Model-Based Closed-Loop Glucose Control in Type 1 Diabetes: The DiaCon Experience -
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Background:
To improve type 1 diabetes mellitus (T1DM) management, we developed a model predictive control (MPC) algorithm for
closed-loop (CL) glucose control based on a linear second-order deterministic-stochastic model. The deterministic part
of the model is specified by three patient-specific parameters: insulin sensitivity factor, insulin action time, and basal insulin
infusion rate. The stochastic part is identical for all patients but identified from data from a single patient. Results of the
first clinical feasibility test of the algorithm are presented.

Methods:
We conducted two randomized crossover studies. Study 1 compared CL with open-loop (OL) control. Study 2 compared
glucose control after CL initiation in the euglycemic (CL-Eu) and hyperglycemic (CL-Hyper) ranges, respectively. Patients
were studied from 22:00–07:00 on two separate nights.

Results:
Each study included six T1DM patients (hemoglobin A1c 7.2% ± 0.4%). In study 1, hypoglycemic events (plasma glucose
< 54 mg/dl) occurred on two OL and one CL nights. Average glucose from 22:00–07:00 was 90 mg/dl [74–146 mg/dl;
median (interquartile range)] during OL and 108 mg/dl (101–128 mg/dl) during CL (determined by continuous glucose
monitoring). However, median time spent in the range 70–144 mg/dl was 67.9% (3.0–73.3%) during OL and 80.8%
(70.5–89.7%) during CL. In study 2, there was one episode of hypoglycemia with plasma glucose <54 mg/dl in a CL-Eu
night. Mean glucose from 22:00–07:00 and time spent in the range 70–144 mg/dl were 121 mg/dl (117–133 mg/dl) and
69.0% (30.7–77.9%) in CL-Eu and 149 mg/dl (140–193 mg/dl) and 48.2% (34.9–72.5%) in CL-Hyper, respectively.

Conclusions:
This study suggests that our novel MPC algorithm can safely and effectively control glucose overnight, also when CL
control is initiated during hyperglycemia.

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Resources Engineering, Scientific Computing, Copenhagen University Hospital
Contributors: Schmidt, S., Boiroux, D., Duun-Henriksen, A. K., Frøssing, L., Skyggebjerg, O., Jørgensen, J. B., Poulsen,
N. K., Madsen, H., Madsbad, S., Nørgaard, K.
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