The feasibility and safety of off pump coronary bypass surgery in emergency revascularization

Hyun-Chel Joo

Department of Medicine

The Graduate School, Yonsei University

The feasibility and safety of off pump coronary bypass surgery in emergency revascularization

Directed by Professor Kyung-Jong Yoo

The Master's Thesis
submitted to the Department of Medicine,
the Graduate School of Yonsei University
in partial fulfillment of the requirements for the degree
of Master of Medical Science

Hyun-Chel Joo

June 2015

This certifies that the Master's Thesis

of Hyun-Chel Joo is approved.

Thesis Supervisor: Kyung-Jong Yoo

Thesis Committee Member: Seok-Min Kang

Thesis Committee Member: Young-Lan Kwak

The Graduate School
Yonsei University

June 2015

ACKNOWLEDGEMENTS

I wish to present my gratitude to my supervisior, Professor Kyung-Jong Yoo for his advice on designing and writing this thesis. His comments helped a lot during the start up and finishing of the study.

I would like to thank my instructor Professor Seok-Min Kang, Professor Young-Lan Kwak and Young-Nam Youn for many pieces of advice and much help for the better investigation.

The last, I appreciate to my parents, my wife and my son who are always encouraging me.

<TABLE OF CONTENTS>

LIST OF FIGURES

LIST OF TABLES

ABSTRACT

The feasibility and safety of off pump coronary bypass surgery in emergency revascularization

Hyun-Chel Joo

Department of Medicine
The Graduate School, Yonsei University

(Directed by Professor Kyung-Jong Yoo)

Background: The efficacy and safety of off-pump coronary bypass grafting (OPCAB) in emergency revascularization remains controversial despite its widespread use. The aim of our study is to exam the applicability and safety of OPCAB in patients who were indicated for emergency surgery.

Methods: This single center study reviewed indication, operative data, and early and long-term outcomes of 113 patients (age, 66.5±9.3 years; logistic EuroScore, 14.4±13.5) who underwent emergency OPCAB from January 2003 to December 2014 and were followed up (93.8% rate) for a mean 51.1±40.3 (range, 1-135) months.

Results: Emergency OPCAB in the 113 patients studied was associated with favorable surgical outcomes (on-pump conversion, 4.4%; number of distal

anastomoses per patient, 3.04±0.87; IMA use, 98.2%; and complete revascularization, 82.3%); in-hospital (mortality, 5.3%; low cardiac output syndrome, 5.3%; stroke, 2.7%; pulmonary complications, 8.8%; renal failure, 11.5%; ventilator use duration, 61.59±126.62 hours; ICU stay, 4.77±6.59 days; and hospital stay, 14.98±9.66 days). The 10-year outcomes (survival, 77.0±0.6%; and major cerebral and cardiovascular events, 52.0±1.6%) were also comparable.

Conclusion: Our study suggests that emergency OPCAB can be performed safely and effectively with improved hospital outcomes and comparable long term results. OPCAB strategy can be considered as a good option in emergency revascularization.

Key words: emergency, off-pump coronary bypass grafting

The feasibility and safety of off pump coronary bypass surgery in emergency revascularization

Hyun-Chel Joo

Department of Medicine
The Graduate School, Yonsei University

(Directed by Professor Kyung-Jong Yoo)

I. INTRRODUCTION

With increased surgeon proficiency and device improvement over decades, off-pump coronary artery bypass grafting (OPCAB) has evolved as widely acceptable procedure.[1-2] Recently OPCAB has expanded its indication to high risk patients with multiple comorbidities such as old age, renal failure, poor lung function, and impaired left ventricular function and showed better outcomes than on-pump bypass surgery.[3-7] Purportedly by avoiding the inflammatory reactions and ischemic injury associated with cardiopulmonary bypass(CPB), OPCAB also is useful in patients requiring emergent intervention.[8-11] However, OPCAB use in patients with critical preoperative conditions remains debatable because heart manipulation and displacement might result in compromised hemodynamics and cardiac decompensation. The feasibility and safety of OPCAB in patients meeting indications for emergency surgery therefore was assessed in this review of a 10-year single-center experience.

II. PATIENTS AND METHODS

1. Patients

From January 2003 to April 2015, of the 2825 patients who underwent isolated OPCAB at our institution, 113 (4%) had an emergency OPCAB (starting in 2003) according to current guideline[12] and the following indications: cardiogenic shock with complex anatomy not suitable for percutaneous coronary intervention (PCI) (41, 35.4%); ongoing ischemia despite optimal pharmacotherapy in patients with primary CABG indication (36, 31.8%); PCI complication requiring emergency operation (18, 15.9%); ongoing ischemia despite successful or failed PCI (7, 6.2%); and others (such as left main dissection or plaque rupture; 11, 9.7%). Operations were performed by 2 surgeons with longstanding experience in OPCAB based on their preoperative assessment including hemodynamics and concomitant diseases.

Table 1. Indications for emergency OPCAB

Indications	N (%)
Cardiogenic shock with complex anatomy not suitable for PCI	41 (35.4%)
Ongoing ischemia despite optimal medication in patients with primary CABG indication	36 (31.8%)
PCI complication which requires emergency surgery	18 (15.9%)
Ongoing ischemia despite successful or failed PCI	7 (6.2%)
Others (left main plaque rupture, dissection, total)	11 (9.7%)

Abbreviations: PCI=percutaneous coronary intervention; CABG=coronary artery bypass surgery

2. Surgical procedure

The operation was performed under general endotracheal anesthesia with continuous Swan-Ganz catheter monitoring, TEE, and arterial pressure monitoring. All operations were performed using the off-pump method through a full sternotomy incision. The left internal thoracic artery was first used in all patients and the right internal thoracic artery, radial artery and saphenous vein were used if necessary. The internal thoracic artery was harvested using a semi-skeletonized method and very low voltage unipolar electrocautery. The radial artery was harvested from the non-dominant forearm using a pedicled method and a Hamonic scalpel (Ethicon Endosurgery, Cincinnati, OH, USA). Heparin mixed papaverine was used to avoid vasospasm of the internal thoracic

artery and a calcium channel blocker (Diltiazem) was used to prevent spasm of radial artery during the operation. Heparin was given at a dose of 100 units/kg to achieve a target activated clotting time of at least 300 seconds during the operation. A deep pericardial traction suture was placed using 1-0 Dexon sutures. Purse string sutures for cannulation were placed in the aorta and right atrium as a standby measure in preparation for conversion to on-pump. In cases of unstable hemodynamics, LIMA to LAD grafting was performed first, before other heart procedures (such as pericardial traction suture, heart dispositioning, and aortic manipulation). An Octopus tissue stabilizer (Medtronic, Minneapolis, MN, USA) was used for cardiac stabilization during anastomosis construction. An intracoronary shunt was mainly used for LAD anastomosis, and the proximal snaring technique with a silicone elastomer was used for anastomosis of other left coronary artery systems. For right coronary anastomosis, an intracoronary shunt was usually used for the main RCA, and the proximal snaring technique was used for the posterior descending or posterolateral artery. To remove blood from the sites of arteriotomy, a mixed carbon dioxide blower and irrigation with warm saline were used. When aortic manipulation was needed, side-bite clamping was used until 2008, and heart string thereafter. All anastomoses were constructed using continuous running 7-0 or 8-0 monofilament suture.

3. End points and definitions

The primary end point of this study was in-hospital mortality and late all-cause mortality after operation. The secondary end points were perioperative morbidity and late major adverse cerebral and cardiovascular events (MACCE). Perioperative morbidities included: low cardiac output syndrome (LCOS), perioperative myocardial infarction (MI), neurologic complication, prolonged mechanical ventilation, pulmonary complication, renal failure, and reoperation for bleeding. Prolonged mechanical ventilation was defined as ventilator therapy more than 7 days. Postoperative renal failure was defined as requirement for continuous veno-venous hemofiltration. Major adverse cerebral and cardiovascular events (MACCE) were defined as death from any cause, nonfatal myocardial infarction, reintervention, or stroke. Myocardial infarction was defined as occurrence of wall motion abnormality or CK-MB elevation with appearance of new Q waves or ST segment elevation of more than 2 mm on electrocardiogram. Reintervention was defined as PCI after surgery or redo coronary bypass surgery irrespective of clinical symptomatology

4. Data collection

Preoperative and perioperative data were collected prospectively from the cardiac research databases at our institution. Follow-up data were obtained from reviewing hospital charts, conducting telephone interviews, and searching the National Death Index. The mean follow-up duration was 51.1± 40.3 month

(range 1 to 135). Our study was conducted following approval by the Institutional Review Board of Yonsei University College of Medicine. The individual patient consent was waived.

5. Statistical analyses

The statistical analyses were performed with SPSS for Windows, Release 18.0 (SPSS Inc., Chicago, IL). All continuous data are expressed as mean ± standard deviation (SD), while categorical variables are expressed as frequency. Goodness of fit was assessed by using the Hosmer and Lemeshow chi-squared test. Overall survival and freedom from MACCE during 10-year follow up were calculated using Kaplan-Meier methods. Survival curves were compared by the log-lank test. Logistic regression and the Cox proportional hazards method were used to identify independent predictors of early and late outcomes. Variables with a p value < 0.05 at univariate analysis were included in the regression model as multinomial variable. Statistical significance was defined as a two-tailed P-value<0.05.

III. RESULTS

1. Patients Demographics

Preoperative demographics and risk factors are listed in Table 2. The mean age of the population was 66.46 ± 9.27 years. Cardiogenic shock status was present in 35% of patients; 10% of patients had acute pulmonary congestion requiring preoperative ventilation; and most patients (68.1%) undergoing emergency OPCAB had New York Heart Association class III or IV. The mean logistic Euroscore was 14.36 ± 13.53.

Table2. Baseline patient characteristics

Variables	N=113
Age (years)	66.46 ± 9.27
Age ≥ 70 years	43 (38.1)
BMI	28.62 ± 0.21
Female gender	25 (22.1)
Hypertension	86 (76.1)
Diabetes mellitus	60 (53.1)
Smoker	63 (55.8)
Dyslipidemia	44 (38.9)
PAOD	16 (14.2)
Cerebrovascular disease	17 (15.0)
Old CVA	17 (24.8)
Prior PTCA	28 (24.8)
Post-PCI complication	18 (15.9)
COPD	14 (12.4)
Chronic renal failure	24 (21.2)

Variables	N=113
Dialysis	5 (4.4)
Old MI	21 (18.4)
STEMI	32 (28.3)
NSTEMI	42 (37.2)
3-vessel disease	93 (82.3)
Left main disease	54 (47.8)
LVEF (%)	45.47 ± 15.02
Low LVEF (< 35%)	34 (30.1)
Cardiogenic shock	41 (35.4)
Preoperative IABP	27 (23.9)
Preoperative ventiliation	12 (10.6)
Preoperative resuscitation	4 (3.5)
Preoperative ECMO	3 (2.7)
Mean NYHA class	2.85 ± 0.87
NYHA class III or IV	77 (68.1)
Logistic Euroscore	14.36 ± 13.53

Data are presented as mean ± SD or n (%). Abbreviations: BMI = body mass index; PAOD = peripheral artery occlusive disease; CVA = cerebrovascular accident; PTCA = percutaneous transluminal coronary angioplasty; PCI = percutaneous coronary intervention; COPD = chronic obstructive pulmonary disease; MI = myocardial infarction; STEMI = ST elevation MI; NSTEMI = non-ST elevation MI; LVEF = left ventricular ejection fraction; IABP = intra-aortic balloon pump; ECMO = extracorporeal membrane oxygenation; NYHA = New York Heart Association

2. Operative data

The operative data are listed in Table 3. The mean number of distal anastomoses was more than 3.0 per patient. Completeness of revascularization was achieved in 82.3% of patients. IMA graft was used in all patients except two who needed revascularization in only the right coronary artery (RCA) territory. Total arterial grafting could be conducted in 43.4% of patients. There were 5 (4.4%) conversions to on-pump in patients who had profound shock or arrest during the operation, all of them survived. The detail data about off-pump conversion are summarized in Table 4. The mean operative time was 245 minutes.

Table3. Operative data

Variables	N = 113
Number of distal anastomoses	3.04 ± 0.87
Number of graft used	2.23 ± 0.50
IMA use	111 (98.2)
Total arterial grafting	49 (43.4)
Complete revascularization	93 (82.3)
Operation time (min)	245.15 ± 57.56
Conversion to on-pump	5 (4.4)

Data are presented as mean ± SD or n (%). Abbreviations: IMA =internal mammary artery

Table 4. The data about patients who underwent on-pump conversion

N	Age	Sex	indication	Preoperative condition					Cause of conversion	survival
				AMI	Shock	IABP	CHF	EF		
1	74	F	cadiogenic Shock	O	O	X	O	30	OM anastomosis	discharge
2	68	F	cardiogenic Shock	O	O	X	O	40	OM anastomosis	discharge
3	54	M	cardiogenic Shock	O	O	X	O	51	Aorta partial clamp	discharge
4	73	M	cardiogenic Shock	O	O	X	O	32	Y graft anastomosis	discharge
5	68	M	cardiogenic shock	O	O	O	O	20	IMA harvesting	discharge

Abbreviations: F=female; M=male; AMI=acute myocardial infaction; IABP = intra-aortic balloon pump; CHF=congestive heart failure; EF=ejection fraction; OM=obtuse marginal; IMA=left internal mammary artery

3. Early operative results

Six patients died during the hospital stay period (5.3%): 2 from heart failure, 3 from pulmonary complications, and 1 from ventricular fibrillation. The other major postoperative complications observed after emergency OPCAB are summarized in Table 5. Reoperation for excessive bleeding was performed in only one patient (0.9%). Three patients needed extracorporeal membrane oxygenation during the postoperative period, and all survived. Ten (8.8%) patients experienced pulmonary complication, and 7 (70%) of them needed tracheostomy. length of Intensive care unit (ICU) stay (4.77 ± 6.59 days) and length of hospital stay (14.98 ± 9.66 days) were acceptable. In multivariate analysis, COPD (odds ratio, 30.2 [95% CI, 1.79-509.481]; p=0.017) and

preoperative IABP or ECMO (18.6 [1.68-20.64]; p= 0.018) were the independent predictors of operative death.

Table 5. Postoperative mortality and morbidity

Variables	N=113
Hospital mortality	6 (5.3)
Stroke	3 (2.6)
Perioperative MI	3 (2.6)
Low cardiac output syndrome	6 (5.3)
Reoperation for bleeding	1 (0.9)
Renal support therapy	13 (11.5)
Pulmonary complication	10 (8.8)
Prolonged ventilator (>7days)	(7.1)
Sternal wound complication	5 (4.4)
Mean duration of ventilation (hr)	61.59 ± 126.62
Mean length of ICU stay (day)	4.77 ± 6.59
Mean length of hospital stay (day)	14.98 ± 9.66
Chest tube drainage	730.36 ± 579.76
RBC transfusion	1.4 ± 1.6
FFP transfusion	23 (20.3%)
Platelet transfusion	14 (12.4)

Data are presented as mean ± SD or n (%). Abbreviations: MI=myocardial infarction; ICU=intensive care unit; RBC=packed red bloods cell; FFP=fresh frozen plasma

4. Long-term survivals

The mean follow-up duration was 51.1 ± 40.3 month (range 1 to 135). Survival rate at 1, 5 and 10 years was 91.0%, 85.4% and 75.4%, respectively. Rate of freedom from MACCEs at 1, 5 and 10 years was 85.6%, 78.9% and 69.5%, respectively (Figure 1). The overall survival rate and freedom from MACCEs rate at 10 years were 67.7% and 59.4% for patients with preoperative cardiogenic shock compared to 79.9% and 75.1% for patients with non-cardiogenic shock (Figure 2). PAOD, COPD and cardiogenic shock were independent predictors of late mortality. Among these risk factors, cardiogenic shock had the strongest association with late mortality (odds ratio, 3.67; 95% CI, 1.35 to 9.96; p=0.01) (Table 6).

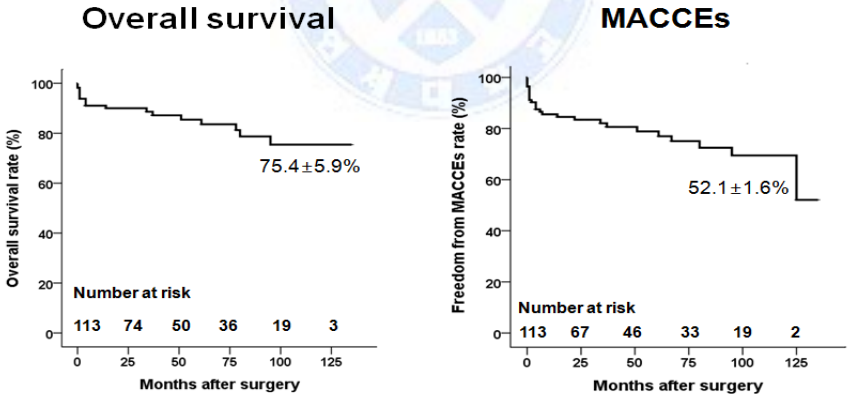

Figure 1. Kaplan-Meier curve for overall survival rate and freedom from MACCE rate after emergency OPCAB during 10 year follow up

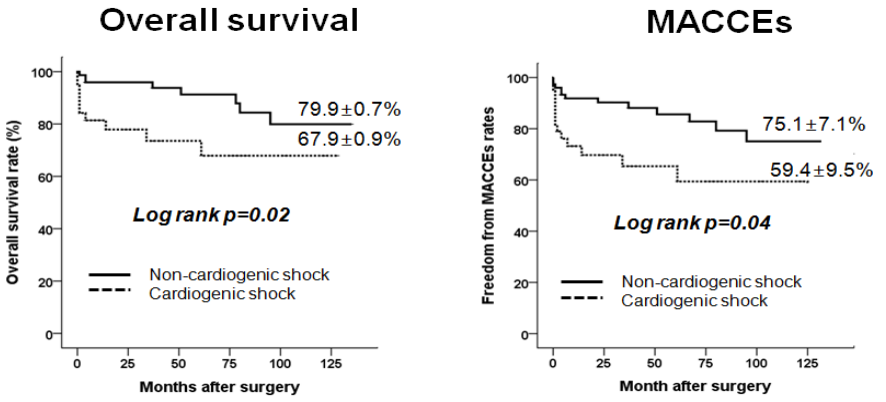

Figure 2. Kaplan-Meier curve for overall survival rate and freedom from MACCE rate during 10 year follow up according to cardiogenic shock

Table 6. Multivariate Cox proportional Hazard Regression analyses of late mortality of emergency OPCAB

Variables	Univariate analysis P value	Multivariate analysis HR,(95% CI), P value
Age (years)	0.24	
Age ≥ 70 years,	0.39	
BMI	0.12	
Female	0.62	
Hypertension	0.34	
Diabetes mellitus	0.05	
Smoker	0.41	
Dyslipidemia	0.47	
PAOD	0.02	2.95 (1.11-11.83) 0.03
Cerebrovascular disease	0.31	
Old CVA	0.75	
Prior PTCA	0.75	
Complicated PCI	0.66	
COPD	0.01	3.41 (1.06-14.26) 0.04
Chronic renal failure	0.13	
Dialysis	0.69	

Variables	Univariate analysis P value	Multivariate analysis HR,(95% CI), P value
Old MI	0.93	
STEMI	0.71	
NSTEMI	0.15	
3-vessel disease	0.30	
Left main disease	0.34	
LVEF %	0.69	
Low LVEF (< 35%)	0.76	
Cardiogenic shock	0.01	3.67 (1.35 – 9.96) 0.01
Preoperative IABP	0.04	
Preoperative ventiliation	0.02	
Preoperative CPR	0.47	
Preoperative ECMO	0.21	
Mean NYHA class	0.17	
NYHA class III or IV	0.40	
Logistic Euroscore	0.22	
Incomplete revascularization	0.40	
No of distal anastomosis	0.54	
On-pump conversion	0.46	
Total arterial grafting	0.07	

Abbreviations: HR=hazard ratio; BMI =body mass index; PAOD= peripheral artery occlusive disease; CVA= cerebrovascular accident; PTCA = percutaneous transluminal coronary angioplasty; PCI=percutaneous coronary intervention; COPD=chronic obstructive pulmonary disease; MI = myocardial infarction; STEMI= ST elevation MI; NSTEMI= non-ST elevation MI; LVEF = left ventricular ejection fraction; IABP=intra-aortic balloon pump; ECMO; extracorporeal membrane oxygenation; NYHA = New York Heart Association

IV. DISCUSSION

Although the off-pump technique in coronary artery bypass surgery has expanded its applicability to high-risk patients, OPCAB has not been considered traditionally as an option for emergent interventions. Several retrospective studies reported on the potentials of emergency OPCAB; however they were relatively small experiences[8-11] and it remained unclear whether OPCAB would be successfully applied in patients requiring emergency coronary bypass surgery. Since 2003, two well-experienced surgeons at our institution have performed OPCAB in emergency situations; the present study reviewed more than 100 such experiences suggesting its feasibility and safety.

The benefit of OPCAB in patients requiring emergency revascularization

Numerous studies have already indicated that off-pump technique is associated with favorable outcomes by avoiding CPB and its associated inflammatory response in coronary bypass surgery.[13-15] However, benefits of OPCAB in emergency situations have been less well defined. Kerendi et al[9] evaluated 44 patients who underwent emergency OPCAB compared to 570 patients who underwent on-pump CABG and reported benefits of emergency OPCAB in terms of postoperative mortality and morbidities. Likewise, Martinez and collagues[11] analyzed a series of 68 patients who underwent emergency OPCAB and documented benefits in terms of pulmonary complication and ventilator

time for emergency OPCAB relative to on-pump CABG. These studies emphasize that in emergency situations, use of the off pump technique by allowing to avoid the adverse effects of CPB can be more beneficial than elective surgery. Because almost patients who underwent emergency surgery had already multi-organ damage and systemic inflammation, the chance that adverse effects of CPB would affect the course of patients was higher than that for elective surgery. Our current study also showed benefits of the off-pump technique on postoperative outcomes, with very low rates of in-hospital mortality (6.2%), operative stroke (2.7%), and reoperation for bleeding (0.9%); rates for other complications (renal failure, prolonged ventilation, wound infection), length of ICU stay (4.77 ± 6.59 days) and hospital stay (14.98±9.66 days) were also acceptable despite the emergency nature of the cases. The benefits of OPCAB therefore could be maximized in emergency situations if properly used.

Overcoming the disadvantages of off-pump technique in emergency surgery

One of the major concerns regarding emergency OPCAB is how to achieve complete revascularization in the situations of unstable hemodynamics. Many studies have pointed out that it is difficult to achieve complete revascularization in OPCAB, especially in the emergency situations, and these lead to worse late outcomes finally.[16-18] Actually, in early periods, many studies reported that the

mean number of distal anastomoses of emergency OPCAB was 2~2.5 and rate of complete revascularization was less than 60%.[8-11] These results have supported a limitation of applicability of OPCAB in emergency. However, recent studies suggest that complete revascularization can be achieved even in the emergency as surgeon's experience matures.[3.9.19.] Puskas and colleague[3] showed that as surgeons gained more experience with OPCAB, complete revascularization comparable to on-pump CABG was achieved. They recommend that a surgeon should attempt emergency cases after performing 200 electives OPCAB procedures.[9] In our institution, two surgeons who had experiences of more than 1000 elective OPCAB procedures perform emergency OPCAB. Ninety nine percent of isolated CABG is being performed as off-pump technique. Our current study presents that the mean distal anastomoses was 3.04 ± 0.87 and complete revascularization could be achieved in 82.3% patients. Outcomes associated with long-term survival and rate of freedom from MACCEs were also acceptable (77.0 ± 0.6% and 52.0 ± 1.6 % during a 10 year follow-up). Our study shows that if performed by well-experienced surgeon, emergency OPCAB can achieve complete revascularization.

The second concerns regarding emergency OPCAB is how to overcome unstable hemodynamic. In the current study more than a third of patients had preoperative shock status and about 50% required support with IABP or ECMO. To overcome unstable hemodynamics, our operative strategy is to perform LAD grafting firstly before other heart procedures such as pericardial traction suture,

handling heart, and aortic manipulation). After successful achievement of LIMA to LAD grafting, hemodynamics improved in almost all cases thereby providing a better background status for other procedures. We were also prepared for the sudden application of CPB by keeping the CPB machine on standby. Although on-pump conversion was needed in 5 patients (4.4%), all could quickly receive CPB support and survive. Finally, our institution has cardiac specific anesthesiologists with experience of over 1000 elective OPCAB cases. This collaboration between cardiac anesthesiologist and well experienced surgeon may contribute to perform OPCAB more safely in emergency situations.

Selection of indication of off-pump

It is important to properly select patients for use of the off-pump technique in emergency situations. At our institution, since 2004, 80% of isolated emergency coronary artery bypass cases have been performed using the off-pump technique, and in particular during the last 5 years, over 90% of all emergency cases. However, as pointed by Kerendi et al[9], use of emergency OPCAB cannot be generalized to all complex cases. In the current study, 5 patients (4.4%) underwent on-pump conversion during OPCAB; all had complex conditions combining severe cardiogenic shock and congestive heart failure with pulmonary edema and desaturation which precluded maintenance of vital signs within an acceptable range despite IABP or ECMO support until achievement of LIMA to LAD grafting. Except in the case of patients who require absolutely

cardiopulmonary support, emergency OPCAB therefore appears safe and effective in almost all cases.

The risk factor on late mortality after emergency OPCAB

Our study showed that PAOD, COPD and cardiogenic shock were independent risk factors on late mortality after emergency OPCAB. Especially cardiogenic shock was the most powerful risk factor of late mortality after emergency OPCAB. The interesting point is that cardiogenic shock can be associated with late mortality as well as perioperative outcomes. Rastan et al[20] mentioned that cardiogenic shock status had significantly worse effect on late mortality after emergency revascularization. They indicated that cardiogenic shock was independent risk factor of late survival regardless of operation method (beating heart or cardioplegic arrest) or incompleteness. The current study showed the consistent findings with them. We found that cardiogenic shock could increase the chance of postoperative morbidities such as pulmonary, neurologic complication and renal failure, finally lead to late mortality.

Limitations

Several limitations with the current study are acknowledged. First of all, this has a limitation as an observational study with retrospective review. We do not totally exclude selection bias that OPCAB is usually performed in patients with more stable hemodynamic compared to on-pump CABG. However, we

performed OPCAB in almost emergency patients and so minimized this selection bias. Furthermore, this study does not compare clinical outcomes with on-pump CABG. So it is difficult to generalize superiority of OPCB strategy compared to on-pump CABG strategy in emergency. Finally, it also contained a relatively small population size. Nonetheless, in the situation that there are no randomized trials in this patient population, this study is valuable in that it is one of the largest reported series of emergency OPCAB.

IV. CONCLUSION

In conclusion, the present study suggests that OPCAB can be performed safely and effectively with favorable in-hospital outcomes. With achievement of complete revascularization, long-term outcomes are also acceptable. OPCAB strategy can be considered as a good option in patients who are indicated for emergency surgery.

REFERENCES

1. Society of Thoracic Surgeons Adult Cardiac Surgery Database, www.sts.org.

2. Puskas JD, Williams WH, Duke PG, et al. Off-pump coronary artery bypass grafting provides complete revascularization with reduced myocardial injury, transfusion requirements, and length of stay: a prospective randomized comparison of two hundred unselected patients undergoing off-pump versus conventional coronary artery bypass grafting. J Thorac Cardiovasc Surg 2003; 125: 797– 808.

3. Boyd WD, Desai ND, Del Rizzo DF, Novick RJ, McKenzie FN, Menkis AH. Off- Pump surgery decreases postoperative complications and resource utilization in the elderly. Ann Thorac Surg 1999; 68: 1490–3.

4. Chamberlain MH, Ascione R, Reeves BC, Angelini GD. Evaluation of the effectiveness of off-pump coronary artery bypass grafting in high-risk patients: an observational study. Ann Thorac Surg 2002; 73: 1866 –73.

5. Magee MJ, Dewey TM, Acuff T, et al. Influence of diabetes on mortality and morbidity: off-pump coronary artery bypass grafting versus coronary artery bypass grafting with cardiopulmonary bypass. Ann Thorac Surg 2001; 72: 776–81.

6. Darwazah AK, Abu Sham'a RA, Hussein E, Hawari MH, Ismail H. Myocardial revascularization in patients with low ejection fraction (35%): effect of pump technique on early morbidity and mortality. J Card Surg 2006; 21:

22–7.

7. Al-Ruzzeh S, Nakamura K, Athanasiou T, et al. Does offpump coronary artery bypass (OPCAB) surgery improve the outcome in high-risk patients? A comparative study of 1398 high-risk patients. Eur J Cardiothorac Surg 2003; 23: 50 –5.

8 Ochi M, Hatori N, Saji Y, Sakamoto S, Nishina D, Tanaka S. Application of off-pump coronary artery bypass grafting for patients with acute coronary syndrome requiring emergency surgery. Ann Thorac Cardiovasc Surg 2003; 9: 29–35.

9 Kerendi F, Puskas JD, Craver JM, Cooper WA, Jones EL, Lattouf OM et al. Emergency coronary artery bypass grafting can be performed safely without cardiopulmonary bypass in selected patients. Ann Thorac Surg 2005; 79:801–6.

10. Darwazah AK, Sham'a RA, Isleem I, Hanbali B, Jaber B. Off-pump coronary artery bypass for emergency myocardial revascularization. Asian Cardiovasc Thorac Ann 2009; 17: 133–8.

11. Martinez EC, Emmert MY, Thomas GN, Emmert LS, Lee CN, Kofidis T. Off-pump coronary artery bypass is a safe option in patients presenting as emergency. Ann Acad Med Singapore 2010; 39: 607–12.

12. ACC/AHA task force on practice guidelines: ACC/AHA 2004 guideline update for coronary artery bypass graft surgery. Circulation. 2004; 110: e340–e437.

13. Wan S, Izzat MB, Lee TW, et al. Avoiding cardiopulmonary bypass in

multivessel CABG reduces cytokine response and myocardial injury. Ann Thorac Surg 1999; 68: 52– 6.

14. Ascione R, Lloyd CT, Underwood MJ, et al. Inflammatory response after coronary revascularization with or without cardiopulmonary bypass. Ann Thorac Surg 2000; 69: 1198– 1204.

15. Wan IYP, Arifi AA, Wan S, et al. Beating heart revascularization with or without cardiopulmonary bypass: evaluation of inflammatory response in a prospective randomized study. J Thorac Cardiovasc Surg 2004; 127: 1624 –31.

16. Locker C, Shapira I, Paz Y, et al. Emergency myocardial revascularization for acute myocardial infarction: survival benefits of avoiding cardiopulmonary bypass. Eur J Cardiothorac Surg 2000; 17: 234–8.

17. Lattouf OM, Puskas JD, Thourani VH, Noora J, Kilgo PD, Guyton RA. Does the number of grafts influence surgeon choice and patient benefit of off-pump over conventional on-pump coronary artery revascularization in multivessel coronary artery disease? Ann Thorac Sur*g* 2007; 84: 1485-94; discussion 1494-5.

18. Lattouf OM, Thourani VH, Kilgo PD, Halkos ME, Baio KT, Myung R, et al. Influence of on-pump versus off-pump techniques and completeness of revascularization on long-term survival after coronary artery bypass. Ann Thorac Surg 2008; 86: 797-805.

19. Song HK, Petersen RJ, Sharoni E, Guyton RA, Puskas JD. Safe evolution towards routine off-pump coronary artery bypass: negotiating the learning curve.

Eur J Cardiothorac Surg 2003; 24: 947–52.

20. Rastan AJ, Eckenstein JI, Hentschel B, Funkat AK, Gummert JF, Doll N, Walther T, Falk V, Mohr FW: Emergency coronary artery bypass graft surgery for acute coronary syndrome: beating heart versus conventional cardioplegic cardiac arrest strategies. Circulation 2006, 114: I477–I485.

ABSTRACT (IN KOREAN)

응급수술 상황에서 무심폐기 관상동맥 우회술 적용의
유용성과 안정성 평가

< 지도교수 유경종 >

연세대학교 대학원 의학과

주 현 철

무심폐기 관상동맥 우회술은 축적된 경험과 발전된 기술을 바탕으로 적용범위가 고위험군으로 확대되고 있다. 하지만 응급 상황으로 수술을 해야 하는 환자에 있어 무심폐기 관상동맥 우회술의 적용은 아직까지 보고된 연구가 부족하고 논란의 여지가 있다. 본 연구는 최근 10년 이상의 경험과 수술 건수를 바탕으로 응급으로 시행되는 무심폐기 관상동맥 우회술의 유용성과 안정성을 평가해 보고자 하였다. 2003년부터 20014년까지 총 113명의 환자가 응급수술을 요하는 적응증으로 응급 무심폐기 관상동맥 우회술을 시행받았다. 본 연구는 응급 무심폐기 관상동맥 우회술의 적응증, 수술 전략, 수술 후 단기 및 만기 성적을 분석하였다. 평균 나이는 66세였고 평균 logistic Euroscore는 14.4였다. 평균 추적 관찰 기간은 51개월이었고 93.8%에서 만기추적이 가능하였다. 수술 중 심폐기 사용으로 전환되는 비율은 4.4%였

다. 전체 환자의 98.2%에서 내흉동맥 사용이 가능하였다. 평균 문합수는 3.04개였고 완전 재관류률은 82.3%에서 가능하였다. 수술 후 병원내 사망률은 5.3%였다. 수술 직후 발생하는 저심박출증, 뇌졸증, 폐관련 합병증 및 신부전 발생률은 각각 5.3% 2.7%, 8.8%, 11.5%였다. 평균 인공호흡기 유지 기간은 61시간이었으며 중환자실 및 입원 재원기간은 4.7일과 14.9일이었다. 10년 추적관찰에서 생존률과 심뇌혈관 합병증 자유률은 각각 77%와 52%였다. 본 연구는 응급수술에 있어서 무심폐기 관상동맥우회술은 향상된 수술관련 사망률 및 합병증 발생률을 보였고 만족할 만한 장기 성적을 보임으로써 안전하고 유용하게 적용될 수 있음을 보여주었다. 그러므로 응급수술의 적응이 되는 환자에 있어 무심폐기 관상동맥 우회술은 유용한 수술 전략으로 고려될 수 있다고 사료된다.

핵심이 되는 말: 응급, 무심폐기, 관상동맥 우회술