Journal of Diabetes Science and Technology
Volume 3, Issue 5, September 2009

REVIEW ARTICLE

Delays in Minimally Invasive Continuous Glucose Monitoring Devices: A Review of Current Technology

D. Barry Keenan, Ph.D.,[1] John J. Mastrototaro, Ph.D.,[1] Gayane Voskanyan, Ph.D.,[1] and Garry M. Steil, Ph.D.[2]

Abstract

Through the use of enzymatic sensors—inserted subcutaneously in the abdomen or *ex vivo* by means of microdialysis fluid extraction—real-time minimally invasive continuous glucose monitoring (CGM) devices estimate blood glucose by measuring a patient's interstitial fluid (ISF) glucose concentration. Signals acquired from the interstitial space are subsequently calibrated with capillary blood glucose samples, a method that has raised certain questions regarding the effects of physiological time lags and of the duration of processing delays built into these devices. The time delay between a blood glucose reading and the value displayed by a continuous glucose monitor consists of the sum of the time lag between ISF and plasma glucose, in addition to the inherent electrochemical sensor delay due to the reaction process and any front-end signal-processing delays required to produce smooth traces. Presented is a review of commercially available, minimally invasive continuous glucose monitors with manufacturer-reported device delays. The data acquisition process for the Medtronic MiniMed (Northridge, CA) continuous glucose monitoring system—CGMS® Gold—and the Guardian® RT monitor is described with associated delays incurred for each processing step. Filter responses for each algorithm are examined using *in vitro* hypoglycemic and hyperglycemic clamps, as well as with an analysis of fast glucose excursions from a typical meal response. Results demonstrate that the digital filters used by each algorithm do not cause adverse effects to fast physiologic glucose excursions, although nonphysiologic signal characteristics can produce greater delays.

J Diabetes Sci Technol 2009;3(5):1207-1214

Author Affiliations: [1]Medtronic MiniMed, Northridge, California; and [2]Children's Hospital Boston, Boston, Massachusetts

Abbreviations: (BG) blood glucose, (CGM) continuous glucose monitoring, (CGMS) continuous glucose monitoring system, (FDA) Food and Drug Administration, (HbA1c) hemoglobin A1c, (ISF) interstitial fluid, (SCGM1) subcutaneous continuous glucose monitoring system, (SMBG) self-monitoring of blood glucose

Keywords: blood glucose, continuous glucose monitoring, insulin, interstitial fluid, sensor

Corresponding Author: D. Barry Keenan, Ph.D., Medtronic MiniMed, 18000 Devonshire Street, Northridge, CA 91325; email address barry.keenan@medtronic.com