AIDA: An Automated Insulin Dosage Advisor

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ABSTRACT

A prototype computer system utilising a model of carbohydrate metabolism linked to an expert system is described. The prototype which integrates quantitative and qualitative computational methodologies can be used to predict blood glucose profiles and adjust insulin doses in type I diabetic subjects.

INTRODUCTION

Diabetes mellitus is a chronic disorder of carbohydrate metabolism. The treatment of insulin-dependent (type I) diabetic patients requires some considerable medical knowledge which may be lacking outside specialised clinics and informed general practices. A number of computer based approaches to help transfer this knowledge from a hospital setting to non-specialist doctors and nurses have been previously reported in the literature. These include knowledge based systems to advise on patient management in out-patient clinics and computer algorithms for insulin-dosage adjustment. Another approach has been to use mathematical models as a means of predicting or simulating patient blood glucose profiles.

This paper provides an overview of an alternative approach which links a rule-based expert system with a clinical model of glucose-insulin interaction in type I diabetes mellitus [1] to provide an integrated decision support environment for assisting a physician or diabetic specialist nurse in the management of insulin-treated diabetic patients [2]. The linkage described represents cooperation between two different types of knowledge representation in which the capabilities of a qualitative reasoner are augmented by a quantitative model while the intelligent use of the latter is guided by a rule-based inference engine.

SYSTEM OVERVIEW

The current version of the prototype runs under DOS on an IBM PC or compatible. A multitasking version is also available for 80386/486 based machines running WINDOWS 3.1. This allows the display of multiple windows showing different parts of the system in operation. For example the data entry screen can be displayed in one window with the results of a simulation in a second and advice from the knowledge based system (KBS) in a third. Figure 1a shows an example of this where the 'BASELINE' curve in the 'DISPLAY' window shows a simulation performed following parameter estimation. The lower ('ADVICE') window shows the two suggestions from the KBS as to how the patient's blood glucose profile might be improved. The glycaemic effect of these two pieces of advice have been simulated in the upper ('DISPLAY') window where it can be seen that advice number (1) to *'increase the before breakfast NPH dose by 2 units'* results in a near normoglycaemic blood glucose profile with a deviation from normoglycaemia (DFN) value [3] of just 0.3 mmol/l.

Figure 1b shows an insulin-dosage optimisation procedure being applied to determine the exact extent of the regimen change required; the NPH injection before breakfast being increased in 1 unit increments until the DFN parameter starts to increase (worsen). Figure 1c displays the final advice once optimisation is complete, along with a simulation of the blood glucose profile which is predicted would result from the implementation of this advice.

DISCUSSION

The system presented here focuses on the adjustment of insulin and/or diet in the insulin-treated diabetic patient. It differs from purely algorithmic and model-based methodologies generally applied for treatment planning by combining rule-based and model-based reasoning to select appropriate control actions. The current version of the system takes account of both insulin therapy and the dietary regimen. However, physical activity, stress and other lifestyle related events are not, at present, included in the prototype as it is assumed that they will remain relatively constant for the duration of the consultation process. Future work will need to address how such factors can be taken into consideration and how the nutritional analysis and dietary planning components of the system, can be more closely linked in with the rest of the prototype. The system is currently undergoing formal testing in the Department of Endocrinology at St. Thomas' Hospital, London.

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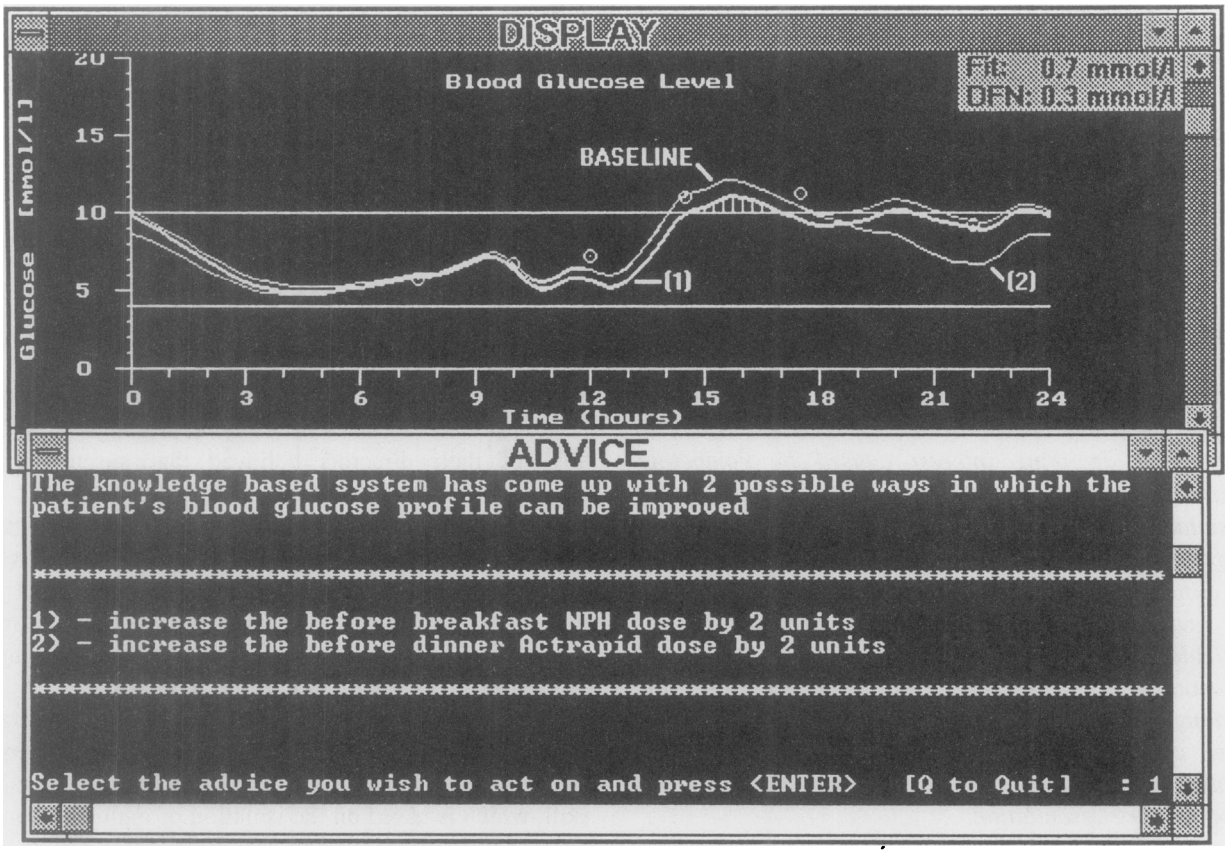

Figure 1a. *Demonstrates the use of the system in a WINDOWS environment. Advice from the KBS to improve the patient's blood glucose profile is shown in the lower window. The glycaemic effect of this advice has been simulated in the upper 'DISPLAY' window where it can be compared with the 'BASELINE' post-parameter estimation simulation.*

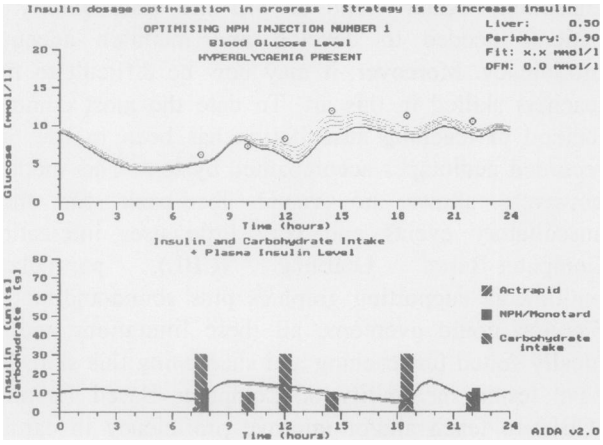

Figure 1b. *Shows insulin-dosage optimisation in progress; the patient's early morning NPH dose being increased in 1 unit increments until the deviation from normoglycaemia starts to increase (worsen).*

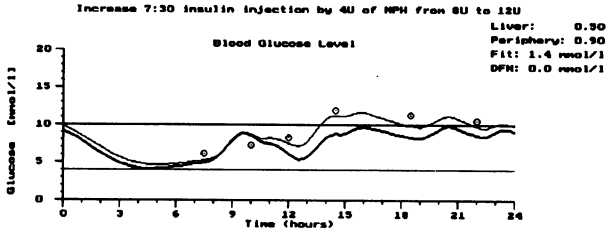

Figure 1c. *Shows insulin-dosage optimisation once complete. The computer's advice is to increase the 7:30am insulin injection by 4 units of NPH from 8 units to 12 units; the normoglycaemia which is predicted to result being clear to see.*

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2. Lehmann ED, Deutsch T. Insulin dosage adjustment in diabetes. *J. Biomed. Eng.* 1992; **14:**243-249.
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