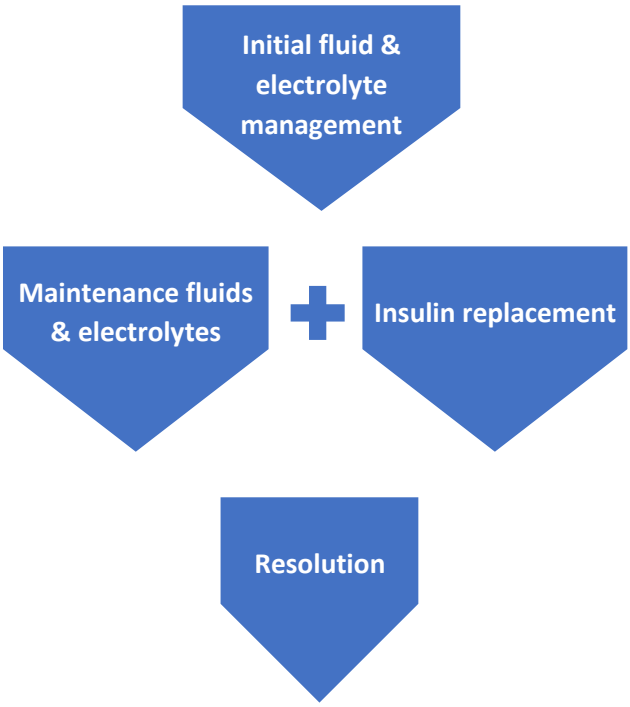
Reference Text:

Diabetic Ketoacidosis (DKA); Adult

This power plan is intended for use in individuals 22 years of age and up. It may also be used in individuals 18-21 years of age if care will not be primarily directed by a pediatric hospitalist (i.e. community hospital admissions, ICU-level care).

Last updated: 1/16/2024

DKA TREATMENT SUMMARY



Initial Management
- Fluid resuscitation
- Electrolyte replacement

Acidosis Treatment
- **Two-bag method**
- Continuous insulin infusion

Transition to Subcutaneous Insulin
- **Requires 2-hr overlap with IV insulin**
- Upon DKA resolution
- Resumption of diet

Regular insulin (IV)

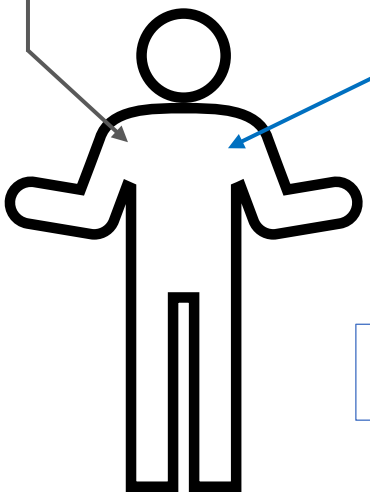
Q1H BG

0.9% NaCl or 0.45% NaCl ± 20 mEq/L KCL

D10 + 0.45% ± 20 mEq/L KCL

Clinical Scenario		Action Required
-	**…Default rate (no bolus, no titration)**	**Infuse at 0.1 unit/kg/hr**
IF	…BG 71-99 mg/dL	-PAUSE INSULIN- *Check BG Q15min until >100. To resume insulin, ensure Bag 2 is running at full rate*
IF	…BG ≤ 70 mg/dL or symptomatic HYPOglycemia	-PAUSE INSULIN- *Follow hypoglycemia protocol. To resume insulin, ensure Bag 2 is running at full rate*
IF	…Patient has persistent or recurrent HYPOglycemia	-CALL PROVIDER- *May consider decreasing insulin rate to 0.05 unit/kg/hr*
IF	…BG does NOT decrease by ≥100 mg/dL within the first two hours	-CALL PROVIDER- *May consider increasing insulin rate to 0.15 unit/kg/hr*
IF	…Potassium < 3.3 mmol/L	-PAUSE INSULIN & CALL PROVIDER- *Replace potassium per DKA electrolyte replacement protocol*

Blood glucose (mg/dL)	DKA Bag 1 rate (mL/hr)	DKA Bag 2 w/Dextrose rate (mL/hr)	TOTAL rate (mL/hr)
STANDARD			
BG >250	250	0 (zero)	250
BG 150-250	125	125	250
BG < 150	0 (zero)	250	250
FLUID RESTRICTED			
BG >250	125	0 (zero)	125
BG 150-250	75	125	200
BG < 150	0 (zero)	250	250

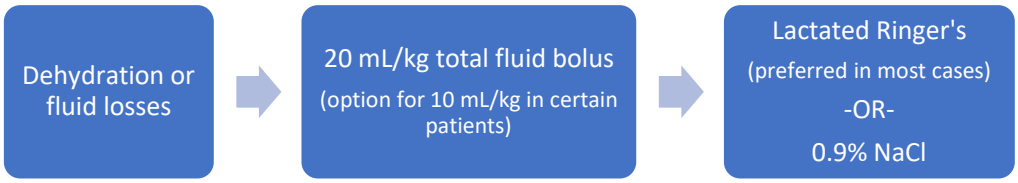


Potassium Level (mmol/L)	Parenteral (as potassium chloride IVPB)
< 3.3	Total dose: 80 mEq over minimum of 4 hours, *AND* 1. PAUSE insulin 2. Call provider to discuss before resuming
3.3 - 3.5	Total dose: 60 mEq over minimum of 3 hours
3.6 - 3.9	Total dose: 40 mEq over minimum of 2 hours
4 - 5.2	Total dose: 20 mEq over minimum of 1 hour
> 5.5	Call provider

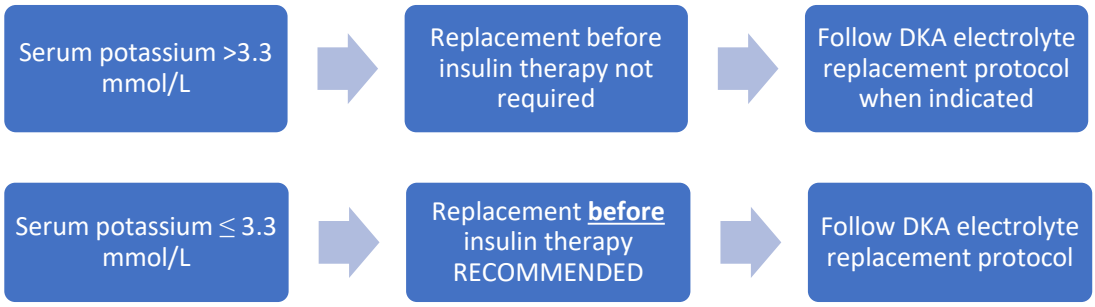
Q4H BMP+ Mg + Phos

PLUS magnesium + phos replacement

1. INITIAL FLUID MANAGEMENT:



2. INITIAL ELECTROLYTE REPLACEMENT:



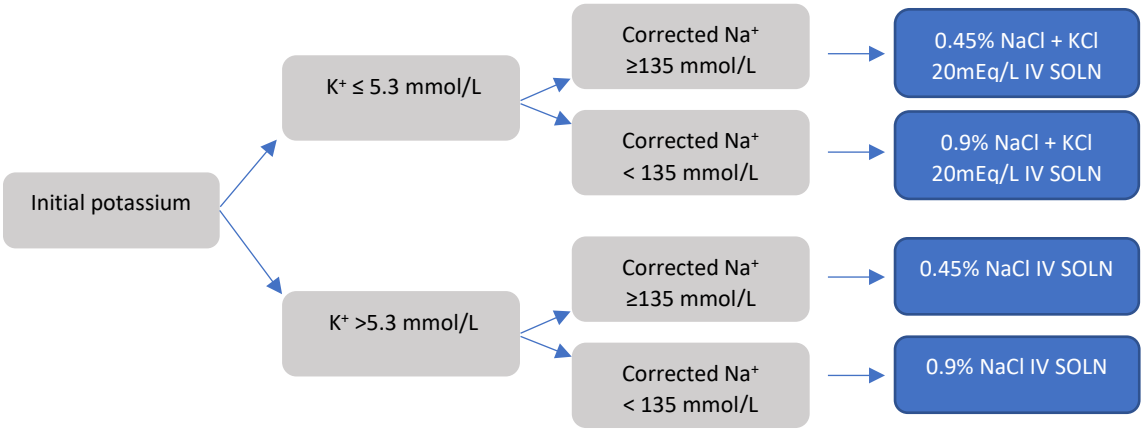
3. IV INSULIN INFUSION

Clinical Scenario		Action Required
-	**…Default rate (no bolus, no titration)**	**Infuse at 0.1 unit/kg/hr**
IF	…BG 71-99 mg/dL	-PAUSE INSULIN- *Check BG Q15min until >100.* ***To resume insulin, ensure Bag 2 is running at full rate***
IF	…BG ≤ 70 mg/dL or symptomatic HYPOglycemia	-PAUSE INSULIN- *Follow hypoglycemia protocol.* ***To resume insulin, ensure Bag 2 is running at full rate***
IF	…Patient has persistent or recurrent HYPOglycemia	-CALL PROVIDER- *May consider decreasing insulin rate to 0.05 unit/kg/hr*
IF	…BG does NOT decrease by 100 mg/dL within the first two hours	-CALL PROVIDER- *May consider increasing insulin rate to 0.15 unit/kg/hr*
IF	…Potassium < 3.3 mmol/L	-PAUSE INSULIN & CALL PROVIDER- *Replace potassium per DKA electrolyte replacement protocol*

4. TWO-BAG MAINTENANCE FLUIDS:

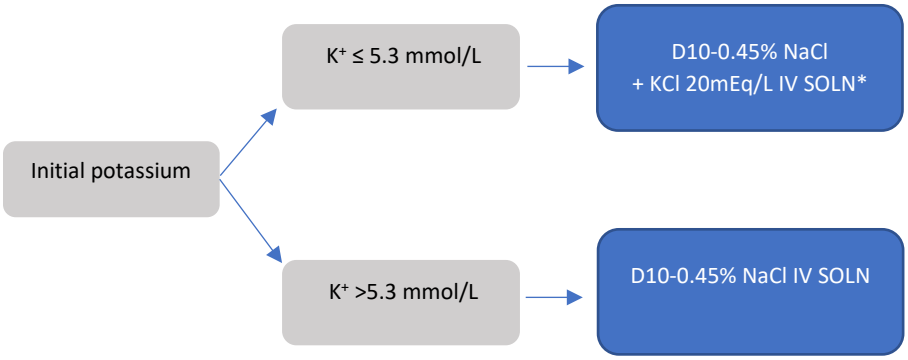
DKA Bag 1 and DKA Bag 2 w/Dextrose are connected to two different IV pumps and connected to each other via Y-site to be administered through one IV line.

DKA Bag 1



Corrected serum sodium = Na + 0.016(blood glucose – 100)*

DKA Bag 2 w/ Dextrose



*Solution requires compounding by pharmacy. If pharmacy unavailable to compound, may utilize D10/0.45 NaCl with electrolyte replacement per protocol.

Bag 1 & 2 titration

a. Standard rate

Blood glucose (mg/dL)	DKA Bag 1 rate (mL/hr)	DKA Bag 2 w/Dextrose rate (mL/hr)	TOTAL rate (mL/hr)	Functional Dextrose
BG >250	250	0	250	0%
BG 150-250	125	125	250	5%
BG < 150	0	250	250	10%

b. Fluid restriction

Blood glucose (mg/dL)	DKA Bag 1 rate (mL/hr)	DKA Bag 2 w/Dextrose rate (mL/hr)	TOTAL rate (mL/hr)	Functional Dextrose
BG >250	125	0	125	0%
BG 150-250	75	125	200	6.25%
BG < 150	0	250	250	10%

5. ONGOING ELECTROLYTE REPLACEMENT (SEE **APPENDIX 1**)

a. Nurse to order and replace per *DKA Electrolyte Replacement Protocol*. **If patient not eligible for replacement protocol, provider to order all electrolyte replacement.**

6. TRANSITION TO SUBCUTANEOUS INSULIN

a. Patients will be transitioned from IV insulin to long-acting subcutaneous (basal) insulin when ALL of the following criteria are met:
   i. pH > 7.3
   ii. Anion gap < 12
   iii. Serum bicarbonate > 15
   iv. Blood glucose < 200
   v. Beta-hydroxybutyrate < 5 or trending down
   vi. Patient is tolerating PO and ready to resume full diet

b. Nurse to call provider when criteria are met to help facilitate transition to next step in DKA management.

c. **Continue insulin infusion and IV fluids for TWO hours after administration of subcutaneous long-acting (basal) insulin.**

DKA TREATMENT RATIONALE

1. Definitions

a. Diabetic ketoacidosis (DKA): An acute metabolic complication of diabetes. DKA is characterized by metabolic acidosis and ketone body derangements (e.g., ketosis) resulting from a profound or absolute lack of insulin in the body. Though hyperglycemia is usually associated with DKA, a minority of patients with DKA will have euglycemia (normal blood glucose).

b. Two-bag system: An approach to DKA management that uses two maintenance fluid solutions (one WITH and one withOUT dextrose), allowing insulin to run at a set rate. In clinical trials, the two-bag system has led to faster DKA resolution, less hypoglycemia, and faster anion gap closure compared to conventional (i.e., methods with insulin titration) approaches.

Table 1. Common diagnostic criteria for DKA. Adapted from *Diabetes Care*. 2009;32(7):1335-1343.

	DKA		
	Mild	***Moderate***	***Severe***
Glucose (mg/dL)*	>250	>250	>250
Arterial pH	7.3 to 7.25	7.24 to 7	<7
Serum bicarbonate (mEq/L)	18 to 15	15 to 10	<10
Urine ketones	Positive	Positive	Positive
beta hydroxybutyrate (mmol/L)	3 to 4	4 to 8	>8
Anion gap	>10	>12	>12
Mental Status	Alert	Alert/drowsy	Stupor/coma

*Blood glucose may be normal in patients with *euglycemic DKA.*

2. **Initial fluid & electrolyte management**
    a. Fluid resuscitation: Patients with DKA frequently present with significant dehydration from GI losses and decreased oral intake. Many of these patients will require IV fluids prior to insulin initiation.
        i. Aggressive fluid resuscitation with 0.9% NaCl may cause renal tubular acidosis. In prospective clinical trials, this has been shown to cause or worsen acidemia and hyperkalemia, leading to increased incidence of AKI and need for renal replacement therapy.[1-4]
        ii. The use of a balanced crystalloid such as Lactated Ringer's (LR) solution may be preferred for DKA management. *Prospective clinical data show that use of balanced crystalloids lead to faster time to DKA resolution and faster time to IV insulin discontinuation compared to 0.9% NaCl.*[5,6]
        iii. Despite theoretical concerns, LR is NOT contraindicated in hyperkalemia, acute renal failure, or lactic acidosis, and is indeed preferred over 0.9% NaCl in these settings.
        iv. Relevant contraindications to LR may include elevated intracranial pressure, metformin-associated lactic acidosis, overt liver failure, and severe hypercalcemia.
    b. Electrolyte replacement: Correction of electrolyte derangements, especially hypokalemia, is recommended prior to the initiation of insulin. Since insulin therapy will decrease potassium further, the cutoffs for potassium replacement are *higher* in DKA compared to other diseases. *Serum potassium levels < 3.3 mmol/L should be repleted before insulin is started.* See **Appendix 1** for more information.
3. **IV insulin infusion**
    a. IV insulin is required to correct the underlying pH abnormalities in DKA. Insulin secondarily lowers blood glucose when elevated.
    b. As opposed to a one-bag system, *the two-bag system for DKA treatment does NOT require insulin titration.* Boluses of IV insulin are NOT recommended with the two-bag system.

4. **Two-bag maintenance fluids**
    a. Treatment of DKA with the two-bag system has been tested in prospective, randomized clinical trials in adults.[7,8] Pertinent findings include:
        i. Faster normalization of blood pH
        ii. Faster closure of the anion gap
        iii. Fewer instances of significant hypoglycemia
        iv. Less IV insulin administered in total
        v. No increase in length of hospital stay
    b. Standard nomenclature will be adopted throughout MHC for the naming of Bag 1 and Bag 2 on labels and smart pump infusion devices:
        i. Bag 1: "DKA Bag 1"
        ii. Bag 2: "DKA Bag 2 w/Dextrose"
    c. DKA Bag 1 and DKA Bag 2 w/Dextrose are connected to two different IV pumps & connected to each other via Y-site, to be administered through one IV line.
    d. There are four (4) options for DKA Bag 1. The choice between these four options is dependent on:
        i. Initial serum potassium, **and**
        ii. Corrected serum sodium
    e. There are two (2) options for DKA Bag 2 w/Dextrose. The choice between the two may be dependent on either initial or subsequent serum potassium levels.
    f. Maintenance fluid titration:
        i. Standard: the total, combined rate of DKA Bag 1 and DKA Bag 2 w/Dextrose is always equal to **250mL/hr.** The specific rates of Bag 1 or Bag 2 will be titrated by nursing per hourly glucose measurement.
        ii. Fluid restriction: the total, combined rate of DKA Bag 1 and DKA Bag 2 w/Dextrose is NOT constant. The specific rates of Bag 1 or Bag 2 will vary between 125 and 250 mL/hr and will be titrated by nursing per hourly glucose measurement.
5. **Ongoing electrolyte replacement**
    a. Prompt recognition and treatment of evolving hypokalemia and other electrolyte derangements is crucial in DKA management, as patients frequently present with electrolyte depletion and insulin therapy may have dramatic effects on serum electrolyte balance.
    b. Electrolytes will be supplemented throughout the treatment window by the nursing-driven by the DKA Electrolyte Replacement Protocol and monitored with Q4H BMP laboratory measurement.
    c. See **Appendix 1** for the *DKA Electrolyte Replacement Protocol*
6. **Transition to subcutaneous insulin**
    a. Biochemical markers: DKA resolution is marked by normalization of blood pH, anion gap, and blood glucose.
    b. Symptoms: Nausea, vomiting, and pertinent GI symptoms from presentation are resolved. Patients are able to tolerate meals.

c. Transition to SQ insulin: To prevent relapse, insulin therapy **MUST** continue after the acute treatment phase. **Continue insulin infusion and IV fluids for TWO hours after administration of subcutaneous long-acting (basal) insulin.**

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1. Astapenko D, Navratil P, Pouska J, Cerny V. Clinical physiology aspects of chloremia in fluid therapy: a systematic review. Perioper Med 2020;9(1).
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4. Magee CA, Bastin MLT, Laine ME, et al. Insidious Harm of Medication Diluents as a Contributor to Cumulative Volume and Hyperchloremia: A Prospective, Open-Label, Sequential Period Pilot Study. Crit Care Med 2018;46(8):1217–23.
5. Self WH, Evans CS, Jenkins CA, et al. 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.
6. Ramanan M, Attokaran A, Murray L, et al. Sodium chloride or Plasmalyte-148 evaluation in severe diabetic ketoacidosis (SCOPE-DKA): a cluster, crossover, randomized, controlled trial. Intensive Care Med 2021;47(11):1248–57.
7. Munir I, Fargo R, Garrison R, et al. Comparison of a 'two-bag system' versus conventional treatment protocol ('one-bag system') in the management of diabetic ketoacidosis. BMJ Open Diabetes Res Care 2017;5(1).
8. Haas NL, Gianchandani RY, Gunnerson KJ, et al. The Two-Bag Method for Treatment of Diabetic Ketoacidosis in Adults. J Emerg Med 2018;54(5):593–9.

APPENDIX 1: DKA ELECTROLYTE REPLACEMENT PROTOCOL

Purpose

To provide a plan for replacing potassium, magnesium, and phosphorus during the acute management of diabetic ketoacidosis in adults.

Criteria for use*

1. Patients must be monitored by continuous telemetry
2. To be used exclusively within the Adult DKA PowerPlan subsequent to a provider order
3. To be discontinued at the time of IV insulin discontinuation
4. Serum creatinine is ≤ 2.5 mg/dL and patient not on renal replacement therapy

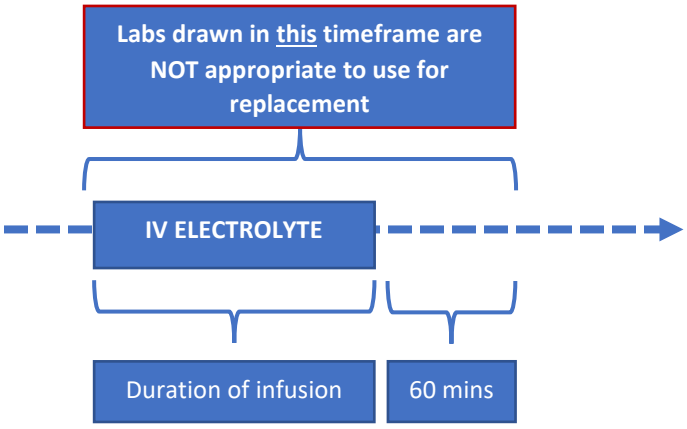
**If patient not eligible for replacement protocol, provider to order all electrolyte replacement.*

Process and Product Selection

1. Nurse to order electrolyte replacement in PowerChart based on potassium, magnesium, or phosphate protocol below.
    a. PowerChart search term: "Nursing - DKA Electrolyte Replacement"
    b. Ordering provider: "Nurse, per protocol"
2. Nurse to discontinue electrolyte replacement protocol when IV insulin is discontinued
3. Parenteral product selection will be guided by site formulary, availability, and MHC system electrolyte policies:
    a. MHC High-Alert Medications Policy
    b. Parenteral Potassium Supplementation Policy- Adult
4. Enteral administration is preferred where indicated

Monitoring

1. Scheduled BMP will be ordered for all patients every 4 hours
2. Nursing to order additional serum potassium levels as directed in *Potassium Replacement Protocol*
3. Replace electrolytes based only on appropriate serum measurements. To be an appropriate measurement, the lab draw must meet the following criteria:
    a. Lab NOT drawn during IV replacement of the electrolyte (electrolytes contained in maintenance IV fluids do not count)
    b. Lab drawn at least 60 minutes after administration of the electrolyte replacement, including oral (PO) replacement



Potassium Replacement Protocol

Replacement rate: 10 mEq/hr. If patient is monitored via continuous telemetry AND has a condition that requires more rapid supplementation, the administration rate shall not exceed 20 mEq/hr.

Potassium Level (mmol/L)	Enteral	Parenteral (as potassium chloride IVPB)	When to recheck level
< 3.3	Use IVPB replacement	Total dose: 80 mEq over minimum of 4 hours, *AND* 1. PAUSE insulin 2. Call provider to discuss before resuming	At next appropriate time until K >3.3 mmol/L *(see graphic above)*
3.3 – 3.5	Use IVPB replacement	Total dose: 60 mEq over minimum of 3 hours	At next appropriate time after replacement has finished *(see graphic above)*
3.6 – 3.9	40 mEq PO/NG x 1 dose Do not give both PO and IV replacement	Total dose: 40 mEq over minimum of 2 hours Do not give both PO and IV replacement	At next appropriate time after replacement has finished *(see graphic above)*
4 – 5.2	20 mEq PO/NG x 1 dose Do not give both PO and IV replacement	Total dose: 20 mEq over minimum of 1 hour Do not give both PO and IV replacement	At next appropriate time after replacement has finished *(see graphic above)*
> 5.5	Call provider		

Magnesium Replacement Protocol

Replacement rate: 1 gram/hour

Magnesium Level (mg/dL)	Parenteral (as magnesium sulfate IVPB)	When to recheck level
≤ 1.5	Total dose: 4 grams over minimum of 4 hours	At next appropriate time after replacement has finished *(see graphic above)*
1.6-1.9	Total dose: 2 grams over minimum of 2 hours	At next appropriate time after replacement has finished *(see graphic above)*

Phosphate Replacement Protocol

Replacement rate: 15 mmol over 1 hour

Phosphorus Level (mg/dL)	Enteral	Parenteral (as sodium phosphate IVPB)*	When to recheck level
< 1.5	K-Phos Neutral 2 tabs q2hr x3	15 mmol x3 doses	At next appropriate time after replacement has finished
1.5 – 1.9	K-Phos Neutral 2 tabs q2hr x2	15 mmol x2 doses	At next appropriate time after replacement has finished

*Solution requires compounding by pharmacy.