Key Aspects of Care

- Patients with type 1 diabetes (T1DM) experience more unpredictable swings in glucose that necessitate more frequent monitoring of glucose and physiologic insulin replacement.
- Physiologic insulin replacement is needed at all times using some form of basal, prandial, and correction coverage.
- Identify patients with diabetic ketoacidosis (DKA) based on physical and laboratory findings.
- Provide appropriate hydration / correct electrolyte derangement.
- Identify precipitating factors of DKA such as surgery, infection, or myocardial infarction.
- Frequent monitoring and assessment of the response to treatment such as mental status, volume status, and resolution of laboratory abnormalities, are integral parts of care.

**Table 1. IV Infusion Insulin- Type 1 Diabetes/DKA**

*Patients with Type 1 Diabetes or DKA should never go without basal insulin (IV, glargine, detemir, NPH, degludec). Do not discontinue IV insulin without administering SQ basal insulin.*

<table>
<thead>
<tr>
<th>Current Glucose</th>
<th>Decreased &gt; 100mg/dL</th>
<th>Decreased 50-100mg/dL</th>
<th>Decreased 25-50 mg/dL</th>
<th>Increased or decreased &lt; 25 mg/dL</th>
<th>Increased 25-50 mg/dL</th>
<th>Increased &gt; 50 mg/dL</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt; 400 mg/dL</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>301-400 mg/dL</td>
<td>No Change</td>
<td>Increase infusion rate by 1 unit/hr</td>
<td>Increase infusion rate by 2 units/hr</td>
<td>Increase infusion rate by 2.5 units/hr</td>
<td>Increase infusion rate by 3 units/hr</td>
<td>Increase infusion by 4 units/hr</td>
</tr>
<tr>
<td>201-300 mg/dL</td>
<td>Run infusion at 75% of current rate</td>
<td>No change</td>
<td>Increase infusion by 1 unit/hr</td>
<td>Increase infusion rate by 1 unit/hr</td>
<td>Increase infusion by 2 units/hr</td>
<td>Increase infusion by 3 units/hr</td>
</tr>
<tr>
<td>151-200 mg/dL</td>
<td>Run infusion at 50% of current rate</td>
<td>Decrease infusion by 1 unit/hr</td>
<td>No Change</td>
<td>Increase infusion by 0.5 unit/hr</td>
<td>Increase infusion by 1 unit/hr</td>
<td>Increase infusion by 2 unit/hr</td>
</tr>
<tr>
<td>120-150 mg/dL</td>
<td>Run infusion at 25% of current rate</td>
<td>Run infusion at 50% of current rate</td>
<td>Run infusion at 75% of current rate</td>
<td>No change</td>
<td>No Change</td>
<td>Increase infusion by 1 unit/hr</td>
</tr>
<tr>
<td>80-120 mg/dL</td>
<td>Stop the infusion, contact the prescriber and recheck glucose in 15 minutes</td>
<td>Run infusion at 10% of current rate; consider contacting prescriber</td>
<td>Run infusion at 25% of current rate</td>
<td>Run infusion at 50% of current rate</td>
<td>Run infusion at 75% of current rate</td>
<td>No change</td>
</tr>
<tr>
<td>&lt; 80 mg/dL</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- **Stop infusion of insulin** and contact the prescriber.
- Double current infusion rate of dextrose solution.
- If not receiving dextrose IV infusion, start D5W at 50 ml/hr.
- **Consider** giving D50% according to the Hypoglycemia Treatment in Non-Pregnant Adults guideline.
  - Recheck glucose and treat according to the Treatment in Non-Pregnant Adults guideline every 15 minutes until glucose > 80 mg/dL.
- **Resume insulin at 25% of previous dose and reduce dextrose back to previous rate** when glucose > 100 mg/dL in the absence of subcutaneous basal insulin (detemir, glargine, NPH).
- This applies to patients with type 1 diabetes and/or DKA only. Click here to access the Type 2 Diabetes and Other Non-Diabetes-associated Hyperglycemia guideline.

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1. Contact prescriber if rate of decline in glucose > 100 mg/dL/hr. Patient may need a more rapid taper of the drip than is indicated in the table above.
2. Example for 25% of current rate: 1 unit/hr (old rate) x 0.25 = 0.25 unit/hr (new rate)
3. Example for 75% of current rate: 4 units/hr (old rate) x 0.75 = 3 units/hr (new rate)
Clinical Evaluation

Initial Assessment

- T1DM is distinguished from T2DM by:
  - Younger age at onset.
  - Greater frequency of DKA.
  - Less frequent family history.
  - Thinner body habitus.
  - Lack of features of insulin resistance (such as acanthosis nigricans).
  - Absolute insulin dependence.

- When the diagnosis is in question, particularly if the patient is prone to severe hypoglycemia or has DKA, treat as Type 1 diabetes.
  - In some cases, low c-peptide and autoantibodies are needed to confirm the diagnosis.

- For pregnant patients with a history of type 1 diabetes, use this guideline.
  - For all other pregnant patients without DKA, use the guideline for type 2 diabetes.

- Age and underlying co-morbid diseases.
- Previous glycemic control:
  - Adherence to insulin and glucose monitoring.
  - History of severe hypoglycemia or hypoglycemia unawareness.
  - Insulin regimen including:
    - Insulin: Carbohydrate ratio.
    - Sensitivity or correction factor.
    - Target glucose.
- Vital signs: BP, PR, and RR.
- Mental status.
- Volume status.

Additional Considerations for DKA

- Identify and treat the precipitating factors and complications of DKA.

Laboratory Evaluation

- Serum glucose.
- Serum electrolytes (with calculation of the anion gap), particularly potassium.
- BUN and plasma creatinine.
  - Note: In DKA, acetocetate artificially raises serum creatinine in the standard colorimetric assay.
- HbA1c

Additional Considerations for DKA

- Complete blood count with differential.
  - Mildly elevated WBC may be a reactive response to DKA.
- Urinalysis and urine ketones by dipstick.
- Plasma osmolality.
- Serum ketones.
  - Note: Since it is the major ketone formed during DKA, serum beta hydroxybutyrate is the preferred ketone test, and is not detected by the traditional urine ketone test that uses the Nitroprusside reaction.
- Arterial blood gas if serum bicarbonate is reduced or patient has underlying respiratory disease.
- Electrocardiogram.
- Pregnancy test in females of child-bearing potential.

Medical Management

A. Patients with T1DM who are NOT in DKA and do NOT require IV insulin

- Patients with type 1 diabetes should NEVER go without some form of basal insulin for > 2 hours. If there is clinical concern for hypoglycemia, the dose should be reduced. Forms of basal insulin include:
  - Glargine
  - Detemir
  - IV insulin
  - Continuous subcutaneous insulin infusion (CSII)

- It is paramount to cover ALL meals and snacks with rapid acting subcutaneous insulin (aspart or lispro) using carbohydrate: insulin promptly before or immediately after meals in order to avoid volatile swings in glucose.
  - Patients typically require the low dose option (1 unit=15-20 grams).

- Correction dosing (sliding scale) should typically be administered using the standard (1 unit per 50 mg/dL) or low dose (1 unit per 100 mg/dL) options.
  - Note: If correction is repeated within 3 hours (6 hours for advanced kidney disease), CrCl <30 ml/min), the dose must be reduced by half in order to avoid insulin stacking and hypoglycemia.

Insulin pumps:

- Patients may continue to self-manage in the hospital provided that they are otherwise well-controlled and cognitively intact.
  - If the pump is discontinued for > 2 hours, basal insulin MUST be provided.
  - Patients must record all boluses and the total basal insulin dose per day.
  - Basal insulin settings (rate and time) must be entered as an electronic order.
  - Nursing must document all boluses whether or not they are self-administered and total insulin doses daily.
  - See Continuous Subcutaneous Insulin Infusion (CSII) Pumps policy.

- Glucose should be checked QACHS and in most cases, at 3 a.m.

B. Patients with T1DM Requiring IV Insulin

- Indications for IV insulin in T1DM:
  - DKA
  - NPO (particularly if major surgery)
  - Critical illness
  - Refractory hyperglycemia (particularly in the setting of severe illness, high dose glucocorticoids, or enteral or parenteral nutrition)

- If patient markedly hypokalemic (K < 3.5 mmol/L), replace potassium before insulin initiation.
Insulin IV Infusion
- Initiate insulin infusion at 1 unit/hr for patients with Type 1 DM without DKA or Type 1 DM with DKA and ESRD
  - Initiate at 2 units/hr for patients with Type 1 DM with DKA and normal renal function.
  - Lower rate of insulin infusion should be considered in patients with ESRD and/or severe labile glucose.
- Monitor finger-stick glucose at least every hour.
  - ICU: Fingerstick (capillary) blood glucose monitoring may be inaccurate in some situations (see BRAVE criteria Brave Criteria). Venous or arterial source may be used for point of care testing.
- Rate of blood glucose (BG) decline should not exceed 100 mg/dL/hr.
  - Order a maximal drip rate.
    - Suggest 20% of the total estimated basal insulin.
    - A patient who typically takes 20 unit of glargine per day = maximal drip rate initially set at 4 unit per hr.
  - If the BG does not decline by 25 mg/dL on the maximal infusion rate for over 2 hours, the provider should be notified.
  - Depending on the history of the patient and the rate of change in glucose, an increase in the maximal infusion rate may be necessary.
  - The minimum infusion rate should be 0.25 units/hr in the absence of hypoglycemia.

Transitioning off the IV Insulin Drip
- Insulin Infusion should not be discontinued abruptly, even if DKA is resolved.
  - Total duration of IV insulin drip should be at least 12-24 hours minimum for assessment of insulin requirements and to get stable resolution of DKA.
- Provide pre-meal subcutaneous insulin coverage with aspart or lispro (correction factor + Insulin:Carb) with meals when patient has good PO intake.
  - If patient begins to eat before infusion is stopped, provide carb coverage (Insulin:Carb) but withhold correction (sliding scale).
- Before the insulin drip is discontinued, basal insulin such as glargine or detemir should be given to overlap with IV insulin for 4 hrs. to prevent rebound hyperglycemia and ketoacidosis.
- After the insulin drip is discontinued, blood glucose should be monitored hourly for 4 hours, then every 3-4 hrs.
- To calculate basal insulin dose, consider patient’s weight, current home basal dose, glucose, and insulin infusion rate.
  - In patients with stable IV insulin requirements, consider current insulin rate/hr (i.e. 1 unit/hr) and multiply by 12.
  - If requiring > 3 units/hr, consider DM consult for transition guidance.
  - Discontinue dextrose when insulin infusion is stopped

C. Pregnant Patients
- OSUWMC Diabetes Mellitus in Pregnancy: Inpatient Management guideline.
- Pregnant patients with T1DM and/or DKA have specific fluid, insulin, and fetal monitoring requirements.
- Early consultation with OB is recommended for pregnant patients with the following:
  - Viable pregnancy with pregestational or gestational diabetes with suboptimal glucose control.
  - BG > 150 mg/dl or < 60 mg/dl on two occasions within 24 hours despite intervention.
  - Major surgery.
  - Diabetic ketoacidosis, hyperosmolar hyperglycemic state.
  - Acute macrovascular events.
  - Serious infections or non-healing wounds.
  - HbA1c > 8%.
  - Specialized diabetes in pregnancy education.

D. Additional Guidelines for DKA
- IV Fluid Resuscitation- Restoration of Circulatory Volume Is the first Priority
  - Isotonic fluid (0.9% NaCl) is recommended.
  - The rate and volume of the fluid replacement may need to be modified according to patients’:
    - Hydration status.
    - Underlying cardiac and renal function.
    - Age.
  - Estimated total fluid deficit may be from 5 to 8 L.
- IF HEMODYNAMICALLY STABLE:
  - Give 0.9% NaCl 500 mL/h for the first 4 hours, followed by 250 mL/h for the next 4 hours.
  - Then, change IV to 0.45% NaCl with 20-40 mEq KCl/L.
- IF NOT HEMODYNAMICALLY STABLE (e.g. orthostasis, sepsis, shock):
  - Rate should be dictated by clinical status.
  - Less aggressive fluid resuscitation in patients with history of CHF, severe COPD, anuria or end-stage renal disease, elderly patients with underlying co-morbid diseases.
  - Subsequent choice for fluid replacement depends on the state of:
    - Hydration
    - Serum electrolyte levels
    - Urine output
- IV Insulin: use IV insulin infusion guideline in section B.
E. Electrolyte Replacement

- **Potassium**
  - Anticipate need for early potassium replacement.
  - Potassium should be replaced prior to insulin infusion in patients who present with hypokalemia (<3.5 mmol/L).
  - Insulin infusion can be initiated upon initiation of potassium replacement (i.e. do not delay insulin infusion until potassium repletion is completed).
  - Initiate potassium replacement after insulin initiation when serum potassium is between 3.5 - 5.4 mmol/L if renal function and urinary output are adequate.
  - Additional replacement dosing for low serum potassium or ECG changes.

- **Bicarbonate / Phosphate (NOT routinely recommended)**
  - Bicarbonate may be indicated in the presence of superimposed metabolic acidosis other than DKA (with arterial pH < 7.0) or hyperkalemia with arrhythmia.
  - If the blood pH < 7, concomitant respiratory acidosis (such as respiratory failure) and metabolic acidosis (such as acute renal failure, lactic acidosis due to infection, and acute abdomen).
  - Serum inorganic phosphate:
    - Routine replacement not recommended.
    - May be indicated with phosphate levels (< 1.0 mg/dL) in the setting of hypoxemia, particularly as related to respiratory failure, left ventricular dysfunction, or anemia.

F. Ongoing Management

- Assess VS and mental status at least every 1-4 hours.
- Finger-stick glucose q1h.
- Repeat electrolytes every 2 hours until potassium and bicarbonate improve, then every 4 hours until stable.
- Repeat arterial or venous pH q 4-8 hours if clinically indicated.
- Prophylaxis for venous thromboembolism (See OSUWMC Deep Venous Thrombosis (DVT): Prevention guideline).
- Repeat monitoring of serum or urine ketones is not necessary.
- **When BG is < 250 mg/dL, add dextrose (5% or 10%) to IVF.**
- IV glucose should be continued until patient has adequate oral intake for both liquid and food.
- **Hypoglycemia:**
  - The blood glucose may fall very rapidly as ketoacidosis is corrected and it is important to prevent hypoglycemia.
  - This may result in a rebound ketosis driven by counter-regulatory hormones.
  - Severe hypoglycemia is associated with cardiac arrhythmias, acute brain injury and death.
- **Diet:** NPO initially.
  - Clears at 12 hours and advance diet as tolerated.

G. DKA Resolution

Patients with DKA should show signs of recovery by both clinical parameters and biochemical data

- **Clinical Parameters:**
  - Mental status.
  - Vital signs (HR, BP, RR).
  - Can tolerate adequate PO liquid and food.
  - Adequate volume status (no sign of dehydration).

- **Biochemical Data**
  - Venous pH > 7.35/arterial pH > 7.3.
  - Glucose < 250 mg/dL.
  - No significant electrolyte abnormalities.
- Bicarbonate > 17 mEq/L.
  - A non-anion gap metabolic acidosis may persist even after anion gap is normalized.
  - Anion gap < 15 mEq/L.
  - **Note:** Ketonemia takes longer to resolve than hyperglycemia, but this is adequately assessed by the anion gap in most patients.

Consult

Consider Diabetes Consult in the following situations:
- Initial clinical / biochemical state markedly abnormal.
- Initial response to standard therapy unsatisfactory.
- Metabolic complications.
- Previously managed by Continuous Infusion Insulin Pump (CSII).
- HbA1c ≥ 9.0.

Diabetes Education

- For specialized diabetes education, obtain a Diabetes Ancillary consult through IHIS.

OSUWMC Guidelines

- Diabetes Mellitus in Non-Pregnant Adults: Inpatient Management
- Diabetes: Type 2 Diabetes Mellitus (T2DM) and Other Non-Diabetes-Associated Hyperglycemia (i.e., Stress Induced)
- Diabetes Mellitus in Pregnancy: Inpatient Management

Order Sets

- OSU IP END: Admission DKA [2046]
- OSU IP END: DKA in Critical Care [2048]
- OSU IP ED: DKA / Hyperglycemia [2439]
- OSU IP END: Insulin Infusion Orders [2322]
References


Quality Measures

- Average time to first glucose test after insulin infusion initiated (hrs)
- Blood glucose lab monitoring occurring hourly while on insulin drip
- Median glucose during drip ≥150 mg/dL
- Number of episodes of > 200 mg/dL while on drip
- Number of episodes of < 70 mg/dL while on drip
- Average time to 150 mg/dL (hrs)
- Effective insulin therapy after drip cessation
- Potentially ineffective insulin therapy
- Initiation of insulin if drip rate >1 unit per hour at the time of drip discontinuation

Guideline Approved


**Disclaimer:** Clinical practice guidelines and algorithms at The Ohio State University Wexner Medical Center (OSUWMC) are standards that are intended to provide general guidance to clinicians. Patient choice and clinician judgment must remain central to the selection of diagnostic tests and therapy. OSUWMC’s guidelines and algorithms are reviewed periodically for consistency with new evidence; however, new developments may not be represented.

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