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ORIGINAL ARTICLE

Feasibility of Overnight Closed-Loop Control Based on Hourly Blood Glucose Measurements

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Abstract

Introduction:

Safe and effective closed-loop control (artificial pancreas) is the ultimate goal of insulin delivery. In this study, we examined the performance of a closed-loop control algorithm used for the overnight time period to safely achieve a narrow target range of blood glucose (BG) concentrations prior to breakfast. The primary goal was to compare the quality of algorithm control during repeated overnight experiments.

Materials and Methods:

Twenty-three subjects with type 1 diabetes performed 2 overnight experiments on each of three visits at the study site, resulting in 138 overnight experiments. On the first evening, the subject's insulin therapy was applied; on the second, the insulin was delivered by an algorithm based on subcutaneous continuous glucose measurements (including meal control) until midnight. Overnight closed-loop control was applied between midnight and 6 a.m. based on hourly venous BG measurements during the first and second nights.

Results:

The number of BG values within the target range (90–150 mg/dl) increased from 52.9% (219 out of 414 measurements) during the first nights to 72.2% (299 out of 414 measurements) during the second nights ($p < .001$, χ^2-test). The occurrence of hypoglycemia interventions was reduced from 14 oral glucose interventions, the latest occurring at 2:36 a.m. during the first nights, to 1 intervention occurring at 1:02 a.m. during the second nights ($p < .001$, χ^2-test).

Conclusions:

Overnight controller performance improved when optimized initial control was given; this was suggested by the better metabolic control during the second night. Adequate controller run-in time seems to be important for achieving good overnight control. In addition, the findings demonstrate that hourly BG data are sufficient for the closed-loop control algorithm tested to achieve appropriate glycemic control.

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Abbreviations: (APTS) automated pancreas test stand, (BG) blood glucose, (CGM) continuous glucose monitoring, (CHO) carbohydrate, (CSII) continuous subcutaneous insulin infusion, (SD) standard deviation

Keywords: artificial pancreas, closed-loop insulin delivery, continuous subcutaneous insulin infusion, overnight control

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