Continuous glucose monitoring in the management of patients after gastric bypass

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Summary

In patients with gastric bypass (GB), high glucose variability (GV) and hypoglycemia have been demonstrated, which could impact the metabolic status and eating behavior. We describe the glucose patterns determined through continuous glucose monitoring (CGM) in two patients with >5 years follow-up after GB and significant weight recovery, who reported hypoglycemic symptoms that interfered with daily activities, and their response to a nutritional and psycho-educative prescription. Case 1: A 40-year-old woman without pre-surgical type 2 diabetes (T2DM) and normal HbA1c, in whom CGM showed high GV and hypoglycemic episodes that did not correlate with the time of hypoglycemic symptoms. Her GV reduced after prescription of a diet with low glycemic index and modification of meal patterns. Case 2: A 48-year-old male with pre-surgical diagnosis of T2DM and current normal HbA1c, reported skipping meals. The CGM showed high GV, 15% of time in hypoglycemia and hyperglycemic spikes. After prescription of a low glycemic index diet, his GV increased and time in hypoglycemia decreased. Through the detailed self-monitoring needed for CGM, we discovered severe anxiety symptoms, consumption of simple carbohydrates and lack of meal structure. He was referred for more intensive psychological counseling. In conclusion, CGM can detect disorders in glucose homeostasis derived both from the mechanisms of bariatric surgery, as well as the patient's behaviors and mental health, improving decision-making during follow-up.

Learning points:

- High glycemic variability is frequent in patients operated with gastric bypass.
- Diverse eating patterns, such as prolonged fasting and simple carbohydrate ingestion, and mental health disorders, including anxiety, can promote and be confused with worsened hypoglycemia.
- CGM requires a detailed record of food ingested that can be accompanied by associated factors (circumstances, eating patterns, emotional symptoms). This allows the detection of particular behaviors and amount of dietary simple carbohydrates to guide recommendations provided within clinical care of these patients.

Background

Bariatric surgery is the most effective treatment to achieve significant and sustained weight loss in patients with moderate and severe obesity and to attain better control of comorbidities compared with diet and exercise.

The gastrointestinal tract is a critical organ for glucose homeostasis, and mixed bariatric procedures such as GB modify different metabolic pathways, as well as hunger and satiety signals (1). Changes in secretion of intestinal

peptides, including glucagon-like peptide type 1 (GLP-1) and gastric inhibitory peptide (GIP), are considered among the main mechanisms that promote improvement in glucose and insulin levels (2). Nevertheless, new regulation of glucose metabolism in subjects with GB can also provoke adverse symptoms derived from the altered gastrointestinal function, predisposing to abrupt variability in glucose levels, reportedly higher than those in subjects with type 2 diabetes (T2DM) (3). The term *dumping* is used to refer to disturbances associated with the adrenergic discharge that occurs with the dilatation of the intestinal loops and to abrupt change in glucose concentrations. Reactive hypoglycemia has been reported in almost two-thirds of these patients, regardless of the diabetes status before surgery (4). These are some of the most common side effects following GB, associated with reduced quality of life and disordered eating behaviors, including responsive carbohydrate consumption and exacerbated insulin secretion.

Continuous glucose monitoring (CGM) performed in patients operated with GB has found significant GV, defined as the maximum/minimum index of glucose levels in 24 h, accompanied by significant hyperglycemic spikes, whether in the presence or absence of hypoglycemia (5), and elevation of glucose concentrations above 300 mg/dL after one of these events. Hanaire *et al*. found values of the mean amplitude of glycemic excursions (MAGEs) among patients operated with GB of 86 ± 58 (mg/dL) and in patients with diabetes of 66 ± 24, respectively (3), compared with values reported for Hispanic population of 21.6 ± 12.6 obtained from a multi-ethnic study (6). Continuous glucose monitoring has also been helpful to confirm the presence of hypoglycemia in patients with and without symptoms of neuroglycopenia after bariatric surgery (5). Two studies have assessed the response of short-term interventions (acarbose and/or reduction in carbohydrate consumption) to reduce hypoglycemic symptoms and GV in patients with GB with favorable results (7, 8). Nevertheless, studies of GV in this population which is rapidly increasing are still limited. This technology is broadly employed in the management of diabetes mellitus, mainly type 1, for its capacity to achieve goals of glycemic control in comparison with multiple measurements of capillary glucose. The capacity to measure detailed glucose patterns has led to the recognition of both GV and hypoglycemia as adverse factors for metabolic and weight control and to impulse their identification and management. These phenomena are not likely to be detected by conventional follow-up, and are imperative to treat, given their potential to influence weight, eating patterns, quality of life and cardiovascular outcomes.

We describe patterns of GV (maximum interstitial glucose (IG), time to postprandial peak IG (TP) and MAGE, assessed using Easy GV© software) by CGM in two patients, one female and a male, who we selected for reporting significant hypoglycemic symptoms associated with significant weight recovery (WR) after GB, and the effect of a nutritional and psycho-educative intervention.

Case presentation

Case 1

A 40-year-old woman without T2DM before surgery, and pre-surgical BMI of 41.65 kg/m². Her pre-surgical weight was 101.4 kg, and she achieved a postoperative weight of 68.8 kg. Two years later, she started a pregnancy weighing 80 kg, developing frequent hypoglycemic symptoms that persisted after the pregnancy. At the baseline visit in this study, she had 6 years of follow-up after bariatric surgery, and her weight was 102.7 kg, a 49% increase from her minimum weight after surgery.

Case 2

A 48-year-old male with diagnosis of T2DM treated with metformin before surgery, microalbuminuria and BMI of 40.3 kg/m². His pre-surgical weight was 137.8 kg and he achieved 89.6 kg 7 months after surgery. One year after surgery, he developed hypoglycemic symptoms related with prolonged fasting due to stress at work. In the initial visit at this study, he had 5 years of follow-up after bariatric surgery, and his weight was 107.8 kg (BMI of 32 kg/m²), a 20% increase from his minimum weight after surgery.

Investigation

Case 1

At the first CGM, BMI was 35.1 kg/m² and HbA1c was 5.4%. Metabolic parameters were triglycerides 67 mg/dL, total cholesterol 182 mg/dL, HDL cholesterol 66 mg/dL, LDL cholesterol 103 mg/dL, folic acid 26.4 ng/mL, Vit B12 464 pg/mL, ferritin 10.1 ng/mL, vitamin D 45.1 ng/mL. She complained of hypoglycemic symptoms and therefore a 2-h glucose tolerance test was performed, in which values for glucose/insulin were the following: basal 58/4.6, 30 min 183/80.6, 60 min 173/100.2,

90 min 101/48.7, 2 h 51/12.2, 3 h 44/2.4, 4 h 70/2.2 and 5 h 81/2.8 (mg/dL/µUI/mL).

Case 2

His HbA1c was 5.6% and he reported the need to consume carbohydrate-rich foods due to frequent symptoms of diaphoresis and light-headedness. Fasting glucose/insulin were 94/8.47 mg/dL/µUI/mL, 2-h postprandial glucose was 79 mg/dL, triglycerides 75 mg/dL, total cholesterol 125 mg/dL, HDL cholesterol 49 mg/dL, LDL cholesterol 59 mg/dL, folic acid 24.2 ng/mL, vitamin B12 308 pg/mL, ferritin 7.4 ng/mL, vitamin D 15.1 ng/mL and albumin/creatinine ratio was 1.9 mg/g.

Treatment

Case 1

In a 4-day CGM, mean IG was 91.2±27.8 mg/dL, maximum IG was 217 mg/dL, minimum IG 48 mg/dL, with 15% of time with <70 mg/dL, TP was 39 min and MAGE was 65.4 mg/dL (Fig. 1). Through self-monitoring, she reported frequent prolonged fasting and consumption of simple carbohydrates. She reported hypoglycemic symptoms manifested by dizziness that did not correlate with sensor-detected hypoglycemia, and she was asymptomatic at night, when she did present hypoglycemia. The nutritionist prescribed a diet with low-glycemic index underscoring certain carbohydrate sources (such as sushi) that provoked the highest glucose peaks and reduction of fasting time. The second CGM

showed mean glucose of 93.7±22.7 mg/dL, maximum IG of 184 mg/dL and minimum IG of 62 mg/dL; TP was 35 min and MAGE was 48.08 mg/dL (Fig. 2).
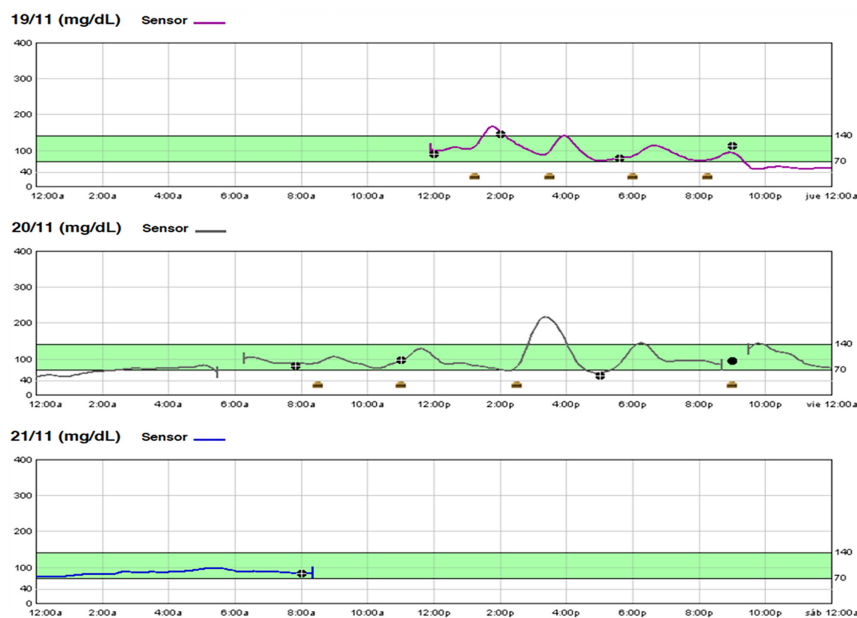
Case 2

In a 5-day CGM, mean glucose was 96.8±29.5 mg/dL, maximum IG was 195 mg/dL, minimum glucose value 50 mg/dL, with 5% of time with <60 mg/dL, TP was 40 min and MAGE was 68.6 mg/dL (Fig. 3). In his self-monitoring, he reported a diet with adequate quality but frequent prolonged fasting. After prescription of a diet with low glycemic index and reduction of fasting, the second CGM reported mean glucose of 115.1±67.9 mg/dL, maximum IG of 400 mg/dL, minimum IG of 46 mg/dL, with 3% of time with glucose <60 mg/dL, TP was 35 min and MAGE was 127.2 mg/dL (Fig. 4). He reported constant anxiety and binge of carbohydrate-rich beverages. Accordingly, management was directed toward more intensive psychological counseling to increase stress-reducing activities, and identification/modification of dysfunctional responses, including substitution of usually consumed carbohydrates with foods with lower glycemic index.
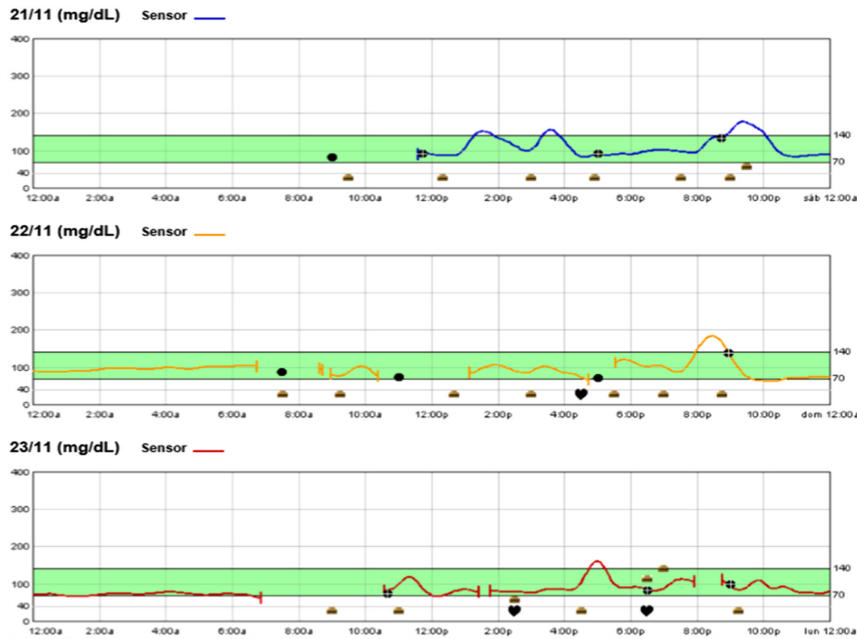
Outcome and follow-up

Case 1

The patient lost 5.5 kg during the following 6 months and reports she has struggled to maintain adequate meal

Figure 1
Basal CGM, case 1.

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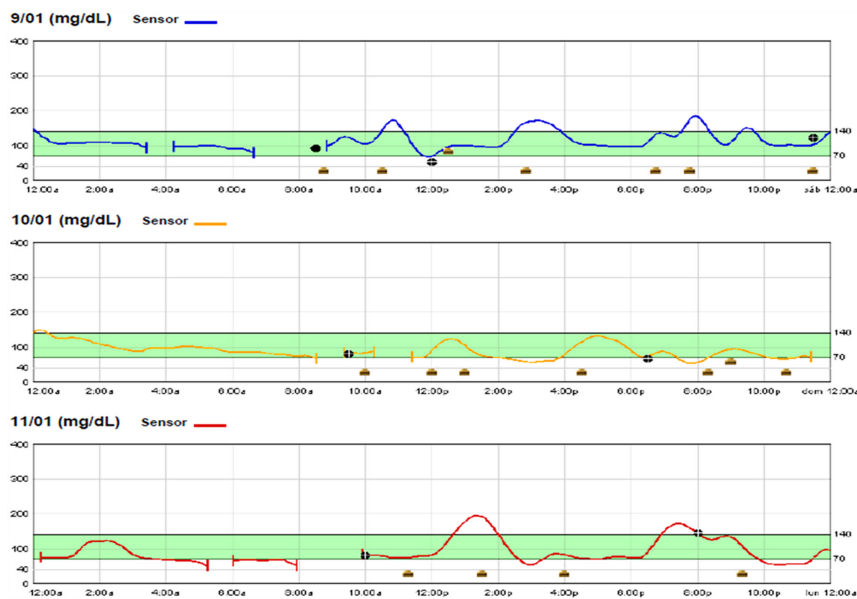**Figure 2**
Second CGM, case 1.

structure but maintains some safety measures such as food provisions on most active days.
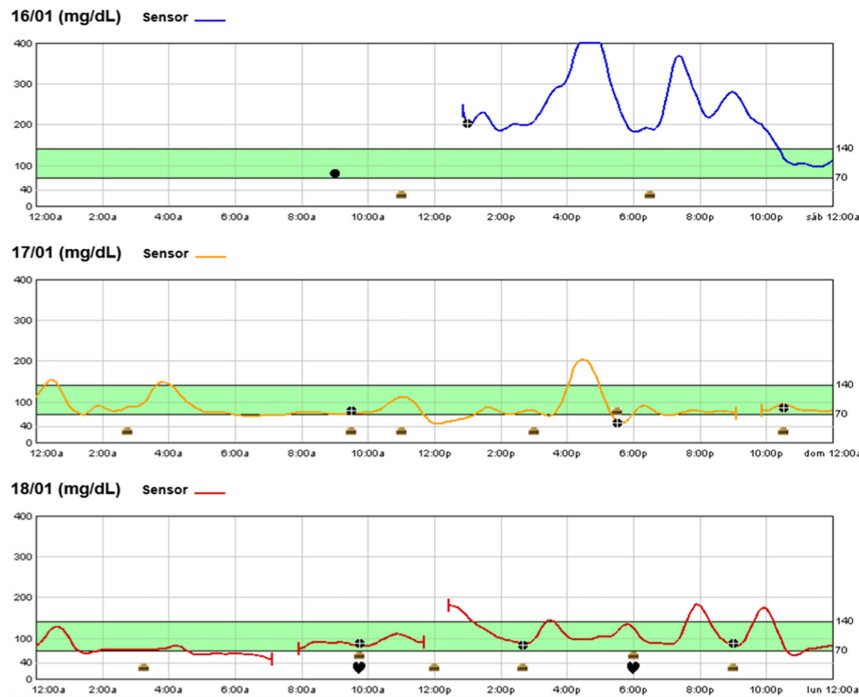
Case 2

The patient started attending monthly group sessions for patients with bariatric surgery, in which he has managed to overcome severe dysfunctional behaviors and thoughts toward meal patterns, achieving greater coping skills and reporting infrequent periods of hypoglycemia.

Discussion

CGM provides dynamic information of disorders in glucose homeostasis linked with complex metabolic responses, the eating behavior and mental health in the context of bariatric surgery (Table 1). With its use, we detected hyperglycemia not correlated with symptoms, significant GV and complex behaviors when trying to confirm the presence of hypoglycemia and its associated factors during management of our patients. These factors are often hard to detect by conventional

Figure 3
Basal CGM, case 2.

Figure 4
Second CGM, case 2.

follow-up, undetected by HbA1c and often do not correlate with hypo- and hyperglycemic spikes (8), which could potentially influence weight regain, disordered eating patterns and potentially adverse cardiovascular outcomes.

Several studies have reported novel findings through CGM in patients with bariatric surgery that underscore the great prevalence of hypoglycemia (6, 9) and aids in the reduction, but not normalization of GV and hypoglycemia after acarbose administration and low glycemic index diets (9, 10). In this study, the use of this technology aided in the recognition of different mechanisms associated with disordered eating behaviors that commonly promote glucose shifts and carbohydrate consumption in subjects with bariatric surgery. Additionally, in our experience, this tool increased the treatment satisfaction and motivation of the patients, making them more informed and prepared for solving problems during follow-up.

We consider the use of CGM as a valuable method to identify potentially harmful glucose disorders in this population, including causes of decompensation. This seems particularly useful in subjects who manifest persistent hypoglycemic symptoms and limited diet structure despite adequate nutritional prescriptions. Information obtained through its self-monitoring provides a practical psycho-educational tool that brings together medical and self-care strategies to be implemented on eating behaviors to improve individual decision-making when addressing difficulties in follow-up, whether for weight goals, symptoms management and metabolic control. Strategies to improve the detection and management of complications arising after GB is relevant, given the increasing number of people who will undergo this treatment the following years, who will need adequate follow-up to avoid unfavorable outcomes,

Table 1 Continuous glucose monitoring data in two subjects with gastric bypass.

	Interstitial glucose			Time spent		TP, min	MAGE
	Mean	Minimum	Maximum	>140 mg/dL	<70 mg/dL		
Case 1							
1st CGM	91	48	217	6%	15%	30	65.4
2nd CGM	94	62	184	6%	5%	35	48.08
Case 2							
1st CGM	96	50	195	9%	15%	40	68.6
2nd CGM	115	46	400	21%	13%	35	127.2

IG, interstitial glucose; TP, time to postprandial peak.

involving control of comorbidities, secondary effects, weight loss and regain and quality of life.

Patient consent

Written informed consent was obtained from both patients for publication of the submitted article.

Author contribution statement

M Rodríguez Flores, R C Cruz Soto, V Vázquez Velázquez, R Soriano Cortés and E García García developed the protocol. M Rodríguez Flores, R C Cruz Soto, V Vázquez Velázquez and R Soriano Cortés performed the clinical interventions. M Rodríguez Flores and C Aguilar Salinas analyzed the data and wrote the manuscript. All authors have reviewed and approved the content of the manuscript.

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