Original Article

Indonesian Journal of Cardiology
Indonesian J Cardiol 2023:44:61-67
pISSN: 2830-3105 / eISSN: 2964-7304
doi: 10.30701/ijc.1546

PEACH Score Validation of Postoperative In–Hospital Mortality in Adult Congenital Heart Disease Patients at Haji Adam Malik General Hospital Medan.

Juang Idaman Zebua[1], Ali Nafiah Nasution[1], Andre Pasha Ketaren[1], Harris Hasan[1], Nizam Zikri Akbar[1].

Abstract

Introduction: Congenital heart disease (CHD) is an abnormality in the structure and function of the heart that is acquired while still intrauterine where the incidence of CHD worldwide is estimated at around 8 cases per 1,000 live births. Even though the development of medical science is currently advanced, there are still CHD patients who are lately diagnosed and found when the patient is an adult so it requires surgical interventions. The PEACH score is a score that can predict postoperative in-hospital mortality in adult CHD patients. This study aims to validate the PEACH score.

Methods: This is a retrospective cohort study of 52 adult patients with CHD who underwent surgery at Haji Adam Malik General Hospital from January 2019 to April 2023. Validation was analyzed using a calibration and discrimination test to the PEACH score in predicting postoperative in-hospital mortality.

Results: Ahe incidence of in-hospital mortality was 8 (15.4%) patients. There is a relationship between the PEACH score group and the incidence of mortality (p=0.006). The results of the calibration test using the Hosmer and Lameshow analysis and the discrimination test using the Receiver Operating Characteristic analysis showed good validation (p=0.85; AUC=0.83)..

Conclusion: The PEACH score is valid for predicting postoperative in-hospital mortality in adult congenital heart disease at Haji Adam Malik General Hospital.

(Indonesian J Cardiol. 2023;44:61-67)

Keywords: PEACH Score, mortality, adult congenital heart disease, validation.

[1] Department of Cardiology and Vascular Medicine, Faculty of Medicine, Universitas Sumatera Utara, Haji Adam Malik General Hospital, Medan, Indonesia.

Correspondence:
Juang Idaman Zebua,

Department of Cardiology and Vascular Medicine, Faculty of Medicine, Universitas Sumatera Utara, Haji Adam Malik General Hospital, Medan, Indonesia

Email: juang.pevensie@gmail.com.

Introduction

Congenital heart disease (CHD) is an abnormality in the structure and function of the heart that is acquired while still intrauterine.[1] The incidence of CHD worldwide is estimated at around 8 cases per 1,000 live births. This prevalence includes 3 cases of moderate to severe CHD for every 1,000 births and 13 cases of mild CHD for every 1,000 births.[2] While in Indonesia, there are no definite figures regarding the prevalence of CHD, research at Dr. Sutomo Hospitals in 2004-2006 had a high mortality rate from CHD patients every year, respectively 11.64%, 11.35%, and 13.44%.[3].

Estimation of mortality events related to surgery in CHD is essential in this condition because it could assist clinicians in weighing the benefits and risks of the planned surgery, which ultimately helps in making decisions and submitting approval for medical interventions.[4]

The score that is specific in predicting postoperative in-hospital mortality in adult CHD patients is the PEACH score developed by Constantine, et al in 2021. They have conducted validation tests on this score with fairly good results in predicting the incidence of postoperative in-hospital mortality in adult CHD patients with an *area under curve* (AUC) value was 0.88 (95% CI 0.82 – 0.94); p-value 0.0002. They even further grouped the score into 3 groups based on the severity of the mortality risk. Score 0 is low risk with an incidence of 0.2% mortality; score 1-2 is a moderate risk with an incidence of 3.6% mortality and score ≥3 is a high risk with an incidence of 17.2% mortality.[4]

The PEACH score is quite specific, simple, and easy to implement in heart health centers, which could be useful in determining prognostics.[4] However, in Indonesia there is no valid data regarding the PEACH score as a predictor of mortality. This study aims to examine the validity of the PEACH score in predicting postoperative in-hospital mortality in adult CHD patients.

Methods

This is a retrospective cohort study conducted on adult patients undergoing CHD surgery at Haji Adam Malik General Hospital from January 2019 – June 2023. The PEACH score was assessed on patients who met the inclusion and exclusion criteria and then followed up until the end of treatment. The inclusion criteria were adult patients ≥16 years who were diagnosed with CHD and underwent surgery at Haji Adam Malik General Hospital. Meanwhile, patients who used long-term mechanical circulatory support underwent heart transplant surgery, underwent repeated operations within 30 days after the initial surgery, and had incomplete medical record data were excluded.

The PEACH score is the total score of the NYHA functional class parameters, hemoglobin level, glomerular filtration rate, active endocarditis, Adult Congenital Heart Surgery (ACHS) score, urgency procedure, and history of multiple sternotomies. The PEACH score has a range of 0 to 7 and is divided into 3 groups, such as low-risk (score 0), intermediate-risk (score 1-2), and high-risk (score ≥3).

Categorical variables are presented with frequency (n) and percentage (%). Numerical variables are presented with mean and standard deviation (SD) or median and interquartile ranges based on distributed data. Bivariate analysis was performed using the *Chi-square test or Fisher's test* for categorical data and the *Independent T-test or Mann-Whitney test for numerical* data. Bivariate analysis was performed to assess the relationship between the parameters of the PEACH score and mortality during hospitalization. Variables are considered significant if the p-value <0.05.

Then a full external validity test was performed on the PEACH score in predicting postoperative in-hospital mortality, such as discrimination and calibration tests. The discrimination test to assess the strength of a model was obtained based on the AUC value in the receiver operating characteristic (ROC) curve. Analysis with Hosmer Lameshow was carried out to assess calibration, with a good calibration result if it is more than 0.5, which means that the PEACH score is quite reliable and suitable for adult patients with CHD

Result

Out of 55 patients, 52 patients were included; while 3 patients were excluded because 1 patient underwent repeated surgery within 30 days after the initial surgery and 2 patients had incomplete medical record data.

This study was dominated by women (59.6%) with the patient's median age at the time of the procedure being 30 years with the range being 16 – 54

Table 1. Characteristics of Adult Patients with Congenital Heart Disease Undergoing Surgery.

Characteristics	
Gender	
Man	21 (40.4%)
Woman	31 (59.6%)
Age at time of procedure (years)	30 (16 – 54)
CHD type	
Atrial Septal Defect	38 (66.7%)
Ventricular Septal Defect	13 (22.8%)
Tetralogy of Fallot	1 (1.7%)
Double Outlet Right Ventricle	1 (1.7%)
Pulmonal Stenosis	3 (5.2%)
Partial Anomaly Pulmonary Venous Disease	1 (1.7%)
Comorbid	
Tricuspid Regurgitation	13 (68.4%)
Aortic Regurgitation	2 (10.5%)
Ruptured Sinus of Valsalva	2 (10.5%)
Infective Endocarditis	2 (10.5%)
CHD Complexity	
Mild	45 (86.5%)
Moderate	6 (11.5%)
Severe	1 (1.9%)
ACHS score	0.5 (0.1 – 2.1)
NYHA FC	
I	8 (15.4%)
II	24 (46.2%)
III	18 (34.6%)
IV	2 (3.8%)
Laboratory	
Haemoglobin	13.44 ± 2.30
Leukocytes	8,024.81 ± 2,444.81
Platelets	265,730.77 ± 73,062.75
Ureum	21 (9 – 248)
Creatinine	0.75 (0.45 – 2.50)
Glomerular Filtration Rate (ml/second)	102.59 ± 32.01
PASP (mmHg)	48.5 (20 – 126)
Infective Endocarditis	2 (3.8%)
Urgency Procedure	6 (11.5%)
Multiple Sternotomy	1 (1.9%)
PEACH score	0 (0 – 5)
Mortality	8 (15.4%)

CHD: Congenital Heart Disease; ACHS: Adult Congenital Heart Surgery; NYHA FC: New York Heart Association functional class; PASP: Pulmonary artery systolic pressure; PEACH: Perioperative Adult Congenital Heart Heart Disease..

Table 2. Association between PEACH Score and Mortality.

Mortality	Calibration Test			P-value
	0	1-2	≥3	
Yes	1 (12.5%)	4 (50%)	3 (37.5%)	0.006
No	27 (61.4%)	15 (34.1%)	2 (4.5%)	

Table 3. Bivariate Analysis of PEACH Score Parameters on Mortality.

Parameter	Mortality		p value	RR (95% CI)
	Yes	No		
NYHA Functional Class			0.12*	
III / IV	5 (26.3%)	14 (73.7%)		2.89 (0.77 – 10.78)
I / II	3 (9.1%)	30 (90.9%)		Reference
ACHS score			>0.99*	
1.6 – 3.0	0 (0.0%)	1 (100.0%)		1.18 (1.05 – 1.33)
0.1 – 1.5	8 (15.7%)	43 (84.3%)		Reference
Hb (mg/dL)			0.04*	
<10/>20	3 (50.0%)	3 (50.0%)		4.60 (1.45 – 14.54)
10 - 20	5 (10.9%)	41 (89.1%)		Reference
GFR (ml/s)			0.02*	
≤60	3 (60.0%)	2 (40.0%)		5.64 (1.88 – 16.85)
>60	5 (10.6%)	42 (89.4%)		Reference
Infective Endocarditis			0.28*	
Yes	1 (50.0%)	1 (50.0%)		3.57 (0.76 – 16.77)
No	7 (14.0%)	43 (86.0%)		Reference
Urgency Procedure			0.04*	
Yes	3 (50.0%)	3 (50.0%)		4.60 (1.45 – 14.54)
No	5 (10.9%)	41 (89.1%)		Reference
Multiple Sternotomy			0.15*	
Yes	1 (100.0%)	0 (0.0%)		3.57 (0.76 – 16.77)
No	7 (13.7%)	44 (86.3%)		Reference

*Uji Fisher; NYHA: New York Heart Association; ACHS: Adult Congenital Heart Surgery; Hb: haemoglobin; GFR: Glomerular Filtration Rate.

years **(Table1)**. Based on CHD types, non-cyanotic congenital heart disease is more common than cyanotic. Several other co-morbidities related to cardiac structural abnormalities were also found in several patients with CHD, especially Tricuspid Regurgitation (68.4%). These comorbidities will also be surgically intervened during CHD surgery. The characteristics of CHD can also be seen from the complexity of the congenital disease lesions. Based on the 2020 ESC Guidelines for Management of ACHD, this study was dominated by mild lesion complexity (86.5%).

The mortality rate during hospitalization was 15.4% (8 patients). Mortality was found in patients with a PEACH score of 5, which was 100.0%. The mortality rate for a PEACH score of 3 was 66.6%, a PEACH score of 2 was 25.0%, a PEACH score of 1 was 20.0%, and a PEACH score of 0 was 3.5%. Meanwhile, no mortality was observed with PEACH score 4, and there were no patients with PEACH scores 6 and 7. Based on the total PEACH scores in patients **(Figure 1)**, PEACH scores

Table 4. Calibration Test and Discrimination of PEACH Score with Mortality.

	Calibration Test		Discrimination Test	
	Chi-square	**p value**	**AUC**	**95% CI**
PEACH Score	0.79	0.85	0.83	0.622 – 1.00

1-2 had a mortality rate of 4 patients (50%), PEACH scores ≥3 had 3 patients (37.5%), and PEACH score of 0 had only 1 patient (12.5%).

The group with PEACH score ≥3 had a higher mortality rate when compared to the group with PEACH scores 1-2 and 0 (p = 0.006; **Table 2)**. If we compare this study's mortality percentages during hospitalization with previous PEACH studies, both studies obtained a higher mortality percentage in the group with PEACH score ≥3.

Each variable from the PEACH score parameter was divided into 2 groups and used as a reference in bivariate analysis **(Table 3)**. From this analysis, it was found that the glomerular filtration rate had the greatest relative risk value with 5.64 (95% CI 1.88 – 16.85), followed by hemoglobin levels and urgency procedures with both relative risk was 4.60 (95% CI 1.45 – 14.54).

Furthermore, the PEACH score validation as a postoperative in-hospital mortality predictor in adult patients undergoing CHD surgery was carried out by calibration and discrimination tests **(Table 4)**. The calibration test was carried out using the Hosmer and Lameshow Test, where a p-value> 0.05 means that there is no significant difference between the observed and expected values; with a well-calibrated score. In this study, the p-value obtained in the Hosmer and Lameshow analysis was 0.85. The discrimination test was carried out using ROC analysis, and the AUC value was 0.83 **(Figure 2)**.

Discussion

Based on the CHD distribution in adults, non-cyanotic CHD was more common than cyanotic. The most frequently diagnosed non-cyanotic CHD is an atrial septal defect (ASD) followed by ventricular septal defect. Hariyanto et. al. stated that the most common cyanotic CHD was ventricular septal defect followed by atrial septal defect.[5]

Very severe pulmonary hypertension is rare in ASD which is < 5% and the development of pulmonary hypertension requires other factors such as reduced left ventricular compliance, increased left atrial pressure due to hypertension, ischemic heart disease, cardiomyopathy, and mitral or aortic valve disorders. These conditions accelerate the occurrence of pulmonary hypertension. The development of pulmonary hypertension tends to take longer causing patients to be asymptomatic and could only be detected in adulthood, causing more common ASD cases in adults.[6]

The higher the PEACH score, the higher the tendency for postoperative in-hospital mortality in adult patients undergoing CHD surgery. This finding is consistent with Constantine et. al., a higher percentage of mortality was found in the PEACH score ≥3 group; which was 17.2%, while the mortality in PEACH score 1-2 was 3.6%; and in PEACH score 0, the mortality percentage was 0.2%.[4]

The PEACH score is the total of clinical, laboratory, lesion complexity, comorbidities, and surgical technique parameters with a total of 7 components. The higher the NYHA functional class, the greater the tendency for mortality with a relative risk of 2.89 (95% CI 0.77 – 10.78). Bredy et al. showed the NYHA classification to be a valid method for classifying Adult Congenital Heart Disease (ACHD) patients according to functional boundaries because it is related to objective measures of exercise capacity, such as peak VO2 and slope of VE/VCO2. The NYHA class corresponds to the severity of the underlying CHD, making it a simple prognostic tool in clinical practice.[7]

Bredy et al. confirmed that the NYHA class has important prognostic implications for patients with significant limitations (NYHA classes 3 and 4). The NYHA class may carry additional prognostic information because the symptoms reported by patients are not limited to exercise intolerance.[7]

Hemoglobin levels showed significant results between the hemoglobin 10 – 20 mg/dL group and the hemoglobin <10 mg/dL or >20 mg/dL group, where the latter level tended to have a higher mortality rate with a relative risk of 4.60 (95% CI 1.45 – 14.54). The oxygen-carrying blood capacity is an important

component of the cardiorespiratory chain which is responsible for providing sufficient oxygen in peripheral tissues to meet tissue metabolic needs. Anemia will result in reduced oxygen-carrying capacity. In Dimopoulos et al. study with 830 adult CHD patients (age 36.5 ± 15.0 years, 49.6% male) the anemia prevalence rate was 13.1% and was highest in patients with transposition of great arteries. Anemia is not uncommon in adult CHD patients and is associated with an increased risk of death.[8]

The glomerular filtration rate shows a significant effect on the mortality rate during hospitalization. The relative risk of mortality during hospitalization was 5.64 (95% CI 1.88 – 16.85) and was the strongest relative risk in this study. Patients with moderate or severe GFR (<ml/min/1.73 m^2) had a 5-fold and 3-fold increase in mortality at 6 years when compared with the normal (≥90 ml/min/1.73 m^2) or mildly reduced GFR (60–89 ml/min/1.73 m^2) group. Rajpal et al. noted a gradual increase in the risk of death and non-elective hospitalization for cardiovascular causes with increasing albuminuria.[9,10]

Fuhrman et al. reported persistent renal dysfunction on discharge in approximately one-third of 195 adult CHD patients admitted to the cardiac intensive care unit who later developed acute renal failure. All patients who died within the first year after discharge from the hospital had chronic kidney disease. Kwiatkowski et al. also reported an incidence of acute renal failure of 36% among adult CHD patients undergoing cardiac surgery.[11,12]

Based on the lesion complexity in adult CHD, there was no significant difference between the ACHS score 1.6 – 3.0 and the ACHS score 0.1 – 1.5 group because no mortality was observed in scores 1.6 – 3.0. The small number of study samples and the diversity of cases that were not varied enough caused the difference in mortality events based on the ACHS score to be insignificant.

In this study, the mortality relative risk in the comorbid active infectious endocarditis group was 3.57 (95% CI 0.76 – 16.77). Mortality of hospitalized cases with active infectious endocarditis in CHD was 2%. Mortality accounts for 6.4% of cases of active endocarditis in patients with simple lesions, 5.7% in patients with moderate complexity, and 5.2% in patients with complex lesions.[13] Maser et al. found 41.5% cases of active endocarditis in the CHD population (n = 1042) requiring cardiac surgery during their stay in the same hospital, with a ratio of 40% in the pediatric population and rising to 70% in those over 40 years of age.[13]

The urgency procedure for adult CHD surgery in this study showed a significant difference in mortality incidence with a relative risk of 4.6 (95% CI 1.45 – 14.54). According to Constantine et al, procedural urgency was associated with mortality in postoperative ACHD patients ($p < 0.0001$).[4] The relative risk of mortality in the multiple sternotomies group was 3.57 (95% CI 0.76 – 16.77). Previous sternotomy could increase the risk of adhesions and bleeding, prolong the surgical procedure, and increase the need for re-operation.[14] Holst et al. stated that there was a tendency for an increase in early mortality to an increase in the number of sternotomies.[15]

Post-operative factors could influence the incidence of mortality. Several conditions were found to occur after surgery or during surgery but were not previously predicted in this study including post-operative bleeding, allergic reactions to anticoagulants, sepsis, and arrhythmias; which are fatal. Berra et. al. stated that surgical site infection and arrhythmias are postoperative parameters that independently determine mortality in adult CHD patients.[16]

The use of anticoagulants is often given to patients undergoing surgery, however, there are reports of delayed-type allergic hypersensitivity events to anticoagulants such as UFH-type anticoagulants. Allergy to this anticoagulant was often associated with allergy to alpha-gal protein and was a syndrome, such as alpha-gal syndrome. Thus, the initial assessment of IgE levels and premedication before receiving high-dose intravenous heparin was recommended. However, this routine examination is still rarely carried out in the population in this study.[17]

Conclusion

The current result shows promising results for PEACH score as a predictor for in-hospital mortality in adult congenital heart disease. Further studies are needed with a bigger sample size in a multicenter study.

Acknowledgements

None to disclosure.

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