

Management of Hyperglycemia in Hospitalized Patients in Non-Critical Care Setting: An Endocrine Society Clinical Practice Guideline

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Objective: The aim was to formulate practice guidelines on the management of hyperglycemia in hospitalized patients in the non-critical care setting.

Participants: The Task Force was composed of a chair, selected by the Clinical Guidelines Subcommittee of The Endocrine Society, six additional experts, and a methodologist.

Evidence: This evidence-based guideline was developed using the Grading of Recommendations, Assessment, Development, and Evaluation (GRADE) system to describe both the strength of recommendations and the quality of evidence.

Consensus Process: One group meeting, several conference calls, and e-mail communications enabled consensus. Endocrine Society members, American Diabetes Association, American Heart Association, American Association of Diabetes Educators, European Society of Endocrinology, and the Society of Hospital Medicine reviewed and commented on preliminary drafts of this guideline.

Conclusions: Hyperglycemia is a common, serious, and costly health care problem in hospitalized patients. Observational and randomized controlled studies indicate that improvement in glycemic control results in lower rates of hospital complications in general medicine and surgery patients. Implementing a standardized sc insulin order set promoting the use of scheduled basal and nutritional insulin therapy is a key intervention in the inpatient management of diabetes. We provide recommendations for practical, achievable, and safe glycemic targets and describe protocols, procedures, and system improvements required to facilitate the achievement of glycemic goals in patients with hyperglycemia and diabetes admitted in non-critical care settings. (*J Clin Endocrinol Metab* 97: 16–38, 2012)

Summary of Recommendations

1.0 Diagnosis and recognition of hyperglycemia and diabetes in the hospital setting

1.1 We recommend that clinicians assess all patients admitted to the hospital for a history of diabetes. When present, this diagnosis should be clearly identified in the medical record. (1⊕○○○)

1.2 We suggest that all patients, independent of a prior diagnosis of diabetes, have laboratory blood glucose (BG) testing on admission. (2⊕○○○)

1.3 We recommend that patients without a history of diabetes with BG greater than 7.8 mmol/liter (140 mg/dl) be monitored with bedside point of care (POC) testing for at least 24 to 48 h. Those with BG greater than 7.8 mmol/liter require ongoing POC testing with appropriate therapeutic intervention. (1⊕○○○)

1.4 We recommend that in previously normoglycemic patients receiving therapies associated with hyperglycemia, such as corticosteroids or octreotide, enteral nutrition (EN) and parenteral nutrition (PN) be monitored with bedside POC testing for at least 24 to 48 h after initiation of these therapies. Those with BG measures greater than 7.8 mmol/liter (140 mg/dl) require ongoing POC testing with appropriate therapeutic intervention. (1⊕○○○)

1.5 We recommend that all inpatients with known diabetes or with hyperglycemia (>7.8 mmol/liter) be assessed with a hemoglobin A1C (HbA1C) level if this has not been performed in the preceding 2–3 months. (1⊕○○○)

2.0 Monitoring glycemia in the non-critical care setting

2.1 We recommend bedside capillary POC testing as the preferred method for guiding ongoing glycemic management of individual patients. (1⊕⊕○○)

2.2 We recommend the use of BG monitoring devices that have demonstrated accuracy of use in acutely ill patients. (1⊕○○○)

2.3 We recommend that timing of glucose measures match the patient's nutritional intake and medication regimen. (1⊕○○○)

2.4 We suggest the following schedules for POC testing: before meals and at bedtime in patients who are eating, or every 4–6 h in patients who are NPO [receiving nothing by mouth (nil per os)] or receiving continuous enteral feeding. (2⊕○○○)

3.0 Glycemic targets in the non-critical care setting

3.1 We recommend a premeal glucose target of less than 140 mg/dl (7.8 mmol/liter) and a random BG of less than 180 mg/dl (10.0 mmol/liter) for the majority of hospitalized patients with non-critical illness. (1⊕⊕○○)

3.2 We suggest that glycemic targets be modified according to clinical status. For patients who are able to achieve and maintain glycemic control without hypoglycemia, a lower target range may be reasonable. For patients with terminal illness and/or with limited life expectancy or at high risk for hypoglycemia, a higher target range (BG < 11.1 mmol/liter or 200 mg/dl) may be reasonable. (2⊕○○○)

3.3 For avoidance of hypoglycemia, we suggest that antidiabetic therapy be reassessed when BG values fall below 5.6 mmol/liter (100 mg/dl). Modification of glucose-lowering treatment is usually necessary when BG values are below 3.9 mmol/liter (70 mg/dl). (2⊕○○○)

4.0 Management of hyperglycemia in the non-critical care setting

4.1 Medical nutrition therapy (MNT)

4.1.1 We recommend that MNT be included as a component of the glycemic management program for all hospitalized patients with diabetes and hyperglycemia. (1⊕○○○)

4.1.2 We suggest that providing meals with a consistent amount of carbohydrate at each meal can be useful in coordinating doses of rapid-acting insulin to carbohydrate ingestion. (2⊕○○○)

4.2 Transition from home to hospital

4.2.1 We recommend insulin therapy as the preferred method for achieving glycemic control in hospitalized patients with hyperglycemia. (1⊕⊕○○)

4.2.2 We suggest the discontinuation of oral hypoglycemic agents and initiation of insulin therapy for the majority of patients with type 2 diabetes at the time of hospital admission for an acute illness. (2⊕○○○)

4.2.3 We suggest that patients treated with insulin before admission have their insulin dose modified according to clinical status as a way of reducing the risk for hypoglycemia and hyperglycemia. (2⊕○○○)

4.3 Pharmacological therapy

4.3.1 We recommend that all patients with diabetes treated with insulin at home be treated with a scheduled sc insulin regimen in the hospital. (1⊕⊕⊕⊕)

4.3.2 We suggest that prolonged use of sliding scale insulin (SSI) therapy be avoided as the sole method for glycemic control in hyperglycemic patients with history of diabetes during hospitalization. (2⊕○○○)

4.3.3 We recommend that scheduled sc insulin therapy consist of basal or intermediate-acting insulin given once or twice a day in combination with rapid- or short-acting insulin administered before meals in patients who are eating. (1⊕⊕⊕○)

4.3.4 We suggest that correction insulin be included as a component of a scheduled insulin regimen for treatment of BG values above the desired target. (2|⊕○○○)

4.4 Transition from hospital to home

4.4.1 We suggest reinstatement of preadmission insulin regimen or oral and non-insulin injectable antidiabetic drugs at discharge for patients with acceptable preadmission glycemic control and without a contraindication to their continued use. (2|⊕○○○)

4.4.2 We suggest that initiation of insulin administration be instituted at least one day before discharge to allow assessment of the efficacy and safety of this transition. (2|⊕○○○)

4.4.3 We recommend that patients and their family or caregivers receive both written and oral instructions regarding their glycemic management regimen at the time of hospital discharge. These instructions need to be clearly written in a manner that is understandable to the person who will administer these medications. (1|⊕⊕○○)

5.0 Special situations

5.1 Transition from iv continuous insulin infusion (CII) to sc insulin therapy

5.1.1 We recommend that all patients with type 1 and type 2 diabetes be transitioned to scheduled sc insulin therapy at least 1–2 h before discontinuation of CII. (1|⊕⊕⊕⊕)

5.1.2 We recommend that sc insulin be administered before discontinuation of CII for patients without a history of diabetes who have hyperglycemia requiring more than 2 U/h. (1|⊕⊕⊕⊕)

5.1.3 We recommend POC testing with daily adjustment of the insulin regimen after discontinuation of CII. (1|⊕⊕⊕○)

5.2 Patients receiving EN or PN

5.2.1 We recommend that POC testing be initiated for patients with or without a history of diabetes receiving EN and PN. (1|⊕⊕⊕⊕)

5.2.2 We suggest that POC testing can be discontinued in patients without a prior history of diabetes if BG values are less than 7.8 mmol/liter (140 mg/dl) without insulin therapy for 24–48 h after achievement of desired caloric intake. (2|⊕○○○)

5.2.3 We suggest that scheduled insulin therapy be initiated in patients with and without known diabetes who have hyperglycemia, defined as BG greater than 7.8 mmol/liter (140 mg/dl), and who demonstrate a persistent requirement (*i.e.* >12 to 24 h) for correction insulin. (2|⊕○○○)

5.3 Perioperative BG control

5.3.1 We recommend that all patients with type 1 diabetes who undergo minor or major surgical procedures receive either CII or sc basal insulin with bolus insulin as required to prevent hyperglycemia during the perioperative period. (1|⊕⊕⊕⊕)

5.3.2 We recommend discontinuation of oral and non-insulin injectable antidiabetic agents before surgery with initiation of insulin therapy in those who develop hyperglycemia during the perioperative period for patients with diabetes. (1|⊕○○○)

5.3.3 When instituting sc insulin therapy in the post-surgical setting, we recommend that basal (for patients who are NPO) or basal bolus (for patients who are eating) insulin therapy be instituted as the preferred approach. (1|⊕⊕⊕○)

5.4 Glucocorticoid-induced diabetes

5.4.1 We recommend that bedside POC testing be initiated for patients with or without a history of diabetes receiving glucocorticoid therapy. (1|⊕⊕⊕○)

5.4.2 We suggest that POC testing can be discontinued in nondiabetic patients if all BG results are below 7.8 mmol/liter (140 mg/dl) without insulin therapy for a period of at least 24–48 h. (2|⊕○○○)

5.4.3 We recommend that insulin therapy be initiated for patients with persistent hyperglycemia while receiving glucocorticoid therapy. (1|⊕⊕○○)

5.4.4 We suggest CII as an alternative to sc insulin therapy for patients with severe and persistent elevations in BG despite use of scheduled basal bolus sc insulin. (2|⊕○○○)

6.0 Recognition and management of hypoglycemia in the hospital setting

6.1 We recommend that glucose management protocols with specific directions for hypoglycemia avoidance and hypoglycemia management be implemented in the hospital. (1|⊕⊕○○)

6.2 We recommend implementation of a standardized hospital-wide, nurse-initiated hypoglycemia treatment protocol to prompt immediate therapy of any recognized hypoglycemia, defined as a BG below 3.9 mmol/liter (70 mg/dl). (1|⊕⊕○○)

6.3 We recommend implementation of a system for tracking frequency of hypoglycemic events with root cause analysis of events associated with potential for patient harm. (1|⊕⊕○○)

7.0 Implementation of a glycemic control program in the hospital

7.1 We recommend that hospitals provide administrative support for an interdisciplinary steering committee

targeting a systems approach to improve care of inpatients with hyperglycemia and diabetes. (1⊕⊕⊕⊕)

7.2 We recommend that each institution establish a uniform method of collecting and evaluating POC testing data and insulin use information as a way of monitoring the safety and efficacy of the glycemic control program. (1⊕○○○)

7.3 We recommend that institutions provide accurate devices for glucose measurement at the bedside with ongoing staff competency assessments. (1⊕○○○)

8.0 Patient and professional education

8.1 We recommend diabetes self-management education targeting short-term goals that focus on survival skills: basic meal planning, medication administration, BG monitoring, and hypoglycemia and hyperglycemia detection, treatment, and prevention. (1⊕○○○)

8.2 We recommend identifying resources in the community to which patients can be referred for continuing diabetes self-management education after discharge. (1⊕○○○)

8.3 We recommend ongoing staff education to update diabetes knowledge, as well as targeted staff education whenever an adverse event related to diabetes management occurs. (1⊕○○○)

Method of Development of Evidence-Based Clinical Practice Guidelines

The Clinical Guidelines Subcommittee of The Endocrine Society deemed the management of hyperglycemia in hospitalized patients in a non-critical care setting a priority area in need of practice guidelines and appointed a Task Force to formulate evidence-based recommendations. The Task Force followed the approach recommended by the Grading of Recommendations, Assessment, Development, and Evaluation (GRADE) group, an international group with expertise in development and implementation of evidence-based guidelines (1). A detailed description of the grading scheme has been published elsewhere (2). The Task Force used the best available research evidence to develop some of the recommendations. The Task Force also used consistent language and graphical descriptions of both the strength of a recommendation and the quality of evidence. In terms of the strength of the recommendation, strong recommendations use the phrase “we recommend” and the number 1, and weak recommendations use the phrase “we suggest” and the number 2. *Cross-filled circles* indicate the quality of the evidence, such that ⊕○○○ denotes very low quality evidence; ⊕⊕○○, low quality; ⊕⊕⊕○, moderate quality; and ⊕⊕⊕⊕, high qual-

ity. The Task Force has confidence that persons who receive care according to the strong recommendations will derive, on average, more good than harm. Weak recommendations require more careful consideration of the person’s circumstances, values, and preferences to determine the best course of action. Linked to each recommendation is a description of the evidence and the values that panelists considered in making the recommendation; in some instances, there are remarks, a section in which panelists offer technical suggestions for testing conditions, dosing, and monitoring. These technical comments reflect the best available evidence applied to a typical person being treated. Often this evidence comes from the unsystematic observations of the panelists and their values and preferences; therefore, these remarks should be considered suggestions.

The prevalence of diabetes has reached epidemic proportions in the United States. The Centers for Disease Control and Prevention recently reported that 25.8 million people, or 8.3% of the population, have diabetes (3). Diabetes represents the seventh leading cause of death (4) and is the fourth leading comorbid condition among hospital discharges in the United States (5). Approximately one in four patients admitted to the hospital has a known diagnosis of diabetes (6, 7), and about 30% of patients with diabetes require two or more hospitalizations in any given year (7). The prevalence of diabetes is higher in elderly patients and residents of long-term-care facilities, in whom diabetes is reported in up to one third of adults aged 65–75 yr and in 40% of those older than 80 yr (8, 9).

The association between hyperglycemia in hospitalized patients (with or without diabetes) and increased risk for complications and mortality is well established (6, 10–14). This association is observed for both admission glucose and mean BG level during the hospital stay. Although most randomized controlled trials investigating the impact of treating hyperglycemia on clinical outcomes have been performed in critically ill patients, there are extensive observational data supporting the importance of hyperglycemia management among non-critically ill patients admitted to general medicine and surgery services. In such patients, hyperglycemia is associated with prolonged hospital stay, increased incidence of infections, and more disability after hospital discharge and death (6, 15–19). This manuscript contains the consensus recommendations for the management of hyperglycemia in hospitalized patients in non-critical care settings by The Endocrine Society and other organizations of health care professionals involved in inpatient diabetes care, including the American Diabetes Association (ADA), American Heart Association, American Association of Diabetes Educators (AADE), European Society of Endocrinology, and the Society of Hos-

pital Medicine. The central goal was to provide practical, achievable, and safe glycemic goals and to describe protocols, procedures, and system improvements needed to facilitate their implementation. This document is addressed to health care professionals, supporting staff, hospital administrators, and other stakeholders focused on improved management of hyperglycemia in inpatient settings.

1.0 Diagnosis and recognition of hyperglycemia and diabetes in the hospital setting

Recommendations

1.1 We recommend that clinicians assess all patients admitted to the hospital for a history of diabetes. When present, this diagnosis should be clearly identified in the medical record. (1⊕○○○)

1.2 We suggest that all patients, independent of a prior diagnosis of diabetes, have laboratory BG testing on admission. (2⊕○○○)

1.3 We recommend that patients without a history of diabetes with BG greater than 7.8 mmol/liter (140 mg/dl) be monitored with bedside POC testing for at least 24 to 48 h. Those with BG greater than 7.8 mmol/liter require ongoing POC testing with appropriate therapeutic intervention. (1⊕○○○)

1.4 We recommend that in previously normoglycemic patients receiving therapies associated with hyperglycemia, such as corticosteroids or octreotide, EN and PN be monitored with bedside POC testing for at least 24 to 48 h after initiation of these therapies. Those with BG measures greater than 7.8 mmol/liter (140 mg/dl) require ongoing POC testing with appropriate therapeutic intervention. (1⊕○○○)

1.1–1.4 Evidence

In-hospital hyperglycemia is defined as any glucose value greater than 7.8 mmol/liter (140 mg/dl) (20, 21). Hyperglycemia occurs not only in patients with known diabetes but also in those with previously undiagnosed diabetes and others with “stress hyperglycemia” that may occur during an acute illness and that resolves by the time of discharge (20, 22, 23). Observational studies report that hyperglycemia is present in 32 to 38% of patients in community hospitals (6, 24), 41% of critically ill patients with acute coronary syndromes (13), 44% of patients with heart failure (13), and 80% of patients after cardiac surgery (25, 26). In these reports, approximately one third of non-intensive care unit (ICU) patients and approximately 80% of ICU patients had no history of diabetes before admission (6, 13, 27–30).

The ADA Clinical Practice Recommendations endorse the initiation of glucose monitoring for both those with

diabetes and those without a known history of diabetes who are receiving therapies associated with hyperglycemia (31). We agree with these recommendations but also suggest that initial glucose measurement on admission by the hospital laboratory is appropriate for all hospitalized patients, irrespective of the presence of preexisting diabetes history or exposure to obvious hyperglycemia inducers. The high prevalence of inpatient hyperglycemia with associated poor outcomes and the opportunity to diagnose new diabetes warrants this approach (6, 24, 32, 33). Because the duration of care is frequently brief in the inpatient setting, the assessment of glycemic control needs to be performed early in the hospital course. Bedside POC testing has advantages over laboratory venous glucose testing. POC testing at the “point of care” allows identification of patients who require initiation or modification of a glycemic management regimen (20, 21). POC monitoring has been demonstrated to be essential in guiding insulin administration toward achieving and maintaining desired glycemic goals as well as for recognizing hypoglycemic events (16, 21, 34, 35). Most currently used bedside glucose meters, although designed for capillary whole-blood testing, are calibrated to report results compatible to plasma, which allows for reliable comparison to the laboratory glucose test (16, 22, 36, 37).

1.1–1.4 Values and preferences

Our recommendations reflect consideration of the face validity of soliciting and communicating the diagnosis of diabetes or hyperglycemia to members of the care team. The risk-to-benefit of glucose testing and documenting a history of diabetes favors this approach despite the lack of randomized controlled trials.

Recommendation

1.5 We recommend that all inpatients with known diabetes or with hyperglycemia (>7.8 mmol/liter) be assessed with an HbA1C level if this has not been performed in the preceding 2–3 months. (1⊕○○○)

1.5 Evidence

We support the ADA recommendation of using a laboratory measure of HbA1C both for the diagnosis of diabetes and for the identification of patients at risk for diabetes (31). The ADA recommendations indicate that patients with an HbA1C of 6.5% or higher can be identified as having diabetes, and patients with an HbA1C between 5.7 and 6.4% can be considered as being at risk for the development of diabetes (31).

Measurement of an HbA1C during periods of hospitalization provides the opportunity to identify patients with known diabetes who would benefit from intensifi-

cation of their glycemic management regimen. In patients with newly recognized hyperglycemia, an HbA1C may help differentiate patients with previously undiagnosed diabetes from those with stress-induced hyperglycemia (32, 38). It is important to note that there are no randomized trials demonstrating improved outcomes using HbA1C levels to assist in the diagnosis of diabetes in inpatients with new hyperglycemia or to assist in tailoring the glycemic management of inpatients with known diabetes. Our recommendations reflect consensus opinion and the practical utility of this strategy.

Clinicians must keep in mind that an HbA1C cutoff of 6.5% identifies fewer cases of undiagnosed diabetes than does a high fasting glucose (38). Several epidemiological studies have reported a low sensitivity (44 to 66%) but a high specificity (76 to 99%) for HbA1C greater than 6.5% in an outpatient population (39, 40). Among hospitalized hyperglycemic patients, an HbA1C level above 6.0% was reported to be 100% specific and 57% sensitive for the diagnosis of diabetes, whereas an HbA1C below 5.2% effectively excluded a diagnosis of diabetes (41).

Glucose and HbA1C values, together with the medical history, can be used to tailor therapy and assist in discharge planning (42, 43). Discharge planning, education, and care transitions are discussed in more detail in *Section 4.4*. Briefly, the discharge plan optimally includes the diagnosis of diabetes (if present), recommendations for short- and long-term glucose control, follow-up care, a list of educational needs, and consideration of appropriate screening and treatment of diabetes comorbidities (30, 42, 44).

There are limitations to the use of an HbA1C for diagnosis of diabetes in an inpatient population. These include the relatively low diagnostic sensitivity and potential altered values in the presence of hemoglobinopathies (hemoglobin C or SC disease), high-dose salicylates, hemodialysis, blood transfusions, and iron deficiency anemia (45). When HbA1C is used for establishing a diagnosis of diabetes, analysis should be performed using a method certified by the National Glycohemoglobin Standardization Program (31), because POC HbA1C testing is not sufficiently accurate at this time to be diagnostic.

2.0 Monitoring glycemia in the non-critical care setting

Recommendations

2.1 We recommend bedside capillary POC testing as the preferred method for guiding ongoing glycemic management of individual patients. (1⊕⊕○○)

2.2 We recommend the use of BG monitoring devices that have demonstrated accuracy of use in acutely ill patients. (1⊕○○○)

2.3 We recommend that timing of glucose measures match the patient's nutritional intake and medication regimen. (1⊕○○○)

2.4 We suggest the following schedules for POC testing: before meals and at bedtime in patients who are eating, or every 4–6 h in patients who are NPO or receiving continuous enteral feeding. (2⊕○○○)

2.1–2.4 Evidence

Matching the timing of POC testing with nutritional intake and the diabetes medication regimen in the hospital setting is consistent with recommendations for the outpatient setting. POC testing is usually performed four times daily: before meals and at bedtime for patients who are eating (16, 21). Premeal POC testing should be obtained as close to the time of the meal tray delivery as possible and no longer than 1 h before meals (46–48). For patients who are NPO or receiving continuous EN, POC testing is recommended every 4–6 h. More frequent glucose monitoring is indicated in patients treated with continuous iv insulin infusion (49, 50) or after a medication change that could alter glycemic control, *e.g.* corticosteroid use or abrupt discontinuation of EN or PN (48, 51, 52), or in patients with frequent episodes of hypoglycemia (16, 28).

Capillary BG data facilitate the ability to adjust insulin therapy based in part on calculation of total correction insulin doses over the preceding 24 h. Consistent sampling sites and methods of measurement should be used because glucose results can vary significantly when alternating between finger-stick and alternative sites, or between samples run in the laboratory *vs.* a POC testing device (53). As in the outpatient setting, erroneous results can be obtained from finger-stick samples whenever the BG is rapidly rising or falling (53).

Quality control programs are essential to meet Food and Drug Administration (FDA) requirements and to maintain the safety, accuracy, and reliability of BG testing (21). The FDA requires that the accuracy of glucose analyzers in the central lab be within 10% of the real value, whereas POC meters are considered acceptable within 20% (21, 37); however, recent reports have advocated improvement or tightening of POC meter accuracy standards (37). Using meters with bar coding capability has been shown to reduce data entry errors in medical records (37). Capillary BG values can vary between POC meters, especially at high or low hemoglobin levels, low tissue perfusion, and with some extraneous substances (36, 53). Although patients can bring their own glucose meter device to the hospital, personal meters should not be used for documentation or for treatment of hyperglycemia. Hospital meters should follow regulatory and licensing quality control procedures to ensure accuracy and reliability of

results. Hospital systems with data management programs can transfer results into electronic records to allow evaluation of hospital-wide patterns of glycemic control (54).

Health care workers should keep in mind that the accuracy of most hand-held glucose meters is far from optimal (53). There are potential inaccuracies of POC testing including intrinsic issues with the technology and variability between different lots of test strips, inadequate sampling site, varying hemoglobin concentrations, and other interfering hematological factors in acutely ill patients (37, 55, 56). One study from the Centers for Disease Control (CDC) of five commonly used glucose meters showed mean differences from a central laboratory method to be as high as 32% and a coefficient of variation of 6 to 11% with a single trained medical technologist (37).

Recent studies suggest that continuous BG monitoring devices may be helpful in reducing incidences of severe hypoglycemia in acute care (57, 58). More studies, however, are needed to determine the accuracy and reliability of continuous BG monitoring devices in hospitalized patients. Although promising, continuous BG monitoring has not been adequately tested in acute care and therefore cannot be recommended for hospitalized patients at this time.

3.0 Glycemic targets in the non-critical care setting

Recommendations

3.1 We recommend a premeal glucose target of less than 140 mg/dl (7.8 mmol/liter) and a random BG of less than 180 mg/dl (10.0 mmol/liter) for the majority of hospitalized patients with non-critical illness. (1⊕⊕⊕⊕)

3.2 We suggest that glycemic targets be modified according to clinical status. For patients who are able to achieve and maintain glycemic control without hypoglycemia, a lower target range may be reasonable. For patients with terminal illness and/or with limited life expectancy or at high risk for hypoglycemia, a higher target range (BG < 11.1 mmol/liter or 200 mg/dl) may be reasonable. (2⊕⊕⊕⊕)

3.3 For avoidance of hypoglycemia, we suggest that antidiabetic therapy be reassessed when BG values fall below 5.6 mmol/liter (100 mg/dl). Modification of glucose-lowering treatment is usually necessary when BG values are below 3.9 mmol/liter (70 mg/dl). (2⊕⊕⊕⊕)

3.1–3.3 Evidence

The Task Force commissioned systematic reviews and meta-analyses of observational and randomized trials to evaluate the effect of intensive glycemic control on morbidity and mortality in patients hospitalized in non-critical care settings. Data were available for analysis from nine

randomized controlled trials and 10 observational studies (59). Intensive glycemic control was associated with reduction in the risk of infection (relative risk, 0.41; 95% confidence interval, 0.21–0.77). There was a trend for increased risk of hypoglycemia (relative risk, 1.58; 95% confidence interval, 0.97–2.57) that was most common in surgical studies. There was no significant effect on death, myocardial infarction, or stroke. The definition of “intensive control” varied across studies but was generally consistent with BG targets in the ADA/American Association of Clinical Endocrinologists Practice Guideline (20, 21). That guideline recommended a premeal glucose of less than 140 mg/dl (7.8 mmol/liter) and a random BG of less than 10.0 mmol/liter (180 mg/dl) for the majority of non-critically ill patients treated with insulin (21). To avoid hypoglycemia (<3.9 mmol/liter), the total basal and prandial insulin dose should be reduced if glucose levels are between 3.9 mmol/liter and 5.6 mmol/liter (70–100 mg/dl). In contrast, higher glucose ranges may be acceptable in terminally ill patients or in patients with severe comorbidities, as well as in those in patient-care settings where frequent glucose monitoring or close nursing supervision is not feasible (20, 21, 31). In such patients, however, it is prudent to maintain a reasonable degree of glycemic control (BG < 11.1 mmol/liter or 200 mg/dl) as a way of avoiding symptomatic hyperglycemia.

4.0 Management of hyperglycemia in the non-critical care setting

Recommendations

4.1 Medical nutrition therapy

4.1.1 We recommend that MNT be included as a component of the glycemic management program for all hospitalized patients with diabetes and hyperglycemia. (1⊕⊕⊕⊕)

4.1.2 We suggest that providing meals with a consistent amount of carbohydrate at each meal can be useful in coordinating doses of rapid-acting insulin to carbohydrate ingestion. (2⊕⊕⊕⊕)

4.1.1–4.1.2 Evidence

MNT is an essential component of inpatient glycemic management programs. MNT is defined as a process of nutritional assessment and individualized meal planning in consultation with a nutrition professional (31, 60). The goals of inpatient MNT are to optimize glycemic control, to provide adequate calories to meet metabolic demands, and to create a discharge plan for follow-up care (16, 60–64). Although the majority of non-critically ill hospitalized patients receive nutrition support as three discrete

meals with or without scheduled snacks each day, some require EN or PN support (see *Section 5*).

Lack of attention to MNT in the hospital contributes to unfavorable changes in BG (28, 46, 65). Nutrition requirements often differ in the home *vs.* the hospital setting. The types of food may change or the route of administration may differ, *e.g.* enteral or parenteral feedings may be used instead of solid foods. Nutritional management in the hospital is further complicated by hospital routines characterized by abrupt discontinuation of meals in preparation for diagnostic studies or procedures, variability in appetite due to the underlying illness, limitations in food selections, and poor coordination between insulin administration and meal delivery that creates difficulties in predicting the efficacy of glycemic management strategies (46).

A consistent carbohydrate meal-planning system may help to facilitate glycemic control in the hospital setting (16, 46). The system is based on the total amount of carbohydrate offered rather than on specific calorie content at each meal. Most patients receive a total of 1500–2000 calories per day, with a range of 12–15 carbohydrate servings. The majority of carbohydrate foods should be whole grains, fruits, vegetables, and low-fat milk, with restricted amounts of sucrose-containing foods (66, 67). An advantage to the use of consistent carbohydrate meal plans is that they facilitate matching the prandial insulin dose to the amount of carbohydrate consumed (16). Another advantage of a consistent carbohydrate diet is the ability to reinforce education regarding meal planning for many persons with diabetes. Although there are no randomized controlled studies comparing different inpatient nutritional strategies, one study conducted during a transition from consistent carbohydrate to patient-controlled meal plans found similar glycemic measures, with a trend toward less hypoglycemia with a consistent carbohydrate plan (16, 61, 68).

4.2 Transition from home to hospital

Recommendations

4.2.1 We recommend insulin therapy as the preferred method for achieving glycemic control in hospitalized patients with hyperglycemia. (1|⊕⊕○○)

4.2.2 We suggest the discontinuation of oral hypoglycemic agents and initiation of insulin therapy for the majority of patients with type 2 diabetes at the time of hospital admission for an acute illness. (2|⊕○○○)

4.2.3 We suggest that patients treated with insulin before admission have their insulin dose modified according to clinical status as a way of reducing the risk for hypoglycemia and hyperglycemia. (2|⊕○○○)

4.2.1–4.2.3 Evidence

Patients with type 1 diabetes have an absolute requirement for insulin therapy and require treatment with basal bolus insulin regimens to avoid severe hyperglycemia and diabetic ketoacidosis. Many patients with type 2 diabetes receiving insulin therapy as basal bolus or multiple daily injections before admission are at risk for severe hyperglycemia in the hospital if insulin therapy is discontinued. Assessment of the need for modification of the home insulin regimen is important because requirements vary according to clinical stressors, reason for admission, altered caloric intake or physical activity, and changes in medical regimens that can affect glycemic levels. There are patients who require reductions in insulin doses to avoid hypoglycemia, whereas others require higher insulin doses to avoid or treat uncontrolled hyperglycemia (69).

Preadmission diabetes therapy in patients with type 2 diabetes can include diet, oral agents, non-insulin injectable medications, insulin, or combinations of these therapies. Careful assessment of the appropriateness of preadmission diabetes medications is required at the time of hospital admission. The use of oral and other non-insulin therapies presents unique challenges in the hospital setting because there are frequent contraindications to their use in many inpatient situations (sepsis, NPO status, iv contrast dye, pancreatic disorders, renal failure, *etc.*) (21). Selected patients may be candidates for continuation of previously prescribed oral hypoglycemic therapy in the hospital. Patient criteria guiding the continued use of these agents include those who are clinically stable and eating regular meals and who have no contraindications to the use of these agents. Each of the available classes of oral antidiabetic agents possesses characteristics that limit their desirability for inpatient use. Sulfonylureas are long-acting insulin secretagogues that can cause severe and prolonged hypoglycemia, particularly in the elderly, in patients with impaired renal function, and in those with poor nutritional intake (70). There are no data on hospital use of the short-acting insulin secretagogues repaglinide and nateglinide; however, the risk of hypoglycemia is similar to that with sulfonylureas, suggesting the need for caution in the inpatient setting. Metformin must be discontinued in patients with decompensated congestive heart failure, renal insufficiency, hypoperfusion, or chronic pulmonary disease (71, 72) and in patients who are at risk of developing renal failure and lactic acidosis, such as may occur with the administration of iv contrast dye or surgery (73). Thiazolidinediones (TZD) can take several weeks for the full hypoglycemic effect, thus limiting the usefulness of these agents for achieving glycemic control in the hospital. These agents are contraindicated in patients with congestive heart failure, hemodynamic instability, or evidence of

hepatic dysfunction. Dipeptidyl peptidase IV inhibitors delay the enzymatic inactivation of endogenously secreted glucagon-like peptide-1, acting primarily to reduce postprandial glycemic excursions. These agents are less useful in patients who are not eating or have reduced oral intake.

Conversion to basal bolus insulin therapy based on POC BG results is both safe and efficacious in the management of hyperglycemic patients with type 2 diabetes (33, 35, 69, 74). Patients with BG levels above 140 mg/dl (7.8 mmol/liter) who are eating usual meals can have basal bolus insulin therapy initiated at a total daily dose based on body weight (33, 35, 75). Patients who are NPO can receive basal insulin alone with correction doses with a rapid-acting analog every 4 h or with regular insulin every 6 h (16, 33, 76, 77). An example of basal bolus protocol and correctional dose protocol is provided in Table 1 (33, 35); however, many successful insulin regimens have been reported in the literature (16, 28, 78, 79).

The practice of discontinuing diabetes medications and writing orders for SSI at the time of hospital admission results in undesirable levels of hypoglycemia and hyperglycemia (80–82). In one study (81), the risk for hyperglycemia (BG > 11.1 mmol/liter or 200 mg/dl) increased 3-fold in patients placed on aggressive sliding-scale regimens.

4.2.1–4.2.3 Values and preferences

The recommendation to discontinue agents other than insulin at the time of hospitalization is based in part on the fact that contraindications to the use of these agents are present in a high percentage of patients on admission or during hospitalization (71, 73). In addition, the use of oral agents to treat newly recognized hyperglycemia can result in delays in achieving desired glycemic targets, with the potential to adversely affect patient outcomes.

4.2.1–4.2.3 Remarks

Hospitals are encouraged to:

- Provide prompts to alert care providers that a patient is receiving an oral antidiabetic agent that may be contraindicated for use in the inpatient setting (e.g. sulfonylureas or metformin in patients with renal insufficiency or TZD in patients with heart failure).
- Implement educational order sets that guide appropriate use of scheduled insulin therapy in the hospital (16, 46, 77, 78, 83).

4.3 Pharmacological therapy

Recommendations

4.3.1 We recommend that all patients with diabetes treated with insulin at home be treated with a scheduled sc insulin regimen in the hospital. (1|⊕⊕⊕⊕)

TABLE 1. Example of a basal bolus insulin regimen for the management of non-critically ill patients with type 2 diabetes

A. Basal insulin orders			
Discontinue oral diabetes drugs and non-insulin injectable diabetes medications upon hospital admission.			
Starting insulin: calculate the total daily dose as follows:			
0.2 to 0.3 U/kg of body weight in patients: aged ≥70 yr and/or glomerular filtration rate less than 60 ml/min.			
0.4 U/kg of body weight per day for patients not meeting the criteria above who have BG concentrations of 7.8–11.1 mmol/liter (140–200 mg/dl).			
0.5 U/kg of body weight per day for patients not meeting the criteria above when BG concentration is 11.2–22.2 mmol/liter (201–400 mg/dl).			
Distribute total calculated dose as approximately 50% basal insulin and 50% nutritional insulin.			
Give basal insulin once (glargine/detemir) or twice (detemir/NPH) daily, at the same time each day.			
Give rapid-acting (prandial) insulin in three equally divided doses before each meal. Hold prandial insulin if patient is not able to eat.			
Adjust insulin dose(s) according to the results of bedside BG measurements.			
B. Supplemental (correction) rapid-acting insulin analog or regular insulin			
Supplemental insulin orders.			
If a patient is able and expected to eat all or most of his/her meals, give regular or rapid-acting insulin before each meal and at bedtime following the "usual" column (Section C below).			
If a patient is not able to eat, give regular insulin every 6 h (6–12–6–12) or rapid-acting insulin every 4 to 6 h following the "sensitive" column (Section C below).			
Supplemental insulin adjustment.			
If fasting and premeal plasma glucose are persistently above 7.8 mmol/liter (140 mg/dl) in the absence of hypoglycemia, increase insulin scale of insulin from the insulin-sensitive to the usual or from the usual to the insulin-resistant column.			
If a patient develops hypoglycemia [BG < 3.8 mmol/liter (70 mg/dl)], decrease regular or rapid-acting insulin from the insulin-resistant to the usual column or from the usual to the insulin-sensitive column.			
C. Supplemental insulin scale			

BG (mg/dl)	Insulin-sensitive	Usual	Insulin-resistant
>141–180	2	4	6
181–220	4	6	8
221–260	6	8	10
261–300	8	10	12
301–350	10	12	14
351–400	12	14	16
>400	14	16	18

The numbers in each column of Section C indicate the number of units of regular or rapid-acting insulin analogs per dose. "Supplemental" dose is to be added to the scheduled insulin dose. Give half of supplemental insulin dose at bedtime. If a patient is able and expected to eat all or most of his/her meals, supplemental insulin will be administered before each meal following the "usual" column dose. Start at insulin-sensitive column in patients who are not eating, elderly patients, and those with impaired renal function. Start at insulin-resistant column in patients receiving corticosteroids and those treated with more than 80 U/d before admission. To convert mg/dl to mmol/liter, divide by 18. Adapted from Refs. 16, 35, and 69.

4.3.2 We suggest that prolonged use of SSI therapy be avoided as the sole method for glycemic control in hyperglycemic patients with history of diabetes during hospitalization. (2|⊕○○○)

4.3.3 We recommend that scheduled sc insulin therapy consist of basal or intermediate-acting insulin given once or twice a day in combination with rapid- or short-acting insulin administered before meals in patients who are eating. (1|⊕⊕⊕○)

4.3.4 We suggest that correction insulin be included as a component of a scheduled insulin regimen for treatment of BG values above the desired target. (2|⊕○○○)

4.3.1–4.3.4 Evidence

The preferred sc insulin regimen for inpatient glycemic management includes two different insulin preparations administered as basal bolus insulin therapy, frequently in combination with a correction insulin scale. The basal component requires administration of an intermediate- or long-acting insulin preparation once or twice a day. The bolus or prandial component requires the administration of short- or rapid-acting insulin administered in coordination with meals or nutrient delivery (Table 1). Correction insulin refers to the administration of supplemental doses of short- or rapid-acting insulin together with the usual dose of bolus insulin for BG above the target range. For patients who are not eating, basal insulin is continued once daily (glargine or detemir) or twice daily [detemir/neutral protamine Hagedorn (NPH)] plus correction doses of a rapid insulin analog (aspart, lispro, glulisine) or regular insulin every 4- to 6-h interval as needed. Correction-dose insulin should not be confused with “sliding scale insulin,” which usually refers to a set amount of insulin administered for hyperglycemia without regard to the timing of the food, the presence or absence of preexisting insulin administration, or even individualization of the patient’s sensitivity to insulin. Correction insulin is customized to match the insulin sensitivity for each patient. Most standardized order sets for sc insulin provide several different correction-dose scales to choose from, depending on the patient’s weight or total daily insulin requirement.

The safety of scheduled basal bolus insulin in patients with either newly recognized hyperglycemia or type 2 diabetes has been demonstrated in several studies of non-critically ill hospitalized patients (33, 35, 69, 74). In one study (35), 130 insulin-naive patients with type 2 diabetes who had glucose levels above 10 mmol/liter (180 mg/dl) were randomized to receive basal bolus insulin with glargine and glulisine insulin or SSI alone. Those in the basal bolus group achieved mean glucose levels of less than 10 mmol/liter (180 mg/dl) by day 2 and of less than 8.8

mmol/liter (160 mg/dl) by day 4 with no increase in hypoglycemia (35). Among patients randomized to SSI alone, 14% required rescue therapy with basal bolus insulin due to persistent BG above 13.3 mmol/liter (240 mg/dl). A second multicenter study compared two different basal bolus insulin regimens (detemir plus aspart *vs.* NPH plus regular) in 130 nonsurgical patients with type 2 diabetes, of whom 56% were receiving insulin therapy before hospitalization (69). There were no group differences in the levels of glycemic control achieved or in the frequency of hypoglycemia, which occurred in approximately 30% of patients in each group. The majority of the hypoglycemic events occurred in patients treated with insulin before admission who were continued on the same insulin dose at the time of randomization, a finding that emphasizes the importance of the recommendation to evaluate the home insulin regimen at the time of hospitalization.

4.3.1–4.3.4 Remarks

A scheduled regimen of sc basal bolus insulin is recommended for most patients with diabetes in non-ICU hospital settings. A suggested method for determining starting doses of scheduled insulin therapy in insulin-naive patients in the hospital can be based on a patient’s body weight and administered as a range of 0.2 to 0.5 U/kg as the total daily dose (Table 1). The total daily dose can be divided into a basal insulin component given once (glargine, detemir) or twice (NPH, detemir) daily and a nutritional or bolus component given before meals in patients who are eating or every 4 to 6 h in patients on continuous EN or PN. In patients who are NPO or unable to eat, bolus insulin must be held until nutrition is resumed; however, doses of correction insulin can be continued to treat BG above the desired range. Adjustments of scheduled basal and bolus insulin can be based on total doses of correction insulin administered in the previous 24 h (35, 74). When correction insulin is required before most meals, it is often the basal insulin that can be titrated upward. When BG remains consistently elevated at one time point, the dose of bolus insulin preceding that measurement can be adjusted (78, 79). Many patients require daily insulin adjustment to achieve glycemic control and to avoid hypoglycemia. The home total basal and prandial insulin dose should be reduced on admission in patients with poor nutrition intake, impaired kidney function, or with admission BG levels less than 5.6 mmol/liter (100 mg/dl).

These recommendations apply for patients with type 1 and type 2 diabetes; however, type 1 diabetes patients completely lack endogenous insulin production. Type 1 diabetes patients need to be provided continuous, exoge-

nous basal insulin, even when fasting, to suppress gluconeogenesis and ketone production. Failure to provide basal insulin to a type 1 diabetes patient can lead to the rapid development of severe hyperglycemia and diabetic ketoacidosis (84, 85). In general, type 1 diabetes patients typically exhibit less insulin resistance and require lower daily insulin dosage than type 2 diabetes patients, especially if they are not obese.

With increasing utilization of insulin pump therapy, many institutions allow patients on insulin pumps to continue using these devices in the hospital; others express concern regarding use of a device unfamiliar to staff, particularly in patients who are not able to manage their own pump therapy (86). Patients who use continuous sc insulin infusion pump therapy in the outpatient setting can be candidates for diabetes self-management in the hospital, provided that they have the mental and physical capacity to do so (20, 86, 87). The availability of hospital personnel with expertise in continuous sc insulin infusion therapy is essential (16, 86, 87). It is important that nursing personnel document basal rates and bolus doses on a regular basis (at least daily). Clear policies and procedures should be established at the institutional level to guide continued use of the technology in the acute care setting.

4.4 Transition from hospital to home

Recommendations

4.4.1 We suggest reinstatement of preadmission insulin regimen or oral and non-insulin injectable antidiabetic drugs at discharge for patients with acceptable preadmission glycemic control and without a contraindication to their continued use. (2|⊕○○○)

4.4.2 We suggest that initiation of insulin administration be instituted at least one day before discharge to allow assessment of the efficacy and safety of this transition. (2|⊕○○○)

4.4.3 We recommend that patients and their family or caregivers receive both written and oral instructions regarding their glycemic management regimen at the time of hospital discharge. These instructions need to be clearly written in a manner that is understandable to the person who will administer these medications. (1|⊕⊕○○)

4.4.1–4.4.3 Evidence

Hospital discharge represents a critical time for ensuring a safe transition to the outpatient setting and reducing the need for emergency department visits and rehospitalization. Poor coordination of patient care at the time of patient transfer between services, transfer to rehabilitation facilities, or discharge to home is associated with medical errors and readmission (88).

For patients discharged home on insulin therapy as a new medication, it is important that patient education and written information be provided for the method and timing of administration of prescribed doses and recognition and treatment of hypoglycemia (44). In general, initiation of insulin therapy should be instituted at least one day before discharge to allow assessment of the efficacy and safety of therapy. Insulin regimens are often complex, usually entailing the administration of two different insulin preparations that may require adjustments according to home glucose readings. Because hospital discharge can be stressful to patients and their family, orally communicated instructions alone are often inadequate. To address this problem, several institutions have established formalized discharge instructions for patients with diabetes as a way of improving the clarity of instructions for insulin therapy and glucose monitoring (44, 79, 89). In addition, patients as well as the provider administering posthospital care should be aware of the need for potential adjustments in insulin therapy that may accompany adjustments of other medications prescribed at the time of hospital discharge (e.g. corticosteroid therapy, octreotide) (51).

Measurement of HbA1C concentration during the hospital stay can assist in tailoring the glycemic management of diabetic patients at discharge. Patients with HbA1C below 7% can usually be discharged on their same outpatient regimen (oral agents and/or insulin therapy) if there are no contraindications to therapy (*i.e.* TZD and heart failure; metformin and renal failure). Patients with elevated HbA1C require intensification of the outpatient antidiabetic regimen (oral agents, insulin, or combination therapy). Patients with severe and symptomatic hyperglycemia may benefit from ongoing insulin therapy (basal or basal bolus regimen).

4.4.1–4.4.3 Remarks

We suggest that the following components of glycemic management be included as part of the transition and hospital discharge record:

- A principal diagnosis or problem list
- The reconciled medication list, including insulin therapy
- Recommendations for timing and frequency of home glucose monitoring
- Information regarding signs and symptoms of hypoglycemia and hyperglycemia with instructions about what to do in each of these cases
- A form or log book for recording POC measures and laboratory BG results
- A list of pending laboratory results upon discharge, and

- Identification of the health care provider who is responsible for the ongoing diabetes care and glycemic management.

Hospitals are encouraged to standardize discharge instruction sheets that provide information on principal diagnosis, key test results from the hospital stay, timing and adjusting of insulin doses, home glucose monitoring, and signs and symptoms of hypoglycemia and hyperglycemia.

5.0 Special situations

Recommendations

5.1 Transition from iv CII to sc insulin therapy

5.1.1 We recommend that all patients with type 1 and type 2 diabetes be transitioned to scheduled sc insulin therapy at least 1–2 h before discontinuation of CII. (1|⊕⊕⊕⊕)

5.1.2 We recommend that sc insulin be administered before discontinuation of CII for patients without a history of diabetes who have hyperglycemia requiring more than 2 U/h. (1|⊕⊕⊕⊕)

5.1.3 We recommend POC testing with daily adjustment of the insulin regimen after discontinuation of CII. (1|⊕⊕⊕○)

5.1.1–5.1.3 Evidence

As patients recovering from critical illness begin to eat regular meals or are transferred to general nursing units, they require transition from iv to sc insulin to maintain reasonable levels of glycemic control (25, 51, 90, 91). Programs that include transition protocols as part of their glycemic management strategy in patients undergoing surgical procedures have demonstrated significant reductions in morbidity and mortality, with lower costs and less need for nursing time (25, 90).

Several different protocols have been proposed to guide the transition from CII to sc insulin (43, 88). The majority of patients without a prior history of diabetes receiving CII at a rate of 1 U/h or less at the time of transition may not require a scheduled sc insulin regimen (78, 83, 92, 93). Many of these patients can be treated with correction insulin to determine whether they will require scheduled sc insulin. In contrast, all patients with type 1 diabetes and most patients with type 2 diabetes treated with oral antidiabetic agents or with insulin therapy before admission require transition to sc long- and short-acting insulin with discontinuation of CII.

To prevent recurrence of hyperglycemia during the transition period to sc insulin, it is important to allow an overlap of 1–2 h between discontinuation of iv insulin and the administration of sc insulin. Basal insulin is given before transition and continued once (glargine/detemir) or twice (detemir/NPH) daily. Rapid-acting insulin analog or

regular insulin is given before meals or as correction doses in the presence of hyperglycemia.

5.1.1–5.1.3 Remarks

In general, the initial dose and distribution of sc insulin at the time of transition can be determined by extrapolating the iv insulin requirement over the preceding 6 to 8 h to a 24-h period. Administering 60 to 80% of the total daily calculated dose as basal insulin has been demonstrated to be both safe and efficacious in surgical patients (16, 90). Dividing the total daily dose as a combination of basal and bolus insulin has been demonstrated to be safe in medically ill patients (90, 92, 94).

It is important that consideration be given to a patient's nutritional status and medications, with continuation of glucose monitoring to guide ongoing adjustments in the insulin dose because changes in insulin sensitivity can occur during acute illness. Correction doses of rapid-acting analogs or regular insulin can be administered for BG values outside the desired range. Hospitals are encouraged to include protocols that guide the transition from CII to sc insulin as a way of avoiding glycemic excursions outside the target range. The use of protocols helps reduce random practices that result in hyperglycemia or unwarranted hypoglycemia.

5.2 Patients receiving EN or PN

Recommendations

5.2.1 We recommend that POC testing be initiated for patients with or without a history of diabetes receiving EN and PN. (1|⊕⊕⊕⊕)

5.2.2 We suggest that POC testing can be discontinued in patients without a prior history of diabetes if BG values are less than 7.8 mmol/liter (140 mg/dl) without insulin therapy for 24–48 h after achievement of desired caloric intake. (2|⊕○○○)

5.2.3 We suggest that scheduled insulin therapy be initiated in patients with and without known diabetes who have hyperglycemia, defined as BG greater than 7.8 mmol/liter (140 mg/dl), and who demonstrate a persistent requirement (*i.e.* >12 to 24 h) for correction insulin. (2|⊕○○○)

5.2.1–5.2.3 Evidence

Malnutrition is reported in up to 40% of critically ill patients (65) and is associated with increased risk of hospital complications, higher mortality rate, longer hospital stay, and higher hospitalization costs (95). Improving the nutritional state may restore immunological competence and reduce the frequency and severity of infectious complications in hospitalized patients (96–99).

There are several retrospective and prospective studies demonstrating that the use of EN and PN is an indepen-

dent risk factor for the onset or aggravation of hyperglycemia independent of a prior history of diabetes (65, 100, 101). Hyperglycemia in this group of patients is associated with higher risk of cardiac complications, infections, sepsis, acute renal failure, and death (102–104). In one study, a strong correlation was reported between PN-induced hyperglycemia and poor clinical outcome. BG measures of more than 150 mg/dl before and within 24 h of initiation of PN were predictors of both inpatient complications and hospital mortality (105). Together, these results suggest that early intervention to prevent and correct hyperglycemia may improve clinical outcomes in patients receiving EN and PN.

To address this question, several clinical trials have investigated the use of diabetes-specific formulas as a way of ameliorating the risk for hyperglycemia with EN. These diabetes-specific formulas differ from standard formulations by supplying a lower percentage of total calories as carbohydrate and substituting monounsaturated fatty acids for a major component of administered fat calories (106). In a meta-analysis of studies comparing these with standard formulations, the postprandial rise in BG was reduced by 1.03–1.59 mmol/liter (18–29 mg/dl) (106). These results suggest that the majority of hyperglycemic patients will still require insulin therapy for control of hyperglycemia while receiving this type of nutritional support.

Achieving desired glycemic goals in patients receiving EN poses unique challenges (65, 74). Unanticipated dislodgement of feeding tubes, temporary discontinuation of nutrition due to nausea, for medication administration (e.g. T₄, phenytoin), or for diagnostic testing, and cycling of EN with oral intake in patients with an inconsistent appetite all pose clinical challenges to the prescribing of scheduled insulin therapy. In one study, patients with persistent elevation in BG above 7.2 mmol/liter (above 130 mg/dl) during EN therapy were randomized to receive glargine once daily at a starting dose of 10 U, in combination with SSI with regular insulin administered every 6 h, or SSI alone. Approximately 50% of patients randomized to SSI required rescue therapy with NPH to achieve a mean BG below 10 mmol/liter (180 mg/dl) (74). The dose of glargine insulin was adjusted on a daily basis according to results of POC testing. If more than one BG was above 10 mmol/liter in the prior 24 h, the dose of glargine was increased by a percentage of the total dose of correction insulin administered on the preceding day. With use of this approach, a mean glucose of approximately 8.8 mmol/liter (160 mg/dl) was achieved with low risk for hyperglycemia.

Suggested approaches using sc insulin therapy in patients receiving continuous, cycled, or intermittent EN

TABLE 2. Approaches to insulin therapy during EN

Continuous EN	Administer basal insulin once (glargine, detemir) or twice (detemir/NPH) a day in combination with a short- or rapid-acting insulin analog in divided doses every 4 h (lispro, aspart, glulisine) to 6 h (regular insulin).
Cycled feeding	Administer basal insulin (glargine, detemir, or NPH) in combination with short- or rapid-acting insulin analog at the time of initiation of EN. Repeat the dose of rapid-acting insulin (lispro, aspart, glulisine) at 4-h intervals or short-acting (regular) insulin at 6-h intervals for the duration of the EN. It is preferable to give the last dose of rapid-acting insulin approximately 4 h before and regular insulin 6 h before discontinuation of the EN.
Bolus feeding	Administer short-acting regular or rapid-acting insulin analog (lispro, aspart, glulisine) before each bolus administration of EN.

Adapted from Refs. 16, 74, and 101.

therapy appear in Table 2. Many members of this writing task force prefer frequent injections of short-acting regular insulin or intermediate-acting insulin over the rapid-acting analogs in this group of patients because of the longer duration of action, requiring fewer injections (Table 2).

For patients receiving PN, regular insulin administered as part of the PN formulation can be both safe and effective. Subcutaneous correction-dose insulin is often used, in addition to the insulin that is mixed with the nutrition. When starting PN, the initial use of a separate insulin infusion can help in estimating the total daily dose of insulin that will be required. Separate iv insulin infusions may be needed to treat marked hyperglycemia during PN.

5.3 Perioperative BG control

Recommendations

5.3.1 We recommend that all patients with type 1 diabetes who undergo minor or major surgical procedures receive either CII or sc basal insulin with bolus insulin as required to prevent hyperglycemia during the perioperative period. (1⊕⊕⊕⊕)

5.3.2 We recommend discontinuation of oral and non-insulin injectable antidiabetic agents before surgery with initiation of insulin therapy in those who develop hyperglycemia during the perioperative period for patients with diabetes. (1⊕○○○)

5.3.3 When instituting sc insulin therapy in the post-surgical setting, we recommend that basal (for patients who are NPO) or basal bolus (for patients who are eating) insulin therapy be instituted as the preferred approach. (1⊕⊕⊕○)

5.3.1–5.3.3 Evidence

There are several case-control studies that demonstrate an increased risk for adverse outcomes in patients under-

going elective noncardiac surgery who have either preoperative or postoperative hyperglycemia (19, 107–110). Postoperative BG values greater than 11.1 mmol/liter (200 mg/dl) are associated with prolonged hospital length of stay and an increased risk of postoperative complications, including wound infections and cardiac arrhythmias (107–110). In one study, the incidence of postoperative infections in patients with glucose levels above 12.2 mmol/liter (220 mg/dl) was 2.7 times higher than in those with glucose levels below 12.2 mmol/liter (109). In a recent report of 3184 noncardiac general surgery patients, a perioperative glucose value above 8.3 mmol/liter (150 mg/dl) was associated with increased length of stay, hospital complications, and postoperative mortality (107).

Perioperative treatment recommendations are generally based on the type of diabetes, nature and extent of the surgical procedure, antecedent pharmacological therapy, and state of metabolic control before surgery (110, 111). A key factor for the success of any regimen is frequent glucose monitoring to allow early detection of any alterations in metabolic control.

All patients receiving insulin before admission require insulin during the perioperative period (112, 113). For most patients, this requirement includes administration of a percentage of the usual basal insulin (NPH, detemir, glargine) in combination with correction doses of regular insulin or rapid-acting insulin analogs for glucose levels from 8.3 to 11.1 mmol/liter (150 to 200 mg/dl). The safety of administering 50% of the basal insulin dose preoperatively was demonstrated in one nonrandomized quality improvement initiative (114). Admission BG levels in 584 patients with diabetes treated according to these recommendations ranged between 3.9 and 11.1 mmol/liter (70–200 mg/dl) in 77% of patients. Hypoglycemia, defined as a BG of less than 3.9 mmol/liter, occurred in only 1.7% of patients.

Patients with type 2 diabetes well-controlled by a regimen of diet and physical activity may require no special preoperative intervention for diabetes (111, 115). Glucose levels in this group of patients can often be controlled with small doses of supplemental short-acting insulin. Insulin-treated patients or those with poor metabolic control while on oral antidiabetic agents will require iv insulin infusions or a basal bolus sc insulin regimen to achieve the desired level of glycemic control.

Patients with type 1 diabetes undergoing minor or major surgical procedures require CII or sc basal bolus insulin administration adjusted according to the results of BG testing to prevent the development of diabetic ketoacidosis (85, 116–118). In one study, BG values in a group of subjects with type 1 diabetes who received their full dose

TABLE 3. Pharmacokinetics of sc insulin preparations^a

Insulin	Onset	Peak	Duration
Rapid-acting analogs	5–15 min	1–2 h	4–6 h
Regular	30–60 min	2–3 h	6–10 h
NPH	2–4 h	4–10 h	12–18 h
Glargine	2 h	No peak	20–24 h
Detemir	2 h	No peak	12–24 h

^a Renal failure leads to prolonged insulin action and altered pharmacokinetics (162).

of glargine insulin on a fasting day were compared with those obtained on a control day when the participants were eating their usual meals (119). There were no significant differences in mean BG levels between these two days, suggesting that it is safe to administer the full dose of basal insulin when a patient is made NPO. For patients with type 1 diabetes whose BG is well controlled, mild reductions (between 10 and 20%) in the dosing of basal insulin are suggested. For those whose BG is uncontrolled [*i.e.* BG > 10 mmol/liter (200 mg/dl)], full doses of basal insulin can be administered.

Because the pharmacokinetic properties of NPH insulin differ from those of glargine and detemir, dose reductions of 25–50% are suggested, together with the administration of short- or rapid-acting insulin for BG > 8.3 mmol/liter (150 mg/dl) (Table 3).

Prolonged use of SSI regimen is not recommended for glycemic control during the postoperative period in hyperglycemic patients with diabetes. In one study of 211 general surgery patients with type 2 diabetes randomly assigned to receive basal bolus insulin or SSI, glycemic control and patient outcomes were significantly better with the former (33). Patients who were treated with SSI had higher mean POC glucose values and more postoperative complications including wound infection, pneumonia, respiratory failure, acute renal failure, and bacteremia. The results of that study indicate that treatment with glargine once daily plus rapid-acting insulin before meals improves glycemic control and reduces hospital complications in general surgery patients with type 2 diabetes (33).

5.3.1–5.3.3 Values and preferences

We place a high value on maintaining glycemic control even for brief periods of time, as occurs during periods of fasting for surgical or other procedures. Although avoidance of hypoglycemia is desired, administering a percentage of the usual dose of long- or intermediate-acting insulin appears to be safe and well tolerated, even for patients who arrive on the morning of the procedure.

5.3.1–5.3.3 Remarks

Hospitals are encouraged to:

- Implement protocols that guide safe glycemic management of patients with hyperglycemia during and after surgical procedures, and
- Abandon practices that allow for random and inconsistent glycemic management in surgical patients.

5.4 Glucocorticoid-induced diabetes

Recommendations

5.4.1 We recommend that bedside POC testing be initiated for patients with or without a history of diabetes receiving glucocorticoid therapy. (1|⊕⊕⊕)

5.4.2 We suggest that POC testing can be discontinued in nondiabetic patients if all BG results are below 7.8 mmol/liter (140 mg/dl) without insulin therapy for a period of at least 24–48 h. (2|⊕⊕⊕)

5.4.3 We recommend that insulin therapy be initiated for patients with persistent hyperglycemia while receiving glucocorticoid therapy. (1|⊕⊕⊕)

5.4.4 We suggest CII as an alternative to sc insulin therapy for patients with severe and persistent elevations in BG despite use of scheduled basal bolus sc insulin. (2|⊕⊕⊕)

5.4.1–5.4.4 Evidence

Hyperglycemia is a common complication of glucocorticoid therapy with a prevalence between 20 and 50% among patients without a previous history of diabetes (51, 120, 121). Corticosteroid therapy increases hepatic glucose production, impairs glucose uptake in peripheral tissues, and stimulates protein catabolism with resulting increased concentrations of circulating amino acids, thus providing precursors for gluconeogenesis (122–124). The observed decrease in glucose uptake with glucocorticoid therapy seems to be a major early defect, contributing to increases in postprandial hyperglycemia. Despite its frequency, the impact of corticosteroid-induced hyperglycemia on clinical outcomes such as morbidity and mortality is not known. Few studies have examined how best to treat glucocorticoid-induced hyperglycemia. In general, discontinuation of oral antidiabetic agents with initiation of sc basal bolus insulin therapy is recommended for patients with glucocorticoid-induced hyperglycemia. The starting insulin dose and timing of insulin administration should be individualized depending on severity of hyperglycemia and duration and dosage of steroid therapy. For patients receiving high-dose glucocorticoids and in those with severe hyperglycemia that is difficult to control, the use of CII is appropriate (16, 50, 125). The use of CII on general wards and in patients receiving high glucocorticoid doses has been shown to result in rapid and sustained gly-

cemic control and a rate of hypoglycemic events similar to that reported in recent ICU trials (50). The majority of patients with steroid-induced hyperglycemia can be treated with a sc basal bolus insulin regimen to achieve glycemic control, with dosing based on a starting dosage of 0.3 to 0.5 U/kg · d.

Adjustment of insulin doses is required when the glucocorticoid dose is changed. Discontinuation or tapering of corticosteroid therapy in patients with diabetes has been associated with risk of developing hypoglycemia (126).

6.0. Recognition and management of hypoglycemia in the hospital setting

Recommendations

6.1 We recommend that glucose management protocols with specific directions for hypoglycemia avoidance and hypoglycemia management be implemented in the hospital. (1|⊕⊕⊕)

6.2 We recommend implementation of a standardized hospital-wide, nurse-initiated hypoglycemia treatment protocol to prompt immediate therapy of any recognized hypoglycemia, defined as a BG below 3.9 mmol/liter (70 mg/dl). (1|⊕⊕⊕)

6.3 We recommend implementation of a system for tracking frequency of hypoglycemic events with root cause analysis of events associated with potential for patient harm. (1|⊕⊕⊕)

6.1–6.3 Evidence

Hypoglycemia is defined as any glucose level below 3.9 mmol/liter (70 mg/dl) (127, 128). This is the standard definition in outpatients and correlates with the initial threshold for the release of counter-regulatory hormones (128, 129). Severe hypoglycemia has been defined by many as less than 2.2 mmol/liter (40 mg/dl) (128), although this is lower than the approximately 2.8 mmol/liter (50 mg/dl) level at which cognitive impairment begins in normal individuals (129).

The fear of hypoglycemia is a key barrier to the implementation of targeted glucose control. Although not as common as hyperglycemia, hypoglycemia is a well-recognized and feared complication in hospitalized patients with or without established diabetes (130). The risk for hypoglycemia is higher during periods of hospitalization due to variability in insulin sensitivity related to the underlying illness, changes in counter-regulatory hormonal responses to procedures or illness, and interruptions in usual nutritional intake (131, 132).

The prevalence of hypoglycemic events varies across studies depending on the definition of hypoglycemia and the specific patient population evaluated. In a 3-month prospective review of consecutive medical records in 2174

hospitalized patients receiving antidiabetic agents, 206 patients (9.5%) experienced a total of 484 hypoglycemic episodes (133). A large glycemic survey examining results of POC bedside glucose tests from 126 hospitals reported a prevalence of hypoglycemia (<3.9 mmol/liter or <70 mg/dl) as 3.5% in non-ICU patients (24). In randomized controlled studies, the prevalence of hypoglycemia has ranged from 3 to 30% of medical and surgical patients with type 2 diabetes treated with sc insulin (33, 35, 69).

The key predictors of hypoglycemic events in hospitalized patients include older age, greater illness severity (presence of septic shock, mechanical ventilation, renal failure, malignancy, and malnutrition), diabetes, and the use of oral glucose lowering medications and insulin (134, 135). In-hospital processes of care that contribute to risk for hypoglycemia include unexpected changes in nutritional intake that are not accompanied by associated changes in the glycemic management regimen (*e.g.* cessation of nutrition for procedures, adjustment in the amount of nutritional support), interruption of the established routine for glucose monitoring (such as transportation off the ward), deviations from the established glucose control protocols, and failure to adjust therapy when glucose is trending down or steroid therapy is being tapered (78, 131).

Hypoglycemia is associated with an increased risk of mortality in various hospitalized patient populations (136, 137). A J-shaped curve for mortality has been observed in patients admitted with acute myocardial infarction and in other patient groups (138). Hypoglycemia is also associated with a prolonged hospital length of stay as compared with that of similar patients who did not experience hypoglycemia (137). Serious adverse events were reported in 4% of patients with hypoglycemic events (133).

Despite these observations, it remains unclear whether episodic in-hospital hypoglycemia is a direct mediator of adverse events or is a marker of greater illness severity. A recent study of nearly 8000 patients hospitalized with acute myocardial infarction evaluated the prognostic impact of incident hypoglycemia separately in patients who developed it spontaneously and those who experienced hypoglycemia after administration of insulin (13, 76). Although patients with spontaneous hypoglycemia had markedly higher rates of in-hospital death (18.4 *vs.* 9.2% in those without hypoglycemia; $P < 0.001$), mortality was not increased in insulin-treated patients with iatrogenic hypoglycemia (10.4 *vs.* 10.2% in those without hypoglycemia; $P = 0.92$). These data have been corroborated by other studies of patients hospitalized with acute myocardial infarction (139–141), on geriatric nursing units (135), and in the ICU (139, 141, 142). These results sug-

gest that inpatient hypoglycemia may be more of a marker for severe illness rather than a direct cause of adverse events.

Although these findings offer some reassurance to clinicians in their efforts to control glucose levels, hypoglycemic events are associated with potential for harm and should be avoided (137). Although well-designed studies evaluating interventions aimed specifically at reducing hypoglycemia are lacking, several strategies appear reasonable. These include use of evidence-based glucose control protocols with a demonstrated safety record, establishment of hospital-wide policies that provide guidance on identification of high-risk patients, and standardization of procedures for detection and treatment of hypoglycemia across nursing units (74, 143, 144). Many patients require daily insulin adjustment to avoid hypoglycemia (BG < 3.9 mmol/liter). The total basal and prandial insulin dose should be reduced if BG levels fall between 3.9 and 5.6 mmol/liter (70–100 mg/dl).

Another method for minimizing risk for hypoglycemia is to avoid medications that are associated with a high risk for hypoglycemia such as sulfonylureas, particularly among elderly patients and those with renal impairment or poor oral intake. Modification of insulin regimens in patients with BG levels below 5.6 mmol/liter (100 mg/dl) helps to reduce risk for a hypoglycemic event. Reductions in the total daily dose of insulin by approximately 20% are recommended when BG falls below 3.9 mmol/liter (70 mg/dl), unless the event is easily explained by other factors (such as a missed meal, *etc.*).

Frequent monitoring of BG levels allows for timely detection and treatment of hypoglycemia. A system for tracking the frequency and severity of all hypoglycemic events allows for ongoing analysis of the safety of a glycemic management program (88, 145). Hypoglycemia treatment protocols that facilitate prompt treatment of any hypoglycemic event can be useful in preventing deterioration to a more prolonged or severe episode that may be associated with adverse outcomes (68, 146). Implementation of such standardized hypoglycemia treatment protocols has been successful at reducing the frequency of severe hypoglycemic events in some institutions (144, 147, 148). The key aspects of hypoglycemia prevention and management are summarized in Table 4; a representative nurse-driven hypoglycemia management protocol is depicted in Table 5.

The success of any hypoglycemia treatment protocol depends on the ability of bedside nurses to recognize signs and symptoms of hypoglycemia, initiate appropriate treatment without delay, and retest BG at prescribed time intervals after treatment (148). For these reasons, educa-

TABLE 4. Key components of hypoglycemia prevention and management protocol

Hospital-wide definitions for hypoglycemia and severe hypoglycemia.
Guidance on discontinuation of sulfonylurea therapy and other oral hypoglycemic medications at the time of hospital admission.
Directions for adjustments in insulin dose and/or administration of dextrose-containing iv fluids for both planned and sudden changes in nutritional intake.
Specific instructions for recognition of hypoglycemia symptoms, treatment, and timing for retesting depending on glucose levels and degree of the patient's neurological impairment and for retesting of glucose levels.
Standardized form for documentation and reporting of hypoglycemic events, including severity, potential cause(s), treatment provided, physician notification, and patient outcome.

tional initiatives at the time of protocol implementation with periodic reinforcement are essential (149).

7.0 Implementation of a glycemic control program in the hospital

Recommendations

7.1 We recommend that hospitals provide administrative support for an interdisciplinary steering committee targeting a systems approach to improve care of inpatients with hyperglycemia and diabetes. (1⊕⊕⊕⊕)

7.2 We recommend that each institution establish a uniform method of collecting and evaluating POC testing data and insulin use information as a way of monitoring the safety and efficacy of the glycemic control program. (1⊕○○○)

TABLE 5. Suggested nurse-initiated strategies for treating hypoglycemia

For treatment of BG below 3.9 mmol/liter (70 mg/dl) in a patient who is alert and able to eat and drink, administer 15–20 g of rapid-acting carbohydrate such as: ^a one–15–30 g tube glucose gel or 4 (4 g) glucose tabs (preferred for patients with end stage renal disease). 4–6 ounces orange or apple juice. 6 ounces "regular" sugar sweetened soda. 8 ounces skim milk.
For treatment of BG below 3.9 mmol/liter (70 mg/dl) in an alert and awake patient who is NPO or unable to swallow, administer 20 ml dextrose 50% solution iv and start iv dextrose 5% in water at 100 ml/h.
For treatment of BG below 3.9 mmol/liter in a patient with an altered level of consciousness, administer 25 ml dextrose 50% (1/2 amp) and start iv dextrose 5% in water at 100 ml/h.
In a patient with an altered level of consciousness and no available iv access, give glucagon 1 mg im. Limit, two times.
Recheck BG and repeat treatment every 15 min until glucose level is at least 4.4 mmol/liter (80 mg/dl).

^a Dose depends on severity of the hypoglycemic event.

7.3 We recommend that institutions provide accurate devices for glucose measurement at the bedside with on-going staff competency assessments. (1⊕○○○)

7.1–7.3 Evidence

It is important for medical centers to target improved care of inpatients with hyperglycemia and/or diabetes by creating and supporting an interdisciplinary steering committee with representation from key groups involved in the care of these patients (51). The steering committee ideally would include representatives from physician groups, nurses, pharmacists, case managers, nutrition, information support, and quality improvement personnel empowered to:

- Assess safety and efficacy of processes for glycemic management with a focus on improving care at the identified areas of deficiency, within a framework of quality improvement.
- Implement strategies that guide staff and physician education with written policies, protocols, and order sets with integrated decision support using computer order entry.
- Consider use of checklists, algorithms, and standardized communication for patient transfers and hand off.
- Monitor the use of order sets and protocols, intervening to reinforce protocol use, and revising protocols as needed to improve integration, clarity, and ease of use.
- Institute continuing education programs for medical, nursing, and dietary staff to enhance adherence to protocols.

The inpatient care of individuals with diabetes and hyperglycemia is complex, involving multiple providers with varying degrees of expertise who are dispersed across many different areas of the hospital. A multidisciplinary systems approach can help guide meaningful progress away from clinical inertia and toward safe glycemic control, hypoglycemia prevention, and patient preparation for care transitions (20, 54, 143, 144, 147).

The transfer of patients between nursing units of clinical care teams is a major cause of error in the care of patients with hyperglycemia in the hospital. Poor coordination of glucose monitoring, meal delivery, and insulin administration is a common barrier to optimal care (43, 150, 151).

Evidence for the advantages of using a systems approach comes from several sources: industry and high reliability organizations; endorsement by major professional organizations, based on consensus opinion and experience (21, 152); extrapolation of experience applied to other disease entities (152); and successful institutional glycemic control efforts via this approach (78, 153–155).

Resources outlining the multidisciplinary approach, protocol, and order set design, implementation strategies, and methods for monitoring and continuously improving the process are available in print and internet media (88).

8.0 Patient and professional education

Recommendations

8.1 We recommend diabetes self-management education targeting short-term goals that focus on survival skills: basic meal planning, medication administration, BG monitoring, and hypoglycemia and hyperglycemia detection, treatment, and prevention. (1|⊕○○○)

8.2. We recommend identifying resources in the community to which patients can be referred for continuing diabetes self-management education after discharge. (1|⊕○○○)

8.3. We recommend ongoing staff education to update diabetes knowledge, as well as targeted staff education whenever an adverse event related to diabetes management occurs. (1|⊕○○○)

8.1–8.3 Evidence

Diabetes self-management education has the ability to reduce length of hospital stay and improve outcomes after discharge (16). In a meta-analysis of 47 studies on the effects of diabetes education on knowledge, self-care, and metabolic control, educational interventions were shown to increase patients' knowledge and ability to perform self-care (156). The AADE inpatient position statement recommends initiation of diabetes self-management education early during the hospitalization to allow time to address potential deficits in patient knowledge (48). With early intervention, the patient will have more opportunities to practice and master survival skills. Family members should be included whenever possible to support and reinforce self-management education (157, 158).

Inpatient diabetes educational goals should focus on the following survival skills: basic meal planning, medication administration, POC testing, and hypoglycemia detection, treatment, and prevention (21, 48). Diabetes education is more complex in the hospital setting because patients are acutely ill, may be experiencing pain, and are under stress. Keeping sessions short and focused with minimal distractions and interruptions contributes to a more productive learning environment (48).

Documentation of teaching sessions by health care professionals promotes communication of progress to the next health care provider and assists in discharge planning. In situations where failure to perform diabetes self-care practices contributed to the need for the hospitalization, education can be focused on the area of deficiency as a way of preventing readmissions (*e.g.* diabetic ketoaci-

dosis) (16, 48, 88). Written discharge instructions on diabetes self-care, offered in the patient's primary language whenever possible, should be reviewed and provided at the time of discharge (44, 159). Efforts should be made to coordinate education with those also caring for the patient and those who will be seeing the patient in transition to maximize the value of education. It would be optimal to provide recommendations, based on observations during the education of the patient, to those in the transition of care.

Staff education together with competency testing can facilitate the ability of nursing personnel to provide both inpatient diabetes management and patient education. Assessment of patients' cognitive and emotional status and medical status should be used to determine the optimal timing and strategy for in-hospital education. Diabetes educators and endocrinologists can assist with curriculum development and teaching, and diabetes resource nurses can serve as role models and sources of information for staff nurses. Topics for staff education should include recognition of types of diabetes, treatment and prevention of hypoglycemia and hyperglycemia symptoms, glycemic targets in critical care and non-critical care settings, and acute complications such as diabetic ketoacidosis (48). The Joint Commission in partnership with the American Diabetes Association has developed an advanced level of certification in inpatient diabetes care (160). Minimum requirements for certification include diabetes staff education, formal BG monitoring protocols, hypoglycemia and hyperglycemia protocols, tracking of hypoglycemia frequency and severity, providing diabetes self-management education, and identification of a program champion or team to spearhead glycemic control initiatives (160).

The principles of diabetes education and management in the hospital apply for patients with type 1 and type 2 diabetes. Due to the lack endogenous insulin production, patients with type 1 diabetes require exogenous insulin to be provided at all times to avoid severe hyperglycemia and diabetic ketoacidosis (84, 85). In addition, patients with type 1 diabetes are less insulin resistant and are more vulnerable to hypoglycemic events than those with type 2 diabetes. Attention to type of diabetes, as well as to family dynamics and psychological and emotional maturity, is essential in developing and implementing an optimal diabetes regimen.

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