Modelling Continuous Glucose Monitoring Data: A Statistical Challenge

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For patients with diabetes, the best defence against the consequences of hypoglycaemia or hyperglycaemia is to be able to recognise it and treat it promptly. The upcoming availability of continuous glucose monitoring will facilitate the development of novel approaches for diabetes management and, particularly, optimisation of insulin therapy. Mathematical derivatives of 24 hour glucose recordings are needed by patients and health care professionals to provide informative feedback on glycaemic status that is easy to comprehend and which can be used to adjust management strategies. Continuous glucose monitoring also offers the possibility of early warning of impending hypoglycaemia and "closed loop" control of insulin infusions to actively maintain glucose levels within clinically desirable limits.

Analysing 24-hour glucose records provides multiple challenges with the need to address both fasting and post prandial periods as well as perturbations induced by administration of insulin or other antidiabetic agents, changes in physical activity and intercurrent infections. Examination of glucose profiles reveals the 'chaotic' nature of the fluctuations in the data in response to these known and to unknown clinical factors. Statistical modelling of such chaotic data is not straight forward. There have been some suggestions in the literature to approach this problem[1, 2]. However, these approaches do not recognise the widely different 'fasting' and 'postprandial' blood glucose dynamics. Also, the issues in exploring the association of clinical and physiological aspects with the glucose fluctuations need to be addressed in a clinically meaningful way.

In this study we explain our experience of exploring the blood glucose dynamics using 72 hour glucose measurements from 50 diabetic patients in an ongoing clinical study. The different non-stationary patterns by 'fasting' and 'postprandial' status are explored. The aspects of unbalanced nature of the time dependent data are addressed. The applicability of non-linear state-space models is discussed. We explore the possibility of developing a Generalized Estimating Equation (GEE) approach to model the temporal variations in the glucose levels. This kind of robust parametric approach will help solve the issue of near-optimum modelling of chaotic fluctuations in glucose levels and exploring the association of various factors with blood glucose measurements, so that the health professionals can be provided with a better picture of the whole dynamics for optimum glycaemia management.

References

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