# Continuous Glucose Monitoring - A Step Towards Better Diabetes Management

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**ABSTRACT**

Self-monitoring of blood glucose (SMBG) & HbA1C, the proven parameters of glycemic control, have certain limitations. These limitations are overcome by continuous glucose monitoring system. CGM helps in real time as well as retrospective detection of blood glucose levels.Technological advancements have made the use of CGM easier and have improved its accuracy. This has helped in better diabetes management by better detection of hypoglycemia &detection of Glycemic excursions. Response to treatment can be effectively monitored with CGM. Evidence exists to prove the efficacy of CGM in better glycemic control & reduction in complications. CGM can be employed across the spectrum ofpatients with diabetes.

**Key words :**Continuous glucose monitoring, glycemic variability, flash glucose monitoring

## Introduction :

Glucose measurement forms the fulcrum of effective diabetes management. Glycosylated hemoglobin till now is the accepted method for assessment of glycemic control. Self-monitoring of blood glucose (SMBG) when included in a structured diabetes management regimen has shown to improve glycemic control & quality of life of patients with diabetes[1,2]. In spite of this gaps remain in effective monitoring of glucose levels thereby hampering effective diabetes management. Continuous glucose monitoring (CGM) systems aim to bridge this gap in glucose monitoring thereby aiding effective & correct decision making in Type1 as well as Type 2 diabetic patients. India with its high prevalence of people with pre diabetes and diabetes which is undiagnosed or poorly controlled; the importance of effective glucose monitoring needs special emphasis[3]. Patient unawareness about their own glucose level fluctuations & potential benefits of effective glycemic management[4] can be addressed with CGM.

## Need for monitoring tools beyond HbA1C & SMBG :

The Diabetes Control and Complications Trial (DCCT) and The Epidemiology of Diabetes Interventions and Complications (EDIC) study[5] have amply demonstrated that HbA1C contributes to microvascular complications in Type 2 DM. Similarly the significance of glycemic control & control of various metabolic parameters for prevention of complications in Type 2 DM has been shown by the UK Prospective Diabetes Study (UKPDS)[6]. Hence all organizations working in the field of diabetology, while recommending individualization of HbA1C target goals, target a HbA1C value ranging from <= 6.5% to 7%[7,8]. On similar linesself-monitoring of blood glucose (SMBG) has a direct correlation with favorable diabetes outcomes[1,2,9]. In spite of these evidences for HbA1C & SMBG as glucose monitoring tools they suffer from certain limitations. HbA1C being a measure of glucose levels over past 3 months fails to detect hypoglycemic & hyperglycemic episodes occurring on a daily basis. Also it is an unreliable measure in pregnancy, patients with haemoglobinopathies or iron deficiency anemia[10,11,12]. This is especially important in India with high prevalence of iron deficiency[13]. SMBG while providing the blood glucose value at that point of time does not give idea about the temporal profile of blood glucose levels. As such therapeutic decisions, especially insulin dosing based solely on the basis of SMBG values can at time be erroneous. 60% of hypoglycemia are not detected with SMBG alone[14]. Moreover, as SMBG requires a finger prick it requires a high level of patient motivation.

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Glycemicvariability, an independent risk factor for coronary artery disease& cognitive dysfunction[15,16,17] is not detected by HbA1C as well as SMBG. Thus HbA1C and SMBG though important does not reveal the complete picture. Continuous glucose monitoring systems (real time as well as retrospective / intermittent) help to fill in these gaps & help provide a complete picture.

***Figure 1 :*** **CGM vs. SMBG**

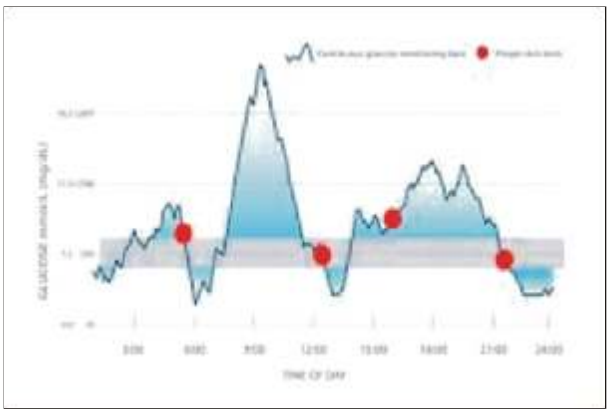
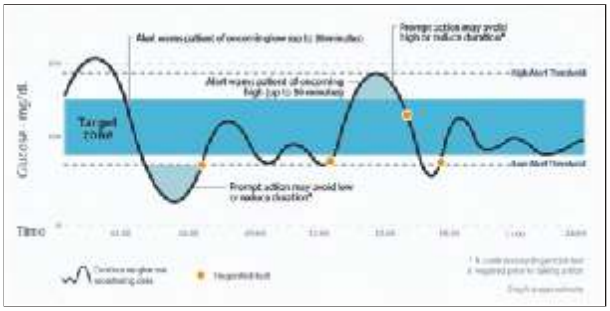


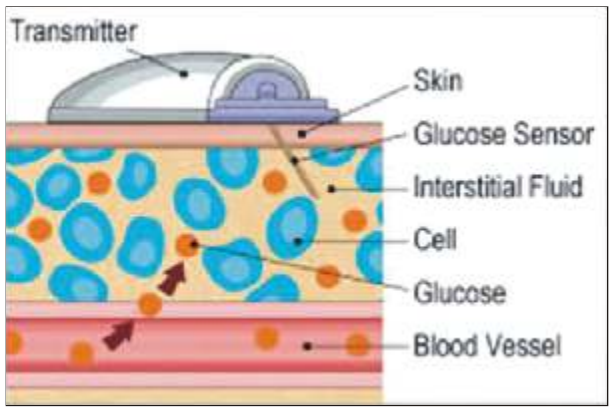
***Figure 2 :*** **Advantages of CGM**



**Basics of Continuous glucose monitoring :**

The glucose level in the interstitial fluid, the fluid in between the blood vessels and cells is measured by continuous glucose monitoring systems. This is measured via a sensor, which is placed subcutaneously. Glucose in the interstitial fluid penetrates the semi permeable membrane of the sensor, reacts with the glucose oxidase present in the sensor, producing electrons, which are measured as the input signal. This input signal value is converted into blood glucose value by using calibration blood glucose values[18]. Glucometers used for SMBG measure glucose in the blood capillaries. Glucose passes from blood capillaries into the interstitial fluid & then into the cells. CGM measures glucose value in the interstitial fluid. Hence the glucose value measured by CGM briefly lags the blood glucose value.

***Figure 3 :*** **Mechanism of CGM**




**Types of CGM devices :**

There are 2 major types of CGM systems-real time CGM (rtCGM) & intermittently viewed CGM (iCGM). RtCGM uniformly tracks interstitial fluid glucose values providing almost real time glucose values while iCGM tracks glucose values at regular intervals, which can be recovered as & when required by the observer. The rtCGM systems have alarms to warn of impending hypoglycemia. They are mostly used in Type1 DM patients. They can be effectively used with insulin pumps[19] and are a part of 'bionic pancreas'[20]. The first rtCGM 'Gluco watch' was launched in 1999. Since then many CGM systems MinimediPro, Enlite 2, Enlite enhanced, Enlite 3 (Medtronic), Dexcom STS, Dexcom 3,7, Gen 4 and 5 (Dexcom) and Navigator (Abbott) have been launched over the years with advances in technology of monitoring. These systems require 2-4 calibrations per day[21,22]. Since calibrations are based on SMBG, it is important that the blood glucose tests are performed properly and the glucometers are functioning properly.

IPro 2 (Medtronic) & Freestyle Libre Pro (Abbott) are examples of intermittent glucose monitoring systems. iCGM provides retrospective data which can be accessed by the patient or health care provider. They monitor interstitial fluid glucose

over a period of 14 days. Freestyle Libre Pro marks an important technological advancement in that it requires no calibration on part of the patient or health care provider as it is factory calibrated[21]. Freestyle Libre Pro is also referred to as flash glucose monitoring system (FGM). It has no alarms hence and can overcome 'alarm fatigue' seen with conventional CGMs[23].

**Figure 4 : Types of CGM**

***4a : Real time CGM***

***4b : Intermittent CGM- i Pro***

***4c (i) : Free style libre pro***

***4c (ii) : FGM sensor***


**Recommendations for CGM :**

Numerous clinical studies have demonstrated clinical benefits of CGM across the entire spectrum of patients with diabetes-paediatric, adolescents, type 1, and type 2 - with various levels of dysglycemia[24,25]. Benefit is directly proportional to the frequency of use[26]. CGM use has been associated with improvement in HbA1C, lower risk of hypoglycemia, better quality of life[19]. RtCGM has shown to reduce incidence of complications[27]. Mean absolute relative difference (MARD) is a measure of accuracy of CGM systems. A lower percentage indicates greater accuracy. With technological advancements in CGM systems over the past 20 years the MARD has come down from 20% to nearly 10%[28]. Improvement in the accuracy of CGM has made adjustment of insulin doses based on these CGM values safer[29].

Advanced Technology & Treatments for Diabetes (ATTD) Congress, February 2017 has provided recommendations for using CGM in clinical practice & research[30]. As per the recommendations CGM should be considered in all patients with type 1 & type 2 DM on intensive insulin therapy & not achieving Glycemic targets & are experiencing hypoglycemia. Only CGM systems that provide an acceptable level of accuracy are recommended (MARD around 10%). Detection of hitherto undetected hypoglycemia & preventing it is one of the important aims of CGM. These recommendations have classified hypoglycemia as level 1-glucose value < 70-54 mg/dl with or without

symptoms which should alert the clinician about the individual's risk for hypoglycemia. Level 2 hypoglycemia-glucose level < 54 mg/dl with or without symptoms which requires immediate action. 70% of readings over consecutive 14 days are recommended for generation of report, optimal analysis & decision-making.

In pediatric population AACE recommends CGM for patients with severe hypoglycemia[31], ADA recommends its use as a supplemental tool in those with hypoglycemia unawareness or at risk of hypoglycemia along with diabetes education[32] while Endocrine Society recommends it in Type 1 DM over 8 years of age with A1C < 7% for effective diabetes management & avoiding hypoglycemia[26].

Indian study in T2 DM patients using iPro2 sensor showed favorable HbA1C reduction, insights for changing treatment & better patient compliance[33]. Flash glucose monitoring can be used to assess the effects of insulin dose adjustments, drug add on to insulin regimen within a short interval of time without waiting for changes in HbA1C to occur. Patients on multiple daily doses of insulin experiencing frequent hypoglycemia & hyperglycemia derive benefit from FGM monitoring[34]. Flash glucose monitoring can be used as an alternative to SMBG during insulin intensification. It showed similar reduction in HbA1C with lower incidence of hypoglycemia during insulin intensification[35].

**Barriers for CGM :**

Physician & clinical inertia as introduction of any new modality requires a physician's time, energy, initiative & effort for implementation is a major barrier for CGM usage. Cost, especially in resource-limited settings like ours along with lack of patient compliance, requirement of frequent visits, lack of diabetes educators limits the use of CGM in real world setting. The problem of lag time in earlier systems has been overcome to a large extent with improvement in glucose calculating algorithms. The need for frequent calibrations has an effect on compliance in RTCGM. This problem has been overcome in FGM [27].

**Conclusion :**

CGM is an important addition to the armamentarium of effective glycemic management of patients across the spectrum of diabetes. Hypoglycemia, by virtue of affecting the quality of life as well as its association with increased mortality is a roadblock in achieving targets in diabetes. CGM due to its ability to detect undiagnosed hypoglycemia helps in better decision-making& achieving HbA1ctargets. Flash glucose monitoring has simplified use of CGM as it has done away with the need of calibration. Treatment intensification can be better monitored with use of CGM. Improvement in technology like its integration with smart phones, user friendliness; reduction in cost will result in wider usage of CGM & will improve compliance.

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