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Research on Real-time Monitoring Technology of Blood Glucose Fluctuation of Patients With Hyperglycemia in Perioperative Period

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Abstract: Diabetes is one of the chronic diseases with increasing morbidity in the world, technological advances in the field of diabetes prevention offer many new ways for clinicians to treat this challenging disease. For example, the emergence of CSII improves the infusion of insulin. Moreover, the development of continuous blood glucose monitoring provides patients and doctors with a better way to understand the changes in blood glucose levels in patients with hyperglycemia, which can be used to adjust the dose of insulin infusion. The combination of these devices and Care Link software is real-time dynamic blood glucose monitoring - Sensor Augmented Pump (SAP) treatment, which becomes the main building block that can be developed in artificial pancreas (closed loop systems); This paper summarizes the progress of SAP treatment and its application prospects in the management of a new generation of hyperglycemia patients.

Keywords: Real-time dynamic blood glucose monitoring; Patients with hyperglycemia; Perioperative period; Blood glucose fluctuation

1. Introduction

Nowadays, diabetes and its various acute and chronic complications have become one of the most serious diseases affecting human health. Disability and death in diabetic patients are caused by poor long-term blood glucose control. In order to achieve high blood glucose levels and ideal conditions, only strict control of blood glucose can effectively reduce and delay the occurrence of chronic complications of diabetes. This recognition comes from the results of large-scale clinical research. Diabetes is a worldwide clinical epidemic, and about 50% of diabetic patients need more than one surgical treatment in their lifetime. The perioperative complications and mortality of diabetic patients are about 5 times higher than those of non-diabetics. In order to improve the success rate of surgery, reduce the incidence of complications of perioperative diabetes and reduce the risk, it is the key to control the blood glucose before and after surgery.

Among them, diabetes control and complication test is the largest research in the field of diabetes treatment. In the study of real-time monitoring techniques for blood glucose fluctuations, intensive insulin therapy can significantly reduce the percentage of risk of various complications in diabetic patients compared with traditional diabetes treatment. Because those people enrolled in the study were younger, the 6.5-year follow-up was still defective. Subsequently, a 17-year follow-up on those people was taken by the real-time monitoring technology of blood glucose fluctuations. It is found that patients who were treated with intensive insulin therapy can also reduce the risk of cardiovascular complications by 42% [1].

2. The Accuracy Analysis of Blood Glucose Values Displayed by Real-time Monitoring Technology (SAP)

Real-time monitoring technology for blood glucose fluctuations include real-time dynamic blood glucose monitoring technology, insulin pump infusion insulin technology, and Care Link software.

Real-time monitoring technology for blood glucose fluctuations is an epochal technology in the process of diabetes diagnosis and treatment, which can make medical staff, patients and relatives know the dynamic blood glucose changes of patients in one to three days. In theory, there are two methods for sensor implantation, non-invasive and minimally invasive methods. The non-

invasive method senses the blood glucose information of diabetic patients through electromagnetic wave radiation. The accuracy of the blood glucose value perceived by this method is relatively poor and has not been clinically adopted. The minimally invasive method implants the probe of the blood glucose sensor probe into the subcutaneous tissue of the patient's abdomen and the upper arm deltoid muscle, and perceives the blood glucose concentration in the subcutaneous tissue of the implanted site, and download graphics and generate reports on the computer through the relevant software. Minimally invasive method has a good prospect in clinical applications because of safety, minimally invasive, and can provide comprehensive information ; The probe of real-time monitoring technology for blood glucose fluctuations is relatively thin, and when implanted under the skin, there is just a little uncomfortable feeling to the patient, Therefore, it basically does not affect the daily activities of the patient. And when used extensively in clinical practice, the blood glucose monitored has good accuracy and good performance. Therefore, it can be used clinically to assist medical staff in adjusting blood glucose control programs[2].

This monitoring technology is currently widely used in clinical practice. For example, to discover the changing rules in the individualized blood glucose of diabetic patients, to educate patients with vivid images, and to evaluate the effects of various clinically controlled blood glucose treatments. Also, the relationship between different types of diet, different strengths of exercise and blood glucose can be found out. Its most important application value is to help critically ill patients control blood glucose, which generally requires total parenteral nutrition (TPN). Also, it is helpful for the recovery of critically ill patients. Real-time dynamic blood glucose monitoring can not only download graphics through Care Link software to understand the overall blood glucose fluctuations of diabetic patients, but also to check the patient's blood glucose at any time. Because it can display a blood glucose level and blood glucose development trend in real time on the insulin pump display screen every 5 minutes, as well as high and low blood glucose alarms. Because of these advantages, we can not only deal with high and low blood glucose in a timely manner, but also prevent excessive hyperglycemia. In addition, we can comprehensively evaluate patients with pumps and find out the difficulties and causes of blood glucose control throughout the day. Therefore, it is more reasonable to adjust the basal rate and the pre-prandial large dose. On this basis, the treatment plan can be adjusted in a targeted manner, and the blood glucose can be controlled safely and finely within the target or ideal range [3]. As shown in Table 1:

Table 1. Analysis of Infection Rate and Incidence of Hypoglycemia in Patients With Surgical Incision

Groups	n	Incision infection rate	The incidence of hypoglycemia
SAP group	90	3.50%	2.70%
CSII group	130	11.80%	9.90%
P value		0.003	0.004

China 722 insulin pump system registration clinical study results show that 722 pumps have good accuracy in Chinese patients. At present, the three statistical methods for evaluating the best accuracy of a blood glucose monitor are: consistency rate analysis, the probe value is compared to the YSI value, in the range of 20% or 30% deviation, 8.3% of the probe value is within 20% of the deviation, and 95.7% of the probe value is within 30% of the deviation. Clarke Error Grid Analysis: 48 T1DM and T2DM patients were worn for 3 consecutive days, arbitrarily selected for 3 days during the wear, and venous blood was taken every 15 minutes for 7 consecutive hours and tested with YSI, 99.1% of the YSI-probe pairing data values fall in Zones A and B, and this result exceeds the accuracy threshold sufficient to meet clinical needs; ARD: the ratio of the absolute difference between the probe value to the venous blood (YSI) value to the YSI value; ARD: The venous blood glucose value is about 10.4% compared with the probe value. This result is better than most of the current CGMS accuracy studies. As shown in Table 2:

Table 2. Analysis of Blood Glucose Fluctuations and Insulin Dosage

Groups	n	Average blood glucose fluctuation	Insulin dosage
SAP group	90	2.35±0.44	52.21±0.74
CSII group	130	3.53±0.54	53.31±0.93
P group		0.031	0.084

According to the experimental results published by EASD: 16 diabetic patients were selected to wear SAP, and each probe was worn for three days. After the probe expires, replace the probe again and take venous blood every 30 minutes. The results showed good agreement between the probe value and the venous blood value. In the Clare error grid analysis, A+ B = 96.0%. This study fully demonstrates that the interstitial fluid glucose concentration sensed by the Medtronic sensor probe is a

good response to blood glucose levels. As shown in Table 3 below.

Table 3. Analysis of Preoperative Hospitalization Days, Time of Reaching Target of Glucose, and Postoperative Incision Suture Removal Time

Groups	n	preoperative hospitalization days	time of reaching target	time of stitches removal
SAP group	90	2±0.21	2±0.32	9±0.32
CSII group	130	4±0.33	4±0.45	13±0.45
P group		0.034	0.037	0.041

3. Progress in Clinical Application of Real-time Monitoring Technology for Blood Glucose Fluctuation (SAP)

3.1. Application in patients with type 1 diabetes (T1DM)

In the history of long-term insulin-enhanced hypoglycemic therapy, patients are experiencing the danger of hypoglycemia. In particular, patients with T1DM who are more sensitive to insulin have at least 10 episodes of symptomatic hypoglycemia every week, and at least 1 severe hypoglycemia occurs each year. The risk of hypoglycemia is obvious, it can cause 2%-4% of patients with type 1 diabetes to die; Intensive insulin therapy is also used to control blood glucose. T2DM patients have had hypoglycemia in the proportion of 70%-80%; Although intensive therapy can better control the patient's blood sugar, it also leads to a significant increase in the risk of hypoglycemia [4].

Most T1DM patients are adolescents and children, whose body size is relatively thin. And the patient's islet B cells are severely damaged and basically destroyed. The insulin release test results curve level is basically low. Because the patient is particularly sensitive to insulin, and their blood glucose fluctuates greatly and is not easy to control. The conventional blood glucose monitoring requires more frequent monitoring and still does not well reflect the patient's blood glucose fluctuations. Moreover, it has obviously increased the suffering of the patients, causing some patients, especially children, not to cooperate well.

3.2. Effect on blood glucose control in patients with type 2 diabetes (T2DM)

In the past, the traditional treatment mode for type 2 diabetes was “ladder therapy,” and insulin use was often a “last choice”. In recent years, medical experts at home and abroad have become more active in the treatment of insulin in type 2 diabetes. Studies have shown that early application of insulin can not only make blood glucose meet the standard as soon as possible, reduce hyperglycemia toxicity, but also protect and repair islet cell function, effectively delay the occurrence of chronic complications of diabetes. Recent studies have also found that after 2 weeks of intensive treatment of newly diagnosed type 2 diabetic patients, some patients can be treated with no medication, and can maintain blood glucose stability for a period of time only through diet control and exercise. Some patients who have reduced the effectiveness of sulfonylureas have a function of islet B cells after a period of insulin treatment, and can take oral hypoglycemic agents and stop taking the pancreatic hormone.

Foreign studies have shown that after applying SAP therapy in patients with T2DM, the device can display blood glucose values in real time, as well as high and low blood glucose warning functions. The trend and rate of blood glucose development can be reflected indirectly through these alarm functions. By analyzing the relationship between blood glucose levels at different time points and time periods and Hb Al C, fluctuations in blood glucose levels, blood glucose fluctuations can be understood in detail. The level of Hb A1C is closely related to the average level of blood glucose throughout the day, and fluctuations in postprandial and nocturnal blood glucose can affect intraday blood glucose fluctuations. According to these observations, it can guide more precise adjustment of the basal rate of insulin pump and large dose before meal, and smoothly control blood glucose. Its various alarm functions, the most used are high and low blood glucose alarms, preventing and reducing the occurrence of potential accidental risks such as hypoglycemia. Studies have shown that the blood glucose level of the day after the application of SAP treatment is significantly improved, and can reduce the amount of insulin in the future, which is conducive to long-term control of blood glucose at the target level. The ultimate goal is to achieve as much as possible to delay and reduce the effects of various complications of diabetes[6].

3.3. Further improvement and prospect of real-time monitoring dynamic blood glucose monitoring technology (SAP)

At present, SAP has been widely used in clinical work to control blood glucose, and its importance in the treatment of clinical endocrinology is gradually shown. However, the system needs to provide more convenience to the majority of patients and needs further development and improvement: First, SAP needs to input the blood glucose level measured by the blood glucose meter to correct it. If the blood glucose meter is not accurate enough, its accuracy will be affected. In addition, most widely used SAP instruments are imported from abroad. The screen displays English, and the input of data and the

handling of various alarms require even a period of training for doctors in the endocrinology department. For patients with low education and poor acceptability, it is more complicated, which makes it difficult for clinical staff to promote this advanced treatment method [7].

The SAP integration system is the first step toward the artificial pancreas. If the artificial pancreas is successfully developed, it will bring good news to the majority of diabetic patients. It will go through three stages, currently in the open loop phase, the integration of monitoring and treatment, and the combination of insulin pump and real-time dynamic blood glucose monitoring technology has enhanced blood glucose data management capabilities; The immediate goal is to enter the semi-closed phase, the transition phase, with ideal detector technology and a semi-closed loop system with insulin infusion calculation capabilities; The fully automatic closed-loop insulin infusion system will appear in the near future.

4. Conclusion

Perioperative hypoglycemic therapy in patients with hyperglycemia is a short-term process compared to the treatment of diabetes in patients with diabetes for life. In this short-term treatment process, although there are more cases of doctors ward rounds, it requires medical staff to invest more time and energy, which brings great benefits to patients with diabetes treated by surgery. Because this treatment method is currently the most advanced treatment method in the world, and does not increase the patient's insulin dosage and total medical expenses, it also significantly improves the perioperative blood glucose compliance rate and better control of blood glucose. What's more, it significantly reduces the incidence of hypoglycemia and the risk of surgery, and helps patients with hyperglycemia to successfully pass the perioperative period, which has high clinical application value.

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