional class (NYHA) IV moved from 22 (preoperatively) to II; in class II, from 24 to 10; in class II; and in class I, from 8 to 2.

Only two cases (3.7%) had postoperative major adverse cardiovascular and cerebral event (MACCE) (right internal lacunar infarct). Also, one TIA was detected. After 1 year, cerebrovascular diseases (CVA) were detected in a patient whose carotid arteries were normal.

Number of bypass grafts performed per patient was as follows: 1 graft (LIMA) in 24 cases (44.4%), 2 graft in 22 cases (40.7%), 3 grafts in 8 cases (14.8%). The LIMA conduit was used to the left anterior descending artery in all cases. We placed temporary pacing wires in the four left main coronary artery cases to avoid cardiac arrhythmias. Intra-aortic balloon counter-pulsation (IABP) was introduced in four cases at the end of the operation. In this study, there was no cardiac complication during the postoperative 7 days without four cases.

Outpatients' follow-up control was unproblematic.

Standard anticoagulant therapy (acetyl - salicylic acid 100 mg/day and clopidogrel 75 mg/day per oral) was given to all postoperative cases. Mean duration of intensive care unit (ICU) was 1/day, and the duration of hospital stay was 5 days. Both erythrocyte replacement and fresh frozen plasma were used for bleeding.

the world today.⁽⁴⁻⁵⁾ The average of this number, 150 – 200 thousand, constitutes the beating heart surgery.

Percutaneous coronary intervention reported successful patency rates.⁽⁶⁻⁷⁾ Drug-eluting stents associated with safety and efficacy.⁽⁷⁾ Less blood and faster recovery are benefits of PCI. Recent studies have associated with less morbidity outcomes.⁽⁶⁻⁷⁾

Hybrid coronary revascularization determines both combine arterial coronary artery bypass surgery and percutaneous coronary intervention of multivessel coronary artery disease. It was first began in the mid-2000s. HCR associated with the excellent patency rates and survival benefits with multivessel coronary artery disease.⁽⁶⁾

Stroke is one of the most dramatic complications after cardiac surgery as present studies show that stroke mechanisms are predominantly embolic.⁽⁴⁾ However, numerous reports describe the neurological results of OPCAB.⁽³⁻⁷⁾ Off-pump CABG may reduce the rate of stroke, due to minimal aortic manipulation. OPCAB has been reported to present a lower risk of stroke.⁽⁴⁻¹⁰⁾ Some reports have associated with less morbidity outcomes.⁽⁴⁻¹³⁾

CABG results in excellent long term survival.⁽⁸⁻¹⁰⁾ The durable LIMA graft to the left anterior descending artery has the best patency rates.⁽⁶⁻¹⁰⁾ Studies show that patients with hypertension, diabetes, peripheral vascular disease, aortic disease and stroke have higher risk for coronary artery disease especially in elderly patients.⁽⁷⁻⁸⁾ For coronary artery in patients older than 75 years, OPCAB reported a higher incidence.⁽⁷⁾ Advanced preoperative NYHA heart failure functional class and Canadian Cardiovascular Society angina class are associated with increased morbidity.⁽¹⁰⁾ In this group, stroke, peripheral vascular disease, chronic obstructive pulmonary disease, congestive heart failure, and left main coronary artery diseases are often particularly high.⁽⁸⁻⁹⁾ For cardiac surgery, an age of ≥ 75 years is an independent risk factor for postoperative mortality and morbidity.⁽¹¹⁻¹³⁾ OPCAB is indicated in severe aortic calcification, carotid artery stenosis, history of stroke, renal dysfunction, and pul-

Table 1: The demographic characteristics of the cases (n=54)

Mean Age (yr)	62.51±13.27 (min: 41, max: 86)	
Body Mass Index	28.21±5.1	
Mortality	7.4%	
	n	%
Current Smoker	26	48.1
Hypertension	5	9.25
Diabetes (HbA1c ≥ 7 mg/dl)	6	11.1
History of Myocard Infarction	14	25.9
Chronic Obstructive Pulmonary Disease	5	9.2
Peripheral Vascular Disease	1	1.8
Cerebral Vascular Disease	2	3.7
Atrial Fibrillation	5	9.2
Number of affected coronary arteries		
1 vessel	24	44.4
2 vessel	22	40.7
3 vessel	8	14.8

Discussion

Isolated coronary artery bypass grafting, and cardiopulmonary bypass (CPB)'s extensive usage have been made well before the beating heart (Kolessov 1967).⁽¹⁻⁴⁾ CPB's side effects (inflammation, stroke, hemorrhage, renal failure, pulmonary insufficiency, etc.) have been a drawback. Benetti began to perform the Buffalo beating heart in a case of large series in 1990 and 1997.⁽²⁻⁴⁾

Despite increasing technological innovation, the CPB's disadvantages have been increased by age in the following years. Convincing the CABG patients to become candidates is also important. The standard CABG is performed per year for 650 to 950 thousand times in

monary artery diseases.⁽¹⁰⁻¹⁵⁾

Anesthesiologists and surgeons compliance is essential for a successful beating heart surgery. Surgical plan-shape incision, place of the arteriotomy, internal mammary artery (IMA) preparation, and proximal anastomoses to be made before or after operation are important. Also, 'Shunt' or 'Occluder' decision to use for bloodless field and distal perfusion is important for the quality experienced surgical approach. Therefore, beating heart surgeon must do ≥ 50 beating heart cases.⁽²⁻⁴⁾ Invasive monitoring, ischemia time, electrolyte imbalance (magnesium and potassium balance) and pH balance are important during the perioperative period. Reperfusion must begin within 15 min. Full-reperfusion should begin after the proximal anastomosis. In order to maintain hemodynamic stability; 'Trendelenburg position', careful manipulation of the heart, the right pleural and pericardial incision, intra-aortic balloon pump and pacing wires preparation, pharmacological interventions, and anesthesia monitoring are very important. Global left ventricular regional wall motion should be observed carefully during occlusion and 'shunt' placement should be quick and attentive. For the stabilization of the surgical field 'vacuum or compression stabilizers' are required. Stabilizers should protect the hemodynamic function of the heart and avoid the myocardial damage. The stabilizers must create an immobile field. When using compression stabilizers, hemodynamic changes on the posterior aspect of the heart is so important. By contributing with pericardial incisions, the surgeon can take required positions at the heart without hemodynamic changes. In appropriate cases, cardiac position transmitters can be placed in the apex of the heart with using vacuum technology.

Normothermia preservation must be ensured by keeping the operating room warm, avoiding radiant heat loss. The anesthesiologist must be suitable for beating heart surgery as collaboration crucial for success. The follow-up is required with a great experience. Involvement of the anesthesia team is essential for successful beating heart surgery. Also, the availability of heart-lung machine and perfusionist is necessary. Inotropic and beta antagonist blocker agents are important to maintain cardiac output during the manipulations. If necessary, an IABP, cardiac assist devices, pacemaker support can be inserted immediately for temporary support. Fluid and electrolyte balance must be protected during the operation and intensive care unit.

In the current review, we discuss HCR's results, its limitations and procedural challenges with multi-vessel coronary artery disease at mid-term follow up. In addition, limited literature was available about following hybrid coronary revascularization after OPCAB. We preferred the off pump cardiac surgery for hemodynamically unstable patients, patients with other organ-system problems, urgent or emergent operation, re-operative CABG, patients with severe left ventricular dysfunction (LVEF $< 30\%$), and patients with critical left main disease. Also, we have used this approach for patients underwent carotid disease including greater prevalence of cerebrovascular events. Recent studies show us that the CPB is positively associated with the postoperative stroke. The cross clamp ischemia occurs with conventional CABG. Only localized ischemia occurs when coronary artery occlusion is performed in the OPCAB. Patients with ≥ 75 years old should be operated with the beating heart approach to avoid the stroke.

Future studies should examine the results of the OPCAB on long-term outcomes of high-volume centers. Modern surgical techniques and experiences would decline the ratio of the complications.

Conclusions

We believe that HCR should be preferred in selected patients with MVCAD to reduce high risk morbidity. OPCAB performed by an experienced surgical and heart team by using 'hybrid approach' techniques can be a useful strategy in reducing postoperative morbidity and mortality.

Study Limitations

The primary limitation of our study is the risk factors including severe multivessel coronary artery disease. In addition, long-term follow-up and large-scale prospective studies are needed to determine the frequency of HCR.

Disclosure

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Corresponding author:

Dr. Tuğra Gençpınar

Mail: tugra01@yahoo.com