Effect of Internet Therapeutic Intervention on A1C Levels in Patients With Type 2 Diabetes Treated With Insulin

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OBJECTIVE — To assess the effect of an Internet-based glucose monitoring system (IBGMS) on A1C levels in patients with type 2 diabetes treated with insulin.

RESEARCH DESIGN AND METHODS — This trial involved 50 patients randomly assigned to receive either conventional treatment alone or with additional follow-up through an IBGMS for 6 months. Patients randomized to the intervention group uploaded blood glucose readings every 2 weeks to a secure Web site for review and receipt of feedback from their endocrinologist. A1C and laboratory test results were collected at 0, 3, and 6 months.

RESULTS — The baseline parameters were not significantly different. Over a 6-month follow-up, A1C dropped from 8.8 to 7.6% ($P < 0.001$) in the intervention group compared with 8.5 to 8.4% ($P = 0.51$) in the control group.

CONCLUSIONS — The use of IBGMS significantly improved A1C levels in patients with type 2 diabetes treated with insulin.

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In the management of diabetes, self-monitoring of blood glucose (SMBG) is performed as an adjunct to A1C measurements in order to assess and modify treatment (1–3); however, it often requires healthcare professionals to help interpret the results to refine treatment (4–6). The Internet provides a readily accessible platform for communication and remote health monitoring (7). In this study, we evaluated whether the use of an IBGMS would improve the outcome of treatment for patients with type 2 diabetes.

RESEARCH DESIGN AND METHODS

— We enrolled 50 type 2 diabetic patients being treated with insulin alone or in combination with oral antihyperglycemic medications. Inclusion criteria were a recent A1C >7.0%, Internet access, and prior training in SMBG. Patients were randomly assigned to either of the groups using a computer random number generator. All patients were provided with a meter and test strips for testing at least three times daily and were asked to perform a laboratory blood test and visit their endocrinologist every 3 months. Patients randomized to the control group were asked to keep a diary of SMBG for every visit to their endocrinologist. Patients randomized to the intervention group were asked to upload their SMBG readings every 2 weeks to a secure Web site (ALR Technologies, Atlanta, GA). These data were presented in table and graph formats according to the time of day, and automatic calculations were done to show the average, standard deviation, and range for specific time periods. The system allowed the patient to input medications, set alarms, view a summary of readings, and send a message to their endocrinologist who then viewed the readings and sent feedback. The endocrinologist's recommendations included changes in insulin dosage, suggestions on testing frequency, and giving compliments.

Baseline demographical data were collected from patient charts. A1C values were measured using the ADVIA Centaur Immunoassay System (Tarrytown, NY). Data were analyzed using a computerized database (Excel, Microsoft) and the SAS statistical software (SAS Institute, Cary, NC). Paired sample and independent Student *t* tests were used to compare the within- and between-group changes respectively. Primary outcome was the change in A1C levels. The significance of the difference between the A1C levels was evaluated by performing ANCOVA, which tested between-group changes from the start to the end of study while adjusting for baseline values. For all analysis, statistical significance was established at $P < 0.05$.

RESULTS

— Key demographic and baseline clinical characteristics are summarized in Table 1. Baseline demographic and clinical characteristics were similar. At the 3- and 6-month follow-up periods, the within-group change in laboratory measurements were significant only for A1C, total cholesterol, and triglycerides in the intervention group. A comparison of between-group changes was not significant for any of the measurements except A1C. Over the 3- and 6-month period, A1C levels in the IBGMS group dropped from 8.8 ± 1.3 to 8.2 ± 0.91% ($P < 0.05$) and further dropped to 7.6 ± 0.74% ($P < 0.001$), respectively. The control group, on the other hand, dropped from 8.5 ± 1.2 to 8.3 ± 1.1% ($P = 0.42$) after 3 months but rose to 8.4 ± 1.4% ($P = 0.51$) after 6 months. Furthermore, the difference between the two groups at 6 months postintervention was statistically significant even after adjusting for baseline A1C levels ($P < 0.05$).

CONCLUSIONS

— Patients with diabetes treated with insulin are often concerned about the risk of hypoglycemia

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Table 1—*Demographic and baseline clinical characteristics of the study population*

	Usual care*	Intervention*	*P*
n	23	24	
Age (years)	62 ± 7.2	57 ± 10	0.081
Male/female	15/8	14/10	
Duration of diabetes (years)	18.8 ± 6.4	18.8 ± 9.2	0.983
BMI (kg/m^2)	33.1 ± 6.0	33.7 ± 6.4	0.732
A1C (%)	8.5 ± 1.2	8.8 ± 1.3	0.425
Blood pressure (mmHg)	132.6 ± 14.4/71.3 ± 9.2	129.5 ± 20.1/74.2 ± 15.5	0.545/0.439
Total cholesterol (mmol/l)	4.3 ± 1.3	4.2 ± 1.0	0.789
HDL cholesterol (mmol/l)	1.0 ± 0.3	1.2 ± 0.4	0.171
LDL cholesterol (mmol/l)	2.2 ± 1.0	2.2 ± 0.8	0.947
Triglyceride (mmol/l)	2.2 ± 0.9	1.7 ± 0.7	0.058
Total-to-HDL cholesterol ratio	4.4 ± 1.3	3.7 ± 1.0	0.065
Creatinine (μmol/l)	98.2 ± 30.1	85.4 ± 39.0	0.225
Daily insulin dosage (IU)	57.9 ± 45.0	60.4 ± 36.0	0.829

Data are means ± SD. *Two patients in the usual-care group and one patient in the intervention group did not follow protocol and were excluded.

and/or hyperglycemia. A significant number of patients require communication with their physician regarding changes in insulin dosage to achieve stated glucose targets. We utilized and tested an IBGMS for communication between patients and their endocrinologists.

In our study, patients randomized to the intervention group had a significant A1C improvement after 3 months that was sustained over 6 months. Both study groups were provided the resources for testing their blood glucose levels. However, the intervention group was asked to upload their blood glucose levels and were reminded to test. In the intervention group, the ongoing communication allowed the endocrinologist to recommend changes in the insulin dosage and regimen and/or patterns of testing as needed to direct redistribution of the insulin regimen. Although not statistically significant, the intervention group had a higher increase in the average insulin dosages after 3 months (3.5 vs. 1.7 IU) and 6 months (5.7 vs. 5.0 IU) and more patients with changes in insulin regimen (3 vs. 0). Biweekly encounters allowed the endocrinologist to suggest small but more frequent changes in insulin dosage and to change insulin regimens when required. We believe the ongoing communication, patient motivation, and the ability to act upon the results from SMBG ultimately may have led to the significant improvement in the glucose levels.

Advantages of using an IBGMS include automatic uploading, thus removing the need for patients to keep a written diary. In addition, the uploaded data are analyzed and displayed in table and graph formats, giving an accurate sense of glucose trends and monitoring frequency. This can save time for the physician and increase the accuracy of data interpretation (8). Limitations of the system include patient's unwillingness or lack of desire to use the Internet and the absence of a payment model for reimbursing out-of-office consultations.

Previously published studies involving a remote blood glucose monitoring system have also shown improvements in the A1C levels of type 2 diabetic patients who used an IBGMS system compared with control subjects (9–11). However, these studies involved a system that included nurses, dietitians, or an electronic medical records system, whereas our study was limited to the patient's endocrinologist monitoring and making recommendations on an IBGMS. This was not a substitute for the patient-physician interaction in a clinical setting; however, it significantly improved the patients' A1C, and over time we observed good glycemic control and patient satisfaction. This method of follow-up can reduce the inconvenience of booking appointments solely for giving recommendations on changes in insulin dosage and may be a more cost-effective method of follow-up, especially for rural patients who have limited access to a diabetes specialist. In summary, the use of an IBGMS is an effective method of improving glucose control.

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H.T. designed the study, developed the protocol, collected and interpreted data, wrote the manuscript, and reviewed/edited the manuscript. A.M. contributed to protocol development, collected, analyzed, and interpreted data, wrote the manuscript, and reviewed/edited the manuscript. S.R. contributed to study design and protocol development, interpreted data, and reviewed/edited the manuscript. All authors read and approved the final manuscript.

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