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Factors associated with glycemic control after an inpatient program

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Abstract

In this study, we investigated the factors predicting poor glycemic control after an inpatient program. Using the hospital database from April 1999 to May 2003, we retrospectively identified patients with type 2 diabetes mellitus and hemoglobin A_{1C} (HbA_{1C}) of at least 8.0% at the time of admission for an inpatient program. In the primary analysis, factors potentially related to poor glycemic control ($HbA_{1C} \geq 7.0\%$) at 6 months after admission were investigated. Stepwise multivariate regression analysis identified the duration of diabetes (odds ratio, 2.43; 95% confidence interval [CI], 1.54-3.82; $P < .001$), period from the first attendance at our hospital until admission (odds ratio, 1.60; 95% CI, 1.01-2.54; $P = .047$), and number of admissions (odds ratio, 2.28; 95% CI, 1.36-3.82; $P = .002$) as predictors of poor glycemic control. In the secondary analysis, factors related to poor glycemic response (an absolute decrease of HbA_{1C} by <1.5% from the baseline) at 6 months after admission were investigated. Stepwise multivariate regression analysis identified the duration of diabetes (odds ratio, 2.17; 95% CI, 1.19-3.93; $P = .011$), period from the first attendance at our hospital until admission (odds ratio, 2.17; 95% CI, 1.43-3.29; $P < .001$), treatment of diabetes at discharge (oral hypoglycemic agents: odds ratio, 2.52; 95% CI, 1.15-5.51; $P = .021$; insulin: odds ratio, 4.44; 95% CI, 1.96-10.07; $P < .001$), baseline HbA_{1C} (odds ratio, 0.44; 95% CI, 0.37-0.53; $P < .001$), and addition of new medications (odds ratio, 0.41; 95% CI, 0.27-0.62; $P < .001$) as predictors of poor glycemic control.

1. Introduction

Good glycemic control prevents the onset and progression of complications in patients with type 2 diabetes mellitus [1-3]. Current guidelines set a hemoglobin A_{1C} (HbA_{1C}) level less than 7.0% as the goal of treatment [4], which involves oral hypoglycemic agents and/or insulin as well as diet and exercise. However, only a limited number of patients reach this target even if they are treated by diabetologists.

It would be helpful to know the factors related to poor glycemic control from among clinical information that is easily available. Previous studies have identified several factors that might be related to glycemic control [5-9], including clinical characteristics such as the duration of diabetes, C-peptide level, and insulin resistance measured by homeostasis model assessment [6,9]. Psychosocial characteristics that influence glycemic control have also been reported [10,11]. However, there have been few reports about factors that influence glycemic control after a diabetes inpatient program. Accordingly, we explored factors associated with glycemic control in Japanese patients with type 2 diabetes mellitus who participated in an inpatient diabetes program at a single institution. Our objective was to identify simple clinical variables that could predict the outcome for glycemic control at 6 months after admission.

2. Subjects and methods

We conducted a retrospective cohort study at a single diabetes clinic between April 1999 and May 2003 using the hospital database. Patients with type 2 diabetes mellitus who were admitted to our hospital for the inpatient program and had an HbA_{1C} of at least 8.0% at admission were eligible for this study. The exclusion criteria were a serum creatinine greater than 2.0 mg/dL, retinopathy requiring eye surgery, other endocrine disorders, infections, and malignancies. A total of 605 patients were identified.

The goal of the inpatient program (1-2 weeks) was to achieve a postprandial plasma glucose less than 200 mg/dL. Patients ate meals with 25 to 30 kcal/kg of ideal body weight.

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Table 1
Characteristics of the patients at admission

N (male, %)	605 (55.5%)
Age (y)	59.2 ± 12.3
HbA_{1C} (%)	9.74 ± 1.44
BMI (kg/m^2)	24.5 ± 4.3
Duration of diabetes (y)	12.7 ± 8.9
Period from the first visit to admission (y)	5.8 ± 6.6
No. of admissions (times)	1.8 ± 1.6
Discontinuation of regular attendance (%)	22.1%
Treatment of diabetes at discharge (D/O/I)	53/235/317

D indicates diet; O, oral hypoglycemic agents; I, insulin with or without oral hypoglycemic agents. Means ± SD.

They received lectures about meal planning for 30 minutes every day given by dietitians. They also attended classes about diabetes for 30 minutes every day given by diabetologists, nurses, or physical therapists. They were weighed every day before breakfast. If the blood glucose level was improving, they were encouraged to continue their diet and exercise regimen. Otherwise, their oral hypoglycemic agents or insulin therapy was adjusted.

After being discharged, patients were followed up at the outpatient clinic of our hospital at monthly intervals. When the target for glycemic control was not achieved (ie, HbA_{1C} was ≥7.0%), an oral agent or insulin was started or increased as required. The HbA_{1C} values on admission and over time were collected from the database. For the primary analysis, we classified the patients into good (HbA_{1C} <7.0%) and poor (HbA_{1C} ≥7.0%) glycemic control groups using the HbA_{1C} level at 6 months after admission. For the secondary analysis, we classified the patients into good (ΔHbA_{1C} ≥1.5%) and poor (ΔHbA_{1C} <1.5%) responder groups according to the absolute decrease of HbA_{1C} from baseline to 6 months after admission.

Factors with a potential influence on glycemic control, such as the age, duration of diabetes, period from the first attendance at our hospital until admission, HbA_{1C} value, and treatment of diabetes at discharge, were collected from the hospital database. The body mass index (BMI), total number of admissions, hospitalization period, history of discontinuation of regular attendance before admission, and addition of new medications after discharge were also obtained from the medical records.

This study was approved by the ethical review board of Tokyo Women's Medical University.

2.1. Statistical analysis

Analyses were performed using SAS software (version 9.1; SAS Institute, Cary, NC). Student *t* test and Dunnett multiple comparison tests were used to compare groups. To evaluate the influence of various risk factors on a poor outcome (HbA_{1C} ≥7.0% or an absolute decrease of HbA_{1C} by <1.5% from the baseline), both univariate and multiple logistic regression analyses with backward stepwise selection of variables were performed. The influence of profile, interaction, and colinearity on the multivariate model was examined by regression diagnostic analysis. Spearman correlation coefficients were calculated to examine correlations.

3. Results

The characteristics of the patients at the time of admission are shown in Table 1. The HbA_{1C} profiles of the patients stratified into 2 groups based on the HbA_{1C} value at 6 months (≥7.0% or <7.0%) are shown in Fig. 1. No statistical difference was found between the 2 groups' HbA_{1C} levels at admission (P = .21). The HbA_{1C} of patients who did not achieve the target level (<7.0%) decreased until 3 months after admission, but increased again thereafter. In contrast, the patients who achieved the target level showed stable HbA_{1C} values after 4 months (Fig. 1).

The results of logistic regression analysis for the primary outcome are shown in Table 2. According to univariate analysis, the age, BMI, hospitalization period, history of discontinuation of regular attendance before admission, baseline HbA_{1C}, and addition of new medications after discharge were not associated with a poor outcome (HbA_{1C} ≥7.0%) at 6 months after the inpatient program. However, the duration of diabetes (odds ratio, 3.90; 95% confidence interval [CI], 2.58-5.89; P < .001), period from the first visit to admission (odds ratio, 3.38; 95% CI, 2.37-4.83; P < .001), number of admissions (odds ratio, 3.88; 95% CI, 2.55-5.92; P < .001), and treatment of diabetes at discharge (oral hypoglycemic agents: odds ratio, 3.01; 95% CI, 1.63-5.54; P < .001; insulin: odds ratio, 3.55; 95% CI, 1.95-6.47; P < .001) all had an influence on glycemic control. According to stepwise multivariate regression analysis, the significant predictors of poor glycemic control were the duration of

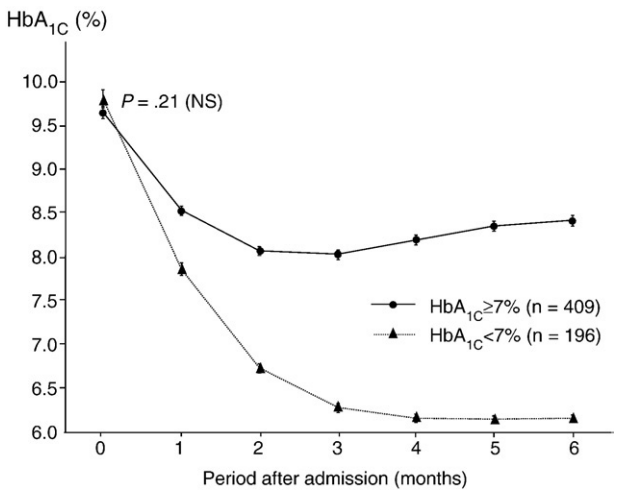

Fig. 1. The HbA_{1C} profiles (mean ± SE) for patients with a value of at least 7% or less than 7.0% at 6 months. Differences between the 2 groups were significant, except at admission (P = .21).

Table 2
Factors associated with poor glycemic control (HbA_{1C} ≥7.0%) at 6 months according to logistic regression analysis

	Total (N = 605)	Poorly controlled (n = 409)	Univariate			Multivariate		
			Odds ratio	95% CI	*P* value	Adjusted odds ratio	95% CI	*P* value
Age (y)								
<50	123	79 (64.2%)	1.00					
50-59	176	127 (72.2%)	1.44	(0.88-2.37)	.146			
60-69	181	121 (66.9%)	1.12	(0.69-1.82)	.636			
≥70	125	82 (65.6%)	1.06	(0.63-1.79)	.821			
BMI (kg/m^2)								
<22	172	114 (66.3%)	1.00					
22-25	198	130 (65.7%)	0.97	(0.63-1.50)	.900			
≥25	235	165 (70.2%)	1.20	(0.79-1.83)	.399			
Duration of diabetes (y)								
<5	123	52 (42.3%)	1.00			1.00		
≥5	482	357 (74.1%)	3.90	(2.58-5.89)	<.001	2.43	(1.54-3.82)	<.001
Period from the first visit to admission (y)								
<1	262	138 (52.7%)	1.00			1.00		
≥1	343	271 (79.0%)	3.38	(2.37-4.83)	<.001	1.60	(1.01-2.54)	.047
No. of admissions								
1	392	229 (58.4%)	1.00			1.00		
≥2	213	180 (84.5%)	3.88	(2.55-5.92)	<.001	2.28	(1.36-3.82)	.002
Hospitalization period (d)								
7	193	134 (69.4%)	1.00					
≥8	412	275 (66.7%)	0.88	(0.61-1.28)	.511			
Discontinuation of regular attendance								
−	471	316 (67.1%)	1.00					
+	134	93 (69.4%)	1.11	(0.74-1.68)	.614			
Treatment of diabetes at discharge								
Diet alone	53	22 (41.5%)	1.00					
Oral hypoglycemic agents	235	160 (68.1%)	3.01	(1.63-5.54)	<.001			
Insulin ± oral agents	317	227 (71.6%)	3.55	(1.95-6.47)	<.001			
Baseline HbA_{1C} (per 1.0% increase)	605		0.93	(0.83-1.04)	.215			
Addition of new medications after discharge								
−	277	194 (70.0%)	1.00					
+	328	215 (65.5%)	0.81	(0.58-1.15)	.240			

diabetes (odds ratio, 2.43; 95% CI, 1.54-3.82; $P < .001$), period from the first visit to admission (odds ratio, 1.60; 95% CI, 1.01-2.54; $P = .047$), and number of admissions (odds ratio, 2.28; 95% CI, 1.36-3.82; $P = .002$).

In the secondary analysis, the factors associated with a poor response (ΔHbA_{1C} <1.5%) were as follows: Univariate analysis showed that age, BMI, hospitalization period, and history of discontinuation of regular attendance before admission did not influence the response. However, the duration of diabetes (odds ratio, 4.88; 95% CI, 3.00-7.95; $P < .001$), period from the first visit to admission (odds ratio, 3.73; 95% CI, 2.64-5.26; $P < .001$), number of admissions (odds ratio, 2.92; 95% CI, 2.07-4.13; $P < .001$), treatment of diabetes at discharge (oral hypoglycemic agents: odds ratio, 2.75; 95% CI, 1.40-5.42; $P = .003$; insulin: odds ratio, 2.91; 95% CI, 1.50-5.64; $P = .002$), baseline HbA_{1C} level (odds ratio, 0.43; 95% CI, 0.36-0.51; $P < .001$), and addition of new medications after discharge (odds ratio, 0.51; 95% CI, 0.37-0.71; $P < .001$) were associated with the response. In a stepwise multivariate regression analysis, variables that were significant predictors of the response were the duration of diabetes (odds ratio, 2.17; 95% CI, 1.19-3.93; $P = .011$), period from the first visit to admission (odds ratio, 2.17; 95% CI, 1.43-3.29; $P < .001$), treatment of diabetes at discharge (oral hypoglycemic agents: odds ratio, 2.52; 95% CI, 1.15-5.51; $P = .021$; insulin: odds ratio, 4.44; 95% CI, 1.96-10.07; $P < .001$), baseline HbA_{1C} (odds ratio, 0.44; 95% CI, 0.37-0.53; $P < .001$), and addition of new medications after discharge (odds ratio, 0.41; 95% CI, 0.27-0.62; $P < .001$).

Among the variables, moderate correlations were noted between the duration of diabetes and period from the first visit to admission ($r = 0.652$, $P < .001$), the duration of diabetes and number of admissions ($r = 0.433$, $P < .001$), and period from the first visit to admission and number of admissions ($r = 0.433$, $P < .001$).

Patients who had diabetes for less than 5 years had higher HbA_{1C} levels at admission, but had the lowest HbA_{1C} levels after 6 months of follow-up (Fig. 2A). Likewise, patients who were admitted within 1 year from first attending our hospital and patients admitted for the first time had higher initial HbA_{1C} levels but achieved better control at 6 months (Fig. 2B, C).

4. Discussion

Achieving the ideal blood glucose level is very difficult for many patients with diabetes. In the United Kingdom Prospective Diabetes Study, only 50% of patients achieved the target HbA_{1C} level of 7.0%, even with intensive treatment [12]. In the present study, one third of our patients with type 2 diabetes mellitus had an HbA_{1C} less than 7.0%.

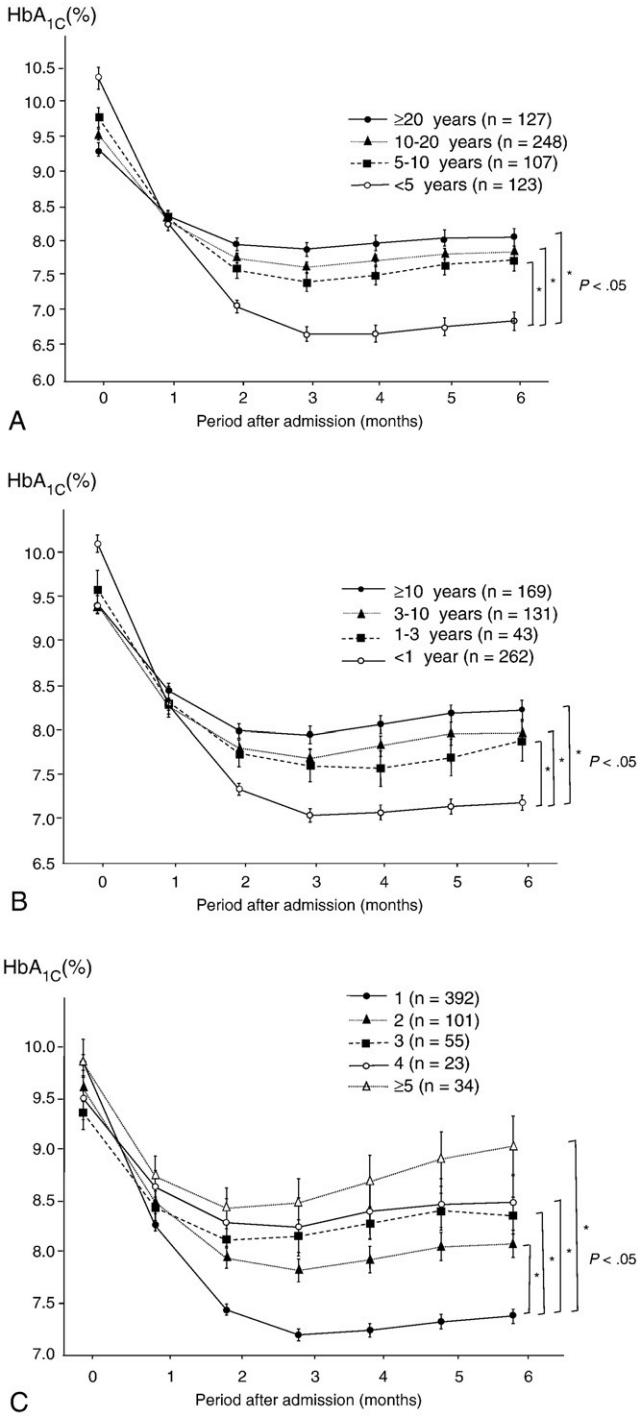

Fig. 2. The HbA_{1C} profiles (mean ± SE) stratified according to 3 factors. A,. Duration of diabetes. B, Period from the first visit to admission. C, Number of admissions.

There have been few studies about the factors related to poor glycemic control in patients with type 2 diabetes mellitus. We attempted to identify factors that associated with HbA_{1C} levels in patients with diabetes after an inpatient program. As a result, the duration of diabetes, period from the first visit to admission, and number of admissions were identified as predictors of poor glycemic control. These variables had moderate correlations with each other (Spearman coefficient, 0.43-0.60; $P < .001$).

Diabetes generally becomes worse over time, so a longer duration is associated with the natural progression of the disease. A low plasma C-peptide level is reported to be associated with poor glycemic control [6,9]. The onset of diabetes may be long before a diagnosis is made, and the precise disease duration is usually unknown. However, a longer history of diabetes appears to predict worse glycemic control, consistent with the findings of previous studies.

Patients who were admitted for the first time achieved better glycemic control compared with those admitted twice or more. First-timers may be more motivated to lower their HbA_{1C}. O'Connor et al [13] reported that a patient's willingness to change may have an important influence on the HbA_{1C}. A longer time from the first attendance of our hospital until admission could also be an indicator of poor motivation. Patients who were willing to participate in the program soon after they first attended our hospital might achieve lower HbA_{1C} levels because of stronger motivation.

Age and weight had no significant influence on glycemic control, which was consistent with the result of another study conducted in the primary care setting [6].

In our study, new medications were added for more than half of the patients during the 6-month follow-up period. Addition of new medications was not a significant factor in the main analysis, but it was significant in the secondary analysis. In patients who started additional medications, HbA_{1C} decreased from 9.9 ± 1.5 to 7.6 ± 1.4. In patients who did not add new medications, HbA_{1C} decreased from 9.5 ± 1.4 to 7.8 ± 1.6. There were a higher baseline HbA_{1C} level and a larger decrease of HbA_{1C} in the patients using additional medications.

Readers may wonder why these patients were admitted to hospital. Not only can we educate the patients; but we can also determine the blood glucose profile when optimum meals are provided, leading to the best method of treatment. Admission to improve glycemic control is common in Japan where specialist diabetologists manage the patients and the cost is largely covered by national health, but the situation is different in many other countries.

The strengths of this study are as follows: (1) There have been no other reports about the predictors of poor glycemic control after inpatient program. Patients in this study were not admitted for a hyperglycemic crisis such as

diabetic ketoacidosis or a hyperglycemic hyperosmolar state, but for a program to improve glycemic control. (2) This study was performed at a single institution, suggesting that treatment was similar for all patients and that variation of laboratory analyses was minimal. (3) Finally, the study population was relatively large.

The limitations of this study were as follows: (1) Our patients had more severe diabetes than those seen in general practice. Our Diabetes Center is involved in tertiary care of diabetes; therefore, many patients were referred from general clinics where they could not be managed. (2) The subjects were all Japanese, and the result may not be applicable to other ethnic groups. (3) This was a retrospective study. (4) Factors such as diet, exercise, and medication compliance [14-16] were not investigated.

In summary, we found that the factors related to poor glycemic control at 6 months after an inpatient program were a long duration of diabetes, a long period from the first attendance at our hospital until admission, and multiple admissions. Progression of diabetes over time and the patient's attitude to the disease may explain these findings.

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