DKA/HHS Management using Subcutaneous Insulin
COVID-19 Pandemic Adjusted Protocol
03-26-2020

Disclaimer: The information presented is intended to be used as a guide for management of DKA and HHS, and does not supercede proper clinical judgment or alternative approaches in certain clinical situations. For any complex case of DKA, early consultation with an endocrinologist is strongly recommended.

During the COVID-19 crisis, we are trying to conserve ICU beds and staff. Appropriate patients in DKA will be admitted to general medicine floor teams and managed by the endocrinology consulting team using the following subcutaneous (SC) protocol.

Rule Out: Pregnancy, Drug use (especially cocaine and methamphetamines), thyrotoxicosis, infection, "spoiled" insulin, myocardial infarction, and other causes of DKA. Patients in 3rd trimester may be best treated in L&D ward.

Therapy (derived from 2004 ADA position statement- *Diabetes Care* (2004) 27:S94-S102, SQ insulin therapy protocol courtesy of Dr. Michael E May, with permission)

Stage 1- initiation

As soon as consulted, examine patient (confirm diagnosis (lab needed is BMP and serum betahydroxybutyrate or UA) and volume status, etc) and initiate therapy. If there are indications for ICU other than DKA (severe resting hypotension, stroke syndrome, glasgow coma score less than 5), consider recommending ICU transfer if feasible. CONFIRM RENAL FUNCTION BEFORE STARTING FLUIDS.

A. Fluids- D5-Lactated Ringers (minimizes development of hyperchloremic metabolic acidosis during recovery) **3.5 ml/kg/hr** (reduce for CHF, edema, chronic renal failure). Do not order IVF rate greater than 250 mL/hr because high rates of peripheral IVF cause superficial thrombophlebitis.

- Alternative: 0.45% (corrected serum Na^+ normal to high) NS or 0.9% (corrected Na^+ low) NS **3.5 ml/kg/hr**
- Once serum K+ level is known to be less than 6.0 and serum creatinine is less than 2.0, add K+ replacement with potassium acetate 40 Meq/L

(The suggested IVF and potassium supplement is a maximum peripheral dosage)B. Insulin- SC protocol

- Bolus with 0.4 units/kg of insulin Lispro- **half given IM, half given SQ (IM for more reliable absorption in severe dehydration)**. e.g for 60 kg patient give 12 units IM insulin lispro + 12 units SQ insulin lispro

C. Check serologic glucose and electrolytes every 8 hours, check bedside glucose every 4 hours to overlap with meals: MN, 0400, 0800 1200, 1600, 2000.

Stage 2-Recovery

A. Fluids- D5-LR + 20-40 Meq/L K-acetate @ 3.5 ml/kg/h OR D5-0.45% NS + 20-40 Meq/L K-Acetate (for elevated corrected Na^+); coordinate fluid orders and patient's volume status closely with primary team.
   - **The rate of fall of serum glucose is so fast and so variable that waiting to add glucose increases risk of hypoglycemia. It is simpler to give the D5-containing fluids from the beginning.**
B. SC insulin maintenance: insulin lispro on q4hour schedule:
   - BG >280= 0.4 u/kg insulin lispro
   - BG 241-280= 0.3 units/kg SQ
   - BG 201-240= 0.2 units/kg SQ
   - BG 161-200= 0.1 unit/kg SQ
   - BG 121-160=0.05 units/kg SQ
   - BG 90-120= 0.025 units/kg SQ as long as IVF have D5
   - 65-90= no insulin
   - BG <65 ½ amp D50, recheck in 15 min
   - When writing the orders, calculate the dose for each glucose interval and write the order in **absolute doses**, not as formulas that the nurse has to recalculate each time
   - Make sure that bedside glucose monitoring is ordered at the correct schedule (eg q4 hours for q4 hour insulin dosing)
   - NOTE: If patient has significant insulin resistance, such as Type 2 diabetes or Type 1 diabetes with obesity, the above insulin doses may have to be increased by 50% at each level.
C. Start Basal Insulin therapy as soon as possible, preferably within the first 12 hours of admission: glargine 0.3 units/kg SQ every 24 hrs (order written as an absolute dose),.

D. Continue monitoring electrolytes and glucose every 8 hours
E. Patients should have a full liquid diet ordered initially, advance to regular diet (young healthy patient) or cardiac diet (older patient with CAD/HTN/CHF) or renal diet (patient with advanced CRF)- 3 meals NO snacks

Stage 3- transition to discharge

Once metabolic derangements and electrolytes have been corrected **(defined as resolution of serum ketosis and serum CO2 >=20)**, patient is ready to be transitioned to standard SC insulin therapy in anticipation of discharge

If there is no major co-morbid condition, expect resolution and discharge in 24-48 hours. If there is a major co-morbid condition, that treatment will dictate length of stay post-acidemia.

A. If you haven't started basal insulin, you should have by now (see above)
B. If patient is eating, give them an appropriate dose of meal insulin (regular, humalog, or novalog) for each meal- generally 0.05-0.1 units/kg/meal if patient has adequate PO intake plus sliding scale if needed. Change your bedside glucose monitoring to QID AC and HS.
C. Continue maintenance IV fluids (D5-LR or D5-0.45% NS plus 20-40 Meq/L K+) at 2 ml/kg/hr as required to complete replacement of free H2O and electrolyte deficits
D. Make sure any underlying causes have been appropriately treated. If the patient's DKA was precipitated by omission of insulin- provide appropriate education and refer for diabetes education/ endocrine follow up as an outpatient as indicated
E. If patient has history of recurrent admissions for DKA, screen for psychosocial issues- adverse home situation, depression, alcohol/substance abuse, eating disorder, lack of social support, etc)
F. Discharge planning- identify and contact the provider who will follow up for outpatient diabetes care, decide on a discharge insulin regimen, ensure patient provided with clear discharge instructions, provide all necessary discharge insulin therapy supplies (does the patient have a glucometer?)

Additional Therapy Comments

A. Phosphate- Although mild to moderate phosphate derangement is common in DKA, it seldom requires treatment. The two randomized studies on this topic found no benefit of phosphate therapy in DKA..
B. Bicarbonate- AVOID - this is something that is still given by some clinicians, despite a lack of evidence of benefit, and some evidence of harm (worsening of hypokalemia, delay of metabolic recovery, increased risk of cerebral edema in children). My opinion is that the available data do not support the use of bicarbonate therapy in the treatment of DKA with pH values >6.9. In patients with pH <6.9 the evidence is scant and incomplete and does not suggest benefit. However, the ADA position statement still includes a recommendation for giving bicarbonate for pH ≤7.0, despite a lack of evidence indicating benefit. I would not give bicarbonate to an adolescent DKA patient because it has been associated with an increased risk of cerebral edema in children (N Engl J Med 2001; 344:264-269)
C. Patients often will develop a hyperchloremic metabolic acidosis in the recovery phase, due to the relative excess of chloride and lagging regeneration of bicarbonate. This phenomenon is benign and does not affect outcome, but can be easily avoided by avoiding excess chloride administration in IV fluids (e.g. by using lactated ringers instead of 0.9% NS)