

TIME WILL TELL !

A REVIEW ON THE CLOCK DRAWING TEST FOR DEMENTIA SCREENING

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Summary

The Clock Drawing Test (CDT) is easy and fast to be administered, but not commonly employed in the clinical practice. However, as it engages many cognitive functions (i.e. semantic and visual memory, comprehension, constructive ability, planning, motor programming and execution) it gives a reliable measure of cognition. This paper was aimed at giving an updated information about the CDT effectiveness for screening dementia from its early stage. A literature search was carried out in Medline and Pubmed using the keywords 'clock drawing test', 'clock test and dementia screening', 'clock drawing Alzheimer', 'clock drawing task'. It retrieved 12 papers, dated from 2000 to 2009 and focused on CDT sensitivity and specificity to diagnose the cognitive impairment of adults. Conclusion: the Clock Drawing Test is a reliable tool for screening mild to moderate dementia and may be very useful even in its early stage. In subjects with Mild Cognitive Impairment, the error type might be analyzed as it would give further elements to the appraisal of the patient. In a more general perspective the CDT is strongly recommended being a very useful tool for neurologists and the geriatricians to individuate degenerative cognitive dysfunctions.

Keywords: clock drawing test, clock test and dementia screening, clock drawing Alzheimer, clock drawing task.

Introduction

The Clock Drawing Test (CDT) is a simple, well accepted and easy to be scored test. It consists in asking the patient to draw a clock, to have it all the numbers, and then to draw the hands on a given time. This first part is called "the memory condition". The patients may also be asked to copy an already drawn clock. This is the copy condition. The CDT is fast, well accepted by the patient and easily understood by the caregivers (12). It investigates not only the temporal lobe functions (as memory and language), but also the frontal lobe functions (as the executive planning) and the parietal lobe functions (the visuospatial impairment being demonstrated by a better performance in the memory than in the copy condition). The CDT investigates thus the ability to conceptualize, to perform a visuo-spatial planning and the semantic knowledge (5, 8, 13). The test may be scored in different ways, the quickest consisting in dividing the clock in quadrants and determinate the digit number in each of them (15), the most complex including the qualitative aspect of the errors (12).

Some authors as *Cosentino et al.*, (2004) found a relationship between the white matter damage and the error number suggesting that the cortico-subcortical networks interruption leads to the executive impairment, whereas others as Lee et al. (2008) relate the errors to the right parietal lobe dysfunction. The CDT has a good correlation with the MMSE and may be even more reliable than the MMSE in non Alzheimer Dementias. Here, in fact, the MMSE may be still in the range when the CDT already shows abnormalities (7). In this article we aimed at giving an updated review on the efficacy of the CDT as a screening tool in a) the early stage of Alzheimer disease, b) the diagnosis of the different dementia type and c) in the Mild Cognitive Impairment.

Methods

A systematic literature search was conducted on Medline and Pubmed databases and on the references of published studies and reviews dated from 2000 to 2009. The keywords used were: 'clock drawing test', 'clock test and dementia screening', 'clock drawing Alzheimer', 'clock drawing task', 'mild cognitive impairment'. The selection criteria applied were subjects ≥ 60 years of age, English language, publications dated from 2000 to 2009, keywords present in the title/abstract. A total of 23 papers were identified for further selection and 17 were selected as the CDT was employed in participants not suffering from other central nervous system disorders. The quality assessment of the 12 case series was performed according to the Newcastle–Ottawa Scale (NOS) for case–control studies, limited to the items concerning 'adequacy of the case definition' and 'representativeness of the case'. Following the same principles we have analyzed the relationship between the MCI and the Clock drawing test. Table 1 shows the main characteristics of the studies, classified by first author's name and number of patients. The Study groups are also reported.

Results

23 studies have evaluated the CDT for its usefulness as a cognitive screening. The 'representativeness of the case' (NOS Criteria) was adequate in 12, and the case definition in all. Among the 12 series, 3 focused on AD, 4 on the diagnosis of dementia type and 5 on Mild Cognitive Impairment. Each of the series included not less than 58 patients and the mean age ranged from 60 to 93 years. The procedures employed to evaluate the cognitive impairment were: MMSE, Wechsler Memory Scale, Boston Naming, Stroop Test, Verbal Recall, Digit Span, Digit Symbol, Trail Making Test, Wechsler Adult Intelligence Scale, Tubingen Clock Questionnaire, Rey Figure, Category Fluency Test. The following scales were also employed: GDS (Geriatric Dementia Scale), ADAS-7, (The AD assessment scale for constructional ability), ADL, ICD-10. Only three studies have examined the CDT sensitivity in dementia early stage (table 2).

The studies aimed at evaluating the CDT as a tool for differentiate the various dementia types were five and four of them concluded that CDT helps to differentiate the various dementia types (table 3). The CDT may also help to diagnosis the MCI, but only in one study, by *Yamamoto et al.* (2004) it is indicated as a screening tool. CDT with MMSE in combination are suggested as effective for differentiating vascular MCI (16), however the CDT does not achieve the value of a screening test for MCI (table 4).

Tab.1. The examined studies.

First Author	Sample	Subject Groups
<i>Heinik 2002</i>	88	G1: 52 AD, G2: 36 VD.
<i>Cahn-Weiner 2003</i>	59	G1: 22 AD, G2: 17 PD, G3: 20 DBL
<i>Cosentino 2004</i>	129	G1: 55 VD, G2: 55 AD, G3: 19 PD
<i>Yamamoto 2004</i>	219	G1: 41 HC, G2: 48 MCI, G3: 102 AD, G4: 14 VD, G5: 14 Others
<i>Cacho 2005</i>	140	G1: 70 AD, G2: 70 HC
<i>Blair 2005</i>	86	G1: 25 AD, G2: 36 FTD
<i>Babins 2008</i>	123	G1: 21 HC, G2: 82 MCI, G3: 20 AD, G4: 25 HC
<i>Zhou 2008</i>	160	G1: 80 V-CIND, G2: 80 HC
<i>Heink 2009</i>	65	G1: 24 Mild, G2: 22 MCI, G3: 19 NCI, G4: 80 HC
<i>Ehreke 2009</i>	3198	G1: MCI, G2: without MCI
<i>Leyhe 2009,a</i>	58	G1: HC, G2: MCI, G3: PAD, G4: EAD
<i>Leyhe 2009,b</i>	88	G1: HC, G2: MCI, G3: PAD, G4: EAD

Characteristic of the paper identified in the literature. AD= Alzheimer disease; VD= Vascular Dementia; PD = Parkinson Disease; HC = Healthy Control; Dementia with Lewy bodies; MCI = Mild Cognitive Impairment; NCI = Normal Cognitive Impairment; FTD= Frontotemporal Dementia; EAD: Early Alzheimer Disease; PAD= Progressed Alzheimer Disease.

Tab.2. The CDT in early AD screening.

Authors	Sample	Groups	CDT impairment
<i>Cacho 2005</i>	140	G1: 70 EAD	G1: Lower score in memory
		G2: 70 C	G2: No differences in copy and memory condition G1: 83.5% IP G2: 16.5% IP
<i>Leyhe 2009,a</i>	58	G1: C, G2: MCI G3: PAD, G4: EAD	G4 is discriminated by the minute hand
<i>Leyhe 2009,b</i>	88	G1: HC, G2: MCI G3: PAD, G4: EAD	G4 : minute hand displacement

Tab. 3. Quantitative and qualitative errors found

Author	Sample	Groups	CDT in differential diagnosis	
			Quantitative errors	Qualitative errors
Heinik 2002	88	G1: 52 AD G2: 36 VD	G2: perform worse	G2 more impaired in hands subscores
Cahn-Weiner 2003	59	G1: 22 AD G2: 17 PD G3: 20 DBL	No significant differences within groups.	G3: more conceptual errors G2 and G3: more planning errors
Cosentino 2004	129	G1: 55 VaD G2: 55 AD G3: 19 PD G1 and G2: G4 low WAM G5 high WAM	<i>In the command condition:</i> G4 fewer errors than G3 <i>In the copy condition:</i> G4 fewer errors than G3 and G5	<i>In the copy condition:</i> G4 fewer errors on the time, spatial layout and perseverations than G4 and G3
Blair 2005	86	G1: 25 AD G2: 36 FTD G3: 25 C	G1: lower score than G2	G1: more stimulus bound responses, conceptual, spatial and planning errors than G2

These five studies evaluate the value of CDT to differentiate the various dementia types: Alzheimer disease; Vascular Dementia; Parkinson Disease; Healthy Control; Dementia with Lewy bodies; Mild Cognitive Impairment; Normal Cognitive Impairment; Frontotemporal Dementia.

Discussion

In early AD the CDT is an effective tool. Its score may be higher in the copy condition than in the memory condition. This feature is named Improvement Pattern (IP) and may help in screening early AD (2) as it indicates that the memory is more impaired than the visuospatial ability. Patients with early AD may also fail to draw the minute hand (10) which, as shown in Fig. 1, may be set at the place of the hour hand, or clockwise displaced towards it, or completely missed. This should be due to a semantic memory impairment about clock details, an aspect confirmed in another study of the same author. *Leyhe et al. (2009, b)*. For what concerns the CDT in the differential diagnosis some authors (3) found it useful to differentiate Lewy Body Dementia, AD and PDD as the qualitative analysis may showed mostly conceptual errors in LBD and planning errors in PDD and LBD. Frontotemporal Dementia and AD were also differentiated by CDT (1) as FTD patients scored significantly higher than AD, and had few conceptual, spatial and planning errors.

Tab.4. CDT in the diagnosis of MCI.

Author	Sample	Groups	CDT in MCI
<i>Ehreke 2009</i>	3198	G1: MCI G2: without MCI	G1 lower score than G2 but CDT does not achieve the quality to screen MCI
<i>Heink 2009</i>	65	G1: 24 Mild G2: 22 MCI G3: 19 NCI	CDT-MIA and MMSE alone fail to discriminate G2
<i>Babins 2008</i>	123	G1: 21 C G2: 82 MCI G3: 20 AD	CDT may indicate the MCI individuals progressing to dementia.
<i>Zhou 2008</i>	160	G1: 80 V-CIND G2: 80 HC	CDT and MMSE may screen MCI
<i>Yamamoto 2004</i>	219	G1: 41 C G2: 48 MCI G3: 102 AD G4: 14 VD	CDT is may different G2 subjects

Evaluation of the value of the CDT as a screening tool for diagnosis of Mild Cognitive Impairment.

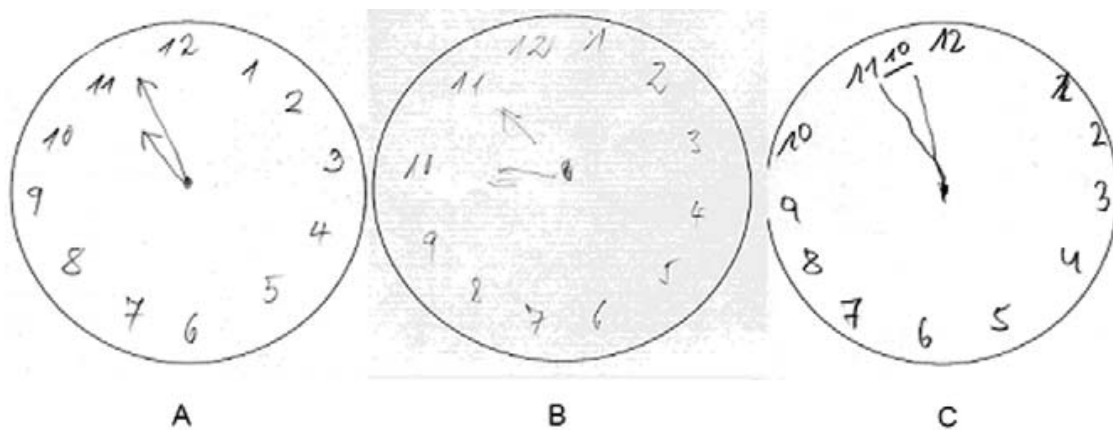


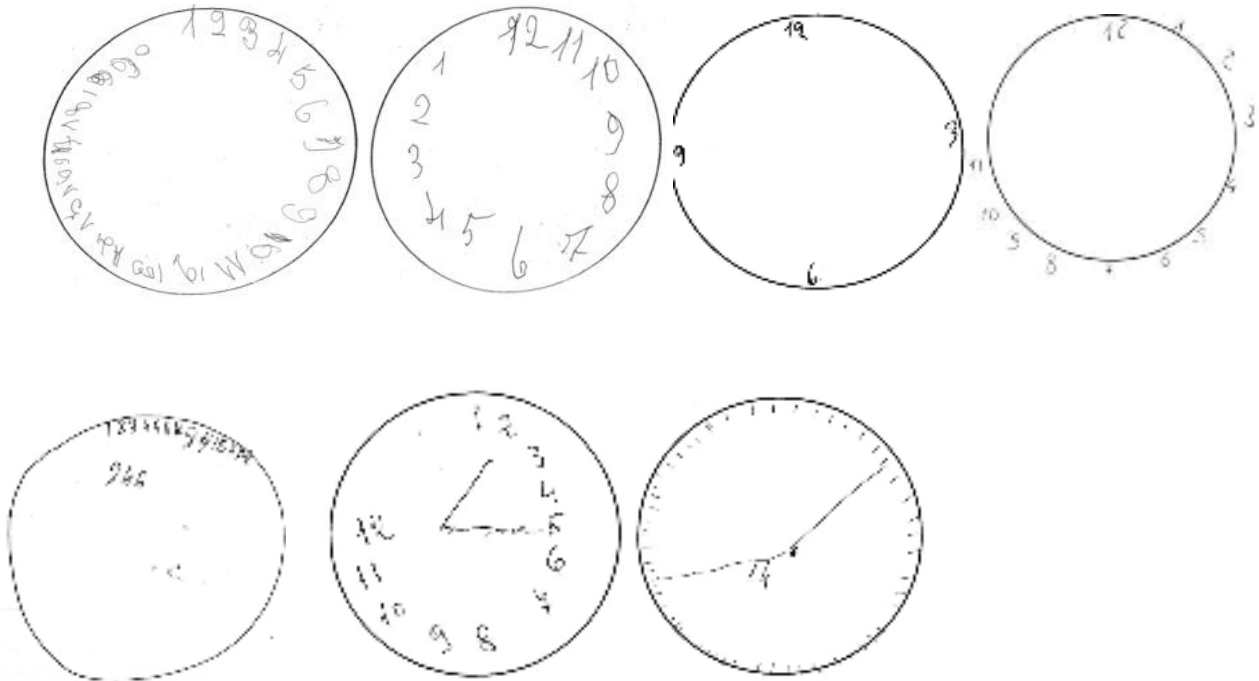
Fig.1. Hand positioning errors found in early AD group (Leyhe et al., 2009 a)

Conclusions

The CDT is a good screening test in moderate dementia, it is less sensitive in its early phase, but here the error type gives significant data to the appraisal of the patient. The qualitative and quantitative errors analyses are also useful for directing the diagnosis in early dementia. The limited data available do not suggest to employ it to diagnose the MCI (14). The errors most often found are of Motor type (Size, Distortion, Segmentation, Multiple Attempts); of Time Representation c) of Spatial type (Number Missing, Number Outside the Clock Face, Anchor Location, Circular Format); d) of Frontal type as Perseverations, Interminable Perseveration, Pull to Stimulus, Counterclockwise Sequence (figure 2). Given these data the neurologists should be strongly encouraged to employ this tool. It gives good indications and requires no more than one minute. If dementia is suspected , ...time will tell !

Tab.4. Error types in dementia.

Error type	Errors	Copy Condition		Command Condition	
<i>Gross Motor Errors</i>	Size				Only the patients with low WMA made fewer total errors than the Parkinson disease group
	Distortion				
	Segmentation				
	Multiple Attempts				
<i>Time Representations</i>	Correct time	Semantic knowledge Index	Patients with low WMA	Executive Control Index	
	Indication of Time				
<i>Spatial Layout</i>	Number Missing		Patients with low WMA (white matter alteration)		
	Number Outside				
	Anchor Location				
<i>Perseveration</i>	Hyperkinetic Perseverations	Executive Control Index	Patients with low WMA (white matter alteration)		
	Interminable Perseverations				
	Pull to Stimulus				
	Counterclockwise				

Fig. 2. Examples of typical errors

The CDT were executed by the patients with Alzheimer disease, cared by the Alzheimer Unit of "A. Cardarelli" Hospital, Naples Top: from left to right perseveration, counterclockwise, numbers missing, numbers outside. Bottom from left to right: spatial layout, incorrect time and particular error.

References

- 1_Blair M, Kertesz A, McMonagle P, Davidson W, Bodi N. (2006) Quantitative and Qualitative analyses of clock drawing in frontotemporale dementia and Alzheimer's disease. *Journal of the International Neuropsychological Society*, 12: 159-165
- 2_Cacho J, Garcia-Garcia R, Fernandez-Calvo B, Gamazo S, Rodriguez-Perez R, Almeida A, Contador I. (2005). Impoverment pattern in the clock drawing test in early Alzheimer's disease. *European Neurology* 53: 140-145.
- 3_Cahn-Weiner DA., Williams K., Grace J., Tremont J., Westervelt H., Stern RA. (2003) Discrimination of Dementia With Lewy Bodies From Alzheimer Disease and Parkinson Disease Using the Clock Drawing Test. *Cognitive and Behavioral Neuro* Connor DJ, Seward JD, Bauer JA, Golden KS, Salmon DP. (2005). Performance of Three Clock Scoring System across different ranges of dementia severity. *Alzheimer Disease and Associated Disorders*. 19 (3): 119-127.
- 4_Cosentino S., Jefferson A., Chute DL., Kaplan E., Libon DJ. (2004) Clock Drawing Errors in Dementia. Neuropsychological and Neuroanatomical Considerations. *Cognitive and Behavioral Neurology*. 17 (2), June.

5_Esteban-Santillan C., Praditsuwan R., Ueda H., Goldemacher DS. (1998) Clock Drawing Test in very Mild Alzheimer's Disease. *JAGS*. 44:1266-69.

6_Heinik J, Solomesh I, Raikher B, Lin R. (2002) Can clock drawing test to differentiate between dementia of the Alzheimer's type and vascular dementia? A preliminary study. *International Journal of Geriatric Psychiatry*. 17:699-703.

7_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. *Canadian Medical Association Journal*. 167(8):859-64.

8_ Lam LCW., Chiu HFK., Ng KO., Chan C., Chan WF., Li SW., Wong M. (1998) Clock Face Drawing, Reading and Setting Test in the Screening of Dementia in Chinese Elderly Adults. *The Journal of Gerontology*. 53 B, 6: 353.

9_Lee AY., Sohn EH., Choi BH., Kim SG., Lee JS., Lee DS., Jhoo JH., Kim KW., Youn JC., Woo JI. (2008) Neural Correlates of the Clock Drawing Test Performance in Alzheimer's Disease: A FDG-PET study. *Dementia and geriatric Cognitive Disorders*. 6: 306-13.

10_Leyhe T., Saur R., Eschweiler GW., Milian M. (2009) Clock Test Deficits Are Associated With Semantic Memory Impairment in Alzheimer Disease. *Geriatr Psychiatry Neurol Online First published on May*

11_Leyhe T., Milian M., Müller S., Eschweiler GW., Saur R. (2009) The Minute Hand Phenomenon in the Clock Test of Patients With Early Alzheimer Disease. *Journal of Geriatric Psychiatry and Neurology* 22(2), June.

12_Rouleau I, Salmon DP, Butters N, Kennedy C, McGuire K. (1992) Quantitative and qualitative analyses of clock drawing in Alzheimer's and Huntington's disease. *Brain Cognition*. 18: 70-87

13_Shulman K.I. (2000) Clock-Drawing: is it the ideal cognitive screening test? *International Journal of Geriatric Psychiatry*. 15:584-561.

14_Yamamoto S., Mogi N., Umegaki H., Suzuki Y., Ando F., Shimokata H., Iguchi A. (2004)The Clock Drawing Test as a Valid Screening Method for Mild Cognitive Impairment. *Dementia and Geriatric Cognitive Disorders*. 18:172-179

15_Watson Y.I., Arfken C.L., and Birge S.J. (1993) Clock Completion: an objective screening test for dementia. *Journal of American Geriatric Society*. 41:1235-40.

16_Zhou A. and Jia J. (2008) The value of the clock drawing test and the mini-mental state examination for identifying vascular cognitive impairment no dementia. *International Journal of Geriatric Psychiatry*. 23:422-26