Patient specific modeling on blood glucose dynamics during liver transplantation

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Objectives

During orthotopic liver-transplantation (OLT) blood glucose (BG) metabolic system affected by disturbances. Using a model based BG control, already during the surgical phase, the possibility for complications caused by extreme low- and high BG concentrations can be significantly reduced. The applied clinically validated Intensive Control Insulin-Nutrition-Glucose (ICING) model proved to be sufficient for one part of the patients. For the other part the model based BG function shows deviation from the clinical measurements. In the background there are rapid pathological changes, which cause time dependency of the model parameter set. The goal of the present study is to investigate this time dependent nature of the ICING model parameters during OLT.

Methods

Data

12 Patients BG data were measured during OLT by blood gas analyzer.

Surgery events

There are four main phases of the OLT which phases are reflected in the BG function as well: Beginning of the surgery, absence of the liver, reperfusion of the transplanted liver and the following10 hours, and afterwards the normalized condition. A significant increase of BG level can be observed in the first two phases, which is followed by a bump-like function, with a global maximum location during reperfusion phase.

Metabolic model

The ICING model with modified parameter set was applied for the altered BG metabolic state. This model describes the endogenous glucose uptake and exogenous feeding, the process of insulin secretion as well the exogenous insulin intake and the uptake of insulin in the blood circulation. The parameter set was modified according to the certain surgery phases in order to reflect the limited physiological functions.

Physiological constraints

Prior studies shows that model parameter modifications may enhance the fitting-accuracy, however the absence of the liver and the reperfusion phase assume patient specific time dependency of certain parameters. These parameters are the endogenous glucose production, the glucose dependent glucose uptake. Their functions are partially overtaken by other organs during the OLT and depend on the pathological condition of the transplanted liver.

Results

The time dependent parameter functions enhance the quality of the fitting. The deviation of the clinical measurements and the model based data decreases, and dynamics of the BG measurement was captured properly by the modified model for each patients.

Conclusion

The advanced model by the time dependent parameter functions can enhance the quality of the fitting, however the model parameter modifications have to be validated by clinical measurements.