ORIGINAL ARTICLE

Self-Monitoring of Blood Glucose—An Overview

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Introduction

GLOBALLY, DIABETES PREVALENCE continues to increase, and now the International Diabetes Federation estimates that by the year 2030 there will be more than half a billion people affected by the disease. Better diabetes management that improves glucose control must include new technology implementations in day-to-day care, e.g., self-monitoring of blood glucose (SMBG), continuous glucose monitoring (CGM), and other devices such as those discussed throughout this yearbook. Recent data indicates a downward trend in all diabetes complications, especially in patients with type 1 diabetes.

According to international standards, all glucose meters on the market for patient use must adhere to the following guidelines: $\geq 95\%$ of blood glucose (BG) results should fall within ± 15 mg/dL of the reference method at BG concentrations < 75 mg/dL, and within $\pm 20\%$ at BG concentrations ≥ 75 mg/dL. However, a 2010 study found that 11 out of 27 meters did not meet these requirements (PMID 20151773). In March 2010, the U.S. Food and Drug Administration/Center for Devices and Radiological Health (FDA/CDRH) held a public meeting to discuss the accuracy of available BG meters. In the future, we might see tighter standards for accuracy of all meters. To provide one example of how real-world factors can affect meter accuracy, a study comparing BG measurements from first-drop blood samples obtained under various states of hand cleanliness found that 11% of participants had a $\geq 10\%$ difference in BG concentrations, depending on whether their hands were washed or unwashed. In washed versus fruit-exposed hands, the $\geq 10\%$ difference occurred in 88% of participants (PMID 21289231). These researchers recommended that if hand washing is not possible, and the patient's hands are not visibly soiled or in recent contact with sugar-containing foods, the patient should wipe away the first drop of blood and use a second drop for the test in order to improve accuracy.

In spite of the potential for inaccurate glucose measurements, SMBG testing is clearly associated with improved A1C levels in patients with type 1 diabetes (T1DM) and insulin-treated type 2 diabetes (T2DM) (PMID 20377657; 20307405).

Patients who do not require insulin may also benefit from SMBG; however, the debate in this area continues. This in part is due to the rising cost, and payers want to reduce their cost and thus the reimbursements. We reviewed more than 380 monitoring systems (MS) and found the following, representing the current debate specifically around new cost, telemedicine, and use of mobile technologies.

Cost of self-monitoring of blood glucose in Canada among patients on insulin regimen for diabetes

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Diabetes Ther 2012; 3: 7

Introduction

People with diabetes are at increased risk for a variety of medical conditions compared to individuals without diabetes, resulting in increased healthcare costs. Self-monitoring of blood glucose (SMBG) is recommended for effective diabetes self-management. However, little is known about the real-world frequency and actual expenditures associated with SMBG or about the impact of SMBG costs relative to the cost of diabetes treatments. The primary aim of this study is to determine the real-world utilization and costs of SMBG tests in Canada among individuals with insulin-treated diabetes during a 12-month follow-up period.

Methods

This retrospective cohort study utilized the IMS Brogan Inc. Drug Plan database from July 1, 2006, through June 30, 2010. During the 12-month follow-up period, the total cost assessment included blood glucose (BG) test strips, insulin therapy, and costs associated with oral antidiabetic medications. The analytical sample included patients who had two or more prescriptions for insulin between January 1, 2007, and December 31, 2009, with the first prescription serving as a

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patient's index date. Each patient was categorized into one of four insulin regimen groups depending on the type of insulin used, whether basal, bolus, premix, or basal-bolus.

Results

The sample population of patients with two or more claims for insulin between January 1, 2007, and December 31, 2009, totaled 142,551. The overall mean utilization of pharmacy-based blood glucose testing materials was approximately 1,094 strips per person per year, with an average cost per test strip of Canadian \$0.79. Therefore, the SMBG treatment costs for insulin users (\$860), specifically those associated with prescription blood glucose test strips, totaled 41.6% of the average annual pharmacy costs of diabetes-related prescriptions (\$2,068).

Conclusion

This study shows that SMBG accounts for slightly more than 40% of the total diabetes-related pharmacy costs for insulin users.

Cost of self-monitoring of blood glucose in the United States among patients on an insulin regimen for diabetes

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J Manag Care Pharm 2012; 18: 21–32

Background

People with diabetes are at an increased risk of developing numerous complications, resulting in increased healthcare expenditures, economic burden, and higher mortality. Self-monitoring of blood glucose (SMBG) is a core component of effective diabetes self-management for patients using an insulin pump or multiple insulin injections. There is little data available to assess the real-world frequency and true costs associated with SMBG as a percentage of the total costs of an insulin regimen for patients in the United States.

Objective

The purpose of this study was to evaluate SMBG frequency, SMBG-related costs (including blood glucose test strips and testing supplies), and insulin therapy costs for patients with diabetes who use insulin and had at least one pharmacy claim for blood glucose test strips during a 12-month follow-up period.

Methods

Retrospective data capture was conducted using the IMS LifeLink Health Plan Claims database. Data analysis focused on the frequency and costs associated with SMBG in relation to a specific insulin regimen, and SMBG expenditure was compared with other treatment costs. The patient cohort studied had two or more claims for insulin between January 1, 2007, and June 30, 2009, with the first claim determining the index date for that patient. Insulin-related costs were evaluated for the same 12-month follow-up period.

Results

Of the initial sample of 373,946 patients with at least two claims for insulin between January 1, 2007, and June 30, 2009, a final cohort of 45,555 patients (12.2%) met the inclusion and exclusion criteria. SMBG-related pharmacy costs accounted for 27% of the total insulin- and SMBG-related treatment costs for insulin users. The average cost per patient for prescription test strips and supplies was \$772 compared to \$2,078 for insulin prescriptions and supplies. The overall mean utilization of pharmacy-based SMBG test strips was 764.3 strips per year, and the average cost per test strip was \$0.98. When utilization costs were subcategorized by insulin type, the annual SMBG costs for total insulin and SMBG-related pharmacy costs were 24.5% for the basal insulin group, 35.8% for bolus, 21.0% for premixed, and 26.4% for basal-bolus.

Conclusion

For insulin users with at least one pharmacy claim for glucose test strips, SMBG-related costs accounted for about 25% of total insulin and SMBG-related pharmacy costs.

Comment

These two studies highlight the significant cost related to SMBG (of the average annual pharmacy costs of diabetes-related pharmacy costs) in Canada and the United States, even in insulin-treated patients. Could there be generic strips that could significantly reduce the ever-increasing cost? With the increasing costs of insulin and all related supplies, assessing the actual costs of SMBG testing as a proportion of all pharmacy costs is a new and possibly important new metric to follow over time.

The role of blood glucose monitoring in non-insulin-treated type 2 diabetes: What is the evidence?

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Prim Care Diabetes 2012; 6: 179–85

Self-monitoring of blood glucose (SMBG) has increasingly been recognized as a core component of effective diabetes self-management among patients with insulin-treated type 2 diabetes (T2DM) over the past few decades. The worldwide prevalence of T2DM continues to increase rapidly, and management of T2DM can be costly. It is critical to determine whether resources devoted to SMBG in patients with non-insulin-treated T2DM are also justified and being used effectively. We review the conflicting evidence on the use of SMBG in patients with insulin-naïve T2DM.

Glycemic control in Iranian children with type 1 diabetes mellitus: effect of gender

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Indian J Pediatr. 2012 Jul;79(7):896–900. doi: 10.1007/s12098-011-0613-8. Epub 2011 Dec 3.

Objectives

The purpose of this study was to assess the effect of gender on glycemic control, diabetic complications, and associated abnormalities in patients with type 1 diabetes mellitus (T1DM).

Methods

This cross-sectional study included patients with T1DM that were referred to an endocrinology clinic in a children's hospital in Tehran from March 2005 through March 2007. Each patient completed a questionnaire, and the effect of gender on glycemic control was evaluated.

Results

The data indicated that male patients performed self-monitoring of blood glucose significantly more often than female patients. The mean HbA1c, used as an indicator of glycemic control, as well as other relevant measures, including insulin dose per kg of body weight, frequency of diabetic ketoacidosis (DKA), height problems, and dyslipidemia were significantly higher in female patients.

Conclusions

This evidence of worse glycemic control and higher incidence of DKA, dyslipidemia, and height problems in female patients suggests the need for a greater emphasis on glycemic control in female patients with T1DM, according to local clinical management guidelines.

Comment

This report is disturbing to note that, in the 21st century, we are still talking about gender differences in the care of diabetes. The authors noted higher incidence of DKA, hyperlipidemia, and height problems related to poor glycemic control in women.

Performance of a new blood glucose monitoring system in the hands of intended users

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Diabetes Technol Ther 2012; **14**: 783–89

Background

This study evaluated the performance of a blood glucose monitoring system (BGMS) in development that uses a new generation of blood glucose test strips to measure blood glucose levels in capillary and venous blood. The new BGMS was assessed in the hands of its intended users, people with diabetes, and healthcare professionals (HCPs).

Subject and Methods

The study population included 93 subjects ≥ 18 years old (median age 33 years) with either type 1 (78%) or type 2 (22%) diabetes. Untrained subjects performed self-test fingersticks using a Microlet®2 lancing device (Bayer HealthCare LLC,

Diabetes Care, Tarrytown, NY) followed by testing of their own capillary blood on the BGMS. HCPs performed fingersticks using a Tenderlett® lancing device (International Technidyne Corp., Edison, NJ) and venipunctures on subjects, and used the BGMS to test both the capillary and venous samples. All BGMS results were compared with laboratory results obtained on a Yellow Springs Instruments analyzer (YSI Life Sciences, Inc., Yellow Springs, OH). Analytical accuracy was assessed according to International Organization for Standardization (ISO) 15197:2003 guidelines (i.e., within ± 15 mg/dL or $\pm 20\%$ of the YSI results for samples with glucose concentrations < 75 mg/dL and ≥ 75 mg/dL, respectively) and more stringent criteria (i.e., within ± 15 mg/dL or $\pm 15\%$ of the YSI results for samples with glucose concentrations < 100 mg/dL and ≥ 100 mg/dL, respectively).

Results

Overall, 98.9% (180/182) of the self-test fingerstick capillary blood results using the Microlet2 capillary fingerstick results, 99.5% (182/183) of the HCP Tenderlett capillary fingerstick results, and 100% (186/186) of the venous results met current ISO criteria and more stringent criteria. The average hematocrit was 44%; values ranged from 32% to 52%.

Conclusions

Blood glucose measurements from both capillary fingerstick and venous samples obtained using a new BGMS in development met current accuracy guidelines as well as proposed tighter criteria.

The impact of self-monitoring of blood glucose on a behavioral weight loss intervention for patients with type 2 diabetes

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Diabetes Educ 2012; Jun 26. [Epub ahead of print]

Purpose

This study was intended to evaluate the association between self-monitoring of blood glucose (SMBG) and weight loss and A1C among participants in a behavioral weight loss intervention.

Methods

The relationship between SMBG and changes in patient weight and A1C levels was evaluated using multivariate

analysis. Bootstrapping was used to determine whether there was an indirect effect of SMBG on weight loss through diet adherence and an indirect effect of SMBG on A1C through weight loss.

Results

The relationship between increased SMBG and greater weight loss was mediated by better adherence to diet. Similarly, the relationship between increased SMBG and greater reductions in the A1C were mediated by greater weight loss.

Conclusions

The results of this study support the hypothesis that SMBG improves adherence to dietary recommendations. For patients who are taught to use diet as a weight loss tool, increased adherence to dietary recommendations is associated with increased weight loss and, subsequently, better glucose control. For patients with type 2 diabetes, SMBG may represent a valuable adjunctive intervention to existing behavioral programs.

Cost-effective use of telemedicine and self-monitoring of blood glucose via Diabetes Tele Management System (DTMS) to achieve target glycosylated hemoglobin values without serious symptomatic hypoglycemia in 1,000 subjects with type 2 diabetes mellitus—a retrospective study

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Diabetes Technol Ther 2012; **14**: 772–76

Objective

This study assessed the effectiveness, safety, and costs of the Diabetes Tele Management System (DTMS) in use at the Jothydev's Diabetes and Research Center (Kerala, India) for the care and follow-up of patients with type 2 diabetes (T2D) in South India.

Research Design and Methods

This retrospective cohort study relied on electronic health records from the Jothydev's Diabetes and Research Center. The patients included in the study had T2D and were 30–75 years old and eligible for a glycosylated hemoglobin (HbA1c) target <6.5%. They had enrolled in DTMS-based management and actively participated in various components of DTMS, such as regular reporting of self-monitoring of blood glucose (SMBG) values and dose adjustments via telemedicine. The HbA1c, lipid profile, and other parameters were measured at the first visit and on subsequent physical visits at months three and six and were used to estimate the incidence of hypoglycemia.

Results

We analyzed records of 1,000 subjects with 6-month follow-up data (mean age, 53.2 ± 9.8 years; 64% male). Patients had an average of 17 ± 2 telemedicine follow-ups and reported 66,745 SMBG values over 6 months. The mean ± SD HbA1c value

was 8.5 ± 1.4% at the initial visit and decreased to 6.3 ± 0.6% at 6 months ($P < 0.0001$). The rate of SMBG values <70 mg/dL was approximately 0.04/patient/month, with 84% of patients reporting no hypoglycemia. We calculated a recurring extra cost per patient for DTMS, not considering the cost of oral drugs and insulin to be U.S. \$9.66/month.

Conclusions

DTMS, comprising telemedicine follow-up and multidisciplinary care with SMBG-based monitoring, appears to be safe and cost-effective in the intensive treatment of patients with T2D who do not have serious co-morbidities. This system overcomes many of the limitations of traditional health care such as the need for frequent physical visits for drug dose adjustment, monitoring and modification of diet, and exercise advice.

Telecare provides comparable efficacy to conventional self-monitored blood glucose in patients with type 2 diabetes titrating one injection of insulin glulisine—the ELEONOR study

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Diabetes Technol Ther 2012; **14**: 175–82

Background

This study compared the effectiveness of telecare and conventional self-monitored blood glucose (SMBG) programs for titrating the addition of a one-bolus injection of insulin glulisine in patients with type 2 diabetes uncontrolled on oral hypoglycemic agents for at least 3 months who were first titrated with basal insulin glargine.

Methods

This randomized, multicenter, parallel-group study included 241 patients who had a mean screening glycosylated hemoglobin [HbA(1c)] of 8.8% (73 mmol/mol). In the run-in phase, all antidiabetes medications except for metformin were discontinued. Metformin was then titrated up to 2 g/day (1 g twice daily) and continued at that dose until study completion. Following run-in, all patients received glargine for 8–16 weeks to achieve a target fasting plasma glucose (FPG) of 5.6 mmol/L using conventional SMBG. Patients who had FPG levels of 7 mmol/L or higher added a glulisine dose at the meal with the highest postprandial plasma glucose excursion, titrated to result in a 2-h postprandial plasma glucose level <7.8 mmol/L using telecare or SMBG for 24 weeks. Patients with FPG >7 mmol/L at week 16 were excluded from the study.

Results

Following glargine titration, 224 patients achieved FPG 7 mmol/L, and there was no significant difference between telecare and SMBG groups (mean $\pm$ SD, 6.2 ± 0.8 vs. 6.0 ± 0.9 mmol/L, respectively). HbA(1c) levels were lower following titration and were similar for telecare and SMBG ($7.9 \pm 0.9\%$ vs. $7.8 \pm 0.9\%$ [63 vs. 62 mmol/mol], respectively). The addition of glulisine led to a further reduction in HbA(1c), a decrease of 0.7% in both groups; 45.2% and 54.8% ($P=0.14$), respectively, of patients achieved HbA(1c) of 7.0% (53 mmol/mol). Weight change and hypoglycemia were similar between groups.

Conclusions

When patients added one dose of glulisine at the meal with the highest postprandial plasma glucose excursion to titrated basal glargine, they achieved comparable improvements in glycemic control, as measured by HbA(1c), regardless of whether traditional or telecare monitoring of blood glucose was used.

Comments

These three studies highlight the need for better use of mobile technologies and telemedicine in improving health outcomes without additional financial burden. Frequent clinic visits are expensive, and in addition, due to the increasing prevalence of diabetes and lack of available endocrinologists/diabetologists and specialists, such modalities need to be properly reimbursed and encouraged.

ACP Journal Club. Meta-analysis: self-monitoring in non-insulin-treated type 2 diabetes improved HbA1c by 0.25%

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Ann Intern Med. 2012 Jun; 156: JC6–12

Objective

To determine whether self-monitoring of blood glucose can improve glycemic control in patients with type 2 diabetes who do not use insulin.

Scope

This review included studies that compared self-monitoring of blood glucose (SMBG) with no SMBG in patients with non-insulin-treated type 2 diabetes. It included 80 patients with 6 months of follow-up. The primary outcome was HbA1c level; secondary outcomes were blood pressure and serum cholesterol level.

Review Methods

The search for randomized controlled trials (RCTs) was carried out on MEDLINE and EMBASE/Excerpta Medica (April 2009 to June 2010); the reference list of systematic reviews included studies from January 2000 to April 2009; ref-

erence lists of other reviews; conference proceedings; and a current controlled trials register. Individual patient data were obtained from the authors of selected studies. Six RCTs ($n=2,552$, mean age 60 years, 54% men) met the required inclusion criteria. Three of those RCTs described the randomization, and all had allocation concealment and blinded outcome assessors. Loss to follow-up ranged from 2% to 31% (mean 15%). The analysis was based on intention-to-treat.

Results

A meta-analysis of individual patient data indicated that SMBG led to a decrease in HbA1c levels at 3, 6, and 12 months compared with no self-monitoring. The mean pooled reduction in HbA1c was 9.6 mmol/mol (0.88%) in the intervention group and 7.5 mmol/mol (0.69%) in the usual care group. There was no significant difference in blood pressure or total cholesterol measurements between the groups. The results were similar across patients with different levels of HbA1c at baseline ($P=0.3$), including those with HbA1c >64 mmol/mol ($>8\%$).

Conclusion

Self-monitoring of blood glucose in patients with non-insulin-treated type 2 diabetes is associated with a reduction in HbA1c by 0.25% at 6 months compared with no self-monitoring.

Self-monitoring of blood glucose in type 2 diabetes: cross-sectional analyses in 1993, 1999, and 2009

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Diabet Med 2012; 29: 792–5

Objective

This study assessed the number of test strips dispensed for self-monitoring of blood glucose (SMBG) to patients with type 2 diabetes in Tayside, Scotland, in 1993, 1999, and 2009.

Methods

The availability of a diabetes clinical information system in Tayside, Scotland, that was linked to electronic dispensed prescribing records made it possible to collate all dispensed prescribing records for three cross-sectional samples of patients with type 2 diabetes during three distinct year-long periods. The total patient sample was comprised of three groups: 1993 ($n=5,728$), 1999 ($n=8,109$), and January 2009 ($n=16,450$). The numbers of reagent strips dispensed during the relevant calendar year were calculated, and patients were stratified by treatment. We also explored the relationship between age, sex, material and social deprivation, and whether a patient received strips.

Results

The proportions of people who received self-monitoring reagent strips increased from 15.5% in 1993 to 24.2% in 1999 to

29.8% in 2009; the numbers of strips dispensed also increased from year to year. While the proportion of diet-treated patients who received reagent strips remained low in 2009 (5.6%), the proportion of those treated with oral agents who received reagent strips tripled from 9.4% to 27.4% between 1993 and 2009. Over 90% of patients treated with insulin received reagent strips and, among non-insulin-treated patients, this was more common among women, younger people, and less deprived groups.

Conclusions

The numbers of reagent strips dispensed for SMBG has increased since 1993, and by 2009, almost all insulin-treated patients received strips. While few diet-treated patients received strips, their use appears to be more extensive among those treated with oral agents. Given that self-monitoring of blood glucose is no longer routinely recommended in non-insulin-treated patients, strategies to reduce unnecessary dispensing of reagent strips are needed.

The role of self-monitoring of blood glucose in glucagon-like peptide-1-based treatment approaches: a European expert recommendation

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J Diabetes Sci Technol 2012; 6: 665–73

The role of glucagon-like peptide (GLP)-1 in the treatment of type 2 diabetes mellitus (T2DM) is increasing. Self-monitoring of blood glucose (SMBG) has been a component of numerous studies on GLP-1 analogs and dipeptidyl peptidase-4 inhibitors; however, the potential role of SMBG in GLP-1-based treatment approaches has not been clearly defined. The expert recommendation suggests the use of individualized SMBG strategies in GLP-1-based treatment approaches that incorporate simple and clinically applicable SMBG schemes. SMBG offers several potential benefits in GLP-1-based treatment approaches, including early assessment of treatment success or failure, timely modification of therapy, detection of hypoglycemic episodes, evaluation of glucose excursions, and support of diabetes management and diabetes education. The duration and frequency of SMBG should depend on the clinical setting and the degree of metabolic control. SMBG can play an important role in the optimization of diabetes management in T2DM patients treated with GLP-1-based approaches.

Self-monitoring of blood glucose in patients with diabetes who do not use insulin—are guidelines evidence-based?

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Diabet Med 2012 March. [Epub ahead of print]; DOI: 10.1111/j.1464-5491.2012.03659.x.

Objective

This study was intended to evaluate whether the clinical practice guidelines regarding self-monitoring of blood glucose (SMBG) in patients with diabetes who do not use insulin follow the principles of evidence-based medicine.

Methods

A search of the literature from 1999 to 2011 led to the discovery of 18 clinical practice guidelines that were included in this study. Recommendations regarding SMBG were graded on a scale from one (strongly against self-monitoring) to four (strongly in favor of self-monitoring) and were compared with similarly graded conclusions of systematic reviews cited within the clinical practice guidelines. We also determined how certain characteristics of the clinical practice guidelines, such as funding sources and quality of references cited, could be related to the guideline recommendations.

Results

This study included a total of 15 systematic reviews, 14 randomized controlled trials, 33 nonrandomized controlled trial papers, and 18 clinical practice guidelines or position statements. The clinical practice guideline recommendations had an average grade of 3.4 (range 2.0–4.0). Higher grades were associated with clinical practice guidelines that acknowledged industry funding (mean value, 4.0) or were issued by organizations that depended on private funding (mean value 3.6 vs. 3.0 for governmental funding). The conclusions of the 15 systematic reviews had a mean grade of 2.2 (range 1.0–3.8). Systematic reviews with low grades were less frequently cited. In total, 21 randomized controlled trials were included in the systematic reviews, and about half of these evaluated an educational intervention in which the effect of SMBG could not be clearly isolated.

Conclusions

Clinical practice guidelines from 1999 to 2011 reviewed in this study had a more favorable view of self-monitoring of blood glucose than did the systematic reviews that were cited. The citation practice was nonsystematic, and industry funding was associated with a more positive attitude toward use of SMBG.

Comments

The above four reports highlight the ongoing controversy of the role of SMBG in T2D. In some parts of Europe, non-insulin-treated patients are discouraged from SMBG. Unless we have a large randomized trial addressing this question, the debate will continue.

The effect of a structured behavioral intervention on poorly controlled diabetes: a randomized controlled trial

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Arch Intern Med 2011; **171**: 1990–9

Nat Rev Endocrinol. 2011 Dec; **7**: 691

Arch Intern Med. 2011 Dec; **171**: 1999–2000

Background

It is clear that maintaining nearly normal blood glucose levels in diabetes can delay the onset and slow the progression of diabetes complications; however, many patients with diabetes, and their physicians, struggle to achieve glycemic targets. The best methods to support patients as they follow diabetes medication and lifestyle regimens and recommendations remain unclear. The aim of this study was to evaluate the efficacy of a behavioral diabetes intervention to improve glycemia in patients with poorly controlled diabetes of long duration.

Methods

The study population included 222 adults with long-duration, poorly controlled diabetes (49% type 1) (mean [SD] age, 53 [12] years; mean [SD] disease duration, 18 [12] years; mean [SD] hemoglobin A(1c) [HbA(1c)] concentration, 9.0% [1.1%]). The subjects were randomized to three treatment groups in which they attended educational intervention sessions: (1) a five-session manual-based, educator-led, structured group intervention with cognitive behavioral strategies (structured behavioral arm); (2) an educator-led, attention control group education program (dietitian education sessions for 6 months (individual control). The outcomes measured at baseline and at 3-, 6-, and 12-months post intervention were HbA(1c) levels (primary), frequency of diabetes self-care, 3-day pedometer readings, 24-hour diet recalls, average number of glucose checks, physical fitness, depression, coping style, self-efficacy, and quality of life (secondary).

Results

Linear mixed modeling found that all groups showed improved HbA(1c) levels ($P < 0.001$). However, greater improvement in 3-month HbA(1c) concentration changes was achieved in the structured behavioral arm (−0.8%) than in the group (−0.4%) and individual (−0.4%) control arms ($P = 0.04$ for group $\times$ time interaction). Furthermore, participants with type 2 disease showed greater improvement than those with type 1 ($P = 0.04$ for type of diabetes $\times$ time interaction). Quality

of life, glucose monitoring, and frequency of diabetes self-care did not differ by intervention over time.

Conclusions

A structured, cognitive behavioral program was more effective at improving glycemia than either of two control interventions in adults with long-duration diabetes. Based on these findings, we suggest that educators can successfully use modified psychological and behavioral strategies.

Comment

This study emphasizes that SMBG cannot be observed in a silo; rather, it is simply one component of a larger multi-component program.

Glucose meters and opportunities for in-hospital transmission of infection: quantitative assessment and management with and without patient assignment

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Am J Infect Control. 2011 Nov; **39**: 752–6

Background

The increasing use of glucose meters in hospitals can create additional opportunities for infection transmission that have not been quantitatively assessed or managed.

Methods

The study design was a before-and-after assessment of the effects of augmentation of glucose meter inventory in a 214-bed hospital on the assignment glucose meters to individual patients and the sequential use of glucose meters on different patients.

Results

During October 2008, 11,665 measurements were performed using 38 glucose meters on 803 patients. A total of 9,302 tests (79.7%) were performed sequentially within 24 hours on different patients. From October 28 through November 27, 2009, the glucose meter inventory on three high-use units increased from 22 to 87 and meters were assigned to individual patients. During that same period, glucose meter inventory increased from 16 to 28 on four low-use units without assignment to individual patients. Sequential glucose meter use on different patients within 24 hours decreased by 95.1% on the high-use units and increased by 17% on the low-use units.

Conclusion

Use of a glucose meter in more than one person was associated with an increased risk of infection transmission. Those transmission opportunities were reduced only when glucose

meters were assigned to individual patients. Recent guidance from the Centers for Disease Control and Prevention and the U.S. Food and Drug Administration to assign glucose meters to individual persons whenever possible is relevant to inpatient care.

Comment

The actual numbers of infections resulting from glucose meters in the hospital are not known but are likely much higher than appreciated. This report attempts to define the denominator of the potential problem. It would be interesting to know if immunosuppressed patients are at a lower risk of infection due to more stringent procedures in place.

The effect of an instant hand sanitizer on blood glucose monitoring results

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Background

People with diabetes mellitus are instructed to remove any dirt or food residue from the site of self blood glucose testing that might affect the reading. Alcohol-based hand sanitizers are becoming increasingly popular when soap and water are not available. The purpose of this study was to determine whether a hand sanitizer used to clean the skin before self-monitoring of blood glucose is compatible with glucose meter testing and is effective for the removal of exogenous glucose.

Methods

The study included 34 nonfasting subjects (14 male and 20 female; mean ages 45 years (standard deviation 9.4); 2 with diagnosed diabetes and 32 without known diabetes). Laboratory personnel prepared four separate fingers on one hand of each subject, preparing each finger using a different method: (1) cleaning the second finger with soap and water and towel drying (control finger); (2) cleaning the third finger with an alcohol-based hand sanitizer; (3) coating the fourth finger with cola and allowing it to air dry; and (4) coating the fifth finger with cola and then cleaning it with instant hand sanitizer after the cola had dried. Fingersticks were performed on each prepared finger and blood glucose was measured. Several *in vitro* studies were also performed to evaluate the effectiveness of hand sanitizer in removing exogenous glucose.

Results

There was no significant difference in mean blood glucose values between the fingers cleaned with instant hand sanitizer and the control finger ($p=0.07$ and 0.08 , respectively); both yielded 100% accurate results. Blood glucose data derived from the fourth (cola-coated) finger were substantially higher on average compared with the levels measured from the other fingers, but glucose levels from the fifth finger (cola-coated then cleaned with hand sanitizer) were similar to those of the control finger. The data from *in vitro* experiments showed that hand sanitizer did not adversely affect the results obtained

with glucose meters, but when an exogenous glucose interference agent was present, the effectiveness of the hand sanitizer on glucose bias (range: 6% to 212%) depended on the surface area and degree of dilution.

Conclusions

The results of this study indicate that use of an instant hand sanitizer is compatible with accurate results on self-monitoring and glucose meter testing and does not affect fingerstick blood glucose results. Depending on the surface area, however, hand sanitizers may not be adequate for cleaning the skin prior to glucose meter testing.

Comment

One of the most obvious changes in the past 10 years is the universal use of hand sanitizer by both healthcare professionals and patients. This is an important study addressing the overall lack of impact of the sanitizer on blood glucose results, although it would have been appreciated if more than one product was used to confirm these results. Still, for clearly dirty hands, washing with soap and water should still be the universal recommendation.

Does blood glucose monitoring increase prior to clinic visits in children with type 1 diabetes?

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Objective

To determine how common white coat adherence is in families with children who have type 1 diabetes.

Research Design and Methods

Blood glucose data were downloaded from the glucose meters of 72 children with type 1 diabetes, ages 2–11 years, at four consecutive clinic visits. To investigate patterns of blood glucose monitoring (BGM) during the 28 days preceding each clinic visit, we used generalized estimating equations to analyze the data.

Results

Overall, more frequent BGM was associated with better glycemic control. We found that BGM frequency increased before a clinic visit—evidence of a white coat adherence effect—only among children with low A1C levels.

Conclusions

Highly motivated families who frequently monitor their child's blood glucose were found to perform BGM with increased frequency before the child's clinic visit. This additional monitoring may be beneficial by providing the

physician with a wealth of blood glucose information to guide treatment recommendations.

Comment

“White coat adherence” is a new term, and in this situation, seems to differentiate families more involved with the diabetes care. This study also once again points out that the more frequent the testing, the better the overall diabetes control.

Effect of ambient temperature on analytical performance of self-monitoring blood glucose systems

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Background

Environmental factors such as temperature can affect the quality of self-monitoring of blood glucose (SMBG). The aim of this study was to evaluate the effect of a shift in the ambient temperature immediately before SMBG and to compare measurements made in the lower and upper parts of the operating temperature range.

Methods

Nine different SMBG systems sold in Norway were tested with heparinized venous blood (4.8 and 19.0 mmol/L). To test the effect of a shift in ambient temperature, the glucometer and strips were equilibrated for 1 hour at 5°C or 1 h at 30°C before the meter and strips were moved to room temperature conditions. Measurements were then taken after 0, 5, 10, 15, and 30 minutes. To compare the lower and upper temperature ranges, measurements were performed after 1 h of equilibration of the glucometer and strips at 10 degree C and at 39 degree C. These experimental measurements were compared with measurements performed simultaneously on a meter and strips kept at room temperature the whole time.

Results

Six of nine SMBG systems overestimated and/or underestimated the results by more than 5% after the meters and strips were moved from 5°C or 30°C to room temperature immediately before the measurements were taken. Two systems underestimated the results at 10°C. One system overestimated and another underestimated the results by more than 5% at 39°C.

Conclusions

The effect on analytical performance of the SMBG meters and strips was most pronounced after a rapid shift in ambient

temperature conditions. Therefore, patients should wait at least 15 minutes for temperature equilibration of affected meters and strips before measuring their blood glucose.

Comment

This study reminds us that modern-day glucose meters have limitations with quick changes in temperature. This is relevant for many real-life situations that often occur.

Comparable efficacy of self-monitoring of quantitative urine glucose with self-monitoring of blood glucose on glycemic control in non-insulin-treated type 2 diabetes

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Objective

This study evaluated the comparative effectiveness, convenience, and safety of self-monitoring of quantitative urine glucose or blood glucose for glycemic control in non-insulin-treated type 2 diabetes.

Methods

The study population was comprised of adults with non-insulin-treated type 2 diabetes. They were randomized into three groups: Group A, self-monitoring with a quantitative urine glucose meter (n=38); Group B, self-monitoring with a blood glucose meter (n=35); Group C, the control group without self-monitoring (n=35). Follow-up for all patients lasted 6 months, during which each group received identical diabetes care.

Results

The data indicated a significant decrease in HbA1c within each group (p<0.05). At the conclusion of the study, the mean changes from baseline in HbA1c were –1.9% for Group A, –1.5% for Group B, and –1.0% for Group C. For Groups A, B, and C, the proportions of patients who achieved HbA1c, <6.5% were 38.9%, 35.3%, and 20.0% respectively. We found no significant differences between the groups. The average frequency of blood glucose monitoring was significantly higher in Group A than in Group B. The incidence of hypoglycemia and quality-of-life scores were similar between the groups.

Conclusions

The results of this study imply that self-monitoring of urine glucose can be as effective as self-monitoring of blood glucose in achieving glycemic control and facilitates better compliance than blood self-monitoring, without affecting quality of life or risk of hypoglycemia.

Comment

This small study will likely be repeated in larger randomized trials. No one questions the improved quantitative information from SMBG compared to urine glucose testing. The question is, for poorly controlled type 2 diabetes patients not receiving insulin, is there an advantage to the more expensive SMBG? This small study suggests “no,” and as time moves forward, we will all be required to provide more proof SMBG is superior for all populations with diabetes.

Conclusions

SMBG is now well into its fourth decade and many of the issues that have created controversy and concern have lingered. Factors impacting accuracy and precision, its role for patients not receiving insulin, and both relative and absolute

cost continue to be examined. While we can expect improved accuracy, many questions remain. For example, how effectively will this technology interact with smart phones? How will the use of more incretin therapy impact the use of SMBG? How will emerging markets such as China and India address the cost of this technology? And what will happen if more randomized studies show no difference between urine glucose testing and SMBG? It is difficult to believe we are even asking this last question in the year 2013, but new data cannot be ignored. We look forward to observing how this therapy evolves in the future.

Author Disclosure Statement

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