Journal of Diabetes Science and Technology
Volume 1, Issue 5, September 2007

SYMPOSIUM

Reconstruction of Glucose in Plasma from Interstitial Fluid Continuous Glucose Monitoring Data: Role of Sensor Calibration

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Abstract

Background:
Continuous glucose monitoring (CGM) sensors measure glucose concentration in the interstitial fluid (ISF). Equilibration between plasma and ISF glucose is not instantaneous. Therefore, ISF and plasma glucose concentrations exhibit different dynamic patterns, particularly during rapid changes. The purpose of this work was to investigate how well plasma glucose can be reconstructed from ISF CGM data.

Methods:
Six diabetic volunteers were monitored for 2 days using the TheraSense FreeStyle Navigator (Abbott Diabetes Care, Alameda, CA), a minimally invasive device that, on the basis of an initial calibration procedure (hereafter referred to as standard calibration), returns ISF glucose concentration. Simultaneously, plasma glucose concentration was also measured every 15 minutes. First we identified, in each subject, the linear time-invariant (LTI) two-compartment model of plasma-interstitium kinetics. Then, a nonparametric regularization deconvolution method was used to reconstruct plasma from ISF glucose.

Results:
Deconvoluted profiles were always closer to plasma glucose than ISF ones. However, the quality of the reconstruction is unsatisfactory. Some visible discrepancies between average plasma and ISF time series suggest problems either in the applicability of the LTI model of plasma-interstitium kinetics to normal life conditions or in the standard calibration with which ISF glucose is determined from the sensor internal readings. Assuming that the LTI model of plasma-interstitium kinetics is correct, we focused on the influence of calibration and we employed a recently proposed method to recalibrate ISF data.

Conclusions:
After the recalibration step, the relative error in reconstructing plasma glucose was reduced significantly. Results also demonstrate that further margins of improvement of plasma glucose reconstruction are possible by developing more sophisticated recalibration procedures.

J Diabetes Sci Technol 2007;1(5):617-623

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Abbreviations: (CGM) continuous glucose monitoring, (CV) coefficient of variation, (ISF) interstitial fluid, (LTI) linear time invariant, (MAPE) mean absolute percentage error, (NLS) nonlinear least squares

Keywords: calibration, continuous glucose monitoring, deconvolution, delay, reconstruction of plasma glucose

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