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IDENTIFICATION OF NOCTURNAL HYPOGLYCEMIA BY FLASH GLUCOSE MONITORING IN PRIMARY CARE: A CASE REPORT AND REVIEW OF THE LITERATURE

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Abstract: Objective: To explore the clinical value of flash glucose monitoring (FGM) in community-based diabetes management through analysis of a case of nocturnal hypoglycemia identified by FGM. **Methods**: A retrospective analysis was conducted on the clinical data of a 74-year-old male patient with type 2 diabetes mellitus. Because of persistently elevated fasting blood glucose levels (7.0-9.0 mmol/L), the patient had been self-adjusting multiple oral hypoglycemic agents over a prolonged period, including acarbose, sitagliptin phosphate, glipizide controlled-release tablets, dapagliflozin, and pioglitazone/metformin. FGM revealed nocturnal hypoglycemia, confirming the presence of the Somogyi phenomenon. Assessment using the Chinese version of the Diabetes Management Self-Efficacy Scale (C-DMSES) indicated low self-efficacy. **Results**: Based on the FGM findings, the glucose-lowering regimen was adjusted by discontinuing glipizide controlled-release tablets and pioglitazone/metformin. Individualized dietary and exercise prescriptions, smoking cessation counseling, and psychological support were also provided. After intervention, the antidiabetic regimen was simplified, and no hypoglycemic events were detected on follow-up FGM. At 3 months, fasting blood glucose was 6.8 mmol/L, 2-hour postprandial blood glucose was 9.4 mmol/L, and glycated hemoglobin (HbA1c) was 6.9%. In addition, the C-DMSES score improved significantly. **Conclusion**: FGM can effectively identify unrecognized nocturnal hypoglycemia in community-dwelling patients with diabetes and provide an objective basis for individualized and precise comprehensive management. For patients receiving multiple glucose-lowering agents and demonstrating low self-efficacy, FGM combined with a general practitioner-specialist collaborative care model may facilitate safe achievement of glycemic targets.
Keywords: Type 2 diabetes mellitus; Flash glucose monitoring; Hypoglycemia; Somogyi phenomenon; Community management

1 INTRODUCTION

Hypoglycemia is a common acute complication in patients with diabetes mellitus, and its timely recognition and appropriate management are crucial for patient safety. In clinical practice, however, nocturnal hypoglycemia and hypoglycemia with atypical symptoms are easily overlooked. Flash glucose monitoring (FGM) provides continuous and comprehensive glucose data over a defined period and offers unique advantages in glucose monitoring, assessment, and management for patients with type 2 diabetes mellitus. In recent years, this technology has gradually been implemented in community-based practice. In the present article, we report a case of unrecognized hypoglycemia identified and diagnosed by continuous glucose monitoring in a community-based joint diabetes clinic, and discuss the relevant literature to provide practical experience for the prevention and management of hypoglycemia in primary care settings.

The patient was a 74-year-old retired man who presented with a 6-year history of recurrent dry mouth, polydipsia, and polyuria. He had been diagnosed with type 2 diabetes mellitus at another hospital 6 years previously and was initially treated with oral hypoglycemic agents, although the specific regimen was unclear. Thereafter, he did not attend regular follow-up visits. Over the preceding 6 months, because of persistently elevated self-monitored fasting blood glucose levels, he had independently purchased and adjusted his antidiabetic medications, resulting in a gradual increase in the number of glucose-lowering agents used. During the 2 months before presentation, his treatment regimen consisted of acarbose 100 mg orally twice daily, sitagliptin phosphate 100 mg once daily, glipizide controlled-release tablets 5 mg twice daily, dapagliflozin 10 mg orally at noon, and pioglitazone/metformin (15 mg/500 mg) one tablet nightly. Despite this regimen, his fasting blood glucose remained between 7 and 9 mmol/L, and he occasionally experienced dry mouth and polydipsia, but reported no typical symptoms of hypoglycemia, such as palpitations or sweating. He engaged in little physical activity, had irregular dietary habits, and had a smoking history of more than 30 years (20 cigarettes/day). Because his mother had had diabetes mellitus and died of myocardial infarction, the patient had developed anxiety regarding his poor glycemic control.

On physical examination, his temperature was 36.4 ℃,pulse rate 72 beats/min, respiratory rate 18 breaths/min, blood pressure 126/78 mmHg, body mass index 28.5 kg/m², and waist circumference 92 cm. He was alert and in generally good condition. No superficial lymphadenopathy was detected. There was no pharyngeal congestion. Breath sounds were clear bilaterally, with no dry or moist rales. Cardiac examination revealed no obvious enlargement of the cardiac borders, a heart rate of 70 beats/min with regular rhythm, and no significant abnormal findings on valvular auscultation. The abdomen was soft, without tenderness or rebound tenderness. No edema was observed in either lower extremity. Bilateral dorsalis pedis pulses were palpable and normal.

Laboratory and ancillary examinations were as follows. On July 25, 2024, self-monitored blood glucose showed a fasting blood glucose level of 8.0 mmol/L and a 2-hour postprandial blood glucose level of 10.8 mmol/L.

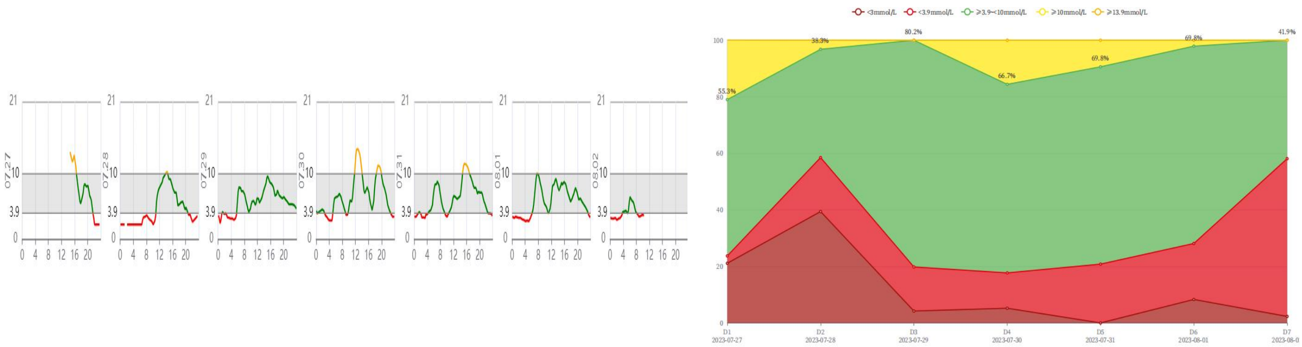
2 DIAGNOSIS, TREATMENT, AND MANAGEMENT

The diagnosis of type 2 diabetes mellitus was confirmed. At presentation, the patient had undergone incomplete follow-up evaluation and exhibited multiple risk factors, including physical inactivity, irregular dietary habits, and a history of smoking. In addition, his glucose-lowering regimen was considered inappropriate, and he demonstrated markedly insufficient confidence in disease self-management, indicating the need for comprehensive intervention. Further laboratory tests and clinical assessments were therefore performed.

The patient scored 76 points on the Chinese version of the Diabetes Management Self-Efficacy Scale (C-DMSES), indicating low self-efficacy.

2.1 Baseline FGM Findings

Baseline FGM revealed repeated nocturnal hypoglycemic episodes together with substantial glycemic fluctuations, providing important evidence for identification of the Somogyi phenomenon. The daily glucose profiles and weekly glucose distribution are shown in Figure 1a and 1b, respectively.



a) b)

Figure 1 Baseline Flash Glucose Monitoring (FGM) Findings before Treatment Adjustment. a) Daily glucose profiles over 1 week demonstrated repeated nocturnal hypoglycemic episodes and marked glycemic fluctuations; b) Weekly glucose distribution showed a substantial proportion of glucose values outside the target range, supporting the presence of unstable glycemic control.

2.2 Additional Examinations and Assessments

Renal function tests showed a urea level of 6.4 mmol/L and a serum creatinine level of 96.00 μmol/L. Fasting insulin was 4.98 μIU/mL, and fasting C-peptide was 0.37 ng/mL. Liver function, urinary microalbumin, electrocardiography, and fundus photography findings were all within normal limits.

Psychological assessment showed a Generalized Anxiety Disorder-7 (GAD-7) score of 6, indicating mild anxiety, and a Patient Health Questionnaire-9 (PHQ-9) score of 3, which was within the normal range.

Flash glucose monitoring (FGM) revealed nocturnal hypoglycemia. Considering the presence of nocturnal hypoglycemia together with rebound fasting hyperglycemia, the patient was diagnosed with the Somogyi phenomenon.

2.3 Treatment and Management Plan

2.3.1 Pharmacological intervention

Given that the patient's oral glucose-lowering regimen was inappropriate and that nocturnal hypoglycemia with rebound fasting hyperglycemia suggested the Somogyi phenomenon, insulin therapy was recommended; however, the patient declined insulin treatment. His antidiabetic regimen was therefore adjusted as follows: acarbose 100 mg twice daily, sitagliptin phosphate 100 mg once daily, and dapagliflozin 10 mg every morning.

2.3.2 Non-pharmacological intervention

A comprehensive behavioral intervention plan was implemented, including dietary counseling, exercise prescription, smoking cessation advice, and psychological support. While undergoing continuous glucose monitoring, the patient was instructed to keep a diary recording dietary intake and physical activity. Review of these records indicated insufficient physical activity and excessive caloric intake. Accordingly, individualized guidance was provided regarding dietary structure, food portion control, and appropriate exercise, and tailored diet and exercise prescriptions were issued. Smoking cessation was strongly recommended to reduce cardiovascular risk, and psychological counseling was arranged to alleviate anxiety.

2.4 Lifestyle Prescriptions

2.4.1 Dietary prescription

The dietary plan aimed to control total caloric intake. Given the patient's BMI of 28.5 kg/m², daily energy intake was recommended to be restricted to 1,600-1,800 kcal/day to facilitate gradual weight reduction.

Macronutrient distribution was prescribed as follows: carbohydrates should account for 45%-50% of total daily energy intake, with preference given to low-glycemic-index foods such as whole grains, legumes, and vegetables; protein should account for 15%-20%, emphasizing high-quality protein sources such as fish, chicken breast, tofu, and eggs; and fat should account for 25%-30%, primarily from unsaturated fatty acids such as olive oil, nuts, and deep-sea fish, while saturated fat and trans fat intake should be limited. Dietary fiber intake was recommended at 25-30 g/day to help delay carbohydrate absorption and stabilize blood glucose levels. The patient was also advised to adopt a pattern of smaller, more frequent meals, consisting of three main meals and two snacks per day, in order to avoid excessive food intake at a single sitting and reduce glycemic fluctuations.

An example meal plan was as follows: breakfast consisting of one slice of whole-wheat bread (approximately 30 g), one boiled egg, 200 mL low-fat milk, and 100 g cucumber or tomato; lunch consisting of 100 g brown rice (raw weight), 100 g steamed fish, 150 g stir-fried broccoli, and 5 g olive oil; dinner consisting of one bowl of millet porridge (50 g millet), 150 g steamed tofu, 150 g stir-fried celery, and 5 g olive oil. Recommended snacks included 15 g nuts (such as walnuts or almonds) plus 100 g sugar-free yogurt in the morning, and one medium-sized apple or one cucumber in the afternoon. To prevent nocturnal hypoglycemia, a bedtime snack of 200 mL low-fat milk plus two whole-wheat biscuits (approximately 20 g) was recommended.

2.4.2 Exercise prescription

The exercise plan emphasized predominantly aerobic exercise combined with resistance training to improve insulin sensitivity. Physical activity was recommended on at least 4-5 days per week, with each session lasting 30-60 minutes. Exercise intensity was prescribed at a moderate level, corresponding to 60%-70% of maximum heart rate (maximum heart rate = 220 - age). Exercise was recommended to begin 1 hour after meals, and fasting exercise was discouraged.

Examples of aerobic exercise included brisk walking for 30-45 minutes per session at an intensity sufficient to induce mild sweating, swimming for 30 minutes per session, particularly for patients with joint discomfort, and cycling for 30-45 minutes per session with appropriate control of intensity.

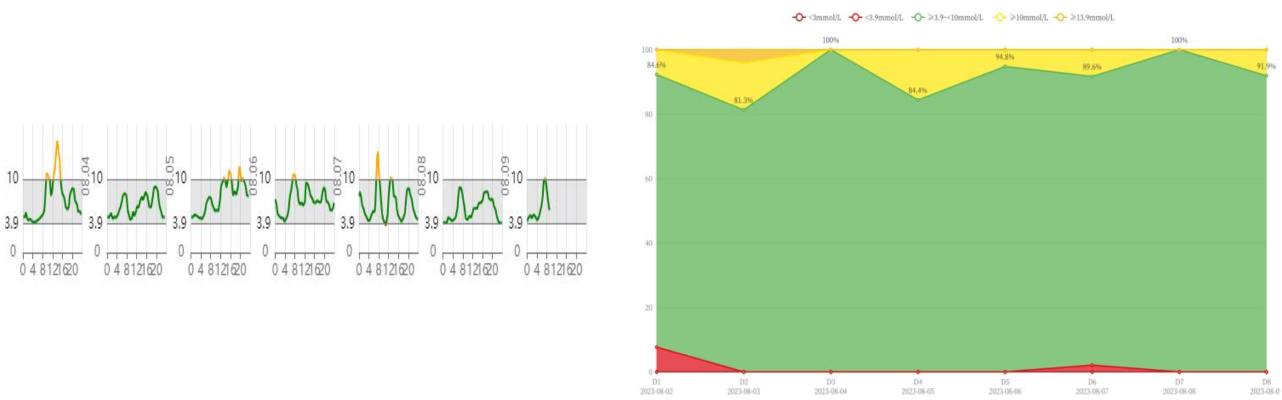
Resistance training recommendations included dumbbell exercises performed 2-3 times per week for 20-30 minutes per session, using light weights (e.g., 2-3 kg) with 10-15 repetitions per set, as well as elastic band training 2-3 times per week for 20 minutes per session, focusing on both upper and lower extremity muscle groups.

2.4.3 Psychological intervention

The patient was referred for psychological counseling to relieve anxiety and to help establish confidence in self-management of blood glucose.

2.5 Follow-up Evaluation

FGM was continued for an additional week, during which no hypoglycemic events were observed and overall glycemic control gradually improved. The frequency of glucose monitoring was subsequently adjusted according to blood glucose levels, and the management plan was modified in a timely manner as needed. The daily follow-up glucose profiles and weekly glucose distribution are shown in Figure 2a and 2b, respectively. At the 3-month follow-up, the patient's BMI had decreased to 27.1 kg/m² and waist circumference to 88 cm. Fasting blood glucose was 6.8 mmol/L, 2-hour postprandial blood glucose was 9.4 mmol/L, and HbA1c was 6.9%.



a) b)

Figure 2 Follow-up Flash Glucose Monitoring (FGM) Findings after Treatment Adjustment. a) Daily glucose profiles over 1 week showed no hypoglycemic events after treatment adjustment; b) Weekly glucose distribution showed that most glucose values were within the target range, indicating gradual improvement in glycemic control.

2.6 Patient Education and Long-term Follow-up

Patient education and follow-up were further strengthened. One month later, follow-up evaluation showed that the patient's score on the Chinese version of the Diabetes Management Self-Efficacy Scale had increased to 130, indicating a marked improvement in self-management ability.Continued intervention was recommended and further enhance long-term self-management capacity.

3 DISCUSSION

This case represents a typical example of the Somogyi phenomenon induced by inappropriate intensification of glucose-lowering therapy, resulting in a vicious cycle of "additional medication intensification–rebound hyperglycemia–further medication escalation." Flash glucose monitoring (FGM) revealed the underlying occult pathophysiological process, and a favorable outcome was achieved after comprehensive intervention. The key issues are discussed below in conjunction with the relevant literature.

3.1 Value of FGM in Identifying Occult Hypoglycemia and the Somogyi Phenomenon

Traditional methods of glucose monitoring have inherent limitations. Capillary fingerstick blood glucose reflects only glucose levels at a single time point, whereas glycated hemoglobin (HbA1c) reflects average glycemic control over the preceding 2–3 months. Neither method adequately captures the details of glycemic variability, particularly asymptomatic hypoglycemia and nocturnal hypoglycemia. Continuous glucose monitoring systems (CGM), in contrast, have significant advantages in detecting asymptomatic and nocturnal hypoglycemia, and their predictive alarm function is particularly important for the prevention of hypoglycemic events [1].

In the present case, FGM/CGM revealed frequent nocturnal hypoglycemic episodes (glucose $\leq$ 3.0 mmol/L), despite the absence of typical hypoglycemic symptoms such as palpitations. This finding suggests that conventional monitoring may have failed to detect asymptomatic hypoglycemia in this patient. Moreover, continuous glucose data enabled earlier recognition of glycemic fluctuation patterns and provided an objective basis for treatment adjustment. Zhou et al. reported that CGM effectively captured recurrent nocturnal and preprandial hypoglycemia in patients with insulinoma, events that were easily missed by conventional monitoring [2]. Hu et al. further demonstrated that dynamic glucose monitoring showed better correlation and accuracy with fingerstick glucose during fasting periods than during postprandial periods, indicating a high degree of reliability in detecting glycemic abnormalities under basal conditions [3]. Wang et al. showed that even among patients with type 2 diabetes mellitus with apparently adequate glycemic control (HbA1c < 7.0%), 20.9% experienced hypoglycemia, of which 84.2% was asymptomatic and most episodes occurred at night [4]. In the present case, repeated nocturnal hypoglycemia identified by FGM supported the diagnosis of the Somogyi phenomenon. This is consistent with previous reports [2], highlighting the important role of CGM/FGM in the differential identification of hypoglycemia, especially asymptomatic nocturnal hypoglycemia.

3.2 Polypharmacy and the Risk of Hypoglycemia

At presentation, the patient was receiving five glucose-lowering agents simultaneously, among which glipizide, a sulfonylurea insulin secretagogue, was considered the principal contributor to hypoglycemia risk. In a case-control study of community-dwelling patients with type 2 diabetes mellitus, Li et al. found that insulin use was an independent risk factor for hypoglycemia [5]. Although the present patient was not using insulin, sulfonylureas share a similar mechanism in promoting insulin secretion and likewise substantially increase the risk of hypoglycemia. Luo, in a study of 109 hospitalized patients with hypoglycemia, reported that drug-induced hypoglycemia accounted for 26.6% of all etiologies, with 75.9% of such cases occurring during glucose-lowering treatment in patients with diabetes [6]; sulfonylureas and insulin were the principal causative agents. Li et al. also identified a history of coronary heart disease and renal disease as risk factors for hypoglycemia [5]. Although the present patient had no known history of coronary heart disease, he had multiple cardiovascular risk factors, including long-term smoking, obesity, and diabetes mellitus. Therefore, the potential harms of hypoglycemia, including the triggering of cardiovascular events, should not be underestimated. Katsiki et al. likewise emphasized the association between hypoglycemia and cardiovascular risk, involving multiple mechanisms such as endothelial dysfunction and inflammatory activation [7]. Accordingly, for patients receiving multiple glucose-lowering agents, especially insulin or insulin secretagogues, systematic assessment of hypoglycemia risk is essential.

3.3 Impact of Psychological Factors and Self-Efficacy

In this case, the patient experienced marked health-related anxiety because his mother had died of myocardial infarction, and his C-DMSES score indicated low self-efficacy. Such negative emotional states and insufficient confidence in self-management may have contributed to his unsupervised escalation of medication. Li et al. reported that fear of hypoglycemia in patients with type 2 diabetes mellitus was significantly associated with psychological distress and adversely affected self-management [8]. A randomized controlled study by Ma et al. further demonstrated that a graded, precision "general practitioner-specialist" collaborative management model could significantly improve fear of hypoglycemia and quality of life through psychological intervention, comprehensive education, and the introduction of family support systems [9]. In the present case, once the underlying cause had been clarified, adjustment of pharmacotherapy alone was insufficient. Specialist psychological counseling and patient empowerment education were also critical to alleviating anxiety, establishing appropriate disease-management concepts, and improving self-efficacy.

3.4 Exploration of an FGM-Based Comprehensive Management Model in the Community

The successful management of this case was attributable to the establishment of a community-based joint diabetes clinic and the application of FGM technology, reflecting the integration of specialist-level precision diagnostic tools with the continuity advantages of general practice. The graded precision "general practitioner-specialist" collaborative management model proposed by Ma et al. emphasizes stratified diagnosis and treatment based on disease severity and advocates data-driven precision management using tools such as CGM [9]. Shen et al. showed that individualized exercise programs developed on the basis of dynamic glucose monitoring could improve glycemic control more effectively [10]. From an evidence-based perspective, a meta-analysis by Wang et al. confirmed that multiple primary care management strategies, including patient self-management in community settings and collaboration within regional medical alliances, significantly reduced blood glucose levels [11]. Because postprandial glycemic fluctuations are substantially more frequent than fasting fluctuations, exercise prescriptions that incorporate moderate physical activity during periods of peak postprandial glycemic excursions may help improve postprandial glucose control; however, delayed exercise-induced hypoglycemia should also be considered. The present case reflects a practical implementation of these principles: FGM enabled precise identification of the underlying problem, after which the general practitioner adjusted the medication regimen and implemented individualized lifestyle interventions, ultimately achieving safe glycemic control. This is consistent with the recommendations of the 2024 Expert Consensus on the Clinical Application of Continuous Glucose Monitoring [12], which advocates the use of CGM in patients with frequent hypoglycemia or high hypoglycemia risk.

4 CONCLUSION AND CLINICAL IMPLICATIONS

In this case, FGM successfully identified and facilitated the management of complex fasting hyperglycemia caused by the Somogyi phenomenon, thereby avoiding inappropriate treatment intensification and enabling stable achievement of glycemic targets through comprehensive management. On the basis of this case and the literature review, the following implications may be drawn.

First, FGM is an effective tool for screening and managing occult hypoglycemia in community settings. In elderly patients, those receiving multiple glucose-lowering agents, those with discordance between HbA1c and fingerstick glucose measurements, or those with marked glycemic variability, FGM should be actively considered to identify potential hypoglycemia risk. This is particularly important in older adults, who may lack typical symptoms because of blunted sympathetic responses, making FGM a valuable complement to traditional monitoring methods.

Second, the risk of hypoglycemia associated with combination glucose-lowering therapy requires close attention. Particular vigilance is warranted when insulin or insulin secretagogues such as sulfonylureas are used, especially with respect to asymptomatic nocturnal hypoglycemia. Previous studies have shown that drug-induced hypoglycemia accounts for 26.6% of the causes of hospitalized hypoglycemia, and that the majority of these cases are related to glucose-lowering therapy [5,6].

Third, psychological factors and self-efficacy should be incorporated into diabetes management. Diabetes care involves more than numerical adjustment of blood glucose values; it also requires attention to anxiety, illness perceptions, and confidence in self-management. Psychological intervention should therefore be regarded as an integral component of comprehensive diabetes care.

Fourth, a community-based diabetes prevention and management strategy combining "technology + management" is feasible and valuable. The integration of emerging technologies such as FGM with graded "general practitioner-specialist" collaborative management and individualized behavioral intervention may promote precision and personalization in community diabetes care. Nevertheless, despite the clear advantages of CGM/FGM, these technologies also have limitations, including complexity in data interpretation and insufficient patient understanding of relevant metrics. Therefore, sustained education and professional guidance from healthcare providers remain essential.

COMPETINGINTERESTS

The authors have no relevant financial or non-financial interests to disclose.

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