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Characteristics Associated With Elevated Time Below Range in Elderly Patients With Type 1 Diabetes Using an Automated Insulin Delivery System

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Abstract

Background: This study investigated the characteristics associated with an increased risk of hypoglycemia, in elderly patients with type 1 diabetes mellitus (T1D) using automated insulin delivery (AID) systems.

Methods: Cross-sectional observational study including patients >60 years, using sensor-augmented insulin pump therapy with predictive low-glucose management (SAPT-PLGM), hybrid closed-loop (HCL), and advanced hybrid closed-loop (AHCL), for more than three months. A geriatric assessment was performed, and body composition was determined to investigate its association with achieving time below range (TBR) <70 mg/dL goals.

Results: The study included 59 patients (47.5% of men, mean age of 67.6 years, glycated hemoglobin [HbA1c] of 7.5 ± 0.6%, time in range (TIR) 77.8 ± 9.9%). Time below range <70 and <54 mg/dL were 2.2 ± 2.3% and 0.4 ± 0.81%, respectively. Patients with elevated TBR <70 mg/dL (>1%) had higher HbA1c levels, lower TIR, elevated time above range (TAR), and high glycemic variability. Regarding body composition, greater muscle mass, grip strength, and visceral fat were associated with a lower TBR <70 mg/dL. These factors were independent of the type of technology used, but TIR was higher when using AHCL systems compared with SAPT-PLGM and HCL systems.

Conclusions: In elderly patients treated with AID systems with good functional status, lower lean mass, lower grip strength, and lower visceral fat percentage were associated with TBR greater than 1%, regardless of the device used. A similar finding along was found with CGM indicators such as higher HbA1c levels, lower TIR, higher TAR, and higher CV. Geriatric assessment is crucial for personalizing patient management.

Keywords
automated insulin delivery, type 1 diabetes, elderly, hyperglycemia, hypoglycemia, time in range

Introduction

With an aging population and improved metabolic control due to technological advances, the number of older people with type 1 diabetes (T1D) is expected to increase in the coming years. Geriatric assessment of medical and functional domains and screening for geriatric syndromes are part of the comprehensive care of the elderly patient diagnosed with T1D, using standardized tools, regardless of the use and type of technology.[1] For those with good cognitive and functional status, as well as sufficient life expectancy, tighter

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glycemic control is beneficial.[1] This group of patients can be managed with similar therapeutic interventions and treatment goals as the younger population with diabetes.[1,2] Despite this, the international consensus on time in range (TIR) recommends different treatment goals for the elderly. Specifically, it recommends a TIR (70-180 mg/dL) greater than 50% and a time below range (TBR) (<70 mg/dL) less than 1%, with treatment goals set to minimize hypoglycemia regardless of frailty and functional status.[3]

The American Diabetes Association's clinical practice guidelines and European guidelines recognize the usefulness and benefits of technologies such as automated insulin delivery (AID) in patients at high risk for hypoglycemia, which could result in improved glycemic control and reduced hypoglycemic events.[4] An AID system comprises an insulin infusion device, a transmitter, and an algorithm that adjusts insulin infusion based on CGM data.[5] Currently, different generations of AID systems are available such as sensor-augmented insulin pump therapy with predictive low-glucose management (SAPT-PLGM), hybrid closed-loop (HCL) system, and advanced hybrid closed-loop (AHCL) system. Sensor-augmented insulin pump therapy with predictive low-glucose management systems incorporate an algorithm that predicts impending hypoglycemia based on CGM readings and suspends basal insulin before hypoglycemia occurs. The MiniMed 670G is an HCL system that utilizes an insulin pump programmed with an algorithm to deliver microboluses of insulin to meet basal insulin requirements based on glucose levels transmitted from a CGM system.[5] The MiniMed 780G is an AHCL system that adjusts basal insulin with autocorrecting boluses every five minutes and offers the option of setting different glucose targets (100, 110, or 120 mg/dL), as well as a temporary target of 150 mg/dL.[5]

Recent studies have evaluated the impact of AID systems on clinical outcomes in older people with T1D, showing improvement in HbA1c without an increase in hypoglycemic events.[6-11] This benefit is comparable to that seen in younger patients.[6,7] However, despite the increasing use of AID systems in elderly patients, information on the factors associated with hypoglycemia in AID users aged >60 years remains limited. Therefore, this study aimed to characterize the association between various components of a comprehensive geriatric assessment and hypoglycemia, defined as TBR <70 mg/dL greater than 1%, in elderly T1D patients using AID systems.

Methods

A cross-sectional observational study was conducted to assess elderly T1D patients managed in the outpatient clinic of the San Ignacio University Hospital (Bogotá, Colombia) with AID systems SAPT-PLGM (MiniMed 640G, Medtronic, Northridge, California), HCL (MiniMed 670G, Medtronic, Northridge), and AHCL (MiniMed 780G, Medtronic) from February 2021 to February 2023. The study included patients aged over 60 years who had used the AID system for at least three months, regardless of their HbA1c levels. Patients with poor sensor calibration, a history of hospitalizations in the last three months, and pacemaker users were excluded, as these devices can interfere with bioimpedance measurements. Since the data collected was part of the patients' routine glucose monitoring, informed consent was not required. This study was approved by the institutional ethics committee (FM-CIE-1170-23).

Sociodemographic and clinical data, including comorbidities, were collected during an appointment based on questions and data included in the electronic medical records. Functionality, frailty, and sarcopenia were assessed, as well as the presence of cognitive alterations and nutritional status, using standardized instruments. Bioimpedance was then measured to determine body composition (percentages of muscle mass, fat mass, and visceral fat), and grip strength was tested. Finally, the Medtronic CareLink system (Medtronic, Minneapolis, Minneapolis, MN) was used to collect CGM data for the 15 days preceding the appointment, including TIR, TBR, time above range (TAR), coefficient of variation (CV), sensor use, time spent in SmartGuard Auto Mode for HCL/AHCL system users, and the glucose management indicator (GMI).

Functional status was assessed at the time of study entry using the Barthel Index[12] and the modified Lawton and Brody scale.[13] Patients with a Barthel Index exceeding 80 and Lawton and Brody scores of eight were considered autonomous for basic and instrumental activities of daily living. Frailty was evaluated using the Fried frailty phenotype,[14] with one or two criteria indicating pre-frailty, and three or more criteria indicating frailty.[14] Sarcopenia was screened using the questionnaire to diagnose sarcopenia (SARC-F) scale[15] and the six-meter walking speed.[16] Cognitive alterations were assessed using the Mini-Mental State Examination,[17] with scores above 30 considered normal. Nutritional status was evaluated using the Mini-Nutritional Assessment,[18] with scores of 24 or higher indicating a normal nutritional status. Bioimpedance was measured using an OMRON HBF-514C device, and the grip strength was assessed using a CAMRY digital hand dynamometer after calibration in each appointment. A single measurement was performed according to the manufacturer's instructions.

Continuous variables were analyzed using measures of central tendency and dispersion. For normally distributed variables, data were expressed as mean and standard deviation. For non-normally distributed variables, data were expressed as median and interquartile range. The Shapiro-Wilk test was used to assess normality. Categorical variables were expressed as absolute values and percentages. An exploratory analysis was conducted to evaluate the association between metabolic control, measured as TIR, and the various scales of the comprehensive geriatric assessment. The Student's t-test, the chi-square test, or the Mann-Whitney U test was used, depending on the type and

Table 1. Clinical Characteristics and Metabolic Control According to the Device.

	Total (n = 59)		AHCL (n = 14)		HCL (n = 23)		*P*[a]	SAPT-PLGM (n = 22)		*P*[a]
Age (*y*), mean (SD)	67.6	(6.5)	69.4	(8)	66.5	(6.1)	.23	67.7	(5.7)	.479
Sex (male), n (%)	28	(47.5)	7	(50)	9	(39.1)	.52	12	(54.5)	.79
Duration of diabetes in years, mean (SD)	24.6	(11.6)	24.2	(10.8)	23.9	(11.1)	.94	25.6	(12.9)	.742
Baseline HbA1c, mean (SD)	7.5	(0.6)	7.5	(0.2)	7.5	(0.7)	.85	7.4	(0.6)	.544
Device use										
Sensor use (%), mean (SD)	89	(9.6)	94.4	(3.6)	88.5	(11.7)	.02	84.4	(15.1)	.056
Time in automatic mode (%), mean (SD)	93.2	(5.8)	99.4	(0.9)	89.2	(3.5)	.001	NA		NA
TDD/kg UI/kg, mean (SD)	0.6	(0.2)	0.6	(0.2)	0.6	(0.2)	.80	0.7	(0.2)	.128
Compliance with glycemic targets										
CV (%)	33.2	5.7	33.5	(4.5)	33.6	(6.7)	.94	32.7	(5.6)	.661
GMI (%)	6.9	0.5	6.6	(0.2)	6.9	(0.6)	.03	7.0	(0.4)	.002
TIR (70-180 mg/dL) >70%, n (%)	43	(72.9)	14	(100)	15	(65.2)	.01	14	(63.6)	.011
TIR (70-180 mg/dL) >50%, n (%)	58	(98.3)	14	(100)	22	95.7	.43	22	(100)	.182
TBR (<70 mg/dL) <5%, n (%)	48	(81.4)	13	(92.9)	18	78.2	.06	20	(90.9)	.837
TBR (<70 mg/dL) <1%, n (%)	13	(22)	4	(28.6)	4	17.4	.44	5	(22.7)	.639
GMI <7%, n (%)	42	(71.2)	14	(100)	15	65.2	.01	13	(59.1)	.006

Abbreviations: AHCL, advanced hybrid closed-loop system (MiniMed 780G, Medtronic); HCL, hybrid closed-loop system (MiniMed 670G, Medtronic); SAPT-PLGM, sensor-augmented insulin pump therapy with predictive low-glucose management (MiniMed 640G, Medtronic); SD, standard deviation; HbA1c, glycated hemoglobin; TDD/kg, total daily dose of insulin per kg of body weight; CV, coefficient of variation; GMI, glycated hemoglobin estimated by continuous glucose monitoring; TIR, percentage of time in range; TBR, percentage of time below range; BMI, body mass index in kg/m^2; TAR, percentage of time above range; NA, not available.
[a]Compared with AHCL.

distribution of each variable. Statistical analysis was performed using Stata 15.

Results

A total of 59 elderly patients aged 60 to 86 years were included in the analysis. The mean age was 67.6 ± 6.5 years, and 47.5% were men. The mean duration of diabetes was 24.6 ± 11.6 years, and the mean HbA1c was 7.5 ± 0.6%. The mean time of AID system use was 6.5 ± 2.2 years, with 37.3% using SAPT-PLGM and 62.7% using HCL/AHCL. Approximately 30% of the population had two or more microvascular complications. The most prevalent microvascular complications were retinopathy (45.8%) and diabetic chronic kidney disease (40.7%). Regarding body mass index (BMI), 5.3% of the population was obese. There were no recorded cases of severe hypoglycemia during the last year of use of the technology or significant differences in the distribution of sociodemographic variables between the different AID technologies.

In Table 1, the clinical characteristics and CGM metrics are shown according to the device. All patients achieved TIR goals for the elderly, but a higher proportion of patients using AHCL systems achieved TIR goals for young adults (63.6% with SAPT-PLGM vs 100% with AHCL, $P = .011$), along with a GMI below 7% (59.1% vs 100%, $P = .006$). In addition, a greater proportion of AHCL system users achieved TIR targets for young adults compared with HCL users (65.2% for HCL systems vs 100% for AHCL systems, $P = .013$), whereas there were no differences in TIR and TBR targets for the elderly. Advanced hybrid closed-loop system users had a TBR <54 mg/dL of 0%. No differences were observed in the proportion of patients achieving TBR goals for young adults and the elderly when comparing the different AID technologies. On average, the population met the glycemic targets set for young adults without high glycemic variability; however, AHCL had a higher mean TIR but lower mean TAR and TBR than other AID systems (Figure 1).

Table 2 summarizes the components of the geriatric assessment and bioimpedance measurements for the study population. None of the patients met the criteria for moderate or severe functional dependence. Most were autonomous elderly for basic and instrumental activities of daily living (Barthel >80 in 95% of patients, and Lawton and Brody score of eight in 84.8%). According to the Fried frailty phenotype scale, 50.1% of the patients were pre-frail, and only three (5.8%) were frail. Analysis of the scores that most affected this scale revealed that most patients had a low grip strength for their BMI and low levels of physical activity. In addition, 5% of patients met the criteria for sarcopenia (SARC-F). No patient met the criteria for malnutrition or moderate to severe cognitive impairment.

Table 3 summarizes the characteristics associated with not achieving TBR targets in the elderly (<1% of the time with <70 mg/dL). Patients who did not achieve this goal had lower TIR, higher Hb1Ac levels, and higher TAR >250 mg/

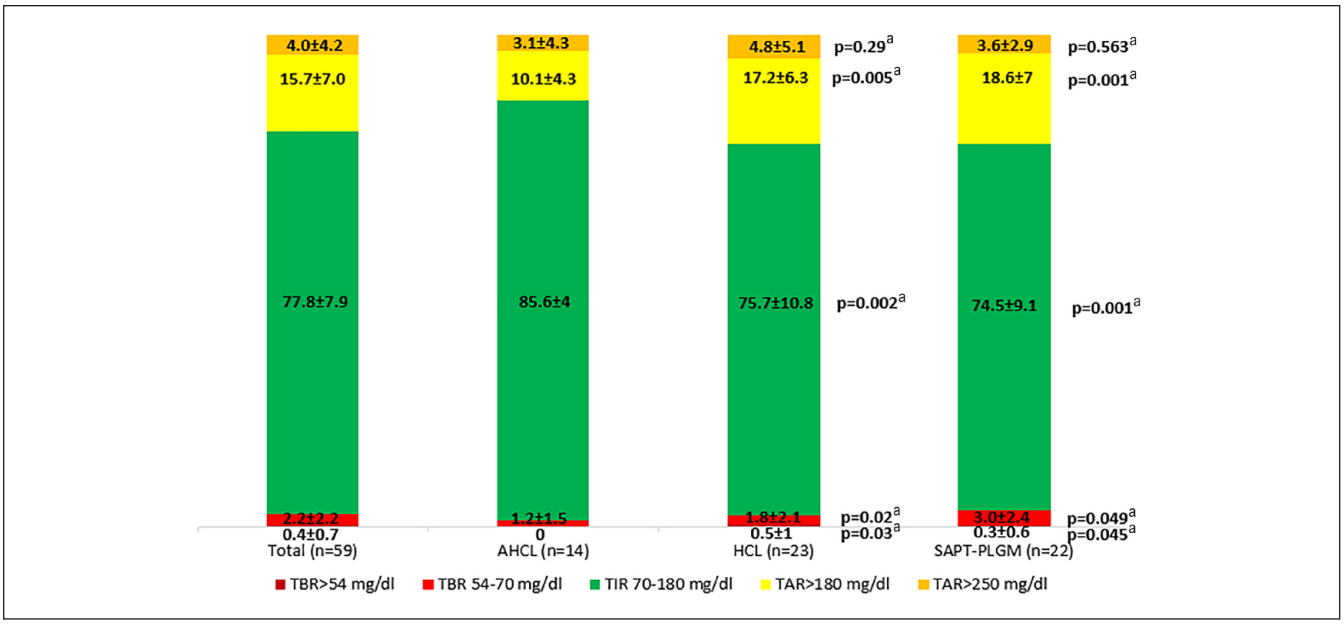

Figure 1. Glycemic targets in elderly T1D patients according to the device. The period covered by the glycemic targets report was generated for 15 days. Time above TAR: percentage of time of the analyzed period when glycemia is >180 mg/dL (>10 mmol/L) and >250 mg/dL (>13.9 mmol/L); TIR: percentage of the time of the analyzed period when glycemia is within the range 70 to 180 mg/dL (3.9-10 mmol/L); TBR: percentage of time during the analyzed period when glycemia is <70 mg/dL (<3.9 mmol/L) and <54 mg/dL (<3 mmol/L).

Abbreviations: TAR, target glucose range; TIR, time in range; TBR, time below target glucose range; AHCL, advanced hybrid closed-loop system; HCL, hybrid closed-loop; SAPT-PLGM, sensor-augmented insulin pump therapy with predictive low-glucose management.

[a]Compared with AHCL.

Table 2. Baseline Characteristics of the Population in the Geriatric Assessment and Bioimpedance Analysis.

	N = 59
Muscle (%), mean (SD)	28.4 (4.9)
Visceral fat (%), mean (SD)	10.9 (4.4)
Total body fat (%), mean (SD)	31.8 (8.3)
Grip strength kg/m^2 (%), mean (SD)	21.6 (7.6)
Muscle mass (kg), mean (SD)	19.6 (6.8)
Gait speed m/s^2, mean (SD)	0.9 (0.2)
SARC-F	
No sarcopenia (0-3)	56 (95)
Sarcopenia (4-10)	3 (5)
Lawton and Brody n (%)	
Mild dependence (6-7)	9 (15.2)
Autonomous (8)	50 (84.8)
Barthel	
>80	56 (95)
<80	3 (5)
FRIED	
Robust elderly (0)	26 (44.1)
Pre-frail elderly (1-2)	30 (50.1)
Frail elderly (3 or more)	3 (5.8)
MNA-SF	
Normal (12-14)	49 (83.1)
Risk of malnutrition (8-11)	10 (16.9)
Malnutrition (0-7)	0
MMSE	
Normal (30)	57 (96.6)
Mild deficit (26-24)	2 (3.4)
Cognitive impairment (<24)	0

Abbreviations: SD, standard deviation; SARC-F, questionnaire to diagnose sarcopenia; FRIED, frailty scale; MNA-SF, Mini-Nutritional Assessment; MMSE, Mini-Mental State Examination.

dL and CV. Finally, greater grip strength (kg/m^2), visceral fat (%), and muscle mass (kg) were associated with TBR less than 1%.

Discussion

The use of AID systems increases TIR with a decrease in time in hypo and hyperglycemia. However, certain clinical factors in older patients using this technology, including body composition and CGM measurements such as TIR, TAR, and CV, were independently associated with changes in the likelihood of not meeting TBR goals, regardless of the device used.

The reduction of the risk of hypoglycemia is an important treatment goal for elderly patients with diabetes. Recurrent hypoglycemic events in the elderly are associated with

Table 3. Characteristics Associated With Hypoglycemia Defined by TBR <70 mg/dL.

	TBR >1% (n = 46)	TBR <1% (n = 13)	*P*
Age (*y*), mean (SD)	67.4 (6.8)	68.5 (5.2)	.60
Sex (male), n (%)	15 (32.6)	7 (49)	.06
Duration of diabetes in years, mean (SD)	25.2 (12.1)	22.5 (9.4)	.47
Baseline HbA1c, mean (SD)	7.6 (0.5)	7.2 (0.8)	.04
Type of pump, n (%)			
SAPT-PLGM	17 (77.3)	5 (22.7)	.06
HCL	19 (82.6)	4 (17.4)	
AHCL	10 (71.4)	4 (28.6)	
History of myocardial infarction, n (%)	8 (17.4)	2 (15.8)	.29
Microvascular complications, n (%)			
Retinopathy	20 (43.5)	7 (53.8)	.51
Neuropathy	19 (41.3)	2 (15.4)	.09
Gastroparesis	2 (4.3)	0	.44
BMI, mean (SD)	26.1 (3.2)	28.3 (4.3)	.06
Creatinine, median (SD)	1.0 (0.4)	1.1 (0.5)	.39
Device use			
Sensor use (%), mean (SD)	89.0 (11.9)	86.8 (11.2)	.57
Time in automatic mode (%), mean (SD)	92.8 (6)	94.7 (4.4)	.44
Metabolic control, mean (SD)			
TIR 70-180 mg/dL (%)	75.7 (8.7)	85.4 (10.4)	.001
TAR >180 mg/dL (%)	16.2 (6.1)	13.7 (9.4)	.25
TAR >250 mg/dL (%)	4.9 (4.3)	0.9 (1.1)	.002
CV (%)	34.7 (4.5)	28.0 (6.7)	.001
GMI (%)	6.9 (0.4)	6.7 (0.5)	.12
Bioimpedance and functional tests, mean (SD)			
Muscle (%)	28.3 (5)	28.6 (4.3)	.85
Visceral fat (%)	10.2 (3.8)	13.4 (5.7)	.02
Grip strength (kg/m^2)	19.9 (6.5)	27.6 (8.4)	.001
Muscle mass (kg)	19.2 (4.7)	21.1 (11.7)	.04
Gait speed m/s^2	0.9 (0.2)	0.8 (0.2)	.92
SARC-F	1.2 (1.2)	1.2 (1)	.96
Lawton and Brody, n (%)	32 (69.6)	10 (76.9)	.55
Barthel	95.5 (7.9)	95.8 (6.4)	.93
FRIED	1.3 (1.3)	1.3 (0.8)	.95
MNA-SF	28.8 (1.2)	29.2 (0.2)	.93
MMSE	28.8 (1.2)	29.2 (0.9)	.24

Abbreviations: TBR, percentage of time below range; SD, standard deviation; HbA1c: glycated hemoglobin; SAPT-PLGM, sensor-augmented insulin pump therapy with predictive low-glucose management; HCL, hybrid closed-loop; AHCL, advanced hybrid closed-loop; BMI, body mass index in kg/m^2; TIR, percentage of time in range; TAR, percentage of time above range; CV, coefficient of variation; GMI, glycated hemoglobin estimated by continuous glucose monitoring; SARC-F, questionnaire to diagnose sarcopenia; FRIED, frailty scale; MNA-SF, Mini-Nutritional Assessment; MMSE, Mini-Mental State Examination.

significant morbidity, physical and cognitive dysfunction, increased hospitalizations, accelerated health decline, and increased risk of frailty, disability, and adverse clinical outcomes.[1,19] In this study, an increase of more than 1% in the percentage of TBR <70 mg/dL was associated with low grip strength, low muscle mass, and low visceral fat percentage. This evidence supports a bidirectional relationship between hypoglycemia and frailty, suggesting that less restrictive glycemic targets may be appropriate for frail elderly patients.[19] Consensus guidelines have prioritized hypoglycemia reduction in this population, advocating less stringent TIR goals in the elderly to minimize time spent in hypoglycemia.[20,21] However, these recommendations do not take into account the patient's functional status or the presence of frailty.

In this study, the population with TBR>1% was associated with lower TIR with greater exposure to hyperglycemia and higher %CV compared with the group with TBR <1%. McAuley et al[10] reported in a controlled clinical trial of patients with T1D over the age of 60 years that the SAPT-treated group had a similar pattern of CGM metrics associated with higher TBR compared with the HCL-treated group. These findings may be related to the fact that the longer the

time in hypoglycemia, the greater the need for corrective action, which favors an increase in exposure to hyperglycemia and an increase in %CV. Therefore, the use of newer technologies such as closed-loop systems could be considered to prevent hypoglycemia and promote glycemic control in functional older adult patients with T1D.

Several reviews and descriptive studies suggest that stricter glycemic targets can be achieved in elderly T1D patients with good functional status without significantly increasing hypoglycemia rates or related adverse events.[7-10,22] In this study, 22% of patients achieved TBR <70 mg/dL goals for the elderly (<1%), whereas 81.4% of patients attained TBR <5%. In addition, 98% of patients met treatment goals for the elderly defined by TIR >50%, and 73% achieved goals defined by TIR >70%, without an increase in TBR. All patients within the cohort met the hyperglycemia goals for the elderly (TAR <60%) and young adults (TAR <30%). These observations suggest that the international consensus TIR goals for the younger population may also apply to elderly patients with good performance in the functionality scales, with no frailty, malnutrition, or sarcopenia.

When SAPT-PLGM was compared with the AHCL system in this study, statistically superior TIR, TAR, and TBR values were observed in users of the AHCL system. In addition, 100% of AHCL system users achieved a TIR >70% with a TBR (<54 mg/dL) of 0%. A real-world study of Latin American AHCL system users reported favorable glycemic control among patients aged over 56 years, with mean TIR (70-180 mg/dL), TAR (180-250 mg/dL), TAR (>250 mg/dL), TBR (54-70 mg/dL), and TBR (<54 mg/dL) of 79.1%, 19.1%, 3.2%, 1.9%, and 0.3%, respectively.[23] Real-world data from another study involving 649 HCL system users aged over 60 years demonstrated improvements in CGM comparable to those of the younger cohort following the initiation of the automatic mode.[24] Data from a cohort of patients over 60 years in Colombia revealed CGM measurements comparable to those of young adults.[25] Similar results have been reported in controlled clinical trials,[10] which have demonstrated the effectiveness of AID systems in improving glycemic control, particularly by preventing hypoglycemic events, especially at night.[26]

Despite the assumption that the use of technology by elderly patients may be hindered by cognitive function or manual dexterity, findings suggest that metabolic control can improve in this population with AID systems, as observed in younger people. This implies that these devices offer an alternative management option for elderly T1D patients.[8-10,27] Furthermore, the study population demonstrated adherence to the technology, with a mean sensor use exceeding 80%.

Most studies on the elderly have not included the use of technologies based on AID systems in their analyses, nor a comprehensive geriatric assessment that evaluates medical, functional, economic, psychosocial, cognitive, and environmental conditions. This comprehensive evaluation facilitates the personalized selection of glycemic control goals and constitutes an important tool to define the benefit of using available technology for diabetes control.[28] Therefore, it is crucial to assess knowledge and self-management skills in the elderly using different scales to define glycemic control goals and the most appropriate treatment.

In this study, the analysis of elderly AID users included both comprehensive geriatric assessments and metabolic control. It suggests that AID systems can help elderly T1D patients achieve stricter metabolic control goals, defined by TIR, without increasing clinically significant hypoglycemia. However, the study has limitations: the lack of a matched control group of younger adults reduces the power of the study conclusions. Future research is needed to compare the impact of geriatric and CGM variables in the hypoglycemia frequency in both groups of age. Also, the population included was not fully representative of the general elderly population as less than 5% of participants had malnutrition, sarcopenia, cognitive impairment, frailty, or functional dependency, which can be different to data observed in other elderly populations. However, one of the main indications for the use of the AID system is to be functional, which is part of real-life practice. In addition, we had a small number of patients with TBR <1% to compare with patients with TBR >1%. Such an unbalanced distribution may reduce the chance to discriminate which variables influence the %TBR level. Therefore, we used a descriptive approach. Future multicentric studies with larger sample sizes are needed to analyze factors causally associated with hypoglycemia in this population. In addition, a prospective study in older adult patients with T1D is currently being conducted at our institution.

Conclusions

In elderly patients with T1D, reducing hypoglycemia risk is a crucial treatment goal. In elderly patients treated with AID systems, who demonstrate good functional status, body composition factors such as lower lean mass, lower grip strength, and lower visceral fat percentage, along with CGM indicators such as higher HbA1c levels, lower TIR, higher TAR, and higher CV, were associated with TBR greater than 1%, regardless of the device used. A comprehensive geriatric assessment is key to personalizing patient management goals and identifying the population that can benefit from this technology.

Abbreviations

ADA, American Diabetes Association; AHCL, advanced hybrid closed-loop; AID, automated insulin delivery; BMI, body mass index; CGM, continuous glucose monitoring; CV, coefficient of variation; DM, diabetes mellitus; HbA1c, glycated hemoglobin; HCL, hybrid closed-loop; SAPT-PLGM, sensor-augmented insulin pump therapy with predictive low-glucose management; T1D, type 1 diabetes mellitus; TAR, time above range; TBR, time below range; TIR, time in range.

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Declaration of Conflicting Interests

The author(s) declared the following potential conflicts of interest with respect to the research, authorship, and/or publication of this article: AMG reports speaker fees from Novo Nordisk, Sanofi, Elli Lilly, Boehringer Ingelheim, Abbott, and Medtronic. DCH reports speaker fees from Novo Nordisk, Sanofi, and Abbott. The other author(s) declare(s) that there is no conflict of interest.

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References

1. 13. Older adults: standards of care in diabetes-2024. *Diabetes Care*. 2024;47(suppl 1):S244-S257.
2. 6. Glycemic goals and hypoglycemia: standards of care in diabetes-2024. *Diabetes Care*. 2024;47(suppl 1):S111-S125.
3. Battelino T, Danne T, Bergenstal RM, et al. Clinical targets for continuous glucose monitoring data interpretation: recommendations from the international consensus on time in range. *Diabetes Care*. 2019;42(8):1593-1603.
4. McCall AL, Lieb DC, Gianchandani R, et al. Management of individuals with diabetes at high risk for hypoglycemia: an endocrine society clinical practice guideline. *J Clin Endocrinol Metab*. 2023;108(3):529-562.
5. Boughton CK, Hovorka R. Automated insulin delivery in adults. *Endocrinol Metab Clin North Am*. 2020;49(1):167-178.
6. Matejko B, Cyganek K, Katra B, et al. Insulin pump therapy is equally effective and safe in elderly and young type 1 diabetes patients. *Rev Diabet Stud*. 2011;8(2):254-258.
7. Ruedy KJ, Parkin CG, Riddlesworth TD, et al; DIAMOND Study Group. Continuous glucose monitoring in older adults with type 1 and type 2 diabetes using multiple daily injections of insulin: results from the DIAMOND trial. *J Diabetes Sci Technol*. 2017;11(6):1138-1146.
8. Kubilay E, Trawley S, Ward GM, et al. Lived experience of older adults with type 1 diabetes using closed-loop automated insulin delivery in a randomised trial. *Diabet Med*. 2023;40(4):e15020.
9. Trawley S, Ward GM, Vogrin S, et al. Glucose profiles of older adults with type 1 diabetes using sensor-augmented pump therapy in Australia: pre-randomisation results from the ORACL study. *Lancet Healthy Longev*. 2022;3(12):e839-e848.
10. McAuley SA, Trawley S, Vogrin S, et al. Closed-loop insulin delivery versus sensor-augmented pump therapy in older adults with type 1 diabetes (ORACL): a randomized, crossover trial. *Diabetes Care*. 2022;45(2):381-390.
11. Boughton CK, Hartnell S, Thabit H, et al. Hybrid closed-loop glucose control compared with sensor augmented pump therapy in older adults with type 1 diabetes: an open-label multicentre, multinational, randomised, crossover study. *Lancet Healthy Longev*. 2022;3(3):e135-e142.
12. Collin C, Wade DT, Davies S, Horne V. The Barthel ADL index: a reliability study. *Int Disabil Stud*. 1988;10(2):61-63.
13. Wei L, Hodgson C. Clinimetrics: the Lawton-Brody instrumental activities of daily living scale. *J Physiother*. 2023;69(1):57.
14. Fried LP, Tangen CM, Walston J, et al. Frailty in older adults: evidence for a phenotype. *J Gerontol A Biol Sci Med Sci*. 2001;56(3):M146-M156.
15. Malmstrom TK, Morley JE. SARC-F: a simple questionnaire to rapidly diagnose sarcopenia. *J Am Med Dir Assoc*. 2013;14(8):531-532.
16. Steffen TM, Hacker TA, Mollinger L. Age- and gender-related test performance in community-dwelling elderly people: six-minute walk test, berg balance scale, timed up & go test, and gait speeds. *Phys Ther*. 2002;82(2):128-137.
17. Folstein MF, Folstein SE, McHugh PR. "Mini-mental state." A practical method for grading the cognitive state of patients for the clinician. *J Psychiatr Res*. 1975;12(3):189-198.
18. Vellas B, Guigoz Y, Garry PJ, et al. The mini nutritional assessment (MNA) and its use in grading the nutritional state of elderly patients. *Nutrition*. 1999;15(2):116-122.
19. Abdelhafiz AH, Rodríguez-Mañas L, Morley JE, Sinclair AJ. Hypoglycemia in older people–a less well recognized risk factor for frailty. *Aging Dis*. 2015;6(2):156-167.
20. Giorda CB, Ozzello A, Gentile S, et al. Incidence and risk factors for severe and symptomatic hypoglycemia in type 1 diabetes. Results of the HYPOS-1 study. *Acta Diabetol*. 2015;52(5):845-853.
21. Cariou B, Fontaine P, Eschwege E, et al. Frequency and predictors of confirmed hypoglycaemia in type 1 and insulin-treated type 2 diabetes mellitus patients in a real-life setting: results from the DIALOG study. *Diabetes Metab*. 2015;41(2):116-125.
22. Beck RW, Riddlesworth TD, Ruedy K, et al. Continuous glucose monitoring versus usual care in patients with type 2 diabetes receiving multiple daily insulin injections: a randomized trial. *Ann Intern Med*. 2017;167(6):365-374.
23. Grassi B, Gómez AM, Calliari LE, et al. Real-world performance of the MiniMed 780G advanced hybrid closed loop system in Latin America: substantial improvement in glycaemic control with each technology iteration of the MiniMed automated insulin delivery system. *Diabetes Obes Metab*. 2023;25(6):1688-1697.
24. Stone MP, Agrawal P, Chen X, et al. Retrospective analysis of 3-month real-world glucose data after the MiniMed 670G system commercial launch. *Diabetes Technol Ther*. 2018;20(10):689-692.
25. Gómez Medina AM, Henao Carrillo DC, Silva León JD, et al. Results from a virtual clinic for the follow-up of patients using the advanced hybrid closed-loop system [published online ahead of print November 9, 2023]. *J Diabetes Sci Technol*. doi:10.1177/19322968231204376.
26. Syed FZ. Type 1 diabetes mellitus. *Ann Intern Med*. 2022;175(3):ITC33-ITC48.
27. Yeoh E, Beato-Vibora P, Rogers H, Amiel SA, Choudhary P. Efficacy of insulin pump therapy in elderly patients. *Diabetes Technol Ther*. 2015;17(5):364-365.
28. Huang ES, Sinclair A, Conlin PR, et al. The growing role of technology in the care of older adults with diabetes. *Diabetes Care*. 2023;46(8):1455-1463.