THE EFFECT OF EARLY DIABETES SELF-MANAGEMENT EDUCATION ON GLYCEMIC CONTROL IN CHILDREN WITH TYPE 1 DIABETES

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Abstract. Although diabetes self-management education (DSME) is provided to most newly diagnosed diabetic patients, some patients continue to experience suboptimal glycemic control. We hypothesize the timing of initiation of DSME after diagnosis may impact outcomes. Therefore we aimed to determine if the timing does impact outcomes. We conducted a retrospective review of pediatric patients with diabetes mellitus who presented to the Pediatric Department at Siriraj Hospital, Bangkok, Thailand, beginning in January 2005. Our review was conducted from May 2015 to January 2016. All patients and their parents underwent a DSME program. Parents and caregivers were interviewed and medical records were reviewed. Subjects were grouped according to the length of time between the diagnosis of type 1 diabetes mellitus and the initiation of DSME: < 1 month (n=58), 1-6 months (n=30), and > 6 months (n=22). The average hemoglobin A1c (A1c) levels for each group at one and two years after DSME were calculated. One hundred ten patients (56.4% female) were included in the program. The mean age at initiation of DSME was 8.6 ± 3.4 years and the mean A1c level at initiation was 11.2 ± 2.7%, at 1 year A1c was 8.7 ± 1.4% and at 2 year was 9.1 ± 1.4%. The percentage of patients who had good glycemic control (A1c < 7.5%) who received DSME within one month of diagnosis was significantly (p=0.035) higher at 1 year (22.4%) than those who had DSME at 1-6 months (10%) and > 6 months (4.5%); however these were not significantly different by 2 years (p=0.64). Factors significantly associated with having a A1c < 7.5% among study subjects throughout the time they had diabetes were higher parental education (p=0.022), having more family members receiving DSME (p=0.025) and having a more intensive insulin regimen (p=0.014). Receiving DSME within one month of diagnosis was associated with better glycemic control at 1 year after DSME but not 2 years. This suggests maintenance of good glycemic control in this study population requires ongoing education and diabetes self-management support.

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Early and ongoing intensive diabetes education is recommended for this study population to improve glycemic control.

Keywords: diabetes self-management education (DSME), A1c, type 1 diabetes, timing

INTRODUCTION

The goals of diabetes management are to maintain good glycemic control and prevent or delay the onset of diabetic complications. In 1993, the Diabetes Control and Complications Trial (DCCT) demonstrated that intensive diabetes management can attain near-normal A1c levels and significantly reduces microvascular and macrovascular complications. New technological devices and the availability of various insulin analogues have improved type 1 diabetes (T1D) care. However, most T1D patients in the United States still have A1c levels higher than recommended targets (American Diabetes Association 11, 2016). The successful management of T1D patients remains a challenge. Diabetes self-management education (DSME) is essential to obtain improved diabetes care and glycemic control, increase quality of life (Norris *et al*, 2001; Haas *et al*, 2012) and reduce hospitalization rates (Svoren *et al*, 2003).

Siriraj Hospital, Mahidol University, Bangkok, Thailand is a tertiary referral center that receives patients with limited resources and have a history of poor glycemic control or diabetic complications. A multidisciplinary diabetes care team was established at Siriraj Hospital in 1996 and includes pediatric endocrinologists, a nurse educator, a dietitian, a social worker and a mental health professional. This team evaluates patients and their families and teaches basic diabetes management skills). DSME is a continuous process that evaluates the patient's self-care management to ensure they can care for themselves at home (Santiprabhob *et al*, 2012) and achieve good glycemic control (Healy *et al*, 2013).

Patients who participate in an intensive diabetes education program can have improved glycemic control, reduced length of hospitalization and readmission rates for diabetic ketoacidosis (DKA) (Likitmaskul *et al*, 2002). Initial assessment begins at diagnosis or soon after referral to our hospital and is continued in the outpatient setting during regular clinic visits.

Although DSME is given to most newly-diagnosed diabetic patients at our institution, some still have poor glycemic control, episodes of severe hypoglycemia and diabetic ketoacidosis (Santiprabhob *et al*, 2007; Beck *et al*, 2012). Silverstein *et al* (2005) reported starting DSME immediately after diagnosis may produce better outcomes. However, Streisand *et al* (2008) reported patient and parental anxiety and depression may reduce the effectiveness of DSME during the first month. However, Gardner *et al* (2012) reported late initiation of DSME might result in developing inappropriate habits, compromising glycemic control in the longer term.

Other factors that may affect glycemic control include ethnicity, socioeconomic status, frequency of self-monitoring blood glucose (SMBG) and total daily insulin dose (TDD) (Redondo *et al*, 2014).

The aim of this study was to determine if the length of time from diagnosis to provision of DSME has a measurable

impact on glycemic control during the first two years among children with T1D and identify factors affecting glycemic control in those patients.

MATERIALS AND METHODS

Study subjects

Study subjects were those aged 1-18 years who presented to the Pediatric Department, Siriraj Hospital, Mahidol University, Bangkok, Thailand since January 2005 and were diagnosed with T1D. The study was performed from May 2015 to January 2016. All subjects had to have received DSME at least 2 years prior to inclusion in the study. All subjects must have had A1c level obtained every 3-4 months to be included.

Study subjects were divided into 3 groups based on the length of time from diagnosis to initiation of DSME: Group one: < 1 month (n=58); Group two: 1-6 month (n=30); Group three: > 6 months (n=22).

Data collection

Data were retrospectively reviewed from the electronic and written medical records: age at diagnosis, gender, ethnicity, clinical presentation at diagnosis, date of diagnosis, onset and duration of DSME, frequency of SMBG at 6 and 12 months, continuing education in the first year, TDD and growth parameters (height, weight and BMI) at 1 year after DSME. Islet beta cell autoantibodies (anti-GAD and IA-2) were determined using the GAD-AB and IA2-AB radioimmunoassay kit (RSR®) (RSR, Cardiff, UK) and considered positive if the levels were ≥1.0 U/ml. The average A1c levels 1 year and 2 years after DSME were calculated and compared.

On enrollment in the study information was obtained by a questionnaire and through interviews with the patients and their families. The characteristics of patient's parents and family, primary caregiver, number of family members who received DSME, current frequency of SMBG and episodes of severe hypoglycemia and DKA in the previous year were recorded. A carbohydrate counting test and an inventory of questions about carbohydrate counting knowledge learned during DSME, were also completed. Patient age, duration of diabetes, healthcare provider and average HbA1c levels in the previous 12 months were collected. The average HbA1c levels were divided into three groups: < 7.5% (good control), 7.5-9.0% (fair control) and > 9.0% (poor control).

Statistical analysis

Mean ± standard deviation (SD) were calculated for normally distributed data and median (min, max) for non-normally distributed data. Categorical variables were assessed using the chi-square test. Comparisons between two groups for continuous variables of normally distributed data were made with the independent t-test and with the Mann-Whitney test for non-normally distributed data. Comparisons among three groups of continuous variables were made using the one-way ANOVA for normally distributed data and the Kruskall-Wallis test for non-normally distributed data. Multivariate analysis was conducted using adjusted data with more than one variable with a p-value less than 0.1. All data were analyzed using SPSS, version 20 (IBM, Armonk, NY). A p-value <0.05 was considered statistically significant.

Informed consent was obtained from subjects aged 18 years old and older and from parents or guardians among subjects aged < 18 years. This study received ethical approval from the Institutional

Table 1
Study subject characteristics.

	Total (*n*=110)	Male (*n*=48, 43.6%)	Female (*n*=62, 56.4%)
Age at diagnosis in years	8.0 ± 3.4	8.2 ± 3.7	7.9 ± 3.1
Severity at diagnosis			
Diabetic ketoacidosis	64 (58.2%)	31 (28.2%)	33 (30.0%)
Hyperglycemic ketosis	15 (13.6%)	4 (3.6%)	11 (10.0%)
Symptomatic DM	30 (27.3%)	13 (11.8%)	17 (15.5%)
Asymptomatic DM	1 (0.9%)	0 (0%)	1 (0.9%)
Hospital at diagnosis			
Siriraj Hospital	18 (16.4%)	5 (4.6%)	13 (11.8%)
Other hospitals	92 (83.6%)	43 (39.1%)	49 (44.5%)
Autoantibodies			
Anti-GAD	60/101 (59.4%)	25/101 (24.8%)	35/101 (34.6%)
IA-2	61/101 (60.4%)	31/101 (30.7%)	30/101 (29.7%)
Both positive	39/101 (38.6%)	18/101 (17.8%)	21/101 (20.8%)
Both negative	19/101 (18.8%)	5/101 (4.9%)	14/101 (13.9%)
Not examined	9 (8.2%)	5 (4.6%)	4 (3.6%)

DM, diabetes mellitus; Anti-GAD, auto antibodies of glutamic acid decarboxylase; IA-2, auto antibodies to islet tyrosine phosphatase 2.

Review Board, Siriraj Hospital, Mahidol University.

RESULTS

Participant characteristics

A total of 110 subjects (56.4% female) were included in the study. The mean age at the time of diagnosis was 8.0±3.4 years. Fifty-eight point two percent of subjects presented with DKA. Eighty-three point six percent of subjects were referred from other hospitals. Anti-GAD and IA-2 antibodies were measured in 101 subjects; 59.4% had anti-GAD antibodies and 60.4% had IA-2 antibodies (Table 1). Fifty-two point seven percent of subjects were initiated DSME program within a month of diagnosis. An intensive insulin regimen (basal and bolus insulin injections or continuous subcutaneous insulin injection) was started in 22.7% of study subjects, modified conventional therapy was prescribed in 62.7% and conventional therapy was used in 14.6% of study subjects. The median number of patient education visits during the first year was 3 (Table 2).

Comparison of mean hemoglobin A1c levels in first and second year after DSME

The overall average A1c level among study subjects was 11.2±2.7%; at the end of the first year it was 8.7±1.4% and at the end of the second year it was 9.1±1.4%.

At the end of the first year after DSME; 22.4% of subjects who received DSME < 1 month had average A1c < 7.5%, 10% who received DSME at 1-6 months had average A1c < 7.5% and 4.5% of subjects who received DSME at > 6 months had average A1c < 7.5%. There was no statistical significance for average A1c < 7.5% among these three groups at first and second years following DSME (Table 3).

Table 2
Selected study subject data after DSME (*n*=110).

	n (%)
Time from diagnosis to DSME	
< 1 month	58 (52.7)
1-6 months	30 (27.3)
> 6 months	22 (20.0)
Insulin regimen	
Conventional (2 shots/day)	16 (14.6)
Modified conventional (3 shots/day)	69 (62.7)
Intensive insulin therapy	25 (22.7)
Number of times received DSME in the first year after diagnosis	
Median (min, max)	3 (0-5)

DSME, diabetes self-management education; DM, diabetes mellitus; min, minimum, max, maximum.

Table 3
Hemoglobin A1c levels among study subjects by length of time from diagnosis of diabetes until initiation of diabetes self-management education.

	<1 month *n* (%)	1-6 months *n* (%)	>6 months *n* (%)	*p*-value
A1c at initiation of DSME (mean = 11.2 ± 2.7)				
A1c 1 year after DSME (mean = 8.7 ± 1.4)				
A1c <7.5% (*n*=17)	13/58 (22.4%)	3/30 (10.0%)	1/22 (4.5%)	0.096
A1c > 7.5% (*n*=93)	45/58 (77.6%)	27/30 (90.0%)	21/22 (95.5%)	
A1c 2 years after DSME (mean = 9.1 ± 1.4)				
A1c <7.5% (*n*=11)	7/58 (12.1%)	3/30 (10.0%)	1/22 (4.5%)	0.641
A1c >7.5% (*n*=99)	51/58 (87.9%)	27/30 (90.0%)	21/22 (95.5%)	

HgbA1c; Hemoglobin A1c; DSME, diabetes self management education.

Table 4
Comparison of factors that might affected mean A1c in 1st year after DSME.

A1c in 1st year	Total (*n*=110)	<7.5% (*n*=17)	>7.5% (*n*=93)	*p*-value
Mean (SD) age at initial DSME (years)	8.6 ± 3.4	10.40 ± 3.6	8.31 ± 3.3	0.018*
Number of days hospitalized for DSME (days)	10 ± 3	10 ± 3	10 ± 3	0.695
Mean (SD) number of SMBG at 6 months (times/day)	3.25 ± 0.87	3.49 ± 0.75	3.22 ± 0.88	0.236
Mean (SD) number of SMBG at 12 months (times/day)	3.04 ± 0.88	3.30 ± 0.83	2.99 ± 0.88	0.194
Insulin regimen				
Conventional	16 (14.5%)	1 (0.9%)	15 (13.6%)	0.030*
Modified conventional	69 (62.7%)	8 (7.3%)	61 (55.4%)	
Intensive insulin regimen	25 (22.7%)	8 (7.3%)	17 (15.4%)	

SMBG, self-monitoring blood glucose; *Statistically significant ($p < 0.05$).

Table 5
Association of selected factors with a hemoglobin A1c <7.5% 1 year after initiation of diabetes self management education.

	Adjusted OR	95% CI	*p*-value
Age in years, at onset of DSME	1.016	0.999 – 1.033	0.066
Insulin regimen			
Conventional	Reference		
Modified conventional	2.075	0.222 – 19.432	0.522
Intensive	5.763	0.535 – 62.028	0.149
Length of time between diagnosis and initiation of DSME			
<1 month	10.572	1.184 – 94.433	0.035
1-6 months	2.818	0.254 – 31.330	0.399
>6 months	Reference		

DSME, diabetes self management education; OR, odds ratio; CI, confidence interval.

Older age (p=0.018) and intensive insulin regimen (p=0.030) were significantly associated with better glycemic control (Table 4). Multivariate analysis showed good glycemic control at 1 year after DSME was significantly associated with having onset of DSME < 1 month after diagnosis but by 2 years this was no longer significant (Table 5). Adjusted odds ratio (OR): 10.572; 95% confidence interval (CI): 1.184-94.433; p=0.035.

Factors affecting glycemic control

Demographic data is shown in Table 6. Diabetes management data is shown in Table 7. The mean duration of disease among study subjects was 4.9±2.9 years, and the length of time since DSME was 4.3±2.6 years. Ninety-three point six percent of study subjects had a A1c > 7.5%. Factors significantly associated with having a A1c <7.5% among study subjects were more family member receiving DSME (p=0.025) and higher parental education (p=0.022).

At the time of the study, 58.2% of our subjects had frequency of SMBG < 3 times/day and also did not count carbohydrate, which are important for intensive insulin therapy (Table 7).

DISCUSSION

Our findings support early DSME (< 1 month) in children with newly-diagnosed T1D consistent with the recommendations of the American Diabetes Association (Silverstein *et al*, 2005). Although a previous study reported anxiety and depression was presented in newly-diagnosed T1D patients and their families within one month of diagnosis (Streisand *et al*, 2008), which could potentially affect the uptake of DSME, we found initiation of DSME within one month of diagnosis was associated with good glycemic control one year later. However, the effect did not last to 2 years after diagnosis.

In the first year after diagnosis, multiple factors have been reported to influence glycemic control, such as ethnicity (Mortensen *et al*, 2010), the insulin regimen (Beck *et al*, 2009; Salemyr *et al*, 2011), and the "honeymoon period" or partial remission phase of the diabetes. The "honeymoon period" is the period which

Table 6
Association between selected factors and hemoglobin A1c levels.

Variables	Hemoglobin A1c levels			*p*-value
	<7.5% (*n*=7)	7.5-9.0% (*n*=39)	>9.0% (*n*=64)	
Age in years at study date	13.5 ± 4.2	13.6 ± 3.0	12.5 ± 4.0	0.365
Duration of diabetes in years at study date	3.2 ± 0.9	4.9 ± 3.0	5.1 ± 2.9	0.264
Percent of family members who received DSME	68 ± 28	51 ± 20	53 ± 26	0.025
Parental education, *n* (%)				
Primary school or less	0 (0%)	5 (4.6%)	19 (17.3%)	0.022
Secondary school	1 (0.9%)	11 (10.0%)	26 (23.6%)	
Bachelors degree	5 (4.6%)	18 (16.3%)	15 (13.6%)	
Masters degree or higher	1 (0.9%)	5 (4.6%)	4 (3.6%)	
Family income in Baht per month, *n* (%)				
<10,000	2 (1.8%)	5 (4.6%)	17 (15.5%)	0.062
10,000-50,000	2 (1.8%)	27 (24.5%)	35 (31.8%)	
50,001-100,000	0 (0%)	4 (3.6%)	6 (5.5%)	
>100,000	3 (2.7%)	3 (2.7%)	6 (5.5%)	
Healthcare coverage				
Universal healthcare coverage	3 (2.7%)	24 (21.8%)	50 (45.5%)	0.150
Government official	2 (1.8%)	8 (7.3%)	11 (10.0%)	
State enterprise	0 (0%)	1 (0.9%)	1 (0.9%)	
Self pay	2 (1.8%)	6 (5.5%)	2 (1.8%)	

DSME, diabetes self -management education.

Table 7
Diabetic data regarding study subjects by hemoglobin A1c levels at the time of this study.

Variables	Hemoglobin A1c level			*p*-value
	<7.5% (*n*=7)	7.5-9.0% (*n*=39)	>9.0% (*n*=64)	
Management of hypoglycemia, *n* (%)of subjects	*n*=6	*n*=39	*n*=62	
Correct	5 (4.7%)	28 (26.2%)	51 (47.6%)	0.482
Incorrect	1 (0.9%)	11 (10.3%)	11 (10.3%)	
Management of hyperglycemia, *n* (%) of subjects	*n*=6	*n*=35	*n*=63	
Correct	5 (4.8%)	29 (27.9%)	53 (51.0%)	0.987
Incorrect	1 (0.9%)	6 (5.8%)	10 (9.6%)	
SMBG (times/day)	3.3 ± 0.9	3.1 ± 1.0	2.7 ± 1.1	0.160
Carbohydrate counting score (%)	55.4 ± 30.5	67.3 ± 17.6	59.6 ± 16.3	0.065
Severe hypoglycemia in the past year (times)				
Median (Min,Max)	0.00 (0.00-1.00)	0.00 (0.00-1.00)	0.00 (0.00-2.00)	0.748
DKA in the past year (times)				
Median (Min,Max)	0.00 (0.00-1.00)	0.00 (0.00-1.00)	0.00 (0.00-3.00)	0.284

SMBG, self-monitoring blood glucose; DKA, diabetic ketoacidosis.

insulin requirements may temporarily decrease following initiation of insulin treatment (Akirav *et al*, 2008). This may be due to a partial β-cell recovery that increases endogenous insulin secretion and improves peripheral insulin sensitivity (Akirav *et al*, 2008). Several clinical characteristics of the "honeymoon period" have been proposed, including a A1c of less than 8.0% with a total daily insulin dose of < 0.5 units/kg/day (Lombardo *et al*, 2002; Bowden *et al*, 2008; Couper and Donaghue, 2009). Mortensen *et al* (2009) propose a formula to define the "honeymoon phase" as the insulin dose-adjusted A1c (IDAA1c), which is calculated as: A1c + 4(total daily insulin dose in units/kg/day) = IDAA1c. The "honeymoon period" is defined as an IDAA1c ≤ 9.0 (Mortensen *et al*, 2009). To evaluate the effect of the "honeymoon period" on glycemic control, we compared the total daily dose of insulin and the duration of diabetes among these 3 glycemic control groups. No significant in the total daily dose of insulin was noted among our study subjects between those with good and poor glycemic control. Therefore, in our study the "honeymoon period" did not contribute to the better glycemic control we found at year one then at 2 years after diagnosis.

Early intensive treatment and good glycemic control help prevent or delay complications of diabetes, such as retinopathy, microalbuminuria and neuropathy (Nathan and Group, 2014). Multiple factors contribute to achieving and sustaining good glycemic. Continuing education in the outpatient setting following intensive DSME should be provided to all diabetic patients (Lange *et al*, 2014). Diabetes self-management support (DSMS) is a patient-centered ongoing process to support positive self-care behaviors, effective problem solving, constructive decision making and psychosocial support for the patients and their families (Chiang *et al*, 2014). A combination of early DSME and DSMS should be provided to all diabetic patients to achieve long-term good glycemic control.

Consistent with earlier studies, we found higher parental education level and more family members receiving DSME were correlated with good glycemic control (Mohammad *et al*, 2012; Nansel *et al*, 2015; American Diabetes Association 11, 2016; Rechenberg *et al*, 2016). Some studies reported an association between age and frequency of SMBG and between duration of diabetes and SMBG (Urbach *et al*, 2005; Mohammad *et al*, 2012; Redondo *et al*, 2014). After mean duration of receiving DSME at 4.32±2.60 years, nearly all of our patients (93.6%) had glycemic control >7.5% and had decreased their daily self-management activities in both carbohydrate counting and SMBG frequency.

The majority (80%) of our subjects came from families with low incomes and low parental education (56.3%); these factors often associated with poor glycemic control (Berhan *et al*, 2015; Rechenberg *et al*, 2016). These findings in our study may explain why most of our subjects had poor glycemic control. We did not study the cost of diabetes self-management activities, such as the cost of glucose strips and injection devices, which are not covered by healthcare coverage in Thailand. Thus it is important for national health policies to provide long-term economic support for T1D patients.

In conclusion, we found early initiation of DSME was associated with better glycemic control during the first year among study subjects, but not afterward. The insulin regimen and family factors were associated with good glycemic con-

trol. Newly-diagnosed patients should recieve DSME during the first month after diagnosis. More studies are needed to determine what methods are useful in preventing the deterioration in glycemic control seen among our subjects after one year.

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