Derivative weighted active insulin control modelling and clinical trials for ICU patients.

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Close control of blood glucose levels significantly reduces vascular complications in Type 1 and Type 2 diabetic individuals. Heavy derivative controllers using the data density available from emerging biosensors are developed to provide tight, optimal control of elevated blood glucose levels, while robustly handling variation in patient response. A two-compartment glucose regulatory system model is developed for intravenous infusion from physiologically verified subcutaneous infusion models enabling a proof-of-concept clinical trial at the Christchurch Hospital Department of Intensive Care Medicine. This clinical trial is the first of its kind to test a high sample rate feedback control algorithm for tight glucose regulation. The clinical trial results show tight control with reductions of 79-89% in blood glucose excursions for an oral glucose tolerance test. Experimental performance is very similar to modelled behaviour. Results include a clear need for an additional accumulator dynamic for insulin behaviour in transport to the blood and strong correlation of 10% or less between modelled insulin infused and the amounts used in clinical trials. Finally, the heavy derivative PD control approach is seen to be able to bring blood glucose levels below the (elevated) basal level, showing the potential for truly tight control.

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