Automating Glycemic Management in Diabetes Mellitus with a Bionic Pancreas

Steven Jon Russell

Diabetes Research Center, Harvard Medical School, Massachusetts General Hospital, Boston, Massachusetts, United States of America

An artificial or bionic pancreas combines a continuous glucose monitor, mathematical algorithms, and drug delivery pumps to automatically regulate blood glucose levels for patients with diabetes mellitus (1,2). Our bihormonal bionic pancreas delivers both insulin and glucagon under the control of autonomously adaptive algorithms that require no information about the patient other than body weight to start, and can quickly adapt to changing insulin needs (3). No carbohydrate counting is required, and qualitative meal announcements are optional. If continuous glucose monitoring is interrupted, intermittent glucose measurements can be substituted until continuous monitoring is reestablished. The bionic pancreas achieved lower mean glucose values with less hypoglycemia vs. conventional insulin pump therapy or sensor augmented pump therapy in volunteers with type 1 diabetes ranging in age from 6 to 76 years in outpatient settings, including diabetes camp studies in adolescents and pre-adolescents and a home use study in adults (4,5,6). For nearly all subjects, the bionic pancreas achieved mean glucose values below those recommended by professional societies for optimal prevention of microvascular complications. Equally important, the bionic pancreas drastically reduces the burden of diabetes management, increases user satisfaction, and reduces diabetes-related distress when compared to usual care. Use of micro-dose glucagon is well tolerated and is not associated with any reduction in effectiveness or adverse safety signals in studies up to 11 days in length.

Approval of a bihormonal system will require approval of a stable glucagon or glucagon analog for chronic intermittent use. There are at least two stable glucagon formulations or analogs that are in clinical trials and could be used in the bionic pancreas in the near term. An insulin-only version of the system is also able to provide effective glycemic regulation, but with modestly higher amounts of hypoglycemia when obtaining the same mean glucose achieved (7). Pivotal registration trials designed to support approval of a fully integrated bionic pancreas device (the iLet) by the U.S. Food and Drug Administration are planned for 2017 with the goal of availability to patients as early as 2018 for the insulin-only system and as early as 2019 for a bihormonal system. The size and duration of the trial for the bihormonal system is largely determined by the requirements for approval of glucagon for chronic intermittent administration.

Automated glucose control may have utility in other patient populations. A preliminary study suggest that the insulin-only version of the bionic pancreas may be effective in the treatment of patients with type 2 diabetes using multiple daily injections of insulin (unpublished data). A glucagon-only version of the device dramatically reduced hypoglycemia in patients managing their own insulin therapy (8) and may be useful in treating post-bariatric hypoglycemia and congenital hyperinsulinism. Future studies with the bionic pancreas will include these populations, as well as specialized populations of patients with type 1 diabetes, including very young children, newly diagnosed patients, the elderly, and patients with severe hypoglycemia unawareness.

Automated glycemic management with a bionic pancreas is feasible and is likely to change the clinical management of patients with insulin-requiring diabetes within the next five years.

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