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CASE REPORT

Application of 3C insulin pump system in combination with non-invasive ventilation in the treatment of a patient with type 2 diabetes and obstructive sleep apnea syndrome

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ABSTRACT

We observed the curative effect of the 3C insulin system in combination with non-invasive ventilation in a patient with type 2 diabetes and obstructive sleep apnea syndrome (OSAS). The 3C insulin pump is a system of devices that closely monitors and effectively regulates blood glucose levels. Non-invasive ventilation has been shown to be an effective treatment for OSAS. A type 2 diabetes patient with concomitant OSAS was treated with a 3C insulin pump system for real-time continuous glucose monitoring and nocturnal non-invasive ventilation for OSAS. Treatment-induced diabetic remission with improved sleep and reduced hypoglycemic episodes was achieved. Therefore, the 3C insulin pump system, in combination with non-invasive ventilation, is an effective treatment for type 2 diabetes patients with concomitant OSAS.

INTRODUCTION

Type 2 diabetes mellitus is often accompanied with obstructive sleep apnea syndrome (OSAS). Type 2 diabetes patients with concomitant OSAS are usually obese[1] with poor glycemic control. The 3C insulin pump is a system of devices that closely monitor and effectively regulate blood glucose levels, with activation of an alarm when hypoglycemia or hyperglycemia occurs. 3C is an abbreviation that represents continuous subcutaneous insulin infusion, continuous glucose monitoring system and CareLink software. Using this system, physicians can precisely regulate blood glucose levels based on the blood glucose records of CareLink software. Non-invasive ventilation has been shown to be an effective treatment for OSAS, and improves nocturnal apnea-hypopnea, as well as hypoxia. We report a case of a type 2 diabetes patient with concomitant OSAS who benefited from the treatment of the 3C insulin pump system in combination with non-invasive ventilation.

CASE REPORT

A male patient aged 29 years was admitted to the Second Affiliated Hospital, Xi'an, China, with the chief complaints of polydipsia, polyphagia and weakness for 4 years, with a recent acute exacerbation of these symptoms in the previous 2 weeks. The patient presented with overt polydipsia, polyuria and lack in strength without obvious predisposing cause for 2 weeks before admission. The patient also presented with pain in the lower extremities. The patient had undergone excision of nasal polyps 4 years previous, and his fasting blood glucose was 13.11 mmol/L at the time before his surgery. He was diagnosed with severe OSAS by sleep monitoring. The patient was treated with hypoglycemic agents, with fasting blood glucose levels controlled between 5 and 6 mmol/L. However, within a year before his most recent admission, the patient had poor adherence to hypoglycemic agents, which contributed to inadequate glycemic control. He felt weak 2 weeks earlier, with a blood glucose level of 14.28 mmol/L at the time of admission. The patient also had a history of hypertension. On physical examination at admission, is blood pressure was 144/112 mmHg, height 179 cm, bodyweight 164.5 kg, waist circumference 151 cm and hip circumference 145 cm.

Investigation

The laboratory tests showed glycosylated hemoglobin of 9.7% (normal range 3–6%), fasting glucose (venous plasma)

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12.9 mmol/L (normal 3.3–6.0 mmol/L) and serum uric acid 524 μmol/L (normal range 150–440 μmol/L). The patient showed abnormal liver function at admission, with direct bilirubin of 7.75 μmol/L (normal range 1–7 μmol/L), indirect bilirubin 9.03 μmol/L (normal range 3–13 μmol/L), aspartate transaminase 206 IU/L (normal 9–50 IU/L) and alanine aminotransferase 154 IU/L (normal 15–40 IU/L). Blood lipid measurements showed total cholesterol of 3.96 mmol/L (normal range 3.3–5.8 mmol/L), triglyceride 1.66 mmol/L (normal range 0.5–1.7 mmol/L), high-density lipoprotein 0.76 mmol/L (normal range 0.8–1.8 mmol/L) and low-density lipoprotein 2.59 mmol/L (normal range 2.3–3.3 mmol/L). Results of an arterial blood gas analysis on day 4 post-admission were: pH 7.43 (normal range 7.35–7.45), PO_2 92 mmHg (normal range 80–100 mmHg), PCO_2 29 mmHg (normal range 35–45 mmHg), HCO_3^- 25.2 mmol/L (normal range 22–29 mmol/L) and standard HCO_3^- 25.7 mmol/L (normal range 22–29 mmol/L). Night sleep monitoring test showed mild OSAS with moderate hypoxia. Abdominal ultrasound showed a fatty liver. Liver function improved remarkably at discharge, with direct bilirubin of 5.21 μmol/L, indirect bilirubin of 4.69 μmol/L, aspartate transaminase of 114 IU/L and alanine aminotransferase of 58 IU/L.

Treatment

Blood glucose levels of the patient were controlled and monitored with lispro insulin infusion and continuous glucose monitoring by the 3C insulin pump system (Medtronic 722; Medtronic Inc., Minneapolis, Minnesota, USA) after admission. The basal rates and bolus doses of the insulin pump were regulated based on records of continuous glucose monitoring, which are shown in Table 1. The patient received nocturnal non-invasive ventilation, and was given bicyclol for hepatic protection and benzbromarone for hypouricemia.

Table 1 | Basal rates and bolus doses of insulin pump

	Total dose	Basal rates	Bolus doses		
			Breakfast	Lunch	Supper
1st to 2nd day	60 U	30 U	10 U	10 U	10 U
3rd to 4th day	70.4 U	38.4 U	11 U	11 U	10 U
5th to 6th day	72 U	40 U	11 U	11 U	10 U

Outcomes and follow up

Fatigue resolved after receiving nocturnal non-invasive ventilation. Records of the ventilator showed a sleep apnea index of 0.4 (normal <5). Dynamic glucose monitoring system showed no hypoglycemia episodes in the first three consecutive days after admission (Figure 1). Fasting blood glucose and postprandial plasma glucose at most time-points dropped to the normal range on the sixth morning after admission, as shown in Table 2. The patient ceased the use of hypoglycemic agents on the seventh day after admission. The patient underwent a 100-g standardized steamed bread tolerance test, as well as insulin and C-peptide release test on the eighth morning after admission, showing diabetic remission, as shown in Table 3. The patient was given metformin and exenatide to control blood glucose after discharge.

DISCUSSION

Type 2 diabetes patients with concomitant OSAS account for 60% of hospitalized patients with type 2 diabetes[2]. Type 2 diabetes results from insulin resistance and β-cell dysfunction. OSAS results in recurrent hypoxia, which aggravates insulin resistance[3] and, therefore, exacerbates poor glycemic control[4]. Patients usually receive a high dose of insulin, which is associated with an increased incidence of hypoglycemia. Real-time glucose monitoring can provide hypoglycemic or hyperglycemic alarms, thus preventing such events. High-dose insulin intensive therapy can rapidly decrease high blood glucose level, improve insulin resistance and restore insulin secretion[5]. Continuous glucose monitoring with the 3C insulin pump system can effectively reduce the incidence of hypoglycemia. In the present case, non-invasive ventilation was used to relieve the patient's apnea-hypopnea and nocturnal hypoxia, with improved OSAS and decreased insulin resistance[6]. Non-invasive ventilation appeared to be a safe treatment for OSAS, which avoided serious nocturnal apnea events. The next morning after treatment, the patient felt more energetic than before admission. The patient's weakness and fatigue were

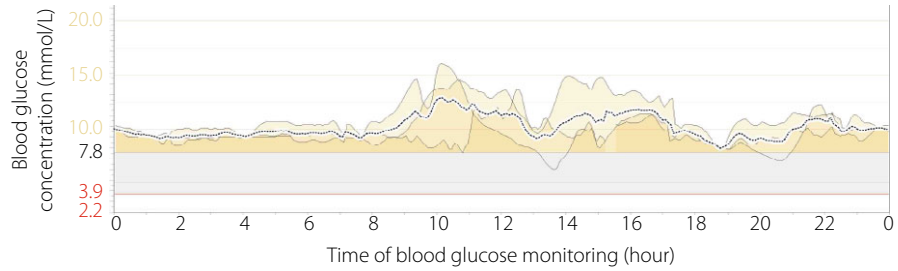

Figure 1 | Blood glucose levels in the first three consecutive days after admission. The solid line represents the blood glucose of a day, and the dotted line represents the average blood glucose of the first three consecutive days.

Table 2 | Peripheral blood glucose levels of the patient

Measuring time	2 h after breakfast	Before lunch	2 h after lunch	Before dinner	2 h after dinner	22.00 hours	00.00 hours	03.00 hours	Fasting
Blood glucose (mmol/L)	10.9	4.6	5.8	5.9	8.5	8.4	7.2	7.7	6.1
Normal range (mmol/L)	4.4–7.8	4.4–7.8	4.4–7.8	4.4–7.8	4.4–7.8	4.4–7.8	4.4–7.8	4.4–7.8	4.4–6.1
Date (2016)	Sep 12	Sep 12	Sep 12	Sep 12	Sep 12	Sep 12	Sep 13	Sep 13	Sep 13

Sep, September.

Table 3 | Results of the standardized steamed bread tolerance test and insulin and C-peptide release test

	Blood glucose level (mmol/L)	Insulin, nmol/L (normal 3.3–6.0)	C-peptide, ng/L (normal 0.4–5.7)
Fasting	5.90 (normal 3.3–6.0)	16.40	4.98
1 h	12.69 (normal <9.0)	65.10	9.05
2 h	9.93 (normal <7.8)	42.80	9.06
3 h	8.76 (normal 3.9–6.2)	38.80	8.90

reduced, and pain in the low extremities was also relieved. The patient's blood glucose level gradually declined to the normal range. The 100-g standardized steamed bread tolerance test on the eighth morning in hospital showed a normal fasting blood glucose and 2-h postprandial blood glucose of <11.1 mmol/L. These findings suggest that the patient entered a state of diabetic remission.

Indeed, these treatments can not only rapidly control hyperglycemia and induce diabetic remission, but also improve sleep quality and correct nocturnal hypoxia.

DISCLOSURE

The authors declare no conflict of interest.

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