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Memory Impairment and Executive Dysfunction are Associated with Inadequately Controlled Diabetes in Older Adults

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Abstract

Objective—To assess the cross-sectional relationship of glycemic control to memory impairment and executive dysfunction in older adults with diabetes treated at an urban primary care center.

Participants and Methods—As part of a primary care-based cognitive screening program, we identified adults age 65 or older with a diagnosis of diabetes. Glycosylated hemoglobin level (HbA1c) was used to define diabetes as controlled (HbA1c <7) or inadequately controlled(HbA1c ≥ 7). Episodic memory was measured by quartile of free recall scores on the Free and Cued Selective Reminding Test. Executive function was measured using an ordinal composite score derived from animal fluency and months backward. These were the main predictors of diabetic control.

Results—The 169 participants with diabetes had a median age of 74. The sample was 38% African American and 42% Latino. One hundred four (61%) had inadequately controlled diabetes. Memory impairment and executive dysfunction were independent predictors of diabetic control after adjusting for age and education. Binary logistic regression models indicated that the odds of inadequately controlled diabetes was higher for patients in the worst quartile of memory functioning compared to patients in higher quartiles of memory functioning (odds ratio = 6.4; 95% confidence interval: 2.3, 17.6). Any level of executive dysfunction increased the odds of inadequately controlled diabetes compared to patients in the best quintile of executive functioning (odds ratio =3.6; 95% confidence interval: 1.58, 8.35).

Conclusions—Memory impairment and executive dysfunction were associated with inadequately controlled diabetes. Though causal inferences are not robust in a cross-sectional study, we suggest that cognitive dysfunction may interfere with diabetes management and that inadequate diabetic control may contribute to cognitive dysfunction.

Keywords

diabetes; dementia; cognitive impairment; African American; Latino

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Declaration of Conflicting Interests

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Introduction

Both diabetes and cognitive impairment are common problems in older adults,[1,2–4] and these problems disproportionally affect African Americans and Latinos.[4,5] Type 2 diabetes is a risk factor for cognitive decline and dementia.[6] Cognitive impairment, in turn, may make optimal glycemic control more difficult, because diabetic self-management activities are cognitively demanding.[7] Recent studies have shown that cognitive impairment is associated with poor glycemic control.[8–10] In the Health and Retirement Study (HRS), respondents in the lowest quartile of their cognitive scale had significantly higher glycosylated hemoglobin (HbA1c) levels than those in the highest quartile.[9] These findings are compatible with the hypothesis that cognitive dysfunction may interfere with diabetic control,[6] or that poor diabetic control contributes to cognitive dysfunction.[11]

Most studies of cognitive function and glycemic control included relatively small numbers of African American and Latino patients, who are at elevated risk for diabetes. In this study, a largely African American and Hispanic cohort of patients with diabetes 65 years and older was recruited from patients making routinely scheduled visits to an urban primary care clinic. Consistent with earlier work, we anticipated that cognitive impairment would predict inadequate glycemic control. We focused separately on memory and executive functioning because impairment of either could interfere with self-management activities. Glycemic control was measured by HbA1c. We expected that both executive dysfunction and memory impairment would predict inadequately controlled diabetes.

Methods

Clinical Setting

Older patients with diabetes were identified from 350 participants in an ongoing memory screening project being conducted in the Adult Primary Care Clinic of the Jacobi Medical Center, which serves a diverse patient population in the Bronx, NY. The project was approved by the Institutional Review Boards at the Albert Einstein College of Medicine and Jacobi Medical Center. The 20-minute screening battery was coordinated with each patient's regularly scheduled clinic appointment.

There were 169 patients with diagnosed diabetes (ICD-9 codes of 249, 250, or 790). Patients were 65 or older, fluent in English or Spanish, and had adequate vision and hearing. We included the 2 patients with dementia ICD-9 codes because there were most certainly patients with unrecognized dementia in the cohort.[12] The HbA1c level closest in time to the screening date was used to define diabetes as controlled (HbA1c<7) or inadequately controlled (HbA1c $\geq$ 7).[13]

One hundred four (61%) of the patients met the definition for inadequately controlled diabetes. The majority of patients were African American (44%) or Latino (49%), and most were women (74%). Patients with inadequately controlled diabetes tended to be younger than patients with good control (72.6 vs 74.5, $P = .06$), did not differ in education (9.4 vs 8.6, $P = .18$), and had had diabetes longer than patients with good control (7.3 vs 5.4, $P = .01$).

Episodic Memory

Episodic memory was assessed with the Free and Cued Selective Reminding Test,[14] which identifies very mild dementia,[15] predicts future dementia and Alzheimer's disease (AD),[16–18] and distinguishes AD from non-AD dementias.[15,19,20] Unlike other memory tests, it includes a study phase that controls attention and cognitive processing to identify memory impairment that is not secondary to other cognitive deficits. Sixteen pictures are

presented 4 at a time; participants identify each picture by naming it (eg, grapes) after its cue is presented (fruit). Immediate cued recall of the 4 pictures is tested before the next set is studied. There are 3 test trials consisting of free recall followed by cued recall of items not retrieved in free recall. Four strata were defined by quartiles for the sum of free recall among the 350 participants in the screening project.

Executive Function

Executive function was measured by a composite score derived from animal fluency and months backwards among the 350 participants in the screening project. In animal fluency, patients have 60 seconds to generate the names of animals, a task that requires rapid self-guided retrieval from semantic memory. Reciting the months backwards requires reversing the normal order and keeping track of one's place. A composite score was constructed with 5 levels, as shown at the bottom of Table 1.

Statistical Analyses

The relationship between glycemic control and cognition was assessed with a series of binary logistic regression models adjusted for age and education, which could confound the relationships of interest. The main predictors were the episodic memory and executive function measures as defined above.

Results

Impaired executive function was a strong predictor of inadequate glycemic control (odds ratio [OR] 3.64, 95% confidence interval [CI] 1.58, 8.35). Lack of glycemic control increased with greater executive function impairment (Table 1). Memory impairment was also a strong predictor of glycemic control (OR 6.39, 95% CI 2.32–17.6). Persons in the lowest quartile of memory function were at increased risk of inadequate control, whereas persons in the second and third quartiles were not (Table 2).

Entering executive dysfunction and memory impairment in the same model did not substantially reduce their predictive values compared to the separate models, nor did they interact (P = .38). Being in the bottom quartile of memory function increased the risk of inadequately controlled diabetes (OR 5.16, 95% CI 1.84, 14.45) as did being other than in the top quintile of executive function (OR 2.56, 95% CI 1.07, 6.13]). Each additional year of diagnosis increased the risk of inadequate control by 29% (OR 1.29, 95% CI 1.12,1.50]). There was a trend for younger patients with diabetes and patients with diabetes who had more education to have inadequately controlled diabetes (both, P = .07).

Discussion

These results confirm our hypothesis that both memory impairment and executive dysfunction would predict inadequate glycemic control in a racially diverse sample of older adults with type 2 diabetes. Patients with any level of executive dysfunction were 3.6 times more likely to have inadequately controlled diabetes (HgA1c ≥ 7) than patients with no executive dysfunction. Patients with more severe executive dysfunction were at greater risk of inadequate control than patients with milder executive dysfunction, suggesting a dose-dependent relationship. These results highlight the need for executive function assessment in primary care settings because of the impact that even the lowest levels of impairment may have on diabetic control.

Patients in the lowest quartile of memory function were 6.4 times more likely to have inadequately controlled diabetes than patients with better memory. The memory impairment displayed by these patients is at the level of patients with very mild dementia.[15] Memory

impairment and executive dysfunction were independent predictors of glycemic control and did not interact. Each year of the diagnosis increased the risk of uncontrolled diabetes by 29%.

The results extend our understanding in 2 ways. First, they extend the previous results linking cognitive impairment and inadequate glucose control to a cohort of African American and Latino primary care patients. Second, in the HRS,[9] cognition was indicated by a single score summarizing cognitive functioning. Because a composite score was used, identifying which aspects of cognition influenced glycemic control was not possible.

Though directionality cannot be established from these cross-sectional studies, we suggest that cognitive dysfunction may interfere with diabetes management and that inadequate diabetic control may contribute to cognitive decline, thereby producing a feed-forward mechanism. Recognizing cognitive impairment would create opportunities to develop management strategies that do not depend on the cognitive status of the patient with diabetes. Unfortunately, cognitive impairment and dementia may go unrecognized in primary care settings,[12,21,22] which may result in missed opportunities to improve the management of diabetes in patients with cognitive impairment. As a first step to improving adherence, we developed and validated several tools for identifying patients with cognitive impairment and dementia in primary care settings,[23–25] and we implemented them here. The second step may be to involve a family member or friend in the patients' diabetes care. In the HRS study, high levels of family support amerliorated the association between cognitive impairment and worse glycemic control.[9] Activating a family to be part of the care team is already an established element of successful collaborative care models for chronic illness.[26,27] Family involvement may be particularly important for cognitively impaired older adults who may be unable to manage their diabetes care effectively without assistance.

This study has several limitations. First, the cross-sectional design does not permit robust inferences about the causal pathways between cognition and diabetic control. A bidirectional relationship is plausible. Second, we did not have sufficient power to examine other factors that might influence diabetic control (eg, racial/ethnic membership, medication regimen). Finally, we decided against removing 2 patients with diagnosed dementia because some patients may have a clinical dementia that was not reflected in ICD-9 codes. Excluding these 2 patients did not affect any of our conclusions. If underdiagnosed dementia is more common in patients with diabetes than in the rest of the sample, this finding could explain some of the observed association between glycemic control and memory and executive functioning. We are not aware of evidence for differential misdiagnosis by diabetes status, which makes confounding unlikely. A test of this explanation awaits the completion of follow-up to ascertain each participant's dementia status.

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Table 1

Level of Executive Dysfunction and Relative Odds of Inadequate Diabetic Control: Results from Multiple Logistic Regression Adjusting for Age and Years of Education

Executive function impairment	Odds ratio vs. reference unimpaired	Lower 95% Confidence Level	Upper 95% Confidence Level	*P*
1	3.59	1.41	9.15	.007
2	3.10	1.16	8.31	.024
3	5.26	1.49	18.55	.01
4	5.25	0.84	32.82	.076

Key to executive function impairment levels (0=unimpaired, reference group):

0= Animal Naming ≥ 15 and no errors on Months Backwards (unimpaired)

1 = Animal Naming 10–14 and no errors in Months Backwards, OR Animal Naming ≥15 and uncorrected errors in Months Backwards

2 = Animal Naming ≤ 9 and no errors in Months Backwards, OR Animal Naming 10–14 and uncorrected errors in Months Backwards, OR Animal Naming ≥ 15 and unable to complete Months Backwards

3 = Animal Naming ≤ 9 and uncorrected error(s) in Months Backwards, OR Animal Naming 10–14 and unable to complete Months Backwards

4 = Animal Naming ≤ 9 and unable to complete Months Backwards

Table 2

Level of Memory Impairment and Relative Odds of Inadequate Diabetic Control: Results from Multiple Logistic Regression Adjusting for Age and Years of Education

Free Recall Score	Odds Ratio vs. Reference Unimpaired (34+)	Lower 95% Confidence Level	Upper 95% Confidence Level	*P*
34+ (ref.)	—	—	—	—
29–33	1.86	0.71	4.87	.207
24–28	1.17	0.44	3.11	.752
Under 24	8.24	2.56	26.60	<.001