Journal of Clinical Gerontology & Geriatrics 5 (2014) 68–71

Contents lists available at ScienceDirect

Journal of Clinical Gerontology & Geriatrics

journal homepage: www.e-jcgg.com

Original article

Undiagnosed diabetes mellitus among residents in Taiwanese long-term care facilities: A comparison of fasting glucose, postprandial plasma glucose, and hemoglobin A1c

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ARTICLE INFO

Article history:
Received 18 October 2013
Accepted 13 January 2014
Available online 20 February 2014

Keywords:
Diabetes mellitus
Elderly
Geriatrics
Long-term care
Nursing home

ABSTRACT

Background: The prevalence of diabetes mellitus (DM) is escalating with an aging population, and the chances of diabetic older patients admitted to long-term care facilities (LTCFs) are increased because of DM-related complications. However, undiagnosed DM among LTCF residents is a recognized hidden problem in this setting and may result in adverse outcomes.

Methods: In May 2011, 10 private LTCFs in northern Taipei participated in this study. Trained research nurses reviewed the medical records and performed physical examinations and blood sampling for all participants. Diabetes mellitus was diagnosed, based on the levels of fasting glucose, 2-hour postprandial plasma glucose, and hemoglobin A1c (HbA1c). Patients were categorized as having DM if they met the diagnostic cut-offs of the aforementioned criteria.

Results: One hundred and ninety-nine residents (mean age, 79.6 ± 10.5 years; 52.3% males) participated in this study. They were all moderately/severely disabled (Karnofsky Performance Scale mean score was 50 ± 13). Forty-six (23.1%) residents were diabetic, based on their medical records, or were current users of antidiabetic agents. The prevalence was 29.6% after testing with a mean HbA1c level of 6.9% ± 0.9%. The overall undiagnosed DM rate was 4%, 3.5%, and 4.5%, based on fasting glucose, 2-hour postprandial plasma glucose, and HbA1c criteria, respectively. Diabetic patients had significantly higher serum levels of prealbumin, compared to nondiabetic patients (220.8 ± 45.9 vs. 201.1 ± 62.2 mg/L; $p = 0.03$), but there were no differences in the levels of hemoglobin, serum albumin, or total cholesterol. Diabetic patients had a significantly higher serum triglyceride level, compared to the nondiabetic patients (1.6 ± 0.7 vs. 1.1 ± 0.5 mmol/L; $p < 0.01$) and a lower high-density lipoprotein level (1.0 ± 0.3 vs. 1.2 ± 0.3 mmol/L; $p < 0.01$). Among 43 pharmacologically treated diabetic patients, 65.1% (28/43) of patients were using oral antidiabetic agents and 41.9% (18/43) of patients had been prescribed insulin, whereas 32.6% of the patients were managed by combination therapy.

Conclusion: The prevalence of DM among LTCF residents in Taipei was 29.6%, and the undiagnosed rate was no more than 5%, based on fasting glucose, 2-hour postprandial plasma glucose, or HbA1c. Further study is needed for the optimal treatment strategy of DM in LTCFs.

1. Introduction

Diabetes mellitus (DM) is a prevalent disease that may result in excess morbidity,[1] functional impairment or disability,[2–4] mortality, reduced life expectancy,[5,6] and increased chance of placement

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2210-8335
http://dx.doi.org/10.1016/j.jcgg.2014.01.003

in a long-term care facility (LTCF) because of disability. In addition to the higher risk of LTCF admission, diabetic LTCF residents have a higher risk of developing DM-related complications. The quality of diabetic care in long-term care settings needs further improvement because it has been reported that diabetic residents in LTCFs are less likely than community-dwelling diabetic elders to receive an annual review, eye examinations, and foot care.[7] Undiagnosed DM in LTCFs residents moreover is reportedly a hidden problem that may be associated with more hyperosmolar nonketotic coma and increased mortality in diabetic LTCF residents.[8,9]

Diabetes mellitus has traditionally been diagnosed by fasting plasma glucose and 2-hour plasma glucose testing during an oral glucose tolerance test[10,11]; however, a glycated hemoglobin A1c (HbA1c) of 6.5% has been recommended as an alternative method to diagnose DM[12] by the American Diabetes Association (ADA) and the World Health Organization (WHO).[13,14] There are several limitations of using HbA1c to diagnose DM,[15] although the superiority of HbA1c in the diagnosis of DM has been recognized because it requires no special patient preparation, it has lower biological variations, and it is unaffected by acute stress or hyperglycemia.[16] The aforementioned advantages of HbA1c make it a suitable tool for diagnosing DM in long-term care settings. Previous reports in Western countries found a high undiagnosed rate of DM in LTCFs,[7] although the rate was only 3.8% in a previous report in Taiwan.[17] However, the Taiwanese study tested fasting plasma glucose only, which may underestimate the prevalence of DM and undiagnosed DM in the elderly. Therefore, the main purpose of this study was to evaluate the undiagnosed DM rate by testing the levels of fasting glucose, postprandial plasma glucose, and HbA1c among LTCF residents in northern Taiwan.

2. Methods

2.1. Study participants

In May 2011, 10 private LTCFs in northern Taipei with bed capacities of 20–50 residents were invited to participate in this study. The residents were enrolled when they, or their families, and the LTCF managers gave full consent and agreed to participate. The study was approved by the Institutional Review Board of the Taipei Veterans General Hospital (Taipei, Taiwan).

2.2. Demography and physical examinations

For each participant, chart records in the LTCFs were reviewed in detail with a special focus on a DM diagnosis and use of oral antidiabetic agents or insulin. Age, sex, functional status (evaluated by the Karnofsky Performance Scale),[18] height, and weight were recorded. The body mass index (BMI) was calculated accordingly.

2.3. Diabetes mellitus, biochemistry, and insulin resistance

Diabetes mellitus was diagnosed primarily on the basis of the medical chart records in the LTCFs. In this study, all participants underwent blood testing after an 8-hour overnight fast, which included fasting plasma glucose; serum levels of prealbumin, albumin, total cholesterol, triglyceride, high- and low-density lipoprotein cholesterol, creatinine, insulin, and HbA1c; and complete blood cell count. For all participants, 2-hour postprandial plasma glucose was tested. A diagnosis of DM was based on the criteria of the American Diabetes Association in 2011.[13] Patients were categorized as having DM if they met the criteria of DM by fasting glucose, postprandial plasma glucose, or HbA1c. Insulin resistance was measured by homeostasis model assessment (HOMA-IR).[19]

2.4. Statistical analysis

Continuous variables of the data in the text and tables were expressed as mean ± standard deviation. Categorical data are expressed as percentages. Comparisons of categorical variables were performed by Chi-square test or Fisher's exact test. Comparisons of continuous variables were performed by the Student *t* test or Mann–Whitney *U* test when appropriate. The kappa value was used to determine the consistency of the DM diagnosis based on fasting glucose, 2-hour postprandial plasma glucose, and HbA1c. For all tests, a $p < 0.05$ (i.e., two-tailed) was considered significant.

3. Results

In this study, 199 residents participated from 10 private LTCFs. The mean age of all participants was 79.6 ± 10.5 years and 52.3% of them were males. Among the residents, 4.5% of residents needed frequent oxygen therapy, 37.2% of residents were fed by nasogastric tubes, and 27.6% of residents had a long-term indwelling urinary catheter. All participants were moderately/severely disabled (with a mean Karnofsky Performance Scale score of 50 ± 13).

Forty-six (23.1%) participants were diabetic, according to the medical records of the LTCFs, or currently used antidiabetic agents; 43 (93.5%) participants were pharmaceutically treated. The data of fasting glucose, 2-hour postprandial plasma glucose, and HbA1c of all participants were compared and showed that 8 patients, 7 patients, and 9 patients, respectively, had undiagnosed DM. The overall prevalence of undiagnosed DM in this study was 4% (fasting glucose), 3.5% (2-hour postprandial plasma glucose), and 4.5% (HbA1c), based on the aforementioned diagnostic criteria. In total, 7.5% (15/199) of participants had undiagnosed DM on combining all three diagnostic criteria, and the prevalence of DM in this study was 29.6%.

Table 1 shows the comparisons of demographic characteristics, nutritional markers, lipid profile, and inflammatory markers

Table 1
Comparison of residents with and without diabetes in long-term care homes.

	DM ($n = 59$)	No DM ($n = 140$)	p
Age (y)	78.0 ± 10.5	80.3 ± 10.5	0.153
Sex, male, % (n)	45.8% (27)	55% (77)	0.233
BMI (kg/m^2)	22.1 ± 3.5	21.1 ± 4.3	0.137
Systolic blood pressure (mmHg)	124.9 ± 15.8	120.4 ± 14.0	0.051
Functional status (KPS)	49 ± 12	50 ± 14	0.551
HbA1c (mmol/mol)	52.0 ± 10.4	38.0 ± 4.8	<0.001*
(%)	6.9 ± 0.9	5.6 ± 0.4	<0.001*
HOMA-IR	6.4 ± 8.5	1.56 ± 1.2	<0.001*
Serum markers of protein-energy nutrition			
Hemoglobin (g/L)	125.0 ± 18.3	120.8 ± 19.6	0.163
Prealbumin (mg/L)	220.8 ± 45.9	201.1 ± 62.2	0.030*
Albumin (g/L)	37.9 ± 3.3	36.8 ± 3.6	0.059
Total cholesterol (mmol/L)	4.4 ± 0.9	4.4 ± 1.0	0.899
Lipid profile			
Triglycerides (mmol/L)	1.6 ± 0.7	1.1 ± 0.5	<0.001*
HDL-C (mmol/L)	1.0 ± 0.3	1.2 ± 0.3	<0.001*
LDL-C (mmol/L)	2.9 ± 0.8	2.8 ± 0.8	0.485
Inflammatory markers			
hs-CRP (nmol/L)	9.8 ± 13.6	12.1 ± 20.0	0.420
WBC count (x10^9/L)	7.93 ± 2.0	6.79 ± 2.56	0.003*
TNC (x10^9/L)	5.2 ± 1.7	4.2 ± 2.4	0.007*
TLC (x10^9/L)	2.0 ± 5.8	1.8 ± 6.7	0.071

Data are presented as mean ± SD or % (n).
BMI = body mass index; HbA1c = glycosylated hemoglobin A1c; HDL = high-density lipoprotein; HOMA-IR = homeostasis model assessment; hs-CRP = high-sensitivity C-reactive protein; KPS = Karnofsky Performance Scale; LDL = low-density lipoprotein; TLC = total lymphocyte count; TNC = total neutrophil count; WBC = white blood cell count.
*$p < 0.05$.

between residents with DM and without DM. The baseline demographic characteristics and functional status were similar between the groups, but diabetic patients had significantly higher levels of HbA1c and HOMA-IR. A comparison of protein-energy nutritional markers showed that diabetic patients, compared to the nondiabetic patients, had significantly higher serum levels of prealbumin (220.8 ± 45.9 vs. 201.1 ± 62.2 mg/L; $p = 0.03$), but no had difference in the levels of hemoglobin, serum albumin, or total cholesterol. However, diabetic patients had significantly higher levels of serum triglyceride (1.6 ± 0.7 vs. 1.1 ± 0.5 mmol/L; $p < 0.01$) and lower high-density lipoprotein level (1.0 ± 0.3 vs. 1.2 ± 0.3 mmol/L; $p < 0.01$), which were compatible with the presentation of diabetic dyslipidemia. The serum levels of high-sensitivity C-reactive protein were similar between the groups. The white blood cell count and total neutrophil count were both higher in diabetic patients, which implied a chronic inflammatory status among diabetic LTCF residents.

Of the 43 pharmacologically treated diabetic patients, 65.1% (28/43) of residents were using oral antidiabetic agents and 41.9% (18/43) of residents had been prescribed insulin. Most residents were managed by monotherapy; 32.6% (14/43) of the residents were controlled by combination therapy (Table 2). For all diabetic patients, the mean HbA1c was controlled at 6.9% ± 0.9%.

4. Discussion

In this study, the overall prevalence of DM among LTCF residents was 29.6%, after the reevaluation of a DM diagnosis. The prevalence of DM in United Kingdom care homes ranges between 9.9% and 20.0%,[20–22] which is lower than the results of this study. However, in the United States, 14.5% of nursing home residents were diagnosed as having DM in 1977,[23] which became 17.2% in 1999,[24] and 21%, in another study in 1999.[25] However, the prevalence of DM may reach as high as 36.1% according to a 2007 report.[26] Recent studies in Taiwan report a DM prevalence of 30.8% and 27.9% in LTCF settings,[17,27] which were similar to the findings of this study. The variation in the DM prevalence in different studies may be the result of several reasons such as different age of the study populations, quality of care in LTCFs, DM diagnostic criteria, and the diagnostic tools used (e.g., questionnaire survey, medical record review, or blood testing).

The undiagnosed rate of DM in this study was 7.5% (15/199) of patients in this study, which was significantly lower than in other reports. Sinclair et al[22] reported that 14.8% of LTCF residents would be undiagnosed as having DM, based on the oral glucose tolerance test. Another study showed that the undiagnosed DM rate was 8.2%, based on fasting glucose testing and 2-hour postprandial plasma glucose testing.[28] In Taiwan, the LTCF accreditation system emphasizes LTCF residents should undergo annual health check-ups. Therefore, the lower rate of undiagnosed DM, compared to previous reports from Western countries, may be a systematic factor. The undiagnosed DM rate may represent quality of care to a certain degree; however, it may be associated with overtreatment in this setting. Optimal diabetic care in LTCFs is an extremely difficult issue that needs extensive research studies for an evidence-based practice guideline. In our study, the undiagnosed DM rates of LTCF residents, based on fasting glucose, 2-hour postprandial plasma glucose, and HbA1c, were 4%, 3.5%, and 4.5%, respectively, which were surprisingly similar. Because of the physiological characteristics related to aging, the prevalence of DM may be higher in older adults, based on postload plasma glucose testing; however, this was not shown in this study. Using HbA1c for the diagnosis of DM has many advantages, except the cost. The effect of aging on HbA1c remains controversial with some studies claiming no age-related changes in HbA1c,[29] and other studies suggesting that HbA1c underestimates the prevalence of DM.[30] In particular, the sensitivity of HbA1c in diagnosing DM may be low in older Asian patients.[31] In DM diagnosis, HbA1c has several advantages, but several concerns need to be clarified such as the potential interracial differences in hemoglobin glycation rates,[30] the optimal cut-off point for different ages and ethnicity backgrounds, and the higher cost of mass screening programs.

In long-term care settings, the recommended glycemic control target was set at HbA1c of 8% by the American Geriatrics Society.[32] Our previous study clearly demonstrated that tight glycemic control was associated with a higher frequency of hypoglycemia and with more functional decline in the follow-up period.[17] Moreover, tight glycemic control in this setting did not prevent LTCF residents from developing pneumonia.[27] Results of this study showed that physicians tending to LTCF residents were somewhat too aggressive in glycemic control, which may result in a higher risk of hypoglycemia for these patients. Determining the optimal target of glycemic control in LTCFs is difficult, and deserves more investigation to establish an evidence-based practice guideline for DM control in LTCFs.

There are several limitations in this study. First, the study was performed by a convenient sample with a relatively small size. This study may not sufficiently represent the whole population in LTCFs, although the results of this study were still of great importance because of the lack of screening DM by HbA1c in LTCFs. Second, the treatment protocol of DM was not standardized among the LTCFs in this study; therefore, the target of glycemic control may vary between institutes. Third, the data of hypoglycemia and clinical outcomes of the participants were not collected in this study, which limited the possibility of exploring the clinical impact of DM control in this setting.

Despite the aforementioned limitations, the strength of this study was the comparisons of DM diagnosis by different diagnostic criteria in LTCFs, which has not been performed in Taiwan or in other countries. In conclusion, 23.1% of LTCF residents in Taipei were diabetic when using medical records and 29.6% when testing fasting glucose, 2-hour postprandial plasma glucose, and HbA1c. By using either one of the diagnostic criteria, the undiagnosed DM rate was no more than 5%.

Table 2
Description of pharmaceutical management.

Medication	*n* (%)
Secretagogues	
Sulfonylureas	14 (32.6)
Meglitinide	5 (11.6)
Metformin	16 (37.2)
Other OADs	9 (20.9)
Insulin	18 (41.9)

OAD = oral antidiabetic agent.

Conflicts of interest

The authors have no conflicts of interest relevant to this article to report.

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