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Research Article

Predictors of Prolonged Intensive Care Unit Stay in Patients with Rheumatic Heart Disease Undergoing Heart Valve Surgery

Soraya Arzhan[1]*, Abbasali Karimi[2], Mahmoud Shirzad[2], Mohammadreza Rezaei[2] and Seyed-Hossein Ahmadi-Tafti[2]

[1]Nephrology Division, Department of Internal Medicine, University of New Mexico Hospital, Albuquerque, New Mexico, United States

[2]Tehran Heart Center, Tehran University of Medical sciences, Tehran, Iran

***Corresponding Author:** Soraya Arzhan, Nephrology Division, Department of Internal Medicine, University of New Mexico Hospital, Albuquerque, New Mexico, United States.

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Abstract

Background: Determining main predictors of prolonged intensive care unit (ICU) stay in patients undergoing heart valve surgeries is used to target high risk group to improve resource utilization and efficiency of ICU care and outcome. The present study aimed to assess clinical status of patients with rheumatologic valvular heart diseases who were candidate for valvular surgeries and also to determine main correlates of prolonged ICU stay in these patients.

Methods: The records of 688 patients with rheumatic heart diseases that underwent different types of heart valve surgeries at the Tehran Heart Center were retrospectively reviewed. The patients were assigned to two groups that experienced prolonged ICU stay (defined as the length of ICU stay longer than 6 days) or with ICU hospitalizations less than 6 days.

Results: The rate of prolonged ICU stay was found to be 10%. With respect to main determinants of prolonged ICU stay and using the stepwise logistic regression modeling, advanced age (OR = 1.237, p = 0.001), the presence of severe pulmonary insufficiency (OR = 3.168, p = 0.022), aortic stenosis (OR = 1.977, p = 0.021), history of brain stroke (OR = 2.410, p = 0.015), and tricuspid replacement procedure (OR = 8.047, p < 0.001) were main correlates of prolonged ICU stay. Moreover, atrial fibrillation correction could effectively shorten ICU stay (OR = 0.264, p = 0.012).

Conclusion: About 10% of patients undergo heart valve surgeries experience prolonged ICU stay that can be well predicted by some factors including advanced age, severe pulmonary insufficiency, aortic stenosis, brain stroke, and tricuspid replacement surgery. Atrial fibrillation correction may shorten ICU stay in these patients.

Keywords: *Rheumatologic Valvular Heart Disease; Valvular Surgery; Intensive Care Unit; Prediction*

Abbreviations

ICU: Intensive Care Unit; CAD: Coronary Artery Disease; OR: Odds Ratio; SD: Standard Deviation

Introduction

Rheumatologic valvular heart defects pose many challenges with regard to achieving proper surgical complications [1]. Particularly, maintaining hemodynamic stability, controlling baseline risk factors, and minimizing postoperative clinical adverse events are the fundamental aims of improving surgical outcomes in these patients [2]. Within the last decade, the remarkable improvement has brought

regarding clinical management of patients with valvular heart diseases and candidate for valvular replacing or repairing surgeries considerably that result in reducing surgical complications as well as shortening hospitalization [3]. In fact, more desired surgical outcome has been achieved through advances in valve reconstruction techniques, correct execution of new developed guidelines, and choosing optimal conditions for surgery leading improvement of surgical outcome [4].

Valvular heart surgeries especially when performed concomitantly can place a hemodynamic instability burden increases the need for long-term hospitalization at intensive care unit (ICU). Although this prolonged ICU stay is essential for the affected patients leading consistent symptomatic relief, hemodynamic improvement, and appropriate long-term survival [5], but ICU prolongation may also cause some serious complications such as catheter-related blood stream infections, ventilator-associated pneumonia, and venous thromboembolism [6-8]. In some studies, it has been even shown that mortality may increase with prolonged ICU stay. The prolonged ICU stay may be even accompanied with long-term adverse consequences such as poor quality of live [9]. In a study by Timmers and colleagues, more than half of patients who underwent valvular heart surgeries reported ongoing problems with mobility, performance of usual activities, and pain and discomfort. Also, among ICU survivors, cognitive disorders, anxiety and depression may appear long time after these surgeries [10]. Thus, identifying main correlates of prolonged ICU stay in these patients may help to prevent early and late surgery related adverse events in patients undergoing heart valve surgeries. In fact, the determining main predictors of prolonged ICU stay can be used in targeting high risk group to improve resource utilization and efficiency of ICU care. The present study aimed to assess clinical status of patients with rheumatologic valvular heart diseases who were candidate for valvular surgeries and also to determine main correlates of prolonged ICU stay in these patients.

Methods

The records of 688 patients with the average age 54 years old with rheumatic heart disease that underwent different types of heart valve surgeries at the Tehran Heart Center as the great referral heart center in Tehran were retrospectively reviewed. Rheumatic heart disease was defined as valvular lesions consistent with rheumatic heart disease on ICD10-AM code 'I05'-'I09'.The baseline characteristics of study population were collected from our center surgery database including preoperative, operative, as well as early postoperative data of the patients undergoing different ischemic, rheumatologic, and congenital cardiovascular defects. Also, the status of valvular heart diseases was determined by preoperative two-dimensional echocardiography. With regard to valvular surgeries, 231 patients underwent aortic valve replacement, 11 underwent aortic valve repair, 650 underwent mitral valve replacement, 10 underwent mitral valve repair, 83 underwent tricuspid valve replacement, 311 underwent tricuspid valve repair, and 3 underwent pulmonary valve replacement. The following data were included for analysis: The preoperative variables: 1) general characteristics: age, gender, and body mass index; 2) preoperative risk factors: current smoking history (patients regularly smokes a tobacco product/products one or more times per day or has smoked in the 30 days prior to admission), hypercholesterolemia (total cholesterol ≥ 5.0 mmol/l, HDL-cholesterol ≤ 1.0 mmol/l in men, or ≤ 1.1 mmol/l in women, triglycerides ≥ 2.0 mmol/l), family history of coronary artery disease (CAD) which means first degree relatives before the age of 55 in men and 65 years in women, hypertension (systolic blood pressure≥140 mmHg and/or diastolic ≥ 90 mmHg and/or on anti-hypertensive treatment), diabetes mellitus (symptoms of diabetes plus plasma glucose concentration ≥ 11.1 mmol/l or fasting plasma glucose ≥ 7.0mmol/l or 2-hp ≥ 11.1 mmol/l); 3) preoperative cardiac status: previous myocardial infarction (an acute event with abnormal creatine phosphokinase and troponin levels), congestive heart failure (CHF), and arrhythmia, 4) and preoperative left ventricular ejection fraction. The patients were assigned to two groups that experienced prolonged ICU stay (defined as the length of ICU stay longer than 6 days) or with ICU hospitalizations less than 6 days.

Results were presented as mean ± standard deviation (SD) for quantitative variables and were summarized by frequency (percentage) for categorical variables. Continuous variables were compared using t test Non-parametric Mann-Whitney test whenever the data did not appear to have normal distribution or when the assumption of equal variances was violated across the study groups. Categorical variables were, on the other hand, compared using chi-square test. The stepwise multivariate logistic regression analysis was used to determine

main predictors of prolonged ICU stay. For the statistical analysis, the statistical software SPSS version 20.0 for windows (SPSS Inc., Chicago, IL) was used. P values of 0.05 or less were considered statistically significant.

Results

Overall, 69 of 688 patients experienced prolonged ICU stay with the rate of 10.0%. The baseline characteristics of study participants are summarized in table 1. Comparing the group with length of ICU stay shorter than 6 days and those with longer ICU stay showed similarity between the two groups in terms of sex distribution (male gender, 30.9% versus 21.7%, p = 0.117), average age (52.07 years versus 56.07), mean body mass index (26.23 kg/m^2 versus 25.56 kg/m^2, p = 0.981), and most cardiovascular risk profile including current smoking (5.8% versus 2.9%, p = 0.314), opium addiction (3.1% versus 2.9%, p = 0.938), diabetes mellitus (13.4% versus 20.3%, p = 0.119), dyslipidemia (24.2% versus 30.4%, p = 0.258), hypertension (17.9% versus 24.6%, p = 0.175), and family history of coronary artery disease (30.7% versus 37.7%, p = 0.236). In this regard, the most frequent risk factor in both groups includes family history of coronary disease followed by dyslipidemia. However, history of cerebrovascular event was significantly less revealed in the group with ICU stay shorter than 6 days (105% versus 21.7%, p = 0.006). The two groups were also comparable in previous ischemic cardiovascular events including myocardial infarction, congestive heart failure, angina, and cardiac arrhythmias. Although mean left ventricular ejection fraction was not different between the two groups, left ventricular hypertrophy based on echocardiography assessment was more found in those with longer ICU stay compared with another group (30.4% versus 17.8%, p = 0.035). The two study groups were also similar in preoperative oral medications such as anti-platelets, anti-coagulants, aspirin, steroids, inotropes, digoxin, amiodarone, beta-blockers, and diuretics. Preoperative echocardiography assessment of heart valves status in the two groups with ICU stay longer than 6 days and the group with shorter ICU stay (Table 2), showed more severe tricuspid stenosis, aorta stenosis, as well as tricuspid insufficiency and pulmonary valve regurgitation. Regarding different surgical procedures performed intraoperatively (Table 3), except for tricuspid replacement and pacemaker implantation that were more scheduled for those with longer ICU stay, other procedures including other cardiac and non-cardiac procedures were similarly conducted in the two groups. In this regard, AF correction was more planned for those with shorter ICU stay. With respect to main determinants of prolonged ICU stay and using the stepwise logistic regression modeling (Table 4), advanced age (OR = 1.237, p = 0.001), the presence of pulmonary insufficiency (OR = 3.168, p = 0.022), aortic stenosis (OR = 1.977, p = 0.021), history of brain stroke (OR = 2.410, p = 0.015), and tricuspid replacement procedure (OR = 8.047, p < 0.001) were main correlates of prolonged ICU stay. Moreover, AF correction could effectively shorten ICU stay (OR = 0.264, p = 0.012).

Characteristics '*	ICU stay < 6 days	ICU stay ≥ 6 days	p-value
Male gender	19 (30.9)	15 (21.7)	0.117
Age, year	52.07±10.97	56.07±12.52	0.442
Body mass index, kg/m^2	26.23±4.80	25.56±4.93	0.981
Current smoking	36 (5.8)	2 (2.9)	0.314
Opium use	19 (3.1)	2 (2.9)	0.938
Diabetes mellitus	83 (13.4)	14 (20.3)	0.119
Dyslipidemia	150 (24.2)	21 (30.4)	0.258
Hypertension	111 (17.9)	17 (24.6)	0.175
Family history of CAD	190 (30.7)	26 (37.7)	0.236
Cerebrovasular disease	65 (10.5)	15 (21.7)	0.006
Peripheral vascular disease	6 (1.0)	1 (1.4)	0.706
Chronic obstructive pulmonary disease	31 (5.0)	1 (1.4)	0.183
History of valvular surgery	49 (7.9)	3 (4.3)	0.288
History of balloon arterectomy	33 (5.3)	3 (4.3)	0.728

History of coronary stenting	5 (0.8)	0 (0.0)	0.454
Non-surgical valoplasty	66 (10.7)	8 (11.6)	0.813
History of myocardial infarction	11 (1.8)	0 (0.0)	0.264
History of heart failure	155 (25.0)	15 (21.7)	0.546
History of angina	140 (22.6)	13 (18.8)	0.474
History of arrhythmia	77 (12.4)	6 (8.7)	0.365
Left bundle branch block	11 (1.8)	0 (0.0)	0.264
Right bundle branch block	18 (2.9)	3 (4.3)	0.510
Left ventricular hypertrophy	110 (17.8)	21 (30.4)	0.035
Left ventricular ejection fraction, %	50.43±6.05	50.00±6.69	0.554
Serum creatinine, mg/dl	0.88±0.38	0.92±0.27	0.276
Medications			
Anti-platelets	5 (0.8)	0 (0.0)	0.454
Anti-coagulants	287 (46.4)	31 (44.9)	0.820
Aspirin	143 (23.1)	21 (30.4)	0.175
Steroids	47 (7.6)	5 (7.2)	0.918
Inotropes	7 (1.1)	1 (1.4)	0.815
Digoxin	324 (52.3)	38 (55.1)	0.667
Amiodarone	13 (2.1)	1 (1.4)	0.716
Beta-blockers	430 (69.5)	5 (73.9)	0.445
Diuretics	419 (67.7)	50 (72.5)	0.419

Table 1: *Baseline Characteristics of Patients in the two Groups with Prolonged and Normal ICU Stay. *Continuous variables: Mean ± Standard Deviation. Categorical variables: Number (%).*

	None	**Trivial**	**Mild**	**Moderate**	**Severe**
Mitral stenosis					
ICU stay < 6 days	1 (0.2)	0 (0.0)	1 (0.2)	155 (25.0)	462 (74.6)
ICU stay ≥ 6 days	0 (0.0)	0 (0.0)	0 (0.0)	10 (14.5)	59 (85.5)
P-value	0.234				
Tricuspid stenosis					
ICU stay < 6 days	593 (95.8)	1 (0.2)	6 (1.0)	10 (1.6)	9 (1.5)
ICU stay ≥ 6 days	54 (78.3)	0 (0.0)	4 (5.8)	7 (10.1)	4 (5.8)
P-value < 0.001					
Aorta stenosis					
ICU stay < 6 days	425 (68.7)	1 (0.2)	56 (9.0)	68 (11.0)	69 (11.1)
ICU stay ≥ 6 days	36 (52.2)	0 (0.0)	6 (8.7)	13 (18.8)	14 (20.3)
P-value 0.031					
Aorta stenosis					
ICU stay < 6 days	616 (99.5)	1 (0.2)	2 (0.3)	0 (0.0)	0 (0.0)

ICU stay ≥ 6 days	68 (98.6)	0 (0.0)	0 (0.0)	0 (0.0)	1 (1.4)
P-value 0.199					
Mitral insufficiency					
ICU stay < 6 days	29 (4.7)	23 (3.7)	200 (32.3)	172 (27.8)	195 (31.5)
ICU stay ≥ 6 days	3 (4.3)	1 (1.4)	28 (40.6)	20 (29.0)	17 (24.6)
P-value 0.531					
Aorta insufficiency					
ICU stay < 6 days	126 (20.4)	51 (8.2)	184 (29.7)	164 (26.5)	94 (15.2)
ICU stay ≥ 6 days	8 (11.6)	4 (5.8)	26 (37.7)	22 (31.9)	9 (13.0)
P-value 0.282					
tricuspid insufficiency					
ICU stay < 6 days	34 (5.5)	27 (4.4)	169 (27.3)	192 (31.0)	197 (31.8)
ICU stay ≥ 6 days	6 (8.7)	2 (2.9)	11 (15.9)	16 (23.2)	34 (49.3)
P-value 0.023					
Pulmonary insufficiency					
ICU stay < 6 days	394 (63.7)	34 (5.5)	173 (27.9)	14 (2.3)	4 (0.6)
ICU stay ≥ 6 days	37 (53.6)	3 (4.3)	20 (29.0)	7 (10.1)	2 (2.9)
P-value 0.004					

Table 2: *Heart Valves Status Based on Preoperative Echocardiography Assessment. Values are Number (%).*

Characteristics	ICU stay < 6 days *	ICU stay ≥ 6 days*	p-value
Repair of ventricular septal defect	1 (0.2)	0 (0.0)	0.738
Repair of atrial septal defect	35 (5.7)	5 (7.2)	0.592
Aorta surgery			0.233
Replacement	202 (32.6)	29 (42.0)	
Repair	11 (1.8)	0 (0.0)	
Mitral surgery			0.179
Replacement	582 (94.0)	68 (98.6)	
Repair	9 (1.5)	1 (1.4)	
Tricuspid surgery			< 0.001
Replacement	56 (9.0)	27 (39.1)	
Repair	289 (46.7)	22 (31.9)	
Pulmonary surgery			0.999
Replacement	3 (0.5)	0 (0.0)	
Repair	0 (0.0)	0 (0.0)	
Pace maker implantation	24 (3.9)	9 (13.0)	0.001
AF correction	105 (17.0)	5 (7.2)	0.037
Other cardiac procedures	212 (34.2)	19 (27.5)	0.263
Other non-cardiac procedures	14 (2.3)	0 (0.0)	0.207

Table 3: *Surgical Procedures Performed in the two Study Groups. *Number (%).*

Item*	P-value	Odds Ratio	95% Confidence Interval
Advanced age	0.001	1.237	1.091 – 1.404
Pulmonary insufficiency	0.022	3.168	1.181 – 8.501
Aortic stenosis	0.021	1.977	1.110 – 3.522
AF correction	0.012	0.264	0.094 – 0.743
History of CVA	0.015	2.410	1.186 – 4.897
Tricuspid replacement	< 0.001	8.047	1.964 – 16.337

Table 4: *Main Determinants of Prolonged ICU Stay.*

**P-value ≤ 0.05.*

Discussion

Several factors and wide range of clinical conditions have been tested to be predictors for prolonged hospital and ICU stays in open heart surgeries, however a few studies focused the main determinants of the increased risk for prolonged ICU stay in patients who undergoing heart valve surgeries due to the presence of considerable rheumatologic heart valve disease. More interestingly, not only the identified factors can be own associated with increased risk for prolonged ICU stay and its related complications, but also the pointed factors may strengthen or weaken other simultaneous effective factors. In our study, the main determinants of prolonged ICU stay in the affected patients were pointed to be advanced age, the presence of pulmonary insufficiency, the presence of aortic stenosis, history of brain stroke, and tricuspid replacement procedure. Due to the different cutoff point for defining prolonged stay, single or multiple valvular surgeries, and even the existence of physical, social, and psychological conditions of included patients, various correlates have been introduced as the determinants of prolonged ICU in such patients. in a study by Wang., *et al* [11], preoperative independent predictors of prolonged ICU stay included high age, chronic obstructive pulmonary disease, atrial fibrillation, left bundle branch block, low ejection fraction, left ventricle weight, low functional capacity, critical preoperative state, perivalvular leakage, tricuspid valve replacement, concurrent CABG, and concurrent other cardiac surgeries. In a multivariate regression modeling by Cacciatore., *et al* [12], female sex, a NYHA class ≥3, CIRS and PASE score were predictors of ICU stay ≥3 days independently of age, off-pump CABG, stroke and renal failure. In another study by Xu., *et al* [13], age older than 65 years, low left ventricular ejection fraction, cardiothoracic ratio higher than 0.68, previous cardiac surgery, maximal voluntary ventilation observed/predicted < 71% and repeat cardiopulmonary bypass during surgery were risk factors for prolonged ICU stay. Regarding central role of advanced age in prolonging ICU stay, it can be due to age-related accompanying disorders leading lower ability of this age subgroup to stand the surgical stress. In this context, it seems that poorer postoperative outcome and prolonged stay in hospital in the elderly can be due to their high susceptibility to ischemic events, arrhythmias, organ failure, and also to various nosocomial infections occurred within ICU hospitalization such as during mechanical ventilation. We also showed that the presence of aortic and pulmonary valve disorders might predispose the patients to prolonged ICU stay that can be referred to poor outcome and common complications of these valvular procedures. As shown by Saxena., *et al* [14], those patients who underwent aortic valve replacement experienced new renal failure, prolonged ventilation, and gastrointestinal complications led to a longer mean length of ICU stay. In addition, it has been well demonstrated that the aortic stenosis or pulmonary regurgitation are more occurred in older individuals and thus the co-effect of advanced age should be also considered.

We also indicated the role of AF correction as a preventive factor for prolonged ICU stay. AF is the most postoperative arrhythmia in ICU patients associated with increased mortality and morbidity [15-20]. It has been also shown higher incidence rate of AT following heart valve surgeries reaching 30 to 40% [21,22]. This arrhythmia can be also associated with other postoperative events such as cardioembolic events and heart failure [23] deteriorating postoperative outcome and explaining the need for prolonged hospital and ICU stay.

We also showed tricuspid valve replacement as a main correlate for prolonged ICU stay. Although all types of valvular surgeries may lead to poor postoperative outcome, but tricuspid valve replacement is significantly associated with higher early and late mortality and complications [24]. As shown by Park., *et al* [25], patients undergoing tricuspid valve replacement had a more advanced preoperative tricuspid regurgitation grade and significantly prolonged hospital stays.

In total, a primary purpose in caring patients undergoing heart valve surgeries is to reduce ICU stay because of ICU-related serious complications. This approach not only can prevent mortality and morbidity in affected patients, but also can improve the quality of medical care and reduce cost and excess use of resources. Our study could introduce some preoperative and intraoperative factors affecting prolonged ICU stay in these patients; however it should be noted that other institutional, medical, social, and psychological factors may be also effective on this outcome. Thus, further studies should conduct to address the impact of each of these categories to shorten ICU stay.

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