Validity of Clock Drawing Test (CDT), Scoring by Chula Clock-Drawing Scoring System (CCSS) in Screening Dementia among Thai Elderly in Community

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Objective: *The present paper was to study the validity of screening dementia among Thai elderly by clock drawing test (CDT).*
Material and Method: *The scoring method selected to apply with CDT was Chula clock-drawing scoring system (CCSS) that was originally developed as clinically-based in Thai elderly patients. The 669 elderly subjects gathered from "Rom Klao" community in Bangkok, Thailand were asked to perform CDT and be examined by a neurologist,using NINCDS-ADRDA diagnosis criteria for probable Alzheimer's disease (AD). CDT was scored by psychiatrists using CCSS.*
Results: *The authors found the demented by clinical diagnosis in 25 cases. Using a CCSS cutoff score of 7, CDT produced positive test results in 191 subjects. Sensitivity was 88%, the specificity was 74% and the area under receiver operation characteristics (ROC) curve was 0.91. The results also showed that comparatively to cutoff point 7, a cutoff point 6 would contribute the higher specificity of 82% and have a similar sensitivity of 88% in this community-based sample.*
Conclusion: *The present study provided strong support that CDT scoring by CCSS is efficient to screen dementia in the general community with satisfactory sensitivity and specificity. However, modifying the CCSS cutoff score from 7 to 6 increases the specificity and is proposed to be applied in the community.*

Keywords: *Clock drawing test, Chula clock-drawing scoring system, Dementia, Community*

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Worldwide, about 7% (4-12%) of the population over the age of 65 and nearly half of those over 85, have some forms of dementing illness[1-4]. The prevalence of dementia in the elderly is closer to 8% to 10% in the United States, United Kingdom, Canada and other developed countries[5-7] while it is about 1.8-3.3%[8,9] in Thailand. Studies have demonstrated that dementia is under diagnosed in primary care settings, with one study showing that less than half of the patients with Alzheimer's disease (AD) are being identified[10]. Reported barriers to testing include increasingly abbreviated office visit, lack of routine use of cognitive screening tools, difficulty interpreting cognitive test results, lack of specificity and sensitivity of screening tools and the risk of offending patients[11]. While the markers, tests, or research have greatly advanced in cerebrospinal test such as measure of tau and amyloid b for AD, the basic (bed side) investigation is still important in developing countries where disease detection is currently problematic[12]. A simple, practically administered, inexpensive, low limited and sensitive screening procedure to screen dementia is needed.

Clock drawing test (CDT) has been used for years as a suitable measure. However, the interpretation of the drawing can be difficult even for individuals with extensive experience[13]. A number of sys-

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tems of scoring clock drawing have been proposed and various techniques are in use[14-21]. One of CDT scoring methods, developed and validated in Thai elderly population, was the "Chula clock-drawing scoring system" (CCSS)[21]. This scoring method had excellent sensitivity and specificity into screening dementia. However, the original paper studied 58 cases who attended the geriatric clinic at King Chulalongkorn Memorial Hospital. Because this study was small, it may lead to concern about the validity of CDT scoring with CCSS in community application. The authors studied, in a larger setting, the CDT scoring with CCSS to prove its adequacy to screen dementia in Thai elderly.

Material and Method

The subjects for the present study consisted of 669 elderly gathered from a survey of "Rom Klao Community", Bangkok, Thailand in 1999-2000. People physically unable to write (such as stroke, severe Parkinson, complete illiteracy) and to see (e.g. blindness) were excluded from the present study. The subjects were asked to perform the CDT on a piece of paper with a preprinted circle twelve centimeters in diameter. They were asked to follow a two-step instruction: first, draw a clock by putting in numbers. Second, put the long and short hands in the clock to make it read ten past eleven (11.10). Instructions were repeated as necessary but additional prompting was not provided. No time limit was placed on this task. They were also examined by a geriatrician and diagnosed "dementia" using NINCDS-ADRDA (National Institute of neurological and communicative disorder)[22] criteria for probable AD. The neurologist did not see or have any information about the patients' clock drawing.

Analysis of Clock drawing errors

After the clock drawing test and clinical diagnosing completion, the paper of CDT was evaluated by 2 psychiatrists using CCSS developed by S. Jitapunkul, et al[21]. The CCSS was a quantitative systematic scoring system. It considered 5 domains consisting of number of digits, errors in number in the worst quadrant, spatial arrangement and number sequencing, hand and placement of hands (scoring rule and example shown in Table 1 and Fig. 1).

Inter-rater reliability, using Spearman coefficient, to assess the agreement between two psychiatrists for CCSS was 0.93. Each rater was blinded to the clinical diagnosis. The relation of clock drawing scores and clinical categories were analyzed for statistical significance by the Fisher Exact test. Sensitivity,

Table 1. Scoring rules of Chula clock-drawing scoring system (CCSS)

	2 points	1 points	0 points
A. Number of digit from 1-12	completed 1 or 2 errors	Missing or adding of digits or more errors	Missing or adding of 3
B. Error in the numbers of digit in the worst quadrant	No errors	1-2 errors	3 or more errors
C. Spatial arrangement and sequencing of the numbers in the right order	Present in the inner side of the circle and present in the counterclockwise direction or not present in the right order	Present in the inner side of circle but number places	Gross spatial distortion
D. Presence of the hands respected and evidence of having centre-point of both hands (unnecessary to have a centre-point	The size difference is hands or no evidence of having or no evidence of having centre-point of both hands	Size difference between the representation of 2 hands or no hands or perseveration on hands	Only one hand or poor
E. Placement of the hands position (11.10) or slight errors	Hands are in correct hand (wrong minutes or hour)	Incorrect position of one both hands or write the time instead of draw the hands	Incorrect position of

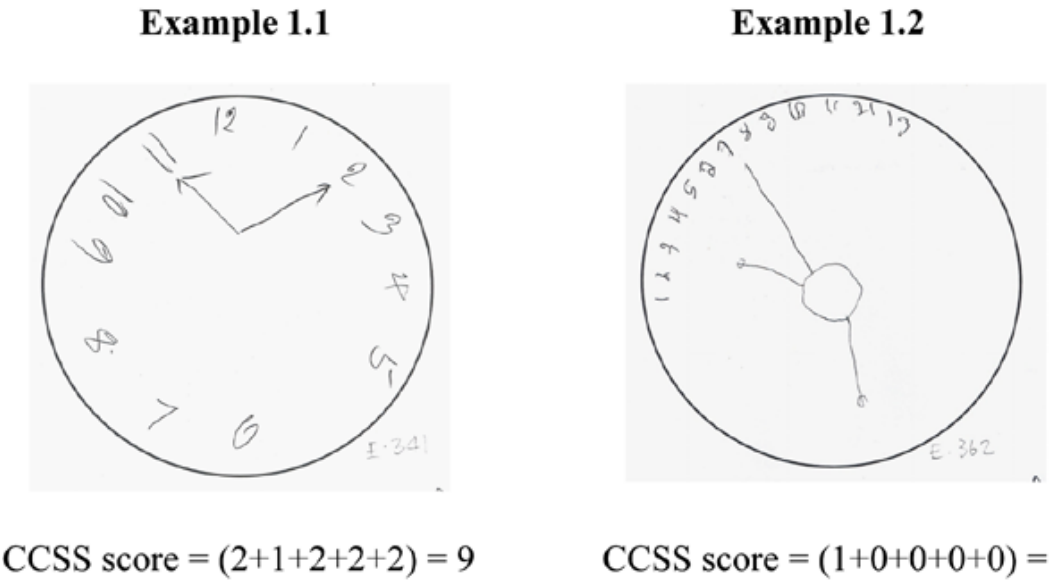

Fig. 1 Example of CDT using CCSS

specificity and receiver operation characteristics (ROC) curve were performed to quantify test accuracy, to characterize the distribution of test scores and to determine the optimal cutoff point to detect dementia.

Results

Six hundred and sixty nine subjects were clinically evaluated and tested. Twenty five were diagnosed with dementia based on NINCDS-ADRDA (for probable AD) criteria by a geriatrician's. Demographic data is shown in Table 2. Most were female and married. average age of the subjects was 62 years old.

The outcome of CCSS scoring system is demonstrated in Table 3. Of the 669 subjects, the authors found 191 subjects with positive test, while the clinical diagnosis, regarded as the gold standard, found 25 dementia cases. The false positive, false negative, true positive and true negative rate can be identified from data in Table 3.

The sensitivity, specificity and area under ROC were calculated as seen in Table 4 and Fig. 2. The

Table 2. Demographic data of sample

		Percent (%)	Number
	Sample	100	669
Gender	Male	42.2	282
	Female	57.8	388
Marital status	Married	55.3	370
	Widow	41.7	279
	Divorced	1.2	8
	Single	1.8	12
Age	50-59 years	41.6	278
	60-69 years	43.5	291
	70-79 years	13.1	88
	80 or more	1.8	12
	Mean age	62.08	
	Min-max age	52-87	
	SD	6.943	

Table 3. Relation between test and clinical diagnosis

CCSS scoring methods of CDT	Clinical Diagnosis		p-value*
	Demented	Non-demented	
Positive	22	169	<0.001
Negative	3	475	

Table 4. Sensitivity and specificity each cutoff level

CCSS Cutoff score	Sensitivity	Specificity	ROC
3	0.62	0.95	0.91
4	0.68	0.92	
5	0.80	0.88	
6	0.88	0.82	
7	0.88	0.74	
8	0.88	0.70	
9	0.92	0.59	

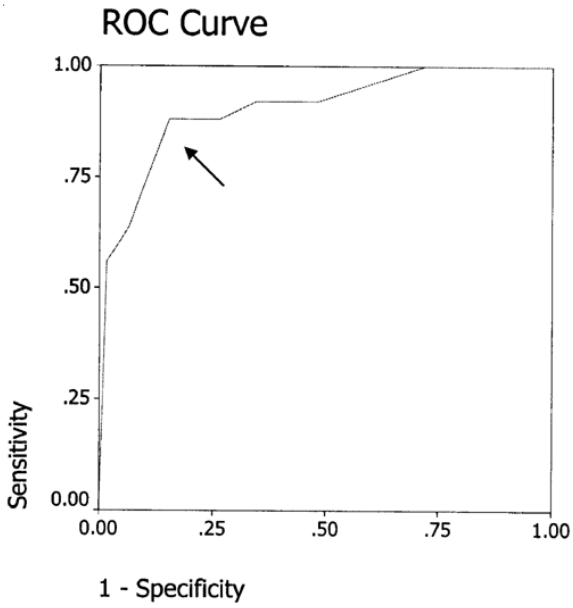

Fig. 2 ROC curve of CDT using CCSS

excellent area under ROC (0.91) and curve that arise almost vertically from the lower left corner and then more horizontally almost along the upper line illustrates that this CDT scoring system has high accuracy to detect abnormality due to low false positive rate (1-specificity) as well as high sensitivity. By using the original cutoff point of CCSS (positive if score less than 7), CCSS had sensitivity 88% and specificity 74%. However, it can be seen from the ROC curve and data in Table 4 that the point under 7 is not the best cutoff point for samples in the community. The cutoff point under 6 (arrow point) would provide higher specificity at 82% as well as similar sensitivity at 88%.

The data in Table 5 compares each cutoff level sensitivity and specificity of CDT scores using CCSS between the original clinically-based paper and the present community-based study. Sensitivity and specificity of the present study are lower than the prior one in every cutoff point.

Discussion

CDT has been accepted as a practical and efficient tool for detecting dementia. The emphasized task of CDT was constructional praxis (visuoperception and visuospatial function)[23,24], reconstruction of verbal command, language comprehension, executive function, semantic and working memory[11,25,26]. A number of brain contributions were included in a test so that CDT has been accepted worldwide as simple and sensitive even in early dementia[16], despite the lack of a single standard for administration or scoring. The CCSS was first published in 2000 as a measure for detecting dementia. Similar to most scoring methods of CDT, the validation process of the CCSS was the gathering of samples in a hospital, so that the subjects were patients visiting the geriatric clinic and who may have had some degree of cognitive impairment and/or other diseases. The clinically-based sample of self-selected or pre-screened subjects may not have been representative of the community-dwelling population because it may lead to an overestimation of the true

Table 5. Comparative sensitivity and specificity between original CCSS study and present study

Cut off level	CCSS (original study in 2000)		CCSS (present study)	
	Sensitivity	Specificity	Sensitivity	Specificity
5	0.82	0.94	0.80	0.88
6**	0.91	0.94	0.88	0.82
7*	1.00	0.94	0.88	0.74
8	1.00	0.74	0.88	0.70

* Original cut off point
** To be proposed cut off point

diagnosis accuracy of the CDT when it is applied to a community based sample[27].

The present study is different from the original paper of CCSS in the way of sample gathering. "Rom Klao Community" represents a general population that the authors chose to survey. The result of the present study provides strong support for validity and competency to detect dementia by using CCSS for CDT among elderly in the community. Between a group of demented and non-demented subjects, standard cutoff CCSS effectively differentiated those with good sensitivity and specificity at 88% and 74%, respectively. Even Table 5 shows decreasing of both sensitivity and specificity if the authors compare between the present study and the Jitapunkul study[21]. The best explanation could be due to difference in sample size and from where subjects originated. Comparative to other studies of CDT in community, Cahn et al[28] used CDT to screen dementia by 3 scoring ways, quantitative, qualitative and global, which take into account both quantitative and qualitative aspects of performance. They achieved 83% sensitivity and 72% specificity. This validity was lower than most in clinical-based studies which is coherent with the present study. However, even with their complicated scoring process, the sensitivity and specificity are not better than CCSS.

Related to the point of sensitivity and specificity of CCSS, the ROC curve in Fig. 1 and data in Table 4 demonstrated that the cutoff point at 7 (less than 7 means abnormal) contribute sensitivity and specificity at 88% and 74%, respectively, while the cutoff level at 6 would yield with a sensitivity of 88% and specificity of 84%. Contrary to the previous information given from a geriatric clinic in the medical school hospital[21], the present study revealed that the original cutoff point at 7 may not provide the best sensitivity and specificity for screening elderly in the community.

In order to decide the best cutoff point, the authors usually trade off between increasing the sensitivity and decreasing the specificity or vice versa. But in this case, making a change of cutoff score to be 6 gives more advantage by increasing specificity without reducing sensitivity. Therefore, the authors would like to propose the modified cutoff level of CCSS in order to detect dementia in the community.

A shortcoming of the present study is related to the relatively small proportion of demented cases (by clinical diagnosis), comparative to non-dementia cases. However, this represents the real prevalence of AD in general among elderly in a community in Thailand. Another point is about the generalizability to detect cognitive impairment that only emphasizes AD as AD was the original purpose of CDT use. Though satisfactory sensitivity and specificity rate were obtained, it has yet to be determined if this will be replicated in different types of dementia.

Conclusion

One of the scoring methods for CDT is CCSS. It had excellent validity in dementia screening for elderly patients. The present study provides strong support that CDT scoring by CCSS is competent to screen AD among the elderly in the general community with satisfactory sensitivity and specificity. However, a modified cutoff score is proposed to apply to the community in order to increase specificity while maintaining high sensitivity.

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ความถูกต้องของการคัดกรองโรคสมองเสื่อมของผู้สูงอายุไทยในชุมชน โดยใช้แบบทดสอบวาดภาพหน้าปัดนาฬิกา และระบบการให้คะแนนวาดหน้าปัดนาฬิกาของจุฬา

บุรณี กาญจนถวัลย์, สุทธิชัย จิตะพันธุ์กุล, ศิริลักษณ์ ศุภปีติพร, สิรินทร ฉันศิริกาญจน

การศึกษานี้ต้องการศึกษาประสิทธิภาพของการคัดกรองโรคสมองเสื่อมของผู้สูงอายุไทยในชุมชน โดยใช้แบบทดสอบวาดภาพหน้าปัดนาฬิกา การให้คะแนนใช้ระบบการให้คะแนนวาดหน้าปัดนาฬิกาของจุฬา ซึ่งระบบให้คะแนนครั้งแรกได้พัฒนาใช้ในผู้ป่วยสูงอายุที่มีปัญหาความจำ เพื่อศึกษาว่าสามารถใช้ในผู้สูงอายุทั่วไปในชุมชนได้หรือไม่ กลุ่มตัวอย่างเป็นผู้สูงอายุจำนวน 669 คน จากชุมชนร่มเกล้า ซึ่งได้รับการทดสอบวาดภาพหน้าปัดนาฬิกา และการตรวจทางระบบประสาทโดยแพทย์อายุรกรรมประสาทว่ามีภาวะสมองเสื่อมหรือไม่โดยใช้เกณฑ์การวินิจฉัย NINCDS-ADRDA สำหรับการวินิจฉัยทางคลินิคของโรค Alzheimer (probable AD) การประเมินคะแนนวาดหน้าปัดนาฬิกาของจุฬา ทำโดยจิตแพทย์ ผลการศึกษาพบว่า มีผู้ป่วยสมองเสื่อมวินิจฉัยโดยการตรวจทางคลินิกจำนวน 25 ราย ขณะที่ผลการทดสอบหน้าปัดนาฬิกา โดยใช้จุดตัดคะแนน 7 พบผลบวก 191 ราย ค่าความไว ความจำเพาะอยู่ที่ 88% และ 74% ตามลำดับ พื้นที่ใต้กราฟ ROC มีค่า 0.91 จากข้อมูลที่ศึกษาในกลุ่มตัวอย่างในชุมชน ยังพบว่าค่าจุดตัดที่ 6 คะแนนจะให้ค่าความจำเพาะที่ดีกว่าจุดตัดที่ 7 คะแนน คือจะได้ความจำเพาะเพิ่มเป็น 82% ขณะที่ยังคงความไวที่ 88% ผลการศึกษานี้สนับสนุนว่า การคัดกรองภาวะสมองเสื่อมโดยการใช้แบบทดสอบวาดภาพหน้าปัดนาฬิกา และระบบการให้คะแนนวาดหน้าปัดนาฬิกาของจุฬา (CCSS) สามารถใช้คัดกรองโรคสมองเสื่อมในผู้สูงอายุในชุมชนได้อย่างมีประสิทธิภาพ มีความไวและความจำเพาะที่น่าพอใจ อย่างไรก็ดี ผู้วิจัยเสนอให้มีการปรับเปลี่ยนจุดตัดจาก 7 คะแนน เป็น 6 คะแนน หากนำไปใช้ในการคัดกรองในชุมชน เนื่องจากจะให้ค่าความจำเพาะที่สูงขึ้น