Bionic Insulin Pump

Type 1 diabetes (T1D) is a process that results in the irreversible destruction of insulin-producing beta cells by an individual’s own immune system. The resulting need for lifelong insulin management requires a staggering amount of attention and care. Decisions must be made on a minute-to-minute daily basis, about how to juggle insulin to match unpredictable factors like stress, illness, food, activity, all of which have meaningful effects on blood sugar. It’s no surprise that people with T1D are often unsuccessful in achieving and maintaining the recommended control of their diabetes.

In addition to being very difficult to achieve, the inability to regulate blood sugars precisely has very serious consequences: in the short-term, low blood glucose levels (hypoglycemia), which can cause seizures, unconsciousness, brain damage or death. The cumulative consequences include serious damage to the circulatory system, excretory system, eyes, and nerves.

Thus, it is of great interest to make insulin therapy safer and less burdensome while we develop a cure for T1D. Our goal is to regulate blood glucose similar to the pancreas using a bi-hormonal pump. My proposal focuses on two technologies to regulate blood sugar and mitigate the threat of hypoglycemia. The first pertains to glucose-responsive insulin (GRI), or “smart insulin” analogs. These are a novel class of insulin analogs that contain a glucose-regulated conformational switch that allows insulin to be active after a meal and then inactive as blood glucose levels decrease. This mechanism will lead to an appropriate level of insulin action released from a bi-hormonal pump to maintain metabolic homeostasis. Additionally, use of GRIs in insulin pumps (especially in closed-loop systems) would enhance time in range.

The second strategy focuses on novel glucagon analogs. Glucagon is a hormone that functions to maintain physiological blood sugar levels. However, it forms inactive clumps called amyloid fibrils when stored as a liquid. I want to make it ultra-stable and ultra-concentrated in the pump reservoir. Such pump-compatible glucagon analog formulations would enable use of bi-hormonal pumps to mitigate hypoglycemic episodes. These two technologies, if used together, could essentially eliminate hypoglycemic episodes in T1D patients using closed-loop systems. The success of either goal would be transformative.

My expectation is that our novel bi-hormonal pump system could operate without the needs of additional glucose-detecting devices. We will reduce the risks of short and long-term complications of T1D, and ultimately, our smart and safe system serves as a native-like pancreas for T1D people.