Evaluation of a Novel Artificial Pancreas: Closed Loop Glycemic Control System With Continuous Blood Glucose Monitoring


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Summary

[Background and objectives]
A closed-loop glycemic control system using an artificial pancreas has been applied with many clinical benefits in Japan since 1987. To update this system incorporating user-friendly features, we developed a novel artificial pancreas (STG-55). The purpose of this study was to evaluate STG-55 for device usability, performance of blood glucose measurement, glycemic control characteristics in vivo in animal experiments, and evaluate its clinical feasibility.

[Materials and Methods]
In order to compare usability improvement based on the design concepts between STG-55 and clinically available artificial pancreas system in Japan (control device: STG-22), we made table for technical specifications, such as compactness for size, weight, reduction of the preparation time, guidance function, and so on. To clarify the accuracy of blood glucose measurement, in-vivo animal studies using six healthy beagle dogs were conducted. Blood glucose concentrations were simultaneously measured by both artificial pancreases that were attached to the same vein as close as possible. We examined correlations of both blood glucose levels between two groups using Clarke’s error grid analysis. And also we conducted animal experiments using three dogs to compare mean glucose infusion rate (GIR) during glucose clamp.

[Results]
The results showed strong correlation in blood glucose concentrations (Pearson’s product-moment correlation coefficient: 0.97; n = 1636). Clarke’s error grid analysis showed that 98.4% of the data fell in Zones A and B, which represent clinically accurate or benign errors, respectively. The mean GIRs during the last 30 minutes of the glucose clamp (mean ± SD; n = 77) were 12.63 ± 1.76 mg/kg/min with control, and 12.81 ± 1.33 mg/kg/min with STG-55. The difference in mean GIRs was less than 0.2 mg/kg/min, which was considered not significant. Clinical feasibility study demonstrated sufficient glycemic control maintaining target glucose range between 80 and 110 (mg/dL), and between 140 and 160 without any hypoglycemia.

[Discussion]
Regarding the improvement from the conventional device, we additionally described new features like LCD touch monitor, and data transportation via a USB memory. Streamlining disposable parts and newly developed glucose sensor make it possible to reduce preparation time.

According to the results by Clarke’s error grid analysis, we found clinically acceptable correlation between STG-55 and control device. Some of the literatures showed error margin of blood glucose should be within 15-20%.

However, it is known that canine blood has different characteristics comparing human blood because of differences in size and thickness of red blood cells (RBCs), and glucose permeability in RBCs. Some researcher shows the difference between STG-22 and hexokinase method as a conventional standard for blood glucose measurement using canine blood, and he also indicates no significant difference between STG-22 and hexokinase method measurement using human blood at the same experiment. We chose STG-22 as a control because STG-55 adopted same glucose sensing methodology as STG-22 and both are continuously measured device for blood glucose.

We also compared GIRs for measured data with both devices, Paired t-test showed no significant difference. Because the blood glucose (BG) for both devices maintained constant during the clamp, standard deviation (SD) and coefficient of variance (CV) were found very small values. Therefore we can consider that both devices have sufficient performance in terms of blood glucose management.

[Conclusion]
A novel artificial pancreas, STG-55 showed improvement of usability and comparable performance with the control device (STG-22) regarding accuracy of blood glucose measurement and glycemic control infusing insulin and glucose. Clinical evaluations using STG-55 indicated stable and safe glycemic control according to targeted blood glucose range. A closed-loop glycemic control system with STG-55 would be a useful tool for surgical and critical patients in intensive care units, as well as diabetic patients.