

A Stepwise Approach toward Closed-Loop Blood Glucose Control for Intensive Care Unit Patients: Results from a Feasibility Study in Type 1 Diabetic Subjects Using Vascular Microdialysis with Infrared Spectrometry and a Model Predictive Control Algorithm

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Abstract

Background:

Glycemic control can reduce the mortality and morbidity of intensive care patients. The CLINICIP (closed-loop insulin infusion for critically ill patients) project aimed to develop a closed-loop control system for this patient group. Following a stepwise approach, we combined three independently tested subparts to form a semiautomatic closed-loop system and evaluated it with respect to safety and performance aspects by testing it in subjects with type 1 diabetes mellitus (T1DM) in a first feasibility trial.

Methods:

Vascular microdialysis, a multianalyte infrared spectroscopic glucose sensor, and a standard insulin infusion pump controlled by an adaptive model predictive control (MPC) algorithm were combined to form a closed-loop device, which was evaluated in four T1DM subjects during 30-hour feasibility studies. The aim was to maintain blood glucose concentration in the target range between 80 and 110 mg/dl.

Results:

Mean plasma glucose concentration was 110.5 ± 29.7 mg/dl. The MPC managed to establish normoglycemia within 105 ± 78 minutes after trial start and managed to maintain glucose concentration within the target range for 47% of the time. The hyperglycemic index averaged to 11.9 ± 5.3 mg/dl.

Conclusion:

Data of the feasibility trial illustrate the device being effective in controlling glycemia in T1DM subjects. However, the monitoring part of the loop must be improved with respect to accuracy and precision before testing the system in the target population.

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Abbreviations: (BG) blood glucose, (CHO) carbohydrate, (CLINICIP) closed-loop insulin infusion for critically ill patients, (ICU) intensive care unit, (ITEGA) insulin titration error grid analysis, (IV) intravenous, (MPC) model predictive control, (SC) subcutaneous, (T1DM) type 1 diabetes mellitus

Keywords: CLINICIP, MPC algorithm, spectroscopic glucose sensor, tight glycemic control, vascular microdialysis

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