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Clock Drawing Test (CDT): is Qualitative Analysis of the CDT Better to Screen Mild Cognitive Impairment than Quantitative Analysis?

Ji Hee Lee, Eung Seok Oh, Eun Hee Sohn and Ae Young Lee*

Department of Neurology, Chungnam National University, South Korea

***Corresponding author:** *Ae Young Lee, Department of Neurology, Chungnam National University, 282 Moonhwa-ro Jung-gu, Daejeon, South Korea, 301-721, Tel: +(82-42)-280-7807, Fax: +(82-42)-252-8654, E-mail: aelee@cnu.ac.kr*

Abstract

Background: Mild cognitive impairment (MCI) was originally used to describe a transitional state between normal condition and dementia. Revised and extended definition of MCI has been proposed that covers a broader range of cognitive impairment, distinct from normal ageing and from Alzheimer's disease. Despite the existence of reports regarding analyses of the Clock Drawing test (CDT) in Alzheimer's disease and vascular dementia, those focusing on MCI subjects are still lacking. The purpose of this study was to assess the characteristics of CDT and compare the results of quantitative and qualitative analyses of CDT performance in patients with MCI.

Materials and methods: Five hundred four consecutive patients with MCI (Korean versions of the Mini-Mental State Examination (K-MMSE)>23) were recruited for the study. All participants were examined by the K-MMSE, modified-MMSE (3MS) and the CDT. Quantitative scoring of the CDT was done by the Manos and Wu's method. Qualitative error types of the CDT were classified as stimulus-bound response (SBR), conceptual deficit (CD), spatial and/or planning deficit (SPD), and perseveration error (PE) by Rouleau's classification. We divided the subjects into two subgroups by the MMSE scores (lower cognitive function group, MMSE=24~26 vs. higher cognitive function group, MMSE=27~30) and compared the CDT scores and frequency of the error types between them.

Results: The total scores in the CDT significantly correlated with the total scores of the K-MMSE, 3MS and the level of education. Of the errors in the CDT, SPD was the most frequent type of error (45.3%) in the total samples. The scores in the K-MMSE and 3MS in the patients having CD errors were lower compared with those of other types of error. The lower cognitive group made more CD error (32.9%) than that of the higher cognitive group (25.5%).

Conclusion: Although the CDT cannot be used solely for clinical diagnosis of dementia, it provides useful cognitive information quantitative as well as qualitative ways, estimating the characteristics of MCI patients as a simple screening test.

Keywords

Clock drawing test, Mild cognitive impairment, Spatial deficit, Conceptual deficit

Introduction

Early detection of dementia is an issue of growing concern because of improved clinical outcome expected as early therapeutic intervention [1] or delaying dementia onset [2]. The term 'mild cognitive impairment (MCI) was originally used to describe a transitional state between normal condition and Alzheimer disease (AD) [3] and they do have cognitive impairment to some degree, but diagnostic criteria for dementia are not fulfilled [4].

In recent years, the clock drawing test (CDT) has been widely used particularly as a cognitive screening instrument for the diagnosis of dementia [5]. The CDT has been arousing the interest of clinicians and researchers as a convenient screening instrument for dementia, either by itself or as a part of a brief neuropsychological test battery [4]. The key benefits are simple and quick application and evaluation in order to survey global cognitive functions and it is easy to comprehend the instruction, making it suitable for elderly patients who may not be able to maintain concentration [6].

Although the CDT has these benefits, it is still a subject for debate on whether the CDT is valid as a screening instrument for MCI [4]. Most of the previous studies using CDT in MCI patients have compared only the average score of the CDT but not the analysis of error type in CDT. We hypothesized that there may be different characteristics of error types in the CDT according to the cognitive function in MCI. The purpose of this study was to evaluate quantitative analysis as well as qualitative characteristics of the errors of the CDT in patients with MCI.

Subjects and Methods

Patients

Subjects were recruited from the geriatric memory clinic at the Chungnam University Hospital from January, 2010 to July, 2014. A total of 504 consecutive patients (male: 237, female: 267) who had either subjective memory complaints or memory loss reported by their informants participated in this study. And neuropsychological assessment in this study based on current MCI concepts for MCI diagnosis as follows [7-9];

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Memory complaint, preferably corroborated by an informant
Objective memory impairment
Normal general cognitive function
Intact activities of daily living
Not demented

None had a history of neurologic or psychiatric disorders, and had been diagnosed as having reversible cause of cognitive impairment.

This study was performed under the permission and monitoring by the Chungnam National University Hospital institutional review board. All patients who participated in the study or legal family member understood and signed the informed consent.

Neuropsychological evaluation

Neuropsychological assessment for the participants in the study included the Korean version of the Mini-Mental State Examination (K-MMSE), Modified-Mini Mental State (3MS) test and the CDT. Participants who got total score of K-MMSE>23 were recruited for the study. We divided the subjects into two subgroups by the K-MMSE scores (lower cognitive function group, K-MMSE=24~26 vs. higher cognitive function group, K-MMSE=27~30) and compared the CDT scores and types of error between the two. Neuropsychological assessment was done by a neuropsychologist who was not aware of individual participant's clinical status.

Clock drawing test

All subjects were given a sheet of paper on which printed a circle of 10 cm diameter. The following instructions were given to each patient: "This circle represents a clock face. Please put in the numbers so that it look like a clock and then set the time to 10 min past 11". We scored the result of CDT using the methodology defined by Manos and Wu [10] quantitatively; clock divided into eights, points given for numbers and hands in right place (0~10).

Qualitative analyses of the errors were performed in order to define the types of error according to the cognitive status in clock drawing. The definitions and types of error were classified by Rouleau et al. [11]; stimulus-bound response (SBR), the tendency of the drawing to be dominated or guided by a single stimulus; conceptual deficit (CD), reflects a loss, or a deficit in accessing knowledge of the attributes, features and meaning of a clock. The hands were set for 10 to 11 instead of 10 after 11. When the time is written besides "11" or between "10 and 11" on the clock, or the hands were absent, this type of error was rated as a conceptual error as well. This category encompasses a wide variety of errors such as: (i) misrepresentation of the clock itself, (ii) misrepresentation of the time of the clock; spatial and/or planning deficit (SPD) was defined, (i) deficit in the layout of numbers on the clock (neglect of the left hemisphere: deficit in planning, leaving a gap before "12" or "3," "6," "9" depending on the strategy used in drawing), (ii) deficit in spatial layout of numbers, without any specific pattern in spatial disorganization, (iii) numbers written outside the clock face, (iv) numbers written counterclockwise; perseveration error (PE), defined as continuation or recurrence of activity without an appropriate stimulus. In clock drawing, different types of perseverative responses could be observed: PE of hands, or of numbers. Two neurologists, who were not aware of the clinical information, scored and analyzed the type of errors in CDT by the above mentioned definition of CDT errors, independently. When there was disagreement on the types of CDT error, enough discussion needed to arrive at a conclusion.

Statistical analysis

All statistical analyses were performed SPSS-PC-software for Windows, Version 16.0. To examine the relationship between the CDT and other variables (age, education, K-MMSE scores, 3MS scores), correlation and their *p* values were calculated using the Spearman rank order correlation coefficients. Multiple response analysis was used to determine error frequency. And to compare two cognitive group, Logistic regression analysis was used. The significance level was set at $p<0.05$.

Table 1: Demographic features of the total patients

Variables	Values (n=504)
Age (yrs)	71.5 ± 8.7
Female (%)	267 (51.5%)
Education(yrs)	8.8 ± 4.4
Mean K-MMSE scores	26.1 ± 1.9
Mean 3MS scores	80.2 ± 9.3
Mean CDT scores	7.8 ± 2.7
Mean CDT time	56.0 ± 29.1

Yrs: years; K-MMSE: Korean version of the Mini-Mental State Examination; 3MS: Modified Mini-Mental State (3MS) test; CDT: Clock Drawing Test.

Table 2: Pearson's correlation coefficients between cognitive function tests and duration of education

Measurement	CDT	3MS	K-MMSE	Education
CDT	1	0.272**	0.277**	0.268**
3MS	0.272**	1	0.739**	0.205**
K-MMSE	0.277**	0.739**	1	0.238**
Education	0.268**	0.205**	0.238**	1

CDT: Clock Drawing Test, 3MS: Modified Mini-Mental State (3MS) test, K-MMSE: Korean version of the Mini-Mental State Examination.

Table 3: Clinical and cognitive features between lower and higher cognitive group. The frequency of SPD and CD errors was significantly common in the lower cognitive group

		Lower cognitive group (n=286)	Higher cognitive group (n=218)	*p*-value
Age (yrs)		70.55	63.97	0.00
Female (%)		151 (52.8%)	116 (53.2%)	ns
Education		7.8 ± 4.3	10.1 ± 4.1	0.00
Mean K-MMSE scores		24.7 ± 0.8	28.1 ± 1.0	0.00
Mean 3MS scores		74.8 ± 7.5	87.3 ± 6.4	0.00
Mean CDT score		7.1 ± 3.0	8.6 ± 2.0	0.00
Mean CDT time		62.1 ± 28.1	48.0 ± 28.5	0.00
Error type (%)	SBR	24.1	29	ns
	CD	53.8	41.9	0.00
	SPD	76.6	67.7	0.00
	PE	8.9	25.8	ns

Yrs: years; K-MMSE: Korean version of the Mini-Mental State Examination, 3MS: Modified Mini-Mental State (3MS) test, CDT: Clock Drawing Test, SBR: Stimulus-bound Response, CD: Conceptual Deficit, SPD: Spatial and/or Planning Deficit, PE: Perseveration Error, ns: no significance.

Results

Demographic characteristics

The mean age and years of education of the total patients was 71.5 years and 8.8 years, respectively. The mean scores of the K-MMSE and CDT were 26.1 and 7.8, respectively (Table 1).

Cognitive assessment and CDT

The total scores in the CDT significantly correlated with the total scores of the K-MMSE, 3MS and the level of education (Table 2). Of the errors in the CDT, SPD was the most frequent type of error (45.3%), followed by CD (30.8%), SBR (15.6%), and PE (8.3%) in the total samples. The scores of the K-MMSE and 3MS in the patients having CD errors were significantly lower compared with those who had other types of error. Analysis of the error types and the frequency between lower and higher cognitive groups was shown in table 3.

Discussion

Recently, MCI described as an entity distinct from normal ageing and from AD, defining as a transitory state between normal cognition and dementia [12,13]. There are various subtypes of MCI characterized by amnestic/non-amnestic or single-domain/multiple domains [13]. Approximately 10% of the patients with amnesic MCI will develop into AD type dementia each year [7] and early intervention in this group could improve the treatment of AD. Disturbances in executive cognitive functioning in AD or

other types of dementia often precede the memory decline and such disturbances result in difficulties with instrumental activities of daily living (e.g., bathing, dressing, cooking, shopping, driving and taking medications). Routine measures of cognition, such as the MMSE, often fail to identify executive dysfunction even if it is quite severe, so that some challenges are needed to identify executive cognitive dysfunction in dementia patients.

The CDT may be an apt means of measuring early cognitive decline [14]. It was originally used to assess visuoconstructive abilities but doing the test requires verbal understanding, memory and spatially coded knowledge in addition to constructive skills [15]. Most authors agree that the clock drawing is primarily on visuospatial and executive functioning [16]. Moreover, it is easy to document graphically in clinical records and it can be used to document deterioration over time in dementia patients [15].

When the MMSE score is abnormal, the suspicion of cognitive impairment is already raised. Under these circumstances the clock-drawing test score is often abnormal, and it reinforces the suspicion of cognitive impairment. Therefore, the CDT can be particularly useful in cases with a history of abnormal function with normal MMSE score [14]. If being with abnormal performance, certainly need further assessment [16] and if with normal clock drawing ability, reasonably excludes cognitive impairment [15].

Most studies evaluated the CDT performance had shown significant correlation with the overall cognition level and executive function. The correlation coefficient between the CDT and MMSE ranges from moderate (0.30) to high (0.77), with a mean of 0.61 [5].

Several studies have analyzed the usefulness of the CDT for very mild AD and found good positive and negative predictive values in very mild AD [17-20] In contrast, Lee et al. suggested that clock drawing ability may be too insensitive to be clinically useful in the detection of early dementia if the ten-point clock test was capable of identifying patients with `very mild' Alzheimer's disease as suggested by an MMSE score>23 [21]. But, the studies showing no usefulness of CDT to identify patients with very mild dementia or MCI analyzed CDT scores only, not the types of error in CDT. Emphasis on the qualitative aspects of clock drawing in defining such difficult cases can maximize its utility [5,22]. Performance of CDT among dementia subtypes were not different in a longitudinal study and the error type analysis of CDT showed that the most common error type was SPD in patients with mild to moderate dementia [23]. Therefore, Error type analysis may be useful not for predicting dementia subtype but the severity of cognitive function.

Kaplan emphasizes the value of examining the qualitative, rather than the quantitative scoring of clock-drawing, which informs our understanding of the brain function [24]. Some studies noticed mistakes among MCI patients primarily in hand-setting and found that errors in substitution and clock setting were significantly more likely in the group that later met criteria for dementia [25,26]. An analysis of time setting errors may yield valuable diagnostic information. Patients with dementia in early stages may still be able to draw the clock face but fail to set the hands on the defined time. Similarly, a possible influence of the time-setting task on the diagnostic accuracy of the CDT was signified [2,5,7,14,15]. The hand-setting task relies on the ability to place the hands correctly and to comprehend time concepts, which are related with visuospatial and abstract tasks. The capacity for visuospatial and conceptual thinking is typically reduced in patients with dementia and can be impaired even in the early stages.

The high frequency of SPD in the total participants in this study suggests early impairment of visuospatial and planning functions even in MCI. Planning deficit may also result from an inability to execute simultaneously two sequential tasks (producing and writing the numbers in the right order and spacing them equally around the clock). Although capacity for visuospatial and conceptual thinking are typically reduced even in patients with early stage of dementia, visuospatial impairment has been observed in MCI or healthy cognitive aging as well. In normal elderly subjects especially those above 80 years of age with a low level of school education, the errors most often encountered are those referring to the placement of numbers on the clock face and the placement or 'semantic' differentiation of hands. Therefore, some suggest that normal CDT performance most likely excludes the presence of even very mild Alzheimer's disease, the opposite may not hold true and recent studies have found a high number of CDT errors in normal elderly subjects [27].

Lower cognitive group in this study made more frequent CD errors than high cognitive group, and the patients having CD errors showed lower scores in the K-MMSE and 3MS compared with those of other error types. This results were same with results of previous studies, showing CD error was the most frequent in severe dementia group [23,28]. These results denote a loss of knowledge regarding the meaning of a clock itself or the clock hands. Some studies suggested that increased frequency of conceptual deficit in AD patients is due to a loss of semantic association evoked by the word "clock"[29,30]. This implies that a qualitative analysis of conceptual deficit, especially time-setting errors yields useful information on the participants' cognitive status and facilitates diagnostic sensitivity of CDT at least in mildly impaired participants [30].

Although it had no statistical significance, the frequency of PE was higher in the higher cognitive group than that of the lower cognitive group. The severity of PE was associated to higher right parietal-occipital activity in a functional study using SPECT [31]. It is possible that higher PE represents relative preservation of parietal-occipital activity but further longitudinal study including various stages of dementia needs to define its clinical significance.

Recent review on comparing scoring systems of CDT suggests that simpler scoring the CDT may be better as a dementia screening instrument [32]. The scoring system we adopted in this study was relatively easy to perform and less test-retest variation.

This study had some limitations. Some MCI participants did not have neuroimaging because of inclusion for the study by the clinical criteria of MCI, so that the heterogeneous causes of MCI may have influence on the performance of CDT. We did not perform structured neuropsychological assessment in detail, so there may be some difference of the cognitive status even in either higher or lower cognitive function groups, resulting in different performance of CDT.

The combination of CDT and MMSE can enhance the diagnostic accuracy in patients with MCI, rather than examined by the MMSE alone. Furthermore, the qualitative analysis of error types in CDT may yield more valuable information that can considerably increase the diagnostic sensitivity with respect to the stages of dementia.

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References

1. Yamamoto S, Mogi N, Umegaki H, Suzuki Y, Ando F, et al. (2004) The clock drawing test as a valid screening method for mild cognitive impairment. Dement Geriatr Cogn Disord 18: 172-179.

2. Luck T, Riedel-Heller SG, Kaduszkiewicz H, Bickel H, Jessen F, et al. (2007) Mild cognitive impairment in general practice: age-specific prevalence and correlate results from the German study on Ageing, cognition and dementia in primary care patients (AgeCoDe). Dement GeriatrCognDisord 24: 307–316.

3. Flicker C, Ferris SH, Reisberg B (1991) Mild cognitive impairment in the elderly: predictors of dementia. Neurology 41: 1006-1009.

4. Ehreke L, Luppa M, König HH, Riedel-Heller SG (2010) Is the Clock Drawing Test a screening tool for the diagnosis of mild cognitive impairment? A systematic review. Int Psychogeriatr 22: 56-63.

5. Shulman KI (2000) Clock-drawing: is it the ideal cognitive screening test? Int J Geriatr Psychiatry 15: 548-561.

6. Shulman KI, Shedletsky R, Silver IL (1986) The Challange of time: Clock-drawing and cognitive function in the elderly. Int J Geriatr Psychiatry 1:135-140.

7. Petersen RC, Smith GE, Waring SC, Ivnik RJ, Tangalos EG, et al. (1999) Mild cognitive impairment: clinical characterization and outcome. Arch Neurol 56: 303-308.

8. Petersen RC, Doody R, Kurz A, Mohs RC, Morris JC, et al. (2001) Current concepts in mild cognitive impairment. Arch Neurol 58: 1985-1992.

9. Winblad B, Palmer K, Kivipelto M, Jelic V, Fratiglioni L, et al. (2004) Mild cognitive impairment--beyond controversies, towards a consensus: report of the International Working Group on Mild Cognitive Impairment. J Intern Med 256: 240-246.

10. Manos PJ, Wu R (1994) The ten point clock test: a quick screen and grading method for cognitive impairment in medical and surgical patients. Int J Psychiatry Med 24: 229-244.

11. Rouleau I, Salmon DP, Butters N (1996) Longitudinal analysis of clock drawing in Alzheimer's disease patients. Brain Cogn 31: 17-34.

12. Petersen RC, O'Brien J (2006) Mild cognitive impairment should be considered for DSM-V. J Geriatr Psychiatry Neurol 19: 147-154.

13. Pinto E, Peters R (2009) Literature review of the Clock Drawing Test as a tool for cognitive screening. Dement Geriatr Cogn Disord 27: 201-213.

14. Juby A, Tench S, Baker V (2002) The value of clock drawing in identifying executive cognitive dysfunction in people with a normal Mini-Mental State Examination score. CMAJ 167: 859-864.

15. Agrell B, Dehlin O (1998) REVIEW The clock-drawing test. Age Ageing: 27: 399-403.

16. Peters R, Pinto EM (2008) Predictive value of the Clock Drawing Test. A review of the literature. Dement Geriatr Cogn Disord 26: 351-355.

17. Esteban-Santillan C, Praditsuwan R, Ueda H, Geldmacher DS (1998) Clock drawing test in very mild Alzheimer's disease. J Am Geriatr Soc 46: 1266-1269.

18. Seigerschmidt E, Mösch E, Siemen M, Förstl H, Bickel H (2002) The clock drawing test and questionable dementia: reliability and validity. Int J Geriatr Psychiatry 17: 1048-1054.

19. Connor DJ, Seward JD, Bauer JA, Golden KS, Salmon DP (2005) Performance of three clock scoring systems across different ranges of dementia severity. Alzheimer Dis Assoc Disord 19: 119-127.

20. Chiu YC, Li CL, Lin KN, Chiu YF, Liu HC (2008) Sensitivity and specificity of the Clock Drawing Test, incorporating Rouleau scoring system, as a screening instrument for questionable and mild dementia: scale development. Int J Nurs Stud 45: 75-84.

21. Lee H, Swanwick GR, Coen RF, Lawlor BA (1996) Use of the clock drawing task in the diagnosis of mild and very mild Alzheimer's disease. Int Psychogeriatr 8: 469-476.

22. Shulman KI (1993) Clock drawing and dementia in the community: a longitudical study. Int J geriatr psychiatry 8: 487-496.

23. Lee JH, Oh ES, Jeong SH, Sohn EH, Lee TY, et al. (2011) Longitudinal changes in clock drawing test (CDT) performance according to dementia subtypes and severity. Arch Gerontol Geriatr 53: e179-182.

24. Kaplan E (1990) The process approach to neuropsychological assessment of psychiatric patients. J Neuropsychiatry Clin Neurosci 2: 72-87.

25. Babins L, Slater ME, Whitehead V, Chertkow H (2008) Can an 18-point clock-drawing scoring system predict dementia in elderly individuals with mild cognitive impairment? J Clin Exp Neuropsychol 30: 173-186.

26. O'Rourke N, Tuokko H, Hayden S, Lynn Beattie B (1997) Early identification of dementia: predictive validity of the clock test. Arch Clin Neuropsychol 12: 257-267.

27. von Gunten A, Ostos-Wiechetek M, Brull J, Vaudaux-Pisquem I, Cattin S, et al. (2008) Clock-drawing test performance in the normal elderly and its dependence on age and education. Eur Neurol 60: 73-78.

28. Konagaya Y, Konagaya M, Watanabe T, Washimi Y (2014) Quantitative and qualitative analyses for characteristics of the clock drawing in Alzheimer's disease. Rinsho Shinkeigaku 54: 109-115.

29. Berger G, Frölich L, Weber B, Pantel J (2008) Diagnostic accuracy of the clock drawing test: the relevance of "time setting'' in screening for dementia. J Geriatr Psychiatry Neurol 21: 250-260.

30. Rouleau I, Salmon DP, Butters N, Kennedy C, McGuire K (1992) Quantitative and qualitative analyses of clock drawings in Alzheimer's and Huntington's disease. Brain Cogn 18: 70–87.

31. Moreno-Iñiguez M, Ortuño F, Bonelli RM, Millán M, Soutullo CA, et al. (2007) Perseverative error in schizophrenia: correlation with cortical blood flow by SPECT. Actas Esp Psiquiatr 35: 20-28.

32. Mainland BJ, Amodeo S, Shulman KI (2014) Multiple clock drawing scoring systems: simpler is better. Int J Geriatr Psychiatry 29: 127-136.