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The Usefulness of Continuous Glucose Monitoring for Nursing Staff in the Pediatric Intensive Care Unit:

Reflections from Clinical Practice

In the Pediatric Intensive Care Unit (PICU), patients with type 1 diabetes mellitus (T1DM) are primarily admitted due to diabetic ketoacidosis (DKA) at disease onset or during metabolic decompensations, making this the leading cause of hospitalization and mortality in children with this metabolic disorder(1).

When a patient with this condition is admitted to the PICU, they usually present with dehydration, respiratory symptoms (tachypnea, Kussmaul breathing pattern), digestive (nausea, vomiting, and/or abdominal pain), and neurological symptoms (confusion and decreased level of consciousness), which will be more or less severe depending on the severity of the diabetic ketoacidosis (DKA).

The primary goal of the medical team is to stabilize the patient, rehydrate, correct electrolyte imbalances, and gradually and controlledly lower blood glucose levels (a sudden drop could lead to severe complications, such as cerebral edema). For this, strict monitoring of glucose levels and other altered parameters, such as electrolytes and ketone bodies, is essential. Until now, these measurements were only obtained from blood samples collected by nurses through minimally invasive procedures (capillary or venous puncture), causing some discomfort to the patient. These measurements, which are taken continuously within the first 24 hours of admission (usually hourly), result in a minimum of 24 punctures in a child who is already in an unfamiliar and distressing environment with a compromised clinical condition, making the nurse-patient relationship more difficult. Moreover, although these techniques provide crucial information for clinical decision-making, they do not show glucose dynamics, as they only provide a single, static value at the time of measurement.

In recent years, there has been significant technological advancement in diabetes management, particularly with **continuous glucose monitoring** (CGM) systems, which allow for a better understanding of glucose behavior and variability. These devices measure interstitial glucose using a flexible filament inserted under the skin in a minimally invasive manner. CGM has played a crucial role in ambulatory diabetes management for years, proving to reduce hypoglycemic episodes, improve glycemic control, and enhance the quality of life for patients (and their caregivers), initially for type 1 diabetes mellitus (T1DM) and now also for type 2 diabetes mellitus (T2DM). In the hospital setting, the use of CGM emerged with the arrival of COVID-19. When health care systems were overwhelmed, and personal protective equipment (PPE) was scarce, CGM sensors minimized direct contact with infected patients while maintaining glucose control. As a result, the *Food and Drug Administration* (FDA) authorized the use of these devices for hospitalized patients during the pandemic (2).

Consequently, most of the existing literature on inpatient CGM focuses on adult diabetic patients on continuous IV insulin infusion. However, some emerging publications highlight the potential of this technology beyond diabetes, including critical care patients, perioperative settings, and recovery after stroke or myocardial infarction. In all these scenarios, reducing glycemic variability (i.e., fluctuations in blood glucose levels) has been shown to significantly decrease the length of stay and mortality rates, leading some experts to suggest **CGM could become the 5th vital sign in critical care** (3,4,5,6,7).

Despite this, CGM remains unregulated for inpatient use, and no consensus guidelines exist regarding target CGM values in hospitalized patients. Some major clinical practice guidelines provide limited recommendations: The Endocrine Society suggests CGM should be used in non-critical patients at risk of hypoglycemia, alongside capillary glucose monitoring. The American Diabetes Association (ADA) recommends CGM only for hospitalized patients who were already using it at home and are competent to continue using it. The Society of Critical Care Medicine does not mention CGM but strongly recommends continuous glucose monitoring for patients receiving continuous insulin infusions. Given this landscape, CGM usage in hospitals remains sporadic, and its benefits still need further validation through research (7,8,9,10).

However, pediatrics lags behind in research and publications, mainly due to ethical constraints in studying children. The limited pediatric literature on inpatient CGM focuses primarily on **diabetic ketoacidosis**, the most critical complication in children and adolescents with diabetes. Existing studies, mostly retrospective, conclude that CGM is feasible and accurate, despite the fact that DKA severity can reduce CGM accuracy. However, CGM is still considered safe and clinically effective, suggesting it may be useful for detecting trends and abnormal values, though larger, high-quality studies are needed (1,11).

At the PICU of Hospital Clínico de Santiago de Compostela (A Coruña, Spain), we asked ourselves 3 years ago: Why not place a CGM sensor in the PICU from the onset of diabetes? With the clear objective of ensuring strict glycemic control while providing high-quality, humanized care, we incorporated CGM sensors into our 2021 Diabetic Ketoacidosis Management Protocol as an essential tool for managing newly diagnosed diabetes cases.

When a newly diagnosed patient is admitted, a CGM sensor is placed as part of our health care system's service portfolio (initially Freestyle Libre 2®, now Freestyle Libre 3®). According to our protocol, within the first few hours of hospitalization, capillary or venous blood samples are taken hourly or every other hour, depending on DKA severity at admission, to measure blood glucose and ketones. At the same time, CGM glucose readings and trends are recorded by nurses hourly, except in cases of hyperor hypoglycemia alerts, which are immediately verified with capillary glucose testing.

Over the past 3 years, the sensor has been placed in 19 patients admitted with a diagnosis of diabetic ketoacidosis as the initial manifestation of T1DM, and the **perception from the nursing team has been unanimous: "a high level of acceptance, highlighting patient safety and improved quality of care."** As in any human team, few changes are free of discrepancies, and the introduction of new materials or techniques often generates internal debates. However, the team's response has been remarkably unified, with 100% agreement that the use of sensors represents a qualitative leap in our patient care.

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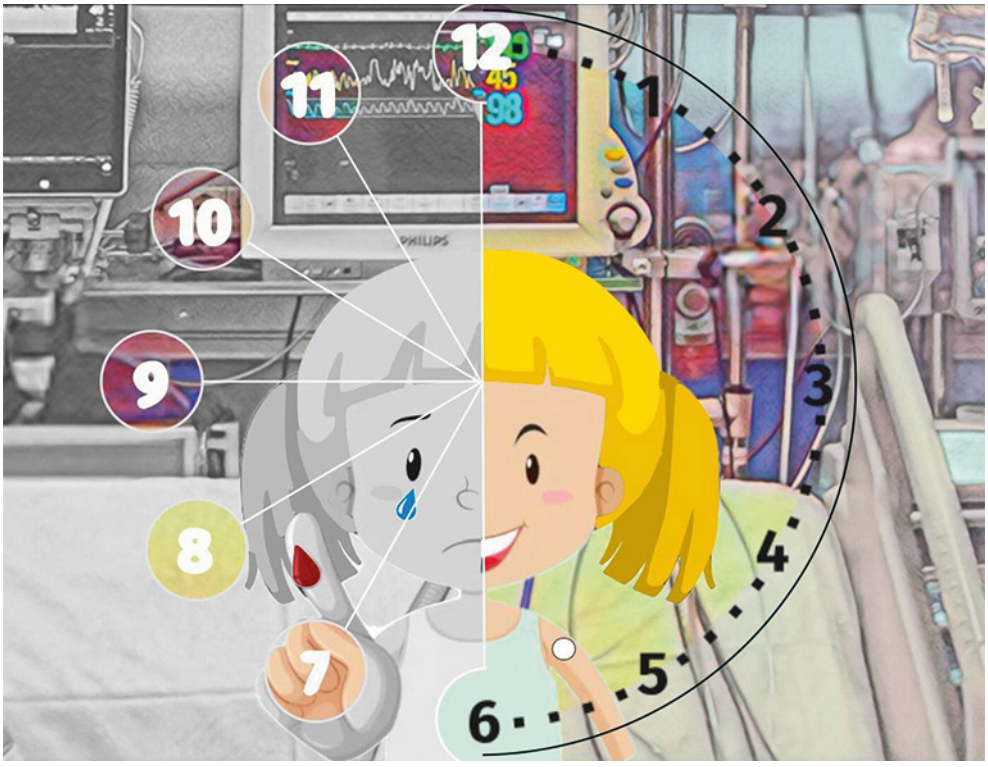

FIGURE 1. CAPILLARY GLUCOSE TESTING VS CONTINUOUS GLUCOSE MONITORING
In color, the contributions of each method: on the left side, finger pricks, discomfort, and isolated, static glucose readings; on the right side, with the sensor, greater comfort and continuous tracking of glucose dynamics.

THE PRIMARY GOAL OF THE MEDICAL TEAM IS TO STABILIZE THE PATIENT, REHYDRATE, CORRECT ELECTROLYTE IMBALANCES, AND GRADUALLY AND CONTROLLEDLY LOWER BLOOD GLUCOSE LEVELS

» Regarding the **advantages** in monitoring and treatment, when comparing capillary glucose values with those from the CGM sensor over the same period, and despite the lack of published results, our impression is that the trends are parallel. A simple review of a nursing record graph is enough to see that a hypoglycemia alert from the sensor is confirmed, to a greater or lesser extent, by a capillary glucose measurement. Moreover, the change is substantial: it is like comparing "24 photos" of our patient's glucose levels (the number of capillary pricks that would be performed) with a live video of their glycemic variability (CGM). This provides greater control over trends, offering valuable **anticipatory information** that facilitates earlier clinical decision-making and allows for spacing out capillary glucose tests, especially at night. However, the advantages go beyond strict monitoring: for nurses, the word **care** defines our profession, and being able to reduce pricks and respect sleep schedules improves humanized care and fosters a positive nurse-patient relationship (both benefits are illustrated in the attached image, ***Figure 1***). This aspect is the most perceived and valued by patients and their families, who express their satisfaction with the use of this new technology.

Nursing, particularly in endocrinology and primary care, is responsible for educating patients and their families on self-care and disease management. However, this therapeutic education begins in our PICU; it is our duty to teach the correct techniques for various procedures (capillary glucose measurement, insulin administration, etc.), and now also the use of the sensor. We understand that its implementation from the moment of admission facilitates learning and adaptation.

The incorporation of the sensor into our clinical practice has highlighted the need for proper training to fully leverage the advantages offered by CGM. Otherwise, the greatest limitation in the use of this new techno- »

» logy would be a lack of knowledge, as it provides a wealth of data that must be systematically recorded and correctly interpreted to anticipate and prevent severe complications. Furthermore, having an in-depth understanding of this technology's functionalities is crucial for effective therapeutic education.

One of the pending tasks, based on recommendations from the International Consensus of Diabetes Experts and our own clinical experience, is the use of dual sensors. These devices would provide continuous monitoring of both glucose and ketones, reducing the need for repeated capillary measurements of both parameters[8]. We hope this will become feasible in the near future. D

CONCLUSIONS

Everything discussed here highlights our satisfaction with CGM use in DKA management in the PICU. Over the past 3 years, CGM has proven its clinical utility, helping us achieve strict glycemic control while providing high-quality, humanized care. However, we recognize the need for further studies to validate our experience, which we hope will contribute to advancements in our field.

WHEN A NEWLY DIAGNOSED PATIENT IS ADMITTED, A CONTINUOUS GLUCOSE MONITORING SENSOR IS PLACED, AS INCLUDED IN THE SERVICE PORTFOLIO OF OUR HEALTHCARE SYSTEM

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