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Dementia Assessment by Rapid Test (DART): An Indian Screening Tool for Dementia

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Abstract

Background: There is a need to develop a quick original screening test for dementia due to paucity of short, education and culture fair tests. Hence, following DSM-V criteria, a quick screening test was developed which can be used for both the clinical and prognostic purposes.

Objective: Develop a quick and valid Indian screening test for geriatric population for early and timely identification of cognitive decline.

Method: Total sample consisted of 150 (88=patients and 62=control) right-handed, consenting subjects between 55-84 yrs of age with minimum elementary education were recruited in the study.

Results: DART scores discriminated between dementia cases and controls clearly. It was also validated against gold standard of MMSE, with sensitivity of 95.5% and specificity of 60.0%; true positive predictive value of 70.2% and true negative predictive value of 93.0%.

Conclusion: DART is a quick and valid screening test for dementia for Indian population.

Keywords: Quick; Dementia screening; Cognition; India; Elderly

Introduction

In an era of increasing capabilities to detect and manage prevalent disorders as early in their course as possible, screening has become an accepted approach for many medical conditions such as breast cancer, cervical cancer, diabetes, hypertension, high cholesterol, obesity, osteoporosis etc., provided treatment can be offered [1]. However, screening for dementia is usually left to chance and only when the patient's cognitive issues start interfering into their caregiver lives, then they take them for diagnostic evaluation [2]. Further, as far as the worldwide prevalence of dementia is concerned, it is forecasted to double every 20 years, increasing from 24 million in 2001 to 40 million in 2020 and 80 million in 2040 [3]. In specific to India, it is predicted an estimate of 3.7 million people aged over 60 has dementia (2.1 million women and 1.5 million men) and such prevalence of dementia would increase steadily with age [4].

Dementia is a progressive neuro-cognitive disorder which leads to cognitive decline which is sufficient to interfere with social or occupational functioning in an alert person [5]. Furthermore, an important distinction must be made between Mild Cognitive impairment (MCI) and dementia where MCI is a transitional stage between normal aging and dementia, and reflects the clinical situation where a person has memory complaints but no evidence of activities of daily living (ADL) impairment and not affecting much quality of life domains [6]. Nonetheless, research shows that both the conditions (MCI/Dementia) exert a substantial burden on patients' lives and the lives of those close to them [7].

Hence, considering the characteristics of MCI and dementia and its prevalence worldwide, it is one of the major public health problems which need attention [8]. Hence, international guidelines (Table 1) for screening programs were developed in order to reduce the global burden of disease [9].

In sync with these guidelines, the United States Preventive Services Task Force [10] recommended cognitive screening of older population for detecting proactively early signs and symptoms based on direct observation, patient report, or concerns raised by others who know them well in order to facilitate primary care which was also supported by a recent research study [11].

- The disease should be an important public health program.
- There should be a recognizable latent or pre-symptomatic stage of the disease
- The natural history of the disease should be adequately understood.
- There should be a treatment for the condition. The treatment should be more beneficial when applied at the pre-symptomatic stage as compared to later stage.
- There should be a test to detect the condition with reasonable sensitivity and specificity
- The test should be acceptable to the population
- The healthcare system should have the capacity and policies in place to test for the condition and deal with consequences.

Table 1: WHO guidelines for the screening programs.

Hence, a study suggests that routine cognitive screening has the potential to delay progression of mild cognitive deficits [12]. Moreover, there is ample evidence supporting the view that screening can improve case identification [13]. Besides, it not only facilitates early diagnosis and better treatment, it also supports public health and fosters research [8].

Therefore, a good screening test plays a crucial role in planning for management of the disease. Additionally, taking the features of a

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Psychometric properties	Sensitivity	What proportion of the test does a negative test result rule out the presence of disease?
	Specificity	What proportion of the test does a positive test result rule out the presence of disease?
	Positive predictive value Negative predictive value	How well do the test results predict the presence or absence of disease in individual?
Feasibility	Acceptability	How efficient is the test? Are the items of the test acceptable to the patients?
	Judgment required	Can the test be interpreted by the non-physicians?
	Cost	What is cost of the work-up resulting from the positive result or what is the cost of time required to administer the test?
Range of applicability	Robustness	Is the test free from culture and education bias free?

Table 2: Features of a screening test (WHO) .

good screening test [14,15] (Table 2), the term screening, in this paper, is defined as the administration of tests to 'sort out apparently well persons who probably have a disease or impairment from those who probably do not'. Henceforth, a screening test is not intended to be diagnostic [16].

Dementia screening tests: International and national status

There are ample screening tests available, for dementia/MCI which fulfils the criteria of a good screening test. Few of the well-known tests are:

1. Mini Mental Status Examination (MMSE) [17]
2. General Practitioner Assessment of Cognition (GPCOG) [18]
3. Memory Impairment Screen (MIS) [19]
4. Mini Cog [20]
5. Montreal Cognitive Assessment (MoCA) [21]
6. Addenbrooke Cognitive Assessment (ACE) [22]
7. Clinical Dementia Rating (CDR) [23]
8. Rowland Universal Dementia Assessment Scale (RUDAS) [24]

These all tests have been validated in high income countries [25]. Unfortunately, in developed countries, there is shortage of adequate and valid screening instruments for dementia [26]. In specific to India, different assessment tools have been used with a wide range of sensitivities and specificities due to its diverse cultural and educational variation [27]. For an example, MMSE [17] is a widely used instrument, especially in screening for dementia. It is quick and easy to use; hence, it is used as 'gold standard' screening instrument for detecting cognitive impairment in elderly people [28]. However, it cannot be used with illiterate population (India major population is illiterate) or with hearing/visual impaired individuals. Apart from MMSE, other tests which are used in India are: MoCA [25]; CDR [23]; ACE [22]; RUDAS [24] and many more.

Each of tests' psychometric properties is mentioned below in Table 3 along with their shortcomings in relation to Indian population culture and education background.

All these tests mentioned above in Table 3 are adapted and validated versions. None of them is originally developed test. Moreover, these tests have certain shortcomings and don't fulfil WHO screening program guidelines. Henceforth, there is a paucity of sensitive and specific measures of cognitive assessment in India, especially for dementia [4].

Therefore, an attempt was made to develop an original, quick, easy to administer, sensitive and specificity screening tool for Indian population which can be used as cognitive screening test for older population at risk and aid in making a timely identification and better planning of secondary and tertiary care.

Methodology

The instrument

Dementia Assessment by Rapid Test (DART) has been developed based on the clinical observation in Out Patient Department (O.P.D), Clinical Neuropsychology, All India Institute of Medical Sciences, New Delhi for a year about cognitive domains of impairment commonly encountered in MCI and possible dementia cases. Also, considering the lengthy evaluation procedures and age factor of dementia patients, there was a need to develop a quick, easy to administer screening tool which is sensitive to dementia cases and can be used as a community screening tool for timely detection of dementia, thereby helping in prompt secondary and tertiary care.

Item selection

DART consisted of four questions/items which were selected as per the domains affected in dementia/MCI following DSM-V (2013). This criterion has been widely used in both clinical and epidemiological research internationally and in India as well [29]. The four cognitive domains are follows:

(i) Repeating dissimilar words: The patient has to repeat 3

Test Name	Sensitivity (95% CI)	Specificity (95% CI)	Shortcomings
MMSE (Mitchell, 2009)	71.1%	81.3%	• Cultural and education biased • Not adequately assess the frontal executive functions • It has no timed element (Royall, Mahurin and Cornell, 1994)
RUDAS (Iype.et.al, 2006)	88.0%	76%	• Only available in Malayalam language
MoCA (Kansagara and Freeman, 2010)	94.0%	50%	• The validity is not thoroughly tested (Zadikoff.et.al, 2008) • It is also influenced by educational level of the patients.
ACE (Mathuranath.et.al, 2000; Cummings, 2000)	93%	71%	• It is education biased.
CDR (O'Bryant.et.al, 2008)	74%	81%	• Reliance on clinical judgment for scoring. • Length of administration • Certain items are not valid for Indian population (Lim, Chong and Sahadevan, 2007)

Table 3: Psychometric properties of adapted tests in relation to MMSE.

common words (elephant, bottle, and paper) This item assesses the domain of recent memory and cover hippocampus area of the brain.

(ii) Naming: The patient is asked to name as many vegetable names within 1 minute. This item assesses the domain of verbal fluency covering the temporal lobe.

(iii) Recall dissimilar words: It was tested by asking the subject to recall 3 words spoken earlier. This item assesses the domain of delayed memory covering both the hippocampus and temporal lobe.

(iv) Clock Drawing: This was tested by asking the patient to draw a clock showing time 10 minutes past 8. This item assesses the domains of visuo-spatial and executive functioning covering both frontal and parietal lobe. (If the patient is not able to draw; then a toy clock with needles is used, where the patient has to rotate the needles and show the prescribed time).

Scoring method

The DART is administered to patients who have subjective cognitive issues or memory problems and is probable case of MCI/Dementia. All the four items has simple scoring. It follows the principles of "all or none". Either the score is 0 or 1. The scoring of the each item is mentioned below:-

(i) Repeating dissimilar words: Score of **1** point if repeated **incorrectly.** Score of **0,** if all three words repeated **correctly**

(ii) Naming: A score of 1 is given if the person is not able to speak 12 names per minute. The minimum cut off was kept as the average names recalled by normative sample of 30 were 12 names per minute.

(iii) Recall dissimilar words: Score of **1** point if repeated **incorrectly.** Score of **0,** if all three words repeated **correctly**

(iv) Clock drawing: Score of **1** point if drawn/shown **incorrectly** in terms of accuracy and hands placement. Score of **0,** if either the hands or the time is **correctly** drawn/shown. (the major point to be seen is here, that there is no confusion in perception or motor coordination)

Thus, the scoring was done in terms of numbers of errors committed. The range of scores is 0-4. Lower the score, less likelihood of cognitive impairment. Higher the score, there is more likelihood of cognitive impairment.

Participants and Procedure

Participants

A sample of 150 participants with minimum elementary education between 55-84 years of age, both males and females were administered on DART. Out of these, there were 88 patients who had come to cognitive disorder and memory clinic with subjective memory problem were seen by neurologist and later were diagnosed by neurologist following National Institute of Neurological and Communicative Disorders and Stroke and the Alzheimer's Disease and Related Disorders Association [30] as having dementia and 62 were controls with similar age, sex and education. Participants who were non-consenting and had co-morbidity of any psychiatric illness were not recruited in the study.

Procedure

Patients coming with cognitive complaints to Clinical Neuro Psychology/Cognitive Disorders and Memory Clinic, Neurosciences Centre, All India Institute of Medical Sciences, New Delhi were recruited in the study. The patients were administered DART and MMSE [31] but the neurological diagnosis of the patient was kept blinded till the analysis of the results. While, the control group participants were a few care-givers of the patients who consented for DART and MMSE [31] and few were collected from various senior citizens welfare committee. The control group complete history was taken up for all possible reasons of cognitive decline such as cardiovascular disease (CVD), Head Injury, Vitamins deficiency (B12, D) along with any subjective memory issues. So overall there were checked on Metabolic Syndrome (MetS) following World Health Organization and National Cholesterol Education Program, Adult Treatment Panel III (WHO and NCEP ATP III) criteria.

Statistical analysis

Sensitivity, specificity, positive predictive value and negative predictive value are widely used in medical and epidemiological research [32]. In clinical practice, the test result is all that is known, so we want to know how good the test is at predicting abnormality, hence, it is one of the most precise approaches to quantifying the diagnostic ability of the test. Therefore, the sensitivity, specificity, positive predictive value and negative predictive value were calculated against MMSE [31]. As per the literature, MMSE is usually taken as gold standard in many cognitive clinics internationally and nationally for cognitive screening in dementia assessment [33].

As evident from Tables 4 and 5, DART has high discriminating ability between controls and cases with varied DART scores. However, there was no significant difference seen in terms of age and gender.

	Controls (N=62)	Dementia (N=88)	p value
Age	67.50 ± 5.92	66.07 ± 10.97	0.32
Sex			
Males	77.4%	72.7%	0.51
Females	22.5%	27.2%	
Education (yrs)			
0-4	41.2%	58.8%	
5-9	68.0%	32.0%	
10-14	27.40%	72.6%	0.35
15+	12.5%	87.5%	
MMSE [18]	26.75 ± 3.60	18.05 ± 8.31	<0.001*
DART			
0	61.2%	4.5%	
1	12.9%	7.9%	
2	19.3%	30.7%	<0.001*
3	6.4%	31.9%	
4	0.0%	25.0%	
	Controls (N=62)	**Dementia (N=88)**	**p value**
Age	67.50 ± 5.92	66.07 ± 10.97	0.32
Sex			
Males	77.4%	72.7%	0.51
Females	22.5%	27.2%	
Education (yrs)			
0-4	41.2%	58.8%	
5-9	68.0%	32.0%	
10-14	27.40%	72.6%	0.35
15+	12.5%	87.5%	
MMSE [18]	26.75 ± 3.60	18.05 ± 8.31	<0.001*
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3	6.4%	31.9%	
4	0.0%	25.0%	

MMSE: mini mental status examination
DART: dementia assessment by rapid test
Table 4: Demographic profile and scores on cognitive parameters (MMSE and DART) between the groups.

Test	Sensitivity	Specificity	PPV	NPV
MMSE	65.9%	87.1%	87.9%	64.3%
DART	95.5%	60.0%	70.2%	93.0%

MMSE: Mini Mental Status Examination
DART: Dementia Assessment by Rapid Test
PPV: Positive Predictive Value
NPV: Negative Predictive Value
Table 5: Sensitivity, specificity and positive, negative predictive values of MMSE and DART with neurologically diagnosed dementia.

As you can see in Table 5, the sensitivity of DART against MMSE (95.5% Vs. 65.9%) was found to be extremely high which is indicative of the fact that DART has a good capability to detect most patients with a morbid condition, i.e., it is sensitive enough to predict probable cases of dementia as compared to MMSE. However, it has low specificity compared to MMSE (87.1% vs. 60.0%) which could be due to few internal flaws of the test such as in the naming item of the test, a cut off of 12 names per minute was taken up on the basis of normative sample. If this number was lowered the test might become more specific without losing too much sensitivity.

Discussion

The proportions of elderly are increasing rapidly in developing countries, where prevalence of dementia is often high. Providing cost-effective services for dementia sufferers and their caregivers in resource-poor regions, including India poses numerous challenges such as low health literacy, (2) limited access to health care, and (3) the stigma associated with dementia and together they lead to huge treatment gap between numbers of people with a health condition and the number of these people who receive at least basic evidence based care, eventually increasing the global burden. In an effort to reduce the burden, researchers have been focusing on the discovery of drugs or precise screening procedures and other therapies that might detect the possible cases in advance or prevent or slow the rate of progression of this disease as early diagnosis of dementia is fundamental to any treatment effort [34].

Hence, a step was taken to develop a screening tool for Indian population which is free from any culture or literacy factors and has good psychometric properties thereby increasing its applicability for the community screening. As the results shows, DART has high discriminating ability between controls and cases. Besides, it has been correlated with MMSE which is generally used as a standardized, brief and practical assessment of cognitive status in geriatric patients both internationally and nationally [35] and came out to be a good sensitive tool (26.75 ± 3.60 vs. 18.05 ± 8.31; $p=<0.001$).

To distinguish between the effects of dementia and the influences of age and education, DART came out with an optimistic picture than MMSE.

According a validity study of MMSE, a clinical sample of 12120 older participants (n=12050 healthy controls and 70 dementia patients) were investigated on MMSE. The results showed two ROC curves; on the first ROC curve a cut-off score of less than 26/30 generated a maximum sensitivity and specificity of 74% and 98% respectively. A second ROC curve was created with scores adjusted for age and education and resulted in a similar optimal cut-off score of less than 26/30 with a sensitivity of 74% and a specificity of 100% positive predictive value was 100% and negative predictive value of 79%. The study concluded with significant (p=0.006) influence of both age and education on MMSE scores [36].

A similar study was done recently, where MMSE was validated on ethnically diverse, highly educated individuals. They determined that in this sample, a cut-off score of 27 provided better estimates of diagnostic accuracy than the original cut-off score of 24. With a cut-off score of 24, the MMSE yielded a sensitivity and specificity of 58% and 98% respectively. A cut-off score of 27 resulted in a sensitivity and specificity of 79% and 90% respectively [37]. Hence, from these studies, the ideal cut-off varies according to age and education as 12% of the variance in MMSE scores can be due to age and education alone. Further, after adjustment, the accuracy is lower in those with less education. Hence, there is a flooring effect in patients with advanced dementia, and in those with little education or in non-English speaking groups, and a ceiling effect for those with mild disease, no disease and for those with high cognitive functioning or high education [38]. Hence, in comparison to MMSE, DART is found to be precisely free from such age, socio-economic background bias (Table 4).

Besides this, the good sensitivity of DART also shows that it can detect the cognitive changes at any stage. As evident in table 4, the number of correct detection of cases increased with DART progressive scores. It has potential to detect cognitive changes ranging from transitional changes from preclinical stage to mild cognitive changes to dementia stage as well, unlike MMSE. Although MMSE is the most widely used screening tool for cognitive screening but according to a recent study it lacks on accurately distinguish MCI from normal [39]. Moreover, the MMSE has been shown to be insensitive to conditions associated with frontal-executive and sub cortical dysfunction and to milder forms of cognitive impairment [40]. Hence, in this case, DART has a potential to screen the possible cases of cognitive impairment domains as it covers assessment of all the lobes in short period of time of 5 minutes.

However, the major limitation of this test was its specificity. In comparison to MMSE, DART specificity is less (87.1% vs. 60.0%) which is showing an evidence that it can detect the likelihood of people without the disease being labelled as having it, or in other words, it label a person as having the likelihood of cognitive impairment, though they are disease-free which may cause worry, lead to the expense of unnecessary further investigation. This could also be due to the fact, that controls recruited in the study were self-proclaimed controls that were not neurologically diagnosed as not having MCI/dementia. Moreover, the item cut off may be higher affecting its specificity.

But at the same time, DART has high negative predictive value of against MMSE respectively. (93.0% vs. 64.3%) contrary to positive predictive value of ((70% vs. 87.9%) suggesting that DART can discriminate between diseased and non-diseased persons; however, this could be due to the influence of data collection setting. Since positive and negative predictive values *are influenced by the prevalence* of disease in the population that is being tested [41].

Hence, overall, taking screening program as a major goal, DART fulfils the criteria of a good screening tool as per Medical Dictionary for the Health Professions and Nursing [42-45] which stated that screening tests by definition have a high sensitivity but low specificity which is sensitive, easy and quick to administer. Though no test can be perfect, and a scope of further improvement is always present.

Conclusion

It can be concluded that in terms of its content and concurrent validity, the DART can be considered as valid and reliable, and can be used across different education and language groups. The tool

is most likely unable to deliver as good a performance in terms of discriminating between different disorders. More studies are required to further evaluate its properties, particularly its specificity. The clinical utility of the DART also needs to be further explored after its clinical use.

Limitations and Future Directions

The major limitation is that it lacks adequate specificity which is one of the future direction too where we would work upon by collecting more control data and revisit its specificity. Apart from this, it would also be used as a community screening scale for creating an awareness through psycho-social connection among the generations' about the timely detection and treatment of the likelihood of dementia.

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