

# Continuous glucose monitoring for diabetes: potential pitfalls for the general physician

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## ABSTRACT

A 31-year-old man presented systemically unwell with diabetic ketoacidosis (DKA). He was using an intermittently scanned continuous glucose monitoring (CGM) device that had been recording low or normal glucose readings for the 48 hours prior to admission. The sensor site had become infected, and we believe this soft tissue infection caused his CGM device to record falsely low glucose readings leading the patient to erroneously lower his insulin doses and take extra carbohydrates, precipitating DKA. CGM devices measure glucose levels in the interstitial fluid. When interstitial glucose readings do not match symptoms or expectations, a capillary blood glucose reading should be taken to correlate and impact treatment decisions. There will be an increase in patients presenting to hospital with CGM devices as the National Institute for Health and Care Excellence guidelines have recently been updated. We use this interesting clinical case to provide context for key learning points about CGM devices for the general physician.

**KEYWORDS:** type 1 diabetes, diabetic ketoacidosis, continuous glucose monitoring, adverse event, infection

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## Case presentation

A 31-year-old man with type 1 diabetes presented to our acute medicine unit (AMU) systemically unwell. His diabetes was managed using a once a day long-acting basal insulin and pre-meal fast-acting insulin. He had been using an NHS-funded FreeStyle Libre device (Fig 1a), a type of continuous glucose monitoring (CGM) device where the sensor is scanned intermittently using a mobile phone or handset to monitor glucose levels. The sensor had been replaced 4 days prior to admission. He was scanning the Libre sensor on a regular basis and noticed his glucose levels were low (<4 mmol/L). He, therefore, decided to reduce his basal insulin dose, omit his pre-meal insulin

and increase his carbohydrate intake. He began to feel non-specifically unwell with nausea the day before admission; his blood glucose readings remained on the lower end of the target range (4–10 mmol/L; Fig 1b). On the day of his attendance to the AMU, he began vomiting, and noted pain and redness surrounding his Libre sensor. The glucose reading on his Libre device was normal at 5.5 mmol/L. On removal of the sensor, pus came out of the insertion site. He had an erythematous, hot and indurated swelling at his Libre sensor insertion site (Fig 1c). Laboratory investigations revealed a significantly raised blood glucose (29 mmol/L), acidosis (pH 7.24), raised lactate (5.3 mmol/L), raised blood ketones (5.8 mmol/L), acute kidney injury (creatinine 136 µmol/L, baseline 90 µmol/L) and raised inflammatory markers (white cell count  $17.9 \times 10^9/L$  and C-reactive protein 17 mg/L). He was diagnosed with diabetic ketoacidosis (DKA) and left arm cellulitis. A fixed-rate intravenous insulin infusion was started with intravenous fluid and potassium replacement as per our hospital protocol. He was reviewed by the plastic surgery team but it was felt the lesion was not large enough to warrant incision and drainage, and was managed conservatively with intravenous antibiotics. He made a good recovery with discharge from hospital 48 hours later.

**What are continuous glucose monitoring devices? Please choose an answer below.**

- a) CGM devices sit on the surface of the skin and measure capillary blood glucose.
- b) CGM devices sit on the surface of the skin and measure glucose in the interstitial fluid.
- c) CGM devices sit on the surface of the skin and measure venous blood glucose.

**Answer:** b) CGM devices sit on the surface of the skin and measure glucose in the interstitial fluid.

CGM devices are used for monitoring glucose levels in interstitial fluid for patients with diabetes. They consist of a small sensor sitting on the surface of the skin with a microneedle projecting into the dermis and interstitial fluid (Fig 1a). The FreeStyle Libre is an intermittently scanned CGM device and the sensor can be scanned by the user's handset or phone to display a glucose reading at times convenient for them.<sup>1</sup> It significantly reduces the need for finger-prick blood glucose monitoring and has transformed diabetes management for many patients. Real-time CGM systems are also available that give a continuous blood glucose reading to a person's smart phone, smart watch or linked handset.

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**Fig 1. a) Photograph of a FreeStyle Libre sensor displaying the microneedle that sits within the dermis of the skin (next to a British pound coin for scale). b) Screenshot of the patient's FreeStyle Libre results uploaded to his phone for the 12 hours before admission. c) Photograph of the patient's sensor insertion site upon admission to hospital.**

**Which of the following statements regarding measurement of glucose in interstitial fluid is correct? Please choose an answer below.**

- Interstitial glucose monitoring with a CGM device will completely stop the need for monitoring finger prick capillary glucose.
- Interstitial glucose readings generally correlate well with blood glucose readings but there are some instances where there can be inaccuracies.
- Interstitial glucose readings lag behind blood glucose readings by an hour.

**Answer:** b) Interstitial glucose readings generally correlate well with blood glucose readings but there are some instances where there can be inaccuracies.

We believe this patient's CGM device was recording falsely low glucose levels secondary to a soft tissue infection. Acting upon this information, he erroneously lowered his insulin doses and omitted his pre-meal insulin injection. Subsequently, he entered a cycle of deterioration with high glucose levels and infection eventually resulting in DKA.

Infections are an uncommon adverse event with CGM devices but severe infections have previously been reported.<sup>2,3</sup> Patients with diabetes are at increased risk of infection and CGM devices create a break in the skin that could act as a conduit for infection. It is possible that the surrounding interstitial fluid could have a lower glucose as a result of bacterial infection at the site, similar to that seen in a lung empyema or the cerebro-spinal fluid in bacterial meningitis. Additionally, inflammation in tissue adjacent to a CGM device can potentially delay and reduce the diffusion of glucose to the sensor and hence its ability to accurately read glucose level in the interstitial fluid.<sup>4</sup>

Measurement of interstitial glucose to monitor diabetes, while convenient and comfortable, is not perfect and blood glucose monitoring is still required in certain circumstances. Interstitial glucose readings can lag behind capillary blood glucose readings by as much as 20 minutes.<sup>4</sup> Our case also suggests that local site inflammation can affect the accuracy of interstitial glucose

readings. The FreeStyle Libre manufacturer advises that if readings on the Libre do not match the user's symptoms or expectations, to use a fingerpick blood glucose monitor to make treatment decisions.<sup>1</sup> Both patients and clinicians should remain aware of this advice and of the limitations of interstitial glucose readings since acting upon incorrect readings can result in potential significant clinical harm, as this case demonstrates.

When managing patients admitted with CGM devices, an individual assessment is required to determine if this can be used for glucose monitoring during the admission. Our local policy is that interstitial glucose levels can be used in medically stable patients to monitor glycaemic control. However, if a patient is systemically unwell, requires tight glycaemic control for a clinical reason or where there is clinical concern that the interstitial glucose levels are erroneous, then blood glucose measurements should be used. The FreeStyle Libre device should be removed for magnetic resonance imaging (MRI) and computed tomography (CT) but can remain in place for most other scans (except where any artefact from the device could cause interference with the scan result).<sup>1</sup>

**Which patient groups are recommended by the National Institute for Health and Care Excellence to have access to CGM devices under the NHS in England and Wales? Please choose an answer below.**

- All patients with type 1 diabetes and a subgroup of people with type 2 diabetes (who are on intensive insulin therapy).
- All patients with type 1 or type 2 diabetes.
- Only patients with type 1 diabetes.

**Answer:** a) All patients with type 1 diabetes and a subgroup of people with type 2 diabetes (who are on intensive insulin therapy).

In March 2022, the National Institute for Health and Care Excellence (NICE) guidelines for diabetes management were updated. All patients with type 1 diabetes (>250,000 people) and a subgroup of patients with type 2 diabetes (who are on intensive insulin therapy; approximately 193,000 people) in

England and Wales will be offered intermittently scanned or real-time CGM devices.<sup>5</sup> The use of CGM devices is set to become more widespread in the near future and, therefore, non-specialist clinicians should develop familiarity with the devices and their benefits and limitations.

### Key points

- > Intermittently scanned or real-time CGM devices provide users with glucose levels from the interstitial fluid that correlate well with blood glucose levels. They significantly reduce the need for finger prick monitoring and, in many cases, have revolutionised diabetes management.
- > When interstitial glucose readings do not match symptoms or expectations, a capillary blood glucose reading should be taken to correlate and impact treatment decisions.
- > There will be an increase in patients presenting to hospital on CGM devices as the NICE guidelines have recently been updated, the general physician will, therefore, need to be familiar with this technology. ■

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