Quantifying the Impact of a Short-interval interruption of Insulin-Pump Infusion Sets on Glycemic Excursions

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ABSTRACT

This prospective, open-label study was designed to measure the impact of short-term infusion-set disconnects on glucose levels. Continuous subcutaneous insulin infusion (CSII) therapy allows for uninterrupted delivery of insulin. Patients disconnect their insulin pumps from their infusion sets when showering, swimming, exercising, or during intimate moments. Interrupting insulin infusion results in cessation of the basal insulin delivery. Nineteen subjects with T1DM were studied on 2 separate in-clinic days. One hour after arriving at the clinic in a fasting state, subjects either temporarily disconnected their infusion sets from their pumps, interrupting basal insulin infusion for 30 minutes, or on a separate day, only changed their infusion sets. Glucose levels were monitored for an additional 4 hours on both occasions. Changing infusion sets did not affect short-term glucose control. However, the 30-minute interruption of basal insulin infusion resulted in significant glucose elevations; approximately 1 mg/dL for each minute basal insulin infusion was interrupted.
Continuous subcutaneous insulin infusion (CSII) therapy allows for uninterrupted, around-the-clock delivery of insulin. In practice, patients disconnect their insulin pumps from their infusion sets when showering, changing clothes, swimming, exercising, or during intimate moments. These periods of interrupted insulin infusion, ranging in time from a few minutes to hours, results in cessation of basal insulin delivery. Interrupting the insulin delivery may be appropriate during periods of exercise when insulin sensitivity increases (1) or during hypoglycemia; however, this cessation of insulin delivery may be detrimental, even for short periods, especially if it occurs when insulin resistance is at its peak. This prospective, open-label study, supported by a grant from Insulet Corporation, was designed to measure the impact of short-term infusion-set disconnects and infusion set changes on glucose levels.

RESEARCH DESIGN AND METHODS

Nineteen subjects with type 1 diabetes mellitus were enrolled in this study: 11 women, 8 men; mean age 44 years, range 20 to 68 years; mean duration of diabetes 22.5 years, range 5 to 51 years; mean A1C 7.3%, range 5.0% to 9.3%. Twelve subjects used Medtronic MiniMed insulin pumps (Medtronic Diabetes, Northridge, CA), eight with Quickset® infusion sets, three with Sof-set®, one with Silhouette®; four subjects used Deltec Cozmo® pumps (Smiths Medical MD, Inc., Saint Paul, MN) with Cleo® infusion sets; and three subjects used Animas® pumps (Johnson & Johnson, New Brunswick, NJ) with Comfort® infusion sets.

Five subjects used insulin aspart (Novolog® from Novo Nordisk A/S, Copenhagen, Denmark), ten subjects used insulin lispro (Humalog® from Eli Lilly and Company, Indianapolis, IN), and four subjects used insulin glulisine (Apidra® from Sanofi-Aventis, Bridgewater, NJ). Criteria for a subject’s inclusion in the study were: use of CSII therapy for at least one year, using U-100 rapid-acting insulin; receiving medical care from a diabetes healthcare professional; having not more than one severe episode of hypoglycemia requiring assistance within the past year, and none within the past 3 months; having not more than one episode of diabetic ketoacidosis within the past year and none within the past 3 months; and having no greater than mild-to-moderate severity of any diabetes-related complication at enrollment. Subjects were excluded from the study if they were pregnant, were taking prescription medications that could complicate the management of glycemic control (steroids, diuretics, or beta blockers), had a clinical diagnosis of hypoglycemia unawareness, or were a relative or family member employed by or affiliated with any manufacturer or distributor of diabetes-related products. Signed, informed consent approved by RCRC IRB (Austin, TX), was obtained from all subjects.

Subjects wore CGMS® System GoldTM devices (Medtronic Diabetes, Northridge, CA) throughout the study, which recorded glucose values every 5 minutes. The devices were calibrated per the manufacturer’s instructions using the Freestyle® blood glucose monitor (Abbott Diabetes Care, Alameda, CA). The subjects were blinded to any CGMS® glucose readings. In-clinic glucose measurements were performed per manufacturer’s instructions using the FreeStyle® blood glucose meter. Alternate site testing was not permitted. Per protocol, each subject wore the CGMS® system home after having it inserted by the research team at the Sansum Diabetes Research Institute. Subjects returned to the Institute at 7 a.m. in a fasting state, having taken no correction boluses of insulin, treatment for
hypoglycemia, or food since midnight. One hour after arriving at the clinic, subjects disconnected from their infusion sets. They reconnected their CSII pumps to their infusion sets 30 minutes later. The subjects rested in a fasting state for an additional 3 hours after reconnecting. On a separate day, under similar conditions, subjects only changed their infusion sets. Glucose results were downloaded from the CGMS® system at the end of each day.

RESULTS
All subjects completed the study. A graphical summary of mean glucose levels for the peri-disconnect and post-infusion set change periods are shown in Figure 1. There was not any significant difference (p = 0.45) between the glucose concentration for the 1-hour period prior to infusion set change (129.5 +/- 8.7 mg/dl) and for the 3.5 hour period after infusion set change (120.4 +/- 19.4 mg/dl). The glucose concentration was 149.1 +/- 9.0 mg/dL (mean +/- SD) during the 1-hour period before disconnecting the infusion set, 154.5 +/- 4.8 mg/dL for the 30-minute period after disconnect. The mean rate of change in glucose concentration for the one hour before disconnecting was 0.021 mg/dL/min and 0.345 mg/dL/min for the one hour after the 30-minute disconnect. From this point through the remainder of the study (105 minutes), the mean rate of change was 0.0006 mg/dL/min. The glucose concentration during this period was 181.5 +/- 9.2 mg/dl. It took 70 minutes after reconnecting to reach a steady-state condition at a mean BG level of 181.3 mg/dL. The mean glucose values were significantly higher (p value < 0.001) at 3, and 3.5 hours after disconnecting the infusion set, compared to glucose levels in the 1-hour period before disconnecting. The rate of rise in glucose concentration over 3 hours was approximately 1 mg/dL for each minute insulin infusion was interrupted.

CONCLUSIONS
Even short-term interruption in insulin delivery can result in disruption in glucose homeostasis. There does not appear to be any short-term affect on glucose control after changing infusion sets. Additional research should be undertaken to further quantify the effects of basal interruption at other times of day and prior to, during, and after different levels of exercise and/or food intake. Some insulin-delivery systems do not allow for disconnecting because they do not use infusion sets. Additionally, some insulin-delivery systems are addressing missed basal insulin from infusion set disconnects by including a disconnect bolus feature in their pump software. Patient education should focus on when and how to safely disconnect infusion sets and discuss the likely impact that disconnecting has on glucose levels.

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REFERENCE
FIGURE 1. Impact of infusion set disconnects on glycemic excursions. The rate of rise in glucose was approximately 1 mg/dL for each minute insulin infusion was interrupted.

♦ = mean blood glucose during disconnect study period
○ = mean blood glucose during infusion set change study period