A Novel Adaptive Basal Therapy Based on the Value and Rate of Change of Blood Glucose

Youqing Wang, Ph.D., Matthew W. Percival, M.Eng., Eyal Dassau, Ph.D., Howard C. Zisser, M.D., Lois Jovanović, M.D., and Francis J. Doyle III, Ph.D.

Abstract

Background: Modern insulin pump therapy for type 1 diabetes mellitus offers the freedom to program several basal profiles that may accommodate diurnal variability in insulin sensitivity and activity level. However, these basal profiles do not change even if a pending hypoglycemic or hyperglycemic event is foreseen. New insulin pumps could receive a direct feed of glucose values from a continuous glucose monitoring (CGM) system and could enable dynamic basal adaptation to improve glycemic control.

Method: The proposed method is a two-step procedure. After the design of an initial basal profile, an adaptation of the basal rate is suggested as a gain multiplier based on the current CGM glucose value and its rate of change (ROC). Taking the glucose value and its ROC as axes, a two-dimensional plane is divided into a nine-zone mosaic, where each zone is given a predefined basal multiplier; for example, a basal multiplier of zero indicates a recommendation to shut off the pump.

Results: The proposed therapy was evaluated on 20 in silico subjects (ten adults and ten adolescents) in the Food and Drug Administration-approved UVa/Padova simulator. Compared with conventional basal therapy, the proposed basal adjustment improved the percentage of glucose levels that stayed in the range of 60–180 mg/dl for all 20 subjects. In addition, the adaptive basal therapy reduced the average blood glucose index values.

Conclusions: The proposed therapy provides the flexibility to account for insulin sensitivity variations that may result from stress and/or physical activities. Because of its simplicity, the proposed method could be embedded in a chip in a future artificial pancreatic β cell or used in a “smart” insulin pump.