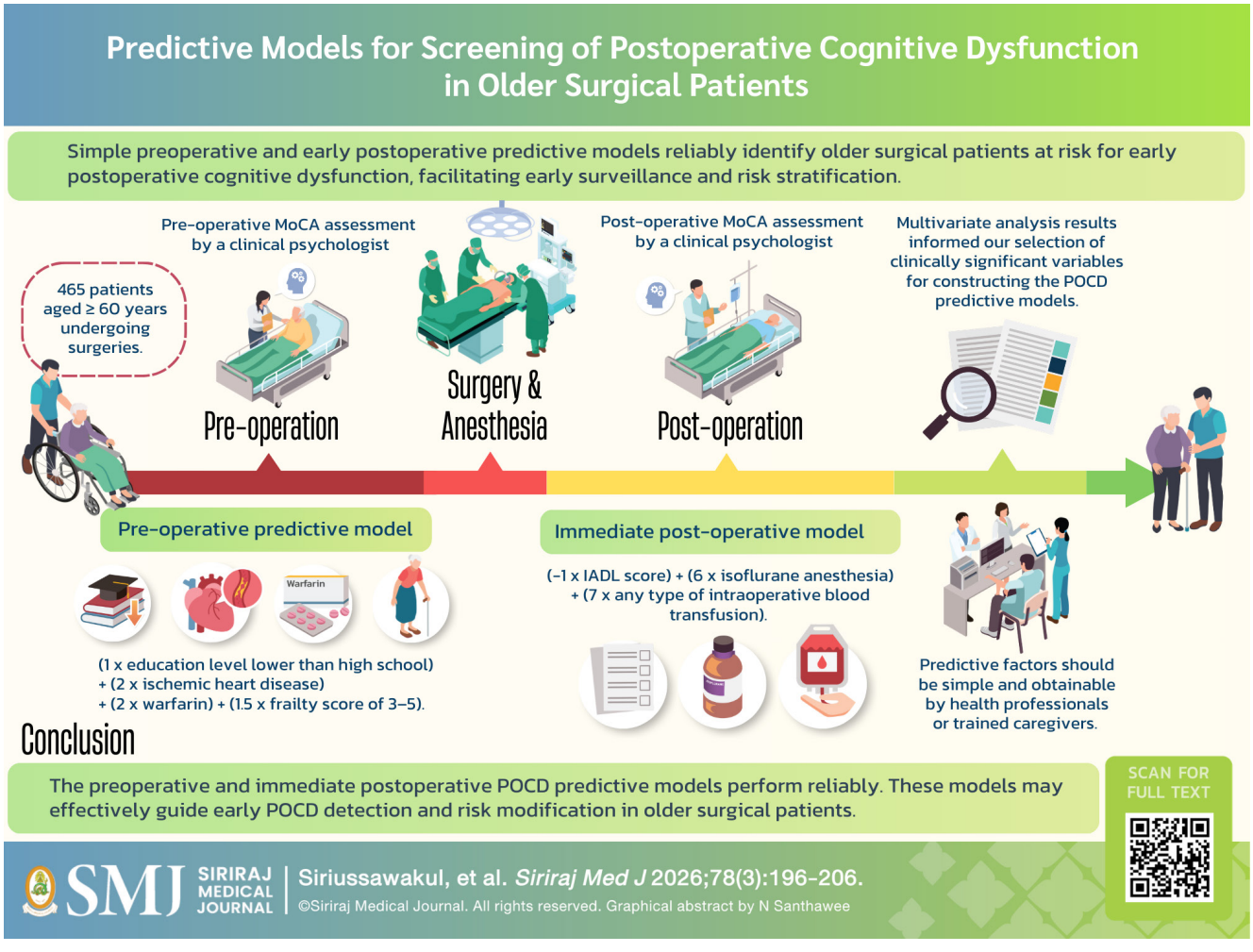
Predictive Models for Screening of Postoperative Cognitive Dysfunction in Older Surgical Patients

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ABSTRACT

Objective: Postoperative cognitive dysfunction (POCD) substantially impacts the long-term quality of life of patients and caregivers. Early detection of POCD is essential. We devised quick vigilance screening models for application preoperatively (model one) and during the postoperative period (model two) to predict the development of early POCD (one week after surgery).

Materials and Methods: We conducted a cohort study on patients aged ≥ 60 years undergoing cardiac or noncardiac surgeries. POCD was defined as a postoperative Montreal Cognitive Assessment decrease of ≥ two points from the baseline preoperative score. We stipulated that predictive factors should be simple and obtainable by health professionals or trained caregivers. Multivariate analysis results informed our selection of clinically significant variables for constructing the POCD predictive models.

Results: Of the 465 patients in the final analysis, the early POCD incidence was 24.9%. The equation used for predictive model one was (1 x education level lower than high school) + (2 x ischemic heart disease) + (2 x warfarin) + (1.5 x frailty score of 3–5). The equation for model two was (-1 x IADL score) + (6 x isoflurane anesthesia) + (7 x any type of intraoperative blood transfusion). Both models displayed well-calibrated curves. The optimal cut-off values of model one and model two to discriminate between a high and low probability of POCD were 2 and 0, respectively.

Conclusions: The preoperative and immediate postoperative POCD predictive models perform reliably. These models may effectively guide early POCD detection and risk modification in older surgical patients.

Keywords: Cognitive impairment; frailty; functional impairment; postoperative neurocognitive disorders; predictive factors (Siriraj Med J 2026;78(3):196-206)

INTRODUCTION

Postoperative cognitive dysfunction (POCD) is characterized by diminished memory orientation, perception, and intellectual performance, that develops after surgery, and can persist for several months.[1] Due to its effect on multiple domains of cognition, POCD diagnosis needs neuropsychological tests, such as neuropsychological (NP) test batteries, Montreal Cognitive Assessment (MoCA), and Mini-Mental State Examination (MMSE), that can be used to assess global cognitive function.[2-7] Although most studies use the NP test, MoCA is easier in daily practice. Moreover, MoCA is better at detecting early cognitive impairment, especially executive dysfunction, than MMSE.[8,9] Despite various diagnostic criteria, POCD is defined as a decline of one or more standard deviations in postoperative cognitive scores, relative to preoperative scores.[2-5] It is commonly found in older surgical patients. One week postoperatively, the incidence of POCD varies with the type of surgery: it has been reported to be 26% – 30% after noncardiac procedures and as high as 71% after cardiac surgeries.[10-13] Even though the incidence drops to 12%–17% at three months and 3% at 12 months, the incidence escalates to over 40% after five years.[12,14] POCD at one week after surgery can be defined as early POCD, and it is not only more prevalent but is also associated with increased 3-month mortality and healthcare utilization.[2,5] However, currently, there is no specific treatment for POCD. The optimal strategy remains preoperative identification and perioperative risk assessment to facilitate POCD prevention and management.[1]

The pathogenesis of POCD development remains unclear, and several contributing factors have been proposed.[15,16] The functional stability of the central nervous system depends on adequate oxygen and blood supply and sufficient internal environment homeostasis. Mechanisms that lead to hypoxia or alter the homeostatic metabolic state of the brain may lead to POCD. Various etiologies, including preexisting cognitive impairment, anesthetic agents, and metabolic derangements, have been proposed as potential contributors following surgeries. These perioperative variables associated with POCD can be classified into four groups.[9,17-23] Firstly, patient-related factors include being aged over 60, a low education level, cardiovascular comorbidities, alcohol consumption, and restricted physical activity. Secondly, surgical factors are significant, including major surgeries and prolonged operative duration (≥2 hours). Thirdly, anesthetic factors include the choice of anesthesia, depth of anesthesia, the drugs and inhalational agents used. Lastly, intraoperative events, such as hypotension, blood transfusion, and desaturation, correlate with POCD occurrence .

Previously proposed models used some variables in patient factor and intraoperative events, which could

predict POCD occurrence; however, those models were only be suitable for the postoperative period.[7,8] The models cannot be applied in the preoperative period. Additionally, MMSE was used to define POCD, which might affect its prevalence. As a result, it could be attributed to the validity of the models. Thus, we need prompt and accurate predictive model assessment to guide a care team's perioperative strategy; thereby, reducing POCD risk and facilitating the monitoring of potential cases. Our study aimed to consolidate multiple POCD contributors into a user-friendly predictive model for non-geriatricians and trained caregivers. Under our comprehensive approach, patients at risk are evaluated twice. The first assessment is conducted preoperatively and draws upon predisposing factors and self-reported instrument data. The second assessment, undertaken after surgery, focuses on baseline function and perioperative precipitating factors, such as anesthetic agents, and intraoperative complications.

MATERIALS AND METHODS

Study design and participants

This prospective cohort study was conducted at a large university hospital and approved by the Siriraj Institutional Review Board, Faculty of Medicine Siriraj Hospital, Mahidol University, Bangkok, Thailand (approval number Si 699/2020). The study adhered to the ethical standards of the 1964 Declaration of Helsinki and subsequent amendments. We recruited Thai-speaking patients aged over 60 who were admitted and scheduled for intermediate to major cardiac or noncardiac surgeries under general anesthesia, with neurosurgical procedures explicitly excluded, from December 2017 to December 2022. All participants provided written informed consent. Excluded were patients unable to communicate in Thai and those with significant visual or auditory impairments, major psychotic disorders, or preoperative delirium.

Data collection

To ensure the accuracy of the study data, research assistants, nurses, psychologists, anesthesiologists, and geriatricians were thoroughly trained in the data required and the collection methods. They obtained information during face-to-face interviews held the day before surgery and again before hospital discharge (approximately one week postoperatively). The data collected from patients included general information (age, sex, education level, alcohol consumption, comorbidities, and medications), preoperative data (American Society of Anesthesiologists physical status classification, laboratory results, and surgery types and sites), and intraoperative variables (anesthesia type, anesthetic drugs, and adverse events such as hypotension, bleeding, and any type of blood transfusion)

In line with recommendations for geriatric perioperative evaluations, the assessments were conducted alongside traditional practices to meet an acceptable minimum standard. These evaluations encompassed cognition, psychological status, delirium, functional status, frailty, and quality of life (Appendix 1). Cognitive assessments using the Thai version of the MoCA tool were conducted one day before and between 5 and 9 days after surgery. A drop of two or more points from the preoperative score indicated POCD. A previous validation study in the general Thai population reported that the standard deviation (SD) of the MoCA was 2.14.[24]

Statistical methods

To estimate the sample size, we followed statistical guidelines for executing multiple logistic regression analyses. These guidelines suggest that the number of older subjects with POCD should be five to ten times the number of risk factors in a logistic model. Our study had 14 risk factors: age > 60, low education level, alcohol consumption, cerebrovascular disease, diabetes mellitus, renal insufficiency, polypharmacy (≥ 5 medications), cardiac surgery, hypotension, blood transfusion, anesthetic drugs, restricted physical activity, frailty, and psychological derangement.[18-23,25] Accordingly, 70–140 subjects with POCD were needed. Given previous reports showing a 25% POCD incidence, a sample of approximately 450 was deemed sufficient for model development.[10-12]

Statistical analyses were performed using IBM SPSS Statistics version 29 (IBM Corp, Armonk, NY, USA), MedCalc Statistical Software (version 17.6; MedCalc Software Ltd, Ostend, Belgium), and Stata Statistical Software (release 14; StataCorp LLC, College Station, TX, USA). Baseline demographic data were summarized by data type: continuous data with means ± SD and categorical data as percentages. Model development utilized data exclusively from the derivation cohort (Appendix 2). The variables known to be related to POCD in older surgical patients were considered. POCD presence or absence was compared using the chi-square test or the independent samples t-test. Our multiple logistic regression model incorporated factors with clinical significance or a p-value < 0.1 from univariate analysis.[26]

The regression coefficients from the multivariable model were used to develop predictive models at two specific time points. First, a predictive model of POCD was developed for the preoperative period. The variables used for the model were predisposing factors and self-

reported instruments. Second, a predictive model of POCD was created for the immediate postoperative period. This model incorporated variables derived from baseline instrumental activities of daily living (IADL) and precipitating factors, such as anesthetic agents, and intraoperative complications.

The calibration of the model, or its fit to the data, was subsequently assessed using the Hosmer–Lemeshow test. The fit was determined by the degree of agreement between the risk score probabilities predicted by the model and the observed probabilities. The model's prognostic ability to discriminate patients with or without risk of POCD was estimated using a receiver operating characteristic (ROC) curve. The estimated shrinkage factor was tested for the performance of the POCD models. The ROC curve that presented the best cut-off point for POCD incorporated Youden's index, sensitivity, specificity, positive predictive value, negative predictive value, AUROC, and 95% confidence interval (CI).[27]

RESULTS

Basic characteristics of patients

The study enrolled 600 patients undergoing intermediate to major surgery between December 2017 and February 2023. The 465 patients included in the final analysis (Appendix 2) had an age range of 60–89 years (mean 71.31 ± 6.38), and 56.1% (261) were males. Approximately half of the patients (53.8%, 250) underwent cardiovascular surgery, 21.9% (102) had intra-abdominal surgery, and 18.5% (86) received orthopedic surgery. The incidence of early POCD was 24.9% (116/465).

Comparison of general and perioperative data between the POCD and non-POCD groups

Based on cognitive function, patients were divided into a POCD group (n = 116) and a non-POCD group (n = 349). Table 1 presents the baseline characteristics and results from self-reported instruments. Compared to the non-POCD group, patients in the POCD group had a lower education level and were more likely to have a previous history of cerebrovascular and cardiovascular diseases ($p < 0.05$). Regarding medications, patients with POCD experienced a higher frequency of polypharmacy ($p = 0.020$). The most common drugs administered to patients with POCD were antihypertensive drugs, warfarin, and diuretics. In terms of self-report instruments related to functional status, patients with POCD had higher frailty scores ($p = 0.026$) and lower IADL scores ($p = 0.019$).

Development and validation of the POCD prediction model for the preoperative period

A multivariate logistic regression analysis was performed using a backward stepwise procedure to obtain an optimized POCD prediction model for the preoperative period (Appendix 3). The analysis incorporated factors reported in the literature[18-23,28] that may influence the development of POCD, along with variables in our univariate analysis with $p < 0{\cdot}1$. The best predictive model for POCD in the preoperative period was formulated as follows (Appendix 4):

(1 x education level lower than high school) + (2 x ischemic heart disease) + (2 x warfarin) + (1.5 x frailty score of 3–5)

The AUROC curve value (95% CI) was 0.66 (0.60–0.72). Table 2 shows the optimal cut-off value for distinguishing between a high and low probability of POCD was set at two. This cut-off yielded the highest value for Youden's index (0.25) (Fig 1A), the best AUROC curve value, and optimal values for sensitivity (67.83%, 95% CI 58.47%–76.23%) and specificity (57.27%, 95% CI 51.85%–62.56%). Subsequently, we utilized the bootstrap method, involving repeated sampling 400 times, to determine the internal validation of the preoperative predictive model of POCD (Appendix 5-7). The AUROC curve value for this validation was 0.67 (95% CI 0.61–0.73). Additionally, the calibration curve demonstrated that the results of the predictive model were closely aligned with the observed results. The predictive model also exhibited strong goodness of fit (Hosmer–Lemeshow test, $\chi^2 = 2.93$, $p = 0.71$). Given the moderate discriminatory performance of the model, as reflected by an AUROC, this predictive model is intended to be used primarily as a screening tool for early risk stratification rather than as a diagnostic instrument for POCD.

Development and validation of the POCD prediction model for the immediate postoperative period

A multivariate logistic regression analysis using a backward stepwise procedure was performed to obtain an optimized POCD prediction model for the immediate postoperative period (Appendix 8). We considered variables reported in the literature that may precipitate the development of POCD during the perioperative period along with those with $p < 0.1$ in our univariate analysis (Table 3). The best predictive model for POCD in the postoperative period was formulated as follows (Appendix 9):

(-1 x IADL score) + (6 x isoflurane) + (7 x any type of intraoperative blood transfusion)

The AUROC curve value (95% CI) was 0.68

TABLE 1. Demographic data.

Variables	No POCD (n=349)	POCD (n=116)	p
Sex; male	194 (55.6%)	67 (57.8%)	0.683
Age (years)	71.6±6.3	70.4±6.6	0.071
BMI (kg/m^2)	24.8±4.2	24.7±4.2	0.828
Education level			
Lower than high school	152 (43.6%)	63 (54.3%)	0.045*
Further/higher education	197 (56.4%)	53 (45.7%)	
Comorbidity			
Hypertension	280 (80.9%)	95 (83.3%)	0.566
Diabetes mellitus	115 (33%)	39 (33.6%)	0.849
Dementia	3 (0.9%)	2 (1.7%)	0.439
Cerebrovascular accident	34 (9.7%)	14 (12.1%)	0.458
CKD stages 3b, 4, and 5	45 (12.9%)	24 (20.7%)	0.036*
Cirrhosis	6 (1.7%)	4 (3.4%)	0.275
Ischemic heart disease/myocardial infarction	123 (35.2%)	68 (58.6%)	<0.001*
Atrial fibrillation	34 (9.7%)	20 (17.2%)	0.032*
Valvular heart disease	69 (19.8%)	36 (31%)	0.013*
Congestive heart failure	35 (10%)	21 (18.1%)	0.023*
Dyslipidemia	238 (68.2%)	85 (73.3%)	0.318
Current smoker	14 (4.0%)	3 (2.6%)	0.479
Alcohol consumption history	332 (95.1%)	114 (98.3%)	0.182
Medications			
Warfarin	24 (6.9%)	17 (14.7%)	0.013*
Antiarrhythmic drug	144 (41.3%)	68 (58.6%)	0.001*
Antihypertensive drug	271 (77.7%)	102 (87.9%)	0.020*
Diuretics	77 (22.1%)	39 (33.6%)	0.014*
Preoperative benzodiazepine use	52 (14.9%)	22 (19%)	0.312
Polypharmacy (current medication ≥ 5)	231 (66.2%)	91 (78.4%)	0.020*
Tools			
Modified IQCODE score	3.13±0.29	3.11±0.31	0.493
9Q ≥ 7 (n %)	19 (5.4%)	11 (9.5%)	0.136
Barthel ADL score	95.12±8.52	94.96±9.96	0.869
IADL score	6.37±1.84	5.88±2.09	0.019*
Frailty; score 3–5 (n %)	38 (10.9%)	22 (19.0%)	0.026*
VAS score	73.88±15.92	70.46±15.97	0.048*
EQ-5D-5L	0.84±0.18	0.85±0.17	0.604

Abbreviations: 9Q: Nine-Questions Depression-Rating Scale; Barthel ADL: Barthel activities of daily living; BMI: body mass index; CKD: chronic kidney disease; EQ-5D-5L: European Quality of Life 5 Dimensions 5 Level Version; IADL: instrumental activities of daily living; kg: kilogram; m^2: square meter; Modified IQCODE: modified informant questionnaire on cognitive decline in the elderly; POCD: postoperative cognitive dysfunction; VAS: visual analogue scale

TABLE 2. Clinical scores with associated probabilities of a POCD positive result at the preoperative stage.

Clinical scores	Probabilities	Sensitivity (95% CI)	Specificity (95% CI)	PPV (95% CI)	NPV (95% CI)	Accuracy (95% CI)	Youden's index
≥ 1.0	18.70	85.22 (77.39 - 91.15)	31.40 (26.52 - 36.59)	29.34 (27.22 - 31.55)	86.40 (79.95 - 91.01)	44.88 (40.27 - 49.56)	0.17
≥ 1.5	22.20	68.07 (59.38 - 77.02)	54.07 (48.64 - 59.43)	33.33 (29.70 - 37.18)	83.78 (79.49 - 87.32)	57.73 (53.07- 62.30)	0.22
≥ 2.0	26.10	67.83 (58.47 - 76.23)	57.27 (51.85 - 62.56)	34.67 (30.80 - 38.74)	84.19 (80.09 - 87.58)	59.91 (55.27 - 64.43)	0.25
≥ 2.5	30.50	47.83 (38.43 - 57.34)	75.00 (7.08 - 79.49)	39.01 (32.93 - 45.45)	81.13 (78.13 - 83.81)	68.19 (63.71 - 72.43)	0.23
≥ 3.0	35.23	46.09 (36.75 - 55.63)	78.20 (73.46 - 82.45)	41.41 (34.79 - 48.35)	81.27 (78.41 - 83.83)	70.15 (65.74 - 74.31)	0.24

Abbreviations: CI: confidence interval; NPV: negative predictive value; POCD: postoperative cognitive dysfunction; PPV: positive predictive value

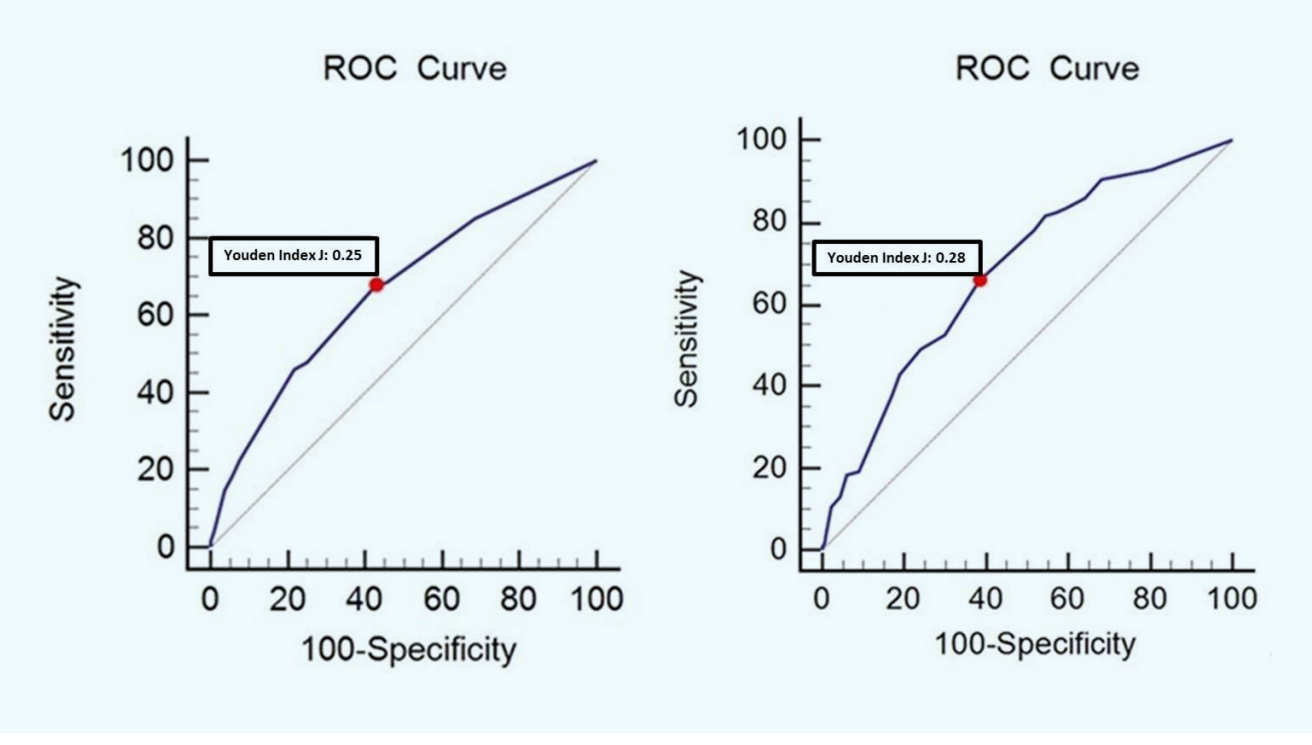


Fig 1. The receiver operating characteristic (ROC) curve for the predictive model of POCD
1A. Preoperative period
1B. Immediate postoperative period

TABLE 3. Preoperative and intraoperative data.

Variables	No POCD (n=349)	POCD (n=116)	p
ASA classification			
ASA ≤ 2	120 (34.4%)	16 (13.8%)	<0.001*
ASA > 2	229 (65.6%)	100 (86.2%)	
Charlson comorbidity index > 5	156 (44.7%)	49 (42.2%)	0.693
Site of surgery			
Cardiac surgery	168 (48.1%)	82 (70.7%)	<0.001*
Noncardiac surgery	179 (51.3%)	34 (29.3%)	
Preoperative Hb (g/dL)[a]			
Normal	186 (53.3%)	68 (58.6%)	0.319
Abnormal	163 (46.7%)	48 (41.4%)	
BIS monitoring	63 (18%)	15 (12.9%)	0.211
NIRS monitoring	45 (12.9%)	22 (19%)	0.114
Received blood product	172 (49.3%)	89 (76.7%)	<0.001*
Complications	222 (63.6%)	70 (60.3%)	0.483
Medications			
Midazolam	101 (28.9%)	55 (47.4%)	<0.001*
Dexmedetomidine	45 (12.9%)	22 (19.0%)	0.114
Isoflurane	49 (14%)	36 (31 %)	<0.001*
Morphine	145 (41.5%)	51 (44.0%)	0.681
Fentanyl	328 (94%)	114 (98.3%)	0.110
Paracetamol	23 (6.6%)	7 (6.0%)	0.822
Nefopam	10 (2.9%)	1 (0.9%)	0.244
Vasopressor use	260 (74.4%)	103 (88.8%)	0.003*

Complications: hypertension, hypotension, and severe arrhythmia. Hb(g/dL)[a] normal Range: 13–17 g/dL for male, 12–15 g/dL for female
Abbreviations: ASA: American Society of Anesthesiologists physical status; BIS: bispectral index; dL: deciliter; g: gram; Hb: hemoglobin; NIRS: near-infrared spectroscopy; POCD: postoperative cognitive dysfunction

(0.62–0.74). Table 4 shows an optimal cut-off value of 0 was chosen to discriminate between a high and low probability of POCD. This cut-off offered the highest value for Youden's index (0.28) (Fig 1B), the best AUROC curve value, and optimal values for sensitivity (65.79%, 95% CI 56.32%–74.42%) and specificity (61.76%, 95% CI 56.37%–66.95%). We subsequently performed the bootstrap method, repeating the sampling 400 times, to determine the internal validation of the immediate postoperative predictive model for POCD (Appendix 10-12). This process yielded an AUROC curve value of 0.68 (95% CI 0.63–0.74). In addition, the calibration curve showed good agreement between the predicted results of the model and the observed results. Moreover, the predictive model exhibited satisfactory performance regarding goodness of fit (Hosmer–Lemeshow test, $\chi^2 = 7.49$, $p = 0.38$). Given the moderate discriminatory performance demonstrated by the AUROC, this immediate postoperative predictive model is intended to function as a screening tool for early risk identification and postoperative surveillance rather than as a diagnostic model for POCD.

TABLE 4. Clinical scores with associated probabilities of a POCD positive result at the immediate postoperative stage.

Clinical scores	Probabilities	Sensitivity (95% CI)	Specificity (95% CI)	PPV (95% CI)	NPV (95% CI)	Accuracy (95% CI)	Youden's index
≥ -3	19.23	82.46 (74.21-88.94)	42.94 (37.61-48.39)	32.64 (29.95-35.45)	87.95 (82.80-91.72)	52.86 (48.16-57.53)	0.25
≥ -2	21.26	81.58 (73.23-88.22)	45.59 (40.21-51.05)	33.45 (30.61-36.42)	88.07 (83.14-91.70)	54.63 (49.92-59.27)	0.27
≥ -1	23.45	78.07 (69.35-85.28)	48.24 (42.81-53.69)	33.58 (30.51-36.81)	86.77 (82.02-90.42)	55.73 (51.02-60.36)	0.26
≥ 0	25.79	65.79 (56.32-74.42)	61.76 (56.37-66.95)	36.59 (32.32-41.0)	84.34 (80.46-87.56)	62.78 (58.15-67.24)	0.28
≥ 1	28.27	52.63 (43.06-62.06)	70.00 (64.82-74.83)	37.04 (31.68-42.74)	81.51 (78.21-84.41)	65.64 (61.07-70.00)	0.23
≥ 2	30.89	49.12 (39.64-58.65)	75.88 (70.97-80.33)	40.58 (34.37-47.10)	81.65 (78.62-84.32)	69.16 (64.69-73.38)	0.25

Abbreviations: CI: confidence interval; NPV: negative predictive value; PPV: positive predictive value

DISCUSSION

Our research focused on developing POCD prediction models for application before and after surgery. The preoperative and immediate postoperative POCD predictive models could be applied before and immediately after surgery, respectively. The two models perform reliably. The significant demographic features (low education level and poor functional status), anesthetic agents (isoflurane), and intraoperative events (such as any type of blood transfusion) incorporated into these models are consistent with reported risk factors for POCD.[9,18-20,23,29]

In the preoperative predictive model, frailty and warfarin were included. However, some controversies exist regarding whether warfarin might reduce POCD incidence, or if frailty correlates with POCD.[30-32] Proposed evidence supported the argument that warfarin being taken by patients with atrial fibrillation (AF) can prevent strokes and silent cerebral infarcts without clinical strokes that can cause cognitive impairment.[30] Contrastingly, our findings indicate that warfarin consumption could elevate the risk of POCD. This finding could be explained by the synergistic effects between warfarin and cardiovascular co-morbid diseases that might be attributed to POCD. In cases involving presurgical anticoagulation bridging, patients may be at a higher risk of bleeding and intraoperative hypotension, both of which could contribute to POCD development. Conversely, without bridging therapy, they might be more susceptible to postoperative stroke, leading to changes in cognitive function postoperatively. Accordingly, we concluded that warfarin use as the current medication before surgery is a fitting variable for inclusion in the preoperative predictive model for POCD.

The previous studies proposed similar inflammatory mechanisms between frailty and POCD that lead to immunological alterations, particularly increased C-reactive protein (CRP) and interleukin-6 (IL-6).[33,34] This evidence could suggest that frailty could be associated with POCD, although the previous study did not find a relationship.[31] The difference in time to detect POCD could influence this finding as frailty was not associated with POCD at 3 months, but an association between frailty and POCD at 1 week was reported.[32] Likewise, our study found a significant connection between frailty and the development of early POCD. Including frailty also enhances the predictive value of established risk scores, such as the Society of Thoracic Surgeons Predicted Risk of Mortality or Major Morbidity.[35] Hence, it is reasonable to consider preoperative frailty as part of the POCD predictive model since frail surgical patients may be at risk of developing POCD.

Regarding the postoperative model prediction, it

includes poor functional status, intraoperative isoflurane, and receiving of intraoperative blood transfusion. These factors align with previous evidence of POCD triggers.[9,19,20,23] Shiraboina et al. identified the intraoperative administration of more than two units of transfused blood (odds ratio 4.32, 95% CI 1.59–11.70, p = 0.004) was a single independent predictor for the development of early POCD after cardiac surgery.[6] Another recent study introduced the use of a nomogram model for POCD prediction. It incorporated preoperative features (age ≥ 70, body mass index < 18.5 kg/m^2, presence of cerebrovascular disease, white blood cell count > 10 x 10^9/L, hemoglobin level < 120 g/L) and intraoperative events (intraoperative blood loss > 400 ml, operative time > 8 hours). The model showed promising discrimination with an acceptable AUROC value of 0.710 (95% CI 0.645–0.775).[7] The calibration value was also satisfactory, with the fit confirmed according to the Hosmer–Lemeshow test (χ^2 5·133, p = 0.274).[7]

However, the previous models were limited to specific surgical populations and included intraoperative variables irrelevant to the preoperative period.[7,8] In contrast, our two models cater to geriatric patients in preoperative and immediate postoperative periods. This attribute broadens their applicability in predicting POCD risk across cardiac and noncardiac surgical patients. Our postoperative model prediction also added intraoperative isoflurane as the potential anesthetic agent with an increasing probability of detecting early POCD.

Our study has several strengths. Firstly, the study identified variables best suited for the POCD predictive model. They were either consistent with or different from factors used in earlier models.[6,7] Despite the variance in components, our predictive model demonstrated comparable AUROC and fit tests to prior studies.[7] Secondly, our approach capitalized on the strength of prospective cohort studies by meticulously collecting all pertinent parameters and confounders during the perioperative period. Lastly, our multidisciplinary team of skilled healthcare personnel also evaluated POCD with the MoCA tool. This instrument has a higher sensitivity than the MMSE screening tool and has proven to be an optimal and effective standalone resource for cognitive screening.[27]

This study has some limitations. While we employed a larger sample size than previous studies, only older patients were included. Given that their mean age was approximately 71 years, the study findings may be less applicable to younger patients. The number of patients in our study was also insufficient to classify POCD risk by surgery type. Furthermore, we created a POCD predictive formula by combining various pre- and intraoperative parameters from other studies to craft the most suitable model. The external validity of this approach requires further verification. Despite these challenges, the model successfully demonstrated satisfactory discrimination and fitness in our tests. Future research could explore the application of this predictive model to various surgical procedures and potentially across different age groups.

CONCLUSIONS

The preoperative and immediate postoperative POCD predictive models could be beneficial for implementation. Early identification of patients at risk for POCD may enable targeted counseling and preventive measures, enhancing patient care and outcomes.

Data Availability Statement

The principal investigator (A.S.) can provide the data that support the findings of this study upon reasonable request.

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Conflict of Interest

The authors assert that the research was undertaken without any commercial or financial relationships that might be construed as potential conflicts of interest.

Registration Number of Clinical Trial

This trial was registered in the Thai Clinical Trials Registry on the 15th of January, 2019 (registration number: TCTR20190115001).

Authors' Contributions

Conceptualization, A.S., P.S., and V.S. ; Methodology, A.S. and S.T. ; Validation, P.S. ; Formal analysis, A.S.

; Managed resources, V.S. ; Evaluated the data, C.J. ; Writing – original draft, A.S. and P.So. ; Writing – review and editing, A.S., P.So., P.S., P.L., U.S., E.M., B.P., S.T. and V.S. ; Funding acquisition, A.S.; Supervision, A.S. All authors have read and agreed to the final version of the manuscript.

Use of Artificial Intelligence

The authors declare that no artificial intelligence tools were used in this study or in the preparation of the manuscript.

Ethics Approval and Consent to Participate

The Institutional Review Board of Siriraj Hospital, Faculty of Medicine Siriraj Hospital, Mahidol University, approved this study (approval number Si 699/2020). It was conducted in accordance with the ethical guidelines set forth in the 1964 Declaration of Helsinki and its subsequent amendments. All participants provided written informed consent.

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