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Clinical Research

A Simple Scoring System for Predicting In–Hospital Mortality after Heart Valve Surgery in A Developing Country

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Abstract

Background: Various scoring systems predict mortality after cardiac surgery, but not many were designed for specific valvular surgery. Developing countries have different characteristics of patients and conditions in cardiac centers compared to developed countries. We aimed to develop a simple scoring system for predicting in-hospital mortality after valve surgery and further validate the scoring system.

Methods: For developing the scoring system, the data was taken from the medical record of patients who underwent valve surgery in 2012 - 2014, and for the validation study, it was from 2015 to 2016. The scoring system was developed using logistic regression models, then validated using calibration and discrimination analysis.

Results: For developing a scoring system, we recruited 1040 patients in the study. The in-hospital mortality rate was 68 (6.5%). Eight variables were incorporated, including; functional class, hypertension, previous open-heart surgery, impaired renal function, right ventricular dysfunction, emergent operation, coronary artery bypass surgery, and tricuspid valve surgery. The mortality risk score has Hosmer Lemeshow (H-L) test p-value = 0.212; AUC = 0.813 (CI 95% = 0.758–0.867); and cut-off point of 5, predicting 14% risk of death (sensitivity 72.1%, specificity 75.3%). In the validation study, 789 subjects were recruited. The observed and predicted mortality were 8.6% and 11.9% respectively, with H-L test p-value = 0.169 and AUC 0.761 (95% CI; 0.702-0.821).

Conclusion: We have developed a simple scoring system for predicting in-hospital mortality after valve surgery. The mortality risk score was well-calibrated with a moderate discrimination value in the validation study.

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Keywords: Heart valves, multiple; Cardiac, Statistics, risk analysis/modeling; Cardiac, Surgery, complications; Cardiac, Mitral valve replacement; Cardiac, Mitral valve repair; Cardiac, Aortic valve, replacement.

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Introduction

Valvular heart disease (VHD) is a global health problem with a major impact, and valve surgery remains the definitive treatment of the disease.[1] Open heart surgery is a relatively high-risk procedure with an increasing number every year. Crude operative mortality alone is deemed inadequate to determine surgical risk or quality of healthcare providers.[2] Advanced rheumatic valvular heart disease is still a major problem in developing countries. It is not unusual that patients come late to have surgery due to many socio-economic problems. Those conditions could carry additional surgical risks.[1,3.]

The risk of a particular procedure is influenced by the type of procedure and disease and other factors such as patient demographic characteristics, heart disease severity, and other comorbidities.[4] The most commonly used predicting risk scores are the European system for general cardiac operative risk evaluation (EuroSCORE) II,[5] and Society of Thoracic Surgeon (STS) risk score.[6,7] Nevertheless, the external validity is not always good when applied in valvular surgery in different conditions.[8,9]

We aim to develop a simple scoring system to predict in-hospital mortality after heart valve surgery in developing countries where patients come in the later stages of the disease's natural course.

Methods

We performed a two stages study. The first stage study aimed to develop a new simple scoring system, and the latter study aimed to validate the new score.

Subject

We included all adult patients who underwent heart valve surgery from 2012 to 2014 for the scoring study and from 2015-2016 for the validation study. All data were collected from the medical record and hospital information system. Institutional review board approval was issued prior to enrolment. Patients with a congenital heart defect (CHD) and operation of the aorta were excluded.

Study Variables

The proposed prognostic variables were grouped into five categories: (1) demographic characteristic: sex, age, body mass index (BMI), (2) clinical parameters: New York Heart Association functional class (NYHA fc), diabetes mellitus (DM), hypertension, history of stroke, atrial fibrillation/flutter (AF), active infective endocarditis (IE), previous open-heart surgery, and pre-operative condition, (3) laboratory parameters: moderate-severe kidney disease, and anemia, (4) echocardiographic parameter: left ventricular ejection fraction (LVEF), right ventricular (RV) function using tricuspid annular plane systolic excursion (TAPSE), and pulmonary hypertension (PH), and (5) procedural aspect: operation timing, number of a valve operated, concomitant CABG, and simultaneous tricuspid valve repair (TVr). The outcome of this study was in-hospital all-cause mortality.

The laboratory and echo data taken were the latest data available as pre-operative baseline data. The time was not uniform, but it was done routinely within one week for laboratory data and within three months for echocardiography data.

Statistical Analysis

We categorized all variables and tested with Chi-square or Fisher's exact test as appropriate. Variables with $p < 0.25$ were included in the multivariate analysis. All eligible variables were then analyzed with logistic regression analysis. The backward stepwise method was used to eliminate variables with the highest p-value until all variables within the model have $P < 0.05$. Models were then calibrated using AUC analysis using the Hosmer Lemeshow test and discrimination value. Calibration was good if H-L test $P \geq 0.05$, and discrimination was good if AUC > 0.8. Final models were then transformed into a scoring system using each variable's coefficient (B) and standard error (SE). Acquired scores were then re-analyzed with logistic regression to develop the logistic equation that calculates each score's probability of the outcome. The scoring systems were then tested again for calibration and discrimination. AUC determined a cut-off point with the best sensitivity and specificity for the scoring system.

The same calibration and discrimination analysis were then used to see how well the risk scores predicted mortality for patients who underwent valve surgery from 2015-2016. Finally, we made an observed and expected in-hospital mortality comparison curve. The statistical analysis was conducted using SPSS (Version 17, SPSSInc, IBM, Armonk, New York).

Result

A total of 1040 subjects were included for the developing study and 789 subjects for the validation study. The subject characteristics from each study are presented in table 1. The median age and gender proportion of both studies were similar. Most of our patients have good LV function, while a significant number of patients have RV dysfunction and pulmonary hypertension.

As presented in table 2, mitral valve diseases were the most valve abnormality, and the rheumatic process was the most common etiology of valvular heart disease in our study. In addition, moderate and severe tricuspid valve regurgitation was present in significant numbers. Our study also found significant cases that underwent double valve surgery.

Table 1. Baseline Characteristics.

Variable	Harkit Score N = 1040	Validation Study N=789
Demographic Characteristic		
Age (Years)	45 (18–76)	45 (18–79)
Age ≥ 65 years	58 (5.6%)	48 (6.1%)
Women	498 (47.9%)	380 (48.2%)
BMI (Kg/m2)	21.43 (12-38)	21.36 (11-48)
BMI < 18.5 Kg/m2	230 (22.1%)	118 (18.1%)
Clinical Parameter		
Diabetes mellitus	129 (12.4%)	111 (14.1%)
Hypertension	272 (26.2%)	170 (21.5%)
Stroke History	68 (6.5%)	44 (5.6%)
Atrial Fibrilation History	412 (39.6%)	352 (44.6%)
Active IE	39 (3.8%)	58 (7.4%)
Previous Surgery	26 (2.5%)	31 (3.9%)
Emergency Surgery	58 (5.6%)	68 (8.6%)
Unstable Preoperative Condition	31 (3.0%)	14 (1.8%)
Functional Class 3-4	416 (40%)	58 (7.4%)
Laboratorium		
Hemoglobin level (gr/dL)	13 (6 – 18)	13 (7 - 17)
Anemia (Hb < 12)	201 (19.3%)	198 (25.2%)
CCT (ml/menit)	74 (10–122)	77 (15-242)
CCT < 50 ml/minute	140 (13.5%)	129 (16.3%)
Echocardiography Parameter		
Left Ventricular Ejection Fraction (%)	61 (19–88)	61 (19-93)
Poor (< 40%)	117 (11.3%)	74 (9.5%)
Moderate (41-60%)	372 (35.8%)	258 (33.2%)
Good (>60%)	551 (53.0%)	444 (57.2%)
TAPSE (cm)	1.9 (0.6–3.8)	1.9 (0.2-3.7)
Right Ventricular Dysfunction (TAPSE< 1.6 cm)	277 (26.6%)	193 (24.5%)
TVG (mmHg)	41 (18 – 158)	43 (8 – 135)
Pulmonar Hypertension	391 (37.6%)	294 (43.5%)
Length of Patient Care	10 (5-62)	8 (1 – 77)

Continuous data are presented by median (min-max); categorical data are presented by frequency (%). BMI: body mass index; CCT; creatinin clearance test; Hb: Hemoglobin; IE: infective endocarditis; LVEF: left ventricular ejection fraction; PH: pulmonary hypertension; RV: right ventricle; TAPSE: tricuspid annular plane systolic excursion; TVG: tricuspid valve gradient

Table 2. Disease and Surgical Characteristic.

Variable	Harkit Score	Validation Study
Valve Abnormality		
Aortic valve	131 (12.6%)	901(11.5%)
Mitral valve	719 (69.1%)	556 (70.5%)
Aortic and mitral valve	190 (18.3%)	142 (18.0%)
Type of Valve Abnormality		
Mitral stenosis predominant	320 (30.8%)	221 (28.0%)
Mitral regurgitation predominant	484 (46.5%)	378 (47.9%)
Aortic stenosis predominant	76 (7.3%)	43 (5.4%)
Aortic regurgitation predominant	91(8.8%)	66 (8.4%)
Multivalve disease	69 (6.6%)	81 (10.3%)
Tricuspid Valve Regurgitation		
Mild	359 (34.5%)	271 (34.4%)
Moderate	255 (24.5%)	197 (25.0%)
Severe	190 (18.3%)	150 (19.0%)
Valve Disease Etiology		
Rheumatic Heart Disease	537 (51.7%)	452 (57.6%)
Non-Rheumatic Heart Disease	502 (48.3%)	333 (42.4%)
Heart Valve With CABG Surgery	162 (15.6%)	113 (14.3%)
Tricuspid Valve Repair	420 (40.4%)	350 (44.4%)
Mitral valve surgery	732 (70.4%)	565 (71.6%)
Aortic valve surgery	141 (13.6%)	94 (11.9%)
Mitral and aortic valve surgery	167 (16.0%)	130 (16.5%)

Data are described by frequency (%). CABG: Coronary Artery Bypass Graft

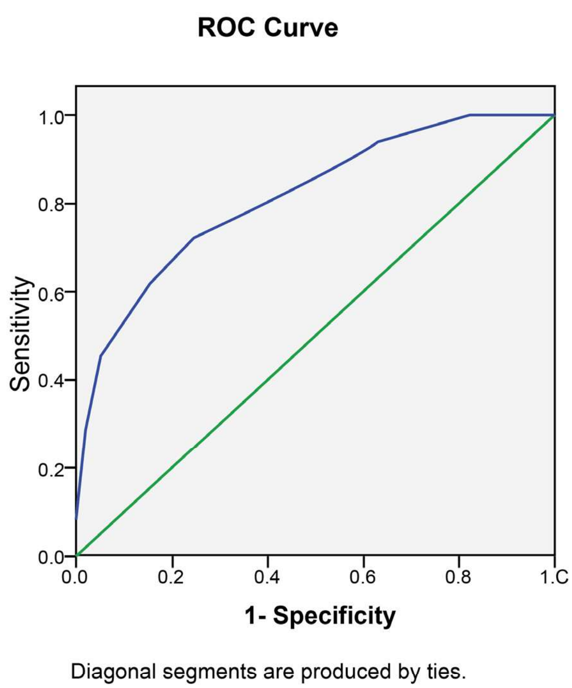

Figure 1. HARKIT Score. Using ROC, the mortality risk score has good discrimination with AUC = 0.813, CI 95% = 0.758 – 0.867)

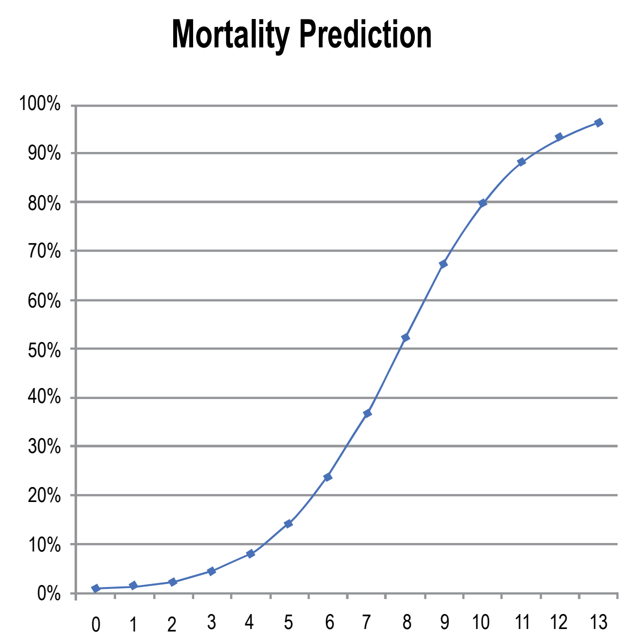

Figure 2. Mortality Prediction Curve. A subject's probability (in percentage) of experiencing mortality based on the total score of the new scoring system.

Table 3. Bivariate Analysis of each Variable to Mortality.

Variable	Death				P	OR	Confidence Interval 95%	
	No		Yes					
	N	%	N	%			Minimum	Maximum
Sex								
Female	471	94.6	27	5.4	0.163	1.428	0.864	2.358
Male	501	92.4	41	7.6				
Age								
< 65 years	924	94.1	58	5.9	0.001	3.319	1.159	6.895
> 65 years	48	82.8	10	17.2				
NYHA Fc								
Class 1 – 2	608	97.4	16	2.6	<0.001	5.429	3.054	9.649
Class 3 – 4	364	87.5	52	12.5				
BMI								
> 18.5 kg/m2	762	94.1	48	5.9	0.133	1.512	0.878	2.604
< 18.5 kg/m2	210	91.3	20	8.7				
Diabetes mellitus								
No	855	93.9	56	6.1	0.175	1.566	0.815	3.008
Yes	117	90.7	12	9.3				
Hypertension								
No	727	94.7	41	5.3	0.009	1.954	1.177	3.244
Yes	245	90.1	27	9.9				
History of stroke								
No	907	93.3	65	6.7	0.463	0.644	0.197	2.105
Yes	65	95.6	3	4.4				
Atrial flutter/fibrillation								
No	591	94.1	37	5.9			0.793	2.131
Yes	381	92.5	31	7.5				
Active IE								
No	938	93.7	63	6.3		P	0.828	5.792
Yes	34	87.2	5	12.8				
Previous open heart surgery								
No	953	93.9	62	6.1			1.871	12.590
Yes	19	76	6	24				
Pre-operative condition								
Stable	951	94.3	58	5.7	<0.001	0.298	3.514	17.348
Unstable	21	67.7	10	32.3				
CCT								
> 50 ml/min	853	94.8	47	5.2	<0.001	0.106	1.850	5.546
< 50 ml/min	119	85	21	15				
Hb level								
> 12 gr/dl	790	94.2	49	5.8	0.063	0.000	0.968	2.928
< 12 gr/dl	182	90.5	19	9.5				

Cont Table 3.

Variable	Death				P	OR	Confidence Interval 95%	
	No		Yes					
	N	%	N	%			Minimum	Maximum
Rheumatic heart disease								
No	467	93.2	34	6.8	0.755	0.925	0.566	1.512
Yes	505	93.7	34	6.3				
LVEF								
> 40%	867	93.9	56	6.1	0.084	1.769	0.919	3.408
< 40%	105	89.7	12	10.3				
TAPSE								
> 1.6 cm	731	95.8	32	4.2	<0.001	3.412	2.074	5.614
< 1.6 cm	241	87	36	13				
TVG								
< 46 mmHg	617	94.2	38	5.8	0.210	1.37	0.835	2.254
> 46 mmHg	355	92.2	30	7.8				
Timing of operation								
Elective	931	94.8	51	5.2	<0.001	7.569	4.024	14.237
Emergent	41	70.7	17	29.3				
Number of a valve operated								
Single valve operation	814	93.5	57	6.5	0.986	0.994	0.510	1.938
Double valve operation	158	93.5	11	6.5				
Concomitant CABG								
No	832	94.8	46	5.2	<0.001	2.842	1.658	4.871
Yes	140	86.4	22	13.6				
Concomitant TVr								
No	589	95	31	5	0.015	1.836	1.120	3.009
Yes	383	91.2	37	8.8				

Chi-Square statistically analyzed data.
NYHA: NYHA Fc: New York Heart Association Functional class; BMI: body mass index; CCT; creatinin clearance test; Hb: Hemoglobin; IE: infective endocarditis; LVEF: left ventricular ejection fraction; PH: pulmonary hypertension; RV: right ventricle; TAPSE: tricuspid annular plane systolic excursion; TVG: tricuspid valve gradient; TVr: tricuspid valve repair

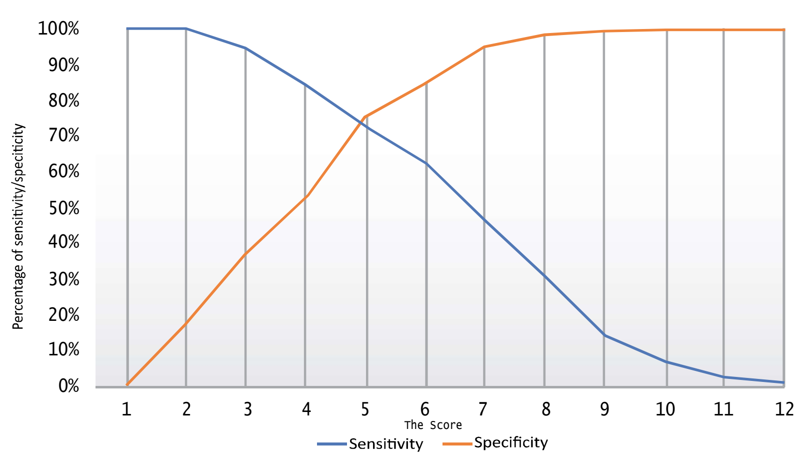

Figure 3. This graphic showed that the score 5 was found to be the cut-off for mortality risk score with 14% probability of death (sensitivity 72.1%, specificity 75.3%).

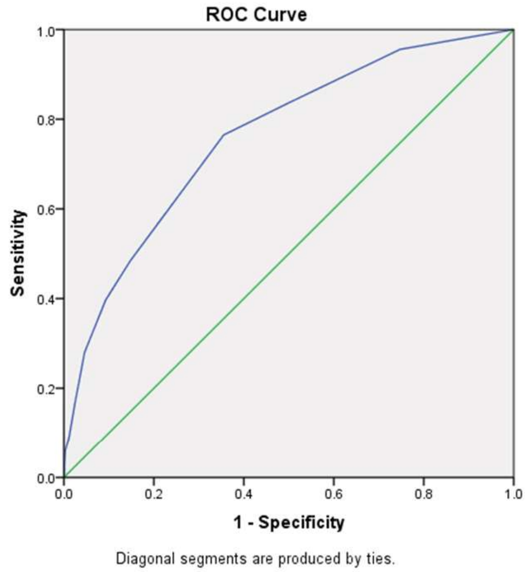

Figure 4. Receiver operating characteristic (ROC) curves at Validation Study. The scoring system has a moderate discrimination (AUC = 0.761; CI 95% = 0.702 – 0.821).

Table 4. Final Model for Mortality Predictor.

Variable	P	OR	Confidence Interval 95%	
			Minimum	Maximum
NYHA Fc 3-4	<0.001	3.674	1.976	6.832
Hypertension	0.024	1.989	1.093	3.620
Previous open-heart surgery	0.050	3.106	1.001	9.638
CCT < 50 ml/min	0.002	2.599	1.406	4.804
TAPSE < 1.6 cm	<0.001	3.234	1.826	5.730
Emergent operation	0.002	3.246	1.565	6.730
Concomitant CABG	0.002	2.942	1.498	5.779
Concomitant TVr	0.015	2.094	1.151	3.808

Chi-Square statistically analyzed data.
NYHA: NYHA Fc: New York Heart Association Functional class; BMI: body mass index; CCT; creatinin clearance test; Hb: Hemoglobin; IE: infective endocarditis; LVEF: left ventricular ejection fraction; PH: pulmonary hypertension; RV: right ventricle; TAPSE: tricuspid annular plane systolic excursion; TVG: tricuspid valve gradient; TVr: tricuspid valve repair

Table 5. Mortality Risk Score.

No	Variable	Score
1	NYHA Fc 3 – 4	2
2	Hypertension	1
3	Previous open-heart surgery	1
4	CCT < 50 ml/min	2
5	TAPSE < 1.6 cm	2
6	Emergent operation	2
7	Concomitant CABG	2
8	Concomitant TVr	1
	Total score	13

NYHA Fc: New York Heart Association functional class; CABG: coronary artery bypass graft; CCT: creatinin clearance test; TAPSE: tricuspid annular plane systolic excursion; TVr: tricuspid valve repair.

Developing the scoring system

The mortality rate of the scoring study was 6.5% (68 from 1040 patients). Heart failure, PH crisis, sepsis, and bleeding were the dominant causes. In addition, the bivariate analysis showed that in-hospital mortality was significantly associated with age ≥ 65-year-old, NYHA Fc 3-4, hypertension, previous open-heart surgery, unstable pre-operative condition, creatinin clearance test (CCT) < 50 ml/min, poor LVEF < 40%, TAPSE < 1,6 cm, emergent operation, concomitant CABG, and TVr (Table 3).

Variables with P < 0.25 at bivariate analysis were included in logistic regression analysis. We developed the final prediction model for mortality using a backward stepwise approach. The results are presented in Table 4. Each model was then evaluated for calibration and discrimination. We found that our final model for prediction of mortality has good calibration and discrimination (H-L test P = 0.240; AUC = 0.814; CI 95% = 0.760–0.868)

We developed our scoring system model named HARKIT score, followed by a re-evaluation of calibration and discriminatory power. The final scoring system is presented in table 5. The scoring system performed similar calibration and discrimination to its source model. Mortality risk score has good calibration and discrimination (H-L test p = 0.212; AUC = 0.813, CI 95% = 0.758 – 0.867) (**Figure 1**).

A subject's probability of experiencing an outcome could be calculated using a logistic equation p = 1/(1+exp (-y). A logistic regression equation obtained the value of "y" from each risk score. The "y" equation for mortality risk score is: y = -5.003 + (0.637 x total score) (**Figure 2**). We calculated each score's sensitivity and specificity using the AUC analysis and determined the cut-off by choosing the best specificity and sensitivity score. The score 5 was found to be the cut-off for mortality risk score with 14% probability of death (sensitivity 72.1%, specificity 75.3%) (**Figure 3**).

The Validation Study

In the validation study, the mortality rate was 8.6% (68 patients from 789 patients) with PH crisis, sepsis, bleeding, heart failure, and cerebrovascular disease as the predominant causes. There was no subject found with scores of 12 and 13. The scoring system has a good calibration (H-L test p=0.169) and moderate discrimination (AUC = 0.761; CI 95% = 0.702 – 0.821) (**Figure 4**). In general, the observed and predicted in-hospital mortality was 8.6% and 11.9%, respectively, and the observed/expected ratio was 0.72.

Discussion

We have developed a simple scoring system to predict in-hospital mortality post valve surgery and validate it with a good result. Overall, our patients were relatively younger than EuroSCORE II,[5] and STS subjects.[6] Mitral valve operation was the highest number of surgery in our study, while EuroSCORE II and STS score performed more aortic valve operations.[5,6] There was a high number of double valve surgery and TVr in our study. These differences are probably due to the predominant rheumatic etiology in our subjects.

Our study's in-hospital mortality rate was higher than EuroSCORE II, 6.5% vs. 4%, respectively.[5] Compared to the STS population, our study also showed a higher mortality rate in isolated valve surgery, 5.2% vs. 3.4%, six and valvular surgery with concomitant CABG operation 13.6% VS 6.8%, respectively.[7] Heart failure, PH crisis, and sepsis were the major cause of death in our study. Except for PH crisis, the other major causes of death are also reported from other studies,[10,11,12] This condition could be due to many VHD patients in Indonesia being of lower economic, lower educational level, and located in a remote area far from the reach of a healthcare facility capable of detecting VHD. Hence intervention is often delayed, and disease has advanced to a later stage with accompanying complications, resulting in a higher risk of intervention.[1,10]

In our study, surgery was grouped into three different categories: 1) single or double (mitral and aorta) valve surgery, 2) with or without concomitant CABG, and 3) with or without TVr. Bernstein Parsonnet Score also separates their valve surgery into each categorical variable.[13] Society of Thoracic Surgeon (STS) risk score only included single (mitral or aorta) valve operation,[6] and single valve with CABG operation,[7] while EuroSCORE II combined its operation into ordinal variable based on the number of procedures performed.[5] By separating each type of surgery into separate variables, our risk score could determine each procedure's influence toward outcome more specifically. As it appears in our mortality risk score, CABG is a significant predictor of mortality, but not double valve surgery. With this separation, we can also identify TVr as a predictor of mortality.

Hypertension was found to be a predictor of in-hospital mortality, as also reported in previous studies.[6,7,13] Our study reported a high prevalence of hypertension compared to other risk factors. Hypertension was associated with mortality at bivariate analysis (5.3% vs 9.9%, P = 0.009), and in multivariate analysis (OR 1.989; CI 95% = 1.093-3.620).

Left ventricular ejection fraction consistently becomes a predictor of mortality in all of the previously developed risk scores,[2,5-7,13] but that was not the case in our study. This finding was probably due to a small number of poor LV functions, and more than half of our subjects have good LV functions. Perhaps younger age and rheumatic etiology could explain our population's low proportion of poor LV function.

Our study included RV function (TAPSE) and TVr as predictors of mortality. We found that TAPSE < 1.6 cm and TVr were significantly associated with mortality, with OR = 3.234; CI 95% = 1.826 – 5.730 and OR = 2.094; CI 95% = 1.151– 3.808, respectively. Prolonged RV dysfunction may cause significant tricuspid regurgitation. Both contribute to low cardiac output, hypotension, and RV failure.[14,15] None of the previous risk scores includes TAPSE and TVr as predictors. Patients requiring TVr were excluded in the STS population due to small case numbers,[6,7] while EuroSCORE II only had 5% of TVr cases.[5] In contrast, we performed 420 (40.4%) TVr. As more scoring systems were based on developed countries' conditions, providing early disease detection and intervention may protect RV function from further deterioration. RV function in VHD is an important sign of duration and severity of PH.[14]

Up to 37% of our study population has PH. Chronic LV valve problems may cause PH, which increases postoperative mortality and morbidity.[16,17,18] Our study found that PH (defined as TVG > 46 mmHg) was not significantly associated with mortality. Pulmonary hypertension due to left heart disease initially occurs as passive PH. If not promptly treated, it may advance to reactive PH, which is associated with worse outcome.[19] Long-standing PH will cause RV failure, which is associated with mortality in 60-70% of severe mitral stenosis cases.[20] The predominated surgery of our study was mitral valve surgery due to the mitral valve disease, with MS being approximately 30% among them, and MR was 46-47%. The mitral valve disease may cause earlier and more pronounced PH. Evidence suggests that the association of PH with mortality and morbidity depends on RV adaptation rather than the pulmonary artery pressure alone. In many cardiac surgeries, the importance of RV function has been described, yet some evidence is based on retrospective or small prospective studies.[21] Perhaps predominated mitral valve disease with PH may cause poor TAPSE is more prevalent than poor LVEF (26.6% VS 11.3%) and associated with mortality. This finding shows the importance of further research on PH and RV failure in heart valve surgery, a concern which also addressed by the National Institute of Health.[22]

There are some studies reported the performance of Euroscore and STS score. A meta-analysis concluded that Euroscore II and STS score performed well as risk prediction models for perioperative mortality during cardiac surgery.[23] There is another meta-analysis reported that Euroscore has low discrimination ability for valve surgery, and it sensibly overpredicts risk. They suggested to consider an alternative risk scoring system.[24] We did an unpublished study comparing the performance of Euroscore II with Harapan Kita score. We found that Euroscore II has a fair validation performance and moderate discrimination ability in predicting in hospital mortality. Harapan kita score has a better validation performance with equal discrimination power when using in our patients. The study report is under review for publication. We did not perform STS score in our patients due to complexity and amount of data needed to calculated the STS score.

We developed a scoring system from a logistic regression model to predict mortality after heart valve surgery with or without CABG for adult patients. Our mortality risk score has a total of 13 scores. Mortality risk scores have the cut-off point of 5. The score of 5 of 13 is associated with a 14% probability of death (sensitivity 72.1%, specificity 75.3%). In the validation study, the observed in-hospital mortality is 8.6%, and predicted mortality is 11.9%, showing that the new score slightly overestimated in-hospital mortality, with an observed/estimated ratio of 0.7. The new simple score has a good calibration with an H-L test p-value of 0.169 and moderate discrimination with AUC 0.761 at the validation study. In addition, the new scoring system uses relatively fewer variables, making it more practical and applicable, especially in developing countries.

Study Limitation

This study is a retrospective study where data collection relies on the accuracy of medical records and hospital information systems. Different surgeons with different experiences and expertise performed the surgery, probably affecting the surgical outcome. This study is a single-center study, so external validation in other cardiac centers is needed to evaluate whether this scoring system can be applied nationwide. In this study, The pre-surgical medical treatment effects on patient mortality were not evaluated. This is also a limitation of the study. However, since pre-surgical treatment may change over time, it makes things quite difficult to be put as one of the scoring variables.

Conclusion

A simple scoring system for predicting in-hospital mortality after heart valve surgery has been developed. The validation study showed that the current scoring system has a good calibration with moderate discrimination in predicting in-hospital mortality.

Abbreviations

AF	:	atrial fibrillation/flutter
AUC	:	area under curve
BMI	:	body mass index
CABG	:	coronary artery bypass graft
CCT	:	creatinine clearance test
CHD	:	congenital heart defect
CI	:	confidence interval
CVD	:	cerebrovascular disease
DM	:	diabetes mellitus
EuroSCORE II	:	European System for Cardiac Operative Risk Evaluation II
Hb	:	Hemoglobin
H-L	:	Hosmer and Lemeshow
IBM	:	International Business Machines
IE	:	infective endocarditis
LV	:	left ventricle
LVEF	:	left ventricular ejection fraction
NCCHK	:	National Cardiovascular Center Harapan Kita
NYHA Fc	:	New York Heart Association functional class
PH	:	pulmonary hypertension
PVR	:	pulmonary vascular resistance
ROC	:	receiving operating curve
RV	:	right ventricle
SPSS	:	Statistical Package for the Social Sciences
STS	:	Society of Thoracic Surgeon
TAPSE	:	tricuspid annular plane systolic excursion
TVG	:	tricuspid valve gradient
TVr	:	tricuspid valve repair
vs	:	Versus
VHD	:	valvular heart disease

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