

Management of Diabetes in the Elderly



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KEYWORDS

• Diabetes mellitus • Geriatric • Insulin • Hypoglycemia • Frailty • Hypertension

KEY POINTS

- Glycemic and blood pressure goals need to be individualized and focused on avoidance of symptomatic hyperglycemia, hypoglycemia, orthostatic hypotension, and other adverse drug effects.
- Presence of geriatric syndromes, major comorbidities, frailty, advanced age, and social support must be considered in the management plan.
- Initial therapy for type 2 diabetes, in the absence of renal insufficiency, is low-dose metformin. The more expensive dipeptidyl peptidase 4 inhibitors are also well tolerated.
- If a sulfonylurea is to be used, consider short-acting glipizide. Insulin, when needed, should be used cautiously, because serious hypoglycemia can be a major problem in the elderly.
- Patient safety, preference, and preservation of quality of life should be primary objectives.

INTRODUCTION

An increasing number of older adults are newly diagnosed with diabetes, and an increasing population have diabetes of greater than 20 years duration. Although type 2 diabetes is most common in the geriatric age group, there are also more older adults than ever with long-standing type 1 diabetes. They have unique and diverse needs and challenges, which should be considered when developing a treatment plan. The approach to management of diabetes in the elderly must be individualized and changed over time depending on the presence and progression of geriatric syndromes, comorbidities, and risk of hypoglycemia. Availability of social support and personal preferences are also important. Current guidelines for the management of diabetes in the geriatric population are reviewed in this article.

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DIABETES IN OLDER ADULTS: OVERVIEW

Incidence and Prevalence of Diabetes and Associated Chronic Complications

Increasing incidence and improving life expectancy have led to an increase in prevalence of diabetes in the geriatric age group.^{1,2} In the United States in 2012, 29.1 million people, 9.3% of the total population, had diabetes, generating \$245 billion in diabetes-related costs.¹ Of those 65 years of age or older, an estimated 11.2 million (25.9%) had diabetes. The rate of new diagnoses per 1000 was 11.5%, representing 400,000 new cases in 2012.¹ The prevalence of diabetes in skilled nursing facilities is even higher.³

The development of the microvascular complications of diabetes (retinopathy, neuropathy, and nephropathy) are related, in large part, to glycemic control and disease duration. Although better glycemic control and earlier detection and treatment of retinopathy and macular edema have helped reduce visual loss and blindness from diabetes, vision impairment remains a larger problem in adults 60 years of age or older with diabetes compared with those without diabetes.⁴

The presence of peripheral neuropathy contributes to difficulties with ambulation and greater propensity for falls. Neuropathies as well as peripheral vascular disease are also risk factors for amputations. Diabetes-related amputations declined between 1990 and 2010.⁵ This decrease is probably related to many factors, including better foot care (improved prevention, early detection and treatment of foot infections and ulcers), reduction in smoking, and improved glycemic control. In 2010, the incidence of amputations (per 10,000) was 37.3 and 36.0 in those aged 65 to 74 years and 75 years and older.⁵ These rates are 5.9 and 2.7 times higher than for adults aged 65 to 74 years and 75 years and older without diabetes.

The incidence of end-stage renal disease (ESRD) in people with diabetes increased from 1990 to 2010.⁵ In 2010, the incidence (per 10,000) was 30.5 and 28.6 in those aged 65 to 74 years and 75 years and older, respectively, representing a 3.7 and 2.1 higher incidence compared with those without diabetes in these age groups. Older adults in 2010 also had more ESRD compared with younger people with diabetes, with a greater events difference (per 10,000) in those aged 75 years and older compared with those aged 65 to 74 years (12.3 and 2.9, respectively). This situation is despite better treatment to prevent or forestall ESRD with use of angiotensin-converting enzyme inhibitors (ACE-I) or angiotensin receptor blockers (ARBs), and better blood pressure and blood glucose control. There are undoubtedly multiple contributing factors. These incidence rates for ESRD are based on initiation of ESRD treatment. It is possible that the higher reported incidence of ESRD in the geriatric population is related, in part, to more elderly people receiving treatment of ESRD.

The macrovascular complications of diabetes (cardiovascular, cerebrovascular, and peripheral arterial disease) are major causes of morbidity and mortality and contribute to the rate of physical disability observed in many older adults with diabetes, although there is some evidence that rates of these complications may be decreasing in the elderly.⁴ Acute myocardial infarctions and strokes (events difference per 10,000) decreased significantly from 1990 to 2010, with the relative differences being even greater in those aged 75 years and older than in those aged 65 to 74 years.⁵ The magnitude of the reduction was greatest for acute myocardial infarctions and stroke, possibly related to better clinical care and identification and treatment of risk factors (eg, use of statins and blood pressure medications and smoking cessation).

Glycemic Control in Older Adults

Glycemic control in people 65 years of age and older has improved in the past 2 decades. Comparing results from the National Health and Nutrition Examination Surveys

of 1988 to 1994 and 1999 to 2010, the percentage of adults aged 65 years and older with A_{1c} levels less than 7.0% and less than 8.0% is higher. This finding was associated with greater use of both oral glycemic control medications and insulin.² In 2005 to 2010, for adults aged 65 years and older with diabetes, of those with A_{1c} levels less than 7.0% (65.9%) and less than 8.0% (88.7%), diabetes medications were being taken by 62.5% and 87.4%, respectively: insulin alone 12.9%, oral agents alone 60.5%, insulin + oral agents 15.4%, and no medications 11.2%.² It is unknown how many of those taking insulin alone had type 1 diabetes.

Studies in older patients with diabetes suggest increased risk of morbidity and mortality at both low and high A_{1c} levels.^{6,7} Results from the Diabetes and Aging Study suggest higher mortality with A_{1c} levels less than 6.0% and greater than 9.0%, and increased diabetes complications with A_{1c} levels 8.0% or higher.⁷ In the ACCORD (Action to Control Cardiovascular Risk in Diabetes) study, the older participants had more hypoglycemia.⁸ It is becoming increasingly clear that overtreatment, particularly in older adults, is a significant problem.⁹

Severe Hypoglycemia in Older Adults

As older adults with diabetes achieve better metabolic control, in part through the use of medications that can cause hypoglycemia, hospitalizations and death caused by hyperglycemia have declined, but serious hypoglycemia is a growing concern.^{2,5,10} Medicare beneficiaries 75 years of age and older were twice as likely to experience a hospitalization between 1999 and 2011 as a result of hypoglycemia as those aged 65 to 74 years.¹⁰ When examining emergency department visits and hospitalizations from 2007 to 2011, those 80 years of age and older had the highest number of emergency department visits for insulin-related hypoglycemia (34.9/1000 insulin-treated patients); compared with 45-year-olds to 64-year-olds with diabetes, they were almost 5 times more likely to require hospitalization.¹¹ Insulin errors causing these events included taking too much short-acting insulin for the mealtime food intake, taking the wrong insulin dose, using the wrong insulin product (mixing up the long-acting and short-acting insulins), taking insulin at the wrong time of day, and taking too much insulin to correct for hyperglycemia. Older adults hospitalized with hypoglycemia have higher morbidity and mortality than younger adults.¹²

Most research on older adults with diabetes has focused on type 2 diabetes. Studies examining insulin-requiring diabetes and hypoglycemia in the geriatric population frequently do not distinguish between type 2 diabetes (most of the geriatric diabetes population) and type 1 diabetes. However, the prevalence of type 1 diabetes in older adults is also increasing. Information from the Type 1 Diabetes Exchange registry indicates that 21% of adults aged 65 years and older with duration of type 1 diabetes of at least 40 years self-report having had a seizure or loss of consciousness from hypoglycemia over the previous 12 months.¹³ Severe hypoglycemia was more likely with A_{1c} levels less than 7.0% and with A_{1c} levels greater than 7.5%. Severe hypoglycemia was as common in poorly controlled (A_{1c} levels 8%–9%) as it was in well-controlled (A_{1c} level <6.5%) type 1 diabetes.

Risk Factors, Symptoms, and Consequences of Hypoglycemia

Insulin therapy is the major risk factor for serious hypoglycemia. Insulin dosing errors occur in the presence of poor cognition, erratic eating, and impairment of vision and dexterity. Treatment with insulin secretagogues, especially long-acting sulfonylurea drugs, is also associated with severe hypoglycemia in the geriatric population. Deterioration in renal function usually requires adjustment in dosing, because most of the drugs have renal clearance. Poor nutritional status and renal or hepatic impairment

can result in impaired mobilization of glucose (in part because of lower glycogen stores and impaired gluconeogenesis) during hypoglycemia. In addition, loss of adrenergic responses to hypoglycemia in the elderly can contribute to more serious hypoglycemic episodes. The most important risk factors for hypoglycemia are shown in **Table 1**.

Because older adults may have impaired counterregulatory responses to hypoglycemia, they can lack the usual autonomic warning signs of hypoglycemia (eg, tremulousness, palpitations, sweating). It is important to recognize and avoid hypoglycemia. Symptoms that can indicate hypoglycemia as well as potential serious consequences are listed in **Table 1**. Because the symptoms of hypoglycemia are frequently nonspecific, blood glucose levels should be tested to confirm hypoglycemia.

MANAGEMENT GOALS

Geriatric-Specific Considerations

The presence of geriatric syndromes, including frailty, cognitive impairment, poor mobility, dexterity, and balance, reduced vision and hearing, depression, and chronic pain, need to be assessed, as described in the article by Carlson and colleagues elsewhere in this issue. Older adults also need to be evaluated for urinary incontinence, polypharmacy, nutritional status, falls, numeracy and literacy skills, treatment adherence, social support, and home safety. These conditions, as well as the presence of other comorbid conditions, such as cardiovascular disease (CVD), cerebrovascular disease, chronic kidney disease, and neuropathy, must be considered when formulating therapeutic approaches and treatment goals.²⁷

| Risk Factors | Symptoms | Consequences |
|--|---|--|
| <ul style="list-style-type: none"> • Older age (>80 y) • Type 1 diabetes of >20 y duration • Insulin treatment • Use of insulin secretagogues, especially sulfonylurea drugs • History of severe hypoglycemia • Hypoglycemic unawareness or poor hypoglycemic awareness • Reduced renal function • Hepatic insufficiency • Alcohol use • Poor nutritional status • Unpredictable food intake • Polypharmacy • Frailty/poor visual-motor skills • Cognitive dysfunction or dementia • Depression | <ul style="list-style-type: none"> Neuroglycopenic Confusion and/or disorientation Unsteady gait and/or falls Difficulty speaking and/or concentrating Impaired vision, blurred or double vision Fatigue and/or drowsiness Lightheadedness Feeling weak and/or dizzy Loss of consciousness Autonomic Tremulousness Hunger and/or nausea Anxiety and/or feeling tearful Palpitations Feeling warm or sweaty | <ul style="list-style-type: none"> • Impaired cognition • Coma • Seizures • Cardiac arrhythmias and other cardiac events • Hospitalizations • Accidents • Depression • Difficulty with ambulation • Difficulty reading • Unsteady gait • Falls and fractures • Increased risk of dementia • Reduced quality of life |

Data from Refs. ¹³⁻²⁶

Glycemic Goals

Because there are few studies comparing diabetes management approaches in older adults, most recommendations are based on expert opinion. Guidelines for glycemic treatment focus on A_{1c} goals, but even in the presence of a high A_{1c} level, the individual may be having serious hypoglycemic episodes.¹³ Review of blood glucose levels is important to detect wide glycemic excursions. Especially with insulin therapy, home glucose monitoring is essential and should help direct therapy. A_{1c} levels may also be misleading in the presence of anemia, renal disease, recent blood loss, and any other condition associated with shortened red blood cell life span.

Goals recommended by different professional groups and associations are summarized in **Table 2**. There is agreement that goals should be individualized, taking into account the overall health status, presence of comorbid conditions and frailty, cognitive status, presence of hypoglycemic unawareness, history of hypoglycemia, life expectancy, available social support, and patient preference. Older adults in excellent health, without functional or cognitive limitations, who desire good glycemic control, can follow guidelines developed for younger adults. Glycemic goals for older adults who are frail, functionally dependent, and have serious comorbidities should be individualized, using higher A_{1c} goals that are acceptable to patients and caregivers, avoiding symptomatic hyperglycemia.

Blood Pressure Goals

Blood pressure goals may be higher in older adults based on their functional and cognitive status, comorbidities, polypharmacy, and life expectancy. Recommendations are shown in **Table 2**. In general, healthy older adults with diabetes and without major comorbidities should aim for blood pressure less than 140/80 mm Hg, whereas for the frail elderly with functional and cognitive impairment and limited life expectancy, the blood pressure goal should be less than 150/90 mm Hg. A systolic blood pressure less than 140 mm Hg may be appropriate in older adults with evidence of renal impairment (estimated glomerular filtration rate [eGFR] <60 mL/min/1.73 m²).³¹

Low-Density Lipoprotein Cholesterol Goals

Goals in the treatment of hyperlipidemia are shown in **Table 2**. With the exception of those with limited life expectancy and individuals who cannot tolerate statin drugs, statin therapy is generally recommended. The American Diabetes Association recommendations state that all individuals older than 40 years with diabetes should be treated with a statin drug if they have at least 1 additional cardiovascular risk factor (hypertension, smoking, dyslipidemia, albuminuria, or family history of CVD),³⁸ but statin use in those older than 80 years remains controversial.³⁹ Low doses of statin drugs can be used to reduce side effects and drug-drug interactions.

PHARMACOLOGIC STRATEGIES

Most older adults with diabetes have type 2 diabetes, most of whom can be treated with oral agents. However, some require insulin therapy, as do all with type 1 diabetes. Type 2 diabetes in the elderly is heterogeneous; some individuals are lean and others obese, some are insulin sensitive and others resistant, and their degree of frailty can vary, necessitating individualized treatment plans. In general, pharmacologic therapy should be initiated with the lowest possible dose. In the presence of geriatric syndromes, additional behavioral interventions may be helpful to increase the overall success of the treatment plan (**Table 3**).

Table 2
Management goals in elderly with diabetes

| Guidelines | Glycemic Goals | Blood Pressure Goal (mm Hg) | LDL Cholesterol Goal (mg/dL) | Recommendations for Statin Therapy |
|---|---|---|--|---|
| American Diabetes Association/American Geriatric Society | Healthy A _{1c} <7.5% Fasting/preprandial BG: 90–130 mg/dL Bedtime BG: 90–150 mg/dL | <140/80 | <100 In the presence of CVD: <70 | Statin therapy recommended unless contraindicated or not tolerated |
| | Frail with complex/intermediate health (several chronic illnesses or mild to moderate cognitive impairment or 2+ instrumental ADL deficits) A _{1c} <8.0% Fasting/preprandial BG: 90–150 mg/dL Bedtime BG: 100–180 mg/dL | <140/80 | | Statin therapy recommended unless contraindicated or not tolerated |
| | Frail with poor health (end-stage chronic disease or moderate to severe cognitive impairment or 2+ ADL deficits) A _{1c} <8.5% Fasting/preprandial BG: 100–180 mg/dL Bedtime BG: 110–200 mg/dL | <150/90 | | Statin therapy recommended unless limited life expectancy, contraindicated or not tolerated |
| | Long-term care facility residents A _{1c} <8.5% Fasting/preprandial BG: 100–180 mg/dL Bedtime BG: 110–200 mg/dL | <150/90 | | Consider benefit with limited life expectancy |
| European Society of Cardiology/European Association for the Study of Diabetes | A _{1c} <8.0% | <140/85 In presence of nephropathy: systolic BP <130 | <100; In the presence of CVD, severe CKD or with 1 or more cardiovascular risk factors and/or target organ damage: <70 or at least ≥50% LDL reduction | Statin therapy recommended unless contraindicated or not tolerated |

| | | | | |
|---|--|--|---|---|
| International Diabetes Federation | Functionally independent: $A_{1c} \leq 7.5\%$ Functionally dependent: $A_{1c} \leq 8.0\%$ Frail or dementia: $A_{1c} \leq 8.5\%$ | <140/90 | <80 In the presence of CVD: <70 Frail or dementia: LDL goal can be relaxed | All older people with diabetes are at high CVD risk and should be considered for treatment with a statin unless contraindicated or considered clinically inappropriate Nonatherosclerotic dementia: appropriateness of statin use should be considered |
| International Association of Gerontology and Geriatrics/European Diabetes Working Party for Older People/ International Task Force of Experts in Diabetes | Healthy: $A_{1c} \leq 7.5\%$ Frail (with major comorbidities: functionally dependent, multisystem disease, home care residency, with dementia): $A_{1c} \leq 8.5\%$ | <140/80 | — | — |
| | | Frail or those aged ≥ 75 y: <150/90 | | |

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Table 2
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| Guidelines | Glycemic Goals | Blood Pressure Goal (mm Hg) | LDL Cholesterol Goal (mg/dL) | Recommendations for Statin Therapy | |
|--|---|---|-------------------------------------|---|--|
| Department of Veterans Affairs/Department of Defense | No major comorbidity or >10 y of life expectancy | Microvascular complications: Absent/mild: A _{1c} <7.0% Moderate: A _{1c} <8.0% Advanced: A _{1c} ≤9.0% | <140/80 | <130 In the presence of CVD: <100 | Statin therapy recommended if LDL level higher than goal, unless contraindicated or not tolerated LDL reduction of 30%–40% from baseline may be considered an alternative therapeutic strategy for patients who cannot meet the goals |
| | Major comorbidity present or 5–10 y of life expectancy | Microvascular complications: Absent, mild, or moderate: A _{1c} <8.0% Advanced: A _{1c} ≤9.0% | | | |
| | Marked (end-stage) comorbidity present or <5 y of life expectancy | A _{1c} ≤9.0% | | | |

Abbreviations: A_{1c}, hemoglobin A_{1c}; ADL, activities of daily living; BG, blood glucose; BP, blood pressure; CKD, chronic kidney disease; LDL, low-density lipoprotein.
Data from Refs. [28–37](#)

Table 3
Diabetes self-management tasks in the elderly with geriatric syndromes

| Self-Management Task | Geriatric Syndrome Affecting Self-Management | Possible Interventions |
|----------------------------------|---|---|
| Self-monitoring of blood glucose | Vision and/or hearing impairment | Audio reminders (eg, devices with alarms) Use of talking home blood glucose monitoring devices Provide instructions printed in large font and with enhanced contrast Referral for vision and/or hearing aids Visual reminders (eg, erase board for refrigerator) |
| | Depression | Antidepressants Referral to mental health professional |
| | Diabetes-related distress | Simplification of regimen if possible Referral to diabetes educator/nurse Increased attention from educators (frequent visits or phone calls between office visits) Social services referral |
| Oral medication administration | Vision and/or hearing impairment and/or cognitive dysfunction | Audio reminders (eg, pill reminder dispensers/devices/organizers with alarms, including audio reminders) Simplify medication regimen Visual reminders (eg, erase board for refrigerator) Medication reminder applications on smart phones Medication reminder call services |
| | Low health literacy | Simplify medication regimen Provide instructions and education materials in appropriate format (eg, picture guides) |
| | Polypharmacy | Titrate medication dose (use lowest doses possible) Discontinue inappropriate medications and those no longer needed Review possible adverse effects of medications on glycemia, perception of hypoglycemia and geriatric syndromes |
| | Mobility issues | Pharmacy assistance program Mobility assistive devices (eg, cane, walker) Pharmacy delivery program Transportation assistance Social services Physical and occupational therapy consultations |

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Table 3
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| Self-Management Task | Geriatric Syndrome Affecting Self-Management | Possible Interventions |
|--|---|---|
| | Diabetes-related distress | Simplification of regimen if possible Referral to diabetes educator/nurse Increased attention by educators (frequent visits or phone calls between office visits) Social services |
| Insulin administration and avoidance of serious hypoglycemia | Hypoglycemia unawareness or poor awareness | Diabetes self-management education Availability of rapidly absorbable carbohydrate; caretaker/partner instruction in use of glucagon (0.5–1 mg intramuscularly for severe hypoglycemia) Blood glucose awareness training Frequent blood glucose monitoring Use of personal continuous glucose monitoring systems Use of advanced insulin pump features (eg, low glucose threshold suspend) Adjustment of glucose targets Adjust timing of insulin administration Medical Alert bracelet or necklace and use of a medical alert system |
| | Vision and/or hearing impairment and/or cognitive dysfunction | Diabetes self-management education Audio reminders (eg, devices with alarms) Magnifier fitted for insulin syringes and/or insulin pump screen Hand or wallet magnifiers Use of insulin pens (count clicks for dosing) Improved lighting Provide instructions printed in large font and with enhanced contrast Use of dark-colored paper under the syringe/pen (to provide contrast) Visual reminders (eg, erase board for refrigerator) Simplification of medication regimen Use of a medical alert system Use of vibration and memory features on pumps Use of insulin pens with memory function Insulin vial stabilizers and needle guides |

| | | |
|-----------|---|---|
| | Low health literacy Poor numeracy skills | Provide instructions and education materials in appropriate format (eg, picture guides) Simplification of regimen Use of insulin dosing calculator Use of insulin pens Increase social support |
| | Dexterity issues | Grip assistance products for syringes Injection aids |
| | Chronic pain | Adequate pain management |
| | Nutrition | Dietary counseling Simplify regimen (eg, change from carbohydrate counting to carbohydrate consistency) Social services (eg, need for Meals on Wheels, home care) Consider fixed mealtime insulin dosing (if eating is reliable and consistent meals can be provided) Consider rapidly acting insulin after the meal (reduce dose for poor food intake) |
| | Depression | Antidepressants Referral to mental health professional |
| | Mobility issues | Mobility assistive devices (eg, cane, walker) Pharmacy assistance program Pharmacy delivery program Transportation assistance Physical and occupational therapy consultations |
| | Diabetes-related distress | Social services Simplification of regimen Referral to diabetes educator/nurse Increased attention by educators (frequent visits or phone calls between office visits) |
| Foot care | Peripheral neuropathy | Proper footwear Foot care education Avoid walking bare foot Use of light color socks Referral to podiatrist Mobility assistive devices (eg, cane, walker) Physical therapy |
| | Vision impairment | Visual aids (use of mirrors for better visualization of feet) |
| | Chronic pain | Adequate pain management |

Data from Refs. 25,28,40-42

Type 1 Diabetes Mellitus

Insulin therapy is required for people with type 1 diabetes. Strategies for insulin delivery differ between healthy older adults and those with frailty and limited life expectancy.⁴³ Family members and caretakers should also receive diabetes education, including training in the administration of insulin and glucagon and in the use of self-monitoring of blood glucose (SMBG). Frequent SMBG is important to guide insulin therapy and detect and avoid hypoglycemia. The use of continuous glucose monitoring systems (CGMS) may also be helpful.

Type 1 diabetes treatment requires multiple insulin injections daily or use of an insulin pump. Over time, these complex insulin regimens can become difficult for a frail older patient to manage. If assistance in insulin administration is unavailable, insulin regimens may need to be simplified according to the patient's ability and preferences to minimize errors.⁴⁴

Injection (basal-bolus) therapy

- In both older and younger adults, injection therapy usually combines a long-acting basal insulin analog (commonly once-daily insulin glargine or once-daily or twice-daily insulin detemir) and a rapidly acting insulin analog for boluses (commonly insulin aspart, lispro, or glulisine) with meals.
- If the patient cannot afford to purchase the more expensive long-acting basal insulin analogs (glargine or detemir), intermediate-acting NPH (neutral protamine Hagedorn) insulin can be given before breakfast and at bedtime. Use of NPH insulin is associated with increased risk for hypoglycemia if the lunch meal is missed. Snacks may be needed mid morning, mid afternoon, and at bedtime to avoid hypoglycemia.^{45,46} Glucose levels should be occasionally checked in the middle of the night to exclude nocturnal hypoglycemia.
- Basal insulin should not be withheld during intercurrent illness or during periods of poor oral intake, because this could lead to severe hyperglycemia and diabetic ketoacidosis.
- Prandial insulin dosing is based on the premeal blood glucose level and anticipated carbohydrate intake for that particular meal. Calculations commonly use a correction (sensitivity) factor to decrease glucose to desired target level and insulin/carbohydrate ratios (or fixed dosing for fixed carbohydrate content of meals) to determine mealtime doses. This approach becomes more difficult with cognitive decline.⁴⁴ Calculators (eg, apps for smart phones and built into insulin pumps) are available.
- If there is unreliable food intake, rapidly acting insulin analogs (lispro, aspart, or glulisine) can be given immediately after the meal so that a lower dose can be given if less food (carbohydrate) was ingested.
- If rapidly acting insulin analogs cannot be purchased, less expensive regular insulin can be used before meals. This insulin has a slower onset and longer duration of action, so it is more likely to cause hypoglycemia several hours after the meal. Snacks may be needed mid to late morning and afternoon and at bedtime. If regular insulin is used with NPH insulin, a lunchtime dose of regular insulin may not be needed.
- Rarely, NPH and regular insulin are used twice daily (before breakfast and dinner).^{47,48} This regimen may be used if the patient has difficulty with self-administration of insulin and assistance is not available at lunch and bedtime. Premixed insulins are rarely used in type 1 diabetes, because of their nonphysiologic profiles and lack of flexibility to match mealtime requirements.

- Insulin pens, magnifiers for insulin syringes, and other aids are available for individuals with impaired vision, hearing, and dexterity (see [Table 3](#)).

Insulin pump/continuous subcutaneous insulin infusion therapy

- A rapidly acting insulin analog (lispro, aspart or glulisine) is delivered continuously to provide basal requirements; boluses are delivered for meals and to correct hyperglycemia. Infusion sets are changed every 2 to 3 days.
- Continuous subcutaneous insulin infusion (CSII) has not been studied extensively in the elderly population, but preliminary studies suggest that it may improve glycemic control and reduce hypoglycemia to the same extent in patients aged between 50 and 65 years as it does in younger patients. Experts routinely recommend continuing CSII in patients who continue to be appropriate candidates.⁴⁹
- Advantages of CSII include the ability to program multiple basal rates, the ability to use reduced temporary basal rates for increased activity, and availability of an insulin bolus calculator (incorporated into the pump) to calculate bolus dosing based on the glucose level and carbohydrate intake.⁴⁹
- As older adults experience functional or cognitive decline, the use of CSII may become difficult. CSII therapy can be continued if the individual (or their partner/caregivers) has received the appropriate training and is capable of properly operating the pump.

Continuous glucose monitoring systems

- Sensors measure glucose levels in the interstitial fluid. Calibration with SMBG is required.
- CGMS alerts individuals when glucose levels increase higher than or decrease lower than preset glucose levels to help avoid serious hyperglycemic/hypoglycemic episodes.
- CGMS is particularly useful in adults with wide glycemic excursions, poor hypoglycemia awareness, or a history of serious hypoglycemia.
- The use of a CGMS-augmented insulin pump with a low glucose threshold suspend feature (suspending insulin infusion for ≤ 2 hours in the presence of hypoglycemia) helps reduce serious hypoglycemia without deterioration in A_{1c} level.⁵⁰ This strategy may be particularly helpful in older adults, given their high risk of hypoglycemia, but further studies in the elderly are needed.

Type 2 Diabetes

For most older adults with type 2 diabetes, initial pharmacologic treatment is an oral medication. The choice of initial therapy is guided by safety, tolerability, hypoglycemia risk, cost, ease of administration, renal and hepatic status, and patient preference. Combination oral therapy may be needed. Available noninsulin therapies and associated side effects are summarized in [Table 4](#). Insulin is added when oral therapy is insufficient to maintain glycemic goals.

- Low-dose metformin is generally the preferred first line of treatment in older adults. It should be avoided in patients 80 years of age or older in the presence of impaired renal function and higher doses (eg, >1000 mg/d) should be used cautiously.
- Glipizide is the preferred sulfonylurea in the elderly, because it is the least dependent on renal function for excretion and is associated with less hypoglycemia

Table 4
Oral and noninsulin injectable medications for the treatment of type 2 diabetes in the elderly

| Medication | Primary Mechanism of Action | Geriatric Dosing | Most Common Side Effects | Geriatric Considerations | Generic Available |
|--|---|---|---|---|-------------------|
| Metformin (Glucophage, Glumetza, Fortamet) | Decreases hepatic glucose production | Initial dose: 500 mg daily. Maintenance dose: 500 mg twice daily or 850 mg once daily Use higher doses cautiously | Diarrhea, abdominal discomfort, constipation, dyspepsia (these GI effects can be transient) Also anorexia, metallic taste, decreased vitamin B ₁₂ | Use with caution in patients >80 y with careful adherence to recommended renal dose adjustments. Do not use if eGFR <30 mL/min/1.73 m ² If eGFR 30–45 mL/min/1.73 m ² , use maximum 1000 mg daily | Yes |
| Sulfonylureas Glimepiride (Amaryl) Glipizide (Glucotrol) Glyburide (Diabeta, Glynase) | Stimulate insulin release from the pancreas | Glimepiride: initial dose: 0.5–1 mg once daily Glipizide: immediate release tablet: 2.5 mg once daily For both, glimepiride and glipizide, dose titration and maintenance dose should be conservative to avoid hypoglycemia (not to exceed 50% of maximum dose) | Hypoglycemia | Avoid long-acting sulfonylureas (especially glyburide) because of the risk of prolonged hypoglycemia Drug excretion of glipizide is least dependent on renal function Glipizide is the preferred sulfonylurea in elderly (least hypoglycemia) Glyburide is not preferred in elderly, because of increased risk of hypoglycemia and weight gain | Yes |

| | | | | | |
|---|---|--|---|--|-------------------|
| Meglitinides Repaglinide (Prandin) Nateglinide (Starlix) | Stimulate glucose-dependent insulin release from the pancreatic β cells | Repaglinide: flexible meal dosing; titrate dose cautiously Patients not previously treated or whose HbA _{1c} is <8%: initial dose 0.5 mg before each meal Patients previously treated with blood glucose-lowering agents whose HbA _{1c} is \geq 8%: 1 mg before each meal Nateglinide: 60 mg 3 times daily before meals | Hypoglycemia | Use with caution because of risk of hypoglycemia | Yes |
| Thiazolidinediones Pioglitazone (Actos) Rosiglitazone (Avandia) | Peroxisome proliferator-activated receptor γ agonists; improve insulin sensitivity in adipose tissue, liver, and skeletal muscle | Pioglitazone: 15 mg once daily Rosiglitazone: 2–4 mg daily as a single daily dose or in divided doses twice daily | Edema, heart failure, weight gain, fractures, increased risk of bladder cancer (pioglitazone) | Avoid in elderly because of increased fluid retention, exacerbation of heart failure and increased risk of fractures Not recommended in patients with symptomatic heart failure | Pioglitazone: yes |
| α -Glucosidase inhibitors Acarbose (Precose) Miglitol (Glyset) | Intestinal α -glucosidase inhibitors; delay intestinal absorption of glucose | 25 mg 3 times daily at the start of each meal | Diarrhea, flatulence, abdominal pain | Not recommended if CrCl \leq 24 mL/min GI side effects limit use | Acarbose: yes |

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Table 4
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| Medication | Primary Mechanism of Action | Geriatric Dosing | Most Common Side Effects | Geriatric Considerations | Generic Available |
|--|--|---|--|--|-------------------|
| DPP-4 inhibitors Sitagliptin (Januvia) Saxagliptin (Onglyza) Linagliptin (Tradjenta) Alogliptin (Nesina) | Inhibit DPP-4, resulting in prolonged action of GLP-1 (increase insulin release, reduce glucagon secretion) | Sitagliptin: 100 mg once daily CrCl 30–50 mL/min: 50 mg once daily CrCl <30 mL/min: 25 mg once daily Saxagliptin: 2.5–5.0 mg once daily For CrCl ≤50 mL/min: 2.5 mg once daily Linagliptin: 5 mg once daily Alogliptin: 25 mg once daily CrCl 30–50 mL/min: 12.5 mg once daily CrCl <30 mL/min: 6.25 mg once daily | Possible pancreatitis Possible increased risk of heart failure outcomes Unknown long-term side effects | Dose should be adjusted for renal impairment, except linagliptin | No |
| GLP-1 receptor agonists Exenatide (Byetta, Bydureon) Liraglutide (Victoza) Albiglutide (Tanzeum) Dulaglutide (Trulicity) | Increase glucose-dependent insulin secretion, decrease inappropriate glucagon secretion, slow gastric emptying, and increase satiety | <i>Exenatide:</i> Immediate release (Byetta): Initial: 5 µg subcut twice daily within 60 min before a meal; after 1 mo, may be increased to 10 µg twice daily (based on response) Extended release (Bydureon): 2 mg subcut once weekly Liraglutide: 0.6 mg subcut once daily for 1 wk; then increase to 1.2 mg once daily; may increase further to 1.8 mg once daily if optimal glycemic response not achieved with 1.2 mg/d Albiglutide: 30 mg subcut once weekly Dulaglutide: 0.75 mg once weekly; maximum 1.5 mg weekly | Hypoglycemia (in combination therapy with sulfonylurea or insulin), nausea (dose-dependent), vomiting, diarrhea, constipation, dyspepsia, weight loss, possible pancreatitis | Injectable Few studies in older adults | No |

| | | | | | |
|--|---|--|---|---|-----------|
| <p>SGLT2 inhibitors Canagliflozin (Invokana) Dapagliflozin (Farxiga) Empagliflozin (Jardiance)</p> | <p>Inhibit SGLT2 in the proximal renal tubules, reduce glucose reabsorption, lower renal threshold for glucose, resulting in increased urinary excretion of glucose</p> | <p>Canagliflozin: 100 mg once daily before first meal of the day Do not use if eGFR <45 mL/min/1.73 m² Dapagliflozin: 5 mg once daily in the morning, with or without food Do not use if eGFR <60 mL/min/1.73 m² Empagliflozin: 10 mg once daily Do not use if eGFR <45 mL/min/1.73 m²</p> | <p>Renal insufficiency, hypovolemia, hypotension, syncope, dehydration, genital mycotic infections, UTIs, polyuria, worsened urinary incontinence</p> | <p>Elderly patients may be predisposed to intravascular volume depletion (hypotension, orthostatic hypotension, dizziness, syncope, and dehydration), renal impairment or failure, increased genital mycotic and urinary infections, and worsened urinary incontinence HbA_{1c} reductions may be lower in patients >65 y compared with younger patients</p> | <p>No</p> |
| <p>Amylin agonist Pramlintide (Symlin)</p> | <p>Delays gastric emptying and inhibits the release of glucagon, reducing the rate of glucose absorption</p> | <p>15 µg subcut immediately before major meal, increased by 15 µg every 3–7 d as tolerated</p> | <p>Nausea, vomiting, abdominal pain, anorexia</p> | <p>Increased risk of severe hypoglycemia in elderly with concomitant use of insulin Avoid use in elderly</p> | <p>No</p> |

Abbreviations: CrCl, creatinine clearance; DPP-4, dipeptidyl peptidase 4; GI, gastrointestinal; GLP-1, glucagonlike peptide 1; HbA_{1c}, hemoglobin A_{1c}; SGLT2, sodium-glucose cotransporter 2; UTI, urinary tract infection.

Data from Refs. ^{51–53}

than the longer-acting sulfonylurea drugs. Glyburide should not be used because of a higher risk of hypoglycemia.

- Dipeptidyl peptidase 4 (DPP-4) inhibitors are safe, weight neutral, and well tolerated in the elderly but are more expensive than metformin or glipizide. Increased rate of heart failure outcomes is possible.⁵⁴ The dose of linagliptin does not need to be changed with declining renal function.
- Meglitinides are short acting and allow for flexible meal dosing but need to be given with each meal and used cautiously. They primarily decrease postprandial blood glucose levels. Hypoglycemia is a potential risk, but this risk is lower than with sulfonylurea drugs.⁵⁵
- Thiazolidinediones cause fluid retention and are associated with weight gain and worsening of heart failure. There is also increased risk of fracture. Pioglitazone is associated with increased risk of bladder cancer. These drugs are generally not recommended in the elderly.
- α -Glucosidase inhibitors delay the absorption of glucose, reducing postprandial glycemic levels.⁵⁶ They are associated with gastrointestinal side effects (especially flatulence and diarrhea) and need to be taken with each meal, which can be difficult in the elderly.
- Glucagonlike peptide 1 receptor agonists are injectable and can cause nausea, vomiting, and weight loss. These effects could be problematic in the frail and malnourished elderly.^{48,57} They have not been well studied in older adults and are generally not recommended in this population.
- Sodium-glucose cotransporter 2 inhibitors can predispose the elderly to intravascular volume depletion and decline in renal function and increases the risk of genital mycotic infections.^{48,58} There can be worsening of urinary incontinence, weight loss, and more urinary tract infections in older women.
- Insulin therapy is indicated when monotherapy or combined therapy with oral medications fails to achieve the desired glycemic target.^{46,47} Insulin should be introduced at low dose only if needed and with caution in the elderly.^{59,60} A basal insulin analog (insulin glargine or detemir) can be added to oral regimens in the presence of fasting hyperglycemia. Care is needed not to give too much basal insulin; fasting glucose levels can reflect not only basal needs but evening food intake. Hypoglycemia is a significant risk.
- If postprandial hyperglycemia is the main cause of an increased A_{1c} level, a rapidly acting insulin analog (insulin aspart, lispro, glulisine) can be added to the largest meal(s) rather than initiating basal insulin. If there is unreliable food intake, the rapidly acting insulin analog can be given immediately after the meal so that a lower dose can be given if less food (carbohydrate) is ingested. Elderly patients with renal insufficiency may experience fewer hypoglycemic episodes when using rapidly acting insulin analogs (compared with longer-acting insulins).^{44,59}
- If basal-bolus insulin injection therapy is needed, recommendations are similar to those described earlier for the management of type 1 diabetes.
- Insulin administration using vials and syringes can be difficult for the elderly, who may have vision impairment and declining manual dexterity. The use of prefilled insulin pens and other aids can be helpful.⁶¹

NONPHARMACOLOGIC STRATEGIES

Diabetes self-management education and training (DSME/T) is essential and should involve the patient, caregivers, family and friends. DSME/T includes instructions

concerning monitoring, medical nutrition therapy, proper administration of medications, sick day rules, and physical activity guidelines. Blood glucose awareness training can also be useful for people with poor hypoglycemic awareness. The American Diabetes Association publishes a consumer guide to diabetes-related products annually in *Diabetes Forecast*.

SMBG frequency should be individualized. For those with satisfactory and stable glycemic control taking oral drugs not associated with hypoglycemia, infrequent testing (0–2 times daily) is reasonable. Medicare Part B covers 100 glucose monitoring strips every 3 months for patients not receiving insulin. Adults on insulin therapy should test more frequently (2–6 times daily), depending on the insulin regimen and propensity for hypoglycemia. For those using a basal-bolus insulin regimen, SMBG should be performed before meals, bedtime, and as needed (eg, with signs or symptoms of hypoglycemia, before driving, before and after exercise, and in the middle of the night for evaluation of nocturnal hypoglycemia). Medicare Part B pays for 300 strips every 3 months for individuals taking insulin, but additional strips can be requested if the treating physician states that they are medically necessary.

Recommendations should be communicated in simple terms aided by visual handouts, models, and written instructions. Addressing barriers such as vision and hearing impairments, pain control, transportation difficulties, caregiver stress, difficulty swallowing, cognitive decline, depression, and problems obtaining or administering medications are important.⁴¹ Nutrition therapy combined with physical activity can improve glycemic and blood pressure control, help preserve, improve, or slow decline in function, and reduce cardiometabolic risk in older adults.⁴⁶

Medical Nutrition Therapy

Medical nutrition therapy is an essential component of diabetes care. In the geriatric population, general nutrition concerns as well as diabetes-specific issues should be addressed. Older adults are at risk for malnutrition, including micronutrient deficiencies caused by anorexia, altered taste and smell, swallowing difficulties, and oral/dental issues. Functional impairments leading to difficulties in preparing or consuming food result in dependence on others for meals and shopping and other medical comorbidities.^{62,63} Weight loss, whether intentional or unintentional, may contribute to nutritional deficits and worsen sarcopenia. Fortified foods and nutritional supplements, including vitamins and minerals, may be needed.

For the older adult with diabetes, specific dietary recommendations can vary, depending on their general nutritional status, and whether the individual requires insulin therapy. For those who require basal-bolus insulin therapy (eg, those with type 1 diabetes), mealtime insulin dosing should primarily match the carbohydrate content of meals. This regimen can be especially challenging in elderly patients with inconsistent food intake or poor numeracy skills. Errors can cause wide glycemic fluctuations. In the presence of poor and unpredictable food intake, the use of carbohydrate-consistent meals may be helpful, and consideration should be given to administering rapid-acting insulin immediately after meals, so lower doses can be given if less food is consumed.⁶⁴

The diet should be individualized to conform to the patient's lifestyle, food preferences, nutritional needs, and socioeconomic factors. Changes may need to be introduced gradually to enhance adherence.^{63,65,66} Adults with type 1 diabetes may also have celiac disease, further affecting food choices. Interventions such as providing small, frequent meals, fortified food, protein shakes, dysphagia diet, or formula feed can also improve caloric intake when needed.²⁸ A healthy balanced low-salt diet

containing complex carbohydrates and fiber, particularly fruits and vegetables, lean proteins, and less than 20% total fat can help improve glycemic and blood pressure control and reduce the need for medications. Older adults may find community resources such as Meals on Wheels or meals served at local senior centers beneficial.²⁸

Physical Activity

Engaging in regular physical activity is an integral part of diabetes care. Older adults with diabetes who are otherwise healthy and functional (youthful older adults) should be encouraged to engage in aerobic activity for 150 min/wk or more. If the individual has been sedentary, this activity may need to be gradually introduced. Those with known heart disease or multiple cardiovascular risk factors, osteoarthritis, chronic lung disease, osteoporosis, or other serious comorbidities should have exercise recommendations revised appropriately. Cardiac testing may be recommended. Exercise regimes should be individualized according to need, functional status, presence of comorbidities, geriatric syndromes, and age.

Muscle mass and strength decline with age, presence of comorbidities, malnutrition, and periods of prolonged immobilization and hospitalization. Physical and occupational therapy can be useful. Fall prevention is critical. Exercise programs prescribed by specialized physical trainers take into account the physical and psychological capabilities of the older adult.⁴⁶ Joining supervised group exercise programs at senior centers, YMCAs, and other community facilities can also be of benefit.

For adults using insulin therapy or taking insulin secretagogues, physical activity can cause hypoglycemia. Instructions on ways to avoid hypoglycemia (reduced medication dosing or eating snacks) and treat hypoglycemia should be provided. It is important to convey that hypoglycemia can occur not only during activity but for a prolonged period after the activity. Glucose monitoring should be used. Wearing a medical alert bracelet or necklace and use of Medical Alert services (eg, pendant or watch medical alert alarm monitoring systems) can be life saving.

EVALUATION AND ADJUSTMENT

The management of diabetes in the elderly includes ongoing individualized assessments, with modifications in the treatment plan as indicated. Periodic assessments for geriatric syndromes (physical function, nutrition, cognition, comorbidities, depression, polypharmacy, pain, incontinence, social support) are recommended. Glycemic, blood pressure, and lipid goals change over time. Elements of routine follow-up diabetes care in the elderly are outlined later.

Screening for diabetes-related complications is also an integral part of diabetes care. For relatively healthy older adults, the screening examinations described later are recommended. For the frail elderly or those with multiple comorbidities and short life expectancy, it is reasonable to consider the expected benefit, burden of intervening, and patient preference.

Diabetes Self-Management Education and Training

The importance of periodic diabetes education, including nutrition counseling, has been previously described. In general, Medicare Part B (medical insurance) pays for 10 hours of initial training and an additional 2 hours annually (exclusive of medical nutrition therapy) if prescribed by a physician and obtained in a program certified by the American Diabetes Association or the Indian Health Service. Medical nutrition therapy is covered if delivered by a registered dietitian or certain other nutrition professionals.

Glycemic Control

Glycemic goals, control, and treatment plans should be reevaluated using A_{1c} testing, review of SMBG logs, consideration of the presence or progression of geriatric syndromes and comorbidities, and history of hypoglycemia. It is important to avoid over-treatment, especially in those with limited life expectancy, frailty, low GFR, and moderate to severe cognitive impairment or dementia. Frequent communications or visits may be needed.^{67,68}

Blood Pressure Control

Blood pressure should be measured at each medical visit, and goals and medications reevaluated. Home blood pressure monitoring may be helpful.

Lipid Management

A lipid profile should be checked annually and statin medications prescribed (if tolerated) in those with CVD or at least 1 additional risk factor (hypertension, smoking, dyslipidemia, albuminuria, or family history of CVD) in the absence of a limited life expectancy.³⁸ As discussed earlier, use of statin drugs in adults older than 80 years or with major comorbidities is controversial. The benefits of fenofibrate for those older than 65 years with mild to moderate hypertriglyceridemia have not been established.⁶⁹

Eye Care

Eye examinations should be performed annually or as recommended by the eye care specialist. Screening for diabetic retinopathy and macular edema as well as for glaucoma should be performed. Cataracts are also more common in diabetes. If there is impaired vision, appropriate evaluation, treatment, and correction for refractive errors or recommendations for vision aids can improve quality of life and help prevent errors in medication administration.

Foot Care

Examination of the feet should occur at each medical visit. Referral to a podiatrist should be considered in the presence of foot deformities, neuropathy, peripheral vascular disease, or a history of foot ulcers or other foot disease. Caregivers should be involved in regular inspection of feet, nail clipping (if the patient is incapable and is not receiving this service from a provider), and proper cleaning of feet when necessary. Proper fitting shoes and white socks (for easy visibility of blood stains) are recommended.

Medicare Part B pays for 1 pair of therapeutic shoes and inserts each year if (1) the physician treating the diabetes certifies that they are needed (presence of ≥ 1 of the following: amputation, history of foot ulcer, peripheral vascular disease, foot deformities, neuropathy with callus, or preulcerative callus) and (2) the shoes/inserts are prescribed by a podiatrist or other qualified doctor. Further details are available at <http://www.medicare.gov>.

Renal Function

Monitoring renal function (serum creatinine and eGFR) in the elderly is important, because decline in renal function is common and necessitates adjustments of medications. In healthy older adults, annual screening for albuminuria, with treatment with an ACE-I or ARB in the presence of persistent microalbuminuria, should be considered. ACE-I and ARBs should not be used in combination.⁷⁰

Additional Recommendations

- Smoking status should be assessed and cessation recommended.
- Aspirin (75–162 mg), if tolerated and not contraindicated, should be considered in the presence of CVD or at least 1 additional risk factor (hypertension, smoking, dyslipidemia, albuminuria, or family history of CVD).⁷¹ Because the elderly are at increased risk of bleeding, potential benefit versus risk must be carefully considered.
- Concerns about social support and financial resources should be elicited, with referral to a social worker or other resources as needed.
- In obese older adults with symptoms suggestive of sleep apnea, screening should be considered.
- Periodontal disease is more common in diabetes. Dental problems can adversely affect eating/nutrition. Consideration should be given for dental care referral.
- The immunization history should be reviewed, and annual influenza vaccination administered. Pneumonia and shingles vaccine should also be offered as per standard vaccination guidelines.^{72,73}

FUTURE CONSIDERATIONS/SUMMARY

With the increasing prevalence of diabetes in the elderly, better management approaches to meet the unique needs of this growing population are needed. This strategy includes more research on the optimal use of oral glycemic control medications in the elderly, better aids to assist individuals with impairments in vision, cognition, and mobility, and safer methods of insulin administration to avoid hypoglycemia. Progress in the development of CGMS, new glycemic control agents, and advances in the development of an artificial pancreas also hold great promise.

Diverse methods of delivering diabetes care to the elderly have been investigated. The use of group visits⁷⁴ and team care, with interim phone contact,^{41,75} can be helpful. Telemedicine has been shown to be of benefit in several studies.⁷⁶ The Informatics for Diabetes and Education Telemedicine (IDEATel) demonstration project in ethnically diverse Medicare beneficiaries used nurse educators and dietitians to conduct home televisits every 6 weeks or as needed. During televisits, self-management education was provided, downloads of home blood glucose and blood pressure values, and annual laboratory data were reviewed, and under the supervision of endocrinologists, recommendations for changes in treatment were made to primary care providers. This project resulted in better glycemic, blood pressure, and lipid control and reduced disparities.^{77–79} Participation in the telemedicine intervention was also associated with lessened decline in physical activity, impairment, and cognition.^{80,81} In addition, we have shown in a pilot study in a long-term care facility that review of glucose values and medications by an endocrinologist using telemedicine has the potential to improve glycemia, including reduction of hypoglycemia.⁸² Additional investigation in this area is needed.

Until results of further research in the elderly with diabetes become available, it is important to individualize, assess, and adjust diabetes care plans periodically with input from the patient and their caretakers. The development or advancement of geriatric syndromes, hypoglycemia, and comorbidities will direct the need for further diabetes education and training, additional social services, and modification of pharmacologic therapy. When possible, use of medications with low risk for hypoglycemia (eg, metformin, DPP-4 inhibitors) is advisable. Initial therapy should use low doses; insulin must be used with caution. Goals should include minimizing hypoglycemia, symptomatic hyperglycemia, orthostatic hypotension, and other drug-related complications and maintaining quality of life.

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