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Original Research Article

Analysis of glycemic trends in elderly patients with diabetes mellitus with continuous glucose monitoring

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ABSTRACT

Background: Glycemic control is critical in elderly diabetics, considering their increased vulnerability to hypo- and hyperglycemic events. Continuous Glucose Monitoring (CGM) offers real-time, 24-hour insights into glucose fluctuations by measuring interstitial glucose levels over 14 days. CGM summarizes glycemic variability using metrics such as time above range (TAR), time in range (TIR), and time below range (TBR), enabling better detection of patterns compared to isolated blood glucose measurements. This study aimed to investigate glycemic variability in elderly diabetics using CGM. Also, to evaluate CGM's relevance in identifying hypo- and hyperglycemia, and provide evidence for the benefits of CGM in diabetes management.
Methods: A six-month observational study at tertiary care hospital in Pune enrolled elderly diabetics on CGM. Data was transmitted by patients periodically. Insulin therapy was remotely titrated in real time as per patient requirement.
Results: The study had a mean age of 70.72 years, with 76% males. Hypoglycemic episodes were reported in 8% of patients, 64.7% of which were asymptomatic and 35.3% symptomatic. In those experiencing early morning hyperglycemia, 48% patients showed Dawn's and 32% Somogyi's phenomenon. 76% of patients had fasting hyperglycemia, while 64% had postprandial hyperglycemia. Following remote insulin titration over 14 days, TAR decreased by 7.1% and TIR increased by 8.7%.
Conclusions: CGM provides a comprehensive, dynamic assessment of glycemic patterns in elderly, surpassing traditional glucose monitoring. Study demonstrates that remote titration of insulin and OHAs based on CGM data significantly improves glycemic control while reducing the risk of hypo- and hyperglycemia. Findings underscore the clinical value of CGM in elderly diabetes care, enabling personalized therapeutic decisions and enhancing safety in a population highly susceptible to glucose fluctuations. Integrating CGM into standard management protocols can optimize outcomes and mitigate complications.

Keywords: Continuous glucose monitoring, Elderly, Glycemic trends

INTRODUCTION

Diabetes mellitus has steadily evolved as a major public health problem over the past quarter century across the globe, and especially in India.[1] India is contributing significantly to the global diabetes burden, and is considered the diabetic capital of the world.[1,2] Elderly population (age >65 years) forms a large part of this number.[3]

Good glycemic control is of paramount importance in diabetic individuals. It is well- known that older adults are more prone to hypoglycaemia and hypo-glycaemic unawareness; however, the severe consequences of the

same are under-appreciated.[4] Complications of hypoglycemia can range from symptoms such as giddiness, sweating, palpitations and loss of consciousness, to severe consequences such as cardiac abnormalities, seizures, coma, hypoglycemic brain injury and even death. Hypoglycaemia and its unawareness poses a significant risk to the older population because of its associated negative outcomes: including falls, incontinence, frailty, cognitive impairment or depressive symptoms.[5]

Continuous glucose monitoring can provide immediate (real-time) feedback on current glucose levels and trends (direction and rate of change), as well as retrospective data that can reveal patterns of glycemic control over specified time periods and glucose metrics that can be compared from visit to visit or for research analysis. Continuous glucose monitoring devices measure glucose levels in interstitial fluid in 1 or 5 min increments (depending on the system used) on a continuous basis.[6] These systems measure interstitial glucose levels and provide real-time numerical and graphical information about the current glucose level, glucose trends and trend arrows, which indicate the direction and velocity of changing glucose.[7] The metric includes three key CGM measurements: percentage of readings and time per day within target glucose range (TIR), time below target glucose range (TBR), and time above target glucose range (TAR). The primary goal for effective and safe glucose control is to increase the TIR while reducing the TBR. A standardized report enables clinicians to readily identify important metrics such as the percentage of time spent within, below, and above each individual's target range, allowing for greater personalization of therapy through shared decision making.[8]

Many CGM devices offer alerts for high or low glucose levels. [9,10] CGM also helps to identify certain phenomenon of early morning hyperglycaemia, such as the Dawn's and Somogyi phenomenon.[15]

The key metrics derived from CGM data include time in Range (TIR) represents the percentage of time a patient's glucose levels remain within a target range, typically 70-180 mg/dL.[11]

Studies suggest that 14 days of CGM data can reliably estimate a patient's typical glucose patterns, with at least 70% of data (approximately 10 days) providing confidence in the assessment.[12]

Time Above Range (TAR) indicates the percentage of time glucose levels exceed the target range (>180 mg/dL).[11] CGM data categorize hyperglycemia into two levels Level 1: 181-250 mg/dL and Level 2: >250 mg/dL.[13] Level 2 hyperglycemia necessitates prompt intervention to prevent adverse outcomes.[13]

Time Below Range (TBR) reflects the percentage of time glucose levels fall below the target range (70 mg/dl), indicating hypoglycaemia, and is categorized as Level 1: 54-69 mg/dL and Level 2: <54 mg/ dL.[13] Level 2 hypoglycemia is considered clinically significant and requires immediate action.[13]

Glycemic Variability (GV) GV measures fluctuations in glucose levels over time, providing insight into the stability of glycemic control.[14]

High GV is associated with an increased risk of hypoglycemia and may impact overall glycemic control.[14]

METHODS

This is an observational study, conducted over six months duration from November 2025 to April 2026 at Smt. Kashibai Navale Medical College and General Hospital. A total of 25 participants were enrolled (N=25).

Inclusion criteria

Elderly patients diagnosed with diabetes mellitus on continuous glucose monitoring.

Exclusion criteria

Non-diabetic patients who are on steroid therapy, not willing for participation, critically ill patients, and patients not able to provide consent were excluded.

Data collection

Data was collected from patients who were on CGM monitoring and willing for participation in the study. The patients were observed during a period 14 days. Data (individual readings, graphs and BSL trends) was transmitted to us by the patients or their relatives periodically, either alternate day or on a weekly basis. HAI/Basalog was titrated remotely in real time, based on the patient's requirement.

Statistical analysis

Data was entered into MS Excel and analyzed using IBM Statistical Package for the Social Sciences (SPSS) for Windows, version 2.5. Categorical variables were summarized as frequencies and proportions. The results were presented in tabular and graphical formats.

RESULTS

The study evaluated CGM metrics across 25 participants, predominantly males (76%, n=19) and diagnosed with type 2 diabetes mellitus (92%, n=23) (Table 1).

Hyperglycaemia was documented in 22 participants, with 68.18% (n=15) presenting level 1 hyperglycaemia (181 to 250 mg/dL) and 31.81% (n=7) exhibiting level 2 (>250 mg/dL); fasting hyperglycaemia was most prevalent manifestation (76%, n= 19), while 56% (n=14)

experienced both fasting and postprandial elevations. Hypoglycaemia occurred in 17 patients, classified into level 1 (64.7%, n=11) and level 2 (35.3%, n=6) (Table 2).

Table 1: Distribution of gender among the study participants (n=25).

Gender	Frequency	Percentage
Male	19	76.0
Female	6	24.0
Total	25	100.0

Table 2: Distribution of hypoglycaemia among the study participants (n=17).

Hypoglycaemia	Frequency	Percentage
Level 1 (BSL- 54-69 mg/dL	11	64.7
Level 2 (BSL <54mg/dL)	6	35.3
Total	17	100.0

Glycaemic excursions also revealed a high incidence of Dawn's phenomena (48%, n=12) and Somogyi phenomena (32%, n=8) (Table 3).

Table 3: Dawn and Somogyi phenomenon incidence among the study participants (n=25).

Dawn and Somogyi phenomenon	Frequency	Percentage
Somogyi phenomenon	8	32
Dawn's phenomenon	12	48
None	5	20
Total	25	100.0

Table 4: Distribution of severity of hyperglyaemia among study participants.

Hyperglycaemia	Frequency	Percentage
Level 1 (BSL 181-250 mg/dL)	15	68.18
Level 2 (BSL >250 mg/dL)	7	31.81
Total	22	100.0

Table 5: Type of diabetes mellitus among study participants.

Type of diabetes mellitus	Frequency	Percentage
Type 1	2	8.0
Type 2	23	92.0
Total	25	100.0

Overall baseline glycaemic control reflected a mean time in range (TIR) of 49.4±28.7%, time above range (TAR) of 44.2±33%, and time below range (TBR) of 6.3±7.6%. Longitudinal comparison from day 1 to day 14 demonstrated marked improvements in glycemic stability across the cohort, characterised by an overall increase in TIR alongside consistent reduction in both TAR and TBR (Table 6, Figure 1-3).

Table 6: Distribution of time in range, above range and below range among the study participants (n=25).

Variables	Mean (SD)	Minimum	Maximum
Time in range	49.4 (28.7)	0	96
Time below range	6.3 (7.6)	0	30
Time above range	44.2 (33.0)	0	100

Table 7: Incidence and distribution of hyperglycaemia.

Hyperglycaemia	Frequency	Percentage
Fasting	19	76.0
Postprandial	16	64.0
Both	14	56.0

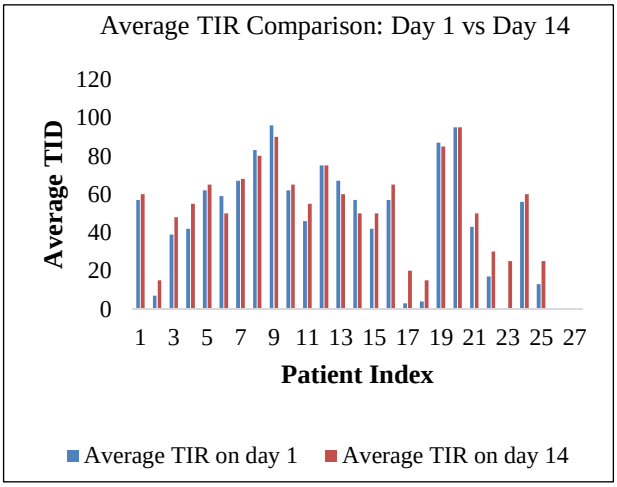

Figure 1: Comparison of TIR on day 1 v/s day 14.

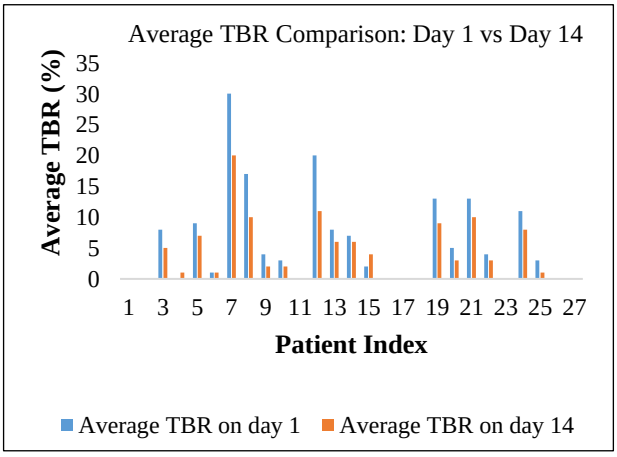

Figure 2: Comparison of TBR on day 1 v/s day 14.

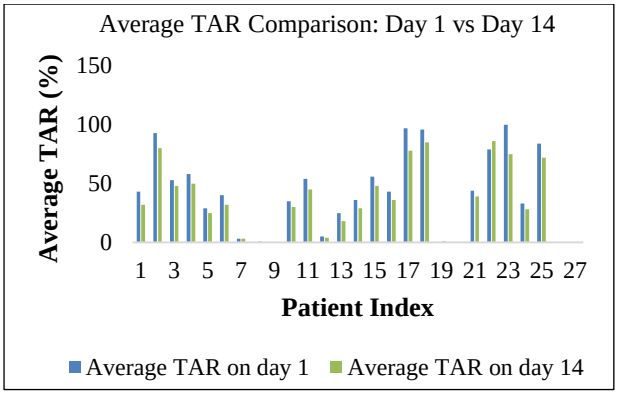

Figure 3: Comparison of TAR on day 1 v/s day 14.

DISCUSSION

This study aims to analyze the glycemic trends in elderly patients with diabetes mellitus with Continuous Glucose Monitoring (CGM). The study population had a mean age of 70.72 years. It aligns with findings from other studies, which indicate that DM is more prevalent in middle-aged and older adults.[15,16]

This is likely due to the progressive nature of insulin resistance and beta-cell dysfunction, which become more pronounced with age. A study by Junhee et al included 28 participants, the majority of whom were male (75.0%), with a mean age of 74.79 years (SD=5.41), ranging from 65 to 84 years.[17]

Similarly, in a study by Kim et al, out of 15 patients, 8 (53.3%) were under 60 years of age (mean age: 51.4±7.0 years), while 7 (46.7%) were 60 years or older (mean age: 72.6±8.8 years).[18]

The gender distribution of the study participants revealed that 76% of participants were male, and 24% of the participants being female. This finding is consistent with studies reporting a higher prevalence of DM in males, which may be attributed to differences in lifestyle factors, such as higher rates of smoking and alcohol consumption, as well as metabolic risk factors like central obesity and insulin resistance.[19,20]

Hypoglycemia was a significant finding in this study, with 68% of participants reporting episodes of low blood glucose. Among these, 64.7% were asymptomatic, while 35.3% reported symptomatic episodes, highlighting the risk of unrecognized hypoglycemia in older adults.

In the study by Ahmad Al-Azayzih et al, hypoglycemia of varying severity was observed in 21.7% of older outpatients (aged ≥60 years) with type 2 diabetes mellitus.[21]

Previous studies have reported hypoglycemia prevalence ranging from 12% to 57.44%.[22-24]

In a study by Chandrakumar et al, conducted across nine old-age care facilities in South India, 86% of diabetic residents experienced hypoglycemia during therapy, with insulin use identified as a major contributor.[25]

In the study by Samya et al, 11.6% of hypoglycemic patients experienced symptoms daily, 21.9% had 2-3 episodes per week, and 48.2% reported 2-3 episodes per month.[22]

The high proportion of asymptomatic cases raises particular concern for severe hypoglycemic episodes in older adults, who may have diminished awareness of early warning signs.

Addressing this, Bao et al compared CGM with blood glucose monitoring (BGM) in adults aged ≥65 years and found a significantly lower incidence of hypoglycemia in the CGM group. The mean time spent with glucose levels below 70 mg/dL was 0.06% in the CGM group compared to 0.21% in the BGM group, with only one severe hypoglycemic event reported in the CGM group. These findings collectively highlight the widespread occurrence of hypoglycemia in older adults with diabetes and emphasize the need for tailored monitoring strategies and individualized care to reduce its frequency and severity.[26]

In the present study, among patients experiencing early morning hyperglycaemia, 48% exhibited Dawn's phenomenon and 32% experienced Somogyi's phenomenon. Dawn's phenomenon refers to early morning hyperglycemia, typically between 3 AM and 5 AM, due to reduced insulin secretion accompanied by an increase in insulin-antagonistic hormones such as growth hormone and cortisol. Somogyi's phenomenon involves nocturnal hypoglycemia, often caused by an excessive insulin dose, followed by rebound hyperglycaemia triggered by the release of counter-regulatory hormones.[27]

Mozersky et al reported a 12.6% prevalence of the Somogyi effect in individuals with type 2 diabetes mellitus.[28]

Another study by Wu et al, involving 306 patients with type 2 diabetes on various insulin regimens, found that 37.9% experienced the dawn phenomenon.[29]

Similarly, Carroll et al reported the dawn phenomenon in approximately 54% of patients with type 1 diabetes and 55% with type 2 diabetes using a defined quantitative threshold.[30]

In a study by Sharif et al, the Somogyi effect was identified in 8 individuals, accounting for 19% of those with morning hyperglycemia.[31]

In this study, among the 22 participants who experienced hyperglycaemia, 68.18% had Level 1 hyperglycaemia with blood sugar levels ranging from 181 to 250 mg/dL, while 31.81% had Level 2 hyperglycaemia with levels exceeding 250 mg/dL. These patients had uncontrolled or poorly controlled diabetes mellitus, and would require modification of ongoing treatment to ensure better glycemic control.

In this study, most participants (92%) had type 2 diabetes mellitus, and 8% had type 1 diabetes, which is similar to the general pattern seen both globally and in India, where type 2 diabetes is more common. Ruan et al reported that among their study population, 7% (n=546) had type 1 diabetes, while the majority, 93% (n=7,538), had type 2 diabetes.[32]

This pattern is primarily due to rising rates of obesity, sedentary lifestyles, and aging populations. Type 1 diabetes, though less common, remains a significant concern, particularly among children and adolescents.[33]

On average, the study population spent 49.4% of their time within the target blood sugar range, 6.3% of their time below the range (indicating episodes of hypoglycaemia), and 44.2% of their time above the range (indicating hyperglycaemia).

The maximum time any individual spent in range was 96%, while the highest recorded time below range was 30%, and above range was 100%.

In a study by Bao et al, CGM use led to significant improvements in glycemic control across all age groups. Among older adults (≥65 years), CGM users experienced a 16% increase in time in range (TIR), while younger adults (<65 years) showed a 17% increase. Time spent above 180 mg/dL decreased by 16% in older and 17% in younger CGM users. Severe hyperglycemia (glucose >250 mg/dL) also dropped by 8% in older adults and 13% in younger adults using CGM. Importantly, CGM did not lead to increased hypoglycemia. Overall, CGM demonstrated clear benefits in increasing time within the target range and reducing hyperglycemic episodes without raising the risk of hypoglycemia.[26]

In this study, 76% of participants were found to have fasting hyperglycemia, while 64% experienced postprandial hyperglycemia. Additionally, 56% had both fasting and postprandial hyperglycemia, indicating persistent elevated blood glucose levels throughout the day. These findings suggest that a significant portion of the study population had poor glycemic control. The presence of both types of hyperglycemia in over half of the participants highlights the need for treatment strategies that address both basal and post-meal glucose levels to achieve better overall glycemic management.

It was observed that TAR reduced from day 1 to day 14 by 7.1%, with a p value of 0.0002. The average TIR increased by 8.7% from day 1 to 14, with a p value of 0.007. The mean TBR dropped from 6.64% to 4.84%, with a p value of 0.001.

While this study provides valuable insights into glycemic patterns among elderly patients using CGM, certain limitations must be acknowledged. As a single-center study with a relatively small sample size, these findings may not be generalizable to broader populations. Additionally, the absence of long-term follow-up restricts assessment of sustained outcomes. Device-related considerations such as sensor accuracy, calibration needs, adhesion issues, and cost may also influence usability and data quality. Patient-related factors including adherence, familiarity with the technology, and access to training may have impacted the effectiveness of CGM use. These factors should be taken into account when interpreting the results and planning future research.

This study has certain limitations. The single-center design and relatively small sample size may limit the generalizability of the findings, while limited long-term follow-up restricts assessment of sustained outcomes. Device-related challenges include sensor accuracy, calibration requirements, limited sensor lifespan, adhesion issues, and cost, particularly for devices enabling real-time data transmission. Patient-related factors such as adherence, acceptance, limited access, and inadequate training may also affect device utilization and data quality. Larger multicenter studies with longer follow-up are warranted to address these limitations.

CONCLUSION

The use of Continuous Glucose Monitoring (CGM) in elderly patients with diabetes mellitus provides a comprehensive and dynamic view of glycemic patterns, offering critical insights that go beyond traditional glucose monitoring methods.

During the course of the study, data was collected from the patient or patient's relatives every alternate day or on a weekly basis, and OHAs and Insulin dosage could be tailored according to the individual patient's need as per requirement, thus reducing the incidence of hypoglycemic and hyperglycemic episodes, and improving overall glycemic control. It was observed that at the end of the 14 day- study of CGM monitoring, there was an increase in the time in range and reduction in post- prandial hyperglycemic surges after Insulin/ Basalog dose adjustment.

The key clinical implication of this study is that remote titration of insulin and/or oral hypoglycemic agents (OHAs) in patients utilizing continuous glucose monitoring (CGM) systems can facilitate improved glycemic control and alleviate the risk of both hyperglycemic and hypoglycemic complications.

Our findings underscore the importance of individualized glycemic targets and careful clinical monitoring in the elderly, considering their increased vulnerability to both hypo- and hyperglycemic events. CGM proved especially valuable in detecting nocturnal hypoglycemia and early morning hyperglycaemia that would likely go unnoticed with standard monitoring. Overall, integrating CGM into routine diabetes care for the elderly can help physicians make better therapeutic decisions to improve glycemic control.

Further long-term studies are warranted to evaluate lasting outcomes, including quality of life, reduction in diabetes-related complications, and healthcare utilization in this growing population segment.

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