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ORIGINAL ARTICLE

Importance of Manually Entering Blood Glucose Readings When Wireless-Compatible Meters Are Not Being Used with an Insulin Pump

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Abstract

Background:

The objective was to determine if there were differences in blood glucose monitoring (BGM) data downloaded from insulin pumps of patients who use meters that wirelessly transmit data to their insulin pumps (i.e., wireless group) and those who do not (i.e., nonwireless group).

Methods:

Blood glucose monitoring data were downloaded from the meters and insulin pumps of 47 children and adolescents with type 1 diabetes mellitus. Independent and paired *t* tests compared BGM data downloaded from meters and BGM data downloaded from insulin pumps.

Results:

There were significant differences in BGM data downloaded from the insulin pumps of patients using wireless meters compared to those using nonwireless meters. Wireless patients appeared to engage in more BGM, had more low and in-range BG readings and fewer very high BG readingss than nonwireless patients. However, a comparison of BGM data downloaded from meters and insulin pumps of nonwireless patients indicated that their insulin pump data significantly underestimated the number of BGM readings conducted, as well as the number of low and in-range readings, while overestimating the number of very high BGM readings.

Conclusions:

Because patients who use nonwireless-compatible meters do not manually enter their low and in-range BGM readings into the insulin pump, BGM data downloaded only from pumps may provide an incomplete representation of BGM frequency or results. It is recommended that patients use meters that directly communicate with pumps or perform bolus calculations. Patients should be educated about the importance of manually entering all BGM readings if they do not use a wireless-compatible meter with their insulin pump.

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Abbreviations: (A1C) hemoglobin A1c, (BGM) blood glucose monitoring

Keywords: adherence, bolus calculator software, children and adolescents, insulin pumps, type 1 diabetes mellitus

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Introduction

The insulin pump is one tool used in intensive diabetes management that can lead to near-normal glycemic control.[1] Advantages of insulin pump use include ease and accuracy of insulin delivery, decreased blood glucose excursions and hypoglycemia, and greater flexibility around mealtimes. Optimizing insulin pump benefits is dependent on a variety of factors, including insulin pump knowledge and skills, insulin adjustment based on blood glucose monitoring (BGM), attention to diet and exercise, and communication with the diabetes medical team.[2,3]

Several types of insulin pumps are currently manufactured for commercial use in the United States, and all of them have data storage capacity (e.g., basal rates, frequency of insulin bolusing, total daily insulin) and compatible software programs that generate summary reports. Diabetes care teams, including physicians, nurses, and certified diabetes educators, can use these reports to evaluate patterns of blood glucose excursions and insulin bolusing and to modify treatment recommendations. Several insulin pumps, including the MiniMed Paradigm Revel® (Medtronic, Northridge, CA), OneTouch® Ping® (Animus Corp., West Chester, PA), and OmniPod® (Insulet Corp., Bedford, MA), wirelessly communicate with a corresponding blood glucose meter [i.e., OneTouch UltraLink, OneTouch Ping, and FreeStyle® (Abbott Diabetes Care, Inc., Alameda, CA), respectively]. Patients using other types of insulin pumps must manually input their BGM readings into the insulin pump if their diabetes health care professionals are to have all available diabetes information from the insulin pump download and for adjusting insulin boluses and corrective doses appropriately.

The purpose of this study was to determine if there were differences in BGM data downloaded from insulin pumps of children and adolescents who use blood glucose meters that wirelessly transmit data to their insulin pumps (i.e., wireless group) and those who do not (i.e., nonwireless group).

Design

Children and adolescents with type 1 diabetes mellitus for ≥1 year, who were part of a larger study assessing BGM patterns, and who were using the Medtronic insulin pump were selected for this study. Thirty-one of these patients used the OneTouch UltraLink (LifeScan, Inc., Milpitas, CA) blood glucose meter, which has a memory capacity of 500 BGM readings and wirelessly communicates them to the Medtronic insulin pump. The other 16 participants used other LifeScan, Inc. meters (e.g., UltraSmart) that are not capable of wirelessly communicating with the insulin pump; if the patient used multiple meters, they were all downloaded during the visit. LifeScan, Inc. provided BGM strips for all patients, and for those not using the UltraLink, the UltraSmart meter was provided.

Blood glucose monitoring data were downloaded from each patient's meter and insulin pump into CareLink Pro software during the patient's routine diabetes clinic visit. Data were then exported into Microsoft Excel for data analyses. The patient's hemoglobin A1c (A1C) representing the average blood glucose level during the past 2.5 to 3 months[4] was obtained using a Siemens Healthcare Diagnostics DCA Vantage (reference range 4.2–6.5%), which is certified as having documented traceability to the Diabetes Control and Complications Trial Reference Method by the National Glycohemoglobin Standardization Program. Informed written consent and assent were obtained from all participants before enrollment in the study. The Florida State University Institutional Review Board approved this study.

Sample

Forty-seven children and adolescents participated in the study. Mean age of the sample was 13.58 ± 3.34 years, with the majority of participants being female (61.7%) and Caucasian (87.2%). Participants had type 1 diabetes mellitus for an average of 6.72 ± 3.80 years and an average A1C of 8.27% ± 1.12%.

Data Analysis

Data were analyzed using Stata Version 12.0 (Statacorp, TX). Independent *t* tests were used to compare BGM data downloaded from insulin pumps between the wireless and nonwireless groups. Comparisons included BGM frequency (total per day and average number of readings performed per day) and occurrences of BGM readings based on the following categories: low (<70 mg/dl), in-range (70–120 mg/dl), high (121–250 mg/dl), and very high (>250 mg/dl). Paired *t* tests were used for the nonwireless group to compare BGM data downloaded from their blood glucose meters with BGM data downloaded from their insulin pumps.

Results

Downloaded Insulin Pump Data: Wireless versus Nonwireless Groups

Comparisons were made between the wireless and nonwireless groups; the nonwireless group was required to manually enter their BGM readings into the pump. Patients in the wireless group had significantly more total BGM readings (333.48 readings) stored in their insulin pumps than the nonwireless group (120.44 readings; $t = -4.86$; $p < .001$). Patients in the wireless group performed significantly more BGM readings per day (4.96 readings) than the nonwireless group (2.24 readings; $t = -4.88$; $p < .001$). In addition, the overall percentage of low (<70 mg/dl) and in-range (70–120 mg/dl) BGM readings was significantly higher for the wireless group than the nonwireless group ($p < .001$, whereas the percentage of very high BGM readings was significantly lower). There were no A1C differences between the two groups (see **Table 1**).

Table 1.
Insulin Pump Data Only: Comparisons between Patients Using a Wireless Compatible Versus Those Using Nonwireless Compatible Meters

Group	Mean	SD	95% Confidence Interval of Mean	Test Statistic
Average blood glucose level				
Wireless	197.85 mg/dl	47.48	180.43–215.26	$t = 3.03$
Nonwireless	247.26 mg/dl	62.55	213.93–280.59	$p < .01$
Average number of blood glucose readings per day				
Wireless	4.96 readings	2.62	4.00–5.92	$t = -4.88$
Nonwireless	2.24 readings	1.21	1.60–2.88	$p = <.001$
Total number of blood glucose readings				
Wireless	333.48 readings	211.51	255.90–411.07	$t = -4.86$
Nonwireless	120.44 readings	87.38	73.88–167.00	$p = <.001$
Average A1C				
Wireless	8.28%	1.16	7.85–8.71	$t = -.10$
Nonwireless	8.24%	1.06	7.68–8.81	$p = .9180$
Percentage of low blood glucose readings				
Wireless	9.90%	6.48	7.53–12.28	$t = -4.92$
Nonwireless	2.62%	3.66	0.68–4.57	$p = <.001$
Percentage of in-range blood glucose readings				
Wireless	19.93%	8.41	16.85–23.01	$t = -2.97$
Nonwireless	11.45%	10.83	5.68–17.22	$p = .01$
Percentage of high blood glucose readings				
Wireless	41.21%	9.98	37.55–44.87	$t = .02$
Nonwireless	41.29%	13.43	34.13–48.44	$p = .9826$
Percentage of very high blood glucose readings				
Wireless	28.96%	17.27	22.62–35.29	$t = 2.67$
Nonwireless	44.64%	22.23	32.80–56.49	$p < .01$

Downloaded Insulin Pump and Blood Glucose Meter Data: Nonwireless Group Only

Blood glucose monitoring data downloaded from a patient's nonwireless meter was compared with BGM data downloaded from the same patient's insulin pump for the nonwireless group only. Low BGM readings were significantly more common in the downloaded meter data (11.68%) than the downloaded pump data (2.62%; t = 4.70; p < .001). In-range BGM readings were significantly more common in the downloaded meter data (20.91%) than the downloaded pump data (11.45%; t = 3.81; p < .001). Very high BGM readings were more common in the downloaded insulin pump data (44.64%) than the meter data (28.71%; t = -3.35; p < .01). In addition, the frequency of BGM readings per day was higher in downloaded meter data as compared with the same patient's insulin pump (p < .01) (see **Table 2**).

Table 2.
Paired Comparisons of Blood Glucose Data Obtained from Meters and Insulin Pumps: Data for Only Those Patients Using a Nonwireless Compatible Meter with Their Insulin Pump

Group	Mean	SD	95% Confidence Interval of Mean	Test Statistic
Average blood glucose level				
Meter	197.40 mg/dl	48.16	171.74–223.07	t = –3.74
Pump	247.26 mg/dl	62.55	213.93–280.59	p < .01
Average number of blood glucose readings per day				
Meter	4.81 readings	1.78	3.87–5.76	t = 6.59
Pump	2.24 readings	1.21	1.60–2.88	p = <.001
Total number of blood glucose readings				
Meter	408.31 readings	299.77	248.58–568.05	t = 3.55
Pump	120.44 readings	87.38	73.88–167.00	p < .01
Percentage of low blood glucose readings				
Meter	11.68 %	6.24	8.35–15.00	t = 4.70
Pump	2.62%	3.66	0.68–4.57	p < .001
Percentage of in-range blood glucose readings				
Meter	20.91%	7.80	16.76–25.07	t = 3.81
Pump	11.45%	10.83	5.68–17.22	p < .001
Percentage of high blood glucose readings				
Meter	38.70%	7.98	34.45–42.95	t = –1.05
Pump	41.29%	13.43	34.13–48.44	p = .311
Percentage of very high blood glucose readings				
Meter	28.71%	15.11	20.66–36.76	t = –3.35
Pump	44.64%	22.23	32.80–56.49	p < 0.01

Discussion

To our knowledge, this is the first study to empirically demonstrate that BGM data downloaded from insulin pumps used by children and adolescents with nonwireless blood glucose meters provide an incomplete representation of the patient's BGM frequency or results. A significant advantage of using a wireless-compatible meter is the automatic transmission of BGM readings to the insulin pump. Specifically, wireless transmission eliminates the need for the patient to manually enter BGM readings into the insulin pump. However, optimal use of the insulin pump regarding diabetes treatment management is dependent on the patient's correct use of its sophisticated technology. Pediatric patients who use nonwireless meters are not taking the extra step of manually entering their low or in-range BGM readings into the insulin pump.

Limitations of this study include small sample size[5,6] and a high percentage of girls,[7,8] but these characteristics are similar to other studies. In addition, the results of this study may not be generalizable to other pump users, as only Medtronic insulin pumps were used. Medtronic insulin pumps are the only pumps that have a meter that wirelessly sends the BGM reading to the pump for bolus calculations. Other meters that are capable of communicating with insulin pumps (e.g., Bayer CONTOUR® NEXT LINK) require an additional step in which the patient needs to manually send the reading to the pump. Regardless, the findings highlight the benefits of using wireless-compatible blood glucose meters for patients using insulin pumps. The sophisticated advantages of wireless meter/insulin pump technology not only eliminates patient burden of manually entering BGM readings, but it provides better and more complete data to the diabetes health care team. Therefore, consideration should be given to recommending that children and adolescents who use an insulin pump only use wireless meters. However, we recognize that some patients are unable to or not interested in using a blood glucose meter that wirelessly communicates with the insulin pump. While some patients prefer smaller-sized meters, others are limited by insurance providers who only approve specific BGM strips for use.

Conclusions

Diabetes care teams who rely only on downloaded insulin pump data (i.e., they do not also download meter data) may conclude or assume that the patient is engaging in less BGM when she or he is actually conducting BGM but not entering the reading into the pump. Our data suggest that patients may be deciding which BGM readings are important to enter manually into the insulin pump. The decision to specifically *not* input low or in-range BGM readings into the pump may lead the health care professional to conclude that the patient's overall blood glucose levels are higher or that the patient is engaging in less BGM than is actually the case.

There are several reasons why a patient using a nonwireless blood glucose meter would choose not to input a BGM reading into their insulin pump. For example, patients often only enter BGM readings when they are making a decision about insulin dosing. If she or he is treating hypoglycemia with food, then it might be assumed that there is no reason to input the low BGM reading into the insulin pump. In addition, if the BGM reading is in range and the patient plans to eat, it may be assumed that entering the BGM reading into the insulin pump is not necessary since there will be no correction component to the insulin dose. Often times, the carbohydrates will be entered since a food correction is necessary. In contrast, patients may be more likely to enter BGM readings when hyperglycemia is occurring since an insulin bolus is needed.

Choosing not to input BGM readings into the insulin pump can lead to an incomplete BGM picture, resulting in treatment recommendations that are not in the patient's best interest. Therefore, patients who use nonwireless meters should be educated about the importance of manually entering *all* BGM readings into their insulin pumps, including those that are low or in-range so that optimal recommendations and changes to the diabetes treatment regimen can be made by their health care provider.

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