KEY ADVANCES
PRACTICE ADVANCE

Diabetic Ketoacidosis

New August 2025

Why is this topic important?

Emergency physicians need to be comfortable with the initial assessment and management of patients presenting with diabetic ketoacidosis (DKA), as it is a life-threatening complication of diabetes in both adults and children. The initial management in the emergency department (ED) plays an important role in improving outcomes and decreasing length of stay in the intensive care units (ICUs) and hospitals. Specific assessment of the patient's volume status, fluid and electrolyte requirements, and potential conditions contributing to the development of DKA (i.e., infection, medication interactions, insulin pump failure, or poor adherence to the medical plan) is critical. Recent literature has helped address many of the debated aspects of the initial management of DKA, including selection of rehydration fluids, rate of rehydration (specifically in children), and rate of insulin administration.

How will this change my clinical practice?

Regardless of the patient's age, the initial management of DKA requires the emergency physician to rapidly assess the patient's volume status, electrolyte derangements, and severity of acidosis. Current evidence supports the use of either normal saline or a balanced crystalloid for the initial volume expansion and recommends 1-1.5 L or 20 mL/kg for both adults and pediatric patients with DKA. As volume resuscitation is occurring, determination of the patient's electrolyte status will help guide selection of the composition of the continued maintenance fluids. Of vital importance is the patient's potassium level as hypokalemia needs to be corrected prior to insulin initiation. The goal of insulin therapy is to correct acidosis and should continue until this is resolved with anticipation of developing hypoglycemia. To avoid this, a 2-bag system can be deployed to help with titration of the dextrose infusion rate based on glucose-level monitoring. In general, the initial dose of insulin is often 0.1 U/kg/h and can be decreased to 0.05 U/kg/h once patient's glucose level is < 250-300 mg/dL.

Synopsis Focus Points:

1. **After determining a patient requires therapy for DKA, the clinical team needs to assess and correct for the patient's hydration status, electrolyte derangements, and acidemia.**
2. **Assessment of volume status and appropriate volume resuscitation is a priority. Initiate isotonic fluids (1-1.5 L or 20 mL/kg) for both adults and pediatric patients with DKA.**
3. **Normal saline or balanced crystalloid (e.g., Plasmalyte or lactated Ringer's) are reasonable options for initial resuscitation for both adults and pediatric patients with DKA.**

4. **A liberal fluid approach is now recommended and has been found to shorten DKA recovery times.**
5. **Determine the patient's potassium level prior to initiation of insulin therapy, hypokalemia (< 3.5 mEq/L) will require correction before starting insulin therapy. Continued maintenance fluids should contain appropriate potassium supplementation to help avoid developing hypokalemia encountered during therapy.**
6. **A starting dose of insulin at 0.1 U/kg/h intravenously (IV) is reasonable for both adults and pediatric patients with DKA. The goal of insulin therapy is resolution of the ketoacidosis, not resolution of hyperglycemia.**
7. **To avoid hypoglycemia related to ongoing insulin therapy, frequent monitoring of glucose levels and utilization of the 2-bag method of maintenance fluids should be considered.**
8. **Continued monitoring of glucose, potassium, and sodium levels is critical. Monitoring for possible signs of cerebral edema in children with DKA is also vital.**
9. **IV bolus of insulin is generally not recommended and should be avoided in children.**

Background:

DKA is a potentially life-threatening metabolic complication of diabetes in adults and children with which all emergency medicine physicians should be familiar. DKA presents with a spectrum of symptoms and findings. Patients with DKA typically present with hyperglycemia, ketonemia, and acidemia; however, euglycemic DKA can occur, especially in patients taking SGLT2 inhibitors. Patients can also present with normal pH, often due to alkalosis from vomiting counterbalancing the anion gap acidosis. DKA is more commonly encountered in patients with type 1 diabetes, but it still does occur in patients with type 2 diabetes.

DKA can be classified as mild, moderate, or severe based on level of acidosis.(1) Mild DKA is defined as a pH of 7.2-7.29 or a bicarbonate level of 10-18 mmol/L. Moderate DKA will have a pH of 7.1-7.19 or a bicarbonate level of 5-9 mmol/L. Severe DKA will have a pH of < 7.1 or a bicarbonate level of < 5 mmol/L. Mild DKA may be able to be treated effectively in the ED and avoid ICU admission, but most moderate and severe DKA will require ICU admission.

Although complete resolution of metabolic disturbances often requires hospitalization and intensive care, the patient's outcomes are integrally linked to the initial management strategies deployed by the emergency medicine team. After determining whether a patient requires therapy for DKA, the clinical team needs to assess and correct the patient's hydration status, electrolyte derangements, and acidemia. These tasks have been the focus of DKA guidelines over the past decades but have lacked consistency and consensus. Management of DKA in the pediatric patient has been further complicated by concern for contributing to the development of cerebral edema – a rare but severe condition. Research has aimed at improving our understanding of these 3 key management tasks for both adults and pediatric patients.

Fluid Type and Rate Selection:

Patients with DKA present in various degrees of dehydration due to osmotic diuresis, decreased oral intake, and vomiting. The dehydration itself can further exacerbate DKA. The goal of IV rehydration is to achieve an euvolemic state. Any shock state needs rapid correction of volume status, but even patients not in overt shock will still require resuscitation with isotonic fluids. For adults, 1-1.5 L and for children 20 mL/kg of isotonic fluids should be given in the first hour of the evaluation in the ED.

The choice of isotonic fluid in DKA management is debated. Some literature favors balanced crystalloids (e.g., lactated Ringer's, Plasmalyte) over normal saline (NS), citing better outcomes, such as faster DKA resolution, fewer electrolyte derangements, and shorter hospital stays.(2,3) A recent systematic review found no strong preference among isotonic crystalloids.(4) NS may have practical advantages, such as greater availability in EDs, improved IV compatibility, and the availability of potassium-containing preparations. Ultimately, fluid choice may depend on available resources and clinical context, with flexibility for transitions between fluids as appropriate.

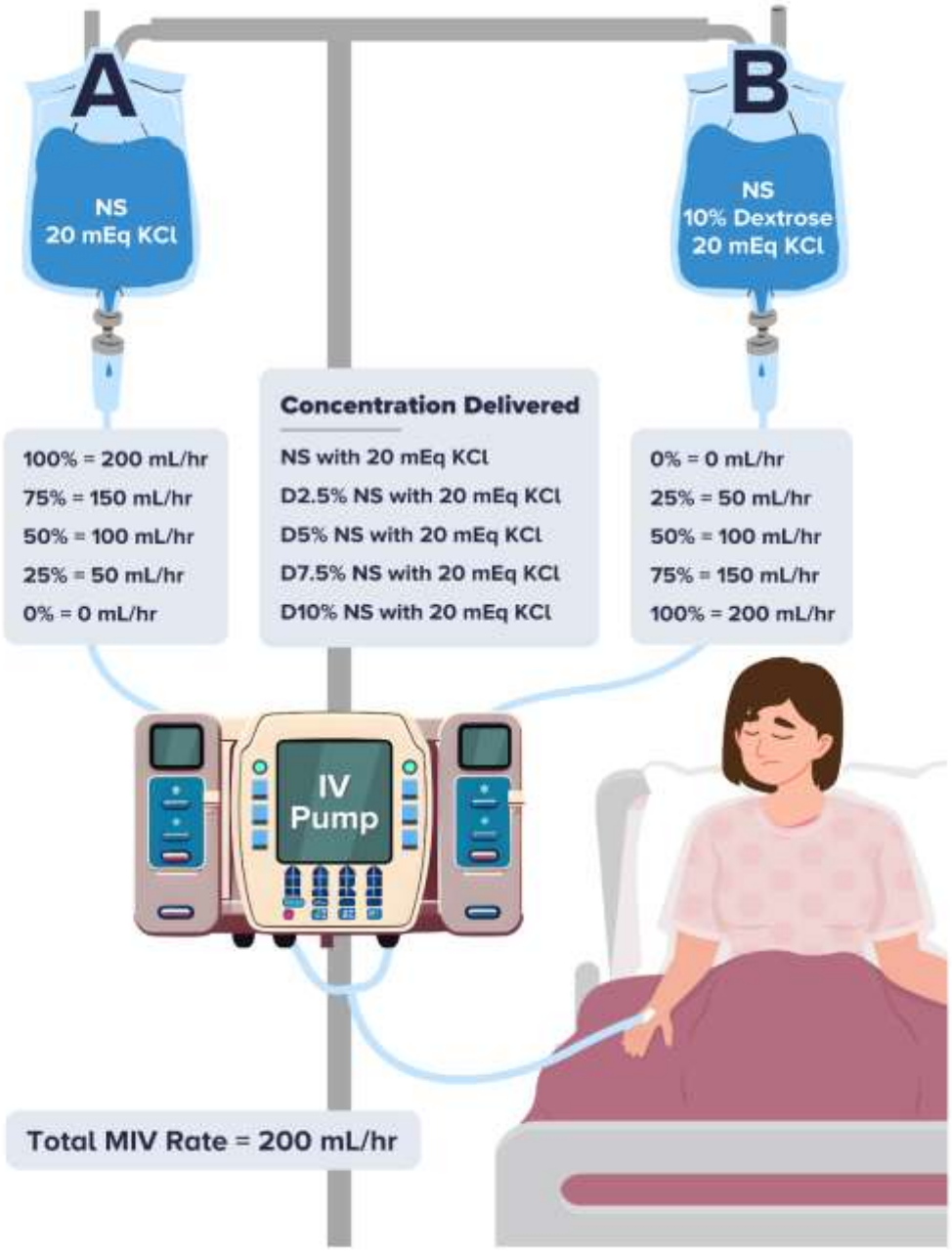
Rapid assessment and treatment of hydration status are also critical in managing pediatric DKA. Historically, rapid rehydration was thought to contribute to cerebral edema, and fluid-restrictive strategies were favored. However, this paradigm has shifted, and a more liberal fluid approach is now recommended based on the available evidence. A recent meta-analysis showed liberal fluid administration shortened DKA recovery times.(5) A Pediatric Emergency Care Applied Research Network study found that faster fluid administration corrected acidosis more rapidly, while slower rates increased hyperchloremic acidosis, leading the authors to recommend fluid management based on individual hydration status.(6) Assessing dehydration in children can be difficult, but a 2023 analysis of 811 pediatric DKA cases found a mean dehydration level of 5.7%, with greater dehydration (~8%) in new-onset diabetes cases.(7) The current recommendation is to give a 20-mL/kg bolus of isotonic fluids, assuming 6% dehydration in established diabetes and 8% in new-onset diabetes or severe acidosis (pH < 7.1).

Electrolytes:
DKA is associated with several electrolyte derangements. Of particular importance are sodium, chloride, potassium, and glucose. Patients will often have pseudohyponatremia and a corrected sodium level should be calculated. This can often provide insights into the volume status of the patient and the response to therapies. In general, the administration of isotonic fluids will address any true hyponatremia and hypochloremia. It should be noted, however, that large volumes of NS may lead to non–anion gap metabolic acidosis.

Importantly, the insulin therapy directed at correcting the underlying anion gap metabolic acidosis (from the generation of ketones) will affect the patient's potassium and glucose levels. Although initially this effect will be beneficial in correcting elevated glucose levels, there is a risk of causing hypoglycemia. Most recommend initiating a continuous dextrose infusion while continuing the insulin therapy to help mitigate this risk when the patient's glucose level is less than ~250 mg/dL.(8) To be able to titrate dextrose infusion rate at the bedside and avoid delays from ordering new dextrose-containing fluids, a 2-bag strategy can be used. This involves having 1 isotonic fluid bag with added potassium (e.g., NS with 20 mEq KCl) and the other bag with identical composition along with dextrose (e.g., D10NS with 20 mEq KCl) (see Image 1). By altering the infusion rates between the 2 bags, it is possible to titrate the total dextrose infusion rate once the new glucose level is known. While the insulin infusion is running, continued vigilance is required to avoid hypoglycemia.

Insulin will also decrease the patient's potassium level. The patient's total body potassium is often low, even if the serum level is initially elevated or normal. It is reasonable to obtain an electrocardiogram early in the management of patients presenting with DKA. Initiation of insulin should wait until a patient's serum potassium level is available. Hypokalemia (< 3.3 mEq/L) will require correction before starting insulin. The addition of 20-30 mEq of potassium to each liter of isotonic fluid is used to help prevent hypokalemia from occurring. A 2021 study of initial fluid selection in patients with DKA found the use of IV fluids containing < 10 mEql/L of potassium was associated with higher in-hospital 28-day mortality compared with fluids containing between 10 and 40 mEq/L.(9)

Image 1. Two-bag strategy. MIV, maintenance IV.



Insulin Dosing:
A typical starting dose of insulin is 0.1 U/kg/h, although this has been debated. Insulin is often administered via IV, although for mild cases of DKA, subcutaneous insulin has been found to help avoid ICU admissions.(4) IV bolus of insulin is generally not recommended. Bolus administration of insulin should particularly be avoided in children with DKA, as this does not improve outcomes and may contribute to development of cerebral edema. A meta-analysis showed that 0.05 U/kg/h can be as effective as standard-dose insulin, but with fewer adverse events.(10) Glucose levels should be monitored frequently, and a dextrose infusion should be initiated if needed to facilitate continued insulin therapy until the acidosis has resolved. Another approach to help balance the need to resolve the acidosis with the risk of hypoglycemia is to reduce the rate of the insulin drip from 0.1 U/kg/h to 0.05 U/kg/h once the glucose level falls below ~250-300 mg/dL.(8) Insulin therapy should not be stopped until the acidosis has improved. It can be transitioned to the subcutaneous route when pH > 7.3.(8)

Cerebral Edema Considerations:
Cerebral edema occurs more commonly in children than adults. Although rare (~1%), it has profound morbidity and mortality. Previous theories about the associated risk factors for developing cerebral edema included the rapid infusion of crystalloids. The risk of cerebral edema, although low, has not decreased despite fluid-limiting protocols.(1) Evidence now indicates that early isotonic fluid therapy does not confer additional risk, so initial isotonic fluid resuscitation is now recommended for all patients.(1) Residual caution with administering fluids to children is still reasonable, but avoidance of volume resuscitation is unfounded and potentially harmful. Signs of cerebral edema include severe/progressive headache, focal neurologic abnormality, Glasgow Coma Scale score < 14, incontinence, inconsolability and/or Cushing's triad (i.e., hypertension, bradycardia, and abnormal breathing pattern). If there is concern for cerebral edema developing, consider administering hypertonic saline (3% NaCl) 5 mL/kg (maximum 250 mL) over 10 minutes. Mannitol can also be considered (0.5-1 g/kg [maximum 100 g]) over 15 minutes. Therapy should not be delayed awaiting computed tomography imaging of the head. The head of bed should also be kept at 30 degrees, and the head should be maintained midline to assist with venous drainage from the head.

References:

1. Gripp KE, Trottier ED, Thakore S, Sniderman J, Lawrence S. Current recommendations for management of paediatric diabetic ketoacidosis. *Paediatr Child Health.* 2023;28(2):128-138.
2. Alghamdi NA, Major P, Chaudhuri D, et al. Saline compared to balanced crystalloid in patients with diabetic ketoacidosis: a systematic review and meta-analysis of randomized controlled trials. *Crit Care Explor.* 2022;4(1):e0613.
3. Self WH, Evans CS, Jenkins CA, et al; Pragmatic Critical Care Research Group. Clinical effects of balanced crystalloids vs saline in adults with diabetic ketoacidosis: a subgroup analysis of cluster randomized clinical trials. *JAMA Netw Open.* 2020;3(11):e2024596.
4. Maharjan J, Pandit S, Arne Johansson K, Khanal P, Karmacharya B, Kaur G, Kumar Aryal K. Effectiveness of interventions for emergency care of hypoglycaemia and diabetic ketoacidosis: a systematic review. *Diabetes Res Clin Pract.* 2024;207:111078.
5. Hamud AA, Mudawi K, Shamekh A, Kadri A, Powell C, Abdelgadir I. Diabetic ketoacidosis fluid management in children: systematic review and meta-analyses. *Arch Dis Child.* 2022;107(11):1023-1028.
6. Rewers A, Kuppermann N, Stoner MJ, et al; Pediatric Emergency Care Applied Research Network (PECARN) FLUID Study Group. Effects of fluid rehydration strategy on correction of acidosis and electrolyte abnormalities in children with diabetic ketoacidosis. *Diabetes Care.* 2021;44(9):2061-2068.
7. Trainor JL, Glaser NS, Tzimenatos L, et al. Clinical and laboratory predictors of dehydration severity in children with diabetic ketoacidosis. *Ann Emerg Med*. 2023;82(2):167-178.

8. Dhatariya KK; Joint British Diabetes Societies for Inpatient Care. The management of diabetic ketoacidosis in adults-an updated guideline from the Joint British Diabetes Society for Inpatient Care. *Diabet Med.* 2022;39(6):e14788.
9. Okada A, Yamana H, Morita K, et al. Potassium concentration in initial fluid therapy and in-hospital mortality of patients with diabetic ketoacidosis. *J Clin Endocrinol Metab.* 2021;106(5):e2162-e2175.
10. Forestell B, Battaglia F, Sharif S, et al. Insulin infusion dosing in pediatric diabetic ketoacidosis: a systematic review and meta-analysis of randomized controlled trials. *Crit Care Explor.* 2023;5(2):e0857.

Resources for additional learning:

Pediatric Diabetic Ketoacidosis Algorithm
AliEM: Balanced Fluids in Diabetic Ketoacidosis
BMJ Best Practice: Diabetic Ketoacidosis
The Internet Book of Critical Care: Diabetic Ketoacidosis

Notes: Practice Advance synopses should be built from a strong body of evidence that likely includes a systematic review. The synopsis will include a recommendation that should be similar in wording to GRADE (Grading of Recommendations Assessment, Development and Evaluation) recommendations. These should not be controversial recommendations and essentially all emergency physicians should adopt them. The impact or "effect size" should be substantial and no significant harm should be associated with this gain.

Authors
Sean Fox, MD (Lead)

Editors
Christopher Carpenter, MD; Christopher Edwards, PharmD; Stephen Hayden, MD; John Kendall, MD; John Marshall, MD, MBA; Ernest Wang, MD