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Improvement of mild and more serious hypoglycemia in patients with DM type 1 and type 2 after introduction of Continuous Glucose monitoring in Internal Medicine Residency Clinic

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Abstract

We are describing our experience of introducing Continuous Glucose Monitoring (CGM) for the first time as far as we know not in specialized endocrine clinic, but in Internal Medicine Residency Clinic in USA. The 25- patients we included in the trial were with type 2 Diabetes Mellitus (DM 2) -85% and Type 1 DM (DM1)-15%. They were treated with multiple injections of Insulin per day and were self-Monitoring their blood glucose (SMBG) 4 times a day. Their HbA1c was in the beginning of the trial was 9.5-to 14%.

Before the introduction of the CGM the patients were spending 1 hour and 14 minutes a day having mild hypoglycemia- between 69-54 mg/dl-4.75% and more significant hypoglycemia- less than 54 mg/dl 29 min a day-3.01%. The CGM was started in the Clinic by the CGM team. In the CGM team were actively participating a10- Internal medicine and Transitional Year Residents under the supervision of board-Certified Endocrinologist who was a member of the clinic also. The CGM used was Dexcom G6. The goal of the project was to show that not only in specialized centers, but in General Internal Medicine Residency clinic we can not only improve the control of DM type 1 and type 2 in those 25-patients but most importantly reduce the time they had hypoglycemia. The Internal Medicine and Transitional year Residents were actively involved in the project. They were educating the patients before starting the CGM on their die and how to adjust their Insulin at home based on written instruction materials and treat their low blood sugar. The patients were called at least once a week by Internal Medicine Clinic representative of the CGM team with instructions how to adjust their Insulin, treat their hypoglycemia and to counsel them about their diet and physical activity.

The patients had scheduled appointment to the clinic once a month.

After the glucotoxicity from the initial high blood sugar was overcomed by using the appropriate dose of Insulin the control of the diabetes was achieved with reduction of HbA1c to 7.04% mean from 11.21% before the introduction of the CGM.

With the help of the CGM the time spent by the patients with BS less than 70 mg/dl decreased from 1 hour and 14 minutes per day-4.75% to 11 minutes per day-0.78% and the time spend with blood sugar less than 54 mg/dl per day decreased from 29 minutes-3.01% to 3 minute per day-0.25%.

Both values after the introduction of CGM were within the American Diabetic Association (ADA) standards- mild hypoglycemia goal of less than 4 % and more significant hypoglycemia goal of less than 1 % per day. Four of the patients were able to have excellent control of their DM 2 without any low blood glucose only on per oral antidiabetic medications and or GLP1-RAG.

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Our experience showed that introduction of CGM instead of SMBG in General Internal Medicine residency Clinic can help a lot of patients with DM type 1 and type 2 on multiple injections of insulin per day to reduce mild and more serious hypoglycemia and improve their blood sugar control with Insulin. Also, we showed that this can be done safely in General Internal Residency clinic and not only in specialized endocrine clinics which can be adopted in other Internal Medicine residency Clinics in USA. This also significantly improves the education and experience with the CGM devise of our Internal Medicine and Transitional Year Medical Residents.

1. Introduction

One of the remarkable advances in diabetes technology in the past decade was the implementation of continuous glucose monitoring (CGM). CGM devices have become smaller, more affordable, more accurate, and more user-friendly. With increasing CGM use, initially mostly in type 1 DM, but later on in patients with type 2 DM, on multiple injections of Insulin, and increased awareness of the limitations of HbA1c in the management of diabetes, new CGM-based metrics such as time in range (TIR), time in hypoglycemia, and blood glucose variability (coefficient of variation or CV) have been recommended by an international expert panel as more meaningful targets for diabetes management than HbA1c [1,2,3].

From the mean glucose, one can also calculate an estimated HbA1c or the glucose management index. Glucose management index (GMI) is more accurate than HbA1C and is not influenced by conditions like anemia, kidney disease, cirrhosis of the liver etc.

The prevalence of type 2 diabetes (T2DM) is higher than T1DM, and over time, insulin often becomes necessary to achieve glycemic control [2,3,4]. Individualized goals for glycemic control in T1DM and T2DM are similar using CGM. They include TIR greater than 70% of the time, time above range with high blood glucose >180-250 mg/dl less than 25% and very high blood glucose above 250 mg/dl less than 5 % of the time per day. The time below range (<70 mg/dL) goal is less than 4%- level one hypoglycemia and time bellow 54 mg/dl- level 2 hypoglycemia less than 1 % goal as well as glucose variability (CV) ≤36% are the other target using CGM[3,4]

Hypoglycemia is a well-described deterrent to the achievement of normal glycemia and impacts patients at all levels of glucose control. Mild hypoglycemia is common in patients with type 1 diabetes and type 2 DM on multiple injections of Insulin per day, occurring daily to weekly. Even when self-treatment is possible, hypoglycemic episodes interfere with the life, decrease cognitive function and performance, and can result in injury [5,6,7,8,9,10].

With the usage of CGM we have 3- levels of hypoglycemia- level 1- with blood glucose less than 70 mg/dl, level 2- with BG less than 54 mg /dl and severe in which the patient needs assistance from other person to treat the low blood glucose. Severe hypoglycemia that requires the assistance of another person, can result in severe arrhythmias, seizures or coma in 25% of cases and death very rarely[8]. Frequent episodes of hypoglycemia may lead to impaired awareness of hypoglycemia (IAH). In elderly patient with DM type 2 the hypoglycemia increases the MACE-Cardiovascular death, non-fatal stroke and non- fatal Myocardial infarction.

Two- studies assessed the effect of CGM versus SMBG in decreasing hypoglycemia in patients with type 1 DM [11,12]. The DIAMOND (Effect of Continuous Glucose Monitoring on Glycemic Control in Adults with Type 1 Diabetes Using Insulin Injections) and GOLD (Continuous Glucose Monitoring vs. Conventional Therapy for Glycemic Control in Adults with Type 1 Diabetes Treated with Multiple Daily Injections) were randomized clinical trials. In Diamond trial the level 1 hypoglycemia <70 mg/dl decreased by using CGM compare to SMBG from 80 min a day to 43 minutes a day. In Gold study the time spent in level 1 hypoglycemia < 70 mg/dl decreased from 4.79% per day to 2.79% by using CGM compare to SMBG.

Gehlaut et al. found that 49% of patients with type 2 diabetes in their study had at least one episode of hypoglycemia during a 5-day analysis with CGM and many of those hypoglycemic episodes were asymptomatic [13]. They also found that 21% of those patients found to have hypoglycemia had values <50 mg/dL and episodes were most common in those on insulin.

Using two or more injections of insulin per day was a predictor of increased hypoglycemia risk [14]. Finally, Pazos-Couselo et al. evaluated 63 insulin-treated patients with type 2 diabetes and showed that CGM over 1 week identified more hypoglycemia than was found on 8 weeks of monitoring with SMBG. Fifty-nine percent of the patients had hypoglycemia by CGM and 30% had nocturnal hypoglycemia [15].

Likewise, the UKPDS data confirmed the increased frequency of hypoglycemia among those with type 2 diabetes who were treated with MDI relative to basal insulin or noninsulin therapy [16]. Although the frequency of hypoglycemia is lower in type 2 diabetes than in type 1 diabetes, the consequences may be greater as this older population with higher cardiovascular risk may be particularly affected. For example, there has been reported >2.5-fold increase in cardiovascular death and in major cardiovascular events in those with type 2 diabetes in the ADVANCE Trial who experienced severe hypoglycemia [17]. Increased arrhythmias have been shown with hypoglycemia and multiple mechanisms have been proposed for hypoglycemia-induced cardiovascular events, including prolonged QT[17,18,19,20]. Therefore, for patients with type 2 diabetes treated with intensive insulin therapy, tools to reduce hypoglycemia could be critically important.

 T2DM patients with hypoglycemia unawareness or with a greater percentage of hypoglycemia at baseline are likely to benefit from CGM; however, further dedicated studies are necessary to establish evidence of CGM utility in hypoglycemia prevention or reduction.

Objectives

- To improve the time, spend by patients with mild hypoglycemia – less than 70 mg/dl to less than 4 % a day and hypoglycemia with Blood glucose less than 54 mg/dl – to less than 1 % per day in patients with Type 1 and Type 2 DM on multiple injections of Insulin per day by switching from SMBG to CGM. This approximates spent less than 70 mg/dl bellow 58 minutes per day and less than 54 mg/dl less than 14 minutes per day after the switch from SMBG to CGM.
- Reflecting the organizational goal and success by showing that not only in specialized Endocrine or Internal Medicine clinics but in Internal medicine Residency Continuity Community clinic with active participation of Transitional Year and Internal Medicine Residents under the supervision of Board Certified Endocrinologist the successful switching from SMBG to CGM is possible and might lead to decrement in level 1, 2 and severe hypoglycemia in patients with Type- 1 and type - 2 DM on multiple injections of Insulin per day.

2. Methods and Procedures

Twenty- five Patients with uncontrolled DM type 1 and type 2 were recruited in our Internal Medicine Residency Clinic by our CGM team in Mountain View Hospital, Las Vegas, Nevada. The team consisted of 4- Transitional Year Residents 5- Internal Medicine Residents and Board- Certified Endocrinologist.

The patients had Type 1 DM- 15% and Type 2 DM- 85%. The patients spend one hour and 14 min having mild level one hypoglycemia per day with BG 69-54 mg/dl – 4.75 % while using SMBG. They spend 29- minutes per day having level 2- hypoglycemia with blood glucose less than 54 mg/dl - 29- minutes per day while SMBG- 3.01%. Their average hbA1C before the switch to CGM was 11.21%. All of the patients and were using 3-4 injections of Insulin per day plus minus antidiabetic oral medications or GLP-RAG and were SMBG four times a day.

The patients were between 42-75 years old.

After the CGM team member in the clinic was notified by the patients about their interest in having CGM and being appropriate candidate instead of SMBG the consent form was signed by the patients after thorough explaining to them the usage of CGM.

No force or coercion was used to convince the patient to sign the form. The decision of the patient to use CGM was completely voluntary. We used in our research the CGM Dexcom G6 because of the availability of the device and technical team to help us and because the devise did not need calibration.

The data were collected using the CGM database and the clinic EMR.

The patients with compatible with the CGM I Phones or Android Phones were given by the CGM team a share code. That way the CGM team was able to monitor 24/7 the blood glucose data of the patients. The patients were seen monthly by the CGM team member.

The patients who did not have compatible with CGM I Phones or Android Phones were given receiver and every month were seen in the clinic. There the patient's data were downloaded and the Insulin adjusted as needed.

Both type of patients were contacted by member of the CGM team twice weekly and their Insulin was adjusted based on their blood glucose readings with the number one goal to decrease the hypoglycemia risk.

The Diabetic patients were given in the clinic pamphlets how to adjust if needed their Insulin at home. Also, they were counseled about diet, and exercise and pamphlet with carbohydrate and caloric content of different foods and meals were given to them.

Also, the patients were educated how to adjust their Insulin and how to treat any BG less than 70 mg/dl.

The patients before starting using CGM needed to show understanding of the procedure and teach back.

2.1. Inclusion Criteria

- Age 18-80
- Having type- 1 or type- 2 Diabetes Mellitus
- Having level 1 hypoglycemia< 70 mg/dl more than 4 % of the time
- while SMBG
- Having level 2 hypoglycemia < less than 54 mg/dl more than 1 %
- of the time while SMBG
- Having HbA1c above 7% uncontrolled while using SMBS four
- times a day
- To be seen only in Internal Medicine Residency clinic
- Patients to have compatible I-Phone or Android phone with the
- CGM device or just using the receiver
- Patients to be on 3 or 4 injections of insulin +/- oral medications or
- GLP1-RAG – oral or injectable once a week
- Patients after the switch to CGM to be on 3-4 injection of insulin
- per day with or without GLP1-RAG and or oral antidiabetic pills
- Patient to be able to understand and adjust their insulin based
- on their CGM data
- To qualify for CGM Dexcom- G6- based on patient's insurance
- Biweekly the member of the CGM team was contacting the
- patients and adjusting their Insulin to avoid Hypoglycemia,
- Instructing the patients how to treat their hypoglycemia and
- Improve their blood glucose control

2.2. Exclusion Criteria

- Diabetic patients who were not on 3-4 Insulin injections per day
- Patients who were non- compliant with the dietary and exercise recommendations
- Patients who were wearing the CGM less than 70% of the time
- Patients with impaired decision-making capacity
- Patients who missed > 2 scheduled visits
- Pregnant or incarcerated patients
- If the patient's insurance does not cover their CGM device
- If the patients do not respond to the calls from the clinic.

3. Results

We had -25- patients in the Project with either DM2-85% or DM 1-15%. They were SMBG - 3-4 times per day before starting the CGM. The patients were between 42-75 years of age. The Mean HbA1c before the switch from SMBG to CGM was 11.21%. The patients had 3-4 on average daily episode of level one hypoglycemia - less than 70mg/dl lasting on average -1 hour and 14- min per day. Also, the patients had 2 to 3 level- 2 episodes of hypoglycemia less than 54 mg/dl per day lasting - 29- min per day before the switch from SMBG to CGM.

Ninety to 120- days after starting the CGM and continuing for 2- years now there was less than 1- per day - mild hypoglycemic episode- BS<70 mg/dl lasting on average – 11- minutes (0.78%) and less than- 1 – more pronounced level 2 hypoglycemic episode per day –BS <54 mg/dl lasting – 3- minutes (0.2%) after the switch from SMBG to CGM. On SMBG the patients had 1 hour and 14 min mild (4.75%) and 29 minutes (3.01%) pronounced hypoglycemia on average per day. The ADA goal for mild hypoglycemia is less than 4% and pronounced hypoglycemia is less than 1% per day which was achieved by us.

4. Discussion

As far as we know this is the first study in the USA to implement CGM in General Internal Residents Clinic with active participation of Transitional Year Residents and Internal Medicine Residents. The Residents were part of so called CGM team. They actively participated in adjusting the Insulin of the patient, trying to avoid hypoglycemia and treat the patient's hypoglycemia. They acted under the supervision of Board-Certified endocrinologist who was a part of the Internal Medicine Residency clinic and the CGM team.

The Results were excellent and statistically significant. The time spent with mild hypoglycemia decreased from 1 hour and 14 minutes average to 11 minutes a day by switching from SMBG to CGM. The time spent with level 2 hypoglycemia- less than 54 mg/dl per day decreased from 29 minutes to 3 minutes per day. All of these goals were within the recommended by ADA goals using CGM [2,3]. For mild hypoglycemia less than 70 mg/dl the goal was less than 4 % and fore level 2 hypoglycemia – less than 54 mg/dl the goal was less than 1 %. The HbA1c decreased from 11.21% to 7.04% in our study. The more significant drop of the level 1 and level 2 hypoglycemia after the switch from SMBG to CGM we attribute to our indigent population who had poorer understanding of their disease and to significant amount of time spend by our team in their education and improvement of patient's knowledge [Fig. 1,2,3].
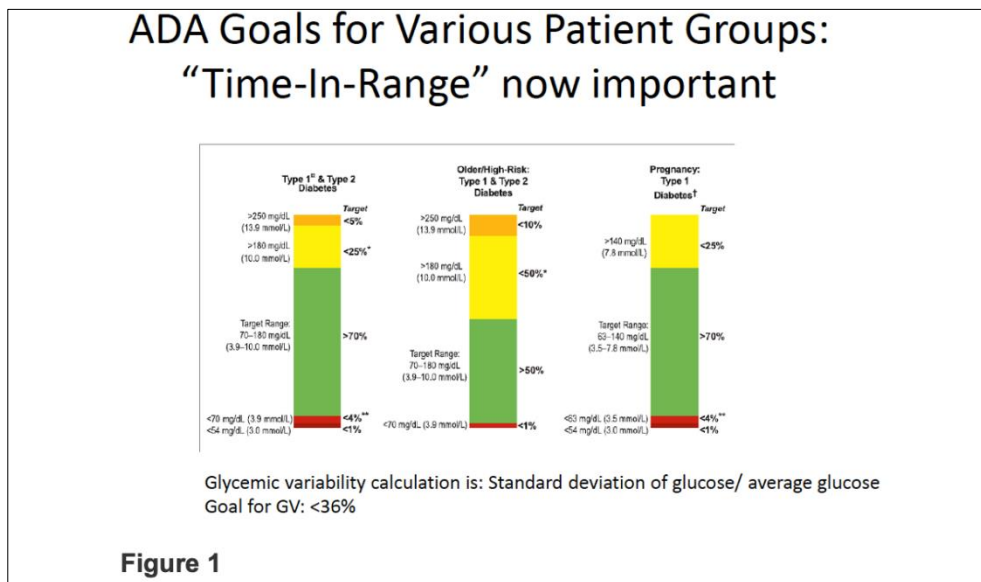
Figure 1 CGM time in range above and bellow range goals of the blood sugar
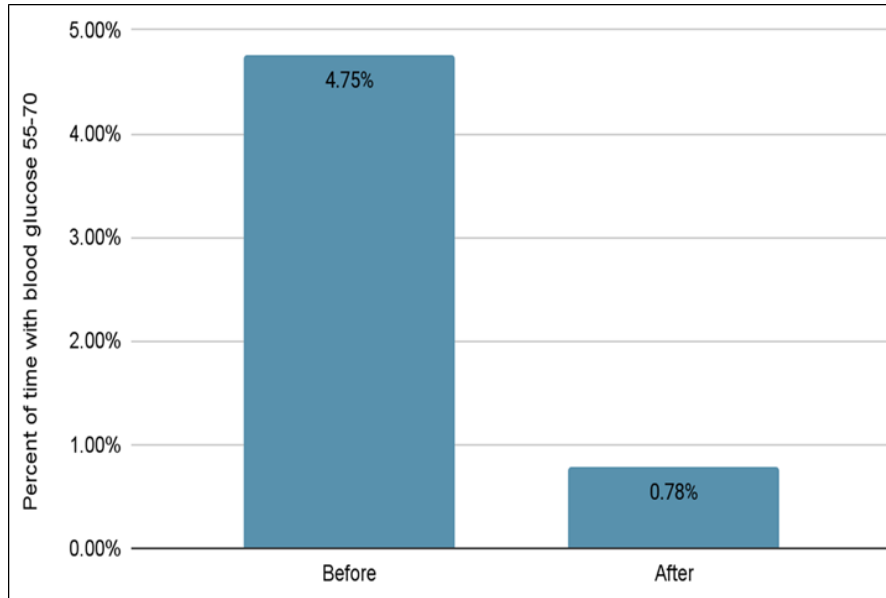
Figure 2 Percent of time with mild hypoglycemia (blood glucose 55-70)
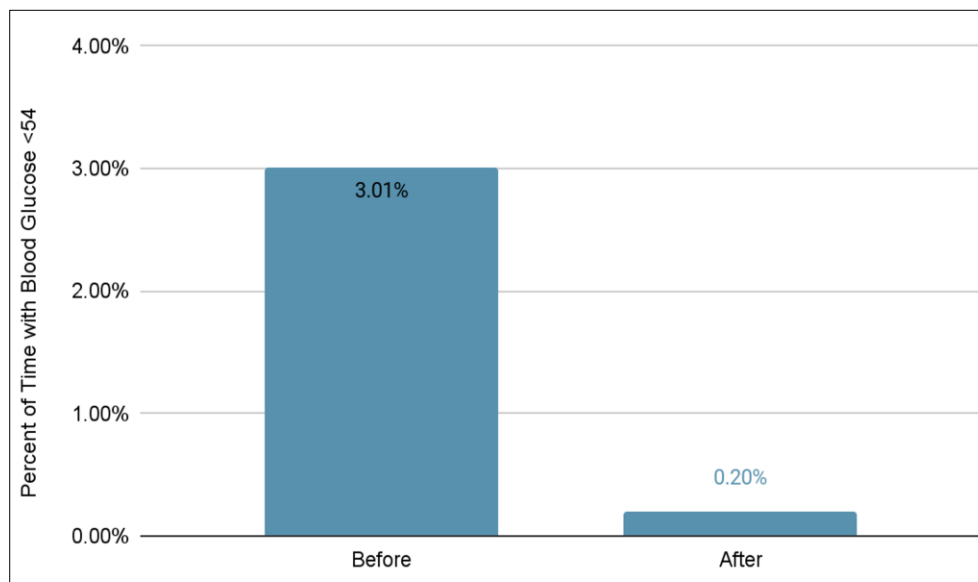
Figure 3 Percent of time in severe hypoglycemia(blood glucose <54)

Significant amount of time spent by our members of the CGM team in explaining the patients the carbohydrates needed to be consumed per meal and their type, the number of calories per day, the exercise programs and frequently following the patients by phone and in the clinic were decisive determinants for the success of our CGM team. Also, having on Board Endocrinologist as a part of the CGM team was critical for our success.

The main barriers we encountered were to assure that the patient understand how to use the CGM data in adjusting their Insulin dosages, treating their hypoglycemia, the problems with the insurance coverage of the CGM device and the lack of Diabetic educator and dietitian in the clinic to help in educating the patients.

The unique value of the study was the successful implementation of CGM in Internal Medicine Continuity Community Residency Clinic in Mountain View hospital, Las Vegas, Nevada.

5. Conclusion

According to Prof. I.Tsanov the governing decision plays a key role in the success of medical experiments .

Our decision to use CGM device together with proper patient's education and follow-up was successful. We have proved that reduction of level 1 and level 2 hypoglycemia in most difficult to treat patients with Type 1 and Type 2 DM on multiple injections of Insulin per day by introducing CGM can be done in residency continuity clinic run by Transitional year and Internal Medicine residents under the supervision of Board-Certified Endocrinologist. The importance of first reducing the hypoglycemia and then striving to achieve excellent glucose control is a concept recognized by all diabetic experts. As discussed above the hypoglycemia is related to increased incidence of Major cardiovascular events in elderly patients as ours and even death. This makes our success really meaningful.

The introduction of CGM was done traditionally in the past in specialized endocrine centers. Our success can be replicated by other Internal Medicine Residency Programs in USA to improve the quality of care of patients with DM on MDI and improve quality of education of Transitional year and Internal Medicine Residents.

Compliance with ethical standards

Disclosure of conflict of interest

All authors have declared that no financial support was received from any organization for the submitted work.

Financial relationships

All authors have declared that they have no financial relationships at present or within the previous three years with any organizations that might have an interest in the submitted work.

Other relationships

All authors have declared that there are no other relationships or activities that could appear to have influenced the submitted work.

Statement of informed consent

Informed Consent was obtained or waived by all participants in this study.

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