Original Article

# Early Stroke Detection in Perioperative Patients: A Simple Educational Intervention and Feasibility Study

Charoenratt Chaicharoentanaporn MD[1], Worawong Slisatkorn MD[2], Saowalak Hunnangkul PhD[3], Usa Pipatsatukit RN[4], Gustavo Saposnik MD[5], Kanokkarn Wongmayurachat RN[6], Yongchai Nilanont MD[1,6]

[1] Neurology Division, Department of Medicine, Faculty of Medicine, Siriraj Hospital, Mahidol University, Bangkok, Thailand

[2] Cardiothoracic Division, Department of Surgery, Faculty of Medicine, Siriraj Hospital, Mahidol University, Bangkok, Thailand

[3] Department of Research and Development, Faculty of Medicine, Siriraj Hospital, Mahidol University, Bangkok, Thailand

[4] Department of Nursing Siriraj Hospital, Faculty of Medicine, Siriraj Hospital, Mahidol University, Bangkok, Thailand

[5] Stroke Outcomes Research Unit, University of Toronto, Canada, Faculty of Medicine, Siriraj Hospital, Mahidol University, Bangkok, Thailand

[6] Siriraj Stroke Center, Faculty of Medicine, Siriraj Hospital, Mahidol University, Bangkok, Thailand

***Background***: Perioperative stroke is uncommon. However, it carries high morbidity and mortality. Unfortunately, the diagnosis is usually delayed resulting in reduced possibility for therapeutic intervention.

***Objective***: To develop a protocol directed at shortening the time to detect neurological deficits in postoperative patients.

***Materials and Methods***: By using a pre-post intervention design to evaluate the time to stroke recognition in post-open heart surgery patients. The intervention consisted of 1) A new protocol to evaluate new neurological deficits within 14 days after surgery, composed of six items of simple neurological assessment applied by CVT nurses during routine vital sign measurement. 2) An educational program for nurses, patients, and family focusing on postoperative stroke complications.

***Results***: Between January 2014 and October 2015, the authors retrospectively reviewed 27 consecutive patients with acute neurological deficit within 14 days after surgery as the pre-intervention population. Twenty-seven consecutive patients with postoperative neurological deficits were enrolled during a post-intervention period, which was between November 2015 and September 2016. Comparing pre- and post-intervention periods, the authors found that stroke fast track activation was significantly increased from 4/27 (14.80%) to 15/27 (55.60%) (p=0.002). The median (min-max) duration from time last seen normal to first neurological deficit detection was reduced from 690 (19 to 9,190) to 130 (5 to 5,935) minutes (p=0.003). The number needed to treat for early detection when the protocol was used was 2.94. There was an increasing trend to endovascular treatment.

***Conclusion***: Perioperative stroke is rare. However, it has negative impact to postoperative patients' outcome. A simple protocol for postoperative neurological assessment after cardiac surgery is feasible to detect perioperative stroke.

***Keywords***: Postoperative, In-hospital, Detection, Recognition, Stroke

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Perioperative stroke is defined as a brain infarction of ischemic or hemorrhagic stroke developed during surgery or within 30 days after surgery(1). Perioperative stroke is uncommon. In general surgery, the incidence was 0.08% to 0.7%, and higher in cardiac and vascular surgeries 7.4% to 9.7%(2). However, perioperative stroke is more severe and carries worse outcome comparing with all stroke(3-5). According to the acute ischemic stroke (AIS) guidelines, it recommends intravenous recombinant tissue plasminogen activator (rtPA) in AIS patients with time window of 4.5 hours and mechanical thrombectomy within 24 hours in AIS with large vessel occlusion (LVO)(6). Additionally, the earlier diagnosis and treatment of AIS associates with better outcome(4,7). However, recognition and diagnosis of stroke in perioperative patient is challenging due to of the complexity and difficulty in the assessment of critically ill patients(3,8,9).

More than twenty stroke assessment scales have been used as the screening tools to detect stroke.

**Correspondence to:**

Nilanont Y.

Siriraj Stroke Center, Neurology Division, Department of Medicine, Siriraj Hospital, Mahidol University, 2 Wang Lang Road, Bangkoknoi, Bangkok 10700, Thailand.

**Phone**: +66-2-4141010, **Fax**: +66-2-4141030

**Email**: ynilanon@gmail.com

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However, most of them are sophisticated and difficult to use[10]. The authors established a new screening tool, aimed for non-neurology medical personnel, nurses, patients, and family use to recognize stroke. The authors conducted a pre- and post-intervention study to promote early recognition of perioperative stroke and proved the feasibility of the screening tool.

## Materials and Methods

The authors conducted the study at Siriraj Hospital, Mahidol University, Thailand, an academic tertiary care hospital. Siriraj stroke center is a comprehensive stroke center providing standard of care for acute stroke patients, 24 hours per day, 7 days a week, by multidisciplinary teams. The study was carried out between January 2014 to October 2015, and November 2015 to September 2016, as pre-intervention and post-intervention, respectively. The study protocol was approved by the Siriraj Institutional Review Board (SIRB) (COA No.256/2558-EC2).

### Study population

Data were collected from patients 18 years and older who underwent coronary artery bypass grafting (CABG), valve and or aortic surgery, and ventricular assist device (VAD) implantation. Primary endpoints consisted of "time interval from completion of surgery to detect neurological deficits", and "rate of true alarm in the post-intervention period". The sample size was calculated based on previous studies[9,11]. The accepted probability of error was 5%, and power of test was 80%. The sample size estimation of events was 27 events in each group.

### Data collection

Data from 779 postoperative patients in the pre-intervention period between January 2014 and October 2015 were collected. It included 27 patients with acute neurological deficit within 14 days after surgery that were consecutively reviewed. Data from 461 postoperative patients in the post-intervention period between November 2015 and September 2016 were reviewed. It included 27 patients with acute neurological deficits within 14 days after surgery. Data from all postoperative patients with neurological deficit were collected, including demographic data, comorbidity, details and types of surgery, severity of neurologic deficits, operative time, time last seen normal, notification time, time to imaging, diagnosis, treatment options, complications, and outcome. Stroke severity was measured by using the National Institutes of Health Stroke Scale (NIHSS). Stroke subtypes were diagnosed based on the Trial of Org 10172 (TOAST) classification, neuroimaging was done by emergency non-contrast computed tomography (CT) scan/CT angiogram or magnetic resonance imaging (MRI) brain/MRI angiogram.

### Intervention

The present study intervention was implemented at the cardiovascular thoracic (CVT) service, which is the intensive care unit (ICU) and CVT surgical ward, of Siriraj Hospital, Mahidol University. The Review Boards and Ethics Committees of the hospital approved the present research protocol (Si455/2015). The protocol involved two components:

1. Knowledge education: The fact sheets and brochures with specific data about stroke such as the early warning signs, and symptoms, were distributed to patients and relatives at the surgery appointment center.

2. Neurological deficit screening: A protocol for early stroke detection in the perioperative patient was developed. Nurses in the CVT service attended a course and training workshop for postoperative stroke and neurological deficit screening as per the protocol. Method of stroke detection was different in each part of the protocol depending on the patient level of awareness. All patients underwent surgery were screened by nurses for neurological deficits. The screening protocol was divided into two parts.

***Part 1: Within the 24-hour postoperative period***: Post-operative patients were transferred to ICU or CVT surgical ward. The level of consciousness was first checked by simple verbal commands as follows, open and close eyes, make a fist, and open hands. Patients were classified as "Well cooperative group" if they could follow all commands and classified as "Not well cooperative group" if they could not follow any one of the commands. The protocol for early stroke detection in the first 24-hour postoperative period, please contact the author. Patients in the "Well cooperative group" were checked for hand grip strength, horizontal extraocular movement (EOM), and foot dorsiflexion in aortic surgery patients only. Patients in the "Not well cooperative group" were checked for eye deviation, hand grip, and bilateral knee flexion strength if they could not do hand grip (please contact the author). The screening protocol was performed during vital sign measurement and recorded until 24 postoperative hours.

***Part 2: After 24 hours until 14 days***: Most of the patient recovered from anesthesia in this period. Neurological symptoms and signs were observed by patients, relatives, and nurse during daily activity.

### Diagnosis

Nurses notified a physician on call if they found any abnormality from the protocol. Stroke fast track activation and neurology service consultation were considered by the MD. Stroke was diagnosed by a neurologist either clinical or imaging and relevant laboratory investigations to exclude stroke mimics.

### 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 attack (TIA) is defined as neurological symptoms lasting less than 24 hours[12,13].

***Postoperative stroke***: The definition of post-operative stroke is any stroke that occurred within 14 days postoperatively corresponding with the clinical practice[12].

***True alarm***: Postoperative patients developed neurological symptoms or signs were diagnosed by either clinical or radiographic imaging as one of the following, AIS, TIA, intra cerebral hemorrhage (ICH), subarachnoid hemorrhage (SAH), or spinal cord infarction.

***False alarm***: Postoperative patients developed neurological symptoms or signs that were not diagnosed as stroke or TIA.

### Statistical analysis

Baseline characteristics were analyzed with descriptive statistics. The results were presented as frequency and percentage for categorical variables, mean ± standard deviation (SD) or median (range) for continuous variables. A comparison of "time from operation completion to notification of neurological deficit" between the two groups were analyzed by Kaplan Meier survival analysis. A comparison of "rate of true alarms" between the two groups were analyzed using the chi-square test or Fisher's exact test. Statistical analysis was performed using PASW Statistics for Windows, version 18.0 (SPSS Inc., Chicago, IL, USA). All tests were 2-tailed, and p-value of less than 0.05 was considered statistically significant.

## Results

Overall, among the 779 patients in the pre-intervention period, which was between January 2014 and October 2015, 27 patients developed perioperative stroke. During the post-intervention period, which was between November 2015 and September 2016, 461 consecutive patients were enrolled, and 27 cases emerged with perioperative stroke. Baseline characteristic was comparable comparing pre- and post-intervention groups. Mean age in pre-intervention versus post-intervention group was 64.5±13.1 versus 63.5±13.2, p=0695. Male gender was 70.4% versus 63.5%, p=0.469 (pre-intervention versus post-intervention). Pre intervention group had aortic surgery more than post intervention group (62.9% versus 25.5%, p<0.0001) (Table 1).

Stroke fast track activations were significantly increased from 4/27 (14.8%) in the pre-intervention to 15/27 (55.6%) in the post-intervention (p=0.002). True alarm was 70.37% versus 66.7%, p=0.77, and false alarm 29.63% versus 33.9%, p=0.77 (pre-intervention versus post-intervention, respectively). Symptoms of neurological deficit were mostly recognized by nurses in both groups (88.9% versus 81.5%, p=0.489). Perioperative stroke patients in both groups were found to have moderate stroke severity (NIHSS scores 16.2 versus 12.0, p=0.266), and cardioembolism (38.5% versus 61.5%, p=0.49) as a stroke mechanism by TOAST classification (Table 2).

Comparing between pre- and post-intervention groups, there was no difference in time of operation to neurological deficit detection (NDD) 36 versus 43.42 hours (p=0.729). Time last seen normal to NDD was decreased from 690 (19 to 9,190) to 130 (5 to 5,935) minutes in the post-intervention group (p=0.003). The median time of NDD to brain imaging was decreased 150 (33 to 11,009) versus 60 (31 to 3,779) minutes in post-intervention group (p=0.091) (Table 2). NNT was 2.94 based on a reduction in duration from time last seen normal to neurological deficit detection. The number and temporal pattern of the postoperative neurological deficit are shown in Figure 1. The percentage of true alarm trended to increase over time (Figure 2).

According to Siriraj acute stroke protocol, none of AIS patients obtained thrombolysis as rtPA as a contraindication in postoperative patients. Nine of AIS patients (9/27, 33.33%) in post-intervention group were eligible for endovascular treatment (EVT) based on stroke onset time of 8 hours or less, only two patients were treated with mechanical thrombectomy (2/25,8%). There was no difference in complication of treatment in both group (3.7% versus 0%, p=0.331). Most of perioperative stroke patients received

**Table 1.** Baseline characteristics between pre- and post-intervention period

| | Pre-intervention (n=27); n (%) | Post-intervention (n=461); n (%) | p-value |
|---|---|---|---|
| Age (years); mean±SD | 64.56±13.13 | 63.53±13.29 | 0.695 |
| Sex; n (%) | | | 0.469 |
| Male | 19 (70.40) | 292 (63.50) | |
| Female | 8 (29.60) | 169 (36.50) | |
| Operationa | | | |
| On-pump CABG | 12 (44.44) | 290 (62.90) | 0.055 |
| Valve surgery | 5 (18.52) | 137 (29.70) | 0.213 |
| Aortic surgery | 17 (62.96) | 117 (25.50) | <0.0001 |
| VAD insertion | 0 (0.00) | 1 (0.22) | - |
| Comorbidity | | | |
| Diabetes mellitus | 10 (37.00) | 144 (31.20) | 0.549 |
| Coronary artery disease | 13 (48.10) | 306 (66.50) | 0.051 |
| Current smoker | 3 (11.10) | 32 (7.00) | 0.431 |
| Hypertension | 22 (81.50) | 385 (83.50) | 0.790 |
| Atrial fibrillation (AF) | 7 (25.90) | 85 (18.50) | 0.337 |
| Dialysis | 1 (3.70) | 26 (5.70) | 1.000 |
| Hyperlipidemia | 12 (44.40) | 308 (67.10) | 0.016 |
| Prior stroke | 5 (18.50) | 36 (7.80) | 0.066 |
| Last serum creatinine (mg/dL); mean±SD | 1.97±1.83 | 1.47±1.56 | 0.111 |
| Last LVEF (%); mean±SD | 49.42±17.30 | 57.36±16.96 | 0.046 |
| Current medication | | | |
| Aspirin | 14 (51.90) | 283 (61.70) | 0.310 |
| Other antiplatelet | 9 (33.30) | 165 (35.90) | 0.783 |
| Beta-blocker | 11 (40.70) | 296 (64.50) | 0.013 |
| Statin | 12 (44.40) | 285 (62.10) | 0.068 |
| ACEI/ARB | 8 (29.60) | 195 (42.50) | 0.188 |
| Warfarin | 6 (22.20) | 73 (15.90) | 0.418 |
| Intra and post-operative | | | |
| Operative duration (minute); median (range) | 280 (80 to 972) | 215 (64 to 1,035) | 0.003 |
| Baseline SBP (mmHg); mean±SD | 133.93±24.02 | 130.88±24.43 | 0.529 |
| The lowest intraoperative (mmHg); mean±SD | 82.96±13.17 | 86.06±11.18 | 0.167 |
| SBP; mean | | | |
| Blood loss (mL); median (range) | 200 (50 to 450) | 350 (10 to 6,500) | 0.373 |
| Intra and post-operative AF | 9 (33.30) | 98 (21.26) | 0.152 |
| CPB time (minute); median (range) | 134.50 (74 to 268) | 105 (41 to 507) | 0.013 |
| Hypoglycemia | 0 (0.00) | 0 (0.00) | - |
| Hyperglycemia | 8 (40.00) | 33 (7.16) | 0.031 |

CABG=coronary artery bypass graft surgery; VAD=ventricular assist device; LVEF=left ventricular ejection fraction; ACEI=angiotensin-converting enzyme inhibitor; ARB=angiotensin-receptor blockers; SBP=systolic blood pressure; CPB=cardiopulmonary bypass

[a] Some patients were performed more than one type of surgery

conservative and medications (100% versus 92.6%). Comparing between pre- and post-intervention group, there was a trend toward the post intervention group to have favorable outcome modified ranking scale (mRS; 0 to 2) 29.6% versus 37%, odds ratio (1.39, 95% CI 0.45 to 4.35), p=0.564 (Table 2). Mortality rate was 18.5% and 37% in pre- and post-intervention group, respectively. The details of mRS at

**Table 2.** Stroke alertness and management

| | Pre-intervention (total alerts=27); n (%) | Post-intervention (total alerts=27); n (%) | p-value |
|---|---|---|---|
| Activate stroke fast track | 4 (14.80) | 15 (55.60) | 0.002 |
| True alarm | | | 0.770 |
| Total true alarm | 19/27 (70.37) | 18/25 (66.7) | |
| Acute ischemic stroke | 14 (73.70) | 13 (72.20) | |
| Transient ischemic attack | 1 (5.30) | 2 (11.10) | |
| Intracerebral hemorrhage | 0 (0.00) | 0 (0.00) | |
| Subarachnoid hemorrhage | 0 (0.00) | 1 (5.60) | |
| Spinal cord infarction | 4 (21.10) | 2 (11.10) | |
| False alarm | | | 0.770 |
| Total false alarm | 8/27 (29.63) | 9/27 (33.9) | |
| Subdural hematoma | 7 (87.50) | 1 (11.10) | |
| Other[b] | 1 (12.50) | 8 (88.90) | |
| TOAST classification (only diagnosis of acute ischemic stroke and TIA) | | | 0.490 |
| 1 | 0 (0.00) | 0 (0.00) | |
| 2 | 5 (38.50) | 8 (61.50) | |
| 3 | 2 (15.40) | 1 (7.70) | |
| 4 | 0 (0.00) | 0 (0.00) | |
| 5 | 6 (46.20) | 4 (30.80) | |
| NIHSS; mean±SD | 16.25±8.45 | 12.07±10.24 | 0.266 |
| Symptom recognition | | | 0.489 |
| Nurse | 24 (88.90) | 22 (81.50) | |
| Doctor | 1 (3.70) | 0 (0.00) | |
| Patient | 1 (3.70) | 2 (7.40) | |
| Relative | 1 (3.70) | 3 (11.10) | |
| Time interval; median (range) | | | |
| Operation completion to NDD (hour) | 36 (3 to 302.92) | 43.42 (1.13 to 546.75) | 0.729 |
| Time last seen normal to NDD (minute) | 690 (19 to 9,190) | 120 (5 to 5,935) | 0.003 |
| NDD to imaging (minute) | 150 (36 to 11,009) | 65 (31 to 3,779) | 0.091 |
| Management | | | |
| Initial blood glucose (mg/dL); mean±SD | 188.62±49.98 | 165.55±67.73 | 0.200 |
| Imaging study performed | 25 (92.60) | 24 (88.90) | 0.639 |
| Option of treatment | | | 0.318 |
| IV rt-PA | 0 (0.00) | 0 (0.00) | |
| Mechanical thrombectomy | 0 (0.00) | 2 (7.40) | |
| Conservative and medication | 27 (100) | 25 (92.60) | |
| Complication of treatment | | | 0.331 |
| Yes | 1 (3.70) | 0 (0.00) | |
| No | 26 (96.30) | 27 (100) | |
| Outcome (mRS of post-intervention compares with pre-intervention group) | | | |
| Favorable mRS (0 to 2) at discharge | 8 (29.6) | 10 (37.0) | 0.564 |
| • Odds ratio (95% CI) | 1.39 (0.45 to 4.35) | | |
| Favorable mRS (0 to 2) at 3 months | 11 (45.8) | 10 (38.5) | 0.598 |
| • Odds ratio (95% CI) | 0.74 (0.24 to 2.28) | | |

TOAST=Trial of Org 10172 in Acute Stroke Treatment; NIHSS=National Institute of Health Stroke Scale; IV rt-PA=intravenous recombinant tissue plasminogen activator; mRS=modified Rankin Scale; NDD=neurological deficit detection; SD=standard deviation; CI=confidence interval

[b] The other diagnosis composed of drug side effect, delirium, and seizure

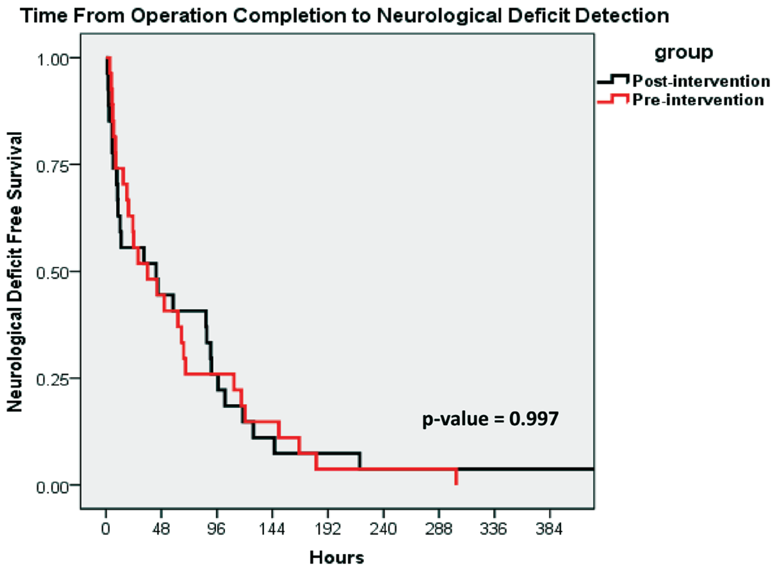
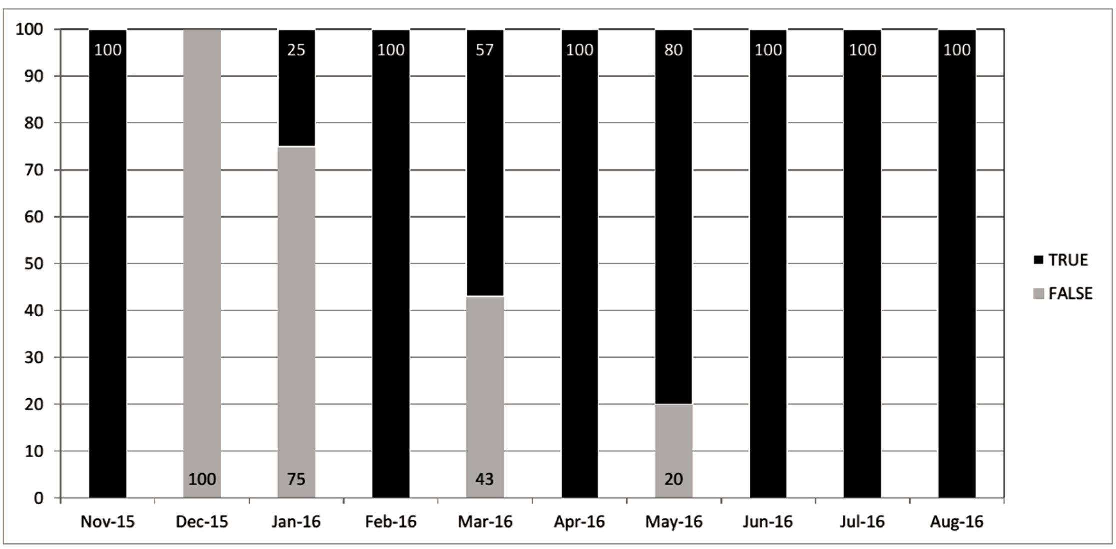



**Figure 1.** Cumulative plots for postoperative neurological deficit free. Nearly half of patients in both groups developed neurological deficit within 2 days and the incidence of postoperative neurological deficit trended to decline over time.




| | Nov-15 | Dec-15 | Jan-16 | Feb-16 | Mar-16 | Apr-16 | May-16 | Jun-16 | Jul-16 | Aug-16 |
|---|---|---|---|---|---|---|---|---|---|---|
| FALSE | 0 | 2 | 3 | 0 | 3 | 0 | 1 | 0 | 0 | 0 |
| TRUE | 2 | 0 | 1 | 1 | 4 | 1 | 4 | 3 | 1 | 1 |

**Figure 2.** Percentage of true and false alarm in post-intervention group.

discharge and 3-month follow-up are demonstrated in Figure 3 and 4.

## Discussion

Perioperative stroke is a rare complication after surgery. The prevalence was found to be higher in cardiac and vascular surgery comparing with non-cardiac and non-major surgery. Despite that it is infrequent, it carries high morbidity and mortality. To diagnose stroke in post- operative patients is challenging because of the post-anesthetic and analgesic effect leading in delayed of diagnosis and treatment[2-4]. The authors developed a new screening tool for non-neurology medical personnels, nurses, patients, and family using to recognize stroke. The authors conducted a pre- and post-intervention study to prove the feasibility of the screening tool.

In the present study, perioperative stroke patients

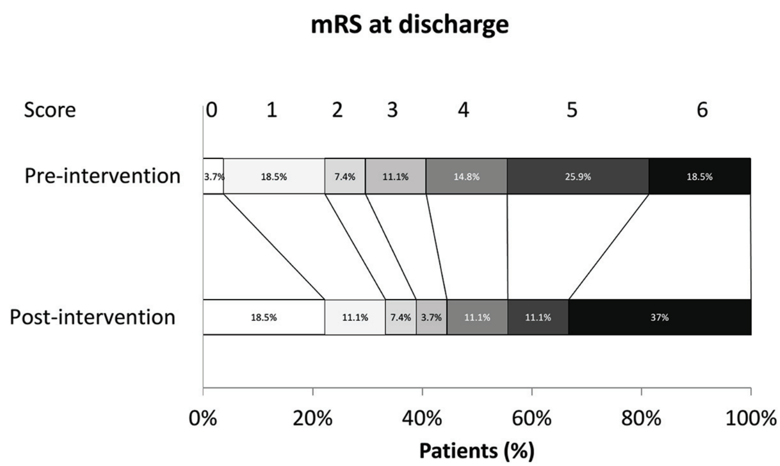



**Figure 3.** Modified Rankin Scale at discharge.

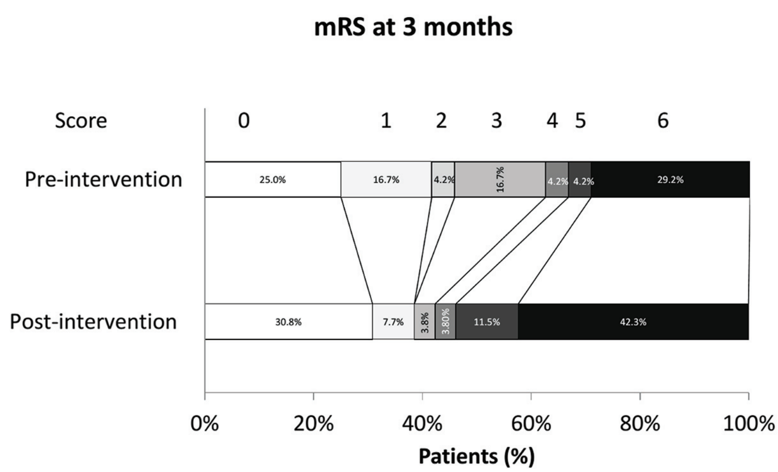



**Figure 4.** Modified Rankin Scale at 3-month follow up

were mostly found in mean age of 64.5±13.1, which is comparable with the previous study[4]. Perioperative stroke patients in both groups were found to have moderate stroke severity and cardioembolism as a stroke mechanism, which is commonly found in CVT surgery[2,13]. From the present study, at least one-fifth of perioperative stroke patients died during hospitalization. Risk factors for perioperative stroke include advanced age, history of cerebrovascular disease, ischemic heart disease, cardiac valvular heart disease, congestive heart failure, atrial fibrillation, renal disease, and major cardiac vascular surgery[2,14].

Plenty of stroke assessment scales have been applied as a screening tools to detect stroke. However, most of them are complicated and time consuming[8-11]. The present protocol for stroke detection includes education about stroke such as early warning signs and symptoms, to the patients and relatives at the surgery appointment center. Nurses in the CVT service attended a course of postoperative stroke and were trained to screen neurological deficit as per the protocol. The present protocol for screening neurological deficit was designed for non-neurology medical personnels and nurses. It is simple and composed of only seven items for neurological examination after routine vital signs measurement. Trained medical staffs can quickly assess patients in five minutes. In the present study, there was a significant reduction of time from last seen normal to NDD, time of NDD to brain imaging and significantly increased in stroke fast track activation after the implementation of the new protocol.

Early detection of stroke is important. It determines the opportunity to intervene with mechanical thrombectomy specifically in postoperative patient contraindicated for thrombolysis. In addition, time to treatment and reperfusion after EVT significantly impact stroke outcome[6,8,9,15]. The present study did not show difference in stroke outcome between pre- and post-intervention group due to the limited number of sample size. However, the present stroke screening protocol has been proven to be feasible to detect perioperative stroke.

Consideration of perioperative stroke carries high morbidity, mortality, and negative postoperative outcome. Implementation of the early detection policy, such as screening high risk patients, consultation with the neurology team, counseling with the patient and family about the risks and education about stroke recognition signs and symptoms, and routinely screening neurological deficit in postoperative patient, should be applied. With earlier diagnosis and proper management of the etiology of the stroke would help to improve the outcome of perioperative stroke patients[1,3,6,10,11,15].

## Strength

The present study was a prospective cohort study with follow-up until discharge. All alarms were confirmed by a neurologist. The present protocol applies to real-world practice because the diagnosis of neurological deficits was based on clinical diagnosis and confirmed by neuroimaging.

## Limitation

The present study was not a randomized study in the same period. Because the study was designed for a time period outcome, the sample size was not sufficient to investigate clinical outcomes. The ability to calculate sensitivity and specificity of the protocol was limited.

## Conclusion

Perioperative stroke is rare, however, it conveys high mortality and had negative impact to postoperative patients' outcome. The authors developed a screening protocol to detect stroke in postoperative patient. The present screening protocol is feasible to detect perioperative stroke.

## What is already known on this topic?

Perioperative stroke is complex and difficult to assess[3,8,9]. It is usually delayed in recognition and intravenous tissue plasminogen activator is contraindicated within 14 days of major surgery. The catheter-based mechanical interventions within 24 hours have a role in post-surgical patients if they met the criteria[15].

## What this study adds?

The present study stroke screening protocol in postoperative patients is simple. Trained medical staffs can quickly assess the patients. It is feasible in detecting perioperative stroke.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## Conflicts of interest

None of the authors have conflicts of interest with profit to this publication.

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