A leap forward in the quest to develop an artificial pancreas

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A diabetes specialist and Artificial Intelligence expert have collaborated to test the prototype of an artificial pancreas. Should a planned clinical study and clinical trial support the excellent 'simulated' results obtained so far, this breakthrough could one day change the lives of millions of people.

People with type 1 diabetes have insufficient levels of insulin producing cells in their pancreas, or none at all, as a result of an autoimmune attack that is not currently preventable. They must inject or infuse insulin several times a day to control their blood sugar levels. This is a very crude substitute for what the body does moment-by-moment when it senses blood sugar and automatically releases the right amount of insulin to control it. Insulin pumps help with management to some extent, but there is much guesswork involved, as insulin values must be entered manually.

High blood sugars cause damage to tissues and organs, and over a lifetime can lead to very serious complications such as kidney failure and blindness.

As a result, research groups around the world are in a race to develop technologies or techniques that will match the body's incredibly sophisticated use of insulin to control blood sugar levels. JDRF, the leading global organisation focused on type 1 diabetes research, has sought to coordinate and accelerate these efforts through the JDRF Artificial Pancreas Project.

Associate Professor Jenny Gunton from Sydney's Garvan Institute of Medical Research and Dr Nigel Greenwood, an Honorary Senior Fellow at the University of Queensland, received an Innovative Grant from JDRF a year ago to carry out initial tests on the prototype already developed by Dr Greenwood.

Dr Greenwood is the founder of the technology company NeuroTech Research Pty Ltd, for which he developed machine intelligence software called 'Neuromathix'. With funding from the directors of his company, as well as some funding from the Queensland government, he built prototypes in 2009/10 of Neuromathix artificial pancreas software.

Greenwood is an applied mathematician with a background in developing machine intelligence software for military aerospace projects and industrial robotics. Such software analyses data, forms 'hypotheses' or possibilities, tests those hypotheses and acts on them, but interacts with people differently from the usual way that has come to be associated with the phrase 'Artificial Intelligence'.

The JDRF-funded project used two virtual or 'simulated' patients, generated by a 'black box' simulator containing the best models of diabetes from the literature, plus typical parameter values for diabetes. These virtual patients' meal data and insulin data were obtained from actual patients with diabetes. This was fed into the simulator, which then generated their blood glucose levels and other medical data as if they were real people.

The patient information was 'interrogated' by the Neuromathix software. To help itself understand what it was observing, the machine-intelligent software generated a further 2,599 possible diabetic profiles to study and control. Out of the maze of outcomes (the diabetes model spans 15 dimensions – and has over 20 parameters that are initially unknown), the software calculated suggested insulin dosages, which were given to the simulated patients. Blood glucose readings were analysed after insulin delivery, over 55 simulated days.

The results of the testing period surprised even Greenwood and Gunton. "Over 55 days of simulated automated insulin therapy, we achieved blood glucose levels within the target interval of 4.4 - 7.8 mmol/L over 90% of the time overall, and we achieved the target 99.8% of the time in the two simulated patients' main case studies, which is extraordinary because the average person with diabetes would be outside that range over 60% of the time," said Greenwood.

"What we have just done couldn't have been done 10 years ago - we are dealing with a profoundly complex model involving many unknowns. For each patient, the software would explore about 15 million different possibilities – so as you can imagine, we relied on high performance computing. We used a desktop supercomputer – something that didn't even exist before 2007."

"The ultimate aim for a 'mechanical cure' for type 1 diabetes would be to have a closed loop system – where you have an insulin pump which knows how much insulin to give at the right time," said Associate Professor Gunton.

"So you have glucose monitoring and insulin administration in the same machine – with very smart pump software keeping people's blood glucose normal."

"The technology we just tested is revolutionary for a whole lot of mathematical reasons – but the point is that it forecasts a completely new approach to programming insulin pumps, with the results from this preliminary grant being extremely impressive."

Greenwood is aiming to reach the market by the end of 2016. He is fundraising at the moment to do a small clinical study next year and a clinical trial in 2014.

"The second trial will be much bigger – we'll be trying to establish not only that our software works on actual people with diabetes, but that it's the best in the world," he said.

JDRF's Head of Research Development Dr Dorota Pawlak said type 1 diabetes is a complex disease that demands coordinated research.

"Combining diabetes expertise with mathematical innovation, this project draws on resources more commonly found in the military or robotics industries, and applies them to the next big diabetes breakthrough, an artificial pancreas."

"This approach to modelling possible human outcomes could expedite some of the lengthy and expensive steps of research that would usually be required."

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