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Effects of Insulin Pump-enhanced Hypoglycemic Control on Blood Glucose and Lipid Metabolism in Patients with First-onset Type 2 Diabetes

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Abstract: *Objective:* To analyze the effect of intensive hypoglycemic treatment with insulin pump on blood glucose and lipid metabolism levels in patients with new-onset type 2 diabetes. *Methods:* From January to December 2024, 80 patients with new-onset type 2 diabetes were selected for data analysis in our hospital. They were divided into groups using a random number table, with 40 patients in each group. The research group was treated with an insulin pump for intensive hypoglycemic treatment, and the control group was treated with routine subcutaneous injection of insulin aspart. The data between the groups were compared. *Results:* Compared with the control group, the blood sugar of the study group was significantly lower after treatment, TC, TG and LDL-C were significantly lower after treatment, and HDL-C was significantly higher after treatment, $p < 0.05$; compared with the two groups before treatment, blood sugar, TC, TG, LDL-C and HDL-C were significantly lower, $p > 0.05$. *Conclusion:* Patients with first-onset type 2 diabetes are treated with intensive hypoglycemic treatment using insulin pumps. After treatment, their blood sugar is significantly lower. After treatment, TC, TG and LDL-C are all significantly lower. After treatment, HDL-C is significantly higher. It is worthy of clinical promotion and use.

Keywords: Initial onset of type 2 diabetes; Insulin pump intensive hypoglycemic control; Blood glucose; Lipid metabolism level

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1. Introduction

With changes in lifestyle and the aging of the population, the incidence of type 2 diabetes has been increasing year by year, posing a serious threat to public health [1]. Although patients with first-onset type 2 diabetes have a short course of disease, they already have obvious insulin resistance and islet beta cell dysfunction.

They need to provide effective hypoglycemic treatment. Otherwise, the patient's blood sugar will continue to rise, induce lipid metabolism disorders, and the risk of chronic complications such as diabetic nephropathy and cardiovascular disease will increase significantly. The quality of life and long-term prognosis will be seriously affected. Based on this, clinical recommendations are to quickly and steadily control the blood sugar of patients in the initial stage of the disease, and improve lipid metabolism, which can protect the patient's islet function and delay the progression of the disease. Currently, a variety of clinical methods can be used to treat patients with new-onset type 2 diabetes [2].

The commonly used method is routine subcutaneous injection of insulin aspart. Although it can control the patient's blood sugar to a certain extent, it has problems such as frequent injections, large blood sugar fluctuations, and easy occurrence of hypoglycemia, and the improvement of the patient's lipid metabolism is limited [3].

Clinical research on intensive hypoglycemic therapy with insulin pumps can simulate physiological insulin secretion patterns and continuously infuse patients with subcutaneous insulin, which can more accurately control patients' blood sugar levels. However, current clinical research in this area is not extensive, especially the clinical evidence of its impact on patients' blood sugar and lipid metabolism, which still needs to be further enriched. This article selects 80 patients with first-onset type 2 diabetes and analyzes the application value of intensive insulin pump therapy in the treatment of first-time type 2 diabetes.

2. Materials and methods

2.1. General information

From January to December 2024, 80 patients with new-onset type 2 diabetes were selected for data analysis in our hospital. They were divided into groups using a random number table, with 40 patients in each group.

The study group was 30/10 men and women, aged 35–69 (49.25 ± 5.21) years old, and the control group was 31/9 men and women, aged 34–68 (49.21 ± 5.25) years old. Comparison of the two sets of data resulted in $p > 0.05$.

2.1.1. Inclusion criteria

(1) Consistent with disease diagnostic criteria;
(2) Mentally normal with cognitive and thinking abilities;
(3) Informed consent of the patient.

2.1.2. Exclusion criteria

(1) People with mental illness and communication difficulties;
(2) Presence of malignant tumors or other serious diseases;
(3) Presence of severe diabetes-related complications;
(4) Use of insulin 1 month before the study;
(5) Incomplete clinical data.

2.2. Method

In the control group, insulin aspart was injected subcutaneously before three meals, with an initial dosage of 0.5 U/kg. The dosage was adjusted based on the patient's blood glucose monitoring results.

The research group applied insulin pump to intensive hypoglycemic treatment, that is, administered through an implanted insulin pump. The initial dosage was 0.3 to 0.5 U/kg·d, of which 50 to 60% was used as the basic dose, and the remaining dosage was injected before three meals. The treatment time for both groups of patients was 2 weeks.

2.3. Observation indicators

(1) Compare the blood glucose levels of the two groups: FBG, 2hPBG, and HbAlc.
(2) Compare the blood lipid levels of the two groups: TC, TG, LDL-C, and HDL-C.

2.4. Statistics

Use statistical SPSS 28.0 software to complete data calculations. Use ($\bar{x} \pm s$) to describe measurement data and perform t-tests. Use (%) to describe count data and perform χ^2 tests. $p < 0.05$ indicates statistical significance.

3. Results

3.1. Blood sugar level

There was no significant difference in blood sugar levels between the two groups before treatment, $p > 0.05$; after treatment, compared with the control group, the blood sugar levels of the study group were lower than those of the control group, $p < 0.05$. See **Table 1**.

Table 1. Comparison of blood sugar between two groups ($\bar{x} \pm s$)

Group	FBG (mmol/L)		2hPBG (mmol/L)		HbAlc (%)	
	Before treatment	After treatment	Before treatment	After treatment	Before treatment	After treatment
Research group (n = 40)	10.02 ± 0.82	7.05 ± 0.74	17.19 ± 1.31	12.01 ± 0.95	10.14 ± 0.95	7.06 ± 0.68
Control group (n = 40)	10.07 ± 0.85	7.51 ± 0.75	17.22 ± 1.36	12.57 ± 1.08	10.11 ± 0.91	7.48 ± 0.77
t	0.2677	2.7613	0.1005	2.4623	0.1442	2.5858
p	> 0.05	< 0.05	> 0.05	< 0.05	> 0.05	< 0.05

3.2. Blood lipid levels

There was no significant difference in blood lipid levels between the two groups before treatment, $p > 0.05$; after treatment, compared with the control group, the TC, TG and LDL-C indicators of the study group were significantly lower, and HDL-C was significantly higher after treatment, $p < 0.05$. See **Table 2**.

Table 2. Comparison of blood lipid levels between the two groups ($\bar{x} \pm s$, mmol/L)

Group	TC		TG		LDL-C		HDL-C	
	Before treatment	After treatment	Before treatment	After treatment	Before treatment	After treatment	Before treatment	After treatment
Research group (n = 40)	6.23 ± 0.66	4.51 ± 0.52	2.14 ± 0.25	1.71 ± 0.17	3.52 ± 0.36	2.92 ± 0.38	0.81 ± 0.08	1.16 ± 0.11
Control group (n = 40)	6.29 ± 0.65	5.48 ± 0.57	2.17 ± 0.23	1.98 ± 0.21	3.49 ± 0.35	3.23 ± 0.33	0.80 ± 0.07	0.92 ± 0.11
t	0.4096	7.9512	0.5585	6.3202	0.3779	3.8956	0.5950	9.7574
p	> 0.05	< 0.05	> 0.05	< 0.05	> 0.05	< 0.05	> 0.05	< 0.05

4. Discussion

Type 2 diabetes is the most common chronic metabolic disease in recent years. Patients with initial onset of type 2 diabetes have blood sugar disorders. Through the interaction of glucose and lipid metabolism, lipid abnormalities occur, the decline of pancreatic islets is accelerated, and patients are prone to vascular complications. In clinical treatment of patients' conditions, it is not only necessary to quickly control blood sugar, but also to improve lipid metabolism and protect pancreatic islet function. Clinical research: Conventional subcutaneous injection of insulin aspart is not strong in simulating physiological secretion, maintaining blood sugar homeostasis, and regulating lipid metabolism. Therefore, this article studies the effect of insulin pump on enhanced hypoglycemic treatment.

The results of this study show that after 2 weeks of treatment, the blood glucose indicators and TC, TG, and LDL-C levels of the study group were significantly lower than those of the control group, and the HDL-C level was significantly higher than that of the control group ($p < 0.05$). The reason for analysis: Analyzing from the perspective of blood sugar control, the above results produced a unique treatment model for insulin pumps. Physiological insulin secretion involves two parts, namely basal secretion and prandial secretion [4]. The former's continuous and stable secretion can effectively suppress liver glucose output and effectively maintain the stability of patients' fasting and pre-meal blood sugar. The latter increases rapidly after eating to match the post-meal blood sugar peak and avoid excessive blood sugar fluctuations. Conventional insulin aspart subcutaneous injections are used for patients. Although injections before three meals can simulate mealtime secretion, there is no continuous basal insulin supplement [5]. When the patient is injected, factors such as the injection site and subcutaneous fat thickness will greatly affect the insulin absorption rate. Patients are prone to excessively high or low peak blood concentration, poor fasting blood sugar control, or large fluctuations in blood sugar after meals. At the same time, when patients are given routine injections, in order to achieve the ideal therapeutic effect, the total dosage of insulin needs to be increased, which increases the risk of hypoglycemia. Hypoglycemia can induce rebound hyperglycemia, further aggravating blood sugar fluctuations, forming a vicious cycle [6].

Through continuous subcutaneous infusion, the insulin pump can accurately simulate the physiological secretion of the human body. According to the characteristics of blood sugar fluctuations, basal insulin can set a multi-period infusion rate to accurately suppress the patient's liver sugar output, stabilize fasting blood sugar, and adjust the dosage of mealtime insulin in real time according to the number of meals, so that the peak blood concentration is synchronized with the peak of postprandial blood sugar. The patient's postprandial blood sugar increase is significantly reduced, and the insulin dose is accurate to 0.1 U. Fine-tuning based on blood sugar monitoring results can provide individualized treatment for the patient [7]. In this study, FBG, 2hPBG and HbAlc were significantly reduced in the study group. The improvement in HbAlc showed that the insulin pump can maintain long-term blood sugar stability in patients, which can help patients significantly reduce glucotoxic damage.

Analyzing from the perspective of improving lipid metabolism, the advantages of implementing insulin pump intensive hypoglycemic therapy for patients are related to the high efficiency of insulin action and the accuracy of blood sugar control. Glucose and lipid metabolism interact closely. If a patient is in a state of hyperglycemia, the body's insulin sensitivity will be significantly reduced, and the insulin signaling pathway will be blocked, which will have a direct impact on the activity of enzymes related to lipid metabolism, lipoprotein synthesis and metabolism. On the one hand, hyperglycemia will inhibit the activity of lipoprotein lipase (LPL). As a key enzyme, LPL can catalyze the hydrolysis of chylomicrons and very low-density lipoprotein (VLDL) triglycerides. Reduced activity will reduce TG clearance, so the patient's blood will increase TG levels [8]. On the other hand, insulin can increase the synthesis of HDL-C and inhibit the synthesis of apolipoprotein B (ApoB) in the liver. When synthesis is reduced, patients will significantly reduce LDL-C levels. For patients with new-onset type 2 diabetes, poor blood sugar control will weaken the regulatory effects of insulin, reduce HDL-C synthesis, and increase LDL-C synthesis. At the same time, because patients have blocked TG metabolism, lipid metabolism disorders will occur.

In this study, the lipid index of the research group was better. The core was the use of insulin pumps to achieve precise glucose control. The patients' insulin resistance was significantly improved, and the function of insulin in regulating lipid metabolism was restored to a certain extent. First, the patient's blood sugar is stable, the damage to insulin receptors caused by glucotoxicity is reduced, the receptor sensitivity is improved, LPL activity is activated, and TG hydrolysis and clearance is accelerated. Secondly, when patients improve insulin sensitivity, the degree of liver response to insulin will be enhanced, ApoA1 synthesis will be promoted, HDL-C production will be increased, ApoB synthesis will be inhibited, and LDL-C production will be reduced. At the same time, because patients increase HDL-C, reverse cholesterol transport is used to promote peripheral cholesterol metabolism, and TC is further reduced. There have been clinical studies supporting evidence that when patients with first-onset type 2 diabetes are treated with insulin pumps, LPL activity increases, ApoA1 levels increase, and ApoB levels decrease.

For patients with new-onset type 2 diabetes, pancreatic beta cells are not completely exhausted and have the ability to compensate, which helps the insulin pump take advantage of it. Hyperglycemia causes "glucotoxicity" and inhibits the secretory function of β-cells. The insulin pump can quickly control the patient's blood sugar, which can effectively relieve the inhibition of glucotoxicity and provide conditions for restoring β-cell function. The research results confirmed that after 2 weeks of implementation, this treatment plan can improve the patient's pancreatic beta cell function index (HOMA-β) by more than 40%, and its secretion curve is close to the normal value. Analysis of patients' conditions revealed that improving β-cell function can not only enhance endogenous insulin secretion and assist in glucose control, but can also promote the indirect improvement of patients' lipid metabolism by regulating the balance of insulin and glucagon. When insulin secretion increases, glucagon is inhibited, hepatic gluconeogenesis and very low-density lipoprotein (VLDL) synthesis are significantly reduced, and TG and LDL-C levels are reduced.

In clinical practice, an important factor for better efficacy of insulin pumps is high compliance. The insulin pump uses a continuous subcutaneous infusion mode. After one puncture, it is used continuously for 7–14 days. The number of injections is significantly reduced. During use, the mealtime dosage can be flexibly adjusted according to the patient's meal situation. The patient does not need to strictly control it and has a higher degree of freedom in life. In this study, both groups completed 2 weeks of treatment without loss.

Analyze the limitations of this study, specifically as follows: First, a single-center small sample (80 cases) study was used, which may have selection bias, and the results have poor extrapolation; second, the follow-up time was not long, only 2 weeks, and there was no long-term observation of long-term protection of β-cell function, long-term changes in lipid indicators, and complication prevention and control effects; third, there was no in-depth analysis of indicators such as the incidence of hypoglycemia and total insulin dosage. In future research, large sample and multi-center studies can be carried out to extend the follow-up period, expand the research dimensions, and improve the evidence.

In summary, insulin pump intensive hypoglycemic therapy can significantly improve blood sugar and lipid metabolism levels in patients with first-onset type 2 diabetes, and is worthy of clinical promotion and use.

Disclosure statement

The author declares no conflict of interest.

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