



American Diabetes Association

## 13. Diabetes Care in the Hospital

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### Recommendations

- Consider performing an A1C on all patients with diabetes or hyperglycemia admitted to the hospital if not performed in the prior 3 months. **C**
- Insulin therapy should be initiated for treatment of persistent hyperglycemia starting at a threshold  $\geq 180$  mg/dL (10.0 mmol/L). Once insulin therapy is started, a target glucose range of 140–180 mg/dL (7.8–10.0 mmol/L) is recommended for the majority of critically ill patients **A** and noncritically ill patients. **C**
- More stringent goals, such as 110–140 mg/dL (6.1–7.8 mmol/L) may be appropriate for selected critically ill patients, as long as this can be achieved without significant hypoglycemia. **C**
- Intravenous insulin infusions should be administered using validated written or computerized protocols that allow for predefined adjustments in the insulin infusion rate based on glycemic fluctuations and insulin dose. **E**
- A basal plus bolus correction insulin regimen is the preferred treatment for noncritically ill patients with poor oral intake or those who are taking nothing by mouth. An insulin regimen with basal, nutritional, and correction components is the preferred treatment for patients with good nutritional intake. **A**
- The sole use of sliding scale insulin in the inpatient hospital setting is strongly discouraged. **A**
- 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 patient. Episodes of hypoglycemia in the hospital should be documented in the medical record and tracked. **E**
- The treatment regimen should be reviewed and changed if necessary to prevent further hypoglycemia when a blood glucose value is  $< 70$  mg/dL (3.9 mmol/L). **C**
- There should be a structured discharge plan tailored to the individual patient. **B**

Both hyperglycemia and hypoglycemia are associated with adverse outcomes, including death (1,2). Therefore, hospital goals for the patient with diabetes include preventing both hyperglycemia and hypoglycemia, promoting the shortest safe hospital stay, and providing an effective transition out of the hospital that prevents complications and readmission.

High-quality hospital care requires both hospital care delivery standards, often assured by structured order sets, and quality assurance standards for process improvement.

### HOSPITAL CARE DELIVERY STANDARDS

“Best practice” protocols, reviews, and guidelines (2) are inconsistently implemented within hospitals. To correct this, hospitals have established protocols for structured patient care and structured order sets, which include computerized physician order entry (CPOE).

### Computerized Physician Order Entry

In 2009, the federal Health Information Technology for Economic and Clinical Health (HITECH) Act was enacted. A core requirement for stage 1 of the HITECH Act’s “meaningful use” included CPOE. The Institute of Medicine also recommends CPOE to prevent medication-related errors and increase efficiency in medication administration (3). A Cochrane review of randomized controlled trials using computerized advice to improve glucose control in the hospital found significant improvement in percentage of time in target glucose range, lower mean blood glucose, and no increase in hypoglycemia (4). As hospitals move to comply with “meaningful

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use,” efforts should be made to ensure that all components of structured insulin order sets are incorporated in the orders (5). Thus, where feasible, there should be routine structured order sets that produce computerized advice for glucose control.

### CONSIDERATIONS ON ADMISSION

Initial orders should state that the patient has type 1 diabetes or type 2 diabetes or no previous history of diabetes. If the patient has diabetes, an order for an A1C should be placed if none is available within the prior 3 months (2). In addition, diabetes self-management education should be ordered and should include appropriate skills needed after discharge, such as taking glycemic medication, glucose monitoring, and coping with hypoglycemia (2).

### GLYCEMIC TARGETS IN HOSPITALIZED PATIENTS

#### Standard Definition of Glucose Abnormalities

Hyperglycemia in hospitalized patients has been defined as blood glucose >140 mg/dL (7.8 mmol/L). Blood glucose levels that are significantly and persistently above this level require reassessing treatment. An admission A1C value  $\geq 6.5\%$  (48 mmol/mol) suggests that diabetes preceded hospitalization (see Section 2 “Classification and Diagnosis of Diabetes”). Hypoglycemia in hospitalized patients has been defined as blood glucose <70 mg/dL (3.9 mmol/L) and severe hypoglycemia as <40 mg/dL (2.2 mmol/L) (6).

#### Moderate Versus Tight Glycemic Control

Glycemic goals within the hospital setting have changed in the last 14 years. The initial target of 80–110 mg/dL (4.4–6.1 mmol/L) was based on a 42% relative reduction in intensive care unit mortality in critically ill surgical patients (7). However, a meta-analysis of over 26 studies, including the largest, Normoglycemia in Intensive Care Evaluation–Survival Using Glucose Algorithm Regulation (NICE-SUGAR), showed increased rates of severe hypoglycemia and mortality in tightly versus moderately controlled cohorts (8). This evidence established new standards: initiate insulin therapy for persistent hyperglycemia greater than 180 mg/dL (10.0 mmol/L). Once

insulin therapy is initiated, a glucose target of 140–180 mg/dL (7.8–10.0 mmol/L) is recommended for most critically ill patients (2). More stringent goals, such as 110–140 mg/dL (6.1–7.8 mmol/L) may be appropriate for select patients, such as cardiac surgery patients (7), and patients with acute ischemic cardiac (9) or neurological events provided the targets can be achieved without significant hypoglycemia.

A glucose target between 140 and 180 mg/dL (between 7.8 and 10.0 mmol/L) is recommended for most patients in noncritical care units (2). Patients with a prior history of successful tight glycemic control in the outpatient setting who are clinically stable may be maintained with a glucose target below 140 mg/dL (7.8 mmol/L). Conversely, higher glucose ranges may be acceptable in terminally ill patients, in patients with severe comorbidities, and in in-patient care settings where frequent glucose monitoring or close nursing supervision is not feasible.

Clinical judgment combined with ongoing assessment of the patient’s 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), should be incorporated into the day-to-day decisions regarding insulin doses (2).

### ANTIHYPERGLYCEMIC AGENTS IN HOSPITALIZED PATIENTS

In most instances in the hospital setting, insulin is the preferred treatment for glycemic control (2). However, in certain circumstances, it may be appropriate to continue home regimens including oral antihyperglycemic medications (10). If oral medications are held in the hospital, there should be a protocol for resuming them 1–2 days before discharge.

#### Insulin Therapy

*The sole use of sliding scale insulin in the inpatient hospital setting is strongly discouraged (2,11).*

#### Critical Care Setting

In the critical care setting, continuous intravenous insulin infusion has been shown to be the best method for achieving glycemic targets. 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 (2,12).

#### Noncritical Care Setting

Outside of critical care units, scheduled subcutaneous insulin injections should align with meals and bedtime or every 4–6 h if no meals or if continuous enteral/parenteral therapy is used (2). A basal plus correction insulin regimen is the preferred treatment for patients with poor oral intake or those who are taking nothing by mouth (NPO) (13). An insulin regimen with basal, nutritional, and correction components (basal–bolus) is the preferred treatment for patients with good nutritional intake (10). In such instances, point-of-care (POC) glucose testing should be performed immediately before meals.

If oral intake is poor, a safer procedure is to administer the short-acting insulin after the patient eats or to count the carbohydrates and cover the amount ingested. A randomized controlled trial has shown that basal–bolus treatment improved glycemic control and reduced hospital complications compared with sliding scale insulin in general surgery patients with type 2 diabetes (14).

#### Type 1 Diabetes

For patients with type 1 diabetes, dosing insulin based solely on premeal glucose levels does not account for basal insulin requirements or calorie intake, increasing both hypoglycemia and hyperglycemia risks and potentially leading to diabetic ketoacidosis (DKA). Typically basal insulin dosing schemes are based on body weight, with some evidence that patients with renal insufficiency should be treated with lower doses (15).

#### Transitioning Intravenous to Subcutaneous Insulin

When discontinuing intravenous insulin, a transition protocol is associated with less morbidity and lower costs of care (16) and is therefore recommended. A patient with type 1 or type 2 diabetes being transitioned to outpatient subcutaneous insulin should receive subcutaneous insulin 1–2 h before the intravenous insulin is discontinued. Converting to basal insulin at 60–80% of the daily infusion dose has been shown to be effective (2,16,17).

#### Noninsulin Therapies

The safety and efficacy of noninsulin antihyperglycemic therapies in the hospital

setting is an area of active research. A recent randomized pilot trial in general medicine and surgery patients reported that a dipeptidyl peptidase 4 inhibitor alone or in combination with basal insulin was well tolerated and resulted in similar glucose control and frequency of hypoglycemia compared with a basal-bolus regimen (18). A report suggested that given the serious consequences of hypoglycemia, incretin agents, which do not cause hypoglycemia, may substitute for insulin, sulfonylureas, or metformin (19). A review of several studies concluded that incretins show promise; however, proof of safety and efficacy compared with standard therapies await the results of further randomized controlled trials (20).

**STANDARDS FOR SPECIAL SITUATIONS**

**Enteral/Parenteral Feedings**

For full enteral/parenteral feeding guidance, the reader is encouraged to consult review articles (2,21) and see **Table 13.1**.

**Glucocorticoid Therapy**

The duration of glucocorticoid action must be considered to prevent hyperglycemia. Once-a-day short-acting steroids such as prednisone peak in about 8 h, so coverage with intermediate-acting insulin (NPH) may be sufficient. For long-acting steroids such as dexamethasone or multidose or continuous steroid use, long-acting insulin may be used (10,21). Whatever orders are started, adjustments based on POC glucose test results are critical.

**Perioperative Care**

Standards for perioperative care include the following:

1. Target glucose range for the perioperative period should be 80–180 mg/dL (4.4–10.0 mmol/L).

2. Preoperative risk assessment for patients at high risk for ischemic heart disease and those with autonomic neuropathy or renal failure.
3. The morning of surgery or procedure, hold any oral hypoglycemic agents and give half of NPH dose or full doses of a long-acting analog or pump basal insulin.
4. Monitor blood glucose every 4–6 h while NPO and dose with short-acting insulin as needed.

A review found that tight perioperative glycemic control did not improve outcomes and was associated with more hypoglycemia (22); therefore, in general, tighter glycemic targets than mentioned above are not advised.

**Moderate Versus Tight Glycemic Control Targets**

In general surgery (noncardiac) patients, basal insulin plus premeal regular or short-acting insulin (basal-bolus) coverage has been associated with improved glycemic control and lower rates of perioperative complications compared with the traditional sliding scale regimen (regular or short-acting insulin coverage only with no basal dosing) (13,14).

**Diabetic Ketoacidosis and Hyperosmolar Hyperglycemic State**

There is considerable variability in the presentation of DKA and hyperosmolar hyperglycemic state, ranging from euglycemia or mild hyperglycemia and acidosis to severe hyperglycemia, dehydration, and coma; therefore, treatment individualization based on a careful clinical and laboratory assessment is needed (23).

Management goals include restoration of circulatory volume and tissue perfusion, resolution of hyperglycemia, and correction of electrolyte imbalance and ketosis. It is also important to treat

any correctable underlying cause of DKA, such as sepsis. Low-dose insulin, given intravenously, intramuscularly, or subcutaneously, is safe and effective in treating DKA (23).

Several studies have shown that in uncomplicated mild-to-moderate DKA, subcutaneous lispro (24) or aspart insulin (25) dosed every 1–2 h is as effective and safe as intravenous regular insulin when used in conjunction with standard intravenous fluid and potassium replacement protocols (23). If subcutaneous administration is used, it is important, for safety reasons, to provide adequate nursing training and care and frequent bedside testing. However, in critically ill and mentally obtunded patients, continuous intravenous insulin infusion is required. Several studies have shown that the use of bicarbonate in patients with DKA made no difference in resolution of acidosis or time to discharge, and its use is generally not recommended (26).

**Continuous Glucose Monitoring**

Continuous glucose monitoring (CGM) provides continuous estimates, direction, and magnitude of glucose trends, which may have an advantage over POC glucose testing in detecting and reducing the incidence of hypoglycemia. Several studies have shown that CGM use did not improve glucose control, but detected a greater number of hypoglycemic events than POC testing. A recent review has recommended against using CGM in adults in a hospital setting until more safety and efficacy data become available (27).

**TREATING AND PREVENTING HYPOGLYCEMIA**

Patients with or without diabetes may experience hypoglycemia in the hospital setting. While increased mortality is associated with hypoglycemia, it may be a marker of underlying disease rather than the cause of increased mortality. However, until it is proven not to be causal, it is prudent to avoid hypoglycemia. Despite the preventable nature of many inpatient episodes of hypoglycemia, institutions are more likely to have nursing protocols for hypoglycemia treatment than for its prevention when both are needed.

**Triggering Events**

Iatrogenic hypoglycemia triggers may include sudden reduction of corticosteroid dose, altered ability of the patient to

**Table 13.1—Insulin dosing for enteral/parenteral feedings**

Situation	Basal	Bolus
Continuous enteral feedings	Glargine q.d. or NPH/detemir b.i.d.	SQ rapid-acting correction every 4 h
Bolus enteral feedings	Continue prior basal; if none, consider 10 units NPH or glargine insulin	SQ rapid-acting insulin with each bolus feeding to cover the bolus feeding and to correct for hyperglycemia
Parenteral feedings	Regular insulin to TPN IV bottle	Rapid-acting insulin SQ every 4 h to correct for hyperglycemia

IV, intravenous; SQ, subcutaneous; TPN, total parenteral nutrition.

report symptoms, reduced oral intake, emesis, new NPO status, inappropriate timing of short-acting insulin in relation to meals, reduced infusion rate of intravenous dextrose, and unexpected interruption of oral, enteral, or parenteral feedings.

#### Predictors of Hypoglycemia

In one study, 84% of patients with an episode of severe hypoglycemia (<40 mg/dL [2.2 mmol/L]) had a prior episode of hypoglycemia (<70 mg/dL [3.9 mmol/L]) during the same admission (28). In another study of hypoglycemic episodes (<50 mg/dL [2.8 mmol/L]), 78% of patients were using basal insulin, with the incidence of hypoglycemia peaking between midnight and 6 A.M. Despite recognition of hypoglycemia, 75% of patients did not have their dose of basal insulin changed before the next insulin administration (29).

#### Hypoglycemia Treatment

There should be a standardized hospital-wide, nurse-initiated hypoglycemia treatment protocol to immediately address hypoglycemia (<70 mg/dL [3.9 mmol/L]) (2).

#### Prevention

Common preventable sources of iatrogenic hypoglycemia are improper prescribing of hypoglycemic medications, inappropriate management of the first episode of hypoglycemia, and nutrition–insulin mismatch, often related to an unexpected interruption of nutrition. A study of “bundled” preventative 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, the study found that the relative risk of a severe hypoglycemic event was 0.44 (95% CI 0.34–0.58) in the postintervention period (30).

#### Hospital Hypoglycemia Prevention and Treatment

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. An American Diabetes Association (ADA) hypoglycemia consensus report suggested that the treatment regimen be reviewed when a blood glucose value is <70 mg/dL (3.9 mmol/L), a

hypoglycemia protocol be adopted and implemented in each hospital system, and all episodes should be tracked in the medical records (2).

#### SELF-MANAGEMENT IN THE HOSPITAL

Diabetes self-management in the hospital may be appropriate for select youth and adult patients. Candidates include patients who successfully conduct self-management of diabetes at home, have the cognitive and physical skills needed to successfully self-administer insulin, and perform self-monitoring of blood glucose. In addition, they should have adequate oral intake, be proficient in carbohydrate estimation, use multiple daily insulin injections or continuous subcutaneous insulin infusion (CSII) pump therapy, have stable insulin requirements, and understand sick-day management. If self-management is to be used, a protocol should include a requirement that the patient, nursing staff, and physician agree that patient self-management is appropriate. If CSII is to be used, hospital policy and procedures delineating guidelines for CSII therapy are advised (31).

#### MEDICAL NUTRITION THERAPY IN THE HOSPITAL

The goals of medical nutrition therapy are to optimize glycemic control, provide adequate calories to meet metabolic demands, address personal food preferences, and create a discharge plan. The ADA does not endorse any single meal plan or specified percentages of macronutrients, and the term “ADA diet” should no longer be used. 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 consumed (32).

When the nutritional issues in the hospital are complex, a registered dietitian, knowledgeable and skilled in medical nutrition therapy, can serve as an individual inpatient team member. That person should be responsible for integrating information about the patient’s clinical condition, meal planning, and lifestyle habits and for establishing realistic treatment goals after discharge.

Orders should also reflect that the meal delivery and nutritional insulin coverage be matched, as their variability often creates the possibility of hyperglycemic and hypoglycemic events.

#### TRANSITION FROM THE ACUTE CARE SETTING

A Cochrane systematic review noted that a structured discharge plan tailored to the individual patient may reduce length of hospital stay, readmission rates, and increase patient satisfaction (33). Therefore, there should be a structured discharge plan tailored to each patient. Discharge planning should begin at admission and be updated as patient needs change.

Transition from the acute care setting is a risky time for all patients. Inpatients may be discharged to varied settings, including home (with or without visiting nurse services), assisted living, rehabilitation, or skilled nursing facilities. For the patient who is discharged to assisted living or to home, the optimal program will need to consider diabetes type and severity, effects of the patient’s illness on blood glucose levels, and the patient’s capacities and desires.

An outpatient follow-up visit with the primary care provider, endocrinologist, or diabetes educator within 1 month of discharge is advised for all patients having hyperglycemia in the hospital. If glycemic medications are changed or glucose control is not optimal at discharge, continuing contact may be needed to avoid hyperglycemia and hypoglycemia. A recent discharge algorithm for glycemic medication adjustment based on admission A1C found that the average A1C in patients with diabetes decreased from 8.7% (72 mmol/mol) on admission to 7.3% (56 mmol/mol) 3 months after discharge (34). Therefore, if an A1C from the prior 3 months is unavailable, measuring the A1C in all patients with diabetes or hyperglycemia admitted to the hospital is recommended.

Clear communication with outpatient providers either directly or via hospital discharge summaries facilitates safe transitions to outpatient care. Providing information regarding the cause of hyperglycemia (or the plan for determining the cause), related complications and comorbidities, and recommended

treatments can assist outpatient providers as they assume ongoing care.

The Agency for Healthcare Research and Quality (AHRQ) recommends that at a minimum, discharge plans include the following (35):

#### Medication Reconciliation

- The patient's medications must be cross-checked to ensure that no chronic medications were stopped and to ensure the safety of new prescriptions.
- Prescriptions for new or changed medication should be filled and reviewed with the patient and family 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 physicians.
- Discharge summaries should be transmitted to the primary physician as soon as possible after discharge.
- Appointment-keeping behavior is enhanced when the inpatient team schedules outpatient medical follow-up prior to discharge.

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

- Identify the health care provider who will provide diabetes care after discharge.
- Level of understanding related to the diabetes diagnosis, self-monitoring of blood glucose, and explanation of home blood glucose goals.
- Definition, recognition, treatment, and prevention of hyperglycemia and hypoglycemia.
- Information on consistent nutrition habits.
- If relevant, when and how to take blood glucose-lowering medications, including insulin administration.
- Sick-day management.
- Proper use and disposal of needles and syringes.

It is important that patients be provided with appropriate durable medical equipment, medications, supplies (e.g., insulin pens), and prescriptions along

with appropriate education at the time of discharge in order to avoid a potentially dangerous hiatus in care.

#### Quality Assurance Standards

Even the best orders may not be carried out in a way that improves quality, nor are they automatically updated when new evidence arises. To this end, the Joint Commission has an accreditation program for the hospital care of diabetes, and the Society of Hospital Medicine has a workbook for program development (36).

#### DIABETES CARE PROVIDERS IN THE HOSPITAL

Appropriately trained specialists or specialty teams may reduce length of stay, improve glycemic control, and improve outcomes, but the studies are few. A call to action outlined the studies needed to evaluate these outcomes (11). Details of team formation are available from the Society of Hospital Medicine and the Joint Commission standards for programs.

#### BEDSIDE BLOOD GLUCOSE MONITORING

##### Indications

Bedside POC blood glucose monitoring guides insulin dosing. In the patient receiving nutrition, glucose monitoring should be performed before meals to match food ingestion. In the patient not receiving nutrition, glucose monitoring is advised every 4–6 h (2). More frequent blood glucose testing ranging from every 30 min to every 2 h is required for patients receiving intravenous insulin. Safety standards should be established for blood glucose monitoring that prohibit the sharing of fingerstick lancing devices, lancets, needles, and pens to reduce the risk of transmission of blood-borne diseases.

##### Limitations in the Hospital Setting

POC meters have limitations for measuring blood glucose. Although the U.S. Food and Drug Administration (FDA) has standards for blood glucose meters used by lay persons, there have been questions about the appropriateness of these criteria, especially in the hospital and for lower blood glucose readings (37). Significant discrepancies between capillary, venous, and arterial plasma samples have been observed in patients with low or high hemoglobin concentrations and with hypoperfusion. Any glucose result that does not correlate with the patient's clinical

status should be confirmed through conventional laboratory glucose tests. The FDA established a separate category for POC glucose meters for use in health care settings and has released a draft on in-hospital use with stricter standards. Before choosing a device, consider the device's approval status and accuracy.

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