16. Diabetes Care in the Hospital: *Standards of Care in Diabetes—2023*

Diabetes Care 2023;46(Suppl. 1):S267–S278 | https://doi.org/10.2337/dc23-S016

Nuha A. ElSayed, Grazia Aleppo, Vanita R. Aroda, Raveendhara R. Bannuru, Florence M. Brown, Dennis Bruemmer, Billy S. Collins, Marisa E. Hilliard, Diana Isaacs, Eric L. Johnson, Scott Kahan, Kamlesh Khunti, Jose Leon, Sarah K. Lyons, Mary Lou Perry, Priya Prahalad, Richard E. Pratley, Jane Jeffrie Seley, Robert C. Stanton, and Robert A. Gabbay, on behalf of the American Diabetes Association

The American Diabetes Association (ADA) "Standards of Care in Diabetes" includes the ADA's current clinical practice recommendations and is intended to provide the components of diabetes care, general treatment goals and guidelines, and tools to evaluate quality of care. Members of the ADA Professional Practice Committee, a multidisciplinary expert committee, are responsible for updating the Standards of Care annually, or more frequently as warranted. For a detailed description of ADA standards, statements, and reports, as well as the evidence-grading system for ADA's clinical practice recommendations and a full list of Professional Practice Committee members, please refer to Introduction and Methodology. Readers who wish to comment on the Standards of Care are invited to do so at professional.diabetes.org/SOC.

Among hospitalized patients, hyperglycemia, hypoglycemia, and glucose variability are associated with adverse outcomes, including increased morbidity and mortality (1). Careful management of people with diabetes during hospitalization has direct and immediate benefits. Diabetes management in the inpatient setting is facilitated by preadmission treatment of hyperglycemia in people with diabetes, having elective procedures, a dedicated inpatient diabetes service applying well-developed and validated standards of care, and careful transition to prearranged outpatient management. These steps can shorten hospital stays, reduce the need for readmission and emergency department visits, and improve outcomes. Some in-depth reviews of in-hospital care and care transitions for adults with diabetes have been published (2–4). For older hospitalized patients or for patients in long-term care facilities, please see Section 13, "Older Adults."

HOSPITAL CARE DELIVERY STANDARDS

Recommendations

16.1 Perform an A1C test on all people with diabetes or hyperglycemia (blood glucose >140 mg/dL [7.8 mmol/L]) admitted to the hospital if not performed in the prior 3 months. **B**

16.2 Insulin should be administered using validated written or computerized protocols that allow for predefined adjustments in the insulin dosage based on glycemic fluctuations. **B**

Considerations on Admission

High-quality hospital care for diabetes requires standards for care delivery, which are best implemented using structured order sets and quality improvement strategies for process improvement. Unfortunately, "best practice" protocols, reviews, and guidelines (2,4) are inconsistently implemented within hospitals. To correct this, medical centers striving for optimal inpatient diabetes treatment should establish protocols and structured order sets, which include computerized provider order entry (CPOE).

Disclosure information for each author is available at https://doi.org/10.2337/dc23-SDIS.

Suggested citation: ElSayed NA, Aleppo G, Aroda VR, et al., American Diabetes Association. 16. Diabetes care in the hospital: Standards of Care in Diabetes—2023. *Diabetes Care 2023;46(Suppl. 1): S267–S278*

Initial orders should state the type of diabetes (i.e., type 1, type 2, gestational diabetes mellitus, pancreatogenic diabetes) when it is known. Because inpatient treatment and discharge planning are more effective if based on preadmission glycemia, A1C should be measured for all people with diabetes or hyperglycemia admitted to the hospital if an A1C test has not been performed in the previous 3 months (5–8). In addition, diabetes self-management knowledge and behaviors should be assessed on admission, and diabetes self-management education provided, especially if a new treatment plan is being considered. Diabetes self-management education should include appropriate skills needed after discharge, such as medication dosing and administration, glucose monitoring, and recognition and treatment of hypoglycemia (9,10). Evidence supports preadmission treatment of hyperglycemia in people scheduled for elective surgery as an effective means of reducing adverse outcomes (11–14).

The National Academy of Medicine recommends CPOE to prevent medication-related errors and increase medication administration efficiency (15). Systematic reviews of randomized controlled trials using computerized advice to improve glycemic outcomes in the hospital found significant improvement in the percentage of time individuals spent in the target glucose range, lower mean blood glucose levels, and no increase in hypoglycemia (16,17). Where feasible, there should be structured order sets that provide computerized guidance for glycemic management. Electronic insulin order templates also improve mean glucose levels without increasing hypoglycemia in people with type 2 diabetes, so structured insulin order sets incorporated into the CPOE can facilitate glycemic management (18,19). Insulin dosing algorithms using machine learning and data in the electronic health record (EHR) currently in development show great promise to more accurately predict insulin requirements during hospitalization compared with existing clinical practices (20).

Diabetes Care Specialists in the Hospital

Recommendation

16.3 When caring for hospitalized people with diabetes, consult with a specialized diabetes or glucose management team when possible. **C**

Appropriately trained specialists or specialty teams may reduce the length of stay and improve glycemic and other clinical outcomes (21–23). In addition, the increased risk of 30-day readmission following hospitalization that has been attributed to diabetes can be reduced, and costs saved when inpatient care is provided by a specialized diabetes management team (21,24,25). In a cross-sectional study comparing usual care to specialists reviewing diabetes cases and making recommendations virtually through the EHR, rates of both hyperglycemia and hypoglycemia were reduced by 30–40% (26). Providing inpatient diabetes education and developing a diabetes discharge plan that includes continued access to diabetes medications and supplies and ongoing education and support are key strategies to improve outcomes (27–29). Details of diabetes care team composition are available in the Joint Commission standards for programs and from the Society of Hospital Medicine (30,31).

Even the most efficacious orders may not be carried out in a way that improves quality, nor are they automatically updated when new evidence arises. The Joint Commission accreditation program for the hospital care of diabetes (31), the Society of Hospital Medicine workbook for program development (30), and the Joint British Diabetes Societies (JBDS) for Inpatient Care Group (32) are valuable resources.

GLYCEMIC TARGETS IN HOSPITALIZED ADULTS

Recommendations

16.4 Insulin therapy should be initiated for the treatment of persistent hyperglycemia starting at a threshold ≥180 mg/dL (10.0 mmol/L) (checked on two occasions). Once insulin therapy is started, a target glucose range of 140–180 mg/dL (7.8–10.0 mmol/L) is recommended for most critically ill and noncritically ill patients. **A**

16.5 More stringent goals, such as 110–140 mg/dL (6.1–7.8 mmol/L) or 100–180 mg/dL (5.6–10.0 mmol/L), may be appropriate for selected patients and are acceptable if they can be achieved without significant hypoglycemia. **C**

Standard Definitions of Glucose Abnormalities

Hyperglycemia in hospitalized patients is defined as blood glucose levels >140 mg/dL (7.8 mmol/L) (33). Blood glucose levels persistently above this level warrant prompt interventions, such as alterations in nutrition or changes to medications that cause hyperglycemia. An admission A1C value ≥6.5% (48 mmol/mol) suggests that the onset of diabetes preceded hospitalization (see Section 2, "Classification and Diagnosis of Diabetes") (33,34). Hypoglycemia in hospitalized patients is categorized by blood glucose concentration and clinical correlates (**Table 6.4**) (35). Level 1 hypoglycemia is defined as a glucose concentration of 54–70 mg/dL (3.0–3.9 mmol/L). Level 2 hypoglycemia is defined as a blood glucose concentration <54 mg/dL (3.0 mmol/L), which is typically the threshold for neuroglycopenic symptoms. Level 3 hypoglycemia is defined as a clinical event characterized by altered mental and/or physical functioning that requires assistance from another person for recovery. Levels 2 and 3 require immediate correction of low blood glucose. Prompt treatment of level 1 hypoglycemia can prevent progression to more significant level 2 and level 3 hypoglycemia.

Glycemic Targets

In a landmark clinical trial conducted in a surgical intensive care unit, Van den Berghe et al. (36) demonstrated that an intensive intravenous insulin protocol with a target glycemic range of 80–110 mg/dL (4.4–6.1 mmol/L) reduced mortality by 40% compared with a standard approach targeting blood glucose of 180–215 mg/dL (10–12 mmol/L) in critically ill hospitalized patients with recent surgery. This study provided robust evidence that active treatment to lower blood glucose in hospitalized patients could have immediate benefits. However, a large, multicenter follow-up study in critically ill hospitalized patients, the Normoglycemia in Intensive Care Evaluation and Survival Using Glucose Algorithm Regulation (NICE-SUGAR) trial (37), led to a reconsideration of the optimal target range for glucose lowering in critical illness. In this trial, critically ill patients randomized to intensive glycemic management (80–110 mg/dL) derived no significant treatment advantage compared with a group with more moderate glycemic targets (140–180 mg/dL [7.8–10.0 mmol/L]) and had slightly but

significantly higher mortality (27.5% vs. 25%). The intensively treated group had 10- to 15-fold greater rates of hypoglycemia, which may have contributed to the adverse outcomes noted. The findings from NICE-SUGAR are supported by several meta-analyses and a randomized controlled trial, some of which suggest that tight glycemic management increases mortality compared with more moderate glycemic targets and generally causes higher rates of hypoglycemia (38–40).

Based on these results, insulin therapy should be initiated for the treatment of persistent hyperglycemia ≥180 mg/dL (10.0 mmol/L) and targeted to a glucose range of 140–180 mg/dL (7.8–10.0 mmol/L) for the majority of critically ill patients. Although not as well supported by data from randomized controlled trials, these recommendations have been extended to hospitalized patients without critical illness. More stringent goals, such as 110–140 mg/dL (6.1–7.8 mmol/L), may be appropriate for selected patients (e.g., critically ill postsurgical patients or patients with cardiac surgery) as long as they can be achieved without significant hypoglycemia (41–43). For inpatient management of hyperglycemia in noncritical care, the expert consensus recommends a target range of 100–180 mg/dL (5.6–10.0 mmol/L) for noncritically ill patients with "new" hyperglycemia as well as people with known diabetes prior to admission. It has been found that fasting glucose levels <100 mg/dL are predictors of hypoglycemia within the next 24 h (44). Glycemic levels >250 mg/dL (13.9 mmol/L) may be acceptable in terminally ill patients with short life expectancy. In these individuals, less aggressive insulin regimens to minimize glucosuria, dehydration, and electrolyte disturbances are often more appropriate. Clinical judgment combined with ongoing assessment of clinical status, including changes in the trajectory of glucose measures, illness severity, nutritional status, or concomitant medications that might affect glucose levels (e.g., glucocorticoids), may be incorporated into the day-to-day decisions regarding insulin dosing (42).

BLOOD GLUCOSE MONITORING

In hospitalized individuals with diabetes who are eating, point-of-care (POC) glucose monitoring should be performed before meals; in those not eating, glucose monitoring is advised every 4–6 h (33). More frequent POC blood glucose monitoring ranging from every 30 min to every 2 h is the required standard for safe use of intravenous insulin. Safety standards for blood glucose monitoring that prohibit sharing lancing devices, other testing materials, and needles are mandatory (45).

The vast majority of hospital glucose monitoring is performed with FDA-approved prescription POC glucose monitoring systems with and capillary blood taken from finger sticks, similar to the process performed by outpatients for home blood glucose monitoring (46). POC blood glucose meters are not as accurate or as precise as laboratory glucose analyzers, and capillary blood glucose readings are subject to artifacts due to perfusion, edema, anemia/erythrocytosis, and several medications commonly used in the hospital (47) (**Table 7.1**). The U.S. Food and Drug Administration (FDA) has established standards for capillary (fingerstick) blood glucose meters used in the ambulatory setting, as well as standards to be applied for POC measures in the hospital (47). The balance between analytic requirements (e.g., accuracy, precision, interference) and clinical requirements (rapidity, simplicity, point of care) has not been uniformly resolved (46,48), and most hospitals have arrived at their own policies to balance these parameters. It is critically important that devices selected for in-hospital use, and the workflow through which they are applied, have careful analysis of performance and reliability and ongoing quality assessments. Recent studies indicate that POC measures provide adequate information for usual practice, with only rare instances where care has been compromised (49,50). Best practice dictates that any glucose result that does not correlate with the patient's clinical status should be confirmed by measuring a serum sample in the clinical laboratory.

Continuous Glucose Monitoring

Real-time continuous glucose monitoring (CGM) provides frequent measurements of interstitial glucose levels and the direction and magnitude of glucose trends. Even though CGM has theoretical advantages over POC glucose monitoring in detecting and reducing the incidence of hypoglycemia, it has not been approved by the FDA for inpatient use. Some hospitals with established glucose management teams allow the use of CGM in selected people with diabetes on an individual basis, mostly in noncritical care settings, provided both the individual and the glucose management team are well educated in the use of this technology. CGM is not currently approved for intensive care unit use due to accuracy concerns such as hypovolemia, hypoperfusion, and use of therapies such as vasopressor agents.

During the coronavirus disease 2019 (COVID-19) pandemic, many institutions were able to use CGM to minimize contact between health care professionals and people with diabetes, especially those in the intensive care unit under an FDA policy of enforcement discretion during the pandemic (51–59). This approach has been helpful in that regard, as well as in minimizing the use of personal protective equipment. The availability of data about the safe and effective use of CGM in the inpatient setting is evolving. Preliminary data suggest that CGM can significantly improve glycemic management and other hospital outcomes (57,60–63).

For more information on CGM, see Section 7, "Diabetes Technology."

GLUCOSE-LOWERING TREATMENT IN HOSPITALIZED PATIENTS

Recommendations

16.6 Basal insulin or a basal plus bolus correction insulin regimen is the preferred treatment for noncritically ill hospitalized patients with poor oral intake or those who are taking nothing by mouth. **A**

16.7 An insulin regimen with basal, prandial, and correction components is the preferred treatment for most noncritically ill hospitalized patients with adequate nutritional intake. **A**

16.8 Use of a correction or supplemental insulin without basal insulin (often referred to as a sliding scale) in the inpatient setting is discouraged. **A**

Insulin Therapy

Critical Care Setting

Continuous intravenous insulin infusion is the most effective method for achieving glycemic targets in the critical care setting. Intravenous insulin infusions should be administered based on validated

written or computerized protocols that allow for predefined adjustments in the infusion rate, accounting for glycemic fluctuations and insulin dose (64).

Noncritical Care Setting

In most instances, insulin is the preferred treatment for hyperglycemia in hospitalized patients. However, in certain circumstances, it may be appropriate to continue home therapies, including oral glucose-lowering medications (64,65). If oral medications are held in the hospital but will be reinstated after discharge, there should be a protocol for guiding resumption of home medications 1–2 days prior to discharge. For people taking insulin, several reports indicate that inpatient use of insulin pens is safe and may be associated with improved nurse satisfaction compared with the use of insulin vials and syringes with safety protocols in place (66–68). Insulin pens have been the subject of an FDA warning because of potential blood-borne diseases if inadvertently shared with more than one person; the warning "For single patient use only" should be rigorously followed using strict safety measures such as barcoding to prevent errors (69,70).

Outside of critical care units, scheduled insulin orders are recommended to manage hyperglycemia in people with diabetes. Orders for insulin analogs or human insulin result in similar glycemic outcomes in the hospital setting (71). The use of subcutaneous rapid- or short-acting insulin before meals, or every 4–6 h if no meals are given or if the individual is receiving continuous enteral/parenteral nutrition, is indicated to correct or prevent hyperglycemia. Basal insulin, or a basal plus bolus correction schedule, is the preferred treatment for noncritically ill hospitalized patients with inadequate oral intake or those restricted from oral intake. An insulin schedule with basal, prandial, and correction components is the preferred treatment for most noncritically ill hospitalized people with diabetes with adequate nutritional intake (72). In people with diabetes with blood glucose $<$240 mg/dL, consider alternatives to basal-bolus therapy as discussed below (72,73).

For individuals who are eating, insulin injections should align with meals. In such instances, POC glucose monitoring should be performed immediately before meals. If oral intake is inadequate, a safer procedure is administering prandial insulin immediately after eating, with the dose adjusted to be appropriate for the amount of carbohydrates ingested (71).

A randomized controlled trial has shown that basal-bolus treatment improved glycemic outcomes and reduced hospital complications compared with a correction or supplemental insulin without basal insulin (formerly known as sliding scale) in general surgery for people with type 2 diabetes (74). Prolonged use of correction or supplemental insulin without basal insulin as the sole treatment of hyperglycemia is strongly discouraged in the inpatient setting, with the exception of people with type 2 diabetes in noncritical care with mild hyperglycemia (23,75,76).

While there is evidence for using premixed insulin formulations in the outpatient setting (77), an inpatient study of 70/30 NPH/regular insulin versus basal-bolus therapy showed comparable glycemic outcomes but significantly increased hypoglycemia in the group receiving insulin mixtures (78). Therefore, insulin mixtures such as 75/25 or 70/30 insulins are not routinely recommended for in-hospital use.

Type 1 Diabetes

For people with type 1 diabetes, dosing insulin based solely on premeal glucose levels does not account for basal insulin requirements or caloric intake, increasing the risk of both hypoglycemia and hyperglycemia. Typically, basal insulin dosing is based on body weight, with some evidence that people with renal insufficiency should be treated with lower doses (79,80). An insulin schedule with basal and correction components is necessary for all hospitalized individuals with type 1 diabetes, even when taking nothing by mouth, with the addition of prandial insulin when eating.

Transitioning From Intravenous to Subcutaneous Insulin

When discontinuing intravenous insulin, a transition protocol is associated with less morbidity and lower costs of care (81,82) and is therefore recommended. A person with type 1 or type 2 diabetes being transitioned to a subcutaneous regimen should receive a dose of subcutaneous basal insulin 2 h before the intravenous infusion is discontinued. Prior to discontinuing an insulin infusion, initiation of subcutaneous basal insulin may help minimize hyperglycemia and avoid rebound hypoglycemia (83,84). The dose of basal insulin is best calculated on the basis of the insulin infusion rate during the last 6 h when stable glycemic goals were achieved (85). For people being transitioned to concentrated insulin (U-200, U-300, or U-500) in the inpatient setting, it is important to ensure correct dosing by utilizing an individual pen or cartridge for each person and by meticulous pharmacy and nursing supervision of the dose administered (85,86).

Noninsulin Therapies

The safety and efficacy of noninsulin glucose-lowering therapies in the hospital setting is an area of active research (73,87–89). Several recent randomized trials have demonstrated the potential effectiveness of glucagon-like peptide 1 receptor agonists and dipeptidyl peptidase 4 inhibitors in specific groups of hospitalized people with diabetes (90–93). However, an FDA bulletin states that health care professionals should consider discontinuing saxagliptin and alogliptin in people who develop heart failure (94).

Sodium–glucose cotransporter 2 (SGLT2) inhibitors should be avoided in cases of severe illness, in people with ketonemia or ketonuria, and during prolonged fasting and surgical procedures (4). Until safety and efficacy are established, SGLT2 inhibitors are not recommended for routine in-hospital use for diabetes management, although they may be considered for the treatment of people with type 2 diabetes who have or are at risk for heart failure (95). Furthermore, the FDA has warned that SGLT2 inhibitors should be stopped 3 days before scheduled surgeries (4 days in the case of ertugliflozin) (96).

HYPOGLYCEMIA

Recommendations

16.9 A hypoglycemia management protocol should be adopted and implemented by each hospital or hospital system. A plan for preventing and treating hypoglycemia should be established for each individual. Episodes of hypoglycemia in the hospital should be documented in the medical record and tracked for quality improvement/quality assessment. **E**

16.10 Treatment regimens should be reviewed and changed as necessary to prevent further hypoglycemia when a blood glucose value of <70 mg/dL (3.9 mmol/L) is documented. **C**

People with or without diabetes may experience hypoglycemia in the hospital setting. While hypoglycemia is associated with increased mortality (97), in many cases, it is a marker of an underlying disease rather than the cause of fatality. However, hypoglycemia is a severe consequence of dysregulated metabolism and/or diabetes treatment, and it is imperative that it be minimized during hospitalization. Many episodes of inpatient hypoglycemia are preventable. Therefore, a hypoglycemia prevention and management protocol should be adopted and implemented by each hospital or hospital system. A standardized hospital-wide, nurse-initiated hypoglycemia treatment protocol should be in place to immediately address blood glucose levels of <70 mg/dL (3.9 mmol/L) (98,99). In addition, individualized plans for preventing and treating hypoglycemia for each individual should also be developed. An American Diabetes Association consensus statement recommends that an individual's treatment plan be reviewed any time a blood glucose value of <70 mg/dL (3.9 mmol/L) occurs, as such readings often predict subsequent level 3 hypoglycemia. Episodes of hypoglycemia in the hospital should be documented in the medical record and tracked (1,2).

Triggering Events and Prevention of Hypoglycemia

Insulin is one of the most common drugs causing adverse events in hospitalized patients, and errors in insulin dosing and/or administration occur relatively frequently (97,100,101). Beyond insulin dosing errors, common preventable sources of iatrogenic hypoglycemia are improper prescribing of other glucose-lowering medications, inappropriate management of the first episode of hypoglycemia, and nutrition–insulin mismatch, often related to an unexpected interruption of nutrition (102). A recent study describes acute kidney injury as an important risk factor for hypoglycemia in the hospital (103), possibly as a result of decreased insulin clearance. Studies of "bundled" preventive therapies, including proactive surveillance of glycemic outliers and an interdisciplinary data-driven approach to glycemic management, showed that hypoglycemic episodes in the hospital could be prevented. Compared with baseline, two such studies found that hypoglycemic events fell by 56–80% (99,104,105). The Joint Commission recommends that all hypoglycemic episodes be evaluated for a root cause and the episodes be aggregated and reviewed to address systemic issues (31).

In addition to errors with insulin treatment, iatrogenic hypoglycemia may be induced by a sudden reduction of corticosteroid dose, reduced oral intake, emesis, inappropriate timing of short- or rapid-acting insulin in relation to meals, reduced infusion rate of intravenous dextrose, unexpected interruption of enteral or parenteral feedings, delayed or missed blood glucose checks, and altered ability of the individual to report symptoms (106).

Recent inpatient CGM studies show promise for CGM as an early warning system to alert of impending hypoglycemia, offering an opportunity to mitigate it before it happens (60–63). The use of personal CGM and automated insulin delivery devices, such as insulin pumps that can automatically deliver correction doses and change basal delivery rates in real time, should be supported for ongoing use during hospitalization for individuals who are capable of using devices safely and independently when proper supervision is available. Hospitals should be encouraged to develop policies and protocols to support inpatient use of individual- and hospital-owned diabetes technology and have expert staff available for safe implementation. Hospital information technology teams are beginning to integrate CGM data into the electronic health record. The ability to download and interpret diabetes device data during hospitalization can inform insulin dosing during hospitalization and care transitions (107).

For more information on CGM, see Section 7, "Diabetes Technology."

Predictors of Hypoglycemia

In people with diabetes in the ambulatory setting, it is well established that an episode of severe hypoglycemia increases the risk for a subsequent event, partly because of impaired counterregulation (108,109). This relationship also holds true for people with diabetes in the inpatient setting. For example, in a study of hospitalized individuals treated for hyperglycemia, 84% who had an episode of "severe hypoglycemia" (defined in the study as <40 mg/dL [2.2 mmol/L]) had a preceding episode of hypoglycemia (<70 mg/dL [3.9 mmol/L]) during the same admission (110). In another study of hypoglycemic episodes (defined in the study as <50 mg/dL [2.8 mmol/L]), 78% of patients were using basal insulin, with the incidence of hypoglycemia peaking between midnight and 6:00 A.M. Despite recognition of hypoglycemia, 75% of individuals did not have their dose of basal insulin changed before the next insulin administration (111).

Recently, several groups have developed algorithms to predict episodes of hypoglycemia in the inpatient setting (112,113). Models such as these are potentially important and, once validated for general use, could provide a valuable tool to reduce rates of hypoglycemia in the hospital. In one retrospective cohort study data, a fasting blood glucose of <100 mg/dL was shown to be a predictor of next-day hypoglycemia (44).

MEDICAL NUTRITION THERAPY IN THE HOSPITAL

The goals of medical nutrition therapy in the hospital are to provide adequate calories to meet metabolic demands, optimize glycemic outcomes, address personal food preferences, and facilitate the creation of a discharge plan. The American Diabetes Association does not endorse any single meal plan or specified percentages of macronutrients. Current nutrition recommendations advise individualization based on treatment goals, physiological parameters, and medication use. Consistent carbohydrate meal plans are preferred by many hospitals as they facilitate matching the prandial insulin dose to the amount of carbohydrate given (114). Orders should also indicate that the meal delivery and nutritional insulin coverage should be coordinated, as their variability often creates the possibility of hyperglycemic and hypoglycemic events (28). Many hospitals offer "meals on demand," where individuals may order meals from

the menu at any time during the day. This option improves patient satisfaction but complicates meal-insulin coordination. Finally, if the hospital food service supports carbohydrate counting, this option should be made available to people with diabetes counting carbohydrates at home (115,116).

SELF-MANAGEMENT IN THE HOSPITAL

Diabetes self-management in the hospital may be appropriate for specific individuals who wish to continue to perform self-care while acutely ill (117,118). Candidates include children with parental supervision, adolescents, and adults who successfully perform diabetes self-management at home and whose cognitive and physical skills needed to successfully self-administer insulin and perform glucose monitoring are not compromised (9,119). In addition, they should have adequate oral intake, be proficient in carbohydrate estimation, take multiple daily insulin injections or use insulin pumps, have stable insulin requirements, and understand sick-day management. If self-management is supported, a policy should include a requirement that people with diabetes and the care team agree that self-management is appropriate on a daily basis during hospitalization. Hospital personal medication policies may include guidance for people with diabetes who wish to take their own or hospital-dispensed diabetes medications during their hospital stay. A hospital policy for personal medication may consider a pharmacy exception on a case-by-case basis along with the care team. Pharmacy must verify any home medication and require a prescriber order for the individual to self-administer home or hospital-dispensed medication under the supervision of the registered nurse. If an insulin pump or CGM is worn, hospital policy and procedures delineating guidelines for wearing an insulin pump and/or CGM device should be developed according to consensus guidelines, including the changing of infusion sites and glucose sensors (107,120,121). As outlined in Recommendation 7.30, people with diabetes wearing diabetes devices should be supported to continue them in an inpatient setting when they are competent to perform self-care and proper supervision is available.

STANDARDS FOR SPECIAL SITUATIONS

Enteral/Parenteral Feedings

For individuals receiving enteral or parenteral feedings who require insulin, the insulin orders should include coverage of basal, prandial, and correctional needs (115,122,123). It is essential that people with type 1 diabetes continue to receive basal insulin even if feedings are discontinued.

Most adults receiving basal insulin should continue with their basal dose, while the insulin dose for the total daily nutritional component may be calculated as 1 unit of insulin for every 10–15 g carbohydrate in the enteral and parenteral formulas. Commercially available cans of enteral nutrition contain variable amounts of carbohydrates and may be infused at different rates. All of this must be considered while calculating insulin doses to cover the nutritional component of enteral nutrition (116). Giving NPH insulin two or three times daily (every 8 or 12 h) to cover individual requirements is a reasonable option. Adjustments in insulin doses should be made frequently. Correctional insulin should also be administered subcutaneously every 6 h with human regular insulin or every 4 h with a rapid-acting insulin analog. If enteral nutrition is interrupted, a 10% dextrose infusion should be started immediately to prevent hypoglycemia and to allow time to select more appropriate insulin doses.

For adults receiving enteral bolus feedings, approximately 1 unit of regular human insulin or rapid-acting insulin per 10–15 g carbohydrate should be given subcutaneously before each feeding. Correctional insulin coverage should be added as needed before each feeding.

In individuals receiving nocturnal tube feeding, NPH insulin administered with the initiation of the feeding represents a reasonable approach to cover this nutritional load.

For individuals receiving continuous peripheral or central parenteral nutrition, human regular insulin may be added to the solution, particularly if >20 units of correctional insulin have been required in the past 24 h. A starting dose of 1 unit of human regular insulin for every 10 g dextrose has been recommended (115) and should be adjusted daily in the solution. Adding insulin to the parenteral nutrition bag is the safest way to prevent hypoglycemia if the parenteral nutrition is stopped or interrupted. Correctional insulin should be administered subcutaneously to address any hyperglycemia. For full enteral/parenteral feeding guidance, please refer to review articles detailing this topic (122,124,125).

Because continuous enteral or parenteral nutrition results in a continuous postprandial state, efforts to bring blood glucose levels to below 140 mg/dL (7.8 mmol/L) substantially increase the risk of hypoglycemia in these patients.

Glucocorticoid Therapy

The prevalence of consistent use of glucocorticoid therapy in hospitalized patients can approach 10%, and these medications can induce hyperglycemia in 56–86% of these individuals with and without preexisting diabetes (126,127). If left untreated, this hyperglycemia increases mortality and morbidity risk, e.g., infections and cardiovascular events. Glucocorticoid type and duration of action must be considered in determining appropriate insulin treatments. Daily-ingested intermediate-acting glucocorticoids such as prednisone reach peak plasma levels in 4–6 h (128) but have pharmacologic actions that can last through the day. Individuals placed on morning steroid therapy have disproportionate hyperglycemia during the day but frequently reach target blood glucose levels overnight regardless of treatment (126). In subjects on once- or twice-daily steroids, administering intermediate-acting (NPH) insulin is a standard approach. NPH is usually administered in addition to daily basal-bolus insulin or in addition to oral glucose-lowering medications. Because NPH action peaks at 4–6 h after administration, it is recommended to administer it concomitantly with intermediate-acting steroids (129). For long-acting glucocorticoids such as dexamethasone and multidose or continuous glucocorticoid use, long-acting basal insulin may be required to manage fasting blood glucose levels (65,130). For higher doses of glucocorticoids, increasing doses of prandial (if eating) and correctional insulin, sometimes as much as 40–60% or more, are often needed in addition to basal insulin (72,131,132). A single-center retrospective study found that increasing the ratio of insulin to steroids was positively associated with

improved time in range (70–180 mg/dL); however, there was an increase in hypoglycemia (133). Whatever insulin orders are initiated, daily adjustments based on levels of glycemia and anticipated changes in type, doses, and duration of glucocorticoids, along with POC blood glucose monitoring, are critical to reducing rates of hypoglycemia and hyperglycemia.

Perioperative Care

It is estimated that up to 20% of general surgery patients have diabetes, and 23–60% have prediabetes or undiagnosed diabetes. Surgical stress and counterregulatory hormone release increase the risk of hyperglycemia as well as mortality, infection, and length of stay (134). There is little data available to guide care of people with diabetes through the perioperative period. To reduce surgical risk in people with diabetes, some institutions have A1C cutoffs for elective surgeries, and some have developed optimization programs to lower A1C before surgery (135).

The following approach (136–138) may be considered:

1. A preoperative risk assessment should be performed for people with diabetes who are at high risk for ischemic heart disease and those with autonomic neuropathy or renal failure.
2. The A1C target for elective surgeries should be <8% (63.9 mmol/L) whenever possible (139,140).
3. The target range for blood glucose in the perioperative period should be 100–180 mg/dL (5.6–10.0 mmol/L) (139) within 4 h of the surgery (1).
4. Metformin should be held on the day of surgery.
5. SGLT2 inhibitors must be discontinued 3–4 days before surgery.
6. Hold any other oral glucose-lowering agents the morning of surgery or procedure and give half of NPH dose or 75–80% doses of long-acting analog or insulin pump basal insulin based on the type of diabetes and clinical judgment.
7. Monitor blood glucose at least every 2–4 h while the individual takes nothing by mouth and dose with short- or rapid-acting insulin as needed.
8. There are no data on the use and/or influence of glucagon-like peptide 1 receptor agonists or ultra-long-acting insulin analogs on glycemia in perioperative care.

A recent review concluded that perioperative glycemic targets tighter than 80–180 mg/dL (4.4–10.0 mmol/L) did not improve outcomes and was associated with more hypoglycemia (137); therefore, in general, stricter glycemic targets are not advised. Evidence from a recent study indicates that compared with usual dosing, a reduction of insulin given the evening before surgery by ~25% was more likely to achieve perioperative blood glucose levels in the target range with a lower risk for hypoglycemia (141).

In noncardiac general surgery patients, basal insulin plus premeal short- or rapid-acting insulin (basal-bolus) coverage has been associated with improved glycemic outcomes and lower rates of perioperative complications compared with the reactive, correction-only short- or rapid-acting insulin coverage alone with no basal insulin dosing (74,134,142).

Diabetic Ketoacidosis and Hyperosmolar Hyperglycemic State

There is considerable variability in the presentation of diabetic ketoacidosis (DKA) and hyperosmolar hyperglycemic states, ranging from euglycemia or mild hyperglycemia and acidosis to severe hyperglycemia, dehydration, and coma; therefore, individualization of treatment based on a careful clinical and laboratory assessment is needed (83,143–145).

Management goals include restoration of circulatory volume and tissue perfusion, resolution of hyperglycemia, and correction of electrolyte imbalance and acidosis. It is also essential to treat any correctable underlying cause of DKA, such as sepsis, myocardial infarction, or stroke. In critically ill and mentally obtunded individuals with DKA or hyperosmolar hyperglycemia, continuous intravenous insulin is the standard of care. Successful transition from intravenous to subcutaneous insulin requires administration of basal insulin 2–4 h before the intravenous insulin is stopped to prevent recurrence of ketoacidosis and rebound hyperglycemia (143). There is no significant difference in outcomes for intravenous human regular insulin versus subcutaneous rapid-acting analogs when combined with aggressive fluid management for treating mild or moderate DKA (146). Individuals with uncomplicated DKA may sometimes be treated with subcutaneous insulin in the emergency department or step-down units (147). This approach may be safer and more cost-effective than treatment with intravenous insulin. If subcutaneous insulin administration is used, it is important to provide an adequate fluid replacement, frequent POC blood glucose monitoring, treatment of any concurrent infections, and appropriate follow-up to avoid recurrent DKA. Several studies have shown that the use of bicarbonate in patients with DKA made no difference in the resolution of acidosis or time to discharge, and its use is generally not recommended (148). For further treatment information, refer to recent in-depth reviews (4,106,149).

TRANSITION FROM THE HOSPITAL TO THE AMBULATORY SETTING

Recommendation

16.11 A structured discharge plan should be tailored to the individual with diabetes. **B**

A structured discharge plan tailored to the individual may reduce the length of hospital stay and readmission rates and increase satisfaction with the hospital experience (150). Multiple strategies are key, including diabetes education prior to discharge, diabetes medication reconciliation with attention to access, and scheduled virtual and/or face-to-face follow-up visits after discharge. Discharge planning should begin at admission and be updated as individual needs change (3,151).

The transition from the acute care setting presents risks for all people with diabetes. Individuals may be discharged to varied settings, including home (with or without visiting nurse services), assisted living, rehabilitation, or skilled nursing facilities. For individuals discharged to home or assisted living, the optimal discharge plan will need to consider diabetes type and severity, effects of the illness on blood glucose levels, and the individual's capabilities and preferences (29,152,153). See Section 13, "Older Adults," for more information.

An outpatient follow-up visit with the primary care clinician, endocrinologist, or diabetes care and education specialist

within 1 month of discharge is advised for all individuals experiencing hyperglycemia in the hospital. If glycemic medications are changed or glucose management is not optimal at discharge, an earlier appointment (in 1–2 weeks) is preferred, and frequent contact may be needed to avoid hyperglycemia and hypoglycemia. A discharge algorithm for glycemic medication adjustment based on admission A1C, diabetes medications before admission, and insulin usage during hospitalization was found useful to guide treatment decisions and significantly improved A1C after discharge (6). If an A1C from the prior 3 months is unavailable, measuring the A1C in all people with diabetes or hyperglycemia admitted to the hospital is recommended upon admission.

Clear communication with outpatient health care professionals directly or via hospital discharge summaries facilitates safe transitions to outpatient care. Providing information regarding the root cause of hyperglycemia (or the plan for determining the cause), related complications and comorbidities, and recommended treatments can assist outpatient health care professionals as they assume ongoing care.

The Agency for Healthcare Research and Quality recommends that, at a minimum, discharge plans include the following (154):

Medication Reconciliation

- Home and hospital medications must be cross-checked to ensure that no chronic medications are stopped and to ensure the safety of new and old prescriptions.
- Prescriptions for new or changed medication should be filled and reviewed with the individual and care partners at or before discharge.

Structured Discharge Communication

- Information on medication changes, pending tests and studies, and follow-up needs must be accurately and promptly communicated to outpatient health care professionals.
- Discharge summaries should be transmitted to the primary care clinician as soon as possible after discharge.
- Scheduling follow-up appointments prior to discharge with people with diabetes agreeing to the time and place increases the likelihood that they will attend.

It is recommended that the following areas of knowledge be reviewed and addressed before hospital discharge:

- Identification of the health care professionals who will provide diabetes care after discharge.
- Level of understanding related to the diabetes diagnosis, glucose monitoring, home glucose goals, and when to call the health care professionals.
- Definition, recognition, treatment, and prevention of hyperglycemia and hypoglycemia.
- Information on making healthy food choices at home and referral to an outpatient registered dietitian nutritionist or diabetes care and education specialist to guide individualization of the meal plan, if needed.
- When and how to take blood glucose-lowering medications, including insulin administration.
- Sick-day management (29,153).
- Proper use and disposal of diabetes supplies, e.g., insulin pen, pen needles, syringes, and lancets.

People with diabetes must be provided with appropriate durable medical equipment, medications, supplies (e.g., blood glucose test strips or CGM sensors), prescriptions, and appropriate education at the time of discharge to avoid a potentially dangerous hiatus in care.

PREVENTING ADMISSIONS AND READMISSIONS

In people with diabetes, the hospital readmission rate is between 14 and 20%, nearly twice that in people without diabetes (151,155). This may result in increased diabetes distress and has significant financial implications. Of people with diabetes who are hospitalized, 30% have two or more hospital stays, and these admissions account for over 50% of hospital costs for diabetes (156). Factors contributing to readmission include male sex, longer duration of prior hospitalization, number of previous hospitalizations, number and severity of comorbidities, and lower socioeconomic and/or educational status; scheduled home health visits and timely ambulatory follow-up care reduce readmission rates (151,155). While there is no standard to prevent readmissions, several successful strategies have been reported (151). These include targeting ketosis-prone people with type 1 diabetes (157), insulin treatment of individuals with admission A1C >9% (75 mmol/mol) (158), and the use of a transitional care model (159). For people with diabetic kidney disease, collaborative patient-centered medical homes may decrease risk-adjusted readmission rates (160). A 2018 published algorithm based on demographic and clinical characteristics of people with diabetes had only moderate predictive power but identified a promising future strategy (161).

Age is also an important risk factor in hospitalization and readmission among people with diabetes (refer to Section 13, "Older Adults," for detailed criteria).

References

1. Seisa MO, Saadi S, Nayfeh T, et al. A systematic review supporting the Endocrine Society clinical practice guideline for the management of hyperglycemia in adults hospitalized for noncritical illness or undergoing elective surgical procedures. J Clin Endocrinol Metab 2022;107:2139–2147
2. Korytkowski MT, Muniyappa R, Antinori-Lent K, et al. Management of hyperglycemia in hospitalized adult patients in non-critical care settings: an Endocrine Society clinical practice guideline. J Clin Endocrinol Metab 2022;107:2101–2128
3. Rubin DJ, Shah AA. Predicting and preventing acute care re-utilization by patients with diabetes. Curr Diab Rep 2021;21:34
4. Moghissi E, Inzucchi S. The evolution of glycemic control in the hospital setting. In *Managing Diabetes and Hyperglycemia in the Hospital Setting.* Draznin B, Ed. Alexandria, VA, American Diabetes Association, 2016, pp. 1–10
5. Pasquel FJ, Gomez-Huelgas R, Anzola I, et al. Predictive value of admission hemoglobin a1c on inpatient glycemic control and response to insulin therapy in medicine and surgery patients with type 2 diabetes. Diabetes Care 2015;38:e202–e203
6. Umpierrez GE, Reyes D, Smiley D, et al. Hospital discharge algorithm based on admission HbA1c for the management of patients with type 2 diabetes. Diabetes Care 2014;37:2934–2939
7. Carpenter DL, Gregg SR, Xu K, Buchman TG, Coopersmith CM. Prevalence and impact of unknown diabetes in the ICU. Crit Care Med 2015;43:e541–e550
8. Nanayakkara N, Nguyen H, Churilov L, et al. Inpatient HbA1c testing: a prospective observational study. BMJ Open Diabetes Res Care 2015;3:e000113
9. Nassar CM, Montero A, Magee MF. Inpatient diabetes education in the real world: an overview of guidelines and delivery models. Curr Diab Rep 2019;19:103
10. Donihi AC. Practical recommendations for transitioning patients with type 2 diabetes from hospital to home. Curr Diab Rep 2017;17:52

11. Garg R, Schuman B, Bader A, et al. Effect of preoperative diabetes management on glycemic control and clinical outcomes after elective surgery. Ann Surg 2018;267:858–862
12. van den Boom W, Schroeder RA, Manning MW, Setji TL, Fiestan GO, Dunson DB. Effect of A1C and glucose on postoperative mortality in noncardiac and cardiac surgeries. Diabetes Care 2018;41:782–788
13. Setji T, Hopkins TJ, Jimenez M, et al. Rationalization, development, and implementation of a preoperative diabetes optimization program designed to improve perioperative outcomes and reduce cost. Diabetes Spectr 2017;30:217–223
14. Okabayashi T, Shima Y, Sumiyoshi T, et al. Intensive versus intermediate glucose control in surgical intensive care unit patients. Diabetes Care 2014;37:1516–1524
15. Institute of Medicine. *Preventing Medication Errors*. Aspden P, Wolcott J, Bootman JL, Cronenwett LR, Eds. Washington, DC, National Academies Press, 2007
16. Gillaizeau F, Chan E, Trinquart L, et al. Computerized advice on drug dosage to improve prescribing practice. Cochrane Database Syst Rev 2013;11:CD002894
17. Sly B, Russell AW, Sullivan C. Digital interventions to improve safety and quality of inpatient diabetes management: a systematic review. Int J Med Inform 2022;157:104596
18. Wexler DJ, Shrader P, Burns SM, Cagliero E. Effectiveness of a computerized insulin order template in general medical inpatients with type 2 diabetes: a cluster randomized trial. Diabetes Care 2010;33:2181–2183
19. Schnipper JL, Liang CL, Ndumele CD, Pendergrass ML. Effects of a computerized order set on the inpatient management of hyperglycemia: a cluster-randomized controlled trial. Endocr Pract 2010;16:209–218
20. Nguyen M, Jankovic I, Kalesinskas L, Baiocchi M, Chen JH. Machine learning for initial insulin estimation in hospitalized patients. J Am Med Inform Assoc 2021;28:2212–2219
21. Akiboye F, Sihre HK, Al Mulhem M, Rayman G, Nirantharakumar K, Adderley NJ. Impact of diabetes specialist nurses on inpatient care: a systematic review. Diabet Med 2021;38:e14573
22. Wang YJ, Seggelke S, Hawkins RM, et al. Impact of glucose management team on outcomes of hospitalizaron in patients with type 2 diabetes admitted to the medical service. Endocr Pract 2016;22:1401–1405
23. Draznin B, Gilden J, Golden SH, et al.; PRIDE investigators. Pathways to quality inpatient management of hyperglycemia and diabetes: a call to action. Diabetes Care 2013;36:1807–1814
24. Bansal V, Mottalib A, Pawar TK, et al. Inpatient diabetes management by specialized diabetes team versus primary service team in non-critical care units: impact on 30-day readmission rate and hospital cost. BMJ Open Diabetes Res Care 2018;6:e000460
25. Ostling S, Wyckoff J, Ciarkowski SL, et al. The relationship between diabetes mellitus and 30-day readmission rates. Clin Diabetes Endocrinol 2017;3:3
26. Rushakoff RJ, Sullivan MM, MacMaster HW, et al. Association between a virtual glucose management service and glycemic control in hospitalized adult patients: an observational study. Ann Intern Med 2017;166:621–627
27. Endocrine Society. Clinical Practice Guidelines. Accessed 30 August 2022. Available from https://www.endocrine.org/clinical-practice-guidelines
28. Magee MF, Baker KM, Bardsley JK, Wesley D, Smith KM. Diabetes to go-inpatient: pragmatic lessons learned from implementation of technology-enabled diabetes survival skills education within nursing unit workflow in an urban, tertiary care hospital. Jt Comm J Qual Patient Saf 2021;47:107–119
29. Pinkhasova D, Swami JB, Patel N, et al. Patient understanding of discharge instructions for home diabetes self-management and risk for hospital readmission and emergency department visits. Endocr Pract 2021;27:561–566
30. Society of Hospital Medicine. Glycemic control for hospitalists. Accessed 30 August 2022. Available from https://www.hospitalmedicine.org/clinical-topics/glycemic-control/
31. Arnold P, Scheurer D, Dake AW, et al. Hospital guidelines for diabetes management and the Joint Commission-American Diabetes Association Inpatient Diabetes Certification. Am J Med Sci 2016;351:333–341
32. Association of British Diabetologists. Joint British Diabetes Societies (JBDS) for Inpatient Care Group. Accessed 7 October 2022. Available from https://abcd.care/joint-british-diabetes-societies-jbds-inpatient-care-group
33. Moghissi ES, Korytkowski MT, DiNardo M, et al.; American Association of Clinical Endocrinologists; American Diabetes Association. American Association of Clinical Endocrinologists and American Diabetes Association consensus statement on inpatient glycemic control. Diabetes Care 2009;32:1119–1131
34. Umpierrez GE, Hellman R, Korytkowski MT, et al.; Endocrine Society. Management of hyperglycemia in hospitalized patients in non-critical care setting: an endocrine society clinical practice guideline. J Clin Endocrinol Metab 2012;97:16–38
35. Agiostratidou G, Anhalt H, Ball D, et al. Standardizing clinically meaningful outcome measures beyond HbA_{1c} for type 1 diabetes: a consensus report of the American Association of Clinical Endocrinologists, the American Association of Diabetes Educators, the American Diabetes Association, the Endocrine Society, JDRF International, The Leona M. and Harry B. Helmsley Charitable Trust, the Pediatric Endocrine Society, and the T1D Exchange. Diabetes Care 2017;40:1622–1630
36. Van den Berghe G, Wouters P, Weekers F, et al. Intensive insulin therapy in critically ill patients. N Engl J Med 2001;345:1359–1367
37. Finfer S, Chittock DR, Su SY, et al.; NICE-SUGAR Study Investigators. Intensive versus conventional glucose control in critically ill patients. N Engl J Med 2009;360:1283–1297
38. Kansagara D, Fu R, Freeman M, Wolf F, Helfand M. Intensive insulin therapy in hospitalized patients: a systematic review. Ann Intern Med 2011;154:268–282
39. Sathya B, Davis R, Taveira T, Whitlatch H, Wu WC. Intensity of peri-operative glycemic control and postoperative outcomes in patients with diabetes: a meta-analysis. Diabetes Res Clin Pract 2013;102:8–15
40. Umpierrez G, Cardona S, Pasquel F, et al. randomized controlled trial of intensive versus conservative glucose control in patients undergoing coronary artery bypass graft surgery: GLUCO-CABG trial. Diabetes Care 2015;38:1665–1672
41. Furnary AP, Wu Y, Bookin SO. Effect of hyperglycemia and continuous intravenous insulin infusions on outcomes of cardiac surgical procedures: the Portland Diabetic Project. Endocr Pract 2004;10(Suppl. 2):21–33
42. Low Wang CC, Draznin B. Practical approach to management of inpatient hyperglycemia in select patient populations. Hosp Pract (1995) 2013;41:45–53
43. Magaji V, Nayak S, Donihi AC, et al. Comparison of insulin infusion protocols targeting 110–140 mg/dL in patients after cardiac surgery. Diabetes Technol Ther 2012;14:1013–1017
44. Flory JH, Aleman JO, Furst J, Seley JJ. Basal insulin use in the non-critical care setting: is fasting hypoglycemia inevitable or preventable? J Diabetes Sci Technol 2014;8:427–428
45. Cobaugh DJ, Maynard G, Cooper L, et al. Enhancing insulin-use safety in hospitals: Practical recommendations from an ASHP Foundation expert consensus panel. Am J Health Syst Pharm 2013;70:1404–1413
46. Rice MJ, Coursin DB. Glucose meters: here today, gone tomorrow? Crit Care Med 2016;44:e97–e100
47. Rice MJ, Smith JL, Coursin DB. Glucose measurement in the ICU: regulatory intersects reality. Crit Care Med 2017;45:741–743
48. Klonoff DC, Draznin B, Drincic A, et al. PRIDE statement on the need for a moratorium on the CMS plan to cite hospitals for performing point-of-care capillary blood glucose monitoring on critically ill patients. J Clin Endocrinol Metab 2015;100:3607–3612
49. DuBois JA, Slingerland RJ, Fokkert M, et al. Bedside glucose monitoring–is it safe? A new, regulatory-compliant risk assessment evaluation protocol in critically ill patient care settings. Crit Care Med 2017;45:567–574
50. Zhang R, Isakow W, Kollef MH, Scott MG. Performance of a modern glucose meter in ICU and general hospital inpatients: 3 years of real-world paired meter and central laboratory results. Crit Care Med 2017;45:1509–1514
51. Wallia A, Prince G, Touma E, El Muayed M, Seley JJ. Caring for hospitalized patients with diabetes mellitus, hyperglycemia, and COVID-19: bridging the remaining knowledge gaps. Curr Diab Rep 2020;20:77
52. Aljehani FA, Funke K, Hermayer KL. Inpatient diabetes and hyperglycemia management protocol in the COVID-19 era. Am J Med Sci 2020;360:423–426
53. Pasquel FJ, Umpierrez GE. Individualizing inpatient diabetes management during the coronavirus disease 2019 pandemic. J Diabetes Sci Technol 2020;14:705–707
54. Ceriello A, Standl E, Catrinoiu D, et al.; "Diabetes and Cardiovascular Disease (D&CVD)" Study Group of the European Association for the Study of Diabetes (EASD). Issues for the management of people with diabetes and COVID-19 in ICU. Cardiovasc Diabetol 2020;19:114
55. Korytkowski M, Antinori-Lent K, Drincic A, et al. A pragmatic approach to inpatient diabetes management during the COVID-19 pandemic. J Clin Endocrinol Metab 2020;105:dgaa342
56. Sadhu AR, Serrano IA, Xu J, et al. Continuous glucose monitoring in critically ill patients with

COVID-19: results of an emergent pilot study. J Diabetes Sci Technol 2020;14:1065–1073
57. Galindo RJ, Aleppo G, Klonoff DC, et al. Implementation of continuous glucose monitoring in the hospital: emergent considerations for remote glucose monitoring during the COVID-19 pandemic. J Diabetes Sci Technol 2020; 14:822–832
58. Agarwal S, Mathew J, Davis GM, et al. continuous glucose monitoring in the intensive care unit during the COVID-19 pandemic. Diabetes Care 2021;44:847–849
59. Faulds ER, Jones L, McNett M, et al. Facilitators and barriers to nursing implementation of continuous glucose monitoring (CGM) in critically ill patients with COVID-19. Endocr Pract 2021; 27:354–361
60. Longo RR, Elias H, Khan M, Seley JJ. Use and accuracy of inpatient CGM during the COVID-19 pandemic: an observational study of general medicine and ICU patients. J Diabetes Sci Technol 2021;16:1136–1143
61. Davis GM, Spanakis EK, Migdal AL, et al. Accuracy of Dexcom G6 continuous glucose monitoring in non-critically ill hospitalized patients with diabetes. Diabetes Care 2021;44:1641–1646
62. Baker M, Musselman ME, Rogers R, Hellman R. Practical implementation of remote continuous glucose monitoring in hospitalized patients with diabetes. Am J Health Syst Pharm 2022;79: 452–458
63. Wright JJ, Williams AJ, Friedman SB, et al. Accuracy of continuous glucose monitors for inpatient diabetes management. J Diabetes Sci Technol. 7 February 2022 [Epub ahead of print]. DOI: 10.1177/19322968221076562
64. Braithwaite SS, Clark LP, Idrees T, Qureshi F, Soetan OT. hypoglycemia prevention by algorithm design during intravenous insulin infusion. Curr Diab Rep 2018;18:26
65. Maynard G, Wesorick DH, O'Malley C; Society of Hospital Medicine Glycemic Control Task Force. Subcutaneous insulin order sets and protocols: effective design and implementation strategies. J Hosp Med 2008;3(Suppl.):29–41
66. Brown KE, Hertig JB. Determining current insulin pen use practices and errors in the inpatient setting. Jt Comm J Qual Patient Saf 2016;42:568–575, AP1–AP7
67. Horne J, Bond R, Sarangarm P. Comparison of inpatient glycemic control with insulin vials versus insulin pens in general medicine patients. Hosp Pharm 2015;50:514–521
68. Veronesi G, Poerio CS, Braus A, et al. Determinants of nurse satisfaction using insulin pen devices with safety needles: an exploratory factor analysis. Clin Diabetes Endocrinol 2015;1:15
69. Najmi U, Haque WZ, Ansari U, et al. Inpatient insulin pen implementation, waste, and potential cost savings: a community hospital experience. J Diabetes Sci Technol 2021;15:741–747
70. U.S. Food and Drug Administration. FDA Drug Safety Communication: FDA requires label warnings to prohibit sharing of multi-dose diabetes pen devices among patients. Accessed 23 October 2022. Available from https://www.fda.gov/Drugs/DrugSafety/ucm435271.htm
71. Bueno E, Benitez A, Rufinelli JV, et al. Basal-bolus regimen with insulin analogues versus human insulin in medical patients with type 2 diabetes: a randomized controlled trial in Latin America. Endocr Pract 2015;21:807–813
72. Dhatariya K, Corsino L, Umpierrez GE. Management of diabetes and hyperglycemia in hospitalized patients. In: Feingold KR, Anawalt B, Boyce A, et al., Eds. Endotext. South Dartmouth, MA, MDText.com, Inc. Accessed 30 August 2022. Available from https://www.ncbi.nlm.nih.gov/books/NBK279093/
73. Sadhu AR, Patham B, Vadhariya A, Chikermane SG, Johnson ML. Outcomes of "real-world" insulin strategies in the management of hospital hyperglycemia. J Endocr Soc 2021; 5:bvab101
74. Umpierrez GE, Smiley D, Jacobs S, et al. Randomized study of basal-bolus insulin therapy in the inpatient management of patients with type 2 diabetes undergoing general surgery (RABBIT 2 surgery). Diabetes Care 2011;34:256–261
75. Colunga-Lozano LE, Gonzalez Torres FJ, Delgado-Figueroa N, et al. Sliding scale insulin for non-critically ill hospitalised adults with diabetes mellitus. Cochrane Database Syst Rev 2018;11:CD011296
76. Migdal AL, Fortin-Leung C, Pasquel F, Wang H, Peng L, Umpierrez GE. Inpatient glycemic control with sliding scale insulin in noncritical patients with type 2 diabetes: who can slide? J Hosp Med 2021;16:462–468
77. Giugliano D, Chiodini P, Maiorino MI, Bellastella G, Esposito K. Intensification of insulin therapy with basal-bolus or premixed insulin regimens in type 2 diabetes: a systematic review and meta-analysis of randomized controlled trials. Endocrine 2016;51:417–428
78. Bellido V, Suarez L, Rodriguez MG, et al. Comparison of basal-bolus and premixed insulin regimens in hospitalized patients with type 2 diabetes. Diabetes Care 2015;38:2211–2216
79. Baldwin D, Zander J, Munoz C, et al. A randomized trial of two weight-based doses of insulin glargine and glulisine in hospitalized subjects with type 2 diabetes and renal insufficiency. Diabetes Care 2012;35:1970–1974
80. Iyengar R, Franzese J, Gianchandani R. Inpatient glycemic management in the setting of renal insufficiency/failure/dialysis. Curr Diab Rep 2018;18:75
81. Shomali ME, Herr DL, Hill PC, Pehlivanova M, Sharretts JM, Magee MF. Conversion from intravenous insulin to subcutaneous insulin after cardiovascular surgery: transition to target study. Diabetes Technol Ther 2011;13:121–126
82. Draznin B. Transitioning from intravenous to subcutaneous insulin. In *Managing Diabetes and Hyperglycemia in the Hospital Setting.* Alexandria, VA, American Diabetes Association, 2016, p. 115–128
83. Hsia E, Seggelke S, Gibbs J, et al. Subcutaneous administration of glargine to diabetic patients receiving insulin infusion prevents rebound hyperglycemia. J Clin Endocrinol Metab 2012;97:3132–3137
84. Lim Y, Ohn JH, Jeong J, et al. Effect of the concomitant use of subcutaneous basal insulin and intravenous insulin infusion in the treatment of severe hyperglycemic patients. Endocrinol Metab (Seoul) 2022;37:444–454
85. Tripathy PR, Lansang MC. U-500 regular insulin use in hospitalized patients. Endocr Pract 2015;21:54–58
86. Lansang MC, Umpierrez GE. Inpatient hyperglycemia management: a practical review for primary medical and surgical teams. Cleve Clin J Med 2016;83(Suppl. 1):S34–S43
87. Umpierrez GE, Gianchandani R, Smiley D, et al. Safety and efficacy of sitagliptin therapy for the inpatient management of general medicine and surgery patients with type 2 diabetes: a pilot, randomized, controlled study. Diabetes Care 2013; 36:3430–3435
88. Pasquel FJ, Fayfman M, Umpierrez GE. Debate on insulin vs non-insulin use in the hospital setting-is it time to revise the guidelines for the management of inpatient diabetes? Curr Diab Rep 2019;19:65
89. Pasquel FJ, Lansang MC, Dhatariya K, Umpierrez GE. Management of diabetes and hyperglycaemia in the hospital. Lancet Diabetes Endocrinol 2021;9:174–188
90. Fushimi N, Shibuya T, Yoshida Y, Ito S, Hachiya H, Mori A. Dulaglutide-combined basal plus correction insulin therapy contributes to ideal glycemic control in non-critical hospitalized patients. J Diabetes Investig 2020;11:125–131
91. Fayfman M, Galindo RJ, Rubin DJ, et al. A randomized controlled trial on the safety and efficacy of exenatide therapy for the inpatient management of general medicine and surgery patients with type 2 diabetes. Diabetes Care 2019;42:450–456
92. Pérez-Belmonte LM, Osuna-Sánchez J, Millán-Gómez M, et al. Glycaemic efficacy and safety of linagliptin for the management of non-cardiac surgery patients with type 2 diabetes in a real-world setting: Lina-Surg study. Ann Med 2019;51:252–261
93. Vellanki P, Rasouli N, Baldwin D, et al. Glycaemic efficacy and safety of linagliptin compared to basal-bolus insulin regimen in patients with type 2 diabetes undergoing non-cardiac surgery: a multicenter randomized clinical trial. Diabetes Obes Metab 2019;21:837–843
94. U.S. Food and Drug Administration. FDA Drug Safety Communication: FDA adds warnings about heart failure risk to labels of type 2 diabetes medicines containing saxagliptin and alogliptin. Accessed 23 October 2022. Available from https://www.fda.gov/Drugs/DrugSafety/ucm486096.htm
95. Levine JA, Karam SL, Aleppo G. SGLT2-I in the hospital setting: diabetic ketoacidosis and other benefits and concerns. Curr Diab Rep 2017;17:54
96. U.S. Food and Drug Administration. FDA revises labels of SGLT2 inhibitors for diabetes to include warnings about too much acid in the blood and serious urinary tract infections. Accessed 30 August 2022. Available from https://www.fda.gov/drugs/drug-safety-and-availability/fda-revises-labels-sglt2-inhibitors-diabetes-include-warnings-about-too-much-acid-blood-and-serious
97. Akirov A, Grossman A, Shochat T, Shimon I. Mortality among hospitalized patients with hypoglycemia: insulin related and noninsulin related. J Clin Endocrinol Metab 2017;102:416–424
98. Ilcewicz HN, Hennessey EK, Smith CB. Evaluation of the impact of an inpatient hyperglycemia protocol on glycemic control. J Pharm Pharm Sci 2019;22:85–92
99. Sinha Gregory N, Seley JJ, Gerber LM, Tang C, Brillon D. Decreased rates of hypoglycemia following implementation of a comprehensive computerized insulin order set and titration

algorithm in the inpatient setting. Hosp Pract (1995) 2016;44:260–265
100. Amori RE, Pittas AG, Siegel RD, et al. Inpatient medical errors involving glucose-lowering medications and their impact on patients: review of 2,598 incidents from a voluntary electronic error-reporting database. Endocr Pract 2008;14:535–542
101. Alwan D, Chipps E, Yen PY, Dungan K. Evaluation of the timing and coordination of prandial insulin administration in the hospital. Diabetes Res Clin Pract 2017;131:18–32
102. Korytkowski M, Dinardo M, Donihi AC, Bigi L, Devita M. Evolution of a diabetes inpatient safety committee. Endocr Pract 2006;12(Suppl. 3):91–99
103. Hung AM, Siew ED, Wilson OD, et al. Risk of hypoglycemia following hospital discharge in patients with diabetes and acute kidney injury. Diabetes Care 2018;41:503–512
104. Maynard G, Kulasa K, Ramos P, et al. Impact of a hypoglycemia reduction bundle and a systems approach to inpatient glycemic management. Endocr Pract 2015;21:355–367
105. Milligan PE, Bocox MC, Pratt E, Hoehner CM, Krettek JE, Dunagan WC. Multifaceted approach to reducing occurrence of severe hypoglycemia in a large healthcare system. Am J Health Syst Pharm 2015;72:1631–1641
106. Umpierrez G, Korytkowski M. Diabetic emergencies - ketoacidosis, hyperglycaemic hyperosmolar state and hypoglycaemia. Nat Rev Endocrinol 2016;12:222–232
107. Galindo RJ, Umpierrez GE, Rushakoff RJ, et al. Continuous glucose monitors and automated insulin dosing systems in the hospital consensus guideline. J Diabetes Sci Technol 2020;14:1035–1064
108. Dagogo-Jack S. Hypoglycemia in type 1 diabetes mellitus: pathophysiology and prevention. Treat Endocrinol 2004;3:91–103
109. Rickels MR. Hypoglycemia-associated autonomic failure, counterregulatory responses, and therapeutic options in type 1 diabetes. Ann N Y Acad Sci 2019;1454:68–79
110. Dendy JA, Chockalingam V, Tirumalasetty NN, et al. Identifying risk factors for severe hypoglycemia in hospitalized patients with diabetes. Endocr Pract 2014;20:1051–1056
111. Ulmer BJ, Kara A, Mariash CN. Temporal occurrences and recurrence patterns of hypoglycemia during hospitalization. Endocr Pract 2015;21:501–507
112. Shah BR, Walji S, Kiss A, James JE, Lowe JM. Derivation and validation of a risk-prediction tool for hypoglycemia in hospitalized adults with diabetes: the Hypoglycemia During Hospitalization (HyDHo) score. Can J Diabetes 2019;43:278–282.e1
113. Mathioudakis NN, Everett E, Routh S, et al. Development and validation of a prediction model for insulin-associated hypoglycemia in non-critically ill hospitalized adults. BMJ Open Diabetes Res Care 2018;6:e000499
114. Curll M, Dinardo M, Noschese M, Korytkowski MT. Menu selection, glycaemic control and satisfaction with standard and patient-controlled consistent carbohydrate meal plans in hospitalised patients with diabetes. Qual Saf Health Care 2010;19:355–359
115. Drincic AT, Knezevich JT, Akkireddy P. Nutrition and hyperglycemia management in the inpatient setting (meals on demand, parenteral, or enteral nutrition). Curr Diab Rep 2017;17:59
116. Draznin B. Food, fasting, insulin, and glycemic control in the hospital. In *Managing Diabetes and Hyperglycemia in the Hospital Setting.* Alexandria, VA, American Diabetes Association, 2016, p. 70–83
117. Mabrey ME, Setji TL. Patient self-management of diabetes care in the inpatient setting: pro. J Diabetes Sci Technol 2015;9:1152–1154
118. Shah AD, Rushakoff RJ. Patient self-management of diabetes care in the inpatient setting: con. J Diabetes Sci Technol 2015;9:1155–1157
119. Yeh T, Yeung M, Mendelsohn Curanaj FA. Managing patients with insulin pumps and continuous glucose monitors in the hospital: to wear or not to wear. Curr Diab Rep 2021;21:7
120. Umpierrez GE, Klonoff DC. Diabetes technology update: use of insulin pumps and continuous glucose monitoring in the hospital. Diabetes Care 2018;41:1579–1589
121. Houlden RL, Moore S. In-hospital management of adults using insulin pump therapy. Can J Diabetes 2014;38:126–133
122. Korytkowski MT, Salata RJ, Koerbel GL, et al. Insulin therapy and glycemic control in hospitalized patients with diabetes during enteral nutrition therapy: a randomized controlled clinical trial. Diabetes Care 2009;32:594–596
123. Hsia E, Seggelke SA, Gibbs J, Rasouli N, Draznin B. Comparison of 70/30 biphasic insulin with glargine/lispro regimen in non-critically ill diabetic patients on continuous enteral nutrition therapy. Nutr Clin Pract 2011;26:714–717
124. Olveira G, Abuín J, López R, et al. Regular insulin added to total parenteral nutrition vs subcutaneous glargine in non-critically ill diabetic inpatients, a multicenter randomized clinical trial: INSUPAR trial. Clin Nutr 2020;39:388–394
125. Draznin B. Glycemic control in the setting of parenteral or enteral nutrition via tube feeding. In *Managing Diabetes and Hyperglycemia in the Hospital Setting.* Alexandria, VA, American Diabetes Association, 2016, p. 84–98
126. Pichardo-Lowden AR, Fan CY, Gabbay RA. Management of hyperglycemia in the non-intensive care patient: featuring subcutaneous insulin protocols. Endocr Pract 2011;17:249–260
127. Donihi AC, Raval D, Saul M, Korytkowski MT, DeVita MA. Prevalence and predictors of corticosteroid-related hyperglycemia in hospitalized patients. Endocr Pract 2006;12:358–362
128. Roberts A, James J; Joint British Diabetes Societies (JBDS) for Inpatient Care. Management of hyperglycaemia and steroid (glucocorticoid) therapy: a guideline from the Joint British Diabetes Societies (JBDS) for Inpatient Care Group. Diabet Med 2018;35:1011–1017
129. Kwon S, Hermayer KL, Hermayer K. Glucocorticoid-induced hyperglycemia. Am J Med Sci 2013;345:274–277
130. Seggelke SA, Gibbs J, Draznin B. Pilot study of using neutral protamine Hagedorn insulin to counteract the effect of methylprednisolone in hospitalized patients with diabetes. J Hosp Med 2011;6:175–176
131. Brady V, Thosani S, Zhou S, Bassett R, Busaidy NL, Lavis V. Safe and effective dosing of basal-bolus insulin in patients receiving high-dose steroids for hyper-cyclophosphamide, doxorubicin, vincristine, and dexamethasone chemotherapy. Diabetes Technol Ther 2014;16:874–879
132. Cheng YC, Guerra Y, Morkos M, et al. Insulin management in hospitalized patients with diabetes mellitus on high-dose glucocorticoids: management of steroid-exacerbated hyperglycemia. PLoS One 2021;16:e0256682
133. Bajaj MA, Zale AD, Morgenlander WR, Abusamaan MS, Mathioudakis N. Insulin dosing and glycemic outcomes among steroid-treated hospitalized patients. Endocr Pract 2022;28:774–779
134. Todd LA, Vigersky RA. Evaluating perioperative glycemic control of non-cardiac surgical patients with diabetes. Mil Med 2021;186:e867–e872
135. Aronson S, Murray S, Martin G, et al.; Perioperative Enhancement Team (POET). Roadmap for transforming preoperative assessment to preoperative optimization. Anesth Analg 2020;130:811–819
136. Smiley DD, Umpierrez GE. Perioperative glucose control in the diabetic or nondiabetic patient. South Med J 2006;99:580–589; quiz 590–591
137. Buchleitner AM, Martínez-Alonso M, Hernández M, Solà I, Mauricio D. Perioperative glycaemic control for diabetic patients undergoing surgery. Cochrane Database Syst Rev 2012;9:CD007315
138. Draznin B. Preoperative, intraoperative, and postoperative glucose management. In *Managing Diabetes and Hyperglycemia in the Hospital Setting.* Alexandria, VA, American Diabetes Association, 2016, p. 129–144
139. Duggan EW, Carlson K, Umpierrez GE. Perioperative hyperglycemia management: an update. Anesthesiology 2017;126:547–560
140. Han HS, Kang SB. Relations between long-term glycemic control and postoperative wound and infectious complications after total knee arthroplasty in type 2 diabetics. Clin Orthop Surg 2013;5:118–123
141. Demma LJ, Carlson KT, Duggan EW, Morrow JG 3rd, Umpierrez G. Effect of basal insulin dosage on blood glucose concentration in ambulatory surgery patients with type 2 diabetes. J Clin Anesth 2017;36:184–188
142. Umpierrez GE, Smiley D, Hermayer K, et al. Randomized study comparing a Basal-bolus with a basal plus correction insulin regimen for the hospital management of medical and surgical patients with type 2 diabetes: basal plus trial. Diabetes Care 2013;36:2169–2174
143. Harrison VS, Rustico S, Palladino AA, Ferrara C, Hawkes CP. Glargine co-administration with intravenous insulin in pediatric diabetic ketoacidosis is safe and facilitates transition to a subcutaneous regimen. Pediatr Diabetes 2017;18:742–748
144. Kitabchi AE, Umpierrez GE, Miles JM, Fisher JN. Hyperglycemic crises in adult patients with diabetes. Diabetes Care 2009;32:1335–1343
145. Vellanki P, Umpierrez GE. Diabetic ketoacidosis: a common debut of diabetes among african americans with type 2 diabetes. Endocr Pract 2017;23:971–978
146. Andrade-Castellanos CA, Colunga-Lozano LE, Delgado-Figueroa N, Gonzalez-Padilla DA. Subcutaneous rapid-acting insulin analogues for diabetic ketoacidosis. Cochrane Database Syst Rev 2016;1:CD011281

147. Kitabchi AE, Umpierrez GE, Fisher JN, Murphy MB, Stentz FB. Thirty years of personal experience in hyperglycemic crises: diabetic ketoacidosis and hyperglycemic hyperosmolar state. J Clin Endocrinol Metab 2008;93:1541–1552
148. Karajgikar ND, Manroa P, Acharya R, et al. Addressing pitfalls in management of diabetic ketoacidosis with a standardized protocol. Endocr Pract 2019;25:407–412
149. Dhatariya KK, Glaser NS, Codner E, Umpierrez GE. Diabetic ketoacidosis. Nat Rev Dis Primers 2020;6:40
150. Shepperd S, Lannin NA, Clemson LM, McCluskey A, Cameron ID, Barras SL. Discharge planning from hospital to home. Cochrane Database Syst Rev 1996;1:CD000313
151. Gregory NS, Seley JJ, Dargar SK, Galla N, Gerber LM, Lee JI. Strategies to prevent readmission in high-risk patients with diabetes: the importance of an interdisciplinary approach. Curr Diab Rep 2018;18:54
152. Rinaldi A, Snider M, James A, et al. The impact of a diabetes transitions of care clinic on hospital utilization and patient care. Ann Pharmacother. 9 June 2022 [Epub ahead of print]. DOI: 10.1177/10600280221102557
153. Patel N, Swami J, Pinkhasova D, et al. Sex differences in glycemic measures, complications, discharge disposition, and postdischarge emergency room visits and readmission among non-critically ill, hospitalized patients with diabetes. BMJ Open Diabetes Res Care 2022;10:e002722
154. Agency for Healthcare Research and Quality. Patient Safety Network – Readmissions and adverse events after discharge, 2019. Accessed 23 October 2022. Available from https://psnet.ahrq.gov/primer.aspx?primerID=11
155. Rubin DJ. Hospital readmission of patients with diabetes. Curr Diab Rep 2015;15:17
156. Jiang HJ, Stryer D, Friedman B, Andrews R. Multiple hospitalizations for patients with diabetes. Diabetes Care 2003;26:1421–1426
157. Maldonado MR, D'Amico S, Rodriguez L, Iyer D, Balasubramanyam A. Improved outcomes in indigent patients with ketosis-prone diabetes: effect of a dedicated diabetes treatment unit. Endocr Pract 2003;9:26–32
158. Wu EQ, Zhou S, Yu A, Lu M, Sharma H, Gill J, et al. Outcomes associated with post-discharge insulin continuity in US patients with type 2 diabetes mellitus initiating insulin in the hospital. Hosp Pract (1995) 2012;40:40–48
159. Hirschman KB, Bixby MB. Transitions in care from the hospital to home for patients with diabetes. Diabetes Spectr 2014;27:192–195
160. Tuttle KR, Bakris GL, Bilous RW, et al. Diabetic kidney disease: a report from an ADA Consensus Conference. Diabetes Care 2014;37:2864–2883
161. Rubin DJ, Recco D, Turchin A, Zhao H, Golden SH. External Validation Of The Diabetes Early Re-Admission Risk Indicator (Derri). Endocr Pract 2018;24:527–541