AIDA: An educational simulator of glucose-insulin interaction and insulin dosage & dietary adjustment in diabetes mellitus

Introduction

AIDA is an interactive PC-based freeware computer program, which contains a simple model of glucose-insulin interaction in the human body. It is intended for simulating the effects on the blood glucose profile of changes in insulin and diet for a *typical* insulin-dependent (type 1) diabetic patient.

AIDA is only intended to be used for educational / teaching / demonstration purposes. Given the complexity of the human glucoregulatory system it is not possible for a simple model, such as that contained within *AIDA*, to accurately predict an *individual* patient's blood glucose profile.

AIDA comes with 40 case scenarios, which can be simulated as examples. Further case scenarios can be added by users.

AIDA also contains a very simple knowledge based system, which can identify problems in the displayed case. A list of suggestions, which might correct some of these problems, can also be generated. This list is provided solely as a prompt to the sort of insulin dosage adjustments that users might like to try simulating with *AIDA*.

Case Scenario - 0001 - "Joy Wilson"...

This woman is on three injections of short and / or intermediate acting insulin each day, with a split-evening dose. She wants to start a family, but consistently has had quite high blood glucose levels in the early afternoon, despite numerous attempts to normalize her control in anticipation of becoming pregnant. Clearly she could decrease the amount that she eats, but this would not be ideal during pregnancy. Using *AIDA* it is possible to see if you can adjust her insulin doses to improve her glycaemic control. The image below shows the *AIDA* data entry screen where details of the current regimen are displayed. Information about the dietary intake, insulin dosage regimen and blood glucose measurements are recorded.

These are the input data which will be used by the *AIDA* model. When simulated, two graphs will be shown on the graphical simulator display. The upper graph will show the "observed" blood glucose readings (o) recorded via the data entry screen, while the lower graph will provide a composite display of information regarding insulin and carbohydrate intake. Superimposed on these graphs, as shown below, are the predicted steady state blood glucose and plasma insulin profiles as calculated by the *AIDA* model. Note: *AIDA* can display blood glucose data in both mmol/l and mg/dl – although units of mmol/l are used on this flyer. To convert mmol/l to mg/dl simply multiply the blood glucose values by 18.
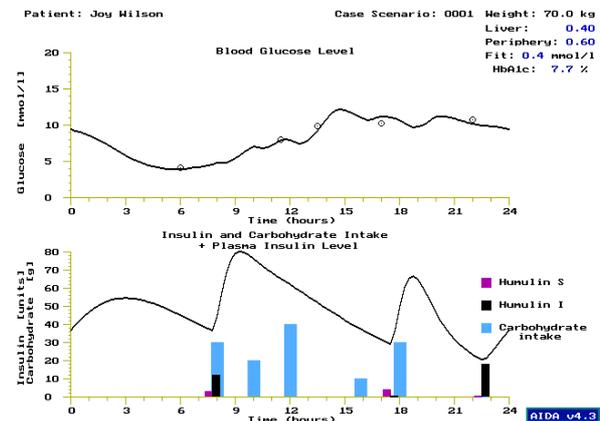
The purpose of *AIDA* is to demonstrate the glycaemic effect of changes in either the dietary intake or insulin regimen – as either a self-learning or demonstration exercise. Having performed a baseline simulation you can change any of the input variables shown on the *AIDA* data entry screen to demonstrate the glycaemic effect of such changes. For example you could simulate what would happen to a hypothetical patient's blood glucose profile if the carbohydrate content of breakfast was increased by 10g or if the supper time Humulin S dose was decreased by 4 units, or the injection time moved earlier or the meal time shifted later. You could replace a split-evening dose insulin regimen with 2 combined injections per day or transfer the patient to Humulin M3 or Mixtard 30/70 in place of the previous short- and intermediate-acting preparations, or perhaps try the case scenario with a 'pen regimen' taking Ultratard nocte and Actrapid three times daily before each main meal. The list of possibilities is endless – a near infinite number of simulations can be performed with *AIDA*.

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Name Joy Wilson          Weight 70.0 kg  Case Number: 0001    AIDA v4.3
Free Text  This woman is on three injections of short and/or intermediate acting
 insulin each day, with a split-evening dose.  She wants to start a family, but
consistently has had quite high blood glucose levels in the early afternoon, des
pite numerous attempts to normalise her control in anticipation of becoming preg
MEALS:          Breakfast     Snack     Lunch     Snack     Supper     Snack
Time (hhmm):      0800        1000      1200      1550      1800       2230
Carbohydrate (g):   30          20        40        10        30         0

INSULIN INJECTIONS:              Number 1  Number 2  Number 3  Number 4
Preparations      Time (hhmm):     0745     1730      2230
Humulin S         dose (U):         3         4        0
Humulin I         dose (U):        12         0       18

GLUCOSTIX MEASUREMENTS:
Time (hhmm):      0600    1130   1330   1700   2200
Glucose (mmol/l):  4.1     8.0    9.9   10.3   10.8

HYPOGLYCAEMIC EPISODES:    Number 1   Number 2     Number 3    Number 4
Time (hhmm):

CLINICAL VARIABLES:        RTG: 9.0 mmol/l        CCR: 100 ml/min

INSULIN SENSITIVITIES:     Hepatic (Sh): 0.4    Peripheral (Sp): 0.6
  Esc=Simulator  F1=Help  F3=Quit  F5=Info  F6=Graphics  F7=Options  F10=Cases
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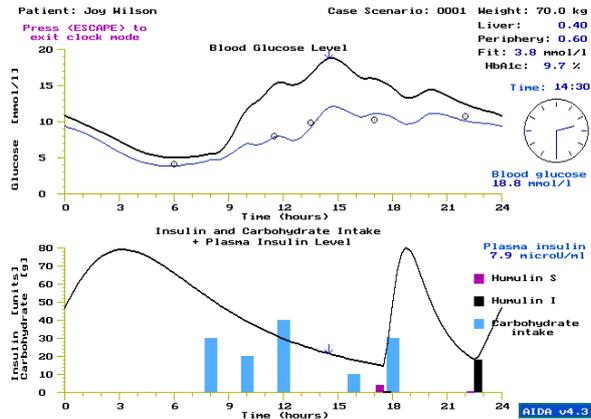
For example we may use *AIDA* to simulate what would happen if Joy forgot to take her morning insulin injection. The image below shows a simulation of the predicted effect on her blood glucose profile. The current (latest) blood glucose simulation is shown as the thicker black line while the previous simulation is shown as a thinner line.


As can be seen, omitting her morning insulin injection would send Joy markedly hyperglycaemic in the afternoon and leave her at significant risk of developing diabetic ketoacidosis. *AIDA* can also be used to simulate the opposite situation where Joy takes her insulin, but rushes off to work without having breakfast. The image below shows a simulation of this situation...
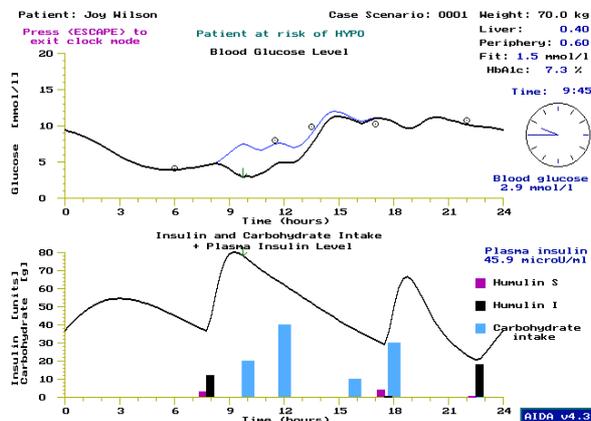
As can be seen, in such a situation Joy would be running a significant risk of hypoglycaemia in the mid-morning. While AIDA, at present, does not include functions for stress or exercise, the exertion of rushing off to work would increase peripheral glucose uptake compounding the low blood glucose predicted to occur during the middle of the morning.

If we wanted to see what the effect might be on Joy's blood glucose profile of halving the carbohydrate content of lunch, this can also be simulated using *AIDA*, as shown opposite. In this case reducing the size of lunch would significantly improve Joy's blood glucose profile later in the day.
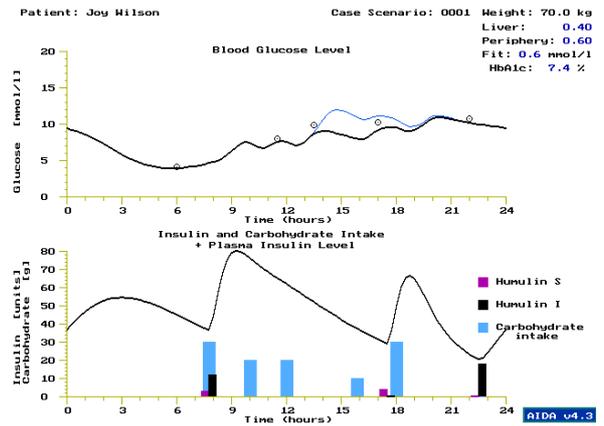
AIDA can do a great deal more than it is possible to show on this flyer. This sheet however is only intended to give you a "flavour" of what *AIDA* can manage. All cases provided within *AIDA* can be experimented with – the intention being to create an educational / learning experience for patients and their relatives, students and possibly health-care workers. Not all the functions incorporated within *AIDA* will necessarily be of use to all users. However, it is hoped that *AIDA* may help improve understanding of the ways in which interactions between insulin and diet can affect the blood glucose profile of insulin dependent (type 1) diabetic patients.

NOTE: *AIDA* is <u>not</u> intended for individual patient glycaemic prediction, individual patient management or therapy planning. Furthermore *AIDA* <u>cannot</u> generate individual patient specific therapeutic advice. Changes in therapy should always be discussed with a doctor.

About *AIDA*

AIDA has been developed by a medical doctor, a computer scientist, and a diabetic patient. It is being made available without charge as a non-commercial contribution to continuing diabetes education.

Both a demonstration version of *AIDA* and the full interactive program can be obtained free of charge via the Internet from:

http://www.2aida.org

Should you not have Internet / Web access, more information about *AIDA* can also be obtained from: **Dr. Eldon D. Lehmann, Department of Imaging (MRU), Imperial College of Science, Technology and Medicine, NHLI Royal Brompton Hospital, London SW3 6NP, U.K.** – or by electronic mail from:

www@2aida.org

To be automatically informed by email when *'AIDA for Windows'* becomes available – please send a blank electronic mail (e-mail) note to *subscribe@2aida.org* to join the very low volume *AIDA* e-mail announcement list.