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Cognitive function of patients with Type 2 Diabetes Mellitus – A cross-sectional study in Northeast India

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Abstract:
Background: *Type 2 diabetes mellitus (T2DM) is increasingly recognized not only for its vascular and metabolic complications, but also for its impact on brain health, including cognitive decline and elevated risk of dementia. In particular, insulin resistance, chronic hyperglycemia, oxidative stress, and cerebral microvascular damage may mediate cognitive impairment. Addenbrooke's Cognitive Examination III (ACE-III) tool is a validated, freely available, brief bedside neuropsychological test for assessment of cognitive function.*
Objectives: *1. To estimate the proportion of the cognitive dysfunction among type 2 diabetic patients attending AGMC & GBPH. 2. To determine the association between cognitive dysfunction and duration of disease.*
Materials and Methods: *A hospital-based cross-sectional study was conducted over three months among adult T2DM attending the diabetic clinic of AGMC & GBP Hospital. Following standard protocol clinically confirmed T2DM cases were enrolled as per American Diabetes Association (ADA) after obtaining informed consent from the participants. Demographic and clinical data, including height, weight, and ACE-III scores, were recorded. Blood glucose parameters were noted to determine diabetic status. Data were recorded in a predesigned case study format and analyzed using SPSS 21. A p-value of <0.05 was considered statistically significant.*
Results:
The study included One hundred and fifteen (115) T2DM patients in that 51% male and 49% are female with the mean age of participants was 54.96 ± 10.10 years; mean duration of diabetes was 8.20 ± 5.53 years. Mean ACE-III domain scores were: attention 17.23 ± 1.01; memory 23.07 ± 2.54; verbal fluency 13.86 ± 0.51; language 25.22 ± 1.72; visuospatial ability 15.92 ± 0.38. Out of 115 patients, 106 (≈92%) scored >88 (normal), 9 (≈8%) scored 84-87 (borderline) and none scored <83 (abnormal). Mean ACE-III scores declined as disease duration increased (96.72 for 1–5 yrs, 96.28 for 6–10 yrs, 92.47 for 11–20 yrs, 87.00 for >21 yrs), showing a clear negative correlation.
Conclusion:
Cognitive dysfunction remains under-recognized in diabetes management highlights a gap; diabetes care protocols should integrate cognitive assessment (even in younger patients) and clinicians should maintain awareness about this 'silent' complication.
Keywords: *Type 2 diabetes mellitus; Cognitive dysfunction; American Diabetes Association; Addenbrooke's Cognitive Examination III;*

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I. INTRODUCTION

Type 2 diabetes mellitus (T2DM) — previously termed non-insulin-dependent or adult-onset diabetes — is characterized by insulin resistance and a relative insulin deficiency. It is associated with reduced life expectancy compared to people without diabetes, due to its complications. Globally, an estimated 415 million people had diabetes in 2015, projected to rise to 642 million by 2040.[1,2]

Diabetes affects multiple organs (eyes, kidneys, nerves, heart, brain) via microvascular and macrovascular damage, and is now recognized to accelerate cognitive decline and increase the risk of dementia.[3] Neurological deficits (e.g., slower cognition, memory loss, lethargy, depression) can emerge early in T2DM, often going unnoticed.[4] Mechanistically, hyperglycemia, insulin resistance and dysregulated metabolism promote oxidative stress, leading to amyloid and neurofibrillary-tangle deposition in the brain, thereby contributing to cognitive impairment and dementia.[5]

Few studies have evaluated cognition in T2DM, and it remains unclear whether cognitive decline is present in early disease. The Addenbrooke's Cognitive Examination–III (ACE-III) a freely available, validated

100-item bedside tool taking ~10-15 minutes offers a practical method to assess cognitive dysfunction and has shown higher sensitivity and positive predictive value in early dementia and mild cognitive impairment.[6,7]

Given cognition is crucial for daily living, work, and education, and that current T2DM management often neglects cognitive dysfunction, exploring cognitive assessment and intervention in diabetes especially as the prevalence in younger age groups rises is imperative. This is why there is a need to explore the less addressed cognitive decline in diabetes. Hence, this study is taken up to examine the impact of type 2 diabetes on cognitive function.

II. Aims & Objectives

1. To estimate the proportion of the cognitive dysfunction among type 2 diabetic patients attending AGMC & GBPH. 2. To determine the association between cognitive dysfunction and duration of disease

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III. Materials and Method

Study type: Observational study
Study design: Hospital based Cross- sectional study
Study duration: Three months
Study area / location: Department of Physiology in collaboration with Department of Medicine, Agartala Govt. Medical College (AGMC).
Study population: Type 2 diabetic patients attending diabetic clinic of AGMC & GBP Hospital.
Inclusion criteria for cases:

1. Confirmed cases of Type 2 Diabetes Mellitus as given by the American Diabetes Association (ADA).[1]
2. Patients willing to do the study.

Exclusion criteria:

1. Patients with past or present history of psychiatric and neurological disorder
2. History of eye disease, chronic alcoholics and chronic smokers,
3. History of thyroid and renal disorder
4. Patients on drugs which may alter the psychomotor function
5. Patients with acute or chronic liver disease

Sampling procedure: Convenient sampling
All the type 2 diabetic patients attending Diabetes & Nutrition clinic who will fulfill the inclusion and exclusion criteria during the period of study were included.

Study tools:

- Stadiometer: Bio plus; height -200cm
- Weight Machine (Mechanical EQ-BR -9201): Brand- Equinox, Weight Limit- 130kg
- Adenbrooke's cognitive examination III (ACE III) questionaries
- Case study format

Study procedure:
The details of the study were explained to all the study participants. Written informed consent was obtained from all the participants. The participants were selected consecutively during the study period, following the inclusion and exclusion criteria, from the Diabetes & Nutrition clinic of Agartala Government Medical College (AGMC) & G B Pant Hospital, Agartala.
All the participants were personally subjected to detailed history-taking regarding name, age, sex, occupation, socioeconomic status, educational status, medical history and clinical features, etc.
According to the American Diabetes Association (ADA) criteria, [1]
Patients who fulfilled any of the following criteria for the diagnosis of diabetes mellitus were included:
a. Symptoms of diabetes plus random blood glucose (RBS) concentration ≥ 11.1 mmol/l (200 mg/dl), or
b. Fasting plasma glucose (FBS) ≥ 7.0 mmol/l (126 mg/dl), or
c. Haemoglobin A1c ≥ 6.5 %, or
d. 2-hour plasma glucose (PPBS) ≥ 11.1 mmol/l (200 mg/dl) during an oral glucose tolerance test.
A complete physical and clinical examination was performed. These findings were recorded in a pre-designed and pre-tested standard questionnaire. Blood sugar level, HbA1c, thyroid level and other laboratory findings were retrieved from previous and current medical documents.
The participants' age was recorded from their birthdates to the nearest completed year. Standing height was measured barefoot in centimetres to the nearest 0.1 cm; the participant was asked to stand straight and two readings were taken, and the average of both was recorded as the subject's height. Weight was recorded to the nearest 0.1

kg; the participant was asked to stand on the weighing machine without shoes and wearing only light clothing. Two readings were taken and their mean was recorded as the subject's weight.

This was followed by the Addenbrooke's Cognitive Examination III (ACE-III), a validated neuropsychological questionnaire, after informed consent had been obtained. Subjects were explained the procedure of the questionnaire. Assessment of cognitive function by ACE-III was based on attention, memory, verbal fluency, language and visuospatial ability. The test took 10-15 minutes to perform. Based on their answers to the questionnaire, scores were assigned to assess cognition.[8] The test score was out of 100, comprising attention-18 points, memory-26 points, verbal fluency-14 points, language-26 points and visuospatial-16 points.

A score of 88 or higher was considered normal; a score below 83 was considered abnormal; and a score between 83 and 87 was considered inconclusive.

Data analysis

Data were analyzed using SPSS 20. Descriptive statistics and other suitable statistical tests were used as per applicability. Data were expressed in terms of mean and standard deviation. Correlation was assessed between BMI and Nerve conduction parameters. A probability value less than 0.05 were considered as significant.

IV. Results

The study included One hundred and fifteen (115) T2DM patients in that 51% male and 49% are female as mentioned in figure 1. The mean age of participants was 54.96 ± 10.10 years; mean height and weight of the participants are 156.76 ± 8.25 and 69.03 ± 12.69; mean duration of diabetes was 8.20 ± 5.53 years as described in Table 1. Mean ACE-III domain scores were: attention 17.23 ± 1.01; memory 23.07 ± 2.54; verbal fluency 13.86 ± 0.51; language 25.22 ± 1.72; visuospatial ability 15.92 ± 0.38 as mentioned in Table 2. Out of 115 patients, 106 (≈92%) scored >88 (normal), 9 (≈8%) scored 84-87 (borderline) and none scored <83 (abnormal) as mentioned in figure 2. Figure 3 shows the domain-wise distribution of cognitive dysfunction, in that memory impairment dominated (50%), followed by attention (28%), Language (15%). When stratified by disease duration: mean ACE-III score was 96.72 for 1–5 years (n = 50), 96.28 for 6–10 years (n = 32), 92.47 for 11–20 years (n = 32), and 87.00 for >21 years (n = 1) as described in the Table 3 and Figure 4 indicating a negative correlation between duration and cognitive score.

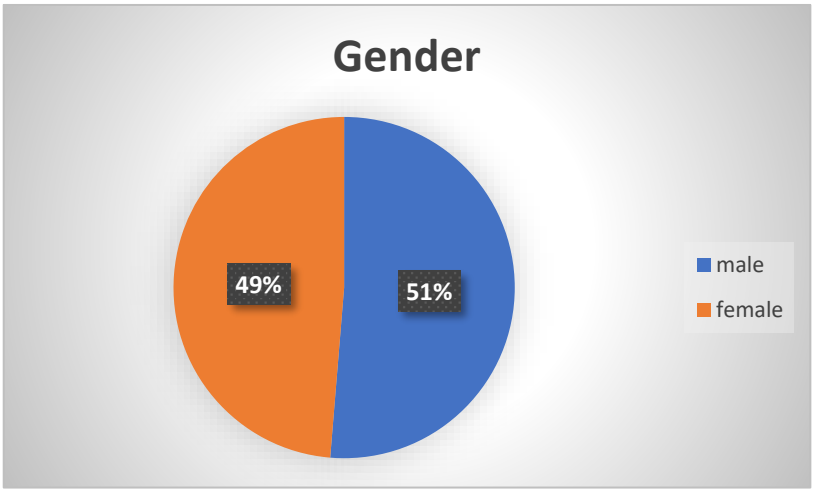

Fig.1: Gender distribution among study participants

	Mean	Std. Deviation
Age (yr)	54.96	± 10.10
Height (cm)	156.76	± 8.25
Weight (kg)	69.03	± 12.69
DM duration	8.20	± 5.53

Table 1: Demographic variables of the participants

	Mean	Std. Deviation
Attention	17.23	± 1.01
Memory	23.07	± 2.54
fluency	13.86	± 0.51
Language	25.22	± 1.72
VS	15.92	± 0.38

Table 2: Mean and St. Deviation for ACE III domain score of the participants

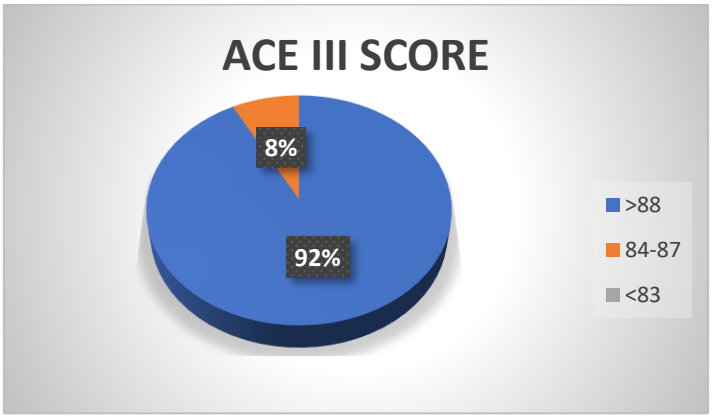

Fig.2: ACE III Score among study participants

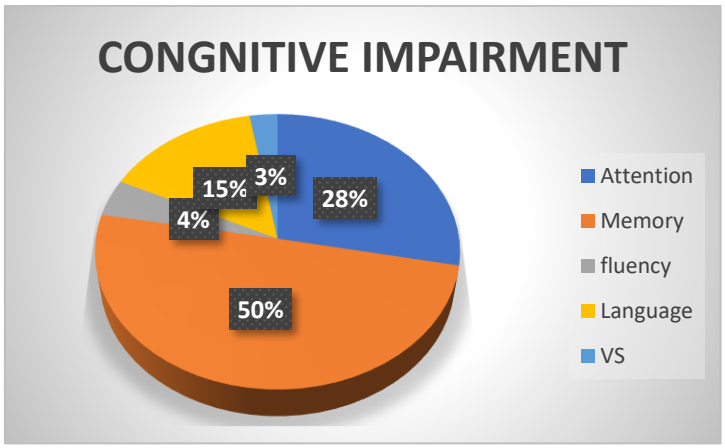

Fig.3: Cognitive Impairment among study participants

DM Duration	No. of Patients	Mean ACE Score
1–5 years	50	**96.72**
6–10 years	32	**96.28**
11–20 years	32	**92.47**
>21 years	1	**87.00**

Table 3: Comparison of ACE III Score with duration of disease

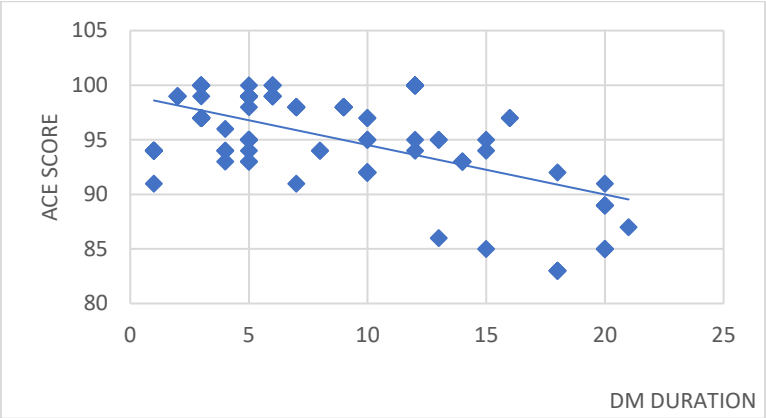

Fig.4: Correlation between Mean ACE III score and DM duration

V. Discussion

The present study assessed cognitive function among individuals with type 2 diabetes mellitus (T2DM) using the Addenbrooke's Cognitive Examination III (ACE-III). Although most participants demonstrated normal cognitive performance, a notable proportion (8%) exhibited borderline scores, with a clear trend of decreasing ACE-III scores with increasing duration of diabetes. This suggests that longer disease duration may be associated with subtle cognitive decline, consistent with the neurodegenerative impact of chronic hyperglycaemia and insulin resistance.

Similar to our study, Krishna Kumar et al. observed that longer duration and poor glycaemic control were associated with lower cognitive performance, indicating that chronic metabolic dysregulation adversely affects brain function.[9] In another study conducted by Nazaribadie et al. reported impairments in executive functions and information processing speed among T2DM and pre-diabetic patients. These findings complement our results, as lower ACE-III domain scores in attention and verbal fluency among participants with longer diabetes duration indicate early executive dysfunction.[10]

Similarly, Spauwen et al., in a 12-year follow-up study, found that T2DM was associated with faster cognitive decline over time, particularly in memory and information processing speed which is significant with our study.[11] Furthermore, Malik et al. reported that nearly half of diabetic participants had some form of cognitive impairment, which was associated with disease duration and poor glycaemic control. In contrast, our study found a lower prevalence (8% borderline), possibly due to better control or younger participant age distribution.[12]

Roy et al. also found cognitive impairment in younger adults with T2DM, underscoring that diabetes-related cognitive changes are not limited to the elderly. Our finding that even middle-aged patients showed borderline scores supports the need for early screening in all age groups.[13]

Cognitive dysfunction and dementia is a common but underdiagnosed complication of diabetes mellitus which has major consequences on functional and social skills. Chronic hyperglycaemia causes damage to microvasculature and microvasculature throughout the body. Damage to cerebral microvasculature can lead to poorer cognitive function and faster cognitive decline.

VI. Conclusion

Cognitive dysfunction remains under-recognized in diabetes management highlights a gap; diabetes care protocols should integrate cognitive assessment (even in younger patients) and clinicians should maintain awareness about this 'silent' complication.

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