Reliability and Validity of the Canadian Neurological Scale, Thai Version

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Background: *The Canadian Neurological Scale (CNS) is one of the most reliable stroke severity assessment scales. There is a strong need for a simple and well validated stroke severity assessment scale among Thais.*
Objective: *To translate and perform a reliability and validity study of the Canadian Neurological Scale, Thai version (CNS-T).*
Material and Method: *Forward and backward translations of the original CNS version were independently performed. The final version of the CNS-T was prospectively tested for reliability and validity in acute ischemic stroke setting. Consecutive series of acute stroke patients were assessed by one of the six raters from three different types of healthcare providers: 2 stroke nurses, 2 internal medicine residents and 2 stroke fellows. Each patient was independently assessed twice at 3 weeks interval using video tape by all raters. Extent of infarction was measured by MRI lesion volume. Clinical outcome at 3 months was measured using modified Rankin Score (mRS). Correlation among the CNS-T and 3-mo mRS and MRI lesion volume were assessed. Inter and intra-observer reliabilities were evaluated.*
Results: *A total of 38 patients were enrolled. Median CNS-T was 8.5. Intra-observer reliability demonstrated a high agreement with an intraclass correlation (ICC) of 0.99, 0.97, 0.98, 0.96, 0.93 and 0.98 for 2 stroke fellows, 2 internal medicine residents and 2 stroke nurses respectively. Inter-observer reliability between the 6 raters was excellent: ICC 0.87 (95% CI; 0.81-0.92). The Spearman rank correlation coefficient was -0.55 ($p = 0.001$) between the initial CNS-T score versus initial MRI lesion volume and -0.61 ($p < 0.001$) between the initial CNS-T score versus 3-mo mRS.*
Conclusion: *The CNS-T can be performed by trained nurses, internists and neurologists with an excellent reliability. The CNS-T is a valid and simple clinical tool for stroke severity assessment among Thais.*

Keywords: *Acute stroke, Canadian Neurological Scale (CNS), Stroke*

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Neurological progression during the first hours and days of onset in cerebral infarction is common and may result in serious clinical problems. The frequency of deterioration varies, ranging from 12%-42%[1]. Detection of neurological deterioration and early therapeutic intervention in those patients could limit the extent of neurological damage and provide a better outcome. Standardized scale for clinical monitoring of acute stroke patients is required to quantify the change of patients' neurological status. The tool needs to be reliable, valid as well as practical, and simple to perform in everyday clinical practice.

Glasgow Coma Scale (GCS) was developed by Teasdale G et al in 1974[2], it has previously been judged to be reliable. The scale is widely used among the neurological and neurosurgical communities. However, GCS was not designed for evaluating and monitoring stroke patients, especially when the level of consciousness is retained which happens in most stroke cases. The use of an inappropriate tool may lead to inaccurate clinical decision making.

The National Institute of Health Stroke Scale (NIHSS) is one of the most reliable stroke severity assessment tools[3-5]. It measures 15 neurological items

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including consciousness, eye movements, vision, facial weakness, arm and leg weakness, ataxia, sensation, language function, dysarthria, sensory and neglect[6,7]. The scale has been widely validated in many prospective and retrospective studies[7-15]. It is commonly used among stroke neurologists in the context of clinical research trials. In addition, its administration may be more problematic for emergency physicians, general practitioners, nurses and paramedics because of its level of complexity[10]. Under utilization of the NIHSS has also been documented in different settings[9,11,12].

The Canadian Neurological Scale (CNS) was developed by Cote R in 1986[16]. It is one of the most reliable stroke severity assessment tools[17,18]. It measured level of consciousness, orientation, perception, facial expression, arms and legs strength. The highest score was 11.5 and the lowest score was 1.5. Higher score represents less severity. One of the great advantages of the CNS scale is that it is simple and practical to use in routine clinical practice while it maintains a good reliability and validity[3].

An informal survey performed at our institute showed that only 7.9% from a total of 127 internal medicine residents practice the NIHSS to evaluate acute stroke patients, whereas 92.1% use the GCS. Currently, there is no simple and well validated clinical tool to assist physicians in evaluating acute stroke patients in Thailand. The present study aimed to translate the original CNS and assess the reliability and validity of the CNS, Thai version (CNS-T).

Material and Method

The CNS was translated forward and backward by two independent neurologists and two independent psychiatrists. Any disagreement was solved through a consensus meeting of the investigator team. The final CNS-T protocol was explained and demonstrated to the study team which composed of 3 levels of health care providers, 2 stroke nurses, 2 internal medicine residents and 2 stroke fellows.

Acute ischemic stroke patients aged 18 years and over presented within 7 days after symptoms onset were included in the present study. The authors excluded those who were in stupor or comatose according to the exclusion criteria of an original CNS version (If the patients were comatose, physicians were recommended to use GCS which was similar to the CNS in simplicity and reliability). Patients who had contraindication for brain MRI, were pregnant or those who had brain pathology, other than ischemic stroke, were also excluded from the present study.

After admission, one of the six raters was randomly selected to perform the CNS-T examination and then scored the deficit (the first CNS-T score). Video recording was made during the examination which required approximately 5-10 minutes. Subsequently, brain MRI was performed within 72 hours after the CNS-T examination. Lesion volume was measured by an independent neuroradiologist (PC) using diffusion-weighted imaging (DWI). After an initial assessment, the video tape was reviewed independently by the rest of the raters (another 5 raters). After 3-5 weeks, all raters were assigned to review the same video tape and rate the second set of CNS-T score, independently.

All study patients were treated according to standard treatment of ischemic stroke at the Siriraj Acute Stroke Unit. Modified Rankin Scale (mRS)[19,20] was recorded during patients' follow-up at 3 months. All raters and treating physicians had no access to MRI lesion volume data. Neuroradiologist (PC) who performed an MRI lesion volume measurement was blinded to all clinical data.

The present study was approved by the Ethics Committee of the Faculty of Medicine Siriraj Hospital, Mahidol University. All participants provided written informed consent before included in the present study.

Statistical analysis

Approximately 30 subjects were needed to achieve an 80% power, 5% type I error and a correlation coefficient of 0.5. The present study required 36 participants after accounting for a 20% loss to follow-up. Continuous data were presented in the form of mean and standard deviation while categorical data were presented in the form of number and percent. Spearman rank correlation was used to analyze a correlation between the CNS-T and MRI lesion volume and 3-month mRS. An intraclass-correlation was used to analyze intra and inter-observer reliability.

Results

A total of 38 subjects were enrolled with a mean $\pm$ SD age of 66 $\pm$ 14.5 years. Men comprised 55.30%. Complete follow-up was achieved for all patients. Vascular risk factors including diabetes, hypertension, coronary artery disease and smoking accounted for 60.5, 60.5, 47.4 and 28.9%, respectively. Subtypes of stroke according to the TOAST classification were as follows: large vessel atherosclerosis 28.9%, cardio-embolic 36.8%, small vessel occlusion 34.2%. Anterior circulation stroke presented in 78.9%

Table 1. Patients' characteristics

Characteristics	
Mean age ± SD, years (range)	66 ± 14.5 (27-91)
Men (%)	21 (55.3)
Comorbidity (%)	
DM	23 (60.5)
HT	23 (60.5)
Coronary artery disease	18 (47.4)
Current smoker	11 (28.9)
Stroke Subtype (%)	
Cardioembolic	14 (36.8)
Large artery atherosclerosis	11 (28.9)
Small vessel occlusion	13 (34.2)
Stroke Location (%)	
Anterior circulation	30 (78.9)
Posterior circulation	8 (21.1)
Median CNS-T	8.5 (IQR; 4.9-10.8)
Median mRS at 3 months Mean	3 (IQR; 0 - 4)
MRI lesion volume ± SD, cm^3(range)	29.43 ± 51.83 (0.16-217.8)

Table 2. Intra-observer reliability

	Intraclass correlation (ICC)	95% CI
Fellow A	0.99	0.99-0.99
Fellow B	0.97	0.95-0.99
Resident A	0.98	0.96-0.99
Resident B	0.96	0.92-0.98
Nurse A	0.93	0.86-0.96
Nurse B	0.98	0.96-0.99

Table 3. Correlation between CNS-T and 3-month mRS and MRI lesion volume

	Correlation coefficient	p-value
CNS-T-3-month mRS	-0.61	$p < 0.01$
CNS-T-DWI	-0.55	$p = 0.001$

of participants. Regarding anti-thrombotic medications, patients received aspirin, aspirin plus dipyridamole, anticoagulant at 86.8, 2.6 and 23.7%. Statin medications were prescribed in 92.1%. There were 2 patients who received rt-PA.

The CNS-T was performed in all patients with a median score of 8.5 (interquartile range; 4.9-10.8). On average, the tool required 2 minutes and 50 seconds to complete. Median mRS at 3 months was 3 (interquartile range; 0-4). Mean MRI lesion volume ± SD was 29.43 ± 51.83 cm^3.

Detail baseline characteristics, stroke location and stroke etiology by TOAST classification are shown in Table 1.

Intra and inter-observer reliability

Intra-observer reliability demonstrated a near perfect agreement with an intraclass correlation (ICC) of 0.99, 0.97, 0.98, 0.96, 0.93 and 0.98 for 2 stroke fellows, 2 internal medicine residents and 2 stroke nurses, respectively. Intra-observer reliability was shown in Table 2. Inter-observer reliability between the 6 raters was excellent with an intraclass correlation of 0.87 (95% CI; 0.81-0.92).

The CNS-T construct validity

The CNS-T functioned as hypothesized. It had a negative correlation with the 3-month mRS and the DWI lesion volume as shown by the Spearman rank correlation coefficient of -0.61 ($p < 0.01$) and -0.55 ($p = 0.001$), respectively, was shown in Table 3. When subgroup analysis was performed in patients with middle cerebral artery stroke, a higher correlation coefficient between the score and the volume of infarction was found at a value of -0.64 ($p = 0.001$).

Discussion

The present study has demonstrated that the

CNS-T is a reliable and valid clinical tool to measure acute ischemic stroke severity.

When compared to the original study, the authors validated the CNS-T score against cerebral infarction volume as measured by an MRI using diffusion-weighted imaging technique (DWI) in which a substantial correlation was shown[16,17]. In addition, the authors tested both inter and intra reliability and found an excellent intraclass correlation coefficient.

To reach a near perfect inter and intra-observer reliability, the following methods were applied in our study. Firstly, the authors used a videotape in the second CNS-T evaluation. Therefore, the possibility of having any changes in neurological signs that might occur overtime can be eliminated. Secondly, training and practice sessions were given to all raters prior to the present study. This can greatly enhance the inter-rater agreement. Finally, this research employed a random sampling method in that the first examiner was randomly selected to exam the patient. This can prevent any prediction of performing the CNS-T examination by raters and thus increases the consistency of the results.

Both the NIHSS and the CNS have been used as clinical tools to determine patient inclusion in clinical trials, to compare patient groups within or between trials, or as an outcome measure. However, the CNS shows characteristics of a more practical scale, including simplicity and brevity of execution, while still retaining its reproducibility and validity. A retrospective study demonstrated that there are more missing items for the completion of the NIHSS when compared to the CNS as it requires a more detailed neurological examination that may not be available from patients' records[9]. This is particularly true in community hospitals where the majority of stroke patients are admitted and treated, and is also true in developing countries where neurological expertise might be limited. In addition, most of the world's stroke patients are managed in settings where only a simpler scale such as the CNS may be used with more reliability.

There are a few limitations in the present study. Firstly, we included only acute ischemic stroke patients to validate the CNS-T; as a result, the scale may not be applicable in hemorrhagic stroke. Secondly, stroke severity depends on the location and extent of lesion. Patients with different infarct locations may get a significantly different score. For example, those with a large periventricular or subcortical infarct may receive a high CNS-T score representing mild stroke while those with the same amount of infarction volume at pons may have a very low score reflecting more severe stroke. For this reason, the relationship between MRI lesion volume and the CNS-T score may not be perfectly correlated, as shown in the present study with a correlation coefficient of -0.55, $p = 0.001$. The assumption was supported with a higher correlation coefficient of -0.64, $p = 0.001$ when the authors performed a subgroup analysis including only patients who presented with middle cerebral artery stroke. Nonetheless, the score was also shown to have a substantial correlation with patients' disability level at 3 months (correlation coefficient of -0.61, $p < 0.01$). Thirdly, it was not practical to perform an MRI brain at the same time interval after stroke onset. This may contribute to a different infarction volume as DWI findings change according to time after brain ischemia.

Although further validation study of the CNS-T in other acute stroke settings, i.e. intracerebral hemorrhage is needed, the authors recommend integrating the scale into a routine neurological evaluation in acute stroke patients as it provides a valid and reliable tool that can serve as an outcome predictor after stroke.

Conclusion

CNS-T is a valid clinical tool to assess stroke severity and predict disability at 3 months and it can be performed by trained nurses, internists and neurologists with excellent inter and intra-rater reliabilities.

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Potential conflicts of interest

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การศึกษาความเชื่อมั่นและความเที่ยงตรงของแบบวัดความรุนแรงของโรคหลอดเลือดสมอง Canadian Neurological Scale (CNS) ภาคภาษาไทย

ลัลธริตา เจริญพงษ์, พิพัฒน์ เชี่ยววิทย์, จุฬาลักษณ์ โกมลตรี, จุลจักร ลิ่มศรีวิไล, สงคราม โชติกอนุชิต, นภาพร แย้มแก้ว, นิรมล ลิรัฐพงค์, นิพนธ์ พวงวรินทร์, ยงชัย นิละนนท์

วัตถุประสงค์: *มากกว่าครึ่งของผู้ป่วยโรคหลอดเลือดสมองตีบหรืออุดตันเฉียบพลันที่ถูกรับตัวไว้รักษาในโรงพยาบาลจะมีอาการทางระบบประสาทเปลี่ยนแปลง ดังนั้นจึงมีความจำเป็นในการประเมินการเปลี่ยนแปลงทางระบบประสาทอย่างต่อเนื่อง แบบวัด Canadian Neurological Scale (CNS) เป็นแบบวัดความรุนแรงของโรคหลอดเลือดสมองที่มีความเที่ยงตรงและเชื่อมั่นสูง การศึกษานี้มีจุดประสงค์เพื่อทดสอบความเที่ยงตรง (Validity) และความเชื่อมั่น (Reliability) ของแบบวัดความรุนแรงของโรคหลอดเลือดสมอง Canadian Neurological Scale ภาคภาษาไทย ในผู้ป่วยโรคหลอดเลือดสมองตีบหรืออุดตันเฉียบพลัน*

วัสดุและวิธีการ: *เป็นการศึกษาแบบติดตามอาการไปข้างหน้า (prospective observational study) ทำการศึกษาในผู้ป่วยโรคหลอดเลือดสมองตีบหรืออุดตันเฉียบพลัน โดยนำCNS ภาคภาษาไทยมาขยายความและแปลกลับเป็นภาษาอังกฤษ จากนั้น ผู้ตรวจ 1 คนซึ่งสุ่มเลือกจาก พยาบาลวิชาชีพ 2 คน, แพทย์อายุรกรรมทั่วไป 2 คน และแพทย์เฉพาะทางระบบประสาท 2 คน ทำการตรวจประเมินผู้ป่วยพร้อมทั้งถ่ายวีดีโอไว้ ถือเป็นการตรวจครั้งแรก จากนั้นจะให้คะแนนครั้งที่ 2 จากวีดีโอ ในเวลาห่างกันอย่างน้อย 3 สัปดาห์ ผู้ป่วยจะได้รับการตรวจเอกซเรย์คลื่นแม่เหล็กไฟฟ้าสมอง ภายใน 72 ชั่วโมงหลังจากตรวจ CNS รังสีแพทย์จะทำการวัดปริมาตรเนื้อสมองที่ขาดเลือด (MRI lesion volume) ผู้ป่วยจะได้รับการประเมินความพิการที่หลงเหลือ ณ เวลา 3 เดือนโดยใช้ modified Rankin Scale (mRS) จากนั้นคะแนน CNS จะถูกนำมาวิเคราะห์หา intra-observer reliability และ inter-observer reliability และ ประเมินความสัมพันธ์ระหว่างคะแนน CNS และปริมาตรเนื้อสมองที่ขาดเลือด และระดับความพิการที่ 3 เดือน*

ผลการศึกษา: *ประชากรที่ศึกษาทั้งหมด 38 คน, คะแนนเฉลี่ย CNS เท่ากับ 8.5 intra-observer reliability มีค่า intraclass correlation (ICC) เท่ากับ 0.99, 0.97, 0.98, 0.96, 0.93 และ 0.98 สำหรับแพทย์เฉพาะทางระบบประสาท 2 คน, แพทย์อายุรกรรมทั่วไป 2 คน และพยาบาล 2 คน ตามลำดับ สำหรับ inter-observer reliability มีค่า ICC 0.87 (95% CI; 0.81-0.92) ความสัมพันธ์ระหว่าง CNS และ MRI lesion volume และ mRS มีค่า correlation coefficient - 0.55 ($p = 0.001$) และ -0.61 ($p < 0.01$) ตามลำดับ*

สรุป: *แบบวัดความรุนแรงของโรคหลอดเลือดสมอง CNS ภาคภาษาไทย สามารถใช้ประเมินความรุนแรงของผู้ป่วยโรคหลอดเลือดสมองได้โดยมีความเชื่อมั่น (reliability) ที่ดีมาก และมีความเที่ยงตรง (validity) ที่ดี นอกจากนี้เครื่องมือนี้ยังสามารถใช้โดยพยาบาล, แพทย์อายุรกรรมทั่วไป และ แพทย์เฉพาะทางอายุรกรรมระบบประสาทได้*