EVALUATION OF CONTINUOUS GLUCOSE MONITORING (isCGM) ON TYPE 2 DIABETES PATIENTS TREATED WITH BASAL – BOLUS INSULIN THERAPY

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SUMMARY

Objective: *Evaluate effectiveness of continuous glucose monitoring (isCGM) on type 2 diabetes patients treated with basal – bolus insulin therapy.* ***Method:*** *Descriptive and interventional study on 29 type 2 diabetes patients treated with basal – bolus insulin therapy at Department of Endocrinology and Diabetes, Bachmai Hospital from 1/2023 to 7/2023.* ***Results:*** *Average age is 61.4 ± 17.4. The majority oral antidiabetic drug is Metformin combined with Anti DDP4 (37%), bolus insulin is Regular (73%), basal insulin is Glargine U100 (97%). Average HbA1c is 10,8 ± 2,8 %, average serum glucose on arrival is 17.2 ± 11.6 mmol/L. Time in range on 14th day 66,2 ± 16.9% higher than the 1st day 55.1 ± 29.0% (p=0.03). CGM can detect more hypoglycemia events than point-of-care capillary blood glucose (34.2% versus 17.2%). Adverse reaction rate is 3.4% only.* ***Conclusion:*** *Continuous glucose monitoring is not only useful in controlling blood glucose level but also in detecting more hypoglycemia events than point-of-care capillary blood glucose.*

Keywords: *continuous glucose monitoring.*

1. BACKGROUND

Type 2 diabetes mellitus is characterized by increased insulin resistance and decreased beta cell function. In disease progression, insulin therapy is an essential treatment, especially in patients. When patients are treated with an intensive insulin therapy, one of complications which clinicians have to face is hypoglycemia. According to the ACCORD study (Action to Control Cardiovascular Risk in Diabetes), in the group of inpatients using intensive insulin therapy, up to 16.2% of patients with hypoglycemia needed support compared with 5.1% of the group treated without insulin. Statistics from the American Diabetes Association show that at least 50% of patients have hypoglycemia event during treatment, more than 50% them are asymptomatic. Fingertip blood sugar monitoring is the most common method for monitoring blood glucose. However, this method often causes pain and only records individual blood glucose samples, which makes it difficult for doctors to control blood glucose precisely. Meanwhile, interstitial blood glucose monitoring with a continuous blood glucose meter (isCGM) has more advantages. First, it can scan many times a day. Moreover, it is a method that can detect blood glucose level changing, especially nocturnal asymptomatic hypoglycemia event. Several studies have shown an improvement in HbA1c and reduction in hypoglycemia episodes in patients using CGMs at least 70% of the time. Because of these advantages, there are several types of CGM devices for patients in Vietnam recently, but there are a few studies related to this problem. We did research on the

results of continuous glucose monitoring (isCGM) on type 2 diabetes patients treated with basal – bolus insulin therapy.

2. METHODS

2.1. Location and time

Department of Endocrinology and Diabetes, Bachmai Hospital, from 1/2023 to 7/2023.

2.2. Participants

Inclusive criteria:

- Type 2 diabetes patients at Department of Endocrinology and Diabetes, Bachmai Hospital, diagnosed with criteria from "Guidelines for the diagnosis and treatment of type 2 diabetes" by the Ministry of Health.
- Patients received basal – bolus insulin therapy.
- Patients have indication and approve to use continuous glucose monitoring (isCGM).

Exclusive criteria:

- Pregnancy.
- Acute critical condition: sepsis, hyperosmolar hypoglycemia, diabetic ketoacidosis.
- Treated with therapy affects blood glucose: high - dose acetaminophen, vitamin C.
- Conditions affect to CGM devices and their accuracy: severe anemia, intermittent hemodialysis, magnetic resonance imaging, skin infection.

2.3. Design

- Descriptive and partly intervened study.
- Sample size: all patients meet the criteria.
- Devices: Intermittently scanned CGM (isCGM) Freestyle Libre 1 from Abbott. Patients is guided to use at least 10 times per day.

2.4. Variable and index

- Characteristics of patients in research: age, gender, occupation, geography, duration of diabetes, type of oral medicine, type of insulin therapy, some paraclinical index (Glucose at admission, HbA1c).
- Results of continuous blood glucose monitoring (CGM) in research patients (TIR, TAR, TBR, Average blood glucose, Blood glucose variation): Evaluation according to Asia-Pacific consensus recommendations for application of continuous glucose monitoring in diabetes management.

2.5. Statistical Analysis

Information and data collected is analyzed with SPSS 26.0 program.

2.6. Research ethics

This is a descriptive and partly intervened study. However, the intervention is measuring and managing patients' blood glucose more effectively, so it is no harm to patients. Information and data collected help physicians control patients' blood glucose more effective and improve the treatment results.

3. RESULTS

3.1. Characteristics of patients in research

Our study included 29 patients with a male-to-female ratio of 1.5:1. The average age of the study group was 61.4 ± 17.4; The patient is 20 years old, the oldest is 86. The average duration of diabetes is 9.8 ± 8.3 years. Among them, the group with disease duration of 5 - 14 years accounts for the majority with a rate of 38%. The average BMI recorded was 23.9 ± 3.7 kg/m^2.

On treatment characteristics, the most common therapy is using insulin combined with Metformin and DPP – IV inhibitors (37%) and insulin combined with DPP – IV inhibitors (29%). The majority of patients in the study used a bolus injection of Regular insulin and a basal injection of Glargine U100. The average total insulin dose was 0.7 ± 0.2 IU/kg. Patients in the study had poor blood glucose control with an average HbA1c of 10.87 ± 2.89 % and average blood glucose at admission of 17.24 ± 11.67 mmol/l.

Table 1. Characteristics of patients in research

Characteristics	All patients (n=29)	Male (n=17)	Female (n=12)
Age (year)	61.4 ± 17.4	56.1 ± 17.8	69.0 ± 14.3
Occupation			
Intellectual work	14 (49)	10 (59)	4 (33)
Worker	8 (27)	4 (23)	3 (25)
Farmer	7 (24)	3 (18)	5 (42)
Duration of diabetes			
< 5 years	10 (34)	8 (47)	2 (16)
5 - <15 years	11 (38)	6 (35)	5 (42)
≥ 15 years	8 (28)	3 (18)	5 (42)
Average	9.7 ± 8.3	7.5 ± 7.8	12.9 ± 8.2
Duration of insulin use (years)	2.7 ± 3.6	4.3 ± 2.7	3.3 ± 3.3
BMI (kg/m^2)	23,9 ± 3,7	24.8 ± 4.0	22.8 ± 3.0
Type of oral medicine			
Metfomin + DDP – 4 inhibitors	13 (37)		
DDP – 4 inhibitors	10 (29)		
Metformin	6 (17)		
SGLT – 2 inhibitors	4 (11)		
Metformin + SGLT – 2 inhibitors	1 (3)		
GLP-1 agonists	1 (3)		
Insulin bolus			
Regular	21 (73)		
Aspart	7 (24)		
Glulisine	1 (3)		
Insulin basal			
Glargine U100	28 (97)		
Detemir	1 (3)		
Average insulin dose (UI/kg/day)	0.7 ± 0.2		
Paraclinical index			
HbA1c (%)	10.8 ± 2.8	10.7 ± 3.2	10.9 ± 2.4
Glucose at admission (mmol/l)	17.2 ± 11.6	20.2 ± 14.2	13.0 ± 6.9

3.2. Results of continuous blood glucose monitoring (CGM) in diabetes type 2 patients received basal – bolus insulin therapy

3.2.1. Results of blood glucose control

Table 2. Results of blood glucose control at the 1st day and the 14th day

Characteristics		1st day	14th day	p
Time above range (TAR)	% of readings & time > 13.9 mmol/l ($\overline{X} \pm SD$)	16.9 ± 22,3	8.9 ± 8.5	**0.049**
	% of readings & time 10.1–13.9 mmol/L ($\overline{X} \pm SD$)	24.1 ± 14.8	20.1 ± 10.5	0.196
Time in range (TIR)	% of readings & time 3.9–10.0 mmol/L ($\overline{X} \pm SD$)	55.1 ± 29.0	66.2 ± 16.9	**0.033**
Time below range (TBR)	% of readings & time 3.0–3.8 mmol/L ($\overline{X} \pm SD$)	2.7 ± 4.3	4.0 ± 7.6	0.270
	% of readings & time < 3.0 mmol/L ($\overline{X} \pm SD$)	1.3 ± 2.8	0.6 ± 0.9	0.180
Mean glucose		9.8 ± 2.9	8.5 ± 1.7	**0.025**
Glycemic variability		30.6 ± 9.69	35.0 ± 6.4	**0.029**

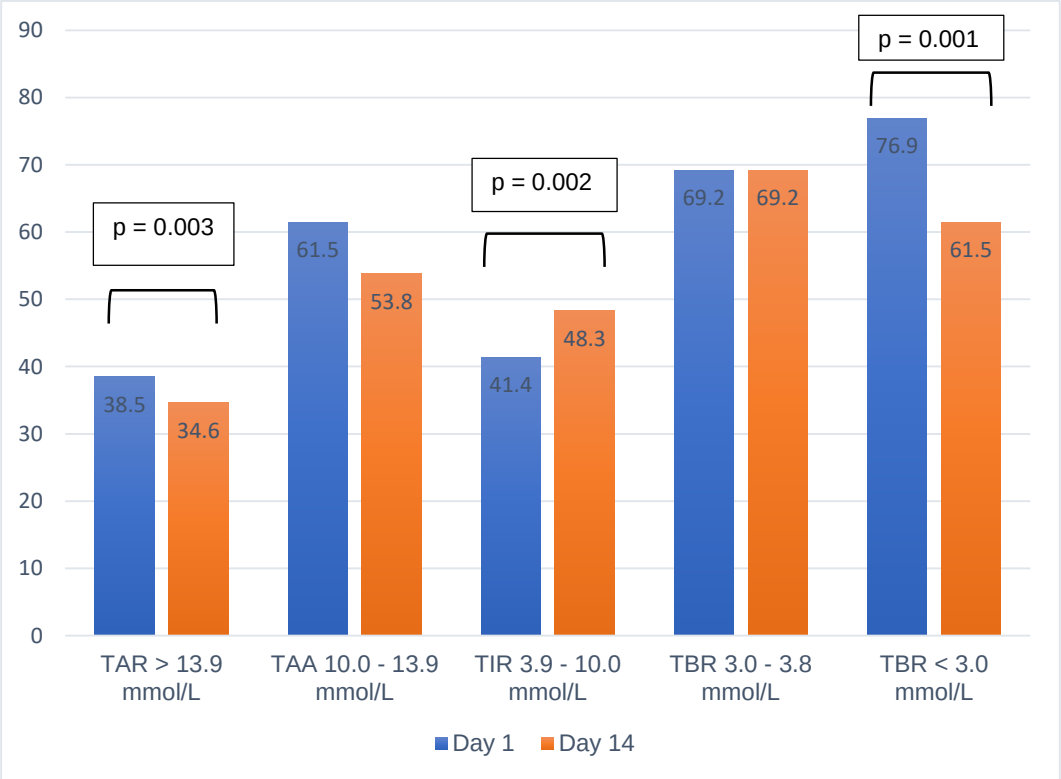

Figure 1. TIR, TAR, TBR reached target after 1 and 14 days of treatment

Our study found an improvement in blood sugar control of patients after 14 days of using CGM. The time above range (TAR) on day 14 was 8.9 ± 8.5 (%) which saw statistically significant drop compared to the first day of treatment (p = 0.049). Similarly, the time in range (TIR) ratio of the 14th day was 66.2 ± 16.9 (%), improved compared to day 1 of 55.1 ± 29.0 (%) with statistical significance (p = 0.033). The mean blood sugar after 14 days of treatment also saw statistically significant increase with p = 0.025. We divided the pass and fail rates of the blood glucose monitoring criteria by CGM. Figure 3.1 shows that the pass rates of TAR, TIR and TBR all improved between day 1 and day 14.

3.2.2. Detecting hypoglycemia by CGM and point-of-care capillary blood glucose

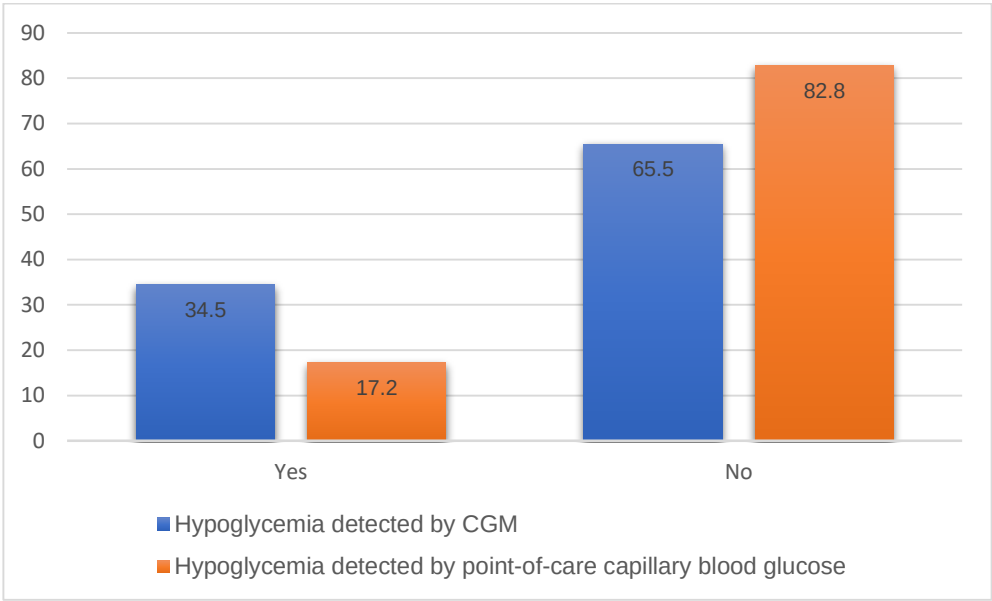

Figure 2. Rate of hypoglycemia detected by CGM and point-of-care capillary blood glucose

CGM detected more hypoglycemic episodes (34.5%) than the point-of-care capillary blood glucose. (17.2%). Among them, CGM detected 38.1% of hypoglycemic events which capillary blood glucose could not detect.

3.2.3. Adverse events

The proportion of patients in our study experiencing side effects when using CGM was relatively low. We only recorded 1 patient with muscle soreness and pain at the point of attachment. No side effects such as skin irritation or infection were noted.

4. DISCUSSION

The mean age of patients in the study was 61.4 ± 17.4 (years). This age is lower than that of western studies such as Gomez's (2016) which was 66.1 ± 8.6 (years) or Morton's (2013) which was 70 ± 15 (years). The ratio of male to female in the study is 1.5:1, some studies on CGM also have a higher male-to-female ratio, for example Gomez's study (2016) was 1.4:1.

The patients in the study suffered diabetes for an average of 9.7 ± 8.3 years, significantly lower than in Gomez's study (2016) of 14.8 ± 9 years.

The study showed that most of the bolus insulin in treatment is Regular insulin, accounting for 73%, while basal insulin, most of the patients treated with Glargine U100 accounted for 97%. The reason why these insulins account for such

high percentages was because this is a type of insulin that was widely available in Bach Mai hospital drugstore.

The average HbA1c index of patients was 10.87 ± 2.89%, higher than that of foreign studies such as Gomez's (2016) which was 9.26 ± 2.62% or Morton's (2013) which was 8.3 ± 1.7%. The patients' blood sugar at hospital admission was 17.24 ± 11.67 mmol/L which was also higher than that of Gomez's study (2016) which was 13.9 ± 0.5. Therefore, patients need more aggressive blood sugar control and CGM will be a safe and effective support solution.

The time above range (TAR) on day 14 of 8.9 ± 8.5 was much lower than on the first day of treatment (p=0.049). Similarly, the time in range (TIR) of the 14th day was 66.2 ± 16.9, which improved compared to the first day of 55.1 ± 29.0 (p = 0.033). The reason for such a difference might be because a part of patients received dose adjustment based on their daily blood sugar measured by CGM.

The rate of hypoglycemia detection by CGM in our study was 34.5%, higher than that of point-of-care capillary blood glucose of 17.2%. In addition, more than 1/3 of cases could only be detected by CGM but not by point-of-care capillary blood glucose. This is similar to most other studies. In Gomez's study (2016), CGM detected 55 hypoglycemia events, while point-of-care capillary blood glucose detected only 12 times. Moreover, asymptomatic hypoglycemia 86.7% could only be detected by CGM, especially nocturnal hypoglycemia. In the research of Morton (2013), only 10% of patients with hypoglycemia from 0h – 7h could be detected by point-of-care capillary blood glucose, especially no patients with blood sugar less than 3.0 mmol/L were detected by this method. hypoglycemia has been identified as a factor that can affect the adherence to treatment and the effectiveness of blood sugar control in patients with diabetes. The detection and prevention of hypoglycemia, especially asymptomatic cases, will help patients achieve the target of blood sugar control and ensure patients' safety during treatment.

The rate of side effects of CGM in our study was very low, only 1 patient, accounting for 3.4%. Moreover, this was only a mild side effect, not dangerous for the patient. This shows that the use of CGM is very safe and ensures patient satisfaction.

5. CONCLUSION

Continuous blood glucose monitoring (CGM) is a new, effective, and safe method for assessing glycemic control in patients on intensive insulin therapy. There is a significant improvement in blood sugar control of diabetic patients when using CGM. Moreover, the ability to detect hypoglycemia is also better than that of fingertip capillary blood glucose.

REFERENCES

1. Effects of Intensive Glucose Lowering in Type 2 Diabetes. New England Journal of Medicine. 2008;358(24):2545-2559.
2. **Workgroup on Hypoglycemia, American Diabetes Association**. Defining and reporting hypoglycemia in diabetes: a report from the American Diabetes Association Workgroup on Hypoglycemia. Diabetes Care. 2005;28(5):1245-1249.
3. **Mian Z, Hermayer KL, Jenkins A**. Continuous Glucose Monitoring: Review of an Innovation in Diabetes Management. The American Journal of the Medical Sciences. 2019;358(5):332-339.
4. **Ministry of Health.** Guidelines for the diagnosis and treatment of type 2 diabetes. 2020.
5. **Kong APS, Lim S, Yoo SH, et al**. Asia-Pacific consensus recommendations for application of continuous glucose

monitoring in diabetes management. Diabetes Research and Clinical Practice. 2023;201:110718. doi:10.1016/j.diabres.2023.110718

6. **Gómez AM, Umpierrez GE, Muñoz OM, et al**. Continuous Glucose Monitoring Versus Capillary Point-of-Care Testing for Inpatient Glycemic Control in Type 2 Diabetes Patients Hospitalized in the General Ward and Treated With a Basal Bolus Insulin Regimen. J Diabetes Sci Technol. 2016;10(2):325-329.
7. **Burt MG, Roberts GW, Aguilar-Loza NR, Stranks SN**. Brief Report: Comparison of Continuous Glucose Monitoring and Finger-Prick Blood Glucose Levels in Hospitalized Patients Administered Basal-Bolus Insulin. Diabetes Technology & Therapeutics. 2013;15(3):241-245.