Original Article

Reliability and Validity Study of a Simple Assessment Tool for Early Detection of Perioperative Stroke

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Background: Stroke is a feared postoperative complication. The diagnosis is usually delayed resulting in a reduced possibility for therapeutic intervention.

Objective: To assess the reliability and validity of a simple assessment tool for early detection of perioperative stroke.

Materials and Methods: The authors set up a short course and workshop for all service nurses in neurological screening method for the assessment tool for early detection of perioperative stroke including observing eye deviation or extraocular muscle limitation, asymmetrical limb weakness, and conscious changes in 24 surgical wards in Siriraj Hospital. The protocol was applied during routine postoperative vital sign measurement to evaluate new neurological deficits within 14 days after surgery. The postoperative patients were selected under the permission. The authors used content validity, sensitivity, specificity, and analysis to measure content and criterion validity, respectively. The authors also tested inter-rater reliability by using Kappa and Fleiss's Kappa statistics.

Results: Four hundred twenty-five postoperative patients between June and December 2018 were assessed by the protocol. The sensitivity was 85.71% and specificity was 98.02%. Positive predictive value (PPV) and Negative predictive value (NPV) was 69.23% and 99.25%, respectively. The accuracy of the tool was 97.41%. The interrater reliability was substantial agreement.

Conclusion: This simple assessment tool is a valid and reliable clinical tool used for perioperative stroke screening. The tool is simple and quick to perform among nurses and physicians. The tool was designed to detect only moderate to severe stroke that required treatment intervention due to postoperative treatment limitation.

Keywords: Diagnosis, Screening, Perioperative, Postoperative, In-hospital, Tool, Stroke

Received 16 November 2020 | Revised 11 January 2021 | Accepted 13 January 2021

J Med Assoc Thai 2021;104(4):527-35

Website: http://www.jmatonline.com

Acute ischemic stroke (AIS) is a time-limited disease for treatment[1]. However, 6.5% to 15.0% of all strokes occur in hospital and most of them are perioperative, which are more severe and worse outcome compared with out of hospital stroke[2-4]. Perioperative stroke is a devastating complication that carries high mortality and disability. Unfortunately, anesthesia and analgesia use in perioperative may obscure important warning signs that may lead to a delay in the assessment and treatment of major stroke after surgery[5]. About 45% of stroke is within the first day after surgery and 55% occur from the second postoperative day. The incidence of perioperative stroke depends on the type and complexity of the surgical procedure[6]. Stroke is a well-recognized complication of cardiac procedures and is less frequent in general surgery[2,4]. Problems in perioperative stroke management include delay in recognition, and intravenous tissue plasminogen activator is relatively contraindicated within 14 days of major surgery[1,2,5,7]. The guidelines recommend that catheter-based mechanical thrombectomy within 6 to 24 hours have a role in post-surgical patients if they meet the criteria[7].

In the previous study, the authors developed a new protocol shortening the time to detect neurological deficits in postoperative cardiovascular

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How to cite this article:

Danworapong W, Kaveeta C, Hunnangkul S, Wongmayurachat K, Kongmuangpuk M, Nilanont Y. Reliability and Validity Study of a Simple Assessment Tool for Early Detection of Perioperative Stroke. J Med Assoc Thai 2021;104:527-35.

doi.org/10.35755/jmedassocthai.2021.04.11004

patients in Siriraj Hospital and showed a significant decreased in the median stroke onset duration. The increased proportion of stroke fast track activations demonstrated the value of the protocol[8]. The authors modified and implemented this protocol to all major types of surgery in the present hospital. The authors proposed to assess the reliability and validity of a simple assessment tool for early detection of perioperative stroke, especially major stroke with severe deficit, that may have benefit from thrombectomy or thrombolysis in 24 surgical units in Siriraj hospital, Bangkok, Thailand.

Objective

To assess the reliability and validity of a simple assessment tool for early detection of perioperative stroke.

Materials and Methods

Study design

This study was a prospective single center cohort study, done between November 2017 and December 2018. The screening simple assessment tool for early detection of perioperative stroke was implemented to all major types of surgery in the authors' hospital after the training program was completed for all related nurses between June and December 2018. The study protocol was approved by the Siriraj Institutional Review Board (813/2560:EC3).

Study population

The present study was performed at an academic university hospital after review and approval by the Institutional Review Board and Ethics Committees. The study was a prospective single center cohort study. Data were collected from patients 18 years or older that underwent the following surgery, general or non-cardiac surgery including minimally invasive surgery, cardiothoracic surgery including open-heart surgery, coronary artery bypass grafting (CABG), valve surgery, aortic surgery, and ventricular assist device implant, vascular surgery and endovascular surgery including coronary angiography, percutaneous coronary intervention, carotid stent placement, and peripheral artery angioplasty, orthopedic surgery, gynecological surgery and head neck tumor surgery in Siriraj Hospital. The authors assessment in 24 surgical wards consisted of six recovery rooms, two surgical intensive care units, two cardiovascular and thoracic intensive care unit, two cardiovascular and thoracic wards, six non-cardiac surgical wards, an orthopedic ward, an ear-nose-throat ward, a post-transplantation ward, and four obstetrical and gynecological wards.

Data collection

The authors collected demographics data, comorbidities, and types and details of surgery and anesthesia. In patients with abnormal screening, the detail of neurologic deficits, operative time, last seen normal time, the activated fast track time, final diagnosis, treatment options, complications, and outcome were collected. Stroke severity and neurological impairment were measured by the National Institutes of Health Stroke Scale (NIHSS) by on-call neurologist at scene when stroke fast track was activated immediately. Diagnosis of stroke was defined by new neurological deficit without other causes or neuroimaging showed new evidence of stroke. Stroke subtype was diagnosed based on the TOAST classification and the initial neuroimaging was done by emergency non-contrast computed tomography (CT) scan or magnetic resonance imaging (MRI) of brain.

Study intervention

Before applying the simple assessment tool, all responsible nurses participated in the stroke educational campaign by the stroke team and bedside workshop in each of the 24 surgical wards. The protocol involved three components as shown in Figure 1.

Knowledge education: The authors set up a short course and hand-on workshop for all nurses about neurological screening in the assessment tool for early detection of perioperative stroke.

Neurological deficit screening: All enrolled post-operative patients will be screened by nurses for neurological deficit during routine postoperative vital signs measurement. The present study categorizes stroke detection into two phases, early and delayed phases according to the pathophysiology of peri-operative stroke. The manner of stroke detection in each phase is different due to patient characteristics and conditions. The nurse will record in the recording form. The neurologists and nurses in the stroke team will reevaluate as protocol once a week in each ward.

The details are shown as the following and as Figure 2.

1. Early phase

Interval: After surgery to 24 hours post-operative

Assessment was performed at recovery room; an hour after the operation or before leaving the recovery room, if leaving earlier, according to patient cooperation.

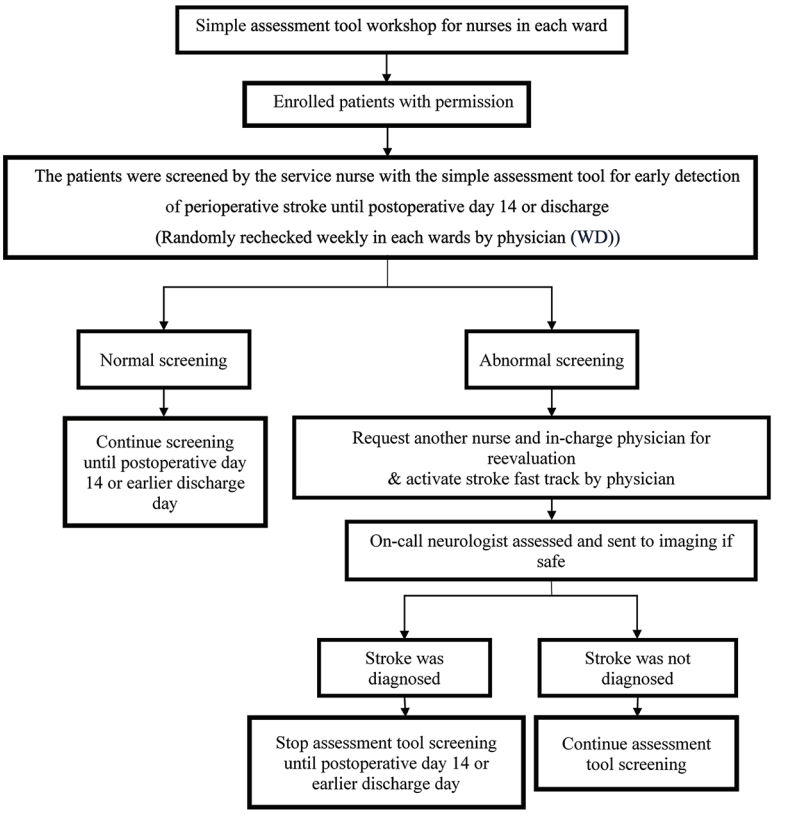

Figure 1. Algorithm in the simple assessment tool screening.

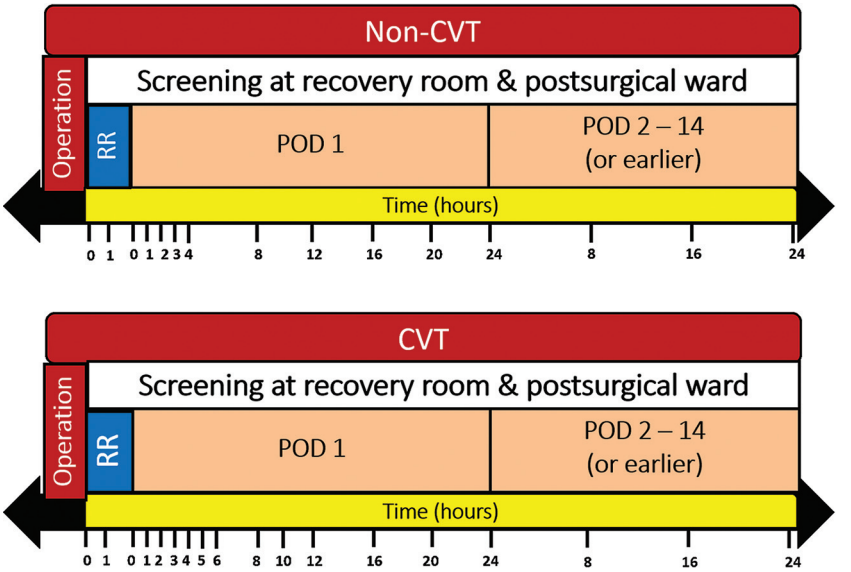

Figure 2. The timeline for neurological screening in each ward.

CVT: cardiovascular and thoracic surgery; POD: postoperative day; RR: recovery room

1.1 Cardiovascular and thoracic surgery (CVT): assessment was performed every hour for the first 6 hours, then every two hours for next 6 hours and every four hours until 24 hours.

1.2 Other surgical types: assessment was performed every hour for the first 4 hours and then every four hours until 24 hours.

• ***In not-well cooperative patient***: assess for

- Eye deviation
- Asymmetrical motor power of hand grip or the inability to sustain both knees in flex position if they cannot do hand grip

• ***In well cooperative patient***: check for

- Horizontal extraocular movement
- Hand grip
- Knee flexion or dorsiflexion of both feet if the patient experience aortic surgery or aortic clamping, groin surgery or any surgery that cannot move the leg

The nurse will notify physician when found any of the neurological deficits as listed above or if alteration in level of consciousness, or not full recovery within four and six hours after CVT operation and other surgery, respectively.

2. Delayed phase

Interval: Postoperative day 2 until post-operative day 14 or discharge

Nurses assessed every eight hours for the new neurological deficits as the protocol.

Diagnosis: When any abnormality was detected by the first nurse, the second nurse will recheck and record. The in-charge physician was notified, and the stroke fast track was activated. Diagnosis of stroke was made by a neurologist based on either clinical or imaging (if available) and relevant laboratory investigations to exclude stroke mimics.

Interrater reliability testing: Raters were assigned in random pairs to individual patients. Evaluations were performed independently by the two nurses and a physician. For minimizing the impact of clinical status changes, the second nurse and neurologist immediately follow the first. Each examiner was blinded from each other, including the result of screening test. Each patient was examined for only one set of evaluations.

Definition

Stroke: Any new permanent global or focal neurological deficit of cerebrovascular cause that persists beyond 24 hours or is interrupted by death within 24 hours. Transient ischemic attacks (TIA) were defined as neurological symptoms lasting less than 24 hours[9,10].

Perioperative stroke: The authors modified the definition for compatibility with the authors' clinical practice as postoperative stroke that occurs within 14 days[9].

True alarm: An alarm that was diagnosed by either clinical or radiographic imaging as one of the following, AIS, transient ischemic attack, intracerebral hemorrhage, subarachnoid hemorrhage, or spinal cord infarction.

False alarm: An alarm caused by other diagnosis.

Nurse: All practical nurses that work in recovery rooms and all including wards. They were also trained for neurological screening in the assessment tool for early detection of perioperative stroke.

Statistical analysis

Analyses were performed with PASW Statistics, version 18.0 (SPSS Inc., Chicago, IL, USA) and comparisons were made with chi-square (χ^2) test for categorical variables. All tests were 2-tailed and p-values of less than 0.05 were considered statistically significant. Analysis of predictive validity such as sensitivity, specificity, negative predictive value (NPV), and positive predictive value (PPV) and odd ratio, internal structure, and interrater reliability in each and overall item in the tool, including the analyses of 2 (two nurses) and 3 (two nurses and a neurologist), independent raters' reliability by using Kappa and Fleiss's Kappa statistics, respectively with 95% confidence interval (CI).

Results

The authors enrolled 427 patients in this study under permission and two patients were excluded due to cancelled operation. Among 425 postoperative patients, 26 patients had abnormal screening. Demographic data were shown in the Table 1 with comparison of true and false alarm group. They were similar in range of age, gender, comorbidities, and anesthetic type in all patient's group. The three most enrolled surgical types were general surgery as non-cardiac at 36.2%, cardiac surgery at 20.2%, and vascular surgery at 13.7%. General anesthesia was used in 86.8%.

Figure 3 showed the number of perioperative patients with normal and abnormal screening with definite diagnosis. Twenty-six patients with abnormal screening tool were activated by stroke fast track protocol, 18 patients had true stroke and eight patients did not and were finally diagnosed with metabolic causes, seizure, and stroke mimics due to medication

Table 1. Baseline and demographic data, stroke risk factors, and anesthetic types

Variables	Total enrolled patients (n=425); n (%)	Abnormal screening tool group; n (%)		
		True alarm (n=18)	False alarm (n=8)	Group comparison p-value
Age (years), mean±SD (range)	56.66±15.47 (18 to 89)	66.94±13.28 (39 to 89)	67.75±8.70 (54 to 78)	0.781
Sex				0.347
Male	202 (47.53)	13 (72.22)	6 (75.00)	
Female	223 (52.47)	5 (27.78)	2 (25.00)	
Type of surgery				0.405
Cardiac	87 (20.20)	7 (38.89)	1 (12.50)	0.178
Vascular	60 (13.69)	3 (16.67)	4 (50.00)	0.077
Thoracic	27 (6.30)	0 (0.00)	0 (0.00)	0
General surgery	156 (36.20)	6 (33.33)	2 (25.00)	0.671
Orthopedic	44 (10.20)	2 (11.11)	1 (12.50)	0.919
Obstetrics/Gynecological	5 (1.20)	0 (0.00)	0 (0.00)	0
Ear/Nose/Throat	52 (12.10)	1 (5.56)*	0 (0.00)	0.497
Comorbidity				
Diabetes mellitus	105 (24.71)	7 (38.89)	4 (50.00)	0.597
Hypertension	214 (50.35)	14 (77.78)	8 (100)	0.147
Dyslipidemia	164 (38.59)	14 (77.78)	7 (87.50)	0.562
Coronary artery disease	66 (15.53)	5 (27.78)	0 (0.00)	0.097
Peripheral artery disease	32 (7.53)	2 (11.11)	2 (25.00)	0.365
Obesity	76 (17.88)	3 (16.67)	1 (12.50)	0.786
Dialysis	28 (6.59)	1 (5.56)	2 (25.00)	0.152
Atrial fibrillation	28 (6.59)	3 (16.67)	1 (12.50)	0.786
Valvular heart disease	41 (9.65)	3 (16.67)	0 (0.00)	0.220
History of stroke	16 (3.76)	1 (5.56)	2 (25.00)	0.152
Cancer	92 (21.65)	5 (27.78)	0 (0.00)	0.097
Smoking	78 (18.35)	4 (22.22)	2 (25.00)	0.877
Usage of antiplatelet or anticoagulant	122 (28.71)	8 (44.44)	6 (75.00)	0.149
Anesthetic types				
General	369 (86.82)	16 (88.89)	7 (87.50)	0.919
Regional	56 (13.18)	2 (11.11)	1 (12.50)	0.919

SD=standard deviation

* This patient was undergone vascular and ear-nose-throat surgery

effect. The prevalence of stroke in the present study was 4.94%. Patients experienced eye abnormality in 24.14%, unilateral limb weakness in 82.76%, alteration of consciousness and Glasgow Coma Scale (GCS) change in 41.38%. The abnormal signs were limb weakness, alteration of consciousness, and eye movement abnormalities, respectively. Perioperative strokes were common in cardiac, general, and vascular surgery, respectively. The 102 nurses spent approximately one to two minutes (57 to 121 seconds, 81.22±15.78 seconds) to complete the protocol.

In 18 stroke patients, four patients had received endovascular thrombectomy. The first was an 84-year-old male with triple vessel disease (TVD) S/P CABG who developed gaze preference and right hemiparesis and diagnosed the internal carotid artery (ICA) occlusion with NIHSS 29/40 (intubation) and post thrombectomy NIHSS 6/42. The second was a 62-year-old female with colonic cancer S/P sigmoidectomy and colorectal anastomosis with cystectomy who developed middle cerebral artery (MCA) occlusion (hemiparesis), which NIHSS 7/42 to full recovery. The third was a 76-year-old male with TVD S/P CABG who developed MCA occlusion as gaze preference and hemiparesis, with NIHSS 18/42 to 7/42. The last was a 47-year-old female with carotid

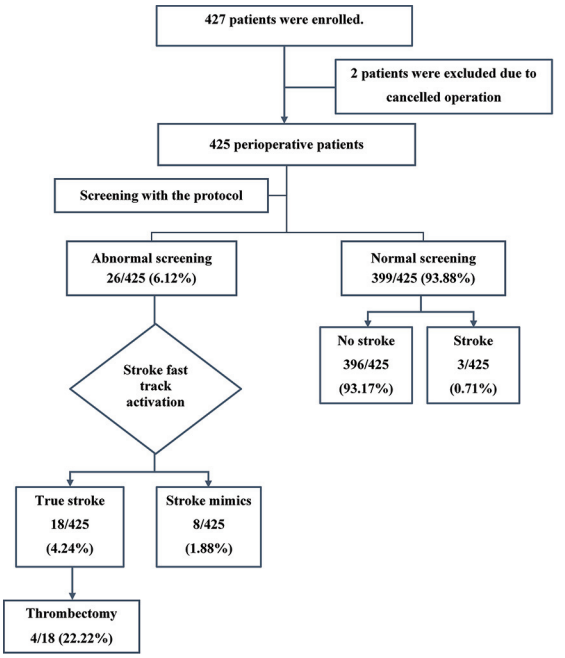

Figure 3. The number of perioperative patients with normal and abnormal screening and with definite diagnosis.

body tumor S/P tumor removal who developed MCA infarction as gaze preference and hemiparesis, which NIHSS 15 to 2/42. Other information in true and false alarm groups are in the Table 2 and 3.

There were 93.88% with normal screening and three patients had minor stroke which required no treatment intervention. These patients had only facial palsy, dysarthria, or sensory impairment that were not the items in simple assessment tool. They were found during ward round with attending physician and did not activate the stroke fast track due to delayed onset of stroke.

The simple assessment tool for early detection of perioperative stroke had 85.71% sensitivity (95% CI 63.66 to 96.95), 98.02% specificity (95% CI 96.14 to 99.14), 69.23% PPV (95% CI 52.57 to 82.04), 99.25% NPV (95% CI 97.89 to 99.74), 43.29 positive likelihood ratio (95% CI 21.33 to 87.86), 0.15 negative likelihood ratio (95% CI 0.05 to 0.42), and 97.41% accuracy (95% CI 95.42 to 98.70), significantly.

From 51 patients, a physician and a pair of nurses examined the patients as the protocol. The interrater reliability in Table 4 shows the Kappa and Fleiss's Kappa statistic and the associated 95% CI and the interrater reliability between two nurses and three raters including two nurses and a physician, for each item in the assessment tool. The calculated values were in the expected range for all items. The values indicated good to excellent agreement for each and overall items of the test. The nurses spent approximately one to two minutes (57 to 121 seconds, 81.22±15.78 seconds) to complete this protocol.

Table 2. Comparison of activated fast track day, operative times, abnormal signs, and management in abnormal screening tool between true and false alarm group

	True alarm (n=18); n (%)	False alarm (n=8); n (%)
Postoperative day that activated stroke fast track		
Day 1	8 (44.4)	6 (75.00)
Day 2	3 (16.67)	1 (12.50)
Day 3	3 (16.67)	1 (12.50)
Day 4	3 (16.67)	0 (0.00)
Day 5	1 (5.56)	0 (0.00)
Day 6 to 14	0 (0.00)	0 (0.00)
Operative time (minutes); mean±SD	233.89±122.67	326.88±222.97
Abnormal signs and symptoms		
Included in tool		
• Eye deviation/limitation of EOM	6 (33.33)	1 (12.50)
• Limb weakness	17 (94.44)	7 (87.50)
• Alteration of consciousness	6 (33.33)	6 (75.00)
Not included in tool		
• GCS changes ≥2	6 (33.33)	6 (75.00)
• Pupillary abnormality	1 (5.56)	1 (12.50)
• Facial weakness	11 (61.11)	0 (0.00)
• Dysarthria	10 (55.56)	1 (12.50)
• Visual field defect	7 (38.89)	0 (0.00)
• Aphasia	3 (16.67)	0 (0.00)
• Neglect	4 (22.22)	0 (0.00)
• Cerebellar dysfunction	0 (0.00)	1 (12.50)
• Abnormal movement	0 (0.00)	3 (37.50)
Management (true alarm)		
Endovascular thrombectomy	4 (22.22)	0 (0.00)
Antiplatelet/anticoagulant	12 (66.67)	0 (0.00)
Thrombolysis	0 (0.00)	0 (0.00)

SD=standard deviation; EOM=extraocular muscle; GCS=Glasgow Coma Scale

Discussion

Standard guideline for postoperative stroke detection had never been established before. Currently, only two stroke assessment scales have been applied in the perioperative setting[5]. The Western Perioperative Neurologic Scale was designed to determine new neurologic deficits after cardiac surgery[11]. The Western perioperative neurologic

Table 3. Summary of gender, age, abnormal signs, localization and management in true alarm group

ID	Sex/age (year)	Eye	Weak	AOC	GCS	Face	Dysarthria	Visual field defect	Cortical lobe signs	Localization#	Management
1	M/62	N	A	N	N	N	N	N	N	3	Medication
2	F/89	N	A	N	N	N	A	N	N	1	Medication
3	M/79	N	A	N	N	N	N	N	N	3	Medication
4	M/84	A	A	A	N	A	N (intubation)	A	A	1	EVT
5	M/66	A	A	A	A	A	N (intubation)	A	A	1	Medication*
6	F/62	N	A	A	A	A	A	N	N	1	EVT
7	F/77	N	A	A	A	N	N	N	N	4	Craniotomy with clot removal
8	M/62	N	A	N	N	N	N	N	N	5	Medication
9	F/72	N	A	N	N	N	N	N	N	3	Medication
10	M/39	A	N	N	N	N	N	A	N	2	Medication
11	F/64	N	A	N	N	A	A	N	N	5	Medication
12	M/65	A	A	N	N	A	A	A	N	1	Medication
13	F/47	A	A	A	A	A	A	A	A	1	EVT
14	M/45	A	A	A	A	A	A	A	A	1**	Craniectomy
15	F/73	N	A	N	N	A	A	N	N	3	Medication
16	F/76	N	A	N	N	A	A	N	N	3	Medication
17	M/67	N	A	N	N	A	A	N	N	3	Medication
18	M/76	A	A	N	N	A	A	A	A	1	EVT

AOC=alteration of consciousness; GCS=Glasgow Coma Scale; M=male; F=female; N=normal; A=abnormal; EVT=endovascular thrombectomy

Localization: 1, anterior circulation (ACA/MCA) stroke; 2, posterior circulation stroke; 3, minor stroke; 4, hemorrhagic stroke; 5, transient ischemic attack (TIA)

* ASPECT 2/10; ** Hemorrhagic transformation in the following day

Table 4. Interrater reliability of the simple assessment tool for early detection of perioperative stroke

Item	2 raters (between 2 nurses)			3 raters (between 2 nurses and a physician)	
	Kappa statistics	95% CI	Interpretation	Fleiss's Kappa statistics	Interpretation
Eye deviation/EOM limitation	0.69	0.37 to 1.00	Substantial	0.72	Substantial
Limb weakness	0.75	0.53 to 0.98	Substantial	0.80	Substantial
Alteration of consciousness	0.78	0.49 to 1.00	Substantial	0.85	Almost perfect
Overall	0.70	0.48 to 0.91	Substantial	0.76	Substantial

EOM=extraocular muscle; CI=confidence interval

scale was designed to detect neurologic deficits after cardiac surgery. It includes 14 items classified into eight domains, which are mentation, speech, cranial nerve function, motor weakness, sensation, and cerebellum, re flexes, and gait. Each item is scored from 0, meaning severe deficit, to 3 as normal, and a maximum score of 42 indicates normal neurological function[11].

In the perioperative setting, the NIHSS has been extensively adopted in clinical trials including trials in cardiac, neurologic, and carotid artery surgery[5]. The NIHSS contains 15 test items to measure acute stroke-related neurological deficit[12]. The scores range from 0 meaning no deficit, to a maximum of 42[12]. However, none of the assessment scales have been tested in non-cardiac, non-neurosurgical surgery[5].

The previous study proposed the new protocol proving the advantage in early stroke detection and increased stroke awareness[5,8]. In general, the important requirements for clinical measurements are reliability and validity. This assessment tool in our study demonstrated a high specificity, sensitivity, accuracy, and NPV for the diagnosis of perioperative stroke. The present study showed that the simple assessment tool has a good validity and interrater reliability for perioperative stroke detection. In the present study, the diagnosis of stroke was confirmed by a neurologist and CT/MRI scan was performed in

all cases. It is applicable to real world practice. The present study involved multiple types of surgery.

The setting of perioperative stroke was very unique due to the contraindication of intravenous thrombolytic therapy and the limitation to perform detailed neurological examination[5,7]. It would be more reasonable to have a simple clinical tool designed to detect only moderate to severe stroke. Owing to the limitation of treatment option in perioperative stroke, the authors selected only the clinical signs that represented marked NIHSS score. If all items were abnormal, it will be equal to 7 to 14 points of NIHSS, which could capture perioperative stroke patients with large vessel occlusion. From high NPV, the present tool was designed to capture only the disabling stroke that the role of thrombectomy or thrombolysis would be considered.

The present tool cannot exclude some mimic conditions that had neurological deficit such as metabolic causes so that there was a low PPV. The overall validity of the tool may be accrued by adding facial palsy and dysarthria. Adding two items can help detect true alarm. However, the nurse will spend more times and the management may be unchanged due to including more minor stroke in the present study.

Test and re-test reliability of the Western Perioperative Neurologic Scale has been established. In 28 patients recovering from stroke, the interclass correlation coefficient for assessments performed a week apart was 0.99[11]. In the present study, the reliability test, based on the calculated statistics, of the present tool is substantially reliable in assessing eye abnormalities as gaze deviation or extraocular muscle [EOM] limitation, limb weakness, and alteration of consciousness. Similar substantial to excellent degrees of interrater agreement was found between the two nurses and three raters. Alteration of consciousness has high intertester reliability. Overall, there is substantial degree in interrater agreement.

Compared to NIHSS that is being used by physicians, which include neurologists and non-specialists, our tool has good agreement among observers[12-14]. The NIHSS can be usually completed within seven minutes[12]. The simple assessment tool is not screened by physician but mainly the responsible nurses to detect perioperative major stroke. It requires shorter times to complete the screening protocol. In the present study, all practical nurses in responsible wards were trained by stroke team.

Conclusion

The present simple assessment tool is a valid and reliable clinical tool used for perioperative stroke screening. The tool is simple and quick to perform among nurses and physicians. The tool was designed to detect only moderate to severe stroke, which required treatment intervention due to postoperative treatment limitation.

What is already known on this topic?

Perioperative stroke is a devastating complication that carries high mortality and functional disability. Unfortunately, residual anesthesia and analgesia may obscure important warning signs and may lead to a delay in the assessment and treatment of major stroke after surgery. Most of the stroke scales were designed to evaluate current neurological deficits after an established stroke event. Problems in perioperative stroke management include delay in recognition, and that intravenous tissue plasminogen activator is relatively contraindicated within 14 days of major surgery. The guidelines recommend that catheter-based mechanical interventions within six hours have a role in post-surgical patients if they meet the criteria.

What this study adds?

The purpose of this study is to examine the utility of the simple assessment tool, for the early recognition of perioperative stroke in the cardiac and non-cardiac surgical population. However, in the general postsurgical wards, given the concern about the workload required, a simple assessment tool may be more appropriate for routine regular stroke surveillance. It is hoped that this simple assessment tool will provide rapid assessment of global neurological function to facilitate timely diagnosis and treatment of perioperative stroke.

Acknowledgement

The present study was greatly supported by the department of nursing, Siriraj Hospital, and all service nurse teams for patient screening in the protocol and the graphic design team in Siriraj hospital. The authors thank Siriraj stroke center for all support.

Conflicts of interest

The authors declare no conflict of interest.

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