Diabetic Ketoacidosis (DKA)
Treatment Guideline
Helen DeVos Children's Hospital

Pathophysiology of DKA

-Critical deficit in insulin
-Results in intracellular starvation of insulin-dependent tissues: this stimulates release of counter-regulatory hormones such as glucagon, catecholamines, cortisol, growth hormone; ultimately results in increased hyperglycemia
-Counter-regulatory hormones released stimulate lipolysis and proteolysis, hepatic and renal glucose production and hepatic oxidation of fatty acids to ketone bodies
-Hyperglycemia also results in osmotic diuresis and dehydration

DKA Definition (must meet ALL of the following criteria):

1)Hyperglycemia
2)Ketosis
3)Metabolic acidosis: venous pH <7.3 or serum bicarbonate <15 mEq/L

Goals of DKA Therapy

-Correct dehydration
-Correct acidosis and reverse ketosis
-Restore blood glucose to near normal
-Monitor for complications of DKA and its treatment:
  - -cerebral edema
  - -electrolyte abnormalities:
    - hypoglycemia
    - hypokalemia
    - hypophosphatemia
    - hyperchloremia

Initial Fluid/Insulin Management

Initial Fluid Bolus:
-0.9NS or Lactated Ringer's 10-20 mL/kg (typically given in ED) given over 1 hour
-No more than 10-20 mL/kg should be given in most cases due to increased risk for cerebral edema with aggressive fluid resuscitation*
-Insulin infusion should be started at 0.1 Units/kg/hr AFTER initial fluid bolus is complete
-Insulin bolus should NOT be given prior to starting insulin drip

-*If continued signs of hypoperfusion or hypotension may consider an additional 10-20 mL/kg of fluid resuscitation. Decision to give additional fluid should be discussed with pediatric intensivist

Initial Laboratory Evaluation

1)Serum electrolytes(including calcium, magnesium, phosphorus), BUN, creatinine

2)Serum glucose

3)Capillary or venous blood gas

4)To be discussed and ordered if indicated: serum osmolality, beta-hydroxybutyrate, CBC, UA, Blood/urine cultures, amylase/lipase, Hemoglobin AIC, urine pregnancy(for all females who have achieved menarche)

5)New onset Diabetes labs: Hemoglobin A1C, TSH/T4, Thyroid Peroxidase Ab level, Transglutaminase IgA Antibody level, Glutamic Acid Decarboxylase Antibody level (GAD65 Ab), IA-2 Ab level, Insulin Ab level, ZnT8 Ab, ICA-512 Ab level

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Common Calculations

Serum Osmolality:
2(Na)+(glucose/18)+(BUN/2.8)

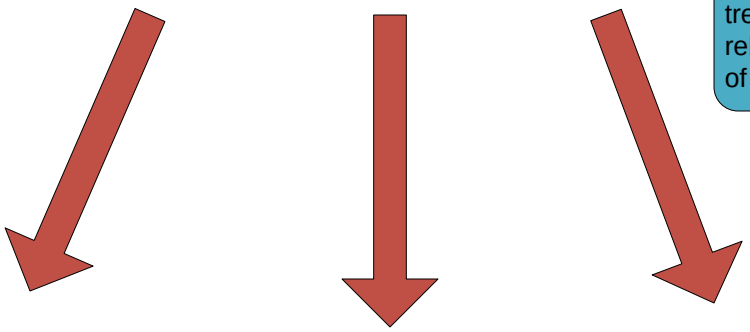
Corrected Serum Sodium:
Measured Na + 0.016 x (serum glucose-100)

Anion Gap:
Na-(Cl + HCO_3)

Initial PCCU Management
-Admission orders
-Order appropriate IVF using 2 bag system
-Continue insulin drip
-Order labs

*all orders should be discussed with attending physician

Neurologic Monitoring in DKA:
-Patients being treated for DKA are at high risk for cerebral edema, especially in the first 24 hours of treatment
-Signs/symptoms suggestive of cerebral edema: headache, vomiting, drowsiness or agitation, bradycardia or hypertension, pupillary changes
-Risk factors for cerebral edema: age<5, severe acidosis, serum osmolality>350, elevated BUN, failure of serum sodium to rise with treatment, large volume of rehydration fluids (>40 mL/kg), use of sodium bicarbonate



Calculating IVF Rate
-Dehydration should be assumed to be 5% (50 mL/kg) corrected over 24 hours
-Maintanence fluid calculation: 100 mL/kg for the first 10 kg + 50 mL/kg for the next 10 kg + 20 mL/kg for each additional kg for 24 hours
-Example for a 25 kg child:
(5% dehydration= 50 X25=1250 mL) + (100 x10=1000 mL) + (50 x10=500 mL) + (20X5=100 mL)=2850 mL/ 24=119 mL/hr

Two Bag IV Fluid System
-Initial IVF to be ordered for ALL patients should be using the 2 bag system
-Fluid to be ordered:
1) 1 bag of sodium chloride 0.9% + potassium acetate 20 mEq/L + potassium phosphate 13.6 mmol/L
2) 1 bag of D10 sodium chloride 0.9% + potassium acetate 20 mEq/L + potassium phosphate 13. 6 mmol/L
*Initial fluid management in the first 4-6 hours of treatment should always be with isotonic fluid

Admission Orders
-Powerplan name is Diabetic Ketoacidosis PCCU
-Basic orders:
-Cardiac monitoring
-Pulse oximetry
-Vital signs q1
-Neuro checks q1
-Strict Is/Os
-NPO with exception of ice chips
-All patients must have 1 dedicated IV for infusion of IVF and insulin and 1 IV to draw labs (if second IV not able to be placed then may have lab draws with butterfly needle but labs may NOT be drawn from IV infusing fluid/insulin)
-Lab Orders:
-Accuchecks q1 hour
-BMP and phosphorus q6 hours
-VBG: discuss need/frequency with attending physician

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Purpose of Two Bag IVF System

-As serum glucose drops all patients with DKA will eventually require addition of dextrose to fluids so that appropriate serum glucose can be maintained while receiving insulin therapy

-Two bag system is used in order to adjust the amount of dextrose being given as the serum glucose changes

Fluid and Glucose Management in the PCCU

-IVF should be managed using two bag system and titrated based on serum glucose concentration

-Adequate urine output should be documented prior to initiation of potassium containing fluids

Insulin Therapy

-Insulin therapy in DKA allows glucose to be adequately utilized by the tissues and therefore ketone body production decreases

-Insulin drip should be maintained at 0.1 Units/kg/hr and dextrose containing IVF titrated appropriately according to serum glucose (see below)

Blood Glucose (mg/dL)	% of Rate from Bag 1 (0.9NS + 20 mEq/L K Acetate + 13.6 mmol/L Kphos)	% of Rate from Bag 2 (D10 0.9NS + 20 mEq/L K Acetate + 13.6 mmol/L Kphos)	Final Dextrose Concentration	Insulin Infusion Rate (units/kg/hr)
>300	100	0	0	0.1
200-300	50	50	5	0.1
100-200	0	100	10	0.1
<100	DC	DC	*Discuss with attending , order D12.5 0.9NS + 20 mEq/L K Acetate + 13.6 mmol Kphos*	0.1
<100 and already on D12.5 NS				*Wean insulin to 0.05*

*If serum glucose is dropping by more than 100 mg/dL per hour notify attending physician

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Common Electrolyte Abnormalities in DKA Management

Hypokalemia or Hypophosphatemia

-Potassium and phosphate replacement should continue throughout IV fluid therapy

-Maximum amount of potassium in maintenance IVF is 80 mEq/L

-Maximum recommended rate of IV potassium replacement is 1 mEq/kg/hr

-Hypophosphatemia is common and should be treated if plasma phosphate is <1 mg/dL and patient is symptomatic

-Maximum infusion rate for phosphate replacement is 0.08 mmol/kg/hr

Hyperchloremic Metabolic Acidosis

-Results from excess chloride administration during correction of DKA

-After initial 4-6 hours of treatment may *consider* changing both bags of IVF to 0.45 sodium chloride + Kacetate 20 mEq/L + Kphos 13.6 mmol/L in order to decrease amount of chloride being administered

-Checking a serum beta-hydroxybutyrate may help differentiate between ongoing ketone production and acidosis secondary to hyperchloremia

Bicarbonate Administration During DKA Treatment

-Not indicated in the treatment of DKA
-No evidence that use of bicarbonate facilitates metabolic recovery
-Bicarbonate administration may cause paradoxical CNS acidosis, may worsen hypokalemia and may cause increased hepatic ketone body production

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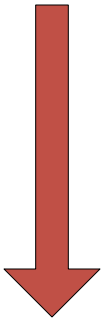
Criteria to Transition from Insulin Drip

-Correction of acidosis (pH>7.3, bicarbonate>18 mEq/L)

-Serum glucose <300 mg/dL

-No vomiting, tolerating ice chips, appears ready to eat



Transition to SQ Insulin

-After discussion with endocrinology, long-acting insulin and short-acting insulin should be ordered to bedside

-Long-acting insulin should be given 30-60 minutes prior to discontinuation of the insulin drip

-Short-acting insulin should be dosed prior to meal based on serum glucose and carbohydrates in the meal

-Patients typically have an insulin:carbohydrate ratio (amount of insulin they should receive for each gram of carbohydrates) and a correction factor (amount serum glucose is excepted to fall for each unit of insulin given)

-Example: Patient has a serum glucose of 300 mg/dL and is going to eat 50 gm of carbohydrates. The CF is 40 and the I:C ratio is 1:8

- -Calculate the amount of insulin needed to correct glucose to 150:
  - -300-150=150; 150/40=3.75 units of insulin
- -Calculate the amount of insulin needed for carbohydrates being eaten:
  - -50/8=6.25 units of insulin
- -TOTAL insulin dose=3.75+6.25=10 units