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Prognostic factor for prolonged ventilator usage and ICU occupancy time after mitral valve replacement surgery: a retrospective cohort study

Supomo[1], Herpringga Lara Sakti[2], Galih Asa Andrianto[3]

[1]Division of Cardiothoracic Surgery, [2]Division of General Surgery, Department of Surgery, Faculty of Medicine, Public Health and Nursing, Universitas Gadjah Mada/ Dr.Sardjito General Hospital, Yogyakarta, [3]Faculty of Medicine, Public Health and Nursing, Universitas Gadjah Mada, Yogyakarta, Indonesia

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ABSTRACT

This study was conducted to identify the prognostic factors for prolonged ventilator usage time and ICU occupancy time after mitral valve replacement (MVR) surgery. It was a retrospective cohort study involving 70 MVR surgery patients at Dr. Sardjito General Hospital, Yogyakarta, Indonesia during the period of January 2013 to December 2018. Prognostic factors as independent variables including age, gender, heart failure, ejection fraction, pulmonary hypertension, chronic pulmonary disease, active endocarditis, renal insufficiency, duration of aortic cross clamp (AOX) time and cardiopulmonary bypass (CPB) time were evaluated. Where as the dependent variables were the prolongation of ventilator usage time (>24 h) and the intensive care unit (ICU) occupancy time (>96 h). Of the total 70 studied patients, 25 patients (35.7%) used ventilator >24 h, meanwhile 15 patients (21.4%) occupied the ICU >96 h. Patients who used ventilator >24 h had CPB time ≥126.5 min (OR=10; 95%CI=2.581-41.252), renal insufficiency (OR= 14; 95%CI = 1.487-150.970), and active endocarditis (OR=7; 95%CI = 1.257-45.213). Meanwhile, patients who occupied the ICU >96 h had age ≥40 years old (OR=6.4; 95% CI = 1.26-15.3), CPB time ≥126.5 min (OR=5.7; 95% CI = 1.8-38.1), and heart failure with NYHA functional classification 3 (OR=9.8; (95% CI = 1.4-67.2). In conclusion, the prognostic factors for prolonged ventilator usage time after MVR surgery are CPB time ≥126.5 min, renal insufficiency and active endocarditis. Furthermore, the prognostic factors for prolonged ICU occupancy time are age ≥40 years old, heart failure with NYHA functional classification 3 and CPB time ≥126.5 min.

ABSTRAK

Penelitian ini dilakukan untuk mengetahui faktor prognostik lama penggunaan ventilator dan lama okupansi ICU setelah operasi penggantian katup mitral (MVR). Penelitian ini merupakan studi kohort retrospektif yang melibatkan 70 pasien operasi MVR di RSUD Dr. Sardjito Yogyakarta, Indonesia selama periode Januari 2013 sampai Desember 2018. Faktor prognostik sebagai variabel bebas meliputi umur, jenis kelamin, gagal jantung, fraksi ejeksi, hipertensi pulmonal, penyakit paru kronik, endokarditis aktif, insufisiensi ginjal, lamanya waktu *aortic cross clamp* (AOX) dan waktu *bypass* kardiopulmoner (CPB)) dievaluasi. Sedangkan sebagai variabel terikat adalah perpanjangan waktu pemakaian ventilator (> 24 jam) dan waktu okupasi di ICU (> 96 jam). Dari total 70 pasien yang diteliti, 25 pasien (35,7%) menggunakan ventilator> 24 h, sementara 15 pasien (21,4%) menempati ICU> 96 jam. Pasien yang menggunakan ventilator> 24 jam memiliki waktu CPB ≥126,5 menit (OR = 10; 95% CI = 2.581-41.252), insufisiensi ginjal (OR = 14; CI 95% = 1.487-150.970), dan endokarditis aktif (OR = 7 ; 95% CI = 1.257-45.213). Sedangkan pasien yang menempati ICU> 96 jam berusia ≥40 tahun (OR = 6,4; CI 95% = 1,26-15,3), waktu CPB ≥126,5 menit (OR = 5,7; CI 95% = 1,8-38,1), dan gagal jantung dengan klasifikasi fungsional NYHA 3 (OR = 9,8 (95 % CI = 1,4-67,2) Kesimpulannya, faktor prognostik lama penggunaan ventilator setelah operasi MVR adalah waktu CPB ≥126,5 menit, insufisiensi ginjal dan endokarditis aktif. Faktor prognostik lama hunian ICU adalah umur ≥40 tahun, gagal jantung dengan klasifikasi fungsional NYHA 3 dan waktu CPB ≥126,5 menit.

Keywords:
mitral valve replacement;
prognostic factor;
prolonged ventilator usage time;
prolonged ICU occupancy;
cardiac surgery;

*corresponding author: supomo.tkv@mail.ugm.ac.id

INTRODUCTION

Mitral valve replacement (MVR) is a difficult procedure with high morbidity and mortality rates. Wang *et al.*[1] reported that the operative mortality rate of MVR was 2.5% and postoperative morbidity including prolonged ventilation and acute renal failure was 18.9%. Morbidity and mortality rates post MVR surgery are affected by preoperative and intraoperative factors. Accordingly, it is important to predict postoperative prognosis based on patient's preoperative and intraoperative conditions. Identification and stratification of those factors are needed to assist clinicians in selecting appropriate protocols and choosing the technique used in the operation.[2]

Studies have been conducted to identify the complication related to cardiac surgery including prolonged post-operative ventilator usage time and intensive care unit (ICU) occupancy time.[3,4] Prolonged ventilator usage time is an important complication following cardiovascular surgeries.[4] Patients who experienced prolonged ventilator usage usually have longer duration of intensive care.[4] Prolonged ICU occupancy is associated with an increase in mortality and morbidity in patients who underwent cardiac surgery. Moreover, prolonged ICU occupancy results in a substantial increase in hospital cost.[5]

In Indonesia, the European System for Cardiac Operative Risk Evaluation II (Euroscore II) is commonly used as the preferred scoring system to predict the outcome of a cardiac surgery. In the Euroscore II scoring system, there are 18 different factors that influence the morbidity of cardiac surgery.[6] However, some limitations of this scoring system are that not included intraoperative factors in the scoring, and it was developed based on the Caucasian population who have differences in demographic and socioeconomic factors compared to Indonesian population.

In this study, we reported our findings concerning the prognostic factors in patients who underwent MVR to predict the prolongation of ventilator usage and ICU occupancy time on the Indonesian population

MATERIALS AND METHODS

Subjects

A retrospective cohort study was conducted to patients who had undergone MVR in the period of January 2013 to December 2018 at Dr. Sardjito General Hospital, Yogyakarta, Indonesia. The data of patients were collected from medical records. All patients involved in this study were operated on by one single surgeon with the same technique. The medical records contained the researched variables were included in this study. Patients with incomplete medical records, a history of diabetes mellitus or random blood glucose >200 mg/dL, and a history of prior heart surgery or non-surgical correction of the mitral valve were excluded.

Seventy MVR surgery patients who met the inclusion and exclusion criteria were included in this study. This study had been approved by the Medical and Health Research Ethics Committee of the Faculty of Medicine, Public Health and Nursing, Universitas Gadjah Mada/Dr. Sardjito General Hospital, Yogyakarta (No. KE/FK/0789/EC/2019) and by Head Office of the Human Resource and Development, Dr. Sardjito General Hospital, Yogyakarta (No. LB.02.01/XI.2.2/17482/2019).

Protocol of study

Prognostic factors as independent variables were divided into preoperative and intraoperative factors. Preoperative risk factors included age (≥40 years old or <40 years old), gender (Male/Female),

ejection fraction (≥55% or <55%), heart failure, renal insufficiency, pulmonary hypertension (no / mild / moderate / severe), chronic pulmonary disease, and active endocarditis.

We used the median age which was 40 years old in our sample as the cut off point. Ejection fraction and pulmonary hypertension were evaluated by a cardiologist in our hospital using an echocardiogram. Heart failure were graded based on NYHA functional classification. Patient was considered not having pulmonary hypertension if pulmonary arterial pressure is <25 mmHg, mild if pulmonary arterial pressure between 26-35 mmHg, moderate if 36-45 mmHg, and severe if >45 mmHg.[7] Renal insufficiency was defined as reduction in renal function characterized by decrease in creatinine clearance calculated by the Cockcroft-Gault equation. Patient was considered having a renal insufficiency if creatinine clearance ≤ 90 mL/min.[8] Chronic lung disease was defined as long-term treatment with steroids or bronchodilator or forced expiratory volume (FEV) <75% in spirometry examination and active endocard it is was diagnosed by a cardiologist in our center.

Intraoperative risk factors in our study were aortic cross clamp (AOX) time (safety time/risk time) and cardiopulmonary bypass (CPB) time (safety time/risk time). The CPB time was defined as the duration in which the patient's blood was exposed to a CPB machine and AOX time was defined as the duration between when the AOX was placed on the ascending aortic vessel until the cross clamp was released. We used the Youden index and receiver operating characteristic (ROC) curve to predict the cut-off points used to define the safety time and risk time. This was done to ensure that our cut-off points were accurate in predicting morbidity post MVR Surgery. Safety time was defined as the duration of AOX and CPB times below the cut-off point, and the risk time was defined as the duration of AOX and CPB above the cut-off point.

Prolongation of ventilator usage time as the dependent variable was defined as the duration of endotracheal tube usage after MVR surgery >24 h.[9] Prolongation of ICU occupancy time as the dependent variable was defined as the duration of intensive care after MVR surgery >96 h.[10] In the hospital, all patients are intubated and admitted to the ICU after MVR surgery and the criteria to discharge patient from ICU are full consciousness, no incisional drainage, stable hemodynamic, balanced electrolyte level, and agreed on by the cardiac surgeon, cardiologist and anesthesiologist.

Statistical analysis

All data were entered into Microsoft Excel 2016 and analyzed using Statistical Package for the Social Sciences (SPSS) 22. Univariate relation in each independent and dependent variable was tested. Bivariate association between independent and dependent variables was tested using Chi-squared or, as appropriate to test for trends between groups with categorical data. The data were presented with relative risk (RR) and confidence interval (CI). Multivariate logistic regression analysis was used to determine the association of multiple independent variables simultaneously. The data were presented with OR (Odds Ratio). For all analyses, p values in which <0.05 considered to be statistically significant were reported.

RESULTS

A total of 70 patients' medical records were included in this study. Characteristics of the MVR surgery patients were presented in TABLE 1.

TABLE 1. Baseline characteristics of the patients

Variable	Sum
Pre operative variable	
Age [n (%)]	
• ≥40 years old	33 (47.1)
• <40 years old	37 (52.9)
Gender [n (%)]	
• Male	24 (34.3)
• Female	46 (65.7)
Ejection fraction [n (%)]	
• <55%	8 (11.4)
• ≥55%	62 (88.6)
Heart failure [n (%)]	
• NYHA functional class III	14 (20.0)
• NYHA functional class II	56 (80.0)
Pulmonary hypertension [n (%)]	
• Severe	25 (35.7)
• Moderate	15 (21.4)
• Mild	9 (12.9)
• No	21 (30.0)
Active endocarditis [n (%)]	
• Yes	49 (70.0)
• No	21 (30.0)
Renal insufficiency [n (%)]	
• Yes	10 (14.3)
• No	60 (85.7)
Chronic lung disease [n (%)]	
• Yes	7 (10.0)
• No	63 (90.0)
Intraoperative variable	
AOX time	138.8±507.5
mean ± SD/ [median (min-max) min]	[76 (47-138)]
CPB time	181.1±619.2
mean ± SD/ [median (min-max) min]	[101 (61-197)]
Dependent variable	
Prolonged ICU occupancy time[n (%)]	
• Yes	15 (21.4)
• No	55 (78.6)
Prolonged ventilator usage time[n (%)]	
• Yes	25 (35.7)
• No	55 (64.3)

NYHA: New York Heart Association; AOX: aortic cross-clamp; CPB: cardiopulmonary bypass

In this study, 25 patients (35.7%) had prolonged ventilator usage time. The mean time of the ventilator usage was 39.3 h with the longest duration was 170 h and the shortest was 10 h. Meanwhile, 15 patients (21.4%) had prolonged ICU Occupancy. The mean time of ICU occupancy was 55 h with the longest ICU occupancy was 384 h and the shortest was 18 h. The ROC curve was applied to predict the cut-off points for the intraoperative variable. The resultsare presented in FIGURE 1.

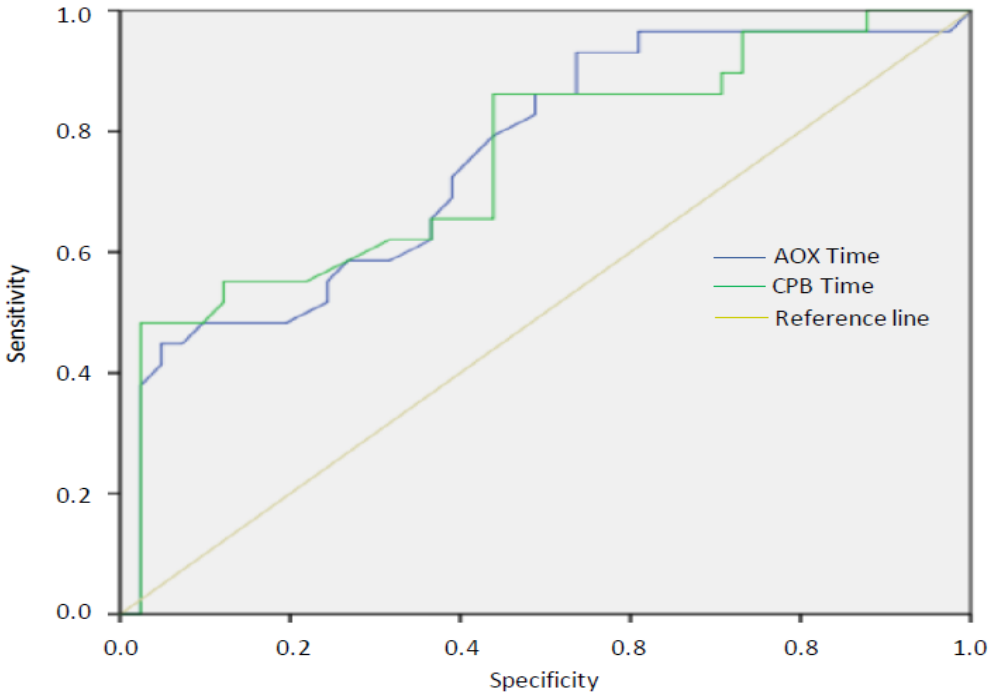

FIGURE 1. Receiver operating characteristic (ROC) curve of AOX time and CPB time

ROC curve of AOX time (blue line) and CPB time (green line) were above the reference line (no predictive value). The area under the curve (AUC) values of AOX time cut-off was 0.756 and CPB time was 0.753. Because the AUC area was 0.7, we concluded that the ROC curve had a good accuracy in predicting the patient's morbidity. The sensitivity of the selected cut-off point is presented in TABLE 2.

TABLE 2. Value of AOX time and CPB time cut-off

Variable	Positive if greater than or equal to	Sensitivity	Specificity
AOX Time	96.5 min	0.448	0.049
CPB Time	126.5 min	0.483	0.024

AOX: aortic cross-clamp; CPB: cardiopulmonary bypass

Sensitivity of AOX cut-off time was 0.448 and CPB cut-off time was 0.483. Based on the cut-off pointobtained, AOX safety time was defined if the AOX duration <96.5 min, AOX risk time if the AOX duration 96.5 min, CPB safety time if the CPB duration < 126.5 min, and CPB risk time if the CPB duration ≥ 126.5 min. The data distribution is showed in TABLE 3 indicated that 15 patients had AOX risk time and CPB risk time simultaneously.

TABLE 3. Distribution of safety and risk margin AOX time and CPB time

Independent variable		Total	%
AOX time	Risk time (≥96.5 min)	15	21%
	Safety time (< 96.5 min)	55	79%
CPB time	Risk time (≥126.5 min)	15	21%
	Safety time (<126.5 min)	55	79%

AOX: aortic cross-clamp; CPB: cardiopulmonary bypass

Bivariate analysis using Shi-squared test to determine the relationship between the independent variable and the dependent variable are presented in TABLE 4 and 5.

TABLE 4. Association of independent variables and prolonged ICU occupancy

Independent variable		Prolonged ICU occupancy		p	RR	95% CI
		Yes (Sum)	No (Sum)			
Age	≥40 years old	11	22	0.022	3.08	1.09-8.76
	<40 years old	4	33			
Gender	Male	6	18	0.599		
	Female	9	37			
Ejection fraction	<55%	6	2	0.001*	5.17	2.50-10.66
	≥55%	9	53			
Heart failure	NYHA class III	9	5	0.001*	6.00	2.56-14.05
	NYHA class II	6	50			
Pulmonary hypertension	Severe	11	14	0.412		
	Moderate	2	13	0.272		
	Mild	1	8	0.105		
Active endocarditis	Yes	15	34	0.003*		
	No	0	21			
Renal insufficiency	Yes	10	0	0.001*	12.00	5.19-27.77
	No	5	55			
Chronic lung disease	Yes	6	1	0.001*	6.00	3.05-11.79
	No	9	54			
AOX time	Risk time	11	4	0.001*	10.1	3.74-27.18
	Safety time	4	51			
CPB time	Risk time	11	4	0.001*	10.1	3.74-27.18
	Safety time	4	51			

*=significant (p<0.05); AOX: aortic cross-clamp; CPB: cardiopulmonary bypass; ICU occupancy: length of stay in intensive care unit; CI: confidence interval; RR: relative risk; NYHA: New York Hearth Association

The data are shown with p-value, RR (relative risk), and 95% CI (confidence interval). The data showed that higher age, lower ejection fraction, higher grade of NYHA functional classification, active endocarditis, renal insufficiency, chronic lung disease, AOX risk time, and CPB risk time had a significant association with prolongation of the ICU occupancy time after MVR surgery (p<0.05).

TABLE 5. Association between independent variable and prolonged ventilator usage time

Independent variable		Prolonged ventilator usage time		p	RR	95% CI
		Yes (Sum)	No (Sum)			
Age	≥40 years old	13	20	0.621		
	<40 years old	12	25			
Gender	Male	8	16	0.764		
	Female	17	29			
Ejection fraction	<55%	6	2	0.021*	2.45	1.42-4.23
	≥55%	19	43			
Heart failure	NYHA class III	11	3	0.001*	3.14	1.85-5.34
	NYHA class II	14	42			
Pulmonary hypertension	Severe	16	9	0.001*		
	Moderate	5	10	0.103	6.72	1.74-25.9
	Mild	2	7	0.563		
Active endocarditis	Yes	23	26	0.003*	4.93	1.28-19.0
	No	2	19			
Renal insufficiency	Yes	9	1	0.001*	3.38	2.11-5.39
	No	16	44			
Chronic lung disease	Yes	6	1	0.007*	2.84	1.76-4.60
	No	19	44			
AOX time	Risk time	12	3	0.001*	3.38	1.98-5.80
	Safety time	13	42			
CPB time	Risk time	13	2	0.001*	3.97	2.32-6.80
	Safety time	12	43			

*=significant(p<0.05); AOX: aortic cross-clamp; CPB: cardiopulmonary bypass; CI: confidence interval; RR: relative risk; NYHA: New York Hearth Association

The data were shown with p-value, RR (relative risk), and 95% CI (Confident interval). The data showed that lower ejection fraction, higher grade of NYHA functional classification, pulmonary hypertension, active endocarditis, renal insufficiency, chronic pulmonary disease, AOX risk time and CPB risk time had a significant association with the prolongation of ventilator usage time after MVR surgery (p<0.05).

Multivariate analysis was conducted to evaluate the effect of the independent variables to the dependent variable simultaneously. The results are presented in TABLE 6 and 7.

TABLE6. Multivariate analysis prolonged ventilator usage time as the dependent variable

Independent variable	p	OR	95% C.I.	
			Lower	Upper
Active endocarditis	0.027*	7.53	1.257	45.213
Renal insufficiency	0.022*	14.9	1.487	150.970
CPB risk time	0.001*	10.3	2.581	41.252

*=significant (p<0.05); OR: odd ratio; CI: confidence interval; CPB: cardiopulmonary bypass

For the prolonged ventilator usage time as the dependent variable, the table showed that active endocarditis had OR of 7.53 (95%CI=1.257-45.213), renal insufficiency had OR of 14.9 (95%CI=1.487-150.970) and CPB risk time had OR of 10.3 (95%CI=2.581-41.252).

TABLE 8. Multivariate analysis prolonged ICU occupancy time as the dependent variable

Independent variable	p	OR	95% CI	
			Lower	Upper
Age	0.046*	5.3	1.819	35.53
Heart failure	0.019*	9.8	1.450	67.23
CPB risk time	0.034*	14.7	1.859	58.18

*=significant (p<0.05); OR: odd ratio; CI: confidence interval; CPB: cardiopulmonary bypass

For the prolonged ICU occupancy time as the dependent variable (TABLE 8), the result showed that heart failure with NYHA functional classification III had OR of 9 (95%CI=1.45-76.23), CPB risk time 126.5 min had OR of 9 (95%CI=1.859-58.18) and age 40 years old had OR of 5 (95%CI=1.819-35.23).

DISCUSSION

It is well known that preoperative prognostic factors of MVR surgery can be calculated using Euroscore II.[11] However, Euroscore II was developed based on the Caucasian population which have differences demographic and socioeconomic factors compared to Mongoloid population, particularly Indonesian. This study focused on identify the preoperative and intraoperative prognostic factors in an Indonesian population.

Previous study showed that prevalence of the prolonged ventilator usage time was 3-9.9% while prolongation in ICU occupancy was 30.8% in patients with valve surgery.[4,10] Although prolongation in ventilator usage has low prevalence rate, it is associated with considerable morbidity and mortality including longer ICU occupancy and hospital length of stay.[4] In this study, the prevalence of prolonged ventilator usage time is 35.7% while ICU occupancy is 21.4%.

This study found that that heart failure with grade of NYHA functional classification 3, lower ejection fraction, renal insufficiency, chronic pulmonary disease and active endocarditis are all preoperative risk factor associated with prolongation of ventilator usage and ICU occupancy based on our analysis.

This study confirmed the previous findings that cardiac surgery patients with heart failure, clinical NYHA Class III and IV have three years of survival rate inferior to patients with clinical NYHA I and II.[12] However, this study is unable to find patients with NYHA I or NYHA IV because in NYHA I usually patients are asymptomatic, so they do not go to the doctor, and we did not operate on patients with NYHA IV since the majority of those patients do not have the necessary physical conditions to tolerate surgery and general anesthesia. The complete answer to this prognostic problem can be obtained by conducting a longitudinal prospective cohort study which includes patients with NYHA Functional Class I and IV.

Ejection fraction is one of the indicators of impaired left ventricular contraction. In post MVR surgery, patients with lower ejection fraction, in addition to having the stressors related to surgery, often experience increased morbidities post-MVR surgery such as stroke, SIRS, post-operation arrhythmia, pleural effusion, and renal failure that will need longer oxygenation and vasoactive support and result in prolonged ICU occupancy.[6] These results confirm previous findings that patients

with low pre-operative left ventricular ejection fraction undergoing cardiac surgery are at higher risk of post-operative complications.[13]

Renal insufficiency and chronic lung disease are preoperative comorbidities that show a significant association with prolongation of ventilator usage and ICU occupancy in post MVR surgery patients. Cardiac, pulmonary, metabolic, and hematological complications increase the risks of having worse outcomes in any cardiac surgery.[14] Having these comorbidities will cause reperfusion injury and tissue ischemia by decreasing perfusion pressure and altering sympathetic tone that will result in prolongation of ventilator usage and ICU occupancy time after MVR surgery.

Active endocarditis is an infection that includes a cardiac valve, septum, and ventricular wall. A surgical procedure that involves any inflamed tissue with or without evacuation of vegetation is a technically complicated procedure that results in prolongation of AOX and CPB time. Patients with endocarditis are prone to systemic complications that need a longer oxygenation and vasoactive support and often result in prolonged ICU occupancy. This result confirms previous findings that presence of positive blood culture and typical microorganism carries worse prognosis in terms of both short- and long-term survival associated with surgical treatment. Among the latter, the most frequent were *Staphylococcus epidermidis* and *Streptococcus viridians*.[15]

This study found that age is significantly associated only to prolongation in ICU occupancy in patient after MVR surgery. This finding is consistent with previous study conducted by Azarfarin *et al.*[10] which also found that age has a significant association in prolonged ICU Occupancy. Advanced age is associated with increased incidence of morbidities that affect prognosis.[16] Degenerative processes in aging such as loss of vascular elasticity, decreases in heart rate, an increased left ventricle afterload, and impaired fibrinolytic activity cause systemic complications, and multi-organ failure resulting in prolonged intensive monitoring and ICU occupancy.[2] However our study found also that age of 40 years old do not have a significant association with prolongation of ventilator usage. Our results are in consistent with those of previous study conducted by Branca *et al.*[17]which also found that age has no association with delayed extubation. Another study conducted by Supomo[18] showed that age >50 years old are associated with prolonged ventilator use. One explanation behind this contradictory result is the difference of cut-off point used to classify the age.

Pulmonary hypertension was found to be associated only to prolongation in ventilator usage time in patient after MVR surgery. This result is consistent with previous study conducted by Borde *et al.*[19] that found that pulmonary hypertension is significantly associated with prolongation of ventilator usage time in patient post cardiac surgery.

Both of the intraoperative variables included in this study showed a significant association with prolongation of ventilator usage and ICU occupancy in patients after MVR surgery. Previous study found that the risk margin of CPB time associated with morbidity and mortality after MVR procedure is >166 min which is similar to our risk time (126.5 min).[20]

Increasing AOX duration times are associated with prolonged ventilation, renal compromise, low cardiac output following surgery.[21] A study conducted by Al-Sarraf *et al.*[21] found that AOX duration (XCL) of >90 min and 90 > XCL > 60 min have 4.7 and 3.1 times higher mortality, respectively, compared to XCL duration of <60 min. Our research found that the risk margin increased with AOX of 96.5 min which is similar to the previous study.

Further analysis of the independent

variables showed that there is a significant association in bivariate analysis with multivariate logistic regression analysis. It was found that heart failure with NYHA functional classification 3, CPB risk time, and older age are the most significant variables that correlate with prolongation of ICU occupancy. This finding confirms a previous study's findings that age, heart failure, and CPB duration induced stroke, post-operation anemia and prolongation of inotropic-vasoactive agent usage resulted in prolongation of ICU occupancy time >96 h post-operation.[10] Meanwhile renal insufficiency, CPB risk time, and active endocarditis are the most significant variables that correlate with prolongation of ventilator usage time. Our study confirms previous study finding that CPB, renal insufficiency and active endocarditis correlate with prolonged ventilator usage time in post MVR surgery patients.[4,22]

This study demonstrated the importance of identifying preoperative and intraoperative factors contributing to post-operative morbidity in patient after MVR procedure. Despite the limitations such as small sample and inability to find heart failure patients with NYHA Functional Class I and IV, our study provides supportive evidence of the prognostic value of preoperative and intraoperative factors in prolongation of ventilator usage and ICU occupancy after MVR surgery.

CONCLUSION

In conclusion, the prognostic factors for the prolonged ICU occupancy time after mitral valve replacement procedure in Dr. Sardjito General Hospital, Yogyakarta are age 40 years old, heart failure with NYHA functional classification 3 and CPB risk time 126.5 min. On the other hand, it is also found that the prognostic factors for the prolonged ventilator usage time after mitral valve replacement surgery in Dr. Sardjito General Hospital, Yogyakarta are renal insufficiency, CPB risk time 126.5 min, and active endocarditis.

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