Journal of Diabetes Science and Technology
Volume 4, Issue 5, September 2010

ORIGINAL ARTICLES

Modeling the Effects of Subcutaneous Insulin Administration and Carbohydrate Consumption on Blood Glucose

Matthew W. Percival, M.Eng.,[1,2] Wendy C. Bevier, Ph.D.,[2] Youqing Wang, Ph.D.,[1,2,3] Eyal Dassau, Ph.D.,[1,2] Howard C. Zisser, M.D.,[1,2] Lois Jovanovič, M.D.,[1,2] and Francis J. Doyle III, Ph.D.[1,2]

Abstract

Background:

Estimation of the magnitude and duration of effects of carbohydrate (CHO) and subcutaneously administered insulin on blood glucose (BG) is required for improved BG regulation in people with type 1 diabetes mellitus (T1DM). The goal of this study was to quantify these effects in people with T1DM using a novel protocol.

Methods:

The protocol duration was 8 hours: a 1–3 U subcutaneous (SC) insulin bolus was administered and a 25-g CHO meal was consumed, with these inputs separated by 3–5 hours. The DexCom SEVEN® PLUS continuous glucose monitor was used to obtain SC glucose measurements every 5 minutes and YSI 2300 Stat Plus was used to obtain intravenous glucose measurements every 15 minutes.

Results:

The protocol was tested on 11 subjects at Sansum Diabetes Research Institute. The intersubject parameter coefficient of variation for the best identification method was 170%. The mean percentages of output variation explained by the bolus insulin and meal models were 68 and 69%, respectively, with root mean square error of 14 and 10 mg/dl, respectively. Relationships between the model parameters and clinical parameters were observed.

Conclusion:

Separation of insulin boluses and meals in time allowed unique identification of model parameters. The wide intersubject variation in parameters supports the notion that glucose-insulin models and thus insulin delivery algorithms for people with T1DM should be personalized. This experimental protocol could be used to refine estimates of the correction factor and the insulin-to-carbohydrate ratio used by people with T1DM.

J Diabetes Sci Technol 2010;4(5):1214-1228

Author Affiliations: [1]Department of Chemical Engineering, University of California, Santa Barbara, CA; [2]Sansum Diabetes Research Institute, Santa Barbara, CA; and [3]Currently at Beijing University of Chemical Technology, Beijing, China

Abbreviations: (AE) algebraic equation, (BG) blood glucose, (CF) correction factor, (CGM) continuous glucose monitoring, (CHO) carbohydrate, (CSII) continuous subcutaneous insulin infusion, (ICR) insulin-to-carbohydrate ratio, (IOB) insulin on board, (IV) intravenous, (ODE) ordinary differential equation, (pEGA) point error grid analysis, (rEGA) rate error grid analysis, (SC) subcutaneous, (T1DM) type 1 diabetes mellitus

Keywords: artificial pancreas, parameter estimation, physiological modeling, type 1 diabetes mellitus

Corresponding Author: Francis J. Doyle III, Ph.D., Department of Chemical Engineering, University of California, Santa Barbara, CA 93106-5080; email address *doyle@engr.ucsb.edu*