Accuracy of Glasgow Coma Score and FOUR Score: A Prospective Study in Stroke Patients at Siriraj Hospital

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Background: *Full Outline of Unresponsiveness Score Coma Scale (FOUR score) is better than Glasgow coma scale (GCS) for predicting neurological outcome in an intensive care and traumatic patients. However, there is no report in stroke patients in emergency department (ED).*

Objective: *Determine the relation between FOUR score and GCS as primary outcome. Secondary outcomes were prognostication of each score.*

Material and Method: *This prospective cohort study was conducted in acute stroke patients. Those with history of head injury were excluded. Patients were evaluated by both scores at ED before definite treatment. All patients were followed-up at day 3, 7, 30, and 90.*

Results: *Sixty patients were included. Overall mean FOUR score was 14.05 (SD 4.02) and mean GCS was 12.45 (SD 3.74). FOUR score and GCS had an excellent correlation with r = 0.821 (p<0.001). FOUR score predicted 3-month mortality rate better than GCS with area under the curve (AUC) of 1.00 (p<0.001, 95% CI 0.94 to 1.00) while AUC for GCS was 0.99 (p<0.001, 95% CI 0.92 to 0.99). FOUR score was also outstanding in predicting the poor neurological outcome (modified Rankin Scale 4 to 6 and cerebral performance category 3 to 5) with AUC of 1.00 (p<0.001, 95% CI 1.00 to 1.00).*

Conclusion: *FOUR score and GCS had an excellent relation. FOUR score is better than GCS for predicting 3-month mortality and poor neurological outcome in acute stroke patients.*

Keywords: *Acute stroke, Full outline of unresponsiveness score coma scale, Glasgow Coma Scale*

J Med Assoc Thai 2017; 100 (9): 960-6
Website: http://www.jmatonline.com

Stroke is the second leading cause of death above the age of 60 years worldwide[1]. Each year, there are about 15 million people suffered from stroke. Of these patients, mortality rate is up to 40%. On average, one people dies from stroke every six seconds[2]. In Thailand, hypertension and cerebrovascular accident rank second among all causes of death[3]. In 2013, mortality rate is 36.13 per 100,000 populations[4]. The incidence increases each year, although there are health promotions aimed at reducing the risk factors. However, disabilities and deaths can be minimized by precise diagnosis and rapid treatment.

Accurate determining of the level of consciousness is important for making a decision for stroke treatment. This process is often done in emergency room because stroke treatment is time sensitive. Glasgow Coma Scale (GCS) is one of the well-known scoring system. Although it is reliable and practical, there is limitation especially in intubated patients. In 2005, Wijdick et al developed a new grading scale which is Full Outline of Unresponsiveness Score Coma Scale (FOUR score)[5]. It consists of four components, which are demonstrated in Table 1. Each component grades as a score ranges from 0 to 4.

There are studies proving that FOUR score has a great yield for evaluating the level of consciousness. For example, FOUR score showed greater inter-rater reliability than GCS in critical care patients[6], and emergency department setting[7]. In stroke patients, there are evidences that FOUR score is reliable[8,9]. However, these studies are in only critical care and stroke unit. Therefore, the present study was aimed to define the relation of FOUR score and GCS in acute stroke patients in the emergency setting.

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Material and Method

We conducted a prospective cohort study in emergency department of Siriraj hospital, a university hospital in Thailand. Our population are acute stroke patients aged over 18 years old. Patients who had history of recent head injury would be excluded. The present study had been approved by the Institutional Review Board. At the beginning, there was a workshop for training about how to use GCS and FOUR score to

Table 1. Details of FOUR score compared with Glasgow Coma Scale (GCS)

FOUR score	Glasgow Coma Scale
Eye response	Eye response
4 = eyelids open, tracking, or blinking to command 3 = eyelids open but not tracking 2 = eyelids closed but open to loud voice 1 = eyelids closed but open to pain 0 = eyelids remain closed with pain	4 = eyes open spontaneously 3 = eyes opening to verbal command 2 = eyes opening to pain 1 = no eyes opening
Motor response	Motor response
4 = thumbs-up, fist, or peace sign 3 = localizing to pain 2 = flexion response to pain 1 = extension response to pain 0 = no response to pain or generalized myoclonus status	6 = obeys commands 5 = localizing pain 4 = withdrawal from pain 3 = flexion response to pain 2 = extension response to pain 1 = no motor response
Brainstem reflexes	Verbal response
4 = pupil and corneal reflexes present 3 = one pupil wide and fixed 2 = pupil or corneal reflexes absent 1 = pupil and corneal reflexes absent 0 = absent pupil, corneal, and cough reflex	5 = oriented 4 = confused 3 = inappropriate words 2 = incomprehensible sounds 1 = no verbal response
Respiration	
4 = not intubated, regular breathing pattern 3 = not intubated, Cheyne-Stokes breathing 2 = not intubated, irregular breathing 1 = breathes above ventilator rate 0 = breathes at ventilator rate or apnea	

FOUR = Full Outline of Unresponsiveness

all emergency residents and physicians. When the patient was included, after inform consent was taken, each stroke patient would be assessed by both scoring systems before receiving definite treatment. This evaluation must not delay the process of diagnosis and treatment. All patients would be treated along standard stroke guideline. After discharge from emergency room, all patients would be followed-up at day 3, 7, 30, and 90 by dialogue telephone call for data of neurological outcome which are modified Rankin Scale (mRS), Cerebral Performance Category (CPC), and mortality rate.

The primary outcome was to determine the correlation between GCS and FOUR score in stroke patients by emergency physicians. The secondary outcome was to identify the predicted value of both scores in neurological outcome and mortality rate. We

$$n = \left(\frac{Z_\alpha + Z_\beta}{Z_{(r_0)} - Z_{(r_1)}}\right)^2 + 3 \quad \left| \quad Z_{(r_0)} = \frac{1}{2}\ln\left(\frac{1+r_0}{1-r_0}\right) \right| \quad Z_{(r_1)} = \frac{1}{2}\ln\left(\frac{1+r_1}{1-r_1}\right)$$

Correlation test that ρ = ρ₁ for x and y bivariate	
	1
Test significance level, α	0.050
1 or 2 sided test?	2
Null hypothesis correlation, ρ_0	0.000
Alternative correlation, ρ_1	0.500
Power (%)	80
n	30

Fig. 1 Calculated nQuery method and program.

defined poor neurological outcome as the patient who has mRS score of 4 to 6 and CPC score of 3 to 5.

Statistical analysis

By nQuery method as shown in Fig. 1, we need 42 patients in the present study for achieving Pearson product-moment correlation coefficient value of 0.5, 0.01 level of significance, and 0.8 power of test. Twenty percent of calculated sample was added for missing data therefore we need at least 60 patients.

Results

From sixty patients included, the median age of them was 65 years (IQR 34 to 91). About half (46.7%) were male. Most common comorbidities were hypertension followed by dyslipidemia and diabetes mellitus respectively as described in Table 2. Most patients had ischemic stroke (75%) and most commonly affected area was frontoparietal (66.7%),

Table 2. Baseline characteristics

Variable	Number (%) (n = 60)	
Median age (min to max)	65 (34 to 91)	
Male	28 (46.7)	
Pathology		
Ischemic stroke	45 (75.0)	
Hemorrhagic stroke	15 (25.0)	
	Ischemic stroke (n = 45)	Hemorrhagic stroke (n = 15)
Underlying disease		
Hypertension	20 (44.4)	13 (86.7)
Dyslipidemia	15 (33.3)	10 (66.7)
Diabetes mellitus	13 (28.9)	8 (53.3)
Atrial fibrillation	12 (26.7)	2 (13.3)
Ischemic heart disease	5 (11.1)	3 (20.0)
Affected area		
Frontoparietal	30 (66.7)	1 (6.7)
Brainstem	8 (17.6)	1 (6.7)
Basal ganglia	3 (6.7)	10 (66.7)
Thalamus	1 (2.2)	3 (20.0)
Unspecified	3 (6.7)	0 (0.0)

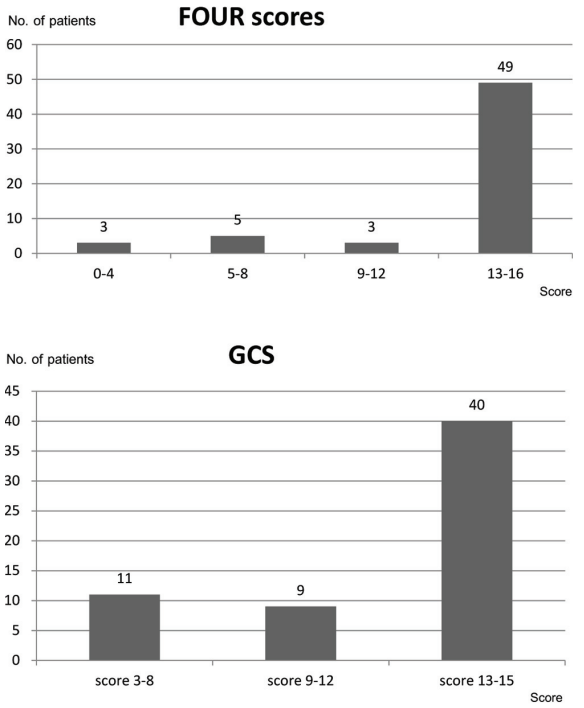

Fig. 2 Distribution of FOUR score (above) and GCS score (below).

followed by brainstem and basal ganglia. While the common of hemorrhagic strokes were found at basal ganglia (66.7%) and thalamus (20%). Only 6% had intraventricular hemorrhage. Only five patients (8.3%) were intubated because of airway compromise and bradypnea. Of these, three were ischemic and two were hemorrhagic stroke.

Mean FOUR score of our population was 14.05 (SD 4.02), which was 10.06 (SD 3.02) for hemorrhagic and 15.37 (SD 1.76) for ischemic stroke. While mean GCS score for overall, hemorrhagic and ischemic stroke patients were 12.45 (SD 3.74), 9.93 (SD 5.11), and 13.28 (SD 2.81), respectively, as shown in Fig. 2.

FOUR score and GCS has an excellent relationship as shown in Fig. 3 and the correlation (r), by Spearman's rank, was 0.821 (p<0.001).

During admission, 10 patients (16.7%) died. Two were diagnosed intracerebral hemorrhage while the rest were ischemic stroke. After three months of follow-up, there was no more death after discharge so in-hospital mortality was 16.7% as same as 90-day mortality. Mean FOUR score and GCS score of non-survival group were 5.6 (SD 2.82) and 5.6 (SD 0.83), respectively. We found that patients who have FOUR score less than ten are not survive. While there is no definite cut point for GCS as shown in Fig. 4.

Area under the curve (AUC) values for predicting three months' mortality of FOUR score and GCS were 1.00 (p<0.001, 95% CI 0.94 to 1.00) and 0.99 (p<0.001, 95% CI 0.92 to 0.99), respectively. Cut-off point of FOUR score was 10 and GCS was 9 (Fig. 5).

Neurological outcome at 90 days was shown in Table 3. The mean mRS and CPC were 3.0 (SD 0.85) and 2.7 (SD 0.50), respectively. Patients with intracerebral hemorrhage had worse prognosis.

Sixteen patients (32%) had poor neurological outcome. Relation between both scaling systems and mRS were demonstrated in Fig. 6. Patients with intracerebral hemorrhage had more severe disability than ischemic group. Relation of neurological outcome (mRS and CPC) at 90 days and FOUR score were shown in Fig. 5. AUC of FOUR score for predicting poor neurological outcome was 1.00 (p<0.001, 95% CI 1.00 to 1.00). GCS had AUC of 0.94 (p<0.001 and

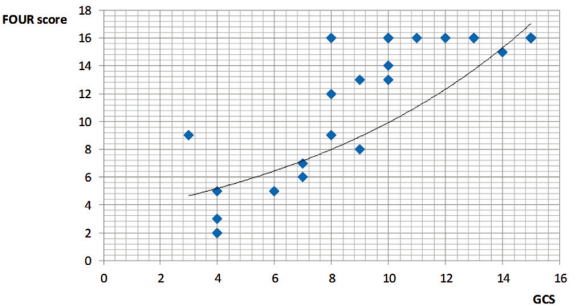

Fig. 3 Correlation between FOUR score and GCS.

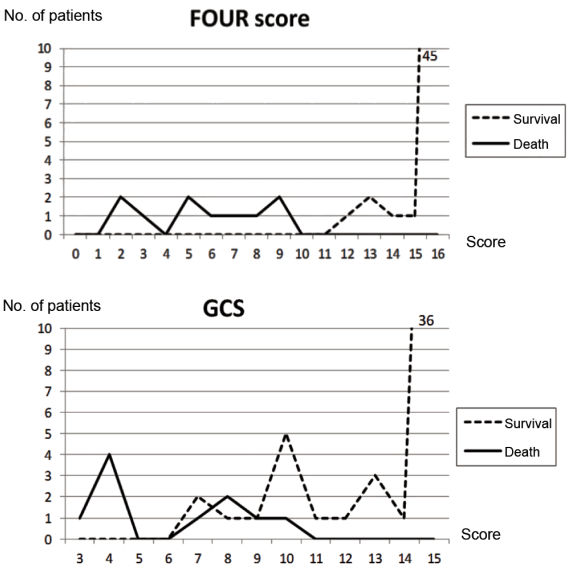

Fig. 4 Frequency of FOUR score (above) and GCS score (below) among survival and death.

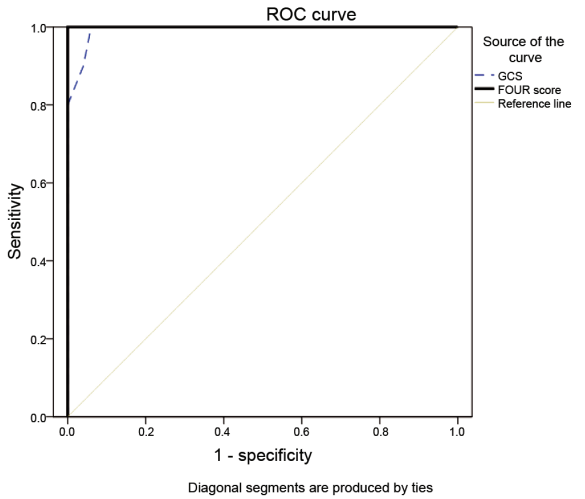

Fig. 5 ROC curve of FOUR score and GCS score for predicting mortality.

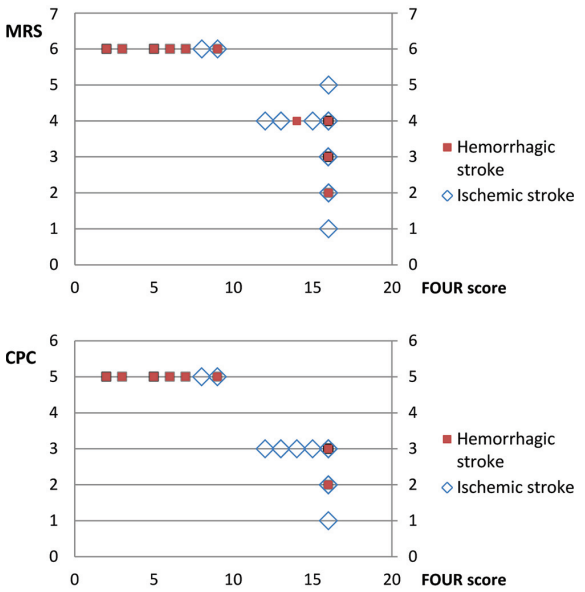

Fig. 6 Relation of FOUR score to modified Rankin Scale (above) and cerebral performance category (below) at 90 days.

95% CI 0.91 to 1.02). Cut-off point as a predictor for morbidity was 10 for FOUR score and 9 for GCS (Fig. 7).

Discussion

Baseline characteristic of our population was similar to the general acute stroke patient[10,11]. Most of them were female, aged over 60 years old and common underlying diseases are hypertension and dyslipidemia, which are risk factors for atherosclerosis. Hemorrhagic stroke had lower incidence. We had only 15 patients

Table 3. 90-day neurological outcome

	Ischemic stroke (n = 45) No. (%)	Hemorrhagic stroke (n = 15) No. (%)
Modified Rankin Scale		
0	0 (0.0)	0 (0.0)
1	1 (2.2)	0 (0.0)
2	12 (26.7)	1 (6.7)
3	15 (33.3)	5 (33.3)
4	14 (31.1)	1 (6.7)
5	1 (2.2)	0 (0.0)
6	2 (4.5)	8 (53.3)
Cerebral performance category		
1	1 (2.2)	0 (0.0)
2	12 (26.7)	1 (6.7)
3	30 (66.7)	6 (40.0)
4	0 (0.0)	0 (0.0)
5	2 (4.4)	8 (53.3)

(25%) with hemorrhagic stroke but most of them died or had poor neurological outcome at 90 days. This result was compatible with reviews from many countries[12-14].

Overall 90-day mortality rate from the present study was 16.6% (4.4% for ischemic stroke and 53.3% for hemorrhagic stroke). This mortality ratio between ischemic stroke and intracerebral hemorrhage was similar to report from Centers for Disease Control (CDC)[15]. FOUR score and GCS had an excellent correlation when using in acute stroke patients by emergency physicians with r = 0.821. Therefore, they both can be used as a prognostication tool in emergency setting as mentioned in study of Kevric et al[7]. There

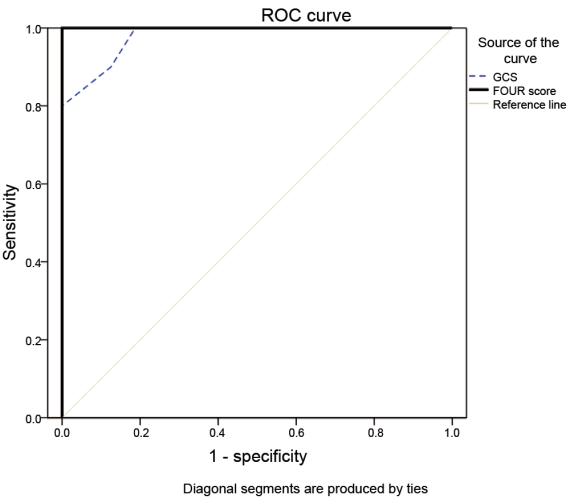

Fig. 7 ROC curve of FOUR score and GCS score for predicting neurological outcome.

were many studies that proved the accuracy of FOUR score in alteration of consciousness patients in the setting of neurosurgery[16], emergency[7,17], and critical care unit[18,19]. In acute stroke patients, there also showed the great yield for determining survival in intensive care unit[9,20]. Mansour et al found that GCS and FOUR score were not different in predicting in-hospital mortality (AUC of 0.977 for FOUR score and 0.975 for GCS)[9]. This study also showed that both GCS and FOUR score were great for predicting mortality of acute stroke patients in emergency setting with AUC of 0.99 and 1.0, respectively.

In the present study, there was 32% of unfavorable neurological outcome at 3 months which was lower than the previous studies. Sturm et al reported that stroke patients with poor neurological outcome at 3 and 12 months were found in 68% and 66%[21] while the Ovbiagele et al reported that severe disability at 1 and 3 months were 60.3% and 52.7% of patients[22]. This might reflect the development of stroke treatment. Early detection and rapid definite treatment significantly improve the long-term neurological outcome.

For prognostication of morbidity, we found that AUC of FOUR score and GCS score for three months' unfavorable neurological outcome were 1.00 (p<0.001, 95% CI 1.00 to 1.00) and 0.94 (p<0.001, 95% CI 0.91 to 1.02) respectively. Our result was consistent with previous studies that included patients with altered mental status in internal medicine ward[23], traumatic patients in emergency department[17], and patients with neurologic symptoms in ICU[6]. However, there was no statistically significant difference between FOUR score and GCS score in predicting neurologic outcome at 3 months (p = 0.052).

Conclusion

FOUR score and GCS had an excellent correlation when using in acute stroke patients by emergency physicians. FOUR score was better than GCS for predicting in-hospital mortality, 3-month mortality and morbidity.

What is already known on this topic?

FOUR score is a reliable prognostic tool in many situations such as critical care and stroke unit.

What this study adds?

FOUR score can also be used in acute stroke patients in emergency room. It was even better than GCS in prognostication.

Potential conflicts of interest

None.

References

1. World Health Organization. The top 10 causes of death [Internet]. 2014 [cited 2016 Sep 23]. Available from: http://www.who.int/mediacentre/factsheets/fs310/en/
2. World Health Organization. WHO Cardiovascular diseases fact sheet no. 317 [Internet]. 2013 [cited 2016 Sep 23]. Available from: http/www.who.int/mediacentre/factsheets/fs317/en/
3. Office of the Permanent Secretary, Ministry of Public Health. Public health statistics A.D. 2013. Nonthaburi: Bureau of Policy & Strategy; 2014.
4. Sawasdimongkol S, editor. Annual report 2014. Bangkok: War Veterans Organization Office of Printing Mill; 2014.
5. Wijdicks EF, Bamlet WR, Maramattom BV, Manno EM, McClelland RL. Validation of a new coma scale: The FOUR score. Ann Neurol 2005; 58: 585-93.
6. Bruno MA, Ledoux D, Lambermont B, Damas F, Schnakers C, Vanhaudenhuyse A, et al. Comparison of the Full Outline of UnResponsiveness and Glasgow Liege Scale/Glasgow Coma Scale in an intensive care unit population. Neurocrit Care 2011; 15: 447-53.
7. Kevric J, Jelinek GA, Knott J, Weiland TJ. Validation of the Full Outline of Unresponsiveness (FOUR) Scale for conscious state in the emergency department: comparison against the Glasgow Coma Scale. Emerg Med J 2011; 28: 486-90.
8. Idrovo L, Fuentes B, Medina J, Gabaldon L, Ruiz-Ares G, Abenza MJ, et al. Validation of the FOUR Score (Spanish Version) in acute stroke: an interobserver variability study. Eur Neurol 2010; 63: 364-9.
9. Mansour OY, Megahed MM, Abd Elghany EHS. Acute ischemic stroke prognostication, comparison between Glasgow Coma Score, NIHS Scale and Full Outline of Unresponsiveness Score in intensive care unit. Alexandria Med J 2015; 51: 247-53.
10. Roger VL, Go AS, Lloyd-Jones DM, Benjamin EJ, Berry JD, Borden WB, et al. Heart disease and stroke statistics--2012 update: a report from the American Heart Association. Circulation 2012; 125: e68-87.
11. Gunarathne A, Patel JV, Gammon B, Gill PS, Hughes EA, Lip GY. Ischemic stroke in South

Asians: a review of the epidemiology, pathophysiology, and ethnicity-related clinical features. Stroke 2009; 40: e415-23.
12. Collins TC, Petersen NJ, Menke TJ, Souchek J, Foster W, Ashton CM. Short-term, intermediate-term, and long-term mortality in patients hospitalized for stroke. J Clin Epidemiol 2003; 56: 81-7.
13. Zhang Y, Chapman AM, Plested M, Jackson D, Purroy F. The incidence, prevalence, and mortality of stroke in France, Germany, Italy, Spain, the UK, and the US: a literature review. Stroke Res Treat 2012; 2012: 436125.
14. Vemmos KN, Bots ML, Tsibouris PK, Zis VP, Takis CE, Grobbee DE, et al. Prognosis of stroke in the south of Greece: 1 year mortality, functional outcome and its determinants: the Arcadia Stroke Registry. J Neurol Neurosurg Psychiatry 2000; 69: 595-600.
15. Centers for Disease Control and Prevention. Mortality multiple cause files [Internet]. 2008 [cited 2016 Sep 23]; Available from: http://www.cdc.gov/nchs/data_access/vitalstatsonline.htm#Mortality_Multiple
16. Akavipat P, Sookplung P, Kaewsingha P, Maunsaiyat P. Prediction of discharge outcome with the full outline of unresponsiveness (FOUR) score in neurosurgical patients. Acta Med Okayama 2011; 65: 205-10.
17. Eken C, Kartal M, Bacanli A, Eray O. Comparison of the Full Outline of Unresponsiveness Score Coma Scale and the Glasgow Coma Scale in an emergency setting population. Eur J Emerg Med 2009; 16: 29-36.
18. Iyer VN, Mandrekar JN, Danielson RD, Zubkov AY, Elmer JL, Wijdicks EF. Validity of the FOUR score coma scale in the medical intensive care unit. Mayo Clin Proc 2009; 84: 694-701.
19. Wijdicks EF, Rabinstein AA, Bamlet WR, Mandrekar JN. FOUR score and Glasgow Coma Scale in predicting outcome of comatose patients: a pooled analysis. Neurology 2011; 77: 84-5.
20. Kocak Y, Ozturk S, Ege F, Ekmekci H. A useful new coma scale in acute stroke patients: FOUR score. Anaesth Intensive Care 2012; 40: 131-6.
21. Sturm JW, Dewey HM, Donnan GA, Macdonell RA, McNeil JJ, Thrift AG. Handicap after stroke: how does it relate to disability, perception of recovery, and stroke subtype?: the north North East Melbourne Stroke Incidence Study (NEMESIS). Stroke 2002; 33: 762-8.
22. Ovbiagele B, Lyden PD, Saver JL. Disability status at 1 month is a reliable proxy for final ischemic stroke outcome. Neurology 2010; 75: 688-92.
23. Gujjar AR, Jacob PC, Nandhagopal R, Ganguly SS, Obaidy A, Al Asmi AR. Full Outline of UnResponsiveness score and Glasgow Coma Scale in medical patients with altered sensorium: interrater reliability and relation to outcome. J Crit Care 2013; 28: 316-8.

ความแม่นยำของการตรวจประเมินระดับความรู้สึกตัวของผู้ป่วยหลอดเลือดสมอง 2 วิธี ในห้องฉุกเฉิน โรงพยาบาลศิริราช

อุษาพรรณ สุรเบญจวงศ์, วีรพล สอนมีทอง, ธันยพร นครชัย

ภูมิหลัง: *Full Outline of Unresponsiveness Score Coma Scale (FOUR score) สามารถพยากรณ์การเสียชีวิตและความทุพพลภาพได้ดีกว่า Glasgow coma scale (GCS) ในผู้ป่วยวิกฤติและผู้ป่วยอุบัติเหตุ อย่างไรก็ดีไม่มีการศึกษาในผู้ป่วยหลอดเลือดสมองในห้องฉุกเฉิน*

วัตถุประสงค์: *วัตถุประสงค์หลัก ได้แก่ การศึกษาความสัมพันธ์ระหว่างระบบคะแนนทั้ง 2 ประเภท และความสามารถในการพยากรณ์การเสียชีวิต และการเกิดภาวะทุพพลภาพของแต่ละระบบคะแนนเป็นวัตถุประสงค์รอง*

วัสดุและวิธีการ: *เป็นการศึกษาเปรียบเทียบไปข้างหน้า ในผู้ป่วยผู้ใหญ่ที่มีภาวะหลอดเลือดสมองเฉียบพลันและไม่มีประวัติได้รับบาดเจ็บที่ศีรษะนำมาก่อน ผู้ป่วยจะได้รับการประเมินคะแนนทั้ง 2 วิธี ที่ห้องฉุกเฉินก่อนได้รับการรักษา และติดตามผลการรักษาที่ 3, 7, 30 และ 90 วัน*

ผลการศึกษา: *จากผู้ป่วย 60 ราย ที่เข้าร่วมการศึกษา พบว่าคะแนนเฉลี่ย FOUR score ของผู้ป่วยทั้งหมดเท่ากับ 14.05 (SD 4.02) และคะแนนเฉลี่ย GCS เท่ากับ 12.45 (SD 3.74) ทั้ง 2 ระบบ คะแนนมีความสัมพันธ์กันในระดับดีเยี่ยมเมื่อใช้ในผู้ป่วยหลอดเลือดสมองในห้องฉุกเฉินด้วยค่า r 0.821 ($p<0.001$) เมื่อนำมาใช้ในการพยากรณ์การเสียชีวิตในโรงพยาบาลและการเสียชีวิตภายใน 3 เดือน พบว่าพื้นที่ใต้โค้งของ FOUR score มีค่าเท่ากับ 1.00 ($p<0.001$, 95% CI 0.94-1.00) ในขณะที่ GCS มีพื้นที่ใต้โค้ง 0.99 ($p<0.001$, 95% CI 0.92-0.99) นอกจากนี้เมื่อศึกษาถึงการพยากรณ์ภาวะทุพพลภาพที่ 3 เดือน (modified Rankin Scale 4-6 และ Cerebral Performance Category 3-5) พบว่า FOUR score สามารถใช้ได้ดีกว่า GCS เนื่องจากมีพื้นที่ใต้โค้งสูงถึง 1.00 ($p<0.001$, 95% CI 1.00-1.00)*

สรุป: *FOUR score และ GCS มีความสัมพันธ์กันในระดับดีเยี่ยม และ FOUR score มีความสามารถในการพยากรณ์การเสียชีวิตและภาวะทุพพลภาพที่ดีกว่า GCS ในผู้ป่วยหลอดเลือดสมองในห้องฉุกเฉิน*