Diagnostic performance of the FAAS stroke screening tool FAAS stroke screening tool in patients who presented to the emergency room with neurological symptoms

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ความสามารถในการคัดกรองของแบบคัดกรองโรคหลอดเลือดสมอง FAAS ในผู้ที่มารับบริการที่ห้องฉุกเฉินด้วยอาการทางระบบประสาท

น.ส.วรงค์พร เผื่อนปฐม

วิทยานิพนธ์นี้เป็นส่วนหนึ่งของการศึกษาตามหลักสูตรปริญญาวิทยาศาสตรมหาบัณฑิต

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หัวข้อวิทยานิพนธ์	ความสามารถในการคัดกรองของแบบคัดกรองโรคหลอดเลือดสมอง FAAS ในผู้ที่มารับบริการที่ห้องฉุกเฉินด้วยอาการทางระบบประสาท
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วรงค์พร เผื่อนปฐม : ความสามารถในการคัดกรองของแบบคัดกรองโรคหลอดเลือดสมอง FAAS ในผู้ที่มารับบริการที่ห้องฉุกเฉินด้วยอาการทางระบบประสาท (Diagnostic performance of FAAS stroke screening tool in patients who presented to the emergency room with neurological symptoms) อ.ที่ปรึกษาวิทยานิพนธ์หลัก: ศ.พญ.นิจศรี ชาญณรงค์ อ.ที่ปรึกษาวิทยานิพนธ์ร่วม: ผศ.พิเศษ พญ.อรอุมา ชุติเนตร, 61 หน้า.

ที่มา: การคัดกรองอย่างรวดเร็วและทันท่วงทีส่งผลต่อความสำเร็จในการรักษาผู้ป่วยโรคหลอดเลือดสมอง ในประเทศไทยพยาบาลคัดกรองเป็นผู้ใช้แบบคัดกรอง FAST คัดกรองผู้ป่วยโรคหลอดเลือดสมองอย่างแพร่หลาย อย่างไรก็ตามแบบคัดกรอง FAST ไม่สามารถคัดกรองผู้ป่วยโรคหลอดเลือดสมองส่วนหลังได้ มีการศึกษาก่อนหน้านี้พบว่าหากเติม ataxia .ในแบบคัดกรองช่วยเพิ่มความสามารถของแบบคัดกรองในการคัดกรองโรคหลอดเลือดสมองส่วนหลัง จึงเป็นที่มาของการศึกษานี้ เพื่อศึกษาการใช้แบบคัดกรอง FAAS ในการคัดกรองผู้ป่วยโรคหลอดเลือดสมอง

วัตถุประสงค์: เพื่อศึกษาและเปรียบเทียบความสามารถในการคัดกรองของแบบคัดกรองโรคหลอดเลือดสมอง FAAS ในผู้ป่วยที่มารับการรักษาที่โรงพยาบาลด้วยอาการทางระบบประสาทในระยะเฉียบพลัน

รูปแบบวิธีวิจัย: การศึกษาแบบวินิจฉัยตัดขวางแบบพหุสถาบัน (Multicenter cross-sectional diagnostic study)

วิธีการเก็บข้อมูลวิจัย: พยาบาลคัดกรองใช้แบบคัดกรอง FAAS และ FAST เพื่อคัดกรองผู้ป่วยซึ่งมีอาการทางระบบประสาทภายใน 7 วันก่อนมาโรงพยาบาล ที่ห้องฉุกเฉินโรงพยาบาลจุฬาลงกรณ์ โรงพยาบาลนพรัตน์ราชธานีและโรงพยาบาลสุรินทร์ ประสาทแพทย์ผู้รับผิดชอบในแต่ละสถาบันเป็นผู้ให้การวินิจฉัยขั้นสุดท้าย โดยใช้ข้อมูลทางคลินิกภาพรังสีประกอบ ค่าความไวค่าความจำเพาะ ค่าทำนายผลบวก ค่าทำนายผลลบและกราฟ ROC ของแบบคัดกรองคำนวณโดยใช้โปรแกรม STATA version 14.

ผลการศึกษา: มีผู้ป่วยจำนวน 146 ราย ได้รับการวินิจฉัยว่าเป็นโรคหลอดเลือดสมอง 127 ราย (86%) ได้รับการวินิจฉัยอื่น 19 ราย (14%) ผลการศึกษาพบว่าความไวของแบบทดสอบ FAAS มากกว่าแบบทดสอบ FAST (96.85% vs 95.28%, p=0.125) และแบบทดสอบ FAAS สามารถวินิจฉัยโรคหลอดเลือดสมองส่วนหลังได้ดีกว่าแบบทดสอบ FAST(94.12% vs 82.35%, p=0.063)

สรุป: แบบทดสอบ FAAS เป็นแบบทดสอบที่มีความไวมากกว่าแบบทดสอบ FAST ในการตรวจคัดกรองโรคหลอดเลือดสมองโดยเฉพาะโรคหลอดเลือดสมองส่วนหลัง

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KEYWORDS: ACUTE STROKE / STROKE ASSESSMENT / EMERGENCY ROOM / SCREENING TOOL INDEX

WARONGPORN PHUENPATHOM: DIAGNOSTIC PERFORMANCE OF THE NEW FAAS STROKE SCREENING TOOL IN PATIENTS WHO PRESENTED TO THE EMERGENCY ROOM WITH NEUROLOGICAL SYMPTOMS

ADVISOR: PROF. NIJASRI CHARNNARONG , M.D. ,

CO-ADVISOR : ASSISTANT PROF . AURAUMA CHUTINET, M.D., 61 pp.

Background: Rapid screening and intervention are the keys to successful early treatment of stroke. In Thailand, the conventional FAST stroke screening tool has generally been used by triage nurses to promptly detect acute stroke. However, the FAST score has a limitation in detecting posterior circulation stroke. Previous studies showed that adding ataxia could increase the sensitivity of posterior circulation stroke detection. Therefore, we studied the performance of a new stroke screening tool, the FAAS score, among acute ischemic stroke patients.

Objectives: To evaluate the diagnostic performance of the FAAS score and compare the diagnostic performance between FAAS and the conventional FAST score.

Study design: Multicenter cross-sectional study.

Materials and methods: The new FAAS and conventional FAST scores were used by triage nurses in patients who presented with acute neurological symptoms within 7 days at the emergency department of King Chulalongkorn Memorial Hospital, Nopparatrajathanee Hospital and Surin Hospital. Final diagnosis was made by a neurologist using clinical and neuroimaging information. The sensitivity, specificity, positive predictive value, negative predictive value, positive likelihood ratio, negative likelihood ratio and the ROC curve were calculated using STATA version 14.

Results: In total, 146 patients were enrolled. Of these, 127 (86 %) had acute ischemic stroke and 19 (14%) had other diagnoses. We found that the sensitivity of the FAAS stroke screening tool was higher than conventional FAST (96.85% vs 95.28%, p = 0.125). The FAAS stroke screening tool detected posterior circulation ischemic stroke better than conventional FAST (94.12% vs 82.35%, p=0.063).

Conclusions: The FAAS stroke screening tool is sensitive for detecting acute stroke, especially posterior circulation stroke.

Field of Study:	Medicine	Student's Signature......................................
Academic Year:	2018	Advisor's Signature.......................................
		Co-Advisor's Signature.................................

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Chapter 1

Introduction

1.1 Background and rationale

Stroke is the second leading cause of death worldwide and the leading cause of death in Thailand. The mortality rate from acute stroke increases each year at a rate of 38.63, 43.28 and 43.54 deaths per 100,000 individuals during 2014-2016 according to a report from the Ministry of Public Health, Thailand.[1]

Rapid screening and intervention are the keys to successful early treatment. Many pre-hospital stroke assessment tools have been delivered and used by paramedics, including the Face Arm Speech Test (FAST)[2], Los Angeles Prehospital Stroke Screen (LAPSS)[3], Cincinnati Prehospital Stroke Scale (CPSS)[4] and Melbourne Ambulance Stroke Screen (MASS)[5]. In Thailand, the conventional FAST stroke screening tool, which stands for face, arm, speech and time to call, has generally been used by triage nurses to detect acute stroke. The FAST score has high sensitivity and specificity, and is easy to use. However, it has several limitations, including a low sensitivity to detect posterior circulation strokes.[6]

Posterior circulation stroke has variable presenting symptoms, which can mislead diagnosing physicians. The consequences of misdiagnosis may be devastating, and misdiagnosis is potentially preventable.[7] Previous studies showed that adding ataxia and visual disturbances, which are the symptoms of cerebellar, brainstem or occipital lobe dysfunction, could increase the sensitivity for detecting posterior circulation strokes.[8-9] The Balance-Eyes-Face-Arms-Speech-Time (BEFAST) score was developed based on this rationale. However, the result was that adding coordination and diplopia assessments to face, arm, and speech assessment did not improve stroke detection in the prehospital setting.[10] An unpublished study in 2013 by Surachet Eiamthanasinchai, “Validation of the new stroke screening program FAS ABCD2 compare with the Cincinnati Prehospital Stroke Scale (FAST) in King Chulalongkorn Memorial Hospital”, studied the FASA score and found that it had higher sensitivity than the conventional FAST score. Although, the A in FASA in that study stood for ataxia, there was no clear definition of ataxia. That study included patients who had nonspecific symptoms, for example, dizziness and altered consciousness. These factors may have contributed to the nonspecific results of that study. Moreover, that study recruited only patients at King Chulalongkorn Memorial Hospital, which was not representative of the overall Thai population.

We aim to evaluate the performance of a new stroke screening tool, the FAAS score, and compare the diagnostic performance between FAAS and the conventional FAST score among patients who presented with neurological symptoms at the emergency departments of three hospitals. The A in FAAS score in this study is clearly defined as ataxia and vertigo. Patients with altered consciousness were excluded to make the results more specific.

1.2 Research question

Primary research question: What is the diagnostic performance* of the new FAAS stroke screening tool in patients who present to emergency rooms with acute neurological symptoms?

Secondary research question: Is the diagnostic performance* of the new FAAS stroke screening tool better than the conventional FAST stroke screening tool?

***Diagnostic performance of the test** consists of sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), likelihood ratio positive (LR+) and likelihood ratio negative (LR-).

1.3 Objectives

1.3.1 To evaluate the diagnostic performance of the FAAS stroke screening tool used to test patients who presented to emergency rooms with acute neurological symptoms.

1.3.2 To compare the diagnostic performance between the FAAS stroke screening tool and the conventional FAST stroke screening tool.

1.4 Hypothesis

1.4.1 The sensitivity of the FAAS stroke screening tool in diagnosing patients presenting to emergency rooms with acute neurological symptoms is more than 85%.

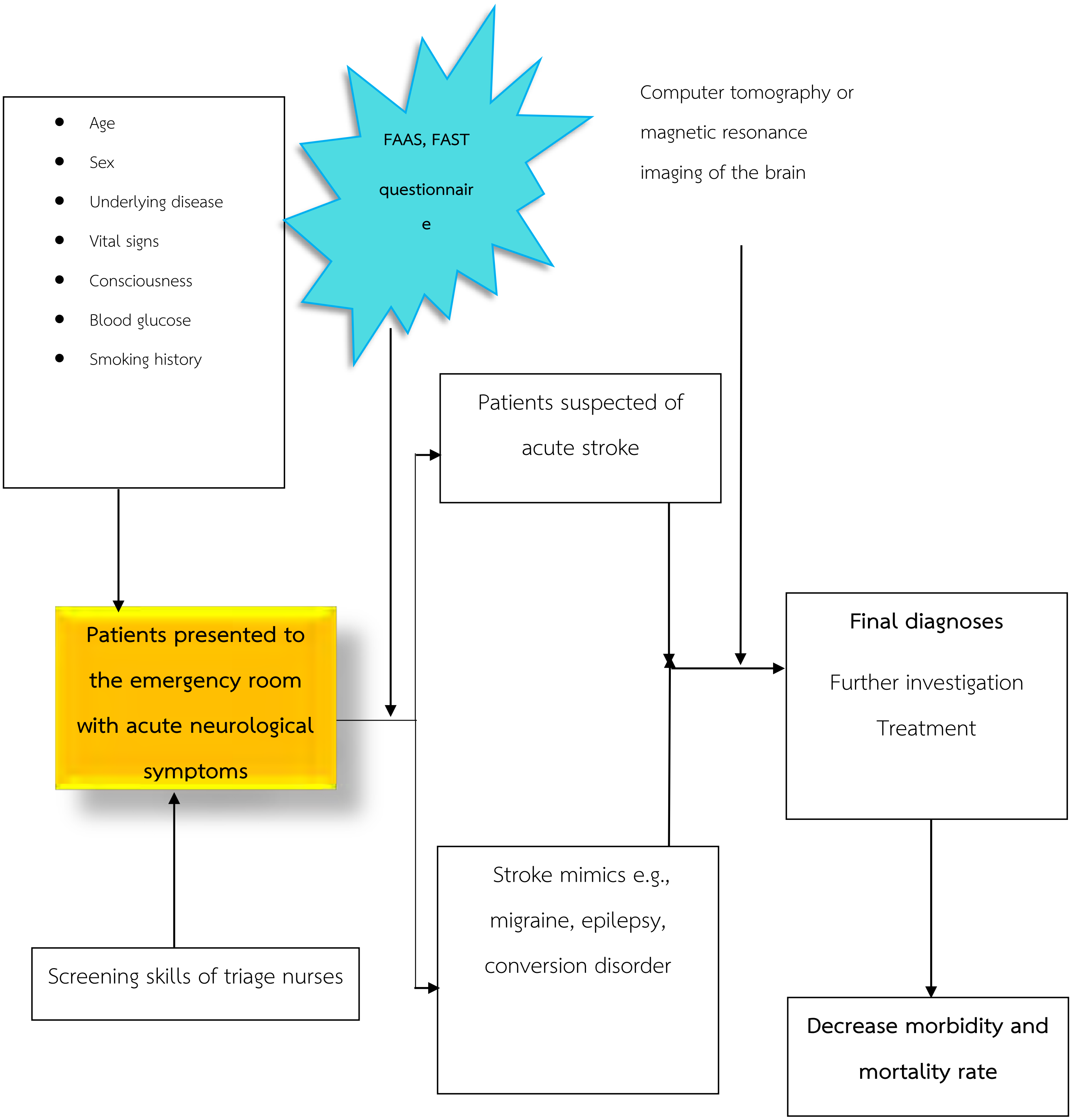
1.4.2 The sensitivity of the FAAS stroke screening tool in diagnosing patients presenting to emergency rooms with acute neurological symptoms is better than the FAST stroke screening tool by more than 5%.

1.4.3 The specificity of the FAAS stroke screening tool in diagnosing patients presenting to emergency rooms with acute neurological symptoms is more than 70%.

1.5 Primary assumption

The screening nurses and health care providers who were trained by the researchers had ability to screen ischemic stroke patients properly.

1.6 Conceptual framework



1.7 Operational definition

Facial drooping in this study is defined by the presence of either of the following:

1. Patient history or observation from a relative of asymmetrical facial fold
2. Asymmetrical facial fold observed when patient smiled

Arm weakness in this study is defined by the presence of either of the following:

1. Patient history or observation from a relative of weakness in one arm
2. Patient lifted both arms for 10 seconds and one arm fell or patient was unable to lift one arm

Ataxia in this study is defined by the presence of either of the following:

1. Patient history or observation from a relative or triage nurses of the patient showing instability when sitting or standing. This study excluded patients who could not or could hardly move their limbs.
2. Subjective sensation of movement, including spinning, turning, tilting, or whirling, of the patient or the surroundings. This study excluded patients who exhibited dizziness or sensation of only lightheadedness.

Speech difficulty in this study is defined by the presence of either of the following:

1. Patient history or observation from a relative of dysarthria, change of voice, or an inability or difficulty to produce speech.
2. Patient could not repeat or had difficulty repeating the name of each hospital after triage nurses said the names.

Subtypes of acute ischemic stroke were defined using the Oxfordshire Community Stroke project Classification System.[11] There are four groups of patients in this classification.

1.7.1 Lacunar infarcts (LACI) are patients diagnosed of pure motor stroke, pure sensory stroke, sensorimotor stroke or ataxic hemiparesis.

1.7.2 Total anterior circulation infarcts (TACI) are patients who have a combination of new higher cerebral dysfunction (e.g. dysphasia), contralateral homonymous visual field defect and contralateral motor and/or sensory deficit in at least two areas (out of face, arm and leg).

1.7.3 Partial anterior circulation infarcts (PACI) are patients who have only two of the three components of a TACI, or with higher cerebral dysfunction alone, or with a motor/sensory deficit more restricted than those classified as LACI (e.g., confined to one limb).

1.7.4 Posterior circulation infarcts (POCI) are patients who have any of the following: ipsilateral cranial nerve palsy with contralateral motor and/or sensory deficit, bilateral motor and/or sensory deficit, disorder of conjugate eye movement, cerebellar dysfunction, isolated homonymous visual field defect.

If there was reluctance to make a diagnosis, the responsible neurologists could consult another neurologist in the same institution to reach a conclusion.

1.8 Expected benefit and application

The diagnostic performance of the new FAAS stroke screening tool will continue to be studied and compared with the FAST score. FAAS score will become an alternative screening tool for patients suspected of acute stroke, especially posterior circulation stroke.

1.9 Obstacles and strategies to solve the problems

1.9.1 We will use a new questionnaire to perform FAAS screening and training of the triage nurses is required. Simulations of actual situations must also be performed before the research is done.

1.9.2 Patients may not come for follow-up, so we will collect the patients' telephone numbers in case of this situation. We will telephone patients for data in cases of loss to following-up.

Chapter 2

Review of related literatures

There are many stroke screening tools worldwide, including the Cincinnati Prehospital Stroke Scale, Los Angeles Prehospital Stroke Screen and Melbourne Ambulance Stroke Scale, which results in rapid screening and intervention of acute stroke patients. Patients with rapidly treated acute stroke have excellent neurologic recovery.[12] Previous studies showed the efficacy of these screening tools.

Rashmi Kothari et al. studied Cincinnati Prehospital Stroke Scale (CPSS) usage, consisting of facial drooping, asymmetrical arm weakness and abnormal speech, to screen prehospital (University of Cincinnati) acute stroke by a board-certified emergency physician. Patients with one item positive would be screened as having acute stroke. A 20- to 75-minute reduction in time to treatment for stroke patients could have a significant impact on the number of patients treated. The sensitivity was 66% (95% CI, 49%–80%) and the specificity was 87% (95% CI, 80%–92%). However, this score is performed by physicians rather than triage nurses, and patients with atypical presentation or posterior circulation stroke could be missed by this scale.[4]

Chelsea Kidwell et al. studied Los Angeles Prehospital Stroke Screen (LAPSS) usage, consisting of measurement items for age over 45 years old, no history of seizures, neurologic symptoms started to present within the last 24 hours, patient is not wheelchair bound or bedridden at the baseline, blood sugar 60–400 mg/dL, and unilateral (and not bilateral) exhibition of facial drooping, grip weakness, and arm weakness or other observable motor asymmetries. LAPSS is used to screen prehospital (University of California) acute stroke and exclude stroke mimics by paramedics who have been trained and certified in the use of the LAPSS. If all of these criteria are met, the LAPSS is positive for stroke. The sensitivity of this score was 91% (95% CI, 76%–98%), the specificity was 97% (95% CI, 93%–99%), the positive predictive value was 86% (95% CI, 70%–95%), and negative predictive value was 98% (95% CI, 95%–99%)[3].

JE Bray et al. studied Melbourne Ambulance Stroke Screen (MASS) usage, which is a combination between CPSS and LAPSS, to screen prehospital acute stroke in eastern Melbourne, Australia by paramedics who served in the Metropolitan Ambulance Service of Melbourne. The sensitivity of this score was 90% (95% CI, 81%–96%), the specificity was 74% (95% CI, 53 %–88%), the positive predictive value was 90% (95% CI, 81%–96%), and the negative predictive value was 74 % (95% CI, 53%–88%).

Harbinson et al. studied modified CPSS usage, consisting of FAST (facial drooping, asymmetrical arm weakness and abnormal speech) to screen acute stroke patients who were referred to Freeman Hospital Stroke Service from emergency rooms, primary care centers and ambulances by emergency physicians, primary care doctors, and ambulance staff. The sensitivity was 79%. The specificity and other values could not be evaluated owing to there being no information on the non-referral groups. Moreover, this study found that physicians could screen only 24% of posterior circulation strokes from all referred posterior circulation stroke patients.

Other limitations of the CPSS included conducting it in an emergency department and not in the community where paramedics routinely assess and treat patients, and selecting patients to be assessed with the CPSS tool by the investigators, with almost half being stroke patients, and not necessarily representative of the types of patients seen ‘in the field’ by paramedics.[6]

Nor AM et al. developed the Recognition of Stroke in the Emergency Room (ROSIER) tool for use by emergency physicians. This tool consists of all FAST items and additionally examines visual field deficit, leg weakness, loss of consciousness or syncope, and seizure activity. ROSIEER increased [12] the percent of sensitivity and significantly reduced non-stroke referrals to the stroke team when compared with FAST. The sensitivity was 93% (95%CI, 89%–97%), the specificity was 83% (95%CI, 77%–89%), the positive predictive value was 90% (95%CI, 85%–95%) and the negative predictive value was 88% (95%CI, 83%–93%).[15]

Chenkin et al. studied Ontario Prehospital Stroke Screening Tool (OPSS) usage to screen prehospital acute stroke and exclude stroke mimics by paramedics. It consists of three inclusion criteria (unilateral weakness, slurred speech or muteness, and facial drooping), a 2-hour time limit from symptom onset, and six exclusion criteria. The exclusion criteria were designed to exclude patients with stroke mimics (hypoglycemia, seizure), patients needing emergency intervention (Canadian Triage and Acuity Scale Level 1, Glasgow Coma Scale score less than 10), and patients ineligible for fibrinolysis (symptoms resolved, terminally ill or palliative). The sensitivity was 89.1% (95% CI 84.4%–92.6%), specificity of 79.5% (95% CI 73.9%–84.2%) and NPV of 88.2% (83.1%–91.9%).[15]

Studnek et al. studied Medic Prehospital Assessment for Code Stroke (Med PACS) usage to screen prehospital acute stroke by paramedics. The Med PACS screening tool was created by combining the perceived strengths of the CPSS and LAPSS. The sensitivity was 74.2% (95%CI, 67.2%–80.2%), the specificity was 32.6 (95%CI, 26.7%–39.1%), the positive predictive value was 47.1% (95%CI, 41.3%–53%) and the negative predictive value was 61% (95%CI, 61.8%–69.6%). [15]

Previous stroke screening tools mostly emphasized anterior circulation stroke and stroke mimics. Posterior circulation strokes could be missed by these scales and few studies were done to develop posterior circulation stroke screening tools.

Hedley Emsley et al. reviewed 36 patients and found that adding cerebellar dysfunction (ataxia-A) and occipital lobe dysfunction (vision disturbance or blindness) to the FAST tool could increase its sensitivity in screening posterior circulation stroke. Therefore, Emsley suggested using the FAST-AV or FAST-AB tool for patients who were FAST negative; A stands for ataxia and V or B stands for visual disturbance or blindness. Hedley Emsley et al. believed that this tool would be simple and easy to use in screening acute stroke after further larger studies had been done.[8]

The conclusion of each factor from previous studies is shown in Table 1. Differences in assessment for each score are shown in Table 2. The diagnostic performance of each score is shown in Table 3.

David Pickham et al. reviewed 359 patients and found that adding coordination and diplopia to face, arm, and speech assessments does not improve stroke detection in the prehospital setting. This score had a sensitivity of 91%, specificity of 56%, positive predictive value of 49% and negative predictive value of 93%.

In Thailand, we use FAST, which is based on the Cincinnati Prehospital Stroke Scale, to screen acute stroke. There was an unpublished study in 2013 by Surachet Eiamthanasinchai, “Validation of the new stroke screening program FAS ABCD2 compare with the Cincinnati Prehospital Stroke Scale (FAST) in King Chulalongkorn Memorial Hospital.” However, the result of the study showed that the FAS ABCD2 screening tool had significantly lower sensitivity than the FAST screening tool. Further analysis of the study described the FASA score, which stands for Face Arm Speech and Ataxia. The researcher found that it had higher sensitivity than the conventional FAST score, and the specificity was comparable. Nevertheless, this previous study used a nonspecific definition of ataxia in the FASA score, without mentioning vertigo or visual disturbances. Furthermore, the study included patients who had nonspecific symptoms, for examples dizziness and altered consciousness. These factors may have contributed to the nonspecific results of the study. Moreover, the study recruited only patients at King Chulalongkorn Memorial Hospital, which was not representative of the overall Thai population. Sensitivity, specificity, PPV, and NPV of FAST, FASA and FAS ABCD2 scores from the study in 2013 by Surachet Eiamthanasinchai are compared with the study of Kothari et al.[4] in Table 4.

Studies	Patient characteristics	Country	Gold standard	Screening score	People who used the score
Kothari, 1999.	Prehospital patients from the University of Cincinnati	United States	CT brain	Cincinnati Prehospital Stroke Scale (CPSS)	Board-certified emergency physician
Kidwell, 2000.	Prehospital patients from UCLA	United States	CT brain	Los Angeles Prehospital Stroke Scale (LAPSS)	Trained paramedics
Bray, 2005.	Admitted patients to an Australian hospital	Australia	CT brain	Melbourne Ambulance Stroke Scale (MASS)	Trained paramedics
Harbinson, 2003.	All patients referred to the Freeman Hospital Stroke Service (by ER, ambulance, or primary care)	United States	CT brain	Face Arm Speech Test (FAST)	Primary care doctors, ambulance staff, ER doctors
Nor Am, 2005.	Suspected strokes in adult patients in the emergency department	United Kingdom	CT/MRI brain	Recognition of Stroke in the Emergency Room (ROSIER) tool	Trained paramedics

Chenkin, 2009.	Stroke suspected in adults by the dispatcher or EMS provider in the field	Canada	CT/MRI brain	Ontario Prehospital Stroke Screening Tool (OPSS)	Trained paramedics
Studnek, 2013.	Adult patients with signs or symptoms of acute stroke or TIA, transported to any one of seven local hospitals, who received a Med PACS screen	United States	CT/MRI brain	Medic Prehospital Assessment for Code Stroke (Med PACS)	Trained paramedics

Table 1: Previous studies, patient characteristics, countries where the studies were conducted, gold standard, screening score used and people who used the score.

Assessment	CPSS (FAST)	LAPSS	MASS	Med PACS	OPSS	ROSIER
Historical factors						
Age > 45 years	-	√	√	-	-	-
Seizure	-	√ (No history of seizure)	√ (No history of seizure)	√ (No history of seizure)	√ (No history of seizure)	-
Patient not wheelchair-bound or bedridden prior to the event	-	√	√	-	-	-
Blood glucose	-	√ (2.8 to 22.2 mmol/L)	√ (2.8 to 22.2 mmol/L)	√ (2.8 to 22.2 mmol/L)	√ (> 4 mmol/L)	√ (> 3.5 mmol/L)
Time since symptom onset	-	√ (≤ 25 hours)	-	√ (≤ 25 hours)	√ (< 2 hours)	-
Glasgow Coma scale > 10	-	-	-	-	√	-
Symptoms have not resolved when EMS arrives	-	-	-	-	√	-
Canadian Triage and Acuity Scale Level ≥ 2 and/or corrected airway, breathing, or circulation problem	-	-	-	-	√	-
Patient not	-	-	-	-	√	-

terminally ill or in palliative care						
Patient conscious/syncope ruled out	-	-	-	-	-	√
Physical examination						
Facial droop	√	√	√	√	√	√
Arm weakness/drift	√	√	√	√	√	√
Leg weakness/drift	-	-	-	√	√	√
Handgrip	-	√	√	-	-	-
Speech difficulty	√	-	√	√	√	√
Gaze preference	-	-	-	√	-	-
Visual fields	-	-	-	-	-	√

Cincinnati Prehospital Stroke Scale (CPSS), Los Angeles Prehospital Stroke Screen (LAPSS), Melbourne Ambulance Stroke Screen (MASS), Medic Prehospital Assessment for Code Stroke (Med PACS), and Ontario Prehospital Stroke Screening Tool (OPSS) are considered positive if any of the physical findings are present after all eligibility criteria (if applicable) are met. Recognition of Stroke in the Emergency Room (ROSIER) scale assigns either a positive or a negative point value to each factor; the scale is positive if the sum is ≥ 1.

Table 2: Differences in assessments for each prehospital stroke scale.

Stroke scale	Study	Sample size	Stroke prevalence	Sensitivity	Specificity	LR+	LR-
CPSS	Bray, 2005.	100	73% (63–81)	95% (86–98)	56% (36–74)	2.10 (1.39–3.25)	0.1 (0.04–0.30)
LAPSS	Bray, 2005.	100	73% (63–81)	78% (67–87)	85% (65–95)	5.2 (2.16–13.13)	0.26 (0.16–0.40)
MASS	Bray, 2005.	100	73% (63–81)	90% (81–96)	74% (54–89)	3.49 (1.83–6.63)	0.13 (0.06–0.27)
Med PACS	Studnek, 2013.	416	45% (40–50)	74% (67–80)	33% (27–39)	1.10 (0.97–1.24)	0.79 (0.58–1.07
OPSS	Chenkin, 2009.	554	57% (53–61)	92% (88–94)	86% (80–90)	6.4 (4.64–8.68)	0.09 (0.06–0.14)
ROSIER	Nor Am, 2005. Fothergill, 2013.	343 295	51.3% 40% (34–46)	93% (89–97) 97% (93–99)	83% (77–89) 18% (11–26)	1.16 1.17 (1.07–1.28)	1.13 0.19 (0.08–0.46)

Cincinnati Prehospital Stroke Scale (CPSS), Los Angeles Prehospital Stroke Screen (LAPSS), Melbourne Ambulance Stroke Screen (MASS), Medic Prehospital Assessment for Code Stroke (Med PACS), Ontario Prehospital Stroke Screening Tool (OPSS), and Recognition of Stroke in the Emergency Room scale (ROSIER).

Table 3: Diagnostic performance for each prehospital stroke scale.

True CVD**	FAST[A]	FASA[B]	FAS ABCD2[C]	FAST[D]	BEFAST[E]
Sensitivity	91.82%	95.45%	95.45%	66%	91%
Specificity	62.16%	51.35%	13.51%	87%	56%
Positive predictive value	87.83%	85.37%	76.64%	83.54%	49%
Negative predictive value	71.88%	79.17%	50.00%	71.9%	93%

[A]FAST ; Face, Arm, Speech Test

[B]FASA ; Face, Arm, Speech, Ataxia

[C]FAS ABCD2 ; Face, Arm, Speech, Ataxia, Blindness, Consciousness, Diplopia, Dysphagia

[D]FAST ; Face, Arm, Speech from the study of Kothari et al.[4]

[E]BEFAST : Balance, Eyes, Face-Arms-Speech-Time[11]

Table 4: Sensitivity, specificity, PPV, and NPV of FAST FASA and FAS ABCD2 scores from the study in 2013 by Surachet Eiamthanasinchai compared with the study of Kothari et al.[4] in the last column (BEFAST).

Chapter 3

Materials and methods

3.1 Study design

Multicenter cross-sectional diagnostic study

3.2 Research methodology

Study population

Patients who presented with acute persistent neurological symptoms at the emergency room of King Chulalongkorn Memorial Hospital, Nopparatrajathanee Hospital and Surin Hospital between October and December 2018

Inclusion criteria

1. Age greater than or equal to18 years old
2. Presenting with persistent neurological symptoms within 7 days and triage nurses suspecting acute stroke.

Exclusion criteria

1. Glasgow Coma Scale Score less than 9
2. Unstable vital signs: Systolic blood pressure less than 90 mmHg, BT ≥ 37.8°C, HR ≥ 100 bpm, RR >24 bpm and oxygen saturation less than 90%.
3. Inability to be assessed by a screening protocol, for example, limb amputation.

3.3 Sample size

The precision calculation for sensitivity formula was used:

$$N = \frac{(Z_{1-\alpha/2})^2 \widehat{Sens}(1-\widehat{Sens})}{d^2 \widehat{prev}},$$

where $Z_{1-\alpha/2}$ is standard normal distribution

At 95% CI $Z_{0.975} = 1.96$,

$\widehat{Sens}$ is the estimated sensitivity; the estimated sensitivity from a previous study was 95% or $\widehat{Sens} = 0.95$

Precision (error margin) or d = 0.05,

$\widehat{Prev}$ is the estimated prevalence or the number of patients who presented with acute neurological symptoms at the emergency room of King Chulalongkorn Memorial Hospital, Nopparatrajathanee Hospital and Surin Hospital and triage nurses suspected acute stroke. The number is on average of 50% or $\widehat{Prev} = 0.5$.

When replaces the value in the formula

$$N = \frac{1.96^2 \times 0.95 \times 0.05}{0.05^2 \times 0.5.} = 146$$

Therefore, the calculated sample size was 146 people at 95%CI and d = 0.05.

3.4 Methods

3.4.1 The screening protocol was modified from conventional FAST score by adding A with clear definition of ataxia and vertigo. Other letters were defined as shown in Figure 1.

3.4.2 All triage nurses were trained to use the screening questionnaire by the researchers for 20 minutes as shown in Photo 1.

3.4.3 After inclusion, information was given to the patient for informed consent.

3.4.4 The baseline characteristics consisting of given name, surname, age, sex, telephone number, vital signs and underlying disease were collected.

3.4.5 Two triage nurses, trained by the researchers, used the FAAS and FAST scores to screen each patient and inserted the results in one form.

3.4.6 The summary of the FAAS and FAST scores and the time used in each screening form were collected. At King Chulalongkorn Memorial Hospital, the primary researcher was the main responsible person. For Nopparatrajathanee and Surin hospitals, the main responsible persons were Doctor Prakitchai Tantipong and Doctor Surachet Eiamthanasinchai, respectively.

3.4.7 After the screening, the patients were divided into screening positive and negative groups by triage nurses.

3.4.8 In the screening positive group, all patients underwent computed tomography. Magnetic resonance imaging was additionally performed in case of no pathologic lesion seen in computed tomography, as determined by the responsible neurologists. The final diagnosis of acute ischemic stroke was given by the responsible neurologists in each institution based on the definition of the Oxfordshire Community Stroke Project Classification.[11]

3.4.9 In the screening negative group, in case of sufficient clinical diagnosis by responsible neurologists in each institution, the patients were scheduled for follow-up at 2 and 6 weeks. On the follow-up date, imaging would be done if new neurological symptoms were found and there was no previous imaging. The researcher would collect the data by telephone for non-follow-up patients.

In case of insufficient clinical diagnosis, computed tomography would be performed in the emergency room. Additional magnetic resonance imaging would be done if necessary, as determined by the responsible neurologists.

3.4.10 The researcher would collect the sum score of each screening form, final diagnosis and time need to perform the screenings in each form.

วันที่ เดือน พ.ศ. เวลา

ชื่อผู้ป่วย นามสกุล

โทรศัพท์

โรคประจำตัว BP PR RR BT GCS DTX

Screening criteria	ใช่	ไม่ใช่
F Face หน้าเบี้ยว		
• ผู้ป่วยหรือญาติแจ้งว่าหน้าเบี้ยว		
• ผู้ป่วยยิ้มแล้วหน้าเบี้ยว		
A Arm แขนอ่อนแรง		
• ผู้ป่วยหรือญาติแจ้งว่าแขนอ่อนแรงข้างใดข้างหนึ่งตกก่อนหรือยกไม่ขึ้น		
• ให้ผู้ป่วยยกแขนสองข้าง สังเกตว่าข้างใดข้างหนึ่งตกก่อน		
A Ataxia เดินเซและมีอาการเวียนศีรษะ		
• ผู้ป่วยหรือญาติสังเกตว่าเดินเซ ร่วมกับรู้สึกเวียนศีรษะบ้านหมุน		
S Speech พูดไม่ชัด เสียงเปลี่ยน ลิ้นแข็ง พูดไม่ออก		
• ผู้ป่วยหรือญาติแจ้งอาการพูดไม่ชัด เสียงเปลี่ยน ลิ้นแข็ง พูดไม่ออก		
• ให้ผู้ป่วยพูดตาม โรงพยาบาล............ แล้วพูดไม่ชัด		
Total score	FAAS	FAST
Total time	Sec/min	

Final Diagnosis ....

Figure 1: Screening protocol used in this study.

Photo 1: Training the triage nurses.

3.5 Data collection

3.5.1 The baseline characteristics, consisting of given name, surname, age, sex, telephone number, vital signs and underlying disease, were collected.

3.5.2 The summary of the FAAS and FAST scores, and the time used in each screening form were collected.

3.5.3 The results of imaging, either computed tomography or magnetic resonance imaging, and the final diagnosis were recorded.

Photo 2: Data collection by triage nurses.

3.6 Study limitation

3.6.1 There were many triage nurses from various institutions, so there might have been variation in scoring methods. The solution was to train the triage nurses before the real situation.

3.6.2 The imaging might not have been done in screening negative group if the clinical diagnosis was sufficient to avoid unnecessary exposure to radiation. The follow-up at 2 and 6 weeks would be used to confirm the diagnosis instead.

3.7 Disclosure of patient information

The patient information would not be disclosed unless there was an authorization. In analyzing the information, the researchers would use the codes for each patient instead of names. In publishing or presenting this research, there would be no disclosure of patient information unless the informed consent was given.

3.8 Statistical analysis

The Student t-test was used for normally distributed data and the chi-squared test was used for independent non-parametric data. The sensitivity, specificity, positive predictive value, negative predictive value, positive likelihood ratio, negative likelihood ratio and the ROC curve were calculated using STATA version 14. A P value < 0.05 was accepted as statistically significant.

Chapter 4

Results

1. Populations and baseline characteristics

A total of 146 people were studied. Overall baseline characteristics are shown in Table 5. For baseline characteristics data, the number of males and females in the acute ischemic stroke group were similar. However, there was larger number of males in the non-stroke group. The mean age was similar in the acute ischemic stroke and non-stroke groups, 64.81 years and 62.63 years, respectively.

For underlying diseases, the largest number of patient had underlying hypertension and the smallest number of patients had underlying dilated cardiomyopathy and hyperthyroid in the acute ischemic stroke group. In the non-stroke group, the largest number of patients had underlying diabetes mellitus and the smallest number of patients had underlying atrial fibrillation. The difference between proportions of patients with each underlying disease in the stroke and non-stroke groups was hard to evaluate because of the large difference in the number of patients in these two groups.

Characteristics	Stroke	Non-stroke
Female n (%)	61 (48.03)	7 (36.84)
Mean (SD) age (years)	64.81 (14.11)	62.63 (12.34)
Underlying disease	**N (%)**	**N (%)**
Previous strokes	35 (27.56)	4 (21.1)
Hypertension	66 (52)	6 (31.6)
Diabetes mellitus	32 (25.2)	10 (52.6)
Hyperlipidemia	26 (20.5)	7 (36.8)
Coronary artery disease	9 (7.1)	3 (15.8)
Cancer	7 (5.5)	2 (10.5)
Atrial fibrillation	9 (7.1)	1 (5.3)
Chronic kidney disease	11 (8.7)	0 (0)
Dilated cardiomyopathy	1 (0.8)	0 (0)
Hyperthyroid	1 (0.8)	0 (0)
Dementia	2 (1.6)	0 (0)
Total patients	127 (100)	19 (100)

Table 5: Overall baseline characteristics of the patients.

In total, 96 patients were enrolled at King Chulalongkorn Memorial Hospital. Nopparatrajathanee Hospital and Surin Hospital enrolled 25 patients each.

Baseline characteristics of the patients at King Chulalongkorn Memorial Hospital are shown in Table 6. For baseline characteristics data, there were similar numbers of males and females in the acute ischemic stroke group; however, there were more males in the non-stroke group. The mean age was also similar in the acute ischemic stroke and non-stroke groups, 65.91 years and 62.63 years, respectively. The baseline characteristics data of patients in King

Chulalongkorn Memorial Hospital was similar to the overall baseline characteristics in the acute ischemic stroke group.

For underlying diseases in King Chulalongkorn Memorial Hospital, the largest number of patients had underlying hypertension and the smallest number of patients had underlying atrial fibrillation, dilated cardiomyopathy, chronic kidney disease and hyperthyroid in the acute ischemic stroke group. In the non-stroke group, the largest number of patients had underlying diabetes mellitus and the smallest number of patients had underlying dementia, chronic kidney disease, dilated cardiomyopathy and hyperthyroid. The difference between the proportions of patients with each underlying disease in the stroke and non-stroke group was hard to evaluate because of the large difference in the number of patients between these two groups.

Characteristics	Stroke	Non-stroke
Female n (%)	42 (54.55)	7 (36.84)
Mean (SD) age (years)	65.91 (20.057)	62.63 (12.34)
Underlying disease	**N (%)**	**N (%)**
Hypertension	44 (57.14)	4 (21.1)
Coronary artery disease	9 (7.1)	3 (15.8)
Cancer	7 (5.5)	2 (10.5)
Diabetes mellitus	5 (6.49)	10 (52.6)
Hyperlipidemia	5 (6.49)	7 (36.8)
Previous strokes	4 (5.19)	6 (31.6)
Dementia	2 (1.6)	0 (0)
Atrial fibrillation	1 (1.3)	1 (5.3)
Chronic kidney disease	1 (1.3)	0 (0)
Dilated cardiomyopathy	1 (1.3)	0 (0)
Hyperthyroid	1 (1.3)	0 (0)
Total patients	77 (100)	19 (100)

Table 6: Baseline characteristics of the patients in King Chulalongkorn Memorial Hospital.

Baseline characteristics of patients in Nopparatrajathanee Hospital are shown in Table 7. There were no patients with non-stroke diagnosis. For baseline characteristics data, there were more male patients in the acute ischemic stroke group. The mean age in the acute ischemic stroke group was 65.929.

The baseline characteristics data of patients in Nopparatrajathanee Hospital was mostly similar to the overall baseline characteristics data except for sex. There were more males in the acute ischemic stroke group while in the overall data there was a similar number of males and females in this group. The remaining data were mostly the same, including mean age and the patients' underlying diseases.

For underlying diseases in Nopparatrajathanee Hospital, the largest number of patients had underlying previous strokes and the smallest number of patients had underlying chronic kidney disease in the acute ischemic stroke group. The difference between the proportions of patients with each underlying disease in the stroke and non-stroke group was hard to evaluate because of the large difference in the number of patients between these two groups.

Characteristics	Stroke	Non-stroke
Female n (%)	9 (36)	0 (0)
Mean (SD) age (years)	65.92 (8.733)	-
Underlying diseases	**N (%)**	**N (%)**
Previous strokes	18 (52)	0 (0)
Diabetes mellitus	8 (16)	0 (0)
Coronary artery disease	4 (8)	0 (0)
Hypertension	4 (8)	0 (0)
Chronic kidney disease	1 (4)	0 (0)
Total patients	25 (100)	0 (0)

Table 7: Baseline characteristics of the patients in Nopparatrajathanee Hospital

Baseline characteristics of patients in Surin Hospital are shown in Table 8. There were no patients with a non-stroke diagnosis. For baseline characteristics data, there were more male patients in the acute ischemic stroke group. The mean age in the acute ischemic stroke group was 62.6.

For underlying diseases in Surin Hospital in the acute ischemic stroke group, the largest number of patients had underlying hypertension and smallest number of patients had underlying cancer, atrial fibrillation and chronic kidney disease.

The baseline characteristics data of patients in Surin Hospital was mostly similar to the overall baseline characteristics data except for sex. There were more males in the acute ischemic stroke group while in the overall data there was a similar number of males and females in this group. Other data were mostly the same, including mean age and the patients' underlying diseases.

Characteristics	Stroke (N=25)	Non-stroke (N=0)
Female n (%)	10 (48.03)	0 (0)
Mean (SD) age (years)	62.6 (13.54)	-
Underlying diseases	**N (%)**	**N (%)**
Hypertension	9 (36)	0 (0)
Previous strokes	5 (20)	0 (0)
Diabetes mellitus	5 (20)	0 (0)
Hyperlipidemia	4 (16)	0 (0)
Cancer	1 (4)	0 (0)
Atrial fibrillation	1 (4)	0 (0)
Chronic kidney disease	1 (4)	0 (0)
Total patients	25 (100)	0 (0)

Table 8: Baseline characteristics of the patients in Surin Hospital

2. Diagnostic performance

There were 136 patients in the FAAS positive group and 10 patients in the FAAS negative group. There were 132 patients in the FAST positive group and 14 patients in the FAST negative group. The mean time used in determining the FAAS score was 39.03 seconds.

In the FAAS positive group, there were 123 patients diagnosed as acute ischemic stroke and 13 patients diagnosed as non-stroke. In the FAAS negative group, there were four patients diagnosed as acute ischemic stroke and six patients diagnosed as non-stroke.

Among the four patients who were diagnosed as acute ischemic stroke in the FAAS negative group, three presented with visual disturbances and one presented with mild dizziness.

In the FAST positive group, there were 121 patients diagnosed as acute ischemic stroke and 11 patients diagnosed as non-stroke. In the FAST negative group, there were six patients diagnosed as acute ischemic stroke and eight patients diagnosed as non-stroke. All the information presented above is shown in Figure 2, Table 6 and Table 7. Note that there were only four patients diagnosed as acute ischemic stroke in the FAAS negative group compared with six patients in FAST negative group.

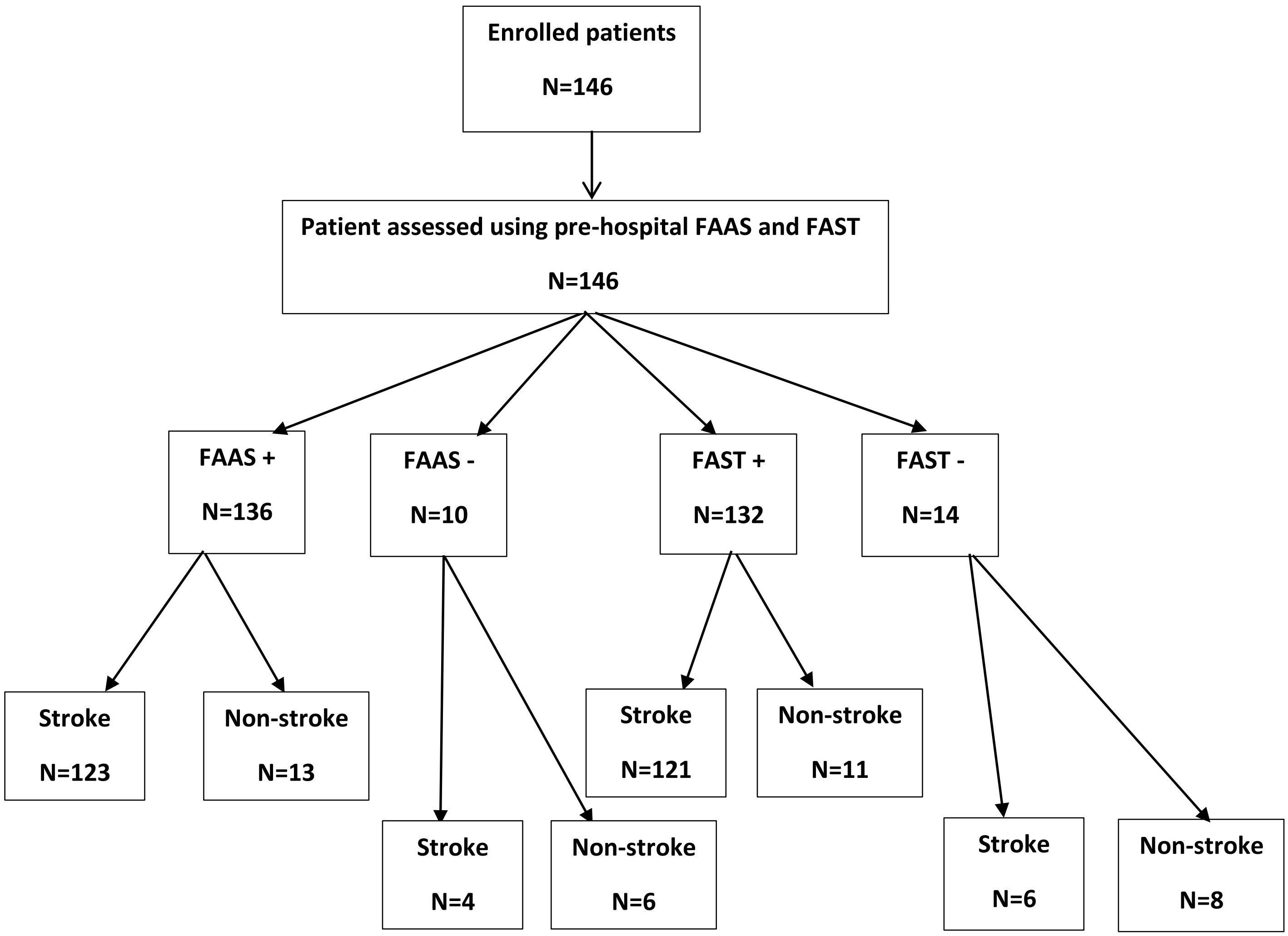


Figure 2: All enrolled patients divided into FAAS positive, FAAS negative, FAST positive and FAST negative groups. The final diagnoses in the stroke and non-stroke groups are shown.

Final diagnoses	FAST +	FAST -	Total
Stroke	121	6	127
Non-stroke	11	8	19
Total	132	14	146

Table 9: FAST positive and FAST negative patients with the final diagnoses of the stroke and non-stroke groups.

Final diagnoses	FAAS +	FAAS -	Total
Stroke	123	4	127
Non-stroke	13	6	19
Total	136	10	146

Table 10: FAAS positive and FAAS negative patients with the final diagnoses of the stroke and non-stroke groups.

/

A total of 127 patients (87%) had a final diagnosis of acute ischemic stroke and 19 patients (13%) had other diagnoses. The sensitivity, specificity, positive predictive value, negative predictive value and likelihood ratio of the FAAS and FAST scores are presented in Table 11 In the FAAS positive group, the sensitivity was higher than the FAST group (96.9% vs 95.3%, p=0.125). The specificity of the FAAS group was less than the FAST group (31.6% vs 42.1%). The positive predictive value of the FAAS group was less than the FAST group (90.4% vs 91.7%). The negative predictive value of the FAAS group was higher than the FAST group (60% vs 57.1%). The positive likelihood ratio in the FAAS group was less than the FAST group (1.42 vs 1.65). The negative likelihood ratio in the FAAS group was similar to the FAST group (0.10 vs 0.11).

Comparing the data between the three hospitals, the sensitivity of FAAS and FAST in King Chulalongkorn Memorial Hospital was the highest as shown in Table 12. In Nopparatrajathanee and Surin hospitals, other values, including positive predictive value, negative predictive value, positive likelihood ratio and negative likelihood ratio, could not be evaluated because no patients were diagnosed as non-stroke. The sensitivity of FAAS and FAST in Nopparatrajathanee Hospital were both 96%. The sensitivity of FAAS and FAST in Surin Hospital were 88% and 80%, respectively.

Tables 13 and 15 show the diagnosis profiles of the patients in the acute ischemic stroke and non-stroke groups, respectively. The largest number of patients was diagnosed as lacunar stroke (29.92%). There were 17 of 127 patients (13.38%) who were diagnosed as posterior circulation acute ischemic stroke. Only one FAAS negative patient was diagnosed with posterior circulation stroke compared with four patients in the FAST group. The rate of posterior circulation stroke detection was 94.12% (FAAS) and 82.35% (FAST), as shown in Table 14 ($p=0.063$). Thus, FAAS could detect posterior circulation stroke better than FAST. If calculated from total patients, the rate of posterior circulation stroke detection would be 10.95% and 8.9% in the FAAS and FAST groups, respectively.

In the non-stroke group, the largest number of patients was diagnosed with migraine and sepsis (15%), followed by conversion disorder, syncope and subdural hematoma (11%). Other diagnoses were cerebral amyloid angiopathy, primary CNS lymphoma, plexopathy, depression disorder, anxiety disorder and sick sinus syndrome as shown in Table 15.

Parameter	FAAS	FAST
Sensitivity	96.9%	95.3%
Specificity	31.6%	42.1%
Positive predictive value	90.4%	91.7%
Negative predictive value	60.0%	57.1%
Likelihood ratio +	1.42	1.65
Likelihood ratio -	0.10	0.11

Table 11: The sensitivity, specificity, positive predictive value, negative predictive value and likelihood ratio of overall FAAS and FAST scores at 95% confidence interval.

Parameter	FAAS	FAST
Sensitivity	97%	96.7%
Specificity	32%	42.1%
Positive predictive value	90%	91.7%
Negative predictive value	61%	57.1%
Likelihood ratio +	1.45	1.65
Likelihood ratio -	0.12	0.11

Table 12: The sensitivity, specificity, positive predictive value, negative predictive value and likelihood ratio of King Chulalongkorn Memorial Hospital FAAS and FAST scores at 95% confidence interval.

Diagnosis	Stroke (N=127)
Total anterior circulation stroke	18 (14.17)
Partial anterior circulation stroke	27 (21.26)
Lacunar stroke	38 (29.92)
Posterior circulation stroke	17 (13.38)

Table 13: Diagnosis profile of the patients in the acute ischemic stroke group.

Screening results	FAAS	FAST
Positive	16 (94.12)	13 (82.35)
Negative	1 (5.88)	4 (17.65)

Table 14: Seventeen patients with a final diagnosis of posterior circulation stroke and prior screening results.

Diagnosis	Non-stroke (N=19)
Migraine	3 (15)
Sepsis	3 (15)
Syncope	2 (11)
Anxiety disorder	2 (11)
Conversion disorder	2 (11)
Subdural hematoma	2 (11)
Depression disorder	1 (5)
Cerebral amyloid angiopathy	1 (5)
Sick sinus syndrome	1 (5)
Plexopathy	1 (5)
Primary CNS lymphoma	1 (5)

Table 15: Diagnosis profiles of the patients in the non-stroke group.

The ROC and area under the curve of FAAS and FAST scores are displayed in Figures 3 and 4. The area under the curve of the FAAS score was similar to the FAST score (0.6421 vs 0.6869). The ROC curve in both groups was over the normal line. Both the FAAS and FAST scores had moderate[16] test characteristics for identifying stroke and performed similarly. We used a cutoff score of 1 for stroke prediction.

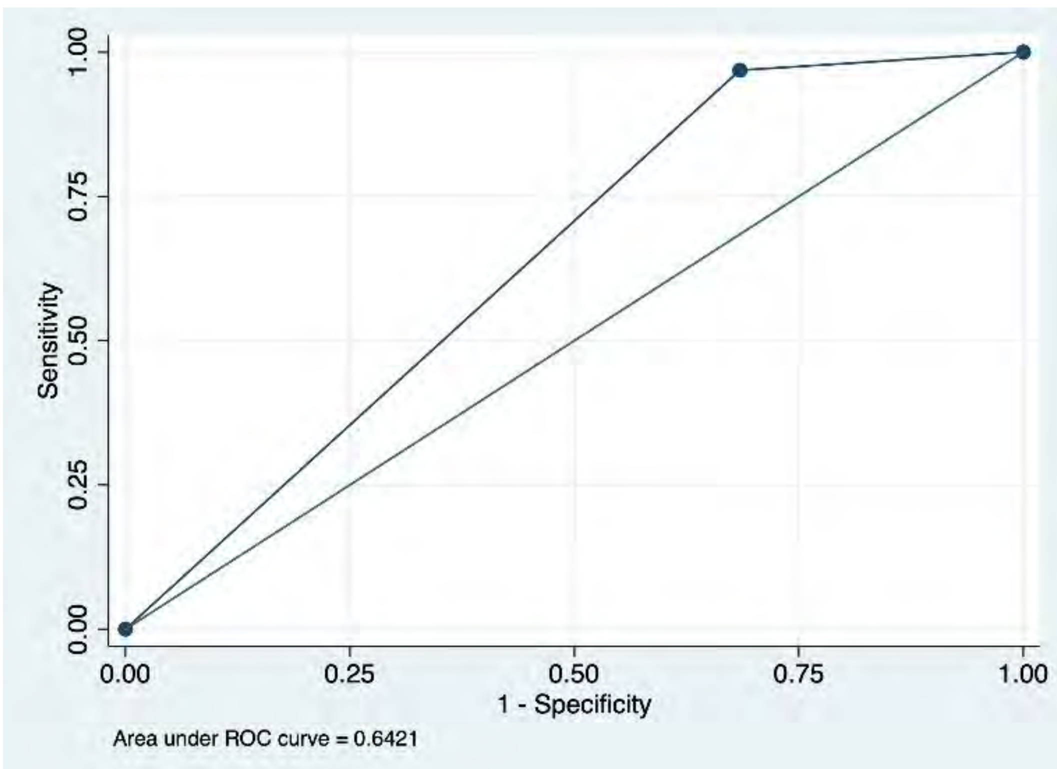


Figure 3 : ROC curve of the FAAS score and its area under the curve.

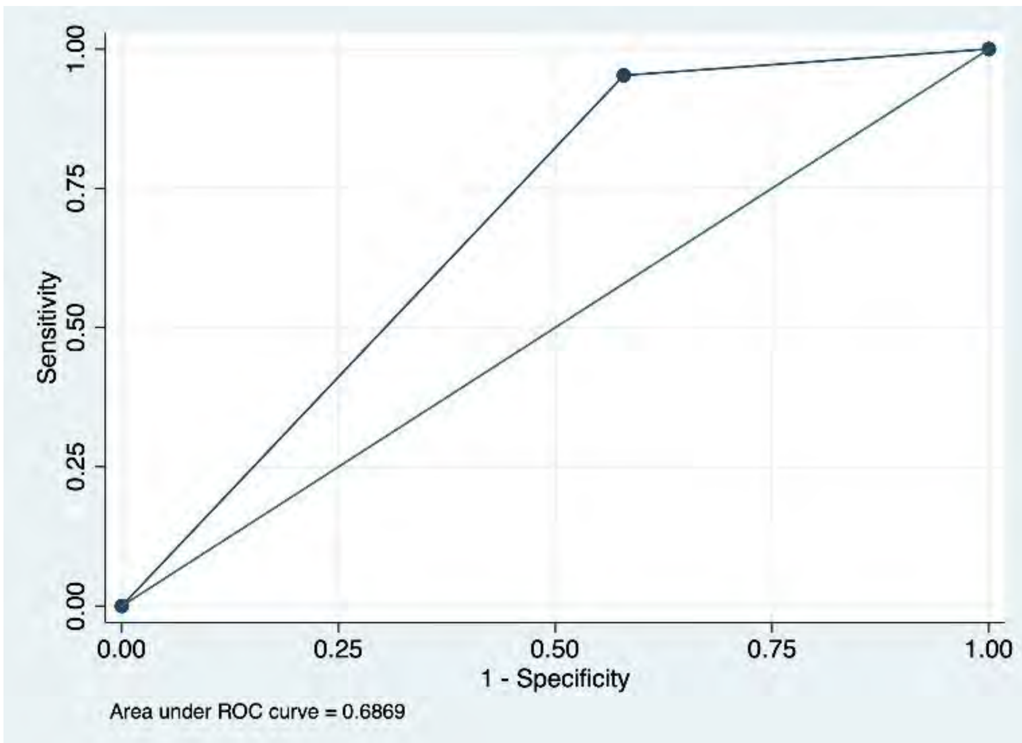


Figure 4 : ROC curve of the FAST score and its area under the curve.

Chapter 5

Discussion conclusion and recommendations

5.1 Discussion

There was a larger proportion of patients with underlying hypertension, atrial fibrillation, chronic kidney disease, dilated cardiomyopathy and hyperthyroid in the acute ischemic stroke group compared with the non-stroke group. However, there was a smaller proportion of patients with diabetes mellitus, hyperlipidemia, coronary artery disease and cancer in the acute ischemic stroke compared with the non-stroke group. This might be explained by smaller numbers of total patients in the non-stroke group compared with the stroke group.

The baseline characteristics data in patients from each hospital was mostly similar to the overall data except for sex and some underlying diseases. However, all patients were diagnosed with acute stroke. In Nopparatrajathanee and Surin hospitals, there were more male patients with acute ischemic stroke. In the overall data, the number of males and females were similar.

For underlying diseases in King Chulalongkorn Memorial Hospital, there was a smaller proportion of patients in the acute ischemic stroke group with previous strokes and atrial fibrillation compared with the non-stroke group. Thus, there was a large number of patients with underlying previous strokes and atrial fibrillation diagnosed with acute ischemic stroke in Nopparatrajathanee and Surin hospitals.

We aimed to study the performance of new stroke screening tool, the FAAS score, among patients who presented with neurological symptoms at emergency department settings of three hospitals. The sensitivity of the FAAS stroke screening tool in this study was higher than conventional FAST (96.85% vs 95.28%, p=0.125). The positive predictive value was also high (90.4% vs 91.7%) compared with the conventional FAST score, which supported the use of the FAAS score in screening acute stroke.

Many factors affected the diagnostic performance of the FAAS score in this study. First, there were no patients diagnosed as non-stroke in Nopparatrajathanee and Surin hospitals, which made the overall sensitivity be mostly represented by King Chulalongkorn Memorial Hospital’s sensitivity. Second, there was a high prevalence in the acute stroke group, which made the positive predictive value high.

To compare between the hospitals, there was a difference in sensitivity of the FAAS and FAST scores. King Chulalongkorn Memorial Hospital had the highest sensitivity, followed by Nopparatrajathanee Hospital and Surin Hospital, respectively. This might be explained by the different levels of screening skill between the triage nurses in each institution.

The new FAAS stroke screening tool detected posterior circulation stroke better than FAST (94.12% vs 82.35%). The Receiver Operator Characteristic curve of both the FAAS and FAST scores are over the normal line and the area under the curve was almost identical. However, the values of the area under the curve at 0.6421 and 0.6869 showed that the accuracy of FAAS and FAST was not high. However, the mean time used in performing FAAS was only 39.03 seconds.

Thus, the FAAS score is a clinical screening stroke scale that is sensitive not only in detecting acute stroke but also in detecting posterior circulation stroke, and it is quick to use. Therefore, it can be used as an alternative stroke screening tool in addition to the conventional FAST score. This study is the first in Thailand to use the FAAS score in multiple hospitals, including a tertiary care hospital (King Chulalongkorn Memorial Hospital), a suburban hospital (Nopparatrajathanee Hospital) and a provincial hospital (Surin Hospital), which allows good generalizability of the results of this study. However, no patients in hospitals other than King Chulalongkorn Memorial Hospital were diagnosed with non-stroke. If more patients had been diagnosed with non-stroke in the other hospitals, the sensitivity, positive predictive value and positive likelihood ratio might have decreased.

Despite its advantages, there were some limitations to this study. First, the specificity was not high (31.58% vs 42.11%), representing the FAAS score accuracy. Nevertheless, we recommended that this score be used as the screening tool; thus, accuracy was less important than sensitivity. Second, imaging was not done for patients being screened in the negative group if the clinical diagnosis was sufficient to avoid unnecessary exposure to radiation. The follow-ups at 2 and 6 weeks were used to confirm the diagnosis instead. Despite that, there were no acute strokes after following up patients from our study. Third, the internal validation between triage nurses had not been calculated. However, all the triage nurses were trained by the researchers to reduce differences in screening skill levels. Further studies should be done to validate the FAAS score.

5.2 Comparisons with previous studies

There were some differences in baseline characteristics between a previous unpublished study in 2013 by Surachet Eiamthanasinchai, “Validation of the new stroke screening program FAS ABCD2 compare with the Cincinnati Prehospital Stroke Scale (FAST) in King Chulalongkorn Memorial Hospital” and this study. In the previous study, there were fewer patients with underlying diseases of hyperlipidemia, coronary heart disease and atrial fibrillation. There were also no patients with cancer, chronic kidney disease, dilated cardiomyopathy, hyperthyroid or dementia in the previous study. This might have been an effect of there having been fewer stroke patients included in the previous study.

The FAAS score in our studies had higher sensitivity compared with previous studies, 96.9% vs 95.45%. The positive predictive value was also higher. However, the specificity and the negative predictive value were lower than previous studies, 31.6% vs 51.35% and 60% vs 79.17%, respectively. This may be explained by the higher prevalence of stroke in this study compared with previous a study in 2013, 87% vs 79.6%.

For stroke diagnoses, there were comparable numbers of patients in total anterior circulation stroke, partial anterior circulation stroke and lacunar stroke. The posterior circulation stoke was the exception. More patients in this study were diagnosed with posterior circulation stroke than in the previous study, 7.69% vs 13.38%. Nevertheless, the rate of posterior circulation stroke detection was not reported in the previous study. Thus, rate of posterior circulation stroke detection between these studies could not be directly compared.

For non-stroke diagnoses, there were variable stroke mimics. However, there were some differences between two studies. In previous study, there were patients diagnosed with Bell's palsy, peripheral vertigo, hypo/hyperglycemia, hyponatremia, cardiac arrest, psychogenic and acute angle closure glaucoma. In this study, there were patients diagnosed with conversion disorder, cerebral amyloid angiopathy, primary CNS lymphoma and subdural hematoma.
The diagnoses, which were the same between the two studies, included migraine, sepsis and plexopathy.

To compare with BEFAST score, which was developed base on the same rationale as this score. The sensitivity and the positive predictive value in this study were higher than BEFAST (96.9% vs 91%, 90.4% vs 49%). The specificity and negative predictive value were lower than BEFAST (31.6% vs 56%, 60%vs 93%). This was different from BEFAST score, which had low positive predictive value and supported the use of FAAS score instead of BEFAST.

Studies	N	Diagnosis	Definition ataxia	Diagnostic performances (%)
This study **(FAAS)**	146	Stroke 127 Nonstroke 19	**Both** ataxia and vertigo **Exclude** weakness, dizziness, lightheadedness	Sens 96.9 Spec 31.6 PPV 90.4 NPV 60 AUC 0.649
Surachet et al. **(FASA)**	147	Stroke 117 Nonstroke 30	Ataxia	Sens 92.31 Spec 50 PPV 87.8 NPV 62.5 AUC 0.841
David et al. (BEFAST)	359	Stroke 159 Nonstroke 200	Finger-to-nose testing, finger-tracking maneuver	Sens 91 Spec 56 PPV 49 NPV 93 AUC 0.7

Table 16 : Previous studies, numbers of patients, diagnosis and diagnostic performance between FAAS, FASA and BEFAST.

5.3 Advantages

This study is the first study in Thailand using FAAS score in multi-center hospital, including tertiary care hospital - King Chulalongkorn Memorial Hospital, suburban hospital - Nopparatrajathanee Hospital and Provincial hospital - Surin Hospital, which makes this study had good generalizability.

This study also emphasized about posterior circulation stroke detection, which was more distinct than previous studies. In Thailand, there were no studies about posterior circulation stroke detection and also posterior circulation stroke screening score. Stating about posterior circulation stroke detection would also facilitate the decreasing of the high mortality rate of undetectable posterior circulation stroke. Moreover, this would contribute to further research about posterior circulation stroke and make researchers pay attention to its significance.

5.4 Disadvantages

First, the specificity was not high (31.58% vs 42.11%), representing the FAAS score accuracy. Nevertheless, we had stated that this score should be used as the screening tool, which accuracy was less important than sensitivity.

Second, the imaging was not all done in screening negative group if the clinical diagnosis was sufficient to avoid unnecessary exposure to radiation. The following up at two and six weeks were used to confirm the diagnosis instead. In spite of that, there were no acute stroke after following up patients from our study.

Third, the internal validation between triage nurses had not been calculated. However, all the triage nurse was trained by the researchers to reduce the difference in screening skill.

Fourth. There were no patients screened and diagnosed as non-stroke in Nopparatrajathanee and Surin hospital. Therefore, the overall diagnostic performance might mostly reflect the diagnostic performance of Chulalongkorn hospital.

5.5 Suggestion

FAAS score can be used as an alternative stroke screening tool other than conventional FAST score for patients suspected of acute stroke, especially posterior circulation stroke . Further studies should be done to confirm the validation of this score.

5.6 Conclusion

The results of this study indicated that the new FAAS stroke screening tool had high sensitivity in promptly detecting acute ischemic stroke, especially the posterior circulation ischemic stroke. Therefore, it can be used as an alternative stroke screening tool other than conventional FAST score. However, further studies should be done to confirm the validation of this score.

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