

Quantifying the Impact of a Short-Interval Interruption of Insulin-Pump Infusion Sets on Glycemic Excursions

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This prospective, open-label study was designed to measure the impact of short-term infusion-set disconnects on glucose levels. Continuous subcutaneous insulin infusion 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 basal insulin delivery. Nineteen subjects with type 1 diabetes were studied on two 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 min, or, on a separate day, changed their infusion sets. Glucose levels were monitored for an additional 4 h on both occasions. Changing infusion sets did not affect short-term glucose control. However, the 30-min interruption of basal insulin infusion resulted in significant glucose elevation; ~ 1 mg/dl for each minute basal insulin infusion was interrupted.

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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. Ranging in time from a few minutes to several hours, these periods of interrupted insulin infusion result in cessation of basal insulin delivery. Interrupting insulin delivery may be appropriate during periods of exercise when insulin sensitivity increases (1) or during hypoglycemia; however, 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

Enrolled in this study were 19 subjects with type 1 diabetes: 11

women and 8 men, with mean age 44 years (range 20–68), mean duration of diabetes 22.5 years (range 5–51), and mean A1C 7.3% (range 5.0–9.3%). Twelve subjects used Medtronic MiniMed insulin pumps (Medtronic Diabetes, Northridge, CA), eight with Quickset infusion sets, three with Sof-set, and one with Silhouette; four subjects used Deltec Cozmo pumps (Smiths Medical MD, 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, Novo Nordisk, Copenhagen, Denmark), 10 subjects used insulin lispro (Humalog, Eli Lilly and Company, Indianapolis, IN), and 4 subjects used insulin glulisine (Apidra, Sanofi-Aventis, Bridgewater, NJ). Criteria for a subject's inclusion in the study were: use of CSII therapy for at least 1 year using U-100 rapid-acting insulin, receiving medical care from a diabetes health care 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 β -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 the RCRC Institutional Review Board (Austin, TX) was obtained from all subjects.

Subjects wore CGMSSystem GoldTM devices (Medtronic Diabetes, Northridge, CA), which recorded glucose values every 5 min, throughout the study. 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 7:00 A.M. in a fasting state, having taken no correction boluses of insulin, treatment for hypoglycemia, or food since midnight. Subjects disconnected from their infusion sets 1 h after arriving at the clinic. They reconnected their CSII pumps to their infusion sets 30 min later. The subjects rested in a fasting state for an additional 3 h 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

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Abbreviations: CSII, continuous subcutaneous insulin infusion.

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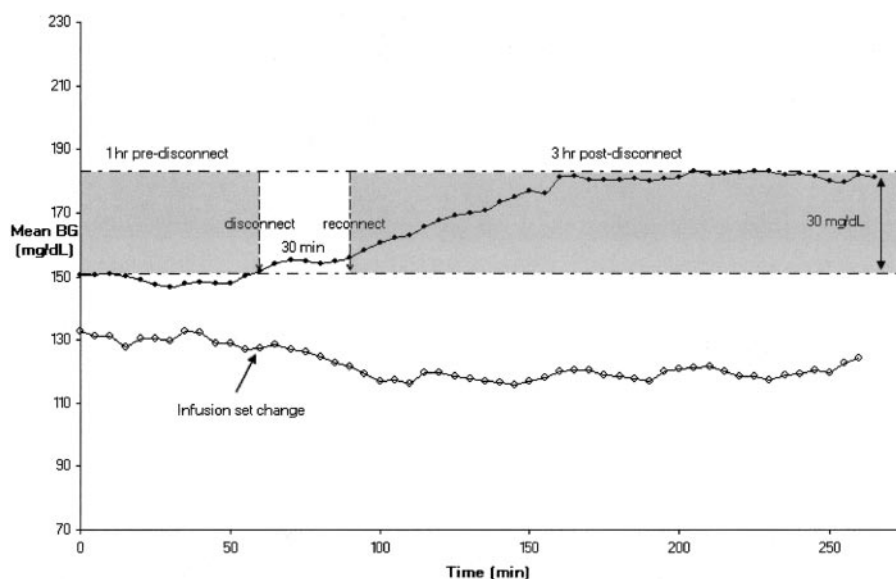


Figure 1—Impact of infusion-set disconnects on glycemic excursions. The rate of rise in glucose was ~ 1 mg/dl for each minute insulin infusion was interrupted. \blacklozenge , mean blood glucose (BG) during disconnect study period; \diamond , mean blood glucose during infusion-set change study period.

shown in Fig. 1. There was not a significant difference ($P = 0.45$) between the glucose concentration for the 1-h period before infusion-set change (129.5 ± 8.7 mg/dl) and for the 3.5-h period after infusion-set change (120.4 ± 19.4 mg/dl). The glucose concentration was 149.1 ± 9.0 mg/dl (mean \pm SD) during the 1-h period before disconnecting the infusion set and 154.5 ± 4.8 mg/dl for the 30-min period after disconnect. The mean rate of change in glucose concentration was $0.021 \text{ mg} \cdot \text{dl}^{-1} \cdot \text{min}^{-1}$ for 1 h before disconnecting and $0.345 \text{ mg} \cdot \text{dl}^{-1} \cdot$

min^{-1} for 1 h after the 30-min disconnect. From this point through the remainder of the study (105 min), the mean rate of change was $-0.0006 \text{ mg} \cdot \text{dl}^{-1} \cdot \text{min}^{-1}$. The glucose concentration during this period was 181.5 ± 9.2 mg/dl. It took 70 min after reconnecting to reach a steady-state condition at a mean blood glucose level of 181.3 mg/dl. The mean glucose values were significantly higher ($P < 0.001$) at 3 and 3.5 h after disconnecting the infusion set, compared with glucose levels in the 1-h period before disconnecting. The rate of rise in glucose concentration over 3 h was ~ 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, as well as before, 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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