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HOME BLOOD GLUCOSE MONITORING IN INSULIN-DEPENDENT DIABETIC CHILDREN*

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It has been shown that poor control is one of the major factors responsible for the microangiopathic complications of diabetes[1,2]. Considerable evidence has also shown that good blood glucose control can prevent or minimize these complications[3]. We should therefore attempt to achieve good control by determining the optimum dose of insulin for the individual patient. However, very often, this is determined by daily urine glucose testing coupled with periodic random outpatient blood glucose estimations. This method has been shown to give a poor reflection of blood glucose levels throughout the day and often can be misleading[4].

Home blood glucose monitoring (HBGM) has been used successfully in adult diabetics to achieve good control[5,6]. Young children with insulin-dependent diabetes mellitus (IDDM) have an even greater need for good control as their growth may be affected and they may develop microangiopathic complications by the time they reach adulthood. This is a report of the use of HBGM in young diabetic children. The purpose of our study was to assess the feasibility of HBGM in young children, and to use it to achieve optimum blood glucose control in these patients.

Material and Methods

All 12 children with IDDM in the University Department of Paediatrics, National University of Singapore, were included in the study which extended over 15 months. There were 11 males and 1 female. Their ages ranged from 4.9 to 17.2 years (mean 11.7 years). There were 8 Chinese, 3 Indians and 1 Malay. One patient was an 11-year-old deaf-mute, 2 were thyrodiabetics, and one was a 17-year-old with Down's syndrome. Only 5 children were in secondary school, 4 in primary school, 1 each in kindergarten, deaf school and a school for retarded children, respectively. All the parents had only primary or secondary education.

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The age of onset of diabetes ranged from 2.5 to 15.2 years (mean 7.1 years) and the duration of the disease ranged from 2.3 to 13.5 years (mean 5.9 years). Ten out of 12 had had previous episodes of diabetic ketoacidosis while the other 2 presented with polyuria and polydipsia at 5 and 10 years, respectively.

All patients were initially on once daily lente insulin, and monitoring control was by daily urine glucose testing and periodic outpatient blood glucose checks. Only 6 out of 12 patients administered their own injections.

HBGM was carried out using Dextrostix strips and the Ames Dextrometer which has been shown to be a reliable technique[7]. Finger-prick blood samples were obtained by means of the Autolet-Monolet System. Patients were individually instructed as outpatients on the use, calibration and maintenance of the Dextrometer. Only two patients, an 8-year-old boy and the 11-year-old deaf-mute, were admitted to the hospital for one week to ensure proficiency in self-monitoring. The three youngest patients, who were under 7 years of age, and the 17-year-old patient with Down's syndrome had their HBGM performed by their parents. The patients performed a blood glucose estimation before each meal and before bedtime. In addition, periodic checks were made 2 hours postprandial and at 2 a.m., and whenever hypoglycemia was experienced or suspected.

Initially, the patients performed blood glucose profiles for 5 days while on their previous insulin regimes. Eleven out of 12 patients needed to have adjustments made in their insulin regimes using HBGM. These were done every 5 to 7 days via telephone when the patient reported the blood glucose profiles for the week. With the aid of HBGM, the optimum insulin dose could thus be obtained.

Glycosylated hemoglobin (HbA_1) was also measured before and after HBGM, using the Helena Glycosylated Hemoglobin-SMC Column Method.

Results

The period of HBGM in the 11 patients who required adjustments in their insulin regimes ranged from 2 to 13 months, the total number of blood glucose estimations per patient ranging from 116 to 299. One patient who showed good control in her blood glucose profile with her existing insulin regime performed HBGM for a week only. The other 11 patients showed marked fluctuations in their 24-hour blood glucose levels while on their previous insulin regimes. Some patients had blood glucose levels always above 180 mg/dl, but a common picture was one of normal pre-breakfast or pre-lunch blood glucose but hyperglycemia in the evening and at night. No patient showed the Somogyi effect during the period of monitoring.

Figure 1 shows mean blood glucose levels (over 5 days) in the 11 patients who showed poor control on their previous insulin regimes and after adjustments made

to their insulin treatment using HBGM. There was a significant drop of mean blood glucose from 250 mg/dl to 150 mg/dl ($p < 0.001$). The percentage drop in mean blood glucose ranged from 31% to 54%. Some patients eventually achieved better control with a smaller dose of insulin than previously.

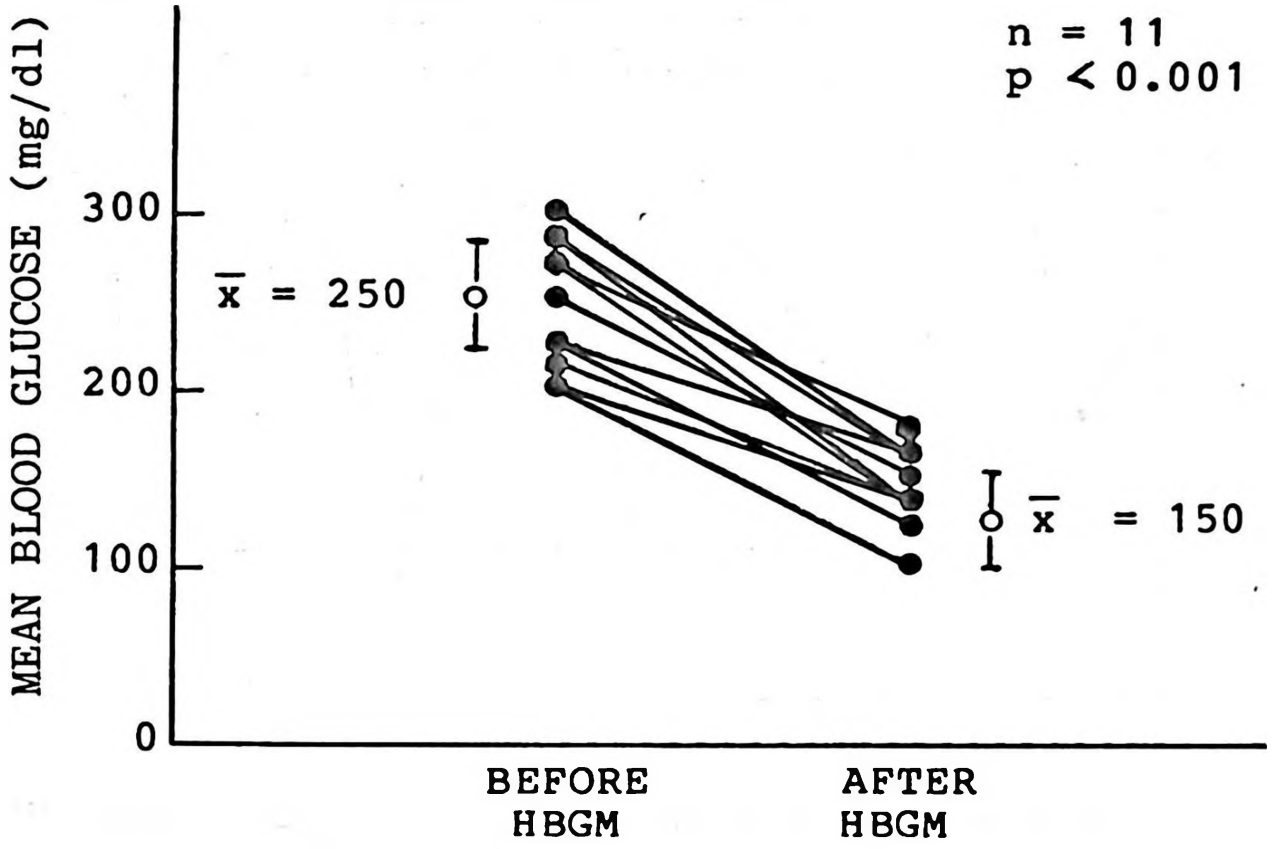

Figure 1

Mean blood glucose levels over 5 days in 11 patients, before and after home blood glucose monitoring.

Whereas many of the patients had been admitted to the hospital for diabetic ketoacidosis while on their insulin regimes before HBGM, none developed diabetic ketoacidosis after adjustments had been made to their insulin treatment using HBGM. Hypoglycemia had been experienced by 11 patients (6 asymptomatic and 5 symptomatic) while on their previous regimes and by only 4 patients during the period of insulin adjustment using HBGM.

Figure 2 shows the blood glucose profile with HBGM in a patient on a once daily combination of lente and soluble insulin over 5 days. It demonstrates wide fluctuations in blood glucose levels showing marked hyperglycemia in the evenings and at

night with the lowest values occurring in the pre-lunch estimations. This is the usual time of the day when diabetic outpatients are seen and have their periodic blood glucose checks and demonstrates how unreliable isolated blood glucose values can be.

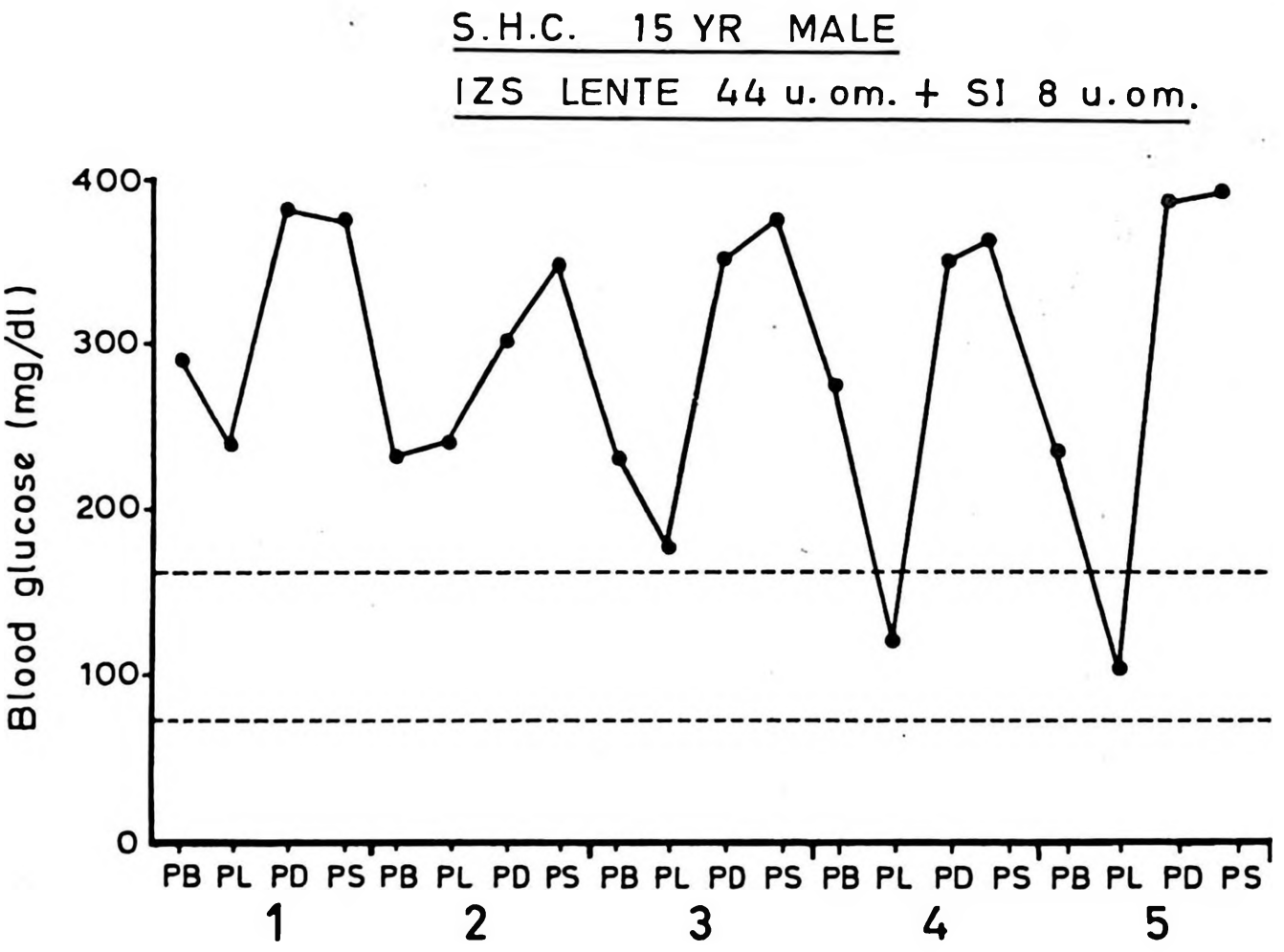

Figure 2

Blood glucose profile over 5 days on HBGM of a 15-year-old diabetic boy on his previous insulin regime, showing wide fluctuations and marked hyperglycemia (previously thought to be well - controlled from random blood glucose estimations).

(PB = Pre-breakfast, PL = Pre-lunch, PD = Pre-dinner, PS = Pre-sleep).

Figure 3 shows the same patient's blood glucose profile soon after some adjustments to his insulin regime. On a dose of semilente, 26 units in the morning, 12 units in the evening, the blood glucose levels are now lower than before but still not perfect. While the pre-breakfast blood glucose levels are normal, the pre-dinner levels are still high. In Figure 4, the morning dose of semilente has been increased by 4 units, and now the overall blood glucose profile with HBGM is more accept-

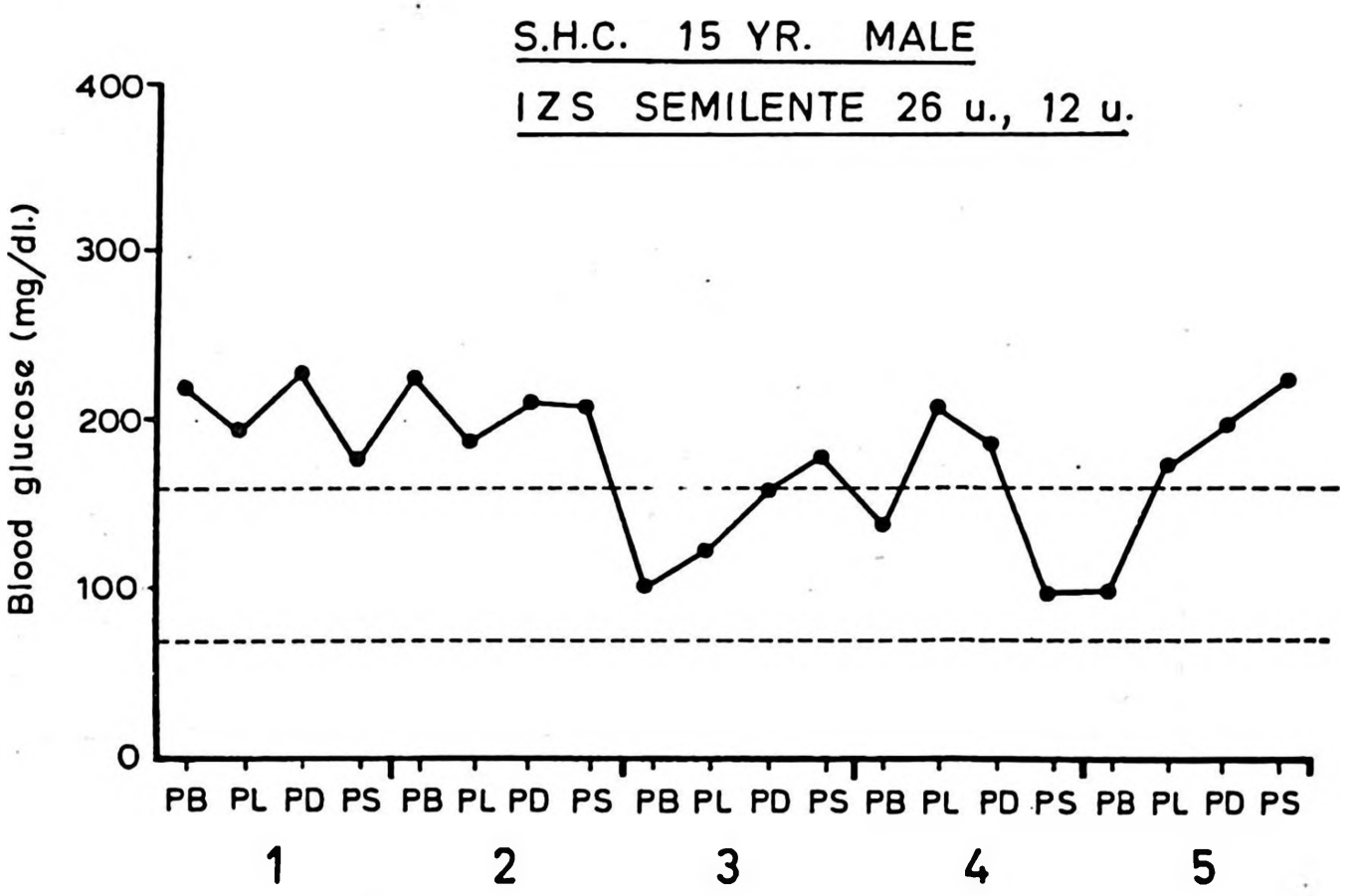

Figure 3

Blood glucose profile on HBGM of the same patient as in Figure 2 after initial adjustments to his insulin regime, showing satisfactory pre-breakfast values but hyperglycemia before dinner.

able. Figure 5, which shows the mean blood glucose levels over 5 days, illustrates the evening hyperglycemia on the patient's previous insulin regime, which disappeared after adjustments to his insulin regime were made with the aid of HBGM.

In Figure 6, the glycosylated Hemoglobin (HbA_1) levels of 10 patients before and after HBGM show a significant drop after insulin adjustments were made using HBGM. Of the remaining 2 patients, one did not perform HBGM for a sufficient period of time, and the other, a thyrodiabetic, developed relapse thyrotoxicosis after the period of HBGM.

Patient and Parent Reactions to HBGM

While all 12 patients performed HBGM, the three patients under 7 years of age and the 11-year-old deaf-mute were hesitant in starting. However, when they realized that finger pricking with the Autolet-Monolet system was not painful, they did not mind it. Only one patient, the 17-year-old with Down's syndrome, did not like

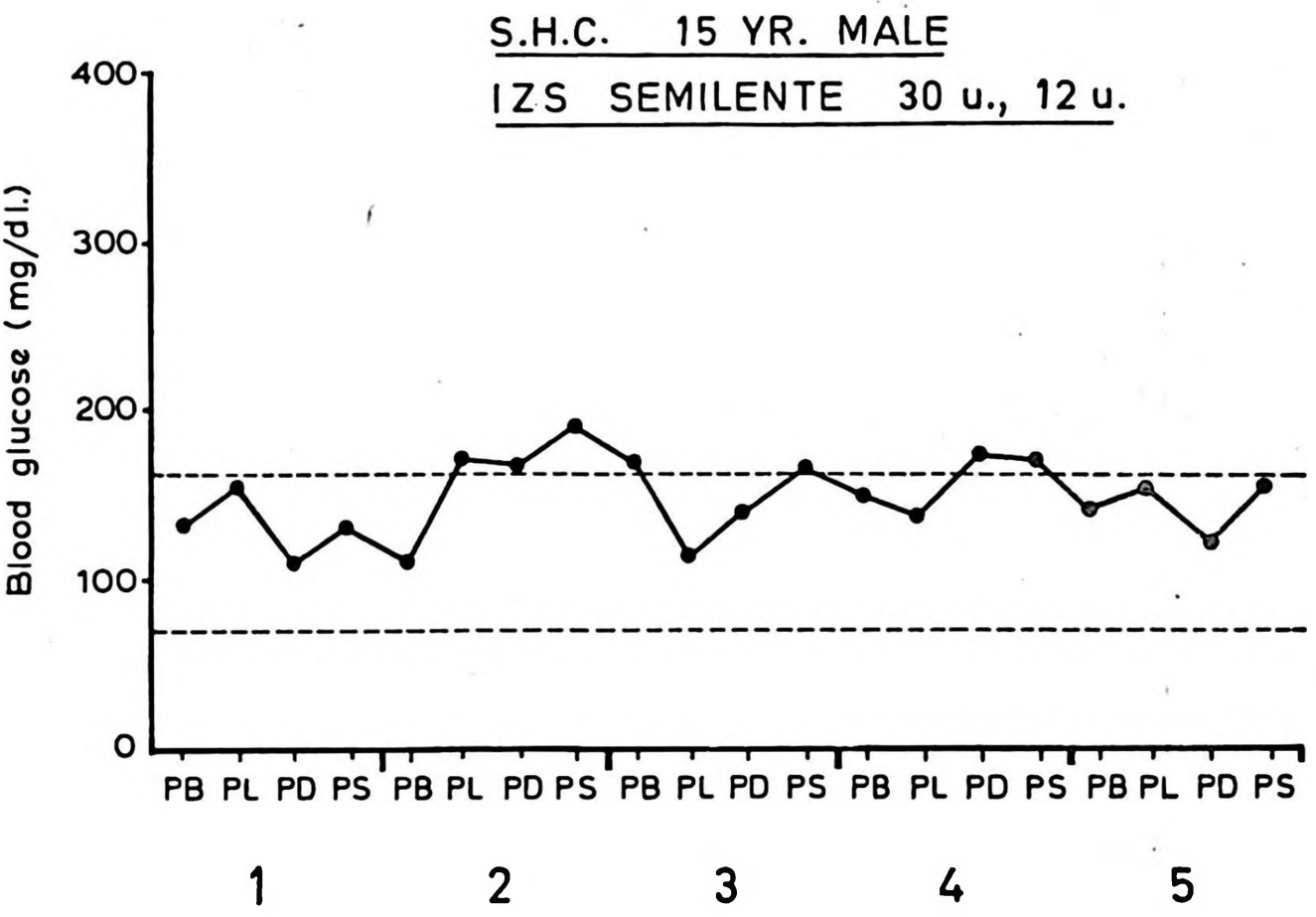

Figure 4

Blood glucose profile on HBGM of the same patient as in Figures 2 and 3 after final adjustments to his insulin regime, showing acceptable blood glucose values throughout the day.

HBGM and found it a nuisance, largely because he could not understand its importance.

Eleven patients complained of sore fingers. However, most of the patients and parents found HBGM to be of tremendous help. They had a better understanding of their illness and were motivated because they were actively participating in its control. Most also preferred HBGM to urine testing because they could now tell their exact blood glucose and whether they were hypoglycemic or not. Some even complained that urine testing was more troublesome and messy.

Outpatient consultations were significantly reduced in frequency as the patients were now more confident and were feeling better. Advice on adjustment of insulin dosage was given via the telephone.

Only two patients could afford to buy their own Dextrometers, but 8 of the other 10 patients were keen to purchase the Dextrometer and Dextrostix if they had not been so expensive.

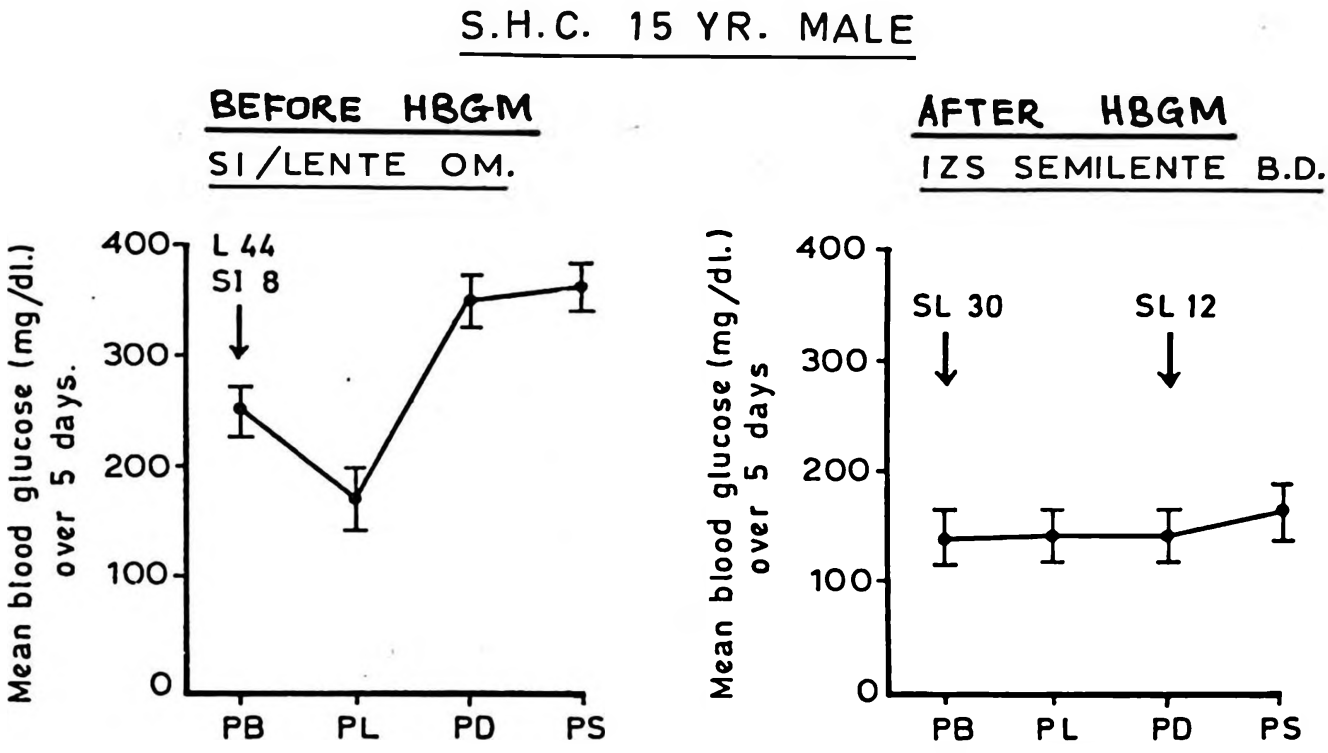

Figure 5

Mean blood glucose values over 5 days for the same patient as in Figures 2, 3 and 4, before and after home blood glucose monitoring.

Discussion

Our study demonstrates that HBGM is possible even in young children. However, more care and time have to be spent in explaining its importance to the patients and their parents. Educational status or medical handicaps did not affect the acceptance of HBGM as demonstrated by the patients with Down's syndrome and deaf-mutism. No problems were encountered by the patients in performing HBGM; the only complaint they had was that of sore fingers.

After HBGM, the patients now felt symptomatically improved and were more motivated because they knew how their insulin regimes were adjusted according to their blood glucose profiles. The 11 patients who needed a second daily injection after HBGM did not mind as they could now see for themselves that their previous insulin regime gave poor blood glucose control and lots of symptoms.

The main barrier to continuation of HBGM in these insulin-dependent diabetic children is the cost of the equipment. We have therefore shown that HBGM is feasible even in young children and it is useful in achieving optimum blood glucose levels in these patients. It is hoped, therefore, that it will be possible to delay the

onset or decrease the severity of the complications of diabetes due to microangiopathy.

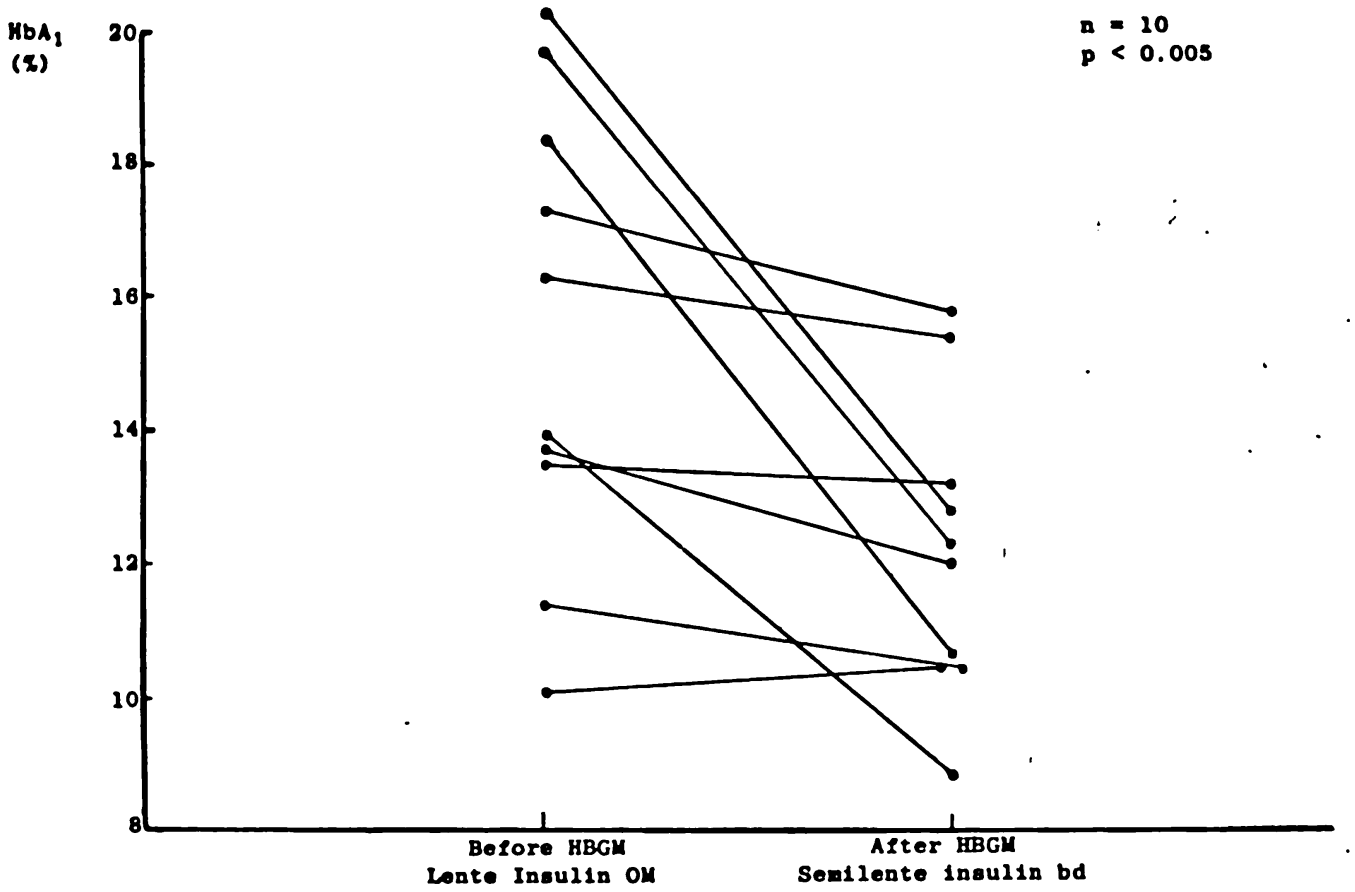

Figure 6

Glycosylated hemoglobin (HbA_1) levels of 10 patients before and after home blood glucose monitoring.

Summary

All 12 insulin-dependent diabetic children on regular follow-up in the Department of Paediatrics were taught HBGM. Their ages ranged from 4.9 to 17.2 years (mean 11.7 years). Blood glucose levels were determined before each meal and before bedtime using Ames Dextrostix and Dextrometers. They had previously been monitored by urine sugar testing and periodic blood glucose estimations and considered to be under satisfactory control with their initial insulin regimes.

HBGM showed wide fluctuations in 24-hour blood glucose levels in 11 patients on their initial insulin regimes. Using HBGM, their insulin regimes were adjusted to

achieve normoglycemia. The mean blood glucose before and after HBGM dropped from 250 mg/dl to 150 mg/dl ($p < 0.001$). Hospital admissions and outpatient visits were reduced following HBGM. Eleven patients found HBGM useful, felt symptomatically improved and complained only of sore fingers. There was a significant drop in HbA_1 values after HBGM.

Our study shows that HBGM is feasible and useful even in young children, who would benefit most from good diabetic control.

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