

Diabetes Information Technology & WebWatch

User Experience with the AIDA Interactive Educational Virtual Diabetes Patient Simulator

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THE PREVIOUS TWO “Diabetes Information Technology & WebWatch” columns have focused on the application of database systems in clinical diabetes care. In this column, and the next two, the focus switches to diabetes education and a topic close to my heart—namely the use of interactive educational diabetes simulators.

One such simulator, called AIDA, which is available for download without charge from the Internet (from: <http://www.diabetic.org.uk/aida.htm>) has been previously described in detail elsewhere in this journal.¹ In this column, various user experience with the software is documented, highlighting some of the different ways in which the simulator has been applied to date by patients with diabetes.

USER EXPERIENCE

A patient writes:

What it does: AIDA is a modeling program that inputs the variables for the management of insulin-dependent diabetes (body weight, insulin, insulin sensitivity, and food as measured in grams of carbohydrate), then graphs the results to show the level of blood glucose control throughout a 24-hour period. Each variable can be altered and then graphed to display the differences in control from the previous simulation. The program’s database includes 40 case studies, each with a different set of variables and each representing a different set of control problems. The user can experiment with each case, adjusting one or all of the variables to see their effect(s) on blood glucose control. The user can even start with a “clean slate,” entering his or her own types of insulin, dosages, times of injection, carbohydrate consumption, meal times, insulin sensitivity, etc. The results can then be saved to the database and reentered and regraphed as desired.

Review: The authors of AIDA describe it as an “educational” tool for assessing the variables of type 1 diabetes self-management, with the goal of achieving good control of blood glucose levels at all times during the day and night. In this they have succeeded to a remarkable degree. AIDA is not just another program to record and graph the user’s personal self-management data; rather it is a serious attempt to help insulin-dependent diabetic patients consider the entire range of factors affecting their blood glucose control.

Dr. Lehmann is a co-developer of the AIDA simulator.

However, the authors caution—repeatedly and in no uncertain terms—that users should not treat the program as a therapy tool. In other words, they should not assume that changing an insulin type or dosage will have the same salubrious (or adverse) effects in the real world as may appear to be the case on the AIDA blood glucose control graphs. Some users may view this as a major flaw. They would, however, be missing the point. The real world knows no “typical” or “model” diabetic patients, only specific ones. Hence AIDA’s authors have not tried to substitute themselves for patients’ own doctors. The program is a teaching tool—nothing more, nothing less.

By contemporary standards, AIDA is neither flashy nor colorful. Nor is the program simple to learn and use. It requires patience. The user manual should be read before proceeding. Screens are dense with text and input boxes, which are accessed serially with the tab (or shift-tab) key (the program is not “mouse-able”). Therefore it is unlikely that many users will be “up and running” with AIDA “right out of the box.”

But despite these minor inconveniences (and despite an inability at present to program the effects of strenuous physical exercise—except by “cheating” by cutting the amount of carbohydrates consumed), AIDA’s rewards are considerable for patients with insulin-dependent diabetes with a little patience and who seek to broaden their knowledge of the aspects of blood glucose control.

David Cohler, South Pasadena, California
(reproduced from Lehmann² with permission)

A patient writes:

I am an adult-onset type 1 diabetic patient diagnosed 15 years ago. Since diagnosis, I have progressed from one injection a day to an intensive, multiple daily injection regime. Recently while that regime—NPH and Humalog (Lispro insulin)—gave pretty good hemoglobin A_{1c} (HbA_{1c}) results, it also gave me a lot of wild swings of hypos and highs. While the averages were staying in the target zones, an awful lot of the actual blood glucose (BG) test readings were way outside. In an attempt to eliminate the swings, my endocrinologist and I decided to switch to a four-injection regime using Humalog and ultralente “to smooth out the peaks.” Initially this appeared to be a complete disaster: I was still getting the swings but the range was even wider than before.

This is where AIDA proved extremely useful. I suspected that many of the highs were in fact rebounds, caused by too much rather than too little insulin. Ultralente’s long duration of action of about 30 hours causes the doses to overlap, making it hard to anticipate its impact at any given time and just where any change in dosage will actually show up. The problem is compounded when fast acting Humalog is added. AIDA, however, indicated just how the ultralente doses overlapped, how the two insulins combined, and just where the dips and peaks were likely to be. It is very difficult to gauge this unless you have a clear idea of the slope and length of the curves. This AIDA showed most graphically.

Of course, this was not a perfect simulation because Humalog (Lispro insulin) has yet to be incorporated and I knew that substituting regular (Humulin R) insulin would not indicate the precise steepness of Humalog’s effect. However it was close enough and did indicate two things I had not suspected before: a high peak BG in the midafternoon, and a very flat line during the night. I checked these out by testing and found both to be the case. I did not put too much credence in the actual BG values predicted but I did find the shape of the curve very helpful. It gave me something to aim at. By substituting different values into the program I was able to get a good idea how the shape of the curve changed and so which injections to vary, and also to anticipate any potential problems. The program certainly

helped me figure out how to get my new regime working. It would have been much more difficult without it, indeed I might have given up and reverted to the old regime, imperfect though it was. I should also add that by using AIDA I was able to visualize a strategy, but before I applied it and made any substantial adjustments I consulted my endocrinologist first.

Inevitably, things are not perfect. Wild BG readings still occur but with a better understanding of the overall picture, control can be restored more quickly, usually in hours, not days. Diabetes is a constant battle. Anything that helps is welcome and I find AIDA certainly helps.

Professor Peter King, Ottawa, Ontario, Canada

A patient writes:

I am a Disabled American Veteran, medically retired from the US Navy. I have been using the AIDA Simulator for the past few months. I have used it about every evening putting in my blood glucose (BG) readings and times, insulin doses and times, times and amounts of carbohydrates for each meal and snack, my weight and times and readings of all hypoglycaemic incidents.

I want to congratulate the developers on producing such a great program that assists in helping the diabetic patient in seeing how "each input" can effect BG levels and overall control of their diabetes.

My diabetes has been extremely hard to control—13 years with BG levels above 200 mg/dL (11.1 mmol/L) and 250 mg/dL (13.8 mmol/L). I was taking 200 units of insulin a day and it was not getting better. Under the direction of a new doctor we decided to go to Rezulin (troglitazone), in September 1998, and my whole life changed. Before that time I could not use the AIDA Simulator because my control (if you call it that) was too erratic. However, with BGs below 120 mg/dL (6.6 mmol/L) the Simulator became a tool to increase my knowledge of how insulin and carbohydrates worked together.

In December 1998, because of my low BGs (below 40 mg/dL [2.2 mmol/L]) brought on by the use of Rezulin, my doctor and I tried everything to bring the "lows" back up to the normal range of between 70 mg/dL (3.8 mmol/L) and 120 mg (dL (6.6 mmol/L). Three times I had accidents that could have resulted in a coma or even death. My insulin was dropped (like the AIDA program suggested) over the months of December 1998, and January, February and March 1999. My insulin intake had dropped from 200 units a day to less than 50 units a day. We were getting control of the "lows."

I took in detailed logs to my doctor in April 1999 and we reduced the insulin again and thought we had it whipped. I fed the details into the AIDA program and it confirmed what the doctor and I thought. Again, not using the program to act on but to confirm and support what my doctor and I thought. Last night I fed in the data again and the program said to "lower" my NPH insulin again. I had another "low" yesterday afternoon and that is what the doctor will do when he sees I am still having some lows.

I use the program as an educator. Something to see all my data at a glance. Something for a "visual" output of all I do in any given day. I have never used it in place of my doctor or his advice. Never! If you remember that the program is only used as a 'guide' in your control of diabetes, the AIDA Simulator will be invaluable!! The program provides 'pointers' for your consideration. I highly recommend the AIDA program to all diabetics—and diabetes educators and doctors as a GREAT learning tool!

Robin M. Smyth, USN (Ret), New Kent, Virginia

A patient writes:

A lot of progress has been made in the treatment of diabetes in recent years. We have outstanding insulins, precise dosing syringes, and pumps. We can measure blood glucose (BG) levels and we know the content of carbohydrates in our food. We know the way insulin and carbohydrates affect BG levels, yet, success in terms of BG control is hard to achieve as we still have to search for a good regimen by trial-and-error, and we remain unsuccessful in many cases.

Why? On the one hand insulin doses and carbohydrates have to be precisely adjusted to one another, and to demand. On the other hand demand, sensitivity, degree of effectiveness, and body-handling differ individually and change regularly or even irregularly. What we are lacking is a quantitative approach that enables us to develop, improve and correct the regimen.

In what follows I offer some suggestions for ways in which patients with diabetes can experiment with the AIDA program.

It may not be easy to understand AIDA at first. It takes some time and effort to become familiar with its functions. Furthermore some people may have difficulties with the graphs and may not know how to deal with them. Moreover, being fed with an individual's data the program may show a BG course that differs from the "real" one in a lot of cases. As a result people may come to the conclusion that AIDA cannot be applied to their own situation. This reaction is understandable, but wrong. People may be disappointed by this at first, but can profit a lot from AIDA even in such cases. AIDA does not simulate all of the individual BG responses but rather a typical, model patient with diabetes. In my view it is an achievement to be able to compare one's own data with a model simulated by AIDA.

The program contains a simple fitting routine to fit its model to individual BG data. This routine does not work with all patients or data but to help it I suggest that patients only enter fasting BG values, all the insulin injections, and all the meals for a single day. Alternatively, they can enter the mean BG values for a week or so to look at a more average response. They can also look at the BG reaction of the AIDA model diabetic, how and when their own data differs from that, and how the differences change if they systematically vary the insulin sensitivities. Users may also find it helps if the liver insulin sensitivity parameter is set smaller than the peripheral insulin sensitivity parameter.

Once patients have compared themselves with the model patient with diabetes they can proceed in several other directions. For example they can look at the twofold task of the liver, which is producing and consuming glucose, dependent on the insulin concentration. This is very important and interesting as it carries a lot of information and is nicely portrayed by AIDA. They can also experiment with different insulin preparations, starting with long-acting insulin—studying the course of insulin concentration on fasting days—and continuing with adding regular, intermediate-acting, and bi-phasic insulin preparations and meals.

The comparison between model patients with diabetes who have different body weights is also very interesting. It is possible to create a fictitious family that consists of mother (50 kg), father (70 kg) and child (35 kg), and using the same amount of long-acting insulin in each case, look at the BG values expected for fasting days. One can also check out the BG levels and variations, and the different reactions to the intake of the same amount of carbohydrate. In this way, it may be possible to gain insights that can help in practice.

Diabetes treatment mainly involves quantitative problems that so far had to be dealt with by trial-and-error. AIDA enables this to be done quasi semi-quantitatively with a model diabetic and with much more understanding. In this respect, AIDA is a playful introduction to quantitative diabetes control. It is not a solution for individual's daily problems, but the program does make a start in the right direction. Some people may be astonished by what

AIDA can offer, others may be disappointed but in my opinion the software is definitely worth experimenting with. If I had owned AIDA 4 years ago I could have saved myself a lot of time and trouble. I really had to compile my knowledge the hard way. It would have been much, much easier with the help of AIDA.

I am certain that diabetes education can be put on a more solid basis with the help of simulation programs like AIDA, and that it will be possible to practice the terrible trial-and-error procedure with more understanding and control. Therefore I hope that AIDA will soon become part of the education of patients, and part of the routine teaching practice of physicians.

Frederick Stevens, Berlin, Germany

A patient writes:

I have type 2 diabetes and sometimes use a small amount of fast-acting insulin to accommodate the carbohydrates in my dinner meal. However, I wanted to know more about insulin as a means for control should my diabetes get worse due to illness or other factors. While the authors make clear that the AIDA model does not cater for endogenous insulin secretion, which occurs in type 2 diabetes, I have nevertheless found the AIDA v4.0 simulator of a "virtual diabetic patient" most informative.

Although one's own body may not be identical, the simulator clearly illustrates the effects of different insulins, different meals, and timing. These are all very important factors to be learned by diabetic patients and care teams. I also found the graphs showing performance of various parts of the body to be quite fascinating. The model incorporates a great deal of useful data.

I personally obtain good control by restricting carbohydrate input and the simulation clearly shows how this reduces insulin needs. My protein food input may be higher than some and I made some attempt to accommodate the steady state effect of this by representing 2 g of dietary protein as equivalent to about 1 g of carbohydrate. I conclude that even for those with type 2 diabetes, the AIDA software provides an effective way for patients and care teams alike to extend their knowledge about controlling the disease.

Derek A. Paice—Palm Harbor, Florida

A patient writes:

I have type 2 diabetes, which is currently controlled by diet and exercise. Although I understand that AIDA was developed with the insulin user in mind, I wanted to see if I could use the software to estimate how various factors might affect my own blood glucose (BG) levels. My "baseline" BG is about 90 mg/dL (5 mmol/L). To follow are a few of the ways in which I have experimented with AIDA v4.0.

The first thing I did was to input zero insulin and 1 g of carbohydrate for a meal, because the program refuses to process starvation, and see what I got. At my weight, that gave me a steady state BG of about 270 mg/dL (15 mmol/L), which is too high. By changing things I was able to see that if I weighed more, I would have a lower steady-state BG, but not low enough. Lowering the renal threshold reduced the BG, but still not enough. So I decided I needed a steady-state "infusion" of insulin.

By trial and error I found that taking between 4 and 7 units of Ultralente every 6 hours would give me a level insulin input and a level background BG, corresponding to my own endogenous insulin output. Depending on the amount of Ultralente input, the sensitivities of the liver and periphery had to be changed to get the background level to match my actual levels. This in itself was very instructive, as I found that changing the sensitivity of the liver had a much greater effect than changing the sensitivity at the periphery. I would have

thought just the opposite, as the amount of glycogen stored in the muscles is much greater than the amount stored in the liver.

Then I started adding food and got the predicted postprandial rises in BG. I then “injected” myself with regular insulin until I found how much I needed to get the postprandial curves to approximate the true curves. One problem here is that the program assumes all meals will be processed at the same rate, so it shows some meals leaving the stomach and peaking at a time when some of my meals would have already peaked and returned to baseline. But it is still fascinating to see.

I find this a lot of fun, and also instructive. I have a “visual memory,” and when I see a picture or graph of something, I can understand and remember it much better.

I tried “eating” some food with no insulin at all, expecting the BG to go up and stay there, but it came down just as if I’d had some insulin. At first I was puzzled, but then I hit the Flux key for analysis and realized that, of course, the kidneys would excrete the excess.

I then tried eating large carbohydrate inputs, similar to those I had eaten before diagnosis, and I could easily see how the kidney was not able to dump the BG from one meal before the second one hit, so the level would stay high.

Another fascinating exercise was adding more and more carbohydrates to a meal and seeing how it takes longer and longer to reach the peak as they are added. Because the trace of the previous simulation remains on screen in a different color, it is easy to see how the changes affect the peak.

I still have not explored all the possibilities of this program, but I find it fascinating and fun as well as instructive, and I eagerly anticipate the time when an expanded version aimed at noninsulin-dependent users, as well as insulin-dependent users, will become available.

Gretchen Becker, West Halifax, Vermont

A patient writes:

AIDA v4.0 is an excellent tool for people with type 1 diabetes who intend to take an active role in managing their disease. The person interested in running a simulation can change the number, type, and quantity of insulin dosage as well as modify carbohydrate intake. By starting with current data, a person can see what takes place if any of these data are changed. For example reducing the number of carbohydrates at lunch and supper.

Even for the computer phobic it is easy to start. At first, I had a minor problem or two. After that, it was easy to run.

The simulation does not take exercise into account. I changed the quantity of carbohydrate to adjust for this. After four modifications of the variables that I could change, I found a reasonable pattern. This permitted me to work with my physician to modify my regimen.

The only other negative is that v4.0 is designed solely for people with type 1 diabetes. All of us type 2s are looking forward to later versions that will permit us to run accurate simulations. Despite these two limitations, I believe that AIDA is as useful as routine blood glucose testing, if not more so, because it permits the operator to graphically see the results of changes without any real world risks.

Robert L. Goldman, Ph.D., San Francisco, California

DISCUSSION

These users all clearly derived benefit from use of the simulator. Their comments also mirror those of independent health-care professionals,³ as well as relatives of patients with diabetes, and other caregivers² that can be found on the Web (<http://www.diabetic.org.uk/aida/review.htm>). However, while intuitively the benefits of such an interactive educational diabetes simulation

approach may seem self-evident, it is acknowledged that formal evaluation studies are still required, as for any other medical intervention, to demonstrate a definite clinical utility for the use of such software.

SYSTEM AVAILABILITY

AIDA can be downloaded, without charge, from the Internet from <http://www.diabetic.org.uk/aida.htm> on the World Wide Web. The program runs on IBM PC or compatible 386/486/Pentium based machines and requires approximately 3 Mb of hard disk storage space. AIDA can also be used on PowerPC Apple Macintosh computers, or older Apple Macs running SoftWindows v2.0 or later. People who wish to be automatically informed about updates and enhancements to the AIDA diabetes software range can subscribe (for free) to the AIDA registration/announcement list by sending a blank e-mail note to aida_simulator-subscribe@listbot.com

FURTHER TOPICS

If you would like to suggest further topics or Web sites for future "Diabetes Information Technology & WebWatch" columns, please e-mail information with a brief description of the site/suggestion to Dr. E.D. Lehmann: aida@globalnet.co.uk (please write Diabetes WebWatch in the subject line). You can also fax information to (503) 218-0828, quoting Diabetes Information Technology & WebWatch.

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