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ORIGINAL RESEARCH

Validation of Open-Heart Intraoperative Risk score to predict a prolonged intensive care unit stay for adult patients undergoing cardiac surgery with cardiopulmonary bypass

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Background: A prolonged stay in an intensive care unit (ICU) after cardiac surgery with cardiopulmonary bypass (CPB) increases the cost of care as well as morbidity and mortality. Several predictive models aim at identifying patients at risk of prolonged ICU stay after cardiac surgery with CPB, but almost all of them involve a preoperative assessment for proper resource management, while one – the Open-Heart Intraoperative Risk (OHIR) score – focuses on intraoperative manipulatable risk factors for improving anesthetic care and patient outcome.

Objective: We aimed to revalidate the OHIR score in a different context.

Materials and methods: The ability of the OHIR score to predict a prolonged ICU stay was assessed in 123 adults undergoing cardiac surgery (both coronary bypass graft and valvular surgery) with CPB at two tertiary university hospitals between January 2013 and December 2014. The criteria for a prolonged ICU stay matched a previous study (ie, a stay longer than the median).

Results: The area under the receiver operating characteristic curve of the OHIR score to predict a prolonged ICU stay was 0.95 (95% confidence interval 0.90–1.00). The respective sensitivity, specificity, positive predictive value, and accuracy of an OHIR score of ≥3 to discriminate a prolonged ICU stay was 93.10%, 98.46%, 98.18%, and 95.9%.

Conclusion: The OHIR score is highly predictive of a prolonged ICU stay among intraoperative patients undergoing cardiac surgery with CPB. The OHIR comprises of six risk factors, five of which are manipulatable intraoperatively. The OHIR can be used to identify patients at risk as well as to improve the outcome of those patients.

Keywords: predictive models, validation studies, cardiac surgical procedures, cardiopulmonary bypass, intensive care units, OHIR score

Introduction

A prolonged stay in an intensive care unit (ICU) after cardiac surgery with cardiopulmonary bypass (CPB) increases not only the overall cost of care but also patient morbidity and mortality.[1] Being able to predict which patients might have a tendency for a prolonged ICU stay would help with patient and resource management.[2]

There are several predictive models for identifying patients at risk of prolonged ICU stay after cardiac surgery with CPB,[3–6] but almost all of them involve a preoperative assessment for proper resource management. One model – the Open-Heart Intraoperative Risk (OHIR) score – considers intraoperative, manipulatable risk factors for improving anesthetic care and patient outcome.[7] The OHIR model comprises six risk factors: age (≥60 years), P_aO_2/F_iO_2 (P/F) ratio (≤200 mmHg), platelet count (≤120,000/mm^3), inotrope/vasopressor

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Table 1 OHIR score model for predicting prolonged ICU stay

Risk factors	Score	
	Present	Absent
Age (≥60 years)	1	0
P/F ratio (≤200 mmHg)	1	0
Platelet count (≤120,000/mm^3)	1	0
Inotrope/vasopressor requirement (≥2 drugs)	2	0
Serum potassium (≤3.2 mEq/L)	1	0
AF[a] (grading ≥2)	1	0

Notes: OHIR score, total score =7; score ≥3 suggests a prolonged stay in ICU. [a]AF grade 0= no AF, AF grade 1= mild degree/need no therapy, AF grade 2= moderate degree/need drug therapy, and AF grade 3= severe degree/refractory to drug therapy.
Abbreviations: ICU, intensive care unit; OHIR, Open-Heart Intraoperative Risk; P/F, P_aO_2/F_iO_2; AF, atrial fibrillation.

requirement (≥2 drugs), serum potassium (≤3.2 mEq/L), and atrial fibrillation (grading ≥2; Table 1). Five factors in the model can be managed intraoperatively. OHIR has a score of 7; a score of ≥3 indicates a prolonged ICU stay is likely. This scoring model has not been reassessed among different patients with the same type of surgery, hence our objective.

Materials and methods

This was a retrospective, observational, and analytical study. The protocol was approved by the Khon Kaen University Ethics Committee in Human Research (HE581287), with a waiver for requiring informed consent from the patient since confidentiality protection was warranted. The data extracting sheets did not include the name of the patient, and so a unique, masked study number was used instead. This study was registered with ClinicalTrial.gov (NCT02945358).

The inclusion criteria were patients between 18 and 75 years of age undergoing cardiac surgery – ie, both coronary bypass graft and valvular that included the use of CPB. The exclusion criteria were patients undergoing emergency surgery or patients receiving special devices such as intra-aortic balloon pump or extracorporeal membrane oxygenation.

Standard anesthetic and surgical techniques for open-heart surgery with CPB were used. Transfusion criteria included the following: hemoglobin level <8 g/dL, platelet number <50,000/mm^3, or clinical coagulopathy. Crystalloid and colloid were used to maintain a central venous pressure of between 8 and 12 mmHg or a pulmonary arterial pressure of between 12 and 15 mmHg. Catecholamine infusions were used to support hemodynamic stability (dobutamine then epinephrine or norepinephrine).

Postsurgery, the patients were transferred to ICU where they received ventilator support. Patients were weaned off the ventilator and extubated when and if they were awake; had satisfactory ventilation and oxygenation (ie, on FiO_2 ≤40% with P_aO_2 >60 mmHg, P_aCO_2 >30 and <50 mmHg, and pH >7.30, or SpO_2 >92%); and had hemodynamic stability. The criteria for discharging patients from the ICU to the cardiovascular ward were as follows: alert and cooperative, respiratory rate <25/min without assistance from mechanical ventilation, P_aO_2 >80 mmHg and P_aCO_2 <45 mmHg, hemodynamically stable, and adequate analgesia.

We reviewed all eligible medical records at Srinagarind Hospital and Queen Sirikit Heart Center of the Northeast, Khon Kaen University, between January 2013 and December 2014. The extracted data comprised patient clinical data and all risk factors in the OHIR score at 3 hours after CPB. We applied the OHIR scoring (Table 1) to our data to assess its performance. We used the same criteria for a prolonged ICU stay as our previous study (namely, a stay longer than the median).[7]

Statistical analyses

The discrimination ability of the OHIR score to predict a prolonged ICU stay was assessed by evaluating the area under the receiver operating characteristic curve (AUC for ROC). We also determined the sensitivity and specificity, positive and negative predictive values, accuracy, and positive likelihood ratio. Statistical analyses were performed using SPSS for Windows version 16.0 (SPSS Inc., Chicago, IL, USA).

Results

A total of 123 cases were recruited. The median ICU stay was 42 (interquartile range 40–62) hours. Fifty-eight cases were classified as being a prolonged ICU stay. The group having a prolonged ICU stay had a higher age, New York Heart Association class, American Society of Anesthesiologists classification, and more comorbidities. The demographic and clinical data of the patients are listed in Table 2.

Patients with an OHIR score between 0 and 2 had a shorter ICU stay than those with a score between 3 and 6. Table 3 lists the mean ICU stay for each OHIR score.

The AUC for ROC of the OHIR score for segregating prolonged ICU stay among our patients yielded a nearly perfect classification of 0.95 (95% confidence interval 0.90–1.00; Figure 1). A cutoff of ≥3 of the OHIR score yielded the maximum sensitivity and specificity (Figure 2).

The OHIR score had a very high sensitivity, specificity, positive predictive value, and accuracy. Table 4 lists the sensitivity, specificity, positive predictive value, negative predictive value, accuracy, positive likelihood ratio, and AUC for ROC of OHIR score ≥3 for discriminating a prolonged ICU stay.

Discussion

To identify patients at risk of a prolonged ICU stay, several predictive models have been proposed and used.

Table 2 Demographic and clinical data

Characteristics	Total (n=123)	Prolonged ICU (n=58)	Nonprolonged ICU (n=65)	*P*-value
Age (years)	56.67±12.34	61.97±10.42	51.94±12.07	<0.001
BMI (kg/m^2)	22.94±4.80	22.68±4.46	23.16±5.09	0.584
Gender				
Male	67 (54.47%)	35 (60.34%)	32 (49.23%)	0.217
Type of operation				
CABG	43	24	19	0.158
Valve surgery	70	26	44	0.011
CABG + valve surgery	10	8	2	0.029
NYHA class				
I–II	102	41	61	<0.001
III–IV	21	17	4	
ASA classification				
1–2	85	31	54	<0.001
3–5	38	27	11	
Ejection fraction	55.36±14.69	52.61±15.77	57.70±13.39	0.062
Preoperative variables				
Hypertension		35	17	<0.001
Diabetes mellitus		24	15	0.029
Myocardial infarction		10	7	0.299
Dyslipidemia		22	18	0.226
Atrial fibrillation		18	25	0.388
Congestive heart failure		13	4	0.009
Kidney impairment/failure		12	4	0.017
Creatinine value (mg/mL)	1.05±0.53	1.24±0.68	0.88±0.25	<0.001
CPB time (minutes)	145.29±74.43	159.90±92.73	132.26±50.35	0.039
Aortic cross-clamp time (minutes)	95.93±38.46	101.05±39.53	91.35±39.14	0.175
Mechanical ventilation (hours)	18.75±37.01	29.75±51.50	9.11±8.12	0.004
Endotracheal tube retaining (hours)	19.01±36.99	29.96±51.45	9.40±8.36	0.004
OHIR score	2 (2–3)	3 (3–4)	2 (1–2)	<0.001
	2.50±1.28	3.5±1.06	1.6±0.63	
ICU stay (hours)	42 (40–62)	63 (45–88)	40 (31–41)	<0.001
	58.58±5.08	84.57±64.27	35.38±8.94	
Hospital stay (days)	14 (11–20)	14 (10–23)	15 (11–20)	0.100
	17.18±9.62	18.82±12.71	15.77±5.50	

Note: Values are presented as mean ± SD, number (%), or median (IQ range).
Abbreviations: ICU, intensive care unit; BMI, body surface area; CABG, coronary artery bypass graph; NYHA, New York Heart Association; ASA, American Society of Anesthesiologists; CPB, cardiopulmonary bypass; OHIR, Open-Heart Intraoperative Risk; SD, standard deviation.

The EuroSCORE was initially constructed for the prediction of early mortality among cardiac patients in Europe,[8,9] but was later validated as a predictive tool for estimating patient risk in terms of ICU stay.[10] The reported common risk factors for prolonged ICU stay include the following: 1) advanced age (>65 years), 2) mean pulmonary artery pressure (>21 mmHg), and 3) decreased P/F ratio (<300 mmHg) on admission to ICU.[3] Another study included the following: 1) body mass index, 2) type of surgery, 3) CPB machine use, 4) use of packed red cells, 5) nonelective surgery, and 6) number of complications.[5]

Table 3 Number of patients and mean ICU stay for each OHIR score

OHIR score	Number of patients	ICU stay (hours)
0	6	44.3±15.90
1	19	35.2±9.02
2	43	38.5±19.18
3	27	62.7±19.91
4	21	95.4±73.06
5	5	119.2±116.22
6	2	161.5±167.58
7	0	0

Note: Values are presented as mean ± SD.
Abbreviations: ICU, intensive care unit; OHIR, Open-Heart Intraoperative Risk; SD, standard deviation.

A 2016 systematic review of 29 articles categorized the predictors of ICU length of stay into 11 patient factors, 19 comorbidity factors, 10 surgical factors, and 6 complication factors.[6] Most of these risk factors were assessed preoperatively for the purpose of resource management. An OHIR score model, published in 2014, comprised six risk factors: age (≥60 years), P/F ratio (≤200 mmHg), platelet count (≤120,000/mm^3), inotrope/vasopressor requirement (≥2 drugs), serum potassium (≤3.2 mEq/L), and atrial fibrillation (grading ≥2).[7] All except one risk factor

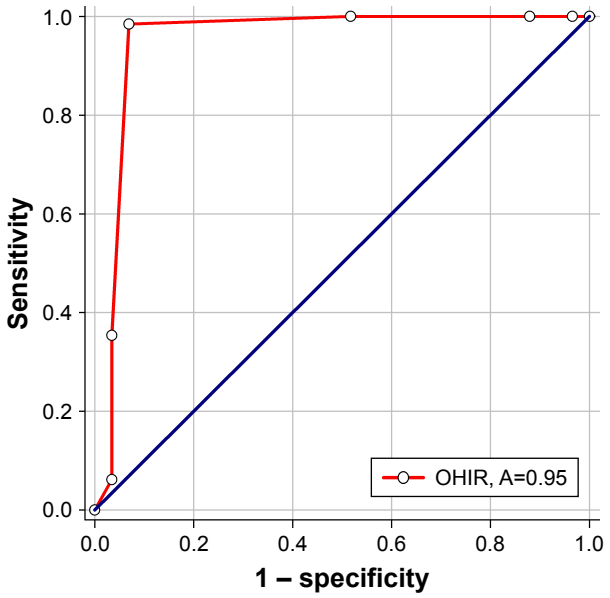

Figure 1 AUC for ROC of the OHIR score to discriminate a prolonged ICU stay.
Abbreviations: OHIR, Open-Heart Intraoperative Risk; A, area; AUC for ROC, area under the receiver operating characteristic curve; ICU, intensive care unit.

(ie, age ≥60 years) are manageable. The model has a total score of 7, with a score ≥3 suggesting a potentially prolonged ICU stay. The authors claimed that the OHIR score could be used as a guide for managing patients intraoperatively, thereby reducing the score to below 3 so that they would have a lower probability of a prolonged ICU stay.

The median ICU stay in this study was 42 hours, which is the same as our previous study,[7] suggesting the appropriateness of the statistical criteria for inferential purposes.

Our study confirms that the OHIR score has a very good discriminatory ability for predicting prolonged ICU stay among adult patients undergoing cardiac surgery with CPB.

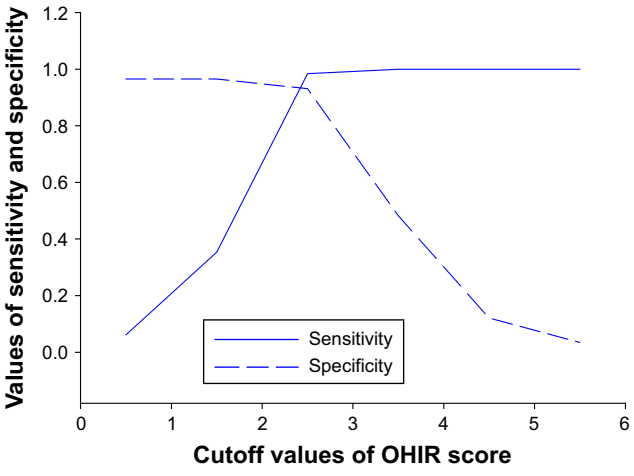

Figure 2 Cutoff point for the OHIR score.
Abbreviation: OHIR, Open-Heart Intraoperative Risk.

Table 4 Sensitivity, specificity, positive predictive value, negative predictive value, and AUC for ROC of the OHIR score ≥3

Parameter	Value	95% CI
Sensitivity (%)	93.10	83.27–98.09
Specificity (%)	98.46	91.72–99.96
Positive predictive value (%)	98.18	88.52–99.74
Negative predictive value (%)	94.12	86.13–97.63
Accuracy (%)	95.9	–
Positive likelihood ratio	60.52	–
AUC for ROC	0.96	0.92–1.00

Abbreviations: AUC for ROC, area under the receiver operating characteristic curve; OHIR, Open-Heart Intraoperative Risk; CI, confidence interval.

The overall performance of the OHIR score in the current context is better than our original study. This model may be used as a guide for managing patients intraoperatively so as to reduce their OHIR score to below 3, thereby shortening their ICU stay.

Limitations

Even though the group of patients in this study was different from our previous study, they were from the same setting. Further study to validate this score in different environments is recommended.

Conclusion

The OHIR score is highly predictive at the intraoperative stage of a prolonged ICU stay among patients undergoing cardiac surgery with CPB. The OHIR comprises six risk factors, with five that are manipulatable intraoperatively. The OHIR can be used to identify patients at risk as well as to improve patient outcomes.

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Disclosure

The authors report no conflicts of interest in this work.

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