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Research Article

Transverse Heart; A New Conversıon Predictor From off-pump to on-Pump Surgery

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Abstract

Introduction: Risk of conversion to on-pump surgery is one of the concerns about off-pump CABG surgery. Conversion to on-pump surgery carries high morbidity and mortality risk. Our study aimed to investigate the relation between transverse heart and the risk of conversion to on-pump CABG .

Materials and Methods: Our study consisted of 3000 patients who underwent isolated off-pump CABG surgery between June 2010 and February 2020. All patients have at least one CABG in the Cx region. We have described vertical and transverse heart according to angle between the left anterior descending artery (LAD) and the left part of the sternal retractor.

Results: Our conversion rate was 7.1%. The average intensive care unit (ICU) stay was 1.17±0.10 days in successful off-pump surgery but 3.11±2.11 days in converted surgery (p=0.001).Average hospital stay was 4.35±1.44 days in off-pump surgery but 7.28±3.31 days (p=0.001) in converted surgery. Twenty-eight patients (1%) died in successful off-pump surgery, but 12 patients (5.6%) died in off-to-on converted surgery(p=0.001).Multivariate analysis has shown that ejection fraction less than 30% (LVEF<30%), cardiomegaly, congestive heart failure (CHF), and transverse heart as a predictor of conversion.

Conclusion: Conversion to off-to-on surgery still has contraversial results. Analysis of predictors preoperative and inspection of heart just before coronary anastomosis should be carefully done. The transverse heart was the statistically significant off-to-on conversion predictor of our study.

Keywords: Off-Pump Surgery; Vertical Heart; Transverse Heart

Introduction

It has been shown that unfavorable outcomes may be seen during conversions from off to on-pump CABG in a few clinical[1,2] and retrospective[3–10] studies. Adverse outcomes including increased early [1–4], [6–14] and late [2,3,8,10] mortality and myocardial infarction risk [4,14,15], stroke [3,6,7,16], need intra-aortic balloon pump [13,14,16], longer ICU [13,14,16], and hospital stay [3,14-16], more red blood cell transfusion requirement [1,8,14,16], increased reoperation risk due to bleeding [6,7,13], respiratory failure [6,7,13], increased dialysis requirement due to renal failure [6,15], increased ventilation support requirement [3,15,16], increased inotropic agent use [1,14], and more hospital readmissions [17].The overall conversion rate was found as 4.9% [18,19] in meta-analyses and ranged from 0-19.4% in published series whereas this rate was found as lower as 2.2% in the Society of Thoracic Surgeons national database reports [20]. However, it remains unclear which risk factors are associated with the conversion and whether these conversions are potentially preventable, since most studies have failed to evaluate these predictors. A variety of risk factors including poor coronary targets [21-23], lower left ventricular ejection fraction [16,24], congestive cardiac failure [4,24], surgeon's experience [2,4,5,16] non-use of a positioning device [7,13], prior CABG [4,6], prior myocardial infarction [6,21], diabetes [6,22] chronic obstructive pulmonary disease [13,15], preoperative atrial fibrillation [10], urgent surgery [6], mitral regurgitation (MR)[13], left ventricular hypertrophy [6], higher Newyork Heart Association(NYHA) angina class [6], LMCA stenosis [16], smaller [6] or larger [1] body surface area have been identified in the literature [21].We prospectively compare the adverse effects of transverse and vertical heart anatomy on outcomes associated with conversion from off to on-pump CABG. We think that transverse heart anatomy may be one of the factors likely to be responsible for adverse outcomes related to conversions from off to on-pump CABG.

Materials and Methods

Definition of Terms

ELECTIVE OPERATION is a procedure performed for a hemodynamically stable patient when brought to the operating room, regardless of angına class or admission status.

EMERGENCY OPERATION is a procedure performed for an acutely ischemic or hemodynamically unstable patient requiring an immediate operation.

HEMODYNAMIC COLLAPSE is a condition characterized by severe and sustained derangements in patient's vital signs, refractory to pharmacological therapy, and likely to result in death without the institution of CPB; excludes transient hemodynamic derangements.

ISCHEMIC COLLAPSE is defined as the primary or inciting cause of the hemodynamic collapse is myocardial ischemia.

MECHANICAL COLLAPSE is a condition due to the primary or inciting cause of the hemodynamic collapse is the alteration of the normal geometry or architecture of the heart from mechanical manipulation (compression, retraction, elevation).

EARLY CONVERSION is defined as conversion before coronary arteriotomy (intramyocardial or small coronary arteries)

LATE CONVERSION is defined as the conversion occur during or just after coronary arteriotomy or during performing coronary anastomosis

CARDIOMEGALY is that cardiac diameter to thoracic cavity diameter ratio on posteroanterior chest x-ray greater than 0.5(14)

TRANSVERSE HEART is that angle of LAD artery direction to the left arm of the sternal retractor is more than 45 degree in neutral heart position (Figure-1A)

VERTICAL HEART is that angle of LAD artery direction to the left arm of the sternal retractor is between 0-45 degree in neutral heart position (FIGURE-1B)

RIGHT HEMITHORAX ADHESION is that dense adhesion of lung to the right chest wall

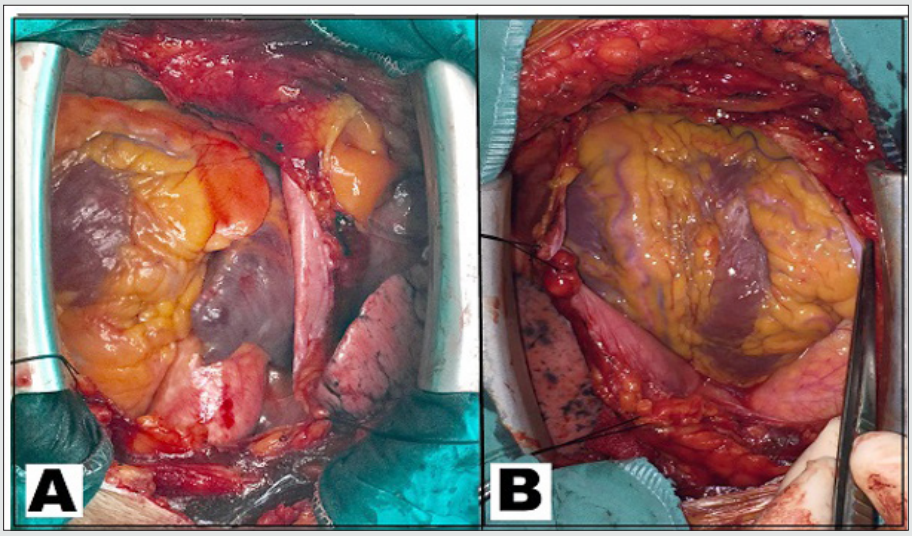

Figure 1:

A)Transverse Heart is that angle of LAD artery direction to the left arm of the sternal retractor is more than 45 degree in neutral heart position.

B)Vertical Heart is that angle of LAD artery direction to the left arm of the sternal retractor is between 0-45 degree in neutral heart position..

Exclusion Criterias

Isolated coronary bypass surgery was performed in all patients. Additional cardiac surgery requirements were evaluated as exclusion criteria. Patients suffering from moderate degree MR were also excluded from the study because of even mild degree MR would cause serious complication during left side coronary surgery [13].Redo coronary surgery were also excluded due to excessive dissection requirement before coronary anastomosis [4-6].The early conversion was accepted as exclusion criteria due to surgery is done in the on-pump. All patients were classified as late conversion group patients. Patients characteristics were detailed in Table-1.

Patients

We have been performing off-pump CABG since 2010.Currently our routine preference for coronary artery bypass surgery is off-pump technique. We have carried out 3000 isolated CABG surgery,

between 2010-2020.There was at least one coronary artery anastomosis requirement at the Cx region in our patients. Patients with isolated LAD and right coronary artery (RCA) disease were not included in the study due to the relatively low conversion rate.

Table 1: Patient Characteristics.

Varıable	Successful off-pump no=2786	Converted off-to-on No=214	P value
no	2786	214	
Gender(M/F)	1172/1614	118/96	0
NYHA(1-4)	2.5±0.87	2.67±0.66	0.001
No. disease vessels	2.41±0.12	2.77±0.2	0.657
LMCA	244	26	0.774
Cardiomegaly	157	54	0.001
LVEF <30%	76	44	0.001
CHF	21	15	0.001
Diabetes	975	86	0.548
Hypertension	815	72	0.671
COPD	334	41	0.562
PreopMI	1064	144	0.001
Stroke	162	10	0.966
PVD	251	18	0.455
CRF(Dialysis Dependent)	167	37	0.022
Vertical Heart	2475	58	0.001
Transverse Heart	311	156	0.001
Right Pleural Adhesion	7	23	0.001
Porcelene Aorta	34	9	0.078

LVEF=left ventricular ejection fraction;MI=myocardial infarction;NYHA=New York Heart Association; PVD=peripheral vascular disease,CRF=chronic renal failure,COPD=chronic obstructive pulmonary disease, LMCA=left main coronary artery,CHF=congestive heart failure

Surgical Technique

All surgical procedures were performed by two surgeons(EK and EO). Patients were routinely kept normothermic and in the supine position. Pump was ready but kept it dry. Central venous catheter was commonly inserted into the jugular vein. Median sternotomy was performed to harvest the LITA/RITA grafts. Both Radial artery (RA) and saphenous vein (SV) grafts were used. Heparin (2mg/kg) was administered before ligation of the distal part of the LITA and the ACT was maintained between 200-300 seconds during the operation. Right pleurotomy and a deep vertical pericardiotomy were performed to create space for entering of the heart into the right thoracic cavity. Operating table was positioned at Trendelenburg position to increase the inflow of the heart. Epicardial-stabilizations were routinely used for all anastomosis. The suction paddles are placed close to and parallel to the coronary artery to obtain maximum immobilization and minimum compromise of muscle function. Suction is activated in each paddle separately and fixed at the target site once suction is –400 mmHg. Several commercially available vacuum stabilization devices(mostly Octopus) were used. Commercially available all apical vacuum devices(mostly Starfish) were routinely used for posterolateral and posterior descending coronary arteries. Coronary arteries were taped proximally and distally by silastic sutures. Coronary shunts were not routinely used. Additional intravenous heparin was administered (with an ACT>480 seconds), and procedure was converted to on-pump, when hemodynamic instability developed. We routinely used LITA grafts for LAD, but LITA was anastomosed to the first diagonal artery in 23 patients. LITA anastomosis was firstly performed between 2010-2013 after then Cx-region anastomoses were firstly done to avoid streching of the LITA graft when deviating the heart to the right thoracic cavity. Apical vacuum devices were routinely used for circumflex posterolateral branches. After performing circumflex anastomosis, LITA anastomosed to LAD, and diagonal artery anastomoses were completed. RCA and its branches revascularization were done lastly. SV was routinely preferred in emergency conditions and proximal anastomosis was done to ascending aorta with 6/0 polypropylene just after distal anastomosis, to avoid severe ischemic complications. Innominate artery (IA) was used for proximal anastomosis in 43 patients. Graft blood flow rates(mL/min) were measured by using Doppler ultrasound after all anastomosis was completed, and protamine administrated. When ischemic collapse developed during distal anastomosis procedure we placed intracoronary shunt and kept the heart neutral position and waited until maintaining hemodynamic

stability. We routinely waited for at least five minutes until the signs of ECG recovered before a second intervention. Hemodynamic collapse was also a serious problem. We wait until hemodynamic parameters return to normal. If both ischemic and hemodynamic collapse persists, then we prefer converting to on-pump surgery. In the presence of serious hemodynamic collapse during the waiting period, we performed a hand massage to the heart and placed a purse-string while the pump lines were prepared. We performed RCA closed endarterectomy through limited arteriotomy in fifty patients in the beginning period of our experience. We also preferred revascularization of the right ventricle branch of the right coronary artery since June 2015. Porcelene aorta was found in 43 patients. We routinely prepared and taped the IA before making coronary anastomosis. The IA was extensively mobilized to supply a place both arterial return in case of conversion and proximal anastomosis of grafts. SV graft was anastomosed to the IA. Proximal anastomosis of other grafts were done on the the main SV.

Statistical Analysis

Data were expressed as mean±standard deviation. Statistical analysis was performed using IBM SPSS ver. 20.0 (IBM Corp., Armonk, NY, USA). Clinical data were expressed as mean values standard deviation. Differences were analyzed by using Fisher's exact test, x2-test, unpaired Student's t-test and Mann–Whitney test. We examined the effects of the variables on Off-to-On conversion by calculating odds ratios (OR) in univariate analyses for all CABG patients. Variables for which the unadjusted p-value in logistic regression analysis were identified as potential risk markers and included in the full model. We conducted stepwise multivariate analyses by using logistic regression.

Results

There was no significant difference between the two groups in terms of the average graft number. Average graft number was 3.12±1.2 on successful off-pump surgery whereas was 3.23±0.9 on converted on-pump surgery patients. Perioperative MI was found significantly (p=0.035) higher in off pump group patients compare to converted group patients (33 and 18 respectively). New strokes were observed in 12 of the successful off-pump group patients whereas only two of the converted group patients had new strokes(p=0.322). New renal failure development was recorded in 12 (four of them required hemodialysis) of the successful off-pump group patients. New renal failure was developed in four (two of them required hemodialysis) of the converted group patients. Rvision due to bleeding was performed in 132 of the successful off-pump group patients whereas only 25 of the converted group patients underwent re-operation due to bleeding. The average drainage amount was noted as 550±125 ml in off-pump surgery group patients, whereas this amount was noted as 701±230 ml in converted surgery group patients. There was a significant(p=0.011) difference between the groups in terms of drainage volume. The average packed blood (PBC) transfusion was reported as 1.56±0.34 units in off-pump group patients and 2.34±1.21 units on converted group patients (p=0.001). There was a significant(p=0.034) difference between two groups in terms of average Fresh Frozen Plasma (FFP) transfusion requirement (1.70±0.42 and 2.27±1.23 respectively). Inotropic agent supplement was required in 21%(611) of the successful off-pump group patients, but 67%(144) of the converted group patients were given an inotropic agent supplement(p=0.001). Intra-Aortic Balloon Pulsation was placed in 21 of the off-pump group patients and in 14 of the converted group patients (p=0.001). Transient postoperative atrial fibrillation was developed in 1785 of the off-pump group patients and in 150 of the converted group patients (p=0.756).The average ventilation duration was 5.11±2.11 hours in off-pump group patients, and 11.3±3.37 hours in converted group patients (p=0.001). The average length of ICU stay was 1.17±0.10 days in successful off-pump group patents, and 4.35±1.44 days in the converted group patients. Mortality rate was 1%(28) in successful off-pump group patients and 5.6%(12) in the converted group patients. The hospital readmission rates within 30 days after surgery were 7.7% in successful off-pump group patients and 15.7% in the converted group patients(p<0.001). The most common cause of hospital-readmission was hypotension (p<0.001) and wound infection (<0.001). The causes of hospital-readmission were detailed in Table-2, 3.

Table 2: Results.

Varıable	Successful off-pump no=2786	Converted off-to-on No=214	P value
Graft Number(no)	3.12±1.2	3.23±0.9	0.351
LITA	2511	191	0.944
RIMA	56	5	0.765
Radıal Artery	1815	127	0.802
Saphenous Veın	4701	276	0.742
Perioperative MI	33	18	0.035
RCA endarterectomy	31	19	0.532
New stroke	12	2	0.622
New renal failure	21	4	0.811

Post-op Atrial fibrillation	1785	150	0.756
Re-exploration for bleeding	132	25	0.322
Average drainage(mL)	550±125	701±230	0.011
Average Transfusion(unit) Blood FFP	1.56±0.34 1.70±0.42	2.34±1.21 2.27±1.23	0.001 0.034
Wound infection Superficial Deep	31 27 4	9 8 1	0.741 0.456 0.325
Inotrope requirement	611	144	0.001
IABP	21	14	0.001
Average Ventilation time(h)	5.11±2.11	11.3±3.37	0.001
Average ICU stay(day)	1.17±0.10	3.11±2.11	0.001
Average Hospital stay(day)	4.35±1.44	7.28±3.31	0.001
Death / %	28 / 1%	12 /5.6%	0.001

ICU=intensive care unit;LITA= left internal thoracic artery;RITA= right internal thoracic artery,FFP=fresh frozen plasma,IABP=intra-aortic balloon pump.

Table 3: Causes of 30-Days RE-Admission.

Varıable	Successful off-pump no=2786	Converted off-to-on No=214	Pvalue
Hypertension	31 (14%)	6 (17.6%)	0.867
Hypotension	84 (38.8%)	23 (67.6%)	<0.001
Atrial Fibrillation	112 (51.8%)	19 (55.8%)	0.567
Ventricular Arhythmias	15 (6.9%)	2 (5.8%)	0.435
Pleural effusion	51 (23.6%)	22 (64.7%)	0.001
Fever	88 (40.7%)	17 (50%)	0.185
Wound infection	45 (20.8%)	11 (32.3%)	0.044
Superficial	39 (18%)	7 (20.5%)	0.542
Deep	6 (2.7%)	4 (11.7%)	<0.001

Predictors of off-to-on conversion

We statistically analyzed 15 variables which likely to be a predictor of off-to-on conversion during the CABG procedure. According to univariate analysis of the parameters factors including age (p=0.211;OR=0.74), NYHA (p<0.001;OR=3.32), LVEF<0.30 (p=0.003;OR=0.95), preoperative MI (p=0.795;OR=0.99), diabetes (p=0.895;OR=1.41), LMCA (p=0.310;OR=0.82), LITA (p=0.154;OR=0.46), hypertension (p=0.872;OR=1.06), renal failure (p=0.010,OR=3.15), cardiomegaly (p=0.005;OR=2.12), average graft number (p=0.670;OR=0.73), vertical heart (p=0.985;OR=1.06), transverse heart (p<0.001;OR=4.75), right pleural adhesion (p=0.011;OR=3.54), CHF (p=0.001,OR=1.13) were found as a predictor of off-to-on conversion and shown in Table-2. The stepwise multivariate analysis of these parameters showed that variables such as LVEF<30 (p=0.002,OR=0.93), CHF (p=0.005:OR=1.05), cardiomegaly (p=0:005;OR=3.15), transverse heart (p<0.001;OR=4.11) were independent risk factors for off-to-on conversion. The univariate and multivariate analysis of patient and surgery dependent variables likely to be the effect on off-to-on conversion during CABG were detailed in Table-4.

Table 4: Variables Effects on The Off-To-On Conversion Based On Univariate And Multivariate Logistic Regression Analyses.

Varıables	Unıvarıate			Multıvarıate		
	Unadjusted Odds ratio	95%CI	Pvalue	Unadjusteda Odds ratio	95%CI	Pvalue
Age	0.74	0.41-1.15	0.211			
NYHA	3.32	2.13-5.19	<0.001	1.23	0.95-2.17	0.27

LVEF <0.30%	0.95	0.91-1.25	0.003	0.93	0.88-0.97	0.002
PreopMI	0.99	0.89-1.15	0.795			
Dıabetes	1.41	0.99-2.11	0.895			
LMCA	0.82	0.78-1.23	0.31			
LITA	0.46	0.31-0.78	0.154			
CHF	1.13	0.85-192	0.001	1.05	0.77-1.68	0.005
Hypertensıon	1.06	0.89-1.65	0.872			
Renal Faılure	3.15	1.97-6.44	0.01	3.07	0.15-3.89	0.685
Cardıomegaly	2.12	1.26-3.58	0.005	3.15	2.75-6.55	0.005
Average Graft No	0.73	0.55-1.42	0.67			
Vertıcal Heart	1.06	0.68-1.65	0.985			
Transverse Heart	4.75	2.38-9.25	<0.001	4.11	3.05-6.22	<0.001
Rıght Pleural Adhesıon	3.54	2.75-5.67	0.011	3.01	2.31-4.15	0.121

NYHA=Newyork heart Association, LVEF<30%=left ventricle ejection fraction less than 30%,LMCA=left main coronary artery, MI=myocardial infarction, LITA: left internal thoracic artery, CHF=congestive heart failure.

Comments

We know that mortality related to coronary surgery mostly results from organ deficiency except for heart failure. Myocardial failure as a cause of mortality was seen in less than 50% of our patients. The other early deaths were mostly due to additional organ failures. Our patients' profiles have considerably changed in recent decades of CABG surgery. More advanced age and co-existence of organ failure are common characteristics of our patients in recent years. Nowadays, percutaneous coronary interventions (PCI) is more commonly preferred in coronary patients worldwide. Thus more complicated cases in terms of limited runoff coronary vessels are more frequently encountered. Classical on-pump cardiac surgery has some deleterious effects due to extracorporeal perfusion and inadequate myocardial preservation and may lead to complications such as myocardial and brain ischemic injury, renal failure, and other organ deficiencies. Surgeons mostly prefer off-pump CABG surgery to avoid these complication risks and mortality. However, off-pump surgery has its own difficulties. Myocardial ischemia and hemodynamic disturbance or both may cause serious complications during off-pump surgery. Especially the Cx region of coronary vessel surgery becomes much more difficult in selected patients [2-17]. Skilled surgeons and their teams have developed several technical tip and tricks to avoid hypotension and prolonged ischemia during off-pump CABG. Despite all technical innovations, conversion from off-pump to on-pump may need to perform complete myocardial revascularization.

We think the "critical topic" is complete revascularization. Many surgeons prefer incomplete myocardial revascularization to avoid complication during off-pump surgery. It's well known that incomplete myocardial revascularization may cause ischemic complications after surgery and patients need additional PCI interventions [25]. The overall conversion rate was reported ranging from 0% to 19.4% [18-20]. Edgerton JR. [4] reported that surgical experience was the most important factor of off-pump surgery.Our CABG procedures were performed by two senior surgeons. Each of these surgeons has performed >500 coronary surgeries per-year. Despite our considerable experience, the conversion rate is about 7% in surgical procedures on three coronary vessels. This rate was noted as 1.12% for procedures including two-vessel (both LAD and RCA), and 0,5% for the a single artery(LAD) in our series. We have routinely explored all coronary vessels after pericardioyomy and prefer conversion to on-pump surgery in the presence of conditions such as intra-myocardial LAD, severely calcified coronary vessels, and small vessels in the first exploration. Conversion from off-to-on surgery has some disadvantages except for early conversion conditions. Particularly, conversion in emergency conditions has multiple deleterious effects and carries high morbidity and mortality risk. Multiorgan failure due to persistent ischemia and prolonged hypertension, increasing transfusion requirements, and increased vulnerability to infection seems to be related to increased morbidity and mortality risk. The development of perioperative MI was also found higher in these group patients. It is well known that blood flow rate measurement in grafts is extremely helpful to reduce the technical mistakes. We have perform re-anastomosis in 95 patients due to a low blood flow rate in the graft. Tabata M.[13] has reported a 14.3% operative mortality rate in patients undergoing emergency conversion whereas 1.2% mortality rate in off-pump surgery group patients. Similar mortality rates were also reported in several studies [7-21]. Hospital re-admissions within 30-days after surgery were significantly more common in our conversion patients. The presence of porcelene aorta is known as an absolute indication of off-pump surgery.

Many surgeons prefer performing incomplete coronary revascularization procedures to avoid complication risks whereas

experienced surgeons may also use LITA artery for proximal anastomosis. We always respect the divine configuration of LITA-LAD. We routinely prefer to use IA for proximal anastomosis in patients with multi-vessel disease requiring more than two proximal anastomosis on LITA. We placed proximal anastomosis of one of the left side SV graft to innominate artery then proximal anastomosis other grafts were placed the saphenous located on IA. Rightward disposition of heart may cause a different degree of MR. Severe MR due to cardiac displacement may cause acute pulmonary edema [13]. Acute pulmonary edema occurs in the presence of prolonged cardiac displacement associated with MR lead to congestion in the left ventricle consequently causes severe hemodynamic instability. Tabata M.[13] has shown that severe MR may develop even in the presence of a completely competent mitral valve preoperatively. The presence of the dense adhesions in the right pleural cavity is one of the most important unfavorable variables during off-pump surgery. Dense adhesions in the right hemithorax may compress the right atrium and ventricle particularly in the deviation of heart toward to right side during the off-pump surgery. Compression of right atrium and ventricle may cause serious hypotension despite reverse Trendelenburg position. Dense adhesions in right hemithorax could not be dissected in our 30 patients. Conversion to on-pump surgery was required in 23 of these patients.

There was no statistical significance of the presence of the dense adhesion in the right hemithorax according to the results of multivariate analysis. The most comprehensive analysis of conversion mortality was reported by Edgerton JR.[4] Their subgroup analyses showed that a fivefold increase in mortality rate depending on whether the conversion was elective(6.1%) or emergency(32.1%), and almost 12-fold higher mortality depending on whether it was early(3.1%) or late (34.5%) respectively. Among emergency conversions alone, the mortality rate increased from 0% to 45%, depending on whether they occurred early or late. Namely outcomes of conversion to on-pump surgery in emergency conditions considerably change depending on whether this occurs before or after the commencement of anastomosis. Early conversion technique was preferred in the conditions such as an uncontrollable severe hemodynamic disturbance during the disposition of the heart, small coronary arteries, diffuse atherosclerotic vessels, and intramyocardial coronary vessels.

As mentioned above the myocardial injury and heart disposition are two principal causes of conversion to on-pump surgery. Myocardial ischemia was mainly dependent on the anastomosis site on the coronary artery and degree of the coronary stenosis. Myocardial ischemia commonly occurred in proximal part of coronary artery occlusion by silastic tapes. More proximal part preference meant more ischemia risk. Intracoronary shunt were frequently required in surgical procedures containing the body part of the RCA. Myocardial ischemia during silastic occlusion is much more common in patients with a relatively low degree coronary stenosis. Predictors related to unfavorable outcomes of conversion to on-pump surgery are extremely important in terms of high morbidity and mortality risk of conversion. We found that transverse heart was relatively new predictor. Off-pump surgery is relatively easy surgical procedure with a low conversion rate in the vertical heart. Disposition of heart is mostly known as a mechanical hemodynamic deterioration factor in transverse heart. Rightward disposition of heart may cause right ventricle outflow tract and pulmonary artery kinking in transverse heart anatomy [26]. Distortion of the heart may cause severe MR which results in the development of acute pulmonary [13]. Our results showed that the presence of the transverse heart is one of the significant predictors of conversion to the on-pump procedure. Currently, we do not prefer off-pump surgery in the presence of the transverse heart.

Conclusion

Conversion to on-pump surgery is a challenging problem due to unfavorable outcomes. Thus predictors likely to be responsible for conversion should be considered before decision making for CABG surgery. Transverse heart is a reasonable predictor of conversion and should be considered as early conversion marker.

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