Hyperglycemia in the Hospital

modified November 2024

The information below is provided to help you prevent and treat hyperglycemia in the hospital. Most suggestions are based on expert opinion. Additional information about diabetes care can be found in the 2024 American Diabetes Association (ADA) guidelines at https://diabetesjournals.org/care/issue/47/Supplement_1.

Question	Answer/Pertinent Information

Should non-insulin diabetes medications be discontinued when a patient is admitted to the hospital?	Non-insulin antihyperglycemics may be appropriate.[1] Individualize.
	• **Sulfonylureas**: hold if no or poor nutritional intake, age 75 years or older, CrCl <30 mL/min (<50 mL/min for glyburide), body weight <75 kg, or blood glucose <70 mg/dL.[2,3] Some hospitals avoid in all patients due to risk of hypoglycemia and difficulty in titrating.[13]
	• **SGLT-2 inhibitor**: due to risk of ketoacidosis, it may be best to hold during most hospitalizations (i.e., hold for acute, severe illness).[1,6] A section below provides risk factors and tips for management of SGLT2 inhibitor-associated ketoacidosis.
	• **Metformin**:
	  • hold for eGFR <30 mL/minute/1.73 m^2 (severe renal impairment).[4,5] Consider holding if eGFR <45 mL/minute/1.73 m^2.[4,5]
	  • hold for at least 48 hrs after receipt of iodinated contrast in patients with eGFR 30 to 60 mL/min/1.73 m^2.[4,5]
	  • hold if there is laboratory or clinical evidence of liver disease or acute alcohol intoxication.[5]
	  • hold for any condition associated with hypoxemia (e.g., heart failure), dehydration, or sepsis.[5]
	• **Gliptins**: consider stopping saxagliptin or alogliptin if heart failure develops.[1]
	• **Pioglitazone**: stop in the event of symptomatic heart failure.[1]
	• **GLP-1 agonist**: gastrointestinal side effects (nausea and vomiting) could impair recovery (e.g., due to reduced oral intake), cause surgical complications, (e.g., vomiting post-coronary bypass), or be mistaken for acute problems (e.g., ileus).[13,20] Avoid.[13]
	• For patients needing surgery see our chart, *Perioperative Management of Diabetes*, for guidance on managing non-insulin diabetes medications before and after surgery.
	• If a medication is held, restart it one to two days before discharge.[1]
	• Consider re-titrating held diabetes meds to improve tolerance, particularly metformin and GLP-1 agonists.

What if the patient is admitted on an insulin pump?	• ISMP (Institute for Safe Medication Practices) recommendations for use of insulin pumps during hospitalization in general are available at: https://home.ecri.org/pages/ismp . • See our FAQ, *Inpatient Use of Ambulatory Pumps*.

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What if the patient is admitted on non-formulary insulin?	• See our chart, *How to Switch Insulin Products*, for help.
What level of hyperglycemia requires treatment in hospitalized patients?	• Treat symptomatic patients (e.g., polyuria, polydipsia), or those with ketosis.[1] • Experts recommend treating blood glucose persistently ≥180 mg/dL (10 mmol/L).[1] • Once treatment is started, consider a target of 140 to 180 mg/dL (7.8 to 10 mmol/L) for most patients [Evidence level B-1].[1,7] However, the goal must be individualized.[1] o A goal of 100 to 180 mg/dL (5.6 to 10 mmol/L) for noncritically ill patients with "new" hyperglycemia or for patients previously diagnosed with diabetes, or perioperatively, is recommended.[1] o A goal of 110 to <140 mg/dL (6.1 to <7.8 mmol/L) may be appropriate (e.g., critically ill surgical patients) if hypoglycemia can be avoided.[1] o A goal >180 mg/dL (10 mmol/L) may be appropriate for patients with limited life expectancy, the elderly, or for patients with significant comorbidities.[1,13]
Which insulin or insulin regimen should be used? *Continued…*	• Insulin infusion is preferred for critical care patients.[1] o Adjust infusion rate per protocol.[1] o Switch patients from insulin infusions to subcutaneous insulin by starting basal insulin two hours before stopping the insulin drip.[1] The dose can be based on the insulin infusion rate administered over a six-to eight-hour period when blood glucose targets were met.[1] • In non-ICU patients, start with a regimen containing basal insulin, such as 0.15 to 0.25 units/kg/day.[8,10] o For most patients with adequate nutritional intake, add prandial (bolus) and correction (sliding scale) doses, especially for those who use this regimen at home, or who take more than two antidiabetic meds at home.[1,13] o Check a premeal fingerstick before administering nutritional insulin doses.[1,9] Consider waiting until after the meal to give insulin if the patient may eat poorly.[1,9] • If admission blood glucose is under 180 mg/dL (10 mmol/L), consider starting with sliding scale insulin as an alternative to basal regimens in non-ICU patients [Evidence level B-3].[11-13] o May be most appropriate for certain patients, such as those who are insulin-naïve or at higher risk for hypoglycemia (e.g., elderly, kidney failure).[13] o Add basal insulin if hyperglycemia persists for 24 to 48 hours.[11] • Patients receiving bolus or continuous enteral nutrition will need basal, nutritional, and correction doses.[1] Patients receiving parenteral nutrition or not eating will need basal plus correction doses.[1] Check fingersticks every four to six hours and give a correction dose of regular insulin if needed.[1] o Before each bolus feeding, consider a dose of 1 unit of subcutaneous regular or rapid-acting insulin per 10 to 15 g of carbohydrates.[1]

Question	Answer/Pertinent Information
Which insulin or insulin regimen, continued	○ For patients on parenteral nutrition, consider adding regular insulin to the solution starting with a dose of 1 unit per 10 g of dextrose, especially if >20 units of correctional insulin is needed per 24 hours.[1] Adjust daily.[1] • Avoid use of premixed insulin in the hospital due to hypoglycemia risk.[1]
How are hyperglycemic crises treated? *Continued…*	• Follow your institution's protocols.[21] Example: https://www.mdanderson.org/documents/for-physicians/algorithms/clinical-management/clin-management-dka-or-hhs-web-algorithm.pdf. • For DKA and HHS, treatment goals are similar and include correction of:[21] ○ dehydration: initially corrected with NS or LR (LR might correct DKA faster, with lower risk of hyperchloremic metabolic acidosis).[19,21] After volume resuscitation, the fluid can be switched to ½ NS (especially if osmolality is not falling in HHS despite correct insulin dosing), unless corrected sodium (see below) is low or plasma osmolality is falling >3 mOsm/kg/hr.[14,18,21] Once glucose reaches ~250 mg/L (13.9 mmol/L), switch to a dextrose-containing fluid to prevent hypoglycemia.[21] ○ electrolyte imbalance: • potassium: insulin deficiency and metabolic acidosis cause potassium to shift extracellularly, so potassium may appear normal or high even if total body stores are depleted.[21] Potassium replacement is needed unless potassium is >5 mEq (mmol)/L.[21] Reassess potassium every two hours, and switch to a potassium-containing fluid when potassium is ≤5 mEq (mmol)/L.[21] Insulin administration causes potassium to shift, so in hypokalemic patients insulin administration should be delayed until potassium replacement has increased serum potassium to >3.5 mEq (mmol)/L.[21] • sodium: hyperglycemia causes water to shift out of the cells, causing a dilutional hyponatremia.[14] "Correct" serum sodium for glucose level (https://www.mdcalc.com/sodium-correction-hyperglycemia). ○ hyperglycemia: traditionally corrected with continuous intravenous insulin infusion (plus the patient's outpatient subcutaneous basal insulin, if applicable).[21] • Evidence is accumulating that using subcutaneous insulin instead of an intravenous infusion for **DKA** in **nonpregnant adults** not sick enough to require ICU care reduces ICU admission without increased risk of hypoglycemia.[15] ○ Patients who are alert and appropriate for regular room or observation bed care (e.g., pH >7.25 to <7.3 or serum bicarbonate >15 mmol/L, beta-hydroxybutryate <6 mmol/L) may be candidates.[21] ○ Generally avoid subcutaneous protocols if insulin absorption or response may be unpredictable (e.g., severe obesity, severe kidney impairment), **or** the patient is unstable (e.g., not alert, potassium <3.3 mEq (mmol)/L, serum bicarbonate <10 mEq (mmol)/L, hypotensive despite 1 L of IV fluid).[15,17]

Question	Answer/Pertinent Information
Treatment of hyperglycemic crises, continued	○ Consider a subcutaneous protocol that starts with **rapid**-acting insulin 0.1 to 0.3 units/kg x 1, then 0.1 units/kg every hour or 0.2 units/kg every two hours.[16,21] Once glucose reaches 250 mg/dL (13.9 mmol/L), step down to 0.1 units/kg every two hours.[21] ○ hyperosmolality (HHS): • Avoid dropping osmolality too quickly due to the risk of osmotic demyelination syndrome and cerebral edema.[21,27] Use normal saline to keep the fall in osmolality to not greater than 3 to 8 mOsm/kg/hr.[21] • Considered resolved when serum osmolality is <300 mOsm/kg, glucose is <250 mg/dL (13.9 mmol/L), urine output is >0.5 ml/kg/h, and cognition has improved.[21] ○ ketonemia (DKA): • Maintain intensive insulin until DKA resolves (e.g., plasma ketones <0.6 mmol/L, plus venous pH ≥7.3 or serum bicarbonate ≥18 mmol/L).[21] Use a dextrose-containing fluid if needed to prevent hypoglycemia.[21] • Do not use sodium bicarbonate for DKA except for life-threatening acidosis (e.g., pH <7).[21] • Monitoring parameters include vitals, input/output, blood beta-hydroxybutyrate, glucose (every one to two hours), and other labs (e.g., electrolytes, venous pH, osmolality, kidney function) every two to four hours until stable.[21]
What is euglycemic DKA?	• These patients meet DKA criteria (blood ketones ≥3 mmol/L and serum bicarbonate <18 mEq/L), but have a glucose <200 mg/dL (11.1 mmol/L).[21] • In addition to SGLT2 inhibitors (most common cause), euglycemic ketoacidosis may be caused by pregnancy, insulin injection, food restriction, alcohol, or liver failure.[21] ○ Also see information about ketoacidosis caused by **SGLT2 inhibitors**, below. • Because glucose is near-normal, it is important to **start a dextrose-containing solution** with the insulin infusion to prevent hypoglycemia.[21]
How do you manage ketoacidosis caused by an SGLT2 inhibitor? *Continued...*	• Prevention ○ Be alert for risk factors: fasting or reduced caloric intake due to illness or surgery, low carbohydrate diet, dehydration, infection, hemodynamic instability, pancreatic disorders, type 1 diabetes, alcohol use, reduction of insulin dose, or history of diabetic ketoacidosis.[6,22] • For patients using insulin at home, ensure adequate insulin dosage.[22] Try not to stop insulin altogether; reduce dose cautiously, and avoid sliding scale insulin alone.[22] • Identification ○ In current or recent users of an SGLT2 inhibitor, watch for ketoacidosis symptoms (e.g., nausea, vomiting, abdominal pain, lethargy, dyspnea).[6,25] ○ Consider checking serum bicarbonate and anion gap daily (e.g., basic metabolic panel).[22]

Question	Answer/Pertinent Information
How do you manage ketoacidosis caused by an SGLT2 inhibitor, continued	○ Laboratory findings suggestive of SGLT2 inhibitor acidosis include metabolic acidosis with an elevated anion gap and low serum bicarbonate.[6] Blood glucose is typically <250 mg/dL (13.9 mmol/L).[6] Check arterial blood gas and **serum** ketones to confirm ketoacidosis.[22] Urine ketones may be undetectable.[22] • Treatment ○ Stop SGLT2 inhibitor if still taking.[6] ○ Treat ketoacidosis as usual, but with some caveats; update your protocol to include distinctions for SGLT2-associated ketoacidosis,[24,26] Start **IV insulin** even with blood glucose <250 mg/dL (13.9 mmol/L), plus an IV dextrose-containing solution to keep glucose 150 to 200 mg/dL (with normal saline for fluid resuscitation).[6,21,24,26] Suggested initial insulin dose is 1 to 2 units/hour, or 2 to 3 units/hour for patients with insulin resistance (e.g., BMI >35 kg/m^2).[28] Consider titrating insulin to serum ketones instead of blood glucose.[23] Patients may require insulin infusion several days, and high doses may be required (e.g., 10 units/hour).[23] ○ Once the patient stabilizes (e.g., resolution of ketoacidosis [e.g., two of: serum bicarbonate ≥15 mmol/L, anion gap ≤12 mmol/L, venous pH >7.3], tolerating oral diet), transition to subcutaneous insulin (e.g., previous home regimen).[22,24] Check a basic metabolic panel in about four hours to confirm resolution.[22] ○ Insulin naïve patients may need to continue insulin at home if they are insulin deficient and therefore at risk of repeat ketosis.[22] ○ With shared decision-making, consider restarting the SGLT2 inhibitor if the patient has an indication for it other than diabetes (i.e., heart failure or kidney disease) and an identifiable trigger for ketoacidosis.[22] Educate the patient about prevention (e.g., sick-day management, adequate hydration, responsible alcohol use, symptom recognition), and ensure the episode is documented for future admissions.[22]
Will patients who need insulin in the hospital need it upon discharge?	• An A1c of 6.5 % or higher on admission suggests that the patient had diabetes preadmission.[1] • Consider insulin as a component if A1c is >9% to 10%.[1] • Consider NPH over newer basal insulin analogues for lower cost, especially in those without hypoglycemia history.[1] • Schedule follow-up within one month or earlier, such as within 1 to 2 weeks for suboptimal glucose control at discharge or if diabetes regimens are changed.[1]

Abbreviations: BMI = body mass index; DKA = diabetic ketoacidosis; HHS = hyperglycemic hyperosmolar state; ICU = intensive care unit; IV = intravenous; LR = lactated Ringer's; NS = normal saline.

Users of this resource are cautioned to use their own professional judgment and consult any other necessary or appropriate sources prior to making clinical judgments based on the content of this document. Our editors have researched the information with input from experts, government agencies, and national organizations. Information and internet links in this article were current as of the date of publication.

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