Factors Associated with Pre-Cardiopulmonary Arrest Signs within the First 24 Hours Post Open Heart Surgery

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ABSTRACT

Objective: To study the relationship between cardiopulmonary bypass time, aortic cross-clamp time during surgery, Left Ventricular Ejection Fraction, co-morbidity, redo cardiac surgery, age, body mass index, and pre-operative depression with pre-cardiopulmonary arrest signs within the first 24 hours post open heart surgery.

Methods: The sample comprised 194 patients who underwent open heart surgery in a university hospital, Bangkok, Thailand. Research instruments included a demographic data recording form, illness and a related data on treatment recording form, Charlson Comorbidity Index (CCI), The Center for Epidemiological Studies Depression Scale, and pre-cardiopulmonary arrest index. Pearson's product-moment correlation coefficient and point biserial correlation were employed to analyze data.

Results: The majority of the samples were males (55.7%) with an average age of 59.9 years, and 41.7% had severe pre-cardiopulmonary arrest scores (≥ 8 points). Factors associated with pre-cardiopulmonary arrest signs within the first 24 hours post open heart surgery were cardiopulmonary bypass time, aortic cross-clamp time, CCI score, pre-operative depression ($r = .24, .23, .20, -.20$; $p < .01$) and redo surgery ($r = .16$; $p < .05$), respectively.

Conclusion: Patients who undergo open heart surgery should be closely monitored for pre-cardiopulmonary arrest signs, especially those who had prolonged cardiopulmonary bypass time and aortic cross-clamp time, have high co-morbidity scores, or experienced redo cardiac surgery. Additional studies should be conducted to explore the effect of pre-operative depression on pre-cardiopulmonary arrest signs after cardiac surgery.

Keywords: Open heart surgery, pre-cardiopulmonary arrest signs

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INTRODUCTION

Within the first 24 hours after open heart surgery, patients always experience dramatic hemodynamic instability which eventually leads to life threatening complications, in particular within the first 2 hours.[1] Moreover, the level of cytokines also increases and reaches the highest level at the sixth hour then gradually declines to normal level within 24 hours due to Systemic Inflammatory Response Syndrome (SIRS) after major surgery.[2] The changes aforementioned lead to complications including cardiovascular and respiratory dysfunction, massive bleeding, and hypothermia[3]. These patients have to be closely monitored because these complications may lead to cardiopulmonary arrest. In the past decade, practitioners who work in critical or emergency care units have begun to use a scoring system and various parameters to monitor patients who experienced hemodynamic instability. These parameters referred to early warning signs or pre-cardiopulmonary arrest signs. When an early warning sign was detected, patients would receive immediate care to prevent life threatening complications and cardiopulmonary arrest.[4] Evidences from previous studies showed that 80% of critically ill patients experienced physiological deterioration which led them to cardiopulmonary arrest during their hospital admission.[5] In particular this problem was prominent among patients who underwent cardiac surgery. It was found that after cardiac surgery, 95% of them suffered from hemodynamic instability within the first 2 hours while 55% had hypotension and 16% had low cardiac output.[3]

There are many factors which influence pre-cardiopulmonary arrest signs after open heart surgery. These include duration of using cardiopulmonary bypass (CPB) or so called CPB-time. Eleven percent of patients who had a CPB-time for more than 150 minutes were at risk of post-operative bleeding so that reoperation was required.[6] Every 30-minute increase in CPB-time was a significant

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risk factor for post-operative cardiovascular complications and mortality.[7] Clamping of the ascending aorta to separate the heart from circulation during corrective surgery may cause myocardial ischemia if cardiac muscles were insufficiently protected.[8] Long aortic cross-clamp times led to severe adverse outcomes e.g. increased low cardiac output, increased mechanical ventilation time, increased renal complications, and increased mortality during hospital admission.[9] Left Ventricular Ejection Fraction (LVEF) also had an effect on post-operative complications. Patients whose LVEF was less than 40% were more likely to develop low cardiac output syndrome[10] and heart failure[11] following open heart surgery.

Co-morbidity was also a risk factor that might cause post-operative pre-cardiopulmonary arrest signs. Patients whose Charlson Comorbidity Index score was more than 2 points were more likely to develop acute renal failure within the first 7 days following open heart surgery with aortic clamping ($p < 0.001$).[12] Previous studies demonstrated that patients who experienced redo surgery were more likely to have cardiovascular complications and their mortality rate increased to 54%. This group of patients would develop early post operative complications including re-operation for bleeding, stroke and low cardiac output.[13] Furthermore, elderly patients had risk for pre-cardiopulmonary arrest signs due to low cardiac output[11] which would lead to increased mortality rate.[14]

Abnormal body mass index (BMI) was also a risk factor for post-operative pre-cardiopulmonary arrest. Patients who had low BMI were at risk for pulmonary edema and pneumonia. Moreover, they required more blood transfusions than patients with normal BMI.[15] Patients whose BMI were higher than 35 kgs/m^2 had reduced left ventricular systolic and diastolic function and increased myocardial reflectivity.[16] Pre-operative depression was associated with adverse outcomes after open heart surgery. Abnormalities of the autonomic nervous system in patients with depression led to decreased function of the parasympathetic system and increased function of the sympathetic nervous system, so heart disease patients, especially coronary artery disease patients, were at risk for myocardial ischemia, ventricular tachycardia/fibrillation and sudden cardiac death.[17] According to studies on moderate to severe pre-operative depression in patients undergoing coronary artery bypass surgery, depression is a risk factor increasing the rate of postoperative mortality by more than 1.6 times [Hazard ratio 1.63 (95% CI:1.02-2.62)].[18]

Nurses in critical care post-operative cardiac surgery units should have knowledge about risk factors and hazards for pre-cardiopulmonary arrest signs which may lead to cardiopulmonary arrest in order to implement an effective monitoring system, reducing the risk of post-operative morbidity and mortality.

The objectives of this study were to study the relationships between CPB time, aortic cross-clamp time, LVEF, co-morbidity, redo cardiac surgery, age, BMI, and pre-operative depression with pre-cardiopulmonary arrest signs within the first 24 hours post open heart surgery.

MATERIALS AND METHODS

The sample comprised heart disease patients aged more than or equal to 18 years who received treatment by open heart surgery at a university hospital and did not include patients in the following groups: patients who received open heart surgery for heart transplants, patients who received open heart surgery for heart support such as extra corporeal membranous oxygenators (ECMO) or ventricular assist device (VAD) and patients who received thoracic aorta surgery with a beating heart.

Research instruments

The research instrument comprised a demographic data recording form, illness and related data on a treatment recording form, a pre-cardiopulmonary arrest signs assessment form which implemented the activation criteria for a medical emergency team[19], by the score of the instrument with 0-11 points. High scores indicated high pre-cardiopulmonary arrest signs severity. The co-morbidity assessment form employed the Charlson Comorbidity Index[20], and the pre-operative depression evaluation form used The Center for Epidemiological Studies Depression Scale (CES-D).[21] The research instruments aforementioned were used to collect data from patients' documents as well as used to interview the patients prior to their surgery.

Data collection

After ethical approval from the Siriraj Institutional Review Board (Si.336/2011), the researcher collected data between July 2011-October 2011 by meeting with the sample one day before surgery to collect demographic data and data on pre-operative illnesses and pre-operative depression. Following surgery, the researcher collected data on illnesses, postoperative treatments and occurrence of pre-cardiopulmonary arrest signs within the first 24 hours post surgery from patient documentation.

Descriptive statistics was employed to analyze general data and data related to illness and treatment while Pearson's product-moment correlation coefficient and point biserial correlation were utilized to analyze the relationships between studied variables.

RESULTS

Most of the sample were males (55.7%) with an average age 59.9 (SD ± 13.9) years, and 64.4% had New York Heart Association (NYHA) functional classification II with average Glomerular Filtration Rate (GFR) levels of 67.8 (SD ± 24.1) ml/ minute/ 1.73 m^2. Nearly all, 97.4% had elective surgery and most of the sample received coronary artery bypass graft (CABG) surgery (42.8%) followed by heart valve surgery (25.8%) and CABG with valvular surgery (11.9%) and the inotropic drug most frequently used after surgery was dobutamine (73.7%).

The sample had an average CPB-time of 101.9 (SD ± 51.4) minutes, an average aortic cross-clamp time of 68.8 (SD ± 36.7) minutes, an average LVEF of 59.1% (SD ± 16.2). Most, 70.6% had an average co-morbidity score of 2 (SD ± 1.4) points, while 12.9% of the sample came to receive redo surgery. The average BMI was 23.7 (SD ± 3.9) kg/m^2, and 16.9% had mild pre-operative depression while 2.6% had moderate to severe pre-operative depression.

With regard to pre-cardiopulmonary arrest signs score within the first 24 hours after open heart surgery, the average highest score of the sample was 7.2 (SD ± 1.6) points along with pre-cardiopulmonary arrest scores during each period of 6 (SD ± 1.8), 5.6 (SD ± 2), 5.2 (SD ± 2), 4.5 (SD ± 2.2), 3.8 (SD ± 2.4) points within the second, sixth, twelfth, eighteenth and twenty-fourth hours, respectively.

Factors correlated with pre-cardiopulmonary arrest

signs within the first 24 hours of post open heart surgery were CPB-time, aortic cross-clamp time, CCI score, pre-operative depression ($r = .24, .23, .20, -.20$; $p < .01$) and redo surgery ($r = .16$; $p < .05$), respectively. However, LVEF, age, and BMI did not correlate with pre-cardiopulmonary arrest signs.

DISCUSSION

All patients demonstrated pre-cardiopulmonary arrest signs. The average highest score of pre-cardiopulmonary arrest signs among them was 7.2 (SD ± 1.6) with the range of 3-10. One hundred and three patients (53.1%) had scores between 5-7 which was referred as high level of severity while 81 patients (41.7%) showed the scores of higher than 8 which was considered as the highest level of severity.[19] This finding confirmed that patients undergoing open heart surgery always need intensive monitoring due to their risk for cardiopulmonary arrest especially within 24 hours post surgery.

As for pre-cardiopulmonary arrest signs' scores in each period, the highest level of average pre-cardiopulmonary arrest signs' scores was the first 2 hours and then they would gradually decline along 24 hours following surgery. According to the study of Currey & Botti[3], 60% of 38 patients post cardiac surgery had hemodynamic instability in the first 2 hours. Those physiological changes had a high risk and could lead to cardiopulmonary arrest.

Factors correlated with pre-cardiopulmonary arrest signs within the first 24 hours post open heart surgery were CPB-time, aortic cross-clamp time, CCI score, redo surgery and pre-operative depression.

For CPB-time, the findings of this study were also consistent with the study of Salis and colleagues[7] who found every thirty minutes of CPB-time to be a significant risk factor for mortality as well as respiratory, renal and neurologic complications with multiple organ failure following heart surgery. The finding can be explained by the fact that, following heart surgery in patients who required CPB during surgery, the blood came into direct contact with the mechanical system caused SIRS, which is a response to inflammation that will trigger the secretion of thrombin complement, cytokines, neutrophils, adhesion molecules, mast cells and multiple inflammatory mediators. Excessive amounts of these substances will cause multi-organ system dysfunctions, such as coagulopathy, respiratory failure, myocardial dysfunction, renal insufficiency and neurocognitive defect.[22] In this study, the sample had an average CPB-time 101.9 minutes and those who had a longer than average CPB-time of more than 101.9 minutes (4.6%) have a risk for high complications post-operation. This group had CABG (33.3%) and had complex operations (44.4%) such as 3 patients had aortic replacement with CABG and valvular heart surgery, with an average co-morbidity score of 2.8 points and 33.3% had NYHA class IV. The severity of disease before surgery and duration time of CPB to correct the complex disease can lead to hemodynamic instability post-operation.

For aortic cross-clamp time, this finding was found to be consistent with AL-Sarraf and colleagues[9] who discovered aortic cross-clamp time to be related to increases in adverse outcome post cardiac surgery, such as low cardiac output, increased renal complications, increased amounts of blood transfusions and increased mortality ($p < 0.05$). Because aortic cross-clamp is a necessary and important process during surgery which may cause cardiac ischemia if the myocardium does not receive sufficient protection, the impacts from ischemia caused by aortic cross-clamp have been found to include swelling of mitochondria and sacroplasmic reticulum in the first 30 minutes, which will lead to increased osmolarity from anaerobic metabolism, which will cause tissue destruction. After 60 minutes, membranes will be destroyed which may lead to cellular necrosis[8]. Long aortic cross-clamp times can lead to increased severity of various adverse outcomes after surgery as shown in previous studies, thereby causing the discovery of a relationship between aortic cross-clamp time and pre-cardiopulmonary arrest signs scores within the first 24 hours post open heart surgery.

For Co-morbidity, this finding was consistent with the study of Che and colleagues[12] who investigated co-morbidity and acute renal failure scores after open heart surgery with aortic cross-clamp and found co-morbidity scores of more than 2 points to be related to post-operative acute renal failure when compared to co-morbidity scores of 0-2 points ($p < 0.001$). In this study, the sample had an average co-morbidity score of 2.0 (SD ± 1.4) points with high severity of co-morbidities while 70.1% had congestive heart failure, followed by myocardial infarction (59.3%) and diabetes (26.8%). The number and severity of co-morbidities caused hemodynamic changes in the initial stages following surgery.

For Redo surgery, the findings of this study were found to be consistent with other studies conducted in groups of patients who underwent heart valve surgery which found 54% have circulatory complications potentially leading to mortality. The complications encountered in the initial stages following surgery consisted of reoperation for bleeding, stroke and low cardiac output.[13] These findings may be explained by patients who had redo cardiac surgery have a strong attachment between the sternum and various heart structures, thereby putting these patients at risk for post-operative blood loss.[23] This study review that patient who underwent redo surgery had longer time of aortic cross-clamping (83.7 vs. 67.9 minutes) and received higher doses of inotropic agents which brought them to more deterioration of their physical condition.

For pre-operative depression, this finding did not relate with previous studies which found the positive relationship between preoperative depression and post-operative complication. The explanation for this finding are described as follows: 1) The samples who demonstrated pre-operative depression had better cardiac function, less severity, less CPB-time, less aortic cross-clamp time and received average postoperative amounts of inotropic agents. 2) In previous studies post-operative complications which were found to be positively correlated with pre-operative depression were late complications or morbidity such as delayed functional capability or delay in resuming previous activities.[18,24] In contrast pre-cardiopulmonary arrest early warning signs among critically ill patients was more likely to occur due to altered physiological conditions rather than psychological changes. 3) In this study, when pre-operative depression was detected, the researcher informed the ward staff for proper management. Therefore, patients might receive proper intervention for depression before surgery. According to this study, LVEF, age, and BMI were not found to be related to pre-cardiopulmonary arrest signs' scores within the first 24 hours after open heart surgery, possibly because both LVEF and BMI had normal average scores. As for age, most of the sample were not senior adults and had an average age of 59.9 years. Since the

most adverse outcome occur in other studies which had low LVEF, age more than 65 years[10] and had abnormal BMI.[15,16]

CONCLUSION

Post open heart surgery patients should be closely monitored for pre-cardiopulmonary arrest signs, especially those who had prolonged cardiopulmonary bypass time and aortic cross-clamp time, had high co-morbidity scores, or experienced redo cardiac surgery. Additional studies should be conducted to explore the effect of pre-operative depression on pre-cardiopulmonary arrest signs after cardiac surgery.

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