Implantable 'artificial pancreas' could help diabetes patients control their blood sugar

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Living with Type 1 diabetes requires constant monitoring of blood sugar levels and injecting insulin daily. Now scientists are reporting in the ACS journal *Industrial & Engineering Chemistry Research* the development of an implantable "artificial pancreas" that continuously measures a person's blood sugar, or glucose, level and can automatically release insulin as needed.

Type 1 diabetes, previously known as juvenile diabetes, affects about 1.25 million Americans. About 200,000 of them are under 20 years old. The condition arises when a person's own immune system destroys the pancreas cells that make insulin, the hormone that converts blood sugar into energy. To make up for this loss of insulin production, patients must take insulin daily. Current delivery methods involve multiple daily injections or insulin pump therapy, both requiring the user to actively track glucose and calculate the needed insulin dose. There is also a significant time lag between when a dose is needed and when it can take effect. Francis J. Doyle III and colleagues wanted to find a way to make monitoring and insulin delivery automatic and needle-free.

The researchers designed an algorithm that monitors blood sugar levels and computes an insulin dose that it delivers quickly and automatically when necessary. The algorithm is designed to work with implanted devices, specifically with an artificial pancreas, and would overcome the delays experienced with current devices. Computer testing of the algorithm simulated the rise and fall of glucose that would correspond to meals and an overnight period of sleep. The artificial pancreas

maintained blood glucose within the target range nearly 80 percent of the time. The researchers say they will soon test the device in animals.

More information: Design and Evaluation of a Robust PID Controller for a Fully Implantable Artificial Pancreas, *Ind. Eng. Chem. Res.*, Article ASAP. DOI: 10.1021/acs.iecr.5b01237

Abstract

Treatment of type 1 diabetes mellitus could be greatly improved by applying a closed-loop control strategy to insulin delivery, also known as an artificial pancreas (AP). In this work, we outline the design of a fully implantable AP using intraperitoneal (IP) insulin delivery and glucose sensing. The design process utilizes the rapid glucose sensing and insulin action offered by the IP space to tune a PID controller with insulin feedback to provide safe and effective insulin delivery. The controller was tuned to meet robust performance and stability specifications. An anti-reset windup strategy was introduced to prevent dangerous undershoot toward hypoglycemia after a large meal disturbance. The final controller design achieved 78% of time within the tight glycemic range of 80–140 mg/dL, with no time spent in hypoglycemia. The next step is to test this controller design in an animal model to evaluate the in vivo performance.

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