Diabetic Ketoacidosis

Nursing Grand Rounds

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Thank you!!

- Thank you Dr. Ildiko Koves MD for leading the Clinical Standard Work Pathway Group at Seattle Children’s Hospital and for the many learnings we have had and continue to have as we continue to improve our DKA care.

- Thank you to Elaine Beardsley RN for the presentation slides.
Disclosure Statement

• I do not have any conflict of interest, nor will I be discussing any off-label product use.

• This class has no commercial support or sponsorship, nor is it co-sponsored.
Learning Objectives

• Describe pathophysiology of diabetic ketoacidosis
• Describe the goals of therapy within the initial hours of therapy
• Describe the assessments and interventions during the initial hours of treatment
A 10 year old presents with difficulty breathing today and vomiting
He appears very dehydrated and seems quite obtunded
https://www.youtube.com/watch?v=TG0vpKae3J
• Upon history, Mom says he has been losing weight and has been drinking a lot but she figured it was because he has been playing a lot more baseball
• Many kids in school also have vomiting and flu-like illness
• Patient had runny nose and cough 1 week ago
His glucose on the meter reads “HIGH” which is greater than 599 mg/dL

- What additional lab tests does he need?
- How much fluid does he need?
- Should he get insulin, and by what route?
PATHOPHYSIOLOGY
Type 1 Diabetes

- Type 1 diabetes results from an autoimmune destruction of the beta cells in the pancreas from genetic polymorphic mutations.
- Often preceding initial Type 1 presentation is a viral illness but causation factors are still being researched.
- Type 1 results in an insulin deficiency.
- **Not called Juvenile onset or insulin dependent diabetes anymore as type 2 can have both.**
Type 2 Diabetes

- Type 2 is rising from obesity epidemic, and patients are becoming younger.
- Type 2 results in insulin resistance and a decrease in responsiveness of the beta cells to secrete insulin (relative insulin deficiency).
- Type 2 can develop DKA but it is more rare; can also get HHS (hyperglycemic hyperosmolar syndrome).
DKA Pathophysiology

• How does DKA develop?
• What is going on at the cellular level to cause such imbalance?

• For the purpose of this lecture, we will not go into the epigenetic modifications that cause the cell destruction
Insulin review

- Insulin is produced by the beta cells in the pancreas
- Insulin is most potent anabolic hormone
- Insulin is the main hormone to regulate blood glucose by facilitating glucose transport into the cells
- In addition, insulin is responsible for glucose storage in muscles and fat (glycogen and lipid) and protein synthesis
- Has an opposite effect of glucagon
Insulin does not work alone.....

- Insulin works very closely with counter-regulatory hormones and somatostatin to maintain glucose homeostasis.
- **Counter-regulatory hormones (CRH)** include glucagon, cortisol, growth hormone, and epinephrine.
- The CRH are responsible for glycogenolysis, proteolysis, lipolysis and gluconeogenesis.
- ***these usually work within a negative feedback system***
Type 1 diabetes

Lack of insulin and CRH ↑ to attempt to help

↓

Glycogen is broken down in muscle and liver (glycogenolysis)

+ Protein is broken down to convert into glucose (glycogenolysis)

+ Fats are broken down into free fatty acids which are converted in the liver to glucose or ketoacids (ketogenesis)

= gluconeogenesis, glycogenolysis, lipolysis
Increased CRH

- When glycogenolysis is related to insulin deficiency, this results in severe hyperglycemia.
- Lipolysis increases the serum free fatty acids.
- Hepatic metabolism of the fatty acids results in ketoacids and ketones.
Hyperglycemia

Increased serum glucose
↓
Osmotic diuresis (polyuria) → fluid/electrolyte loss → dehydration
↓
Kidneys try to compensate (activation of renin-angiotensin-aldosterone)
↓
Increased thirst (polydipsia)
Compensatory Mechanisms

• The rise of the blood concentration of ketoacids initially leads to a state of ketonemia.
• The buffering systems attempt to control but are soon overwhelmed and they overflow into urine (i.e., ketonuria).
• If there are more accumulation of ketoacids the buffering mechanisms fail and metabolic acidosis (i.e., ketoacidosis) results, with a drop in pH and bicarbonate serum levels and a higher anion gap.
• Respiratory compensation results in rapid shallow breathing (Kussmaul respirations).
Increased catabolism

Cellular losses of sodium, potassium, phosphate
Increased fatty acid breakdown
\[\downarrow\]
Ketoacids develop but buffer systems are not effective = ketonemia
\[\downarrow\]
Metabolic Acidosis develops
Ketones

- Ketones = acetate, acetoacetate, beta hydroxybutyrate (BOHB)
- Increased BOHB and acetoacetate induces nausea and vomiting which contributes to dehydration
- Main ketone bodies are acetoacetate and BOHB
- Acetone causes fruity breath
Electrolyte Imbalances from Increased Osmolarity

- $K^+$ is largely an intracellular ion.
- Both lack of insulin and acidosis cause a shift of $K^+$ extracellularly.
- High urinary losses of $K^+$ occur from osmotic diuresis.
- Serum $K^+$ levels can may not represent true body depletion because of acidotic shift of $K^-$. Only extracellular $K^+$ is measured.
Sodium

• Sodium is a main cation of extracellular fluid

****Key point****

• Hyperglycemia ↑ serum osmolarity = water moving from intracellular space into extracellular space = diluted hyponatremia

↑ glucose = ↓ sodium
Corrected Sodium

- In order to have a “true” sodium lab value, the sodium level needs to be “corrected” for the high glucose level

Corrected Sodium Level:

\[ [\text{Na}] + \text{Glucose mg/dl} \times \frac{100 - 100}{100} \times 1.6 \]

100
Other Electrolyte Disturbances

- Phosphate depletion is present in DKA, but the serum phosphate may be normal or elevated due to extracellular movement.
- Routine phosphate administration is not recommended and will return to normal after patient begins eating regularly.
- Calcium and magnesium may be lower, but also do not need routine replacement.
- Bicarbonate should not be replaced.
DKA Definition

- **Hyperglycemia** *(Diabetic)*
  - Blood glucose > 200 mg/dl
- **Ketosis** *(Keto)*
  - Elevated serum or urine ketones
- **Acidosis** *(Acidosis)*
  - pH < 7.30
  - Bicarb < 15 mmol/L
In summary ...

INADEQUATE INSULIN SECRETION

- Fatty acid oxidation
- Gluconeogenesis
- Glycogenolysis
- Peripheral glucose uptake and metabolism

KETONE BODIES

HYPERGLYCEMIA

ACIDOSIS

- Vomiting
- Increased insensible fluid losses

Hyperkalemia

- Renal phosphate loss
- Renal potassium loss

DEHYDRATION

- Osmotic diuresis
- Renal sodium loss

- Poor tissue perfusion

Renal phosphate loss

Increased lactate
Why is breathing like this?

- [https://www.youtube.com/watch?v=TG0vpKae3Js](https://www.youtube.com/watch?v=TG0vpKae3Js)
-
1. Prolonged state without insulin (delayed diagnosis in new onset, non-compliance in established diabetic patient, or pump failure in established diabetic)

2. Change in insulin requirements in established diabetic patients - illness, or growth
DKA

ASSESSMENT
Symptoms at Initial Presentation

- Nausea / Vomiting
- Polydipsia / Polyuria / Nocturia
- May have history of weight loss of new dx
- Abdominal pain
- Kussmaul Breaths
- Weakness
- Headache (possibly)
- Decreased level of consciousness (possibly)
- Fruity breath
- Tachycardia
- BP rarely hypotensive, can be hypertensive
Initial Nursing Assessment

- Weight in Kilograms
- Complete set of vital signs (temp-pulse-respirations-blood pressure-oximetry-ETCO2 (some places use capnography to trend acidosis)
- Pain scale and strict I&O
- Neuro (pupils/GCS/presence of headache)
- Perfusion (temp/cap refill/pulses)
- Respiratory assessment (rate/depth/breath sounds/retractions/positioning)
- Hydration (turgor/mucus membranes)
- Abdominal assessment
Degree of dehydration can be misleading

- Dehydration in DKA appears more pronounced than it actually is which has led to overhydration
- Acidosis can cause vasoconstriction which results in poor perfusion
- Kussmaul breaths can dry out mucous membranes
- Recent evidence suggests dehydration is around 7%
- Hypovolemic shock is very rare
Cerebral Edema

• Although cause is not fully understood, cerebral edema is the leading cause of death in DKA
• Approximately 1% of children will get CE
• Most common with new diagnosis in younger children
• Adults rarely get cerebral edema
Cerebral Edema occurs most after treatment begins

- It is not only the goal to assess who has cerebral edema, but who is at risk for developing cerebral edema!!!
- The cause is not known but may be related to genetics, age and electrolyte/fluid shifts in the brain
- May be related to: sudden change in glucose bolus insulin, overhydration, severe acidosis, severe dehydration
Cerebral Edema most common 4-12 hours after tx

- headache
- ↓ neurological status (restlessness, irritability, increased drowsiness, incontinence, deterioration of GCS)
- specific neurological signs - pupil changes
- progressive heart rate slowing, rising blood pressure, widening pulse pressure (Cushing triad)
- decreasing oximetry saturations
Cerebral Edema

- Detection is key!!!
- **Repeat neuro assessments should be hourly for the first 12 hours**
- Treatment is aimed at decreasing intracranial pressure
- Head of bed elevated 30 degrees
- Initial slow fluid hydration
- Mannitol, Hypertonic saline can be considered
- Imaging if not improved
Initial Laboratory Evaluation

- Glucose
- Venous Blood gas
- BOHB or urine ketones
- Electrolytes with corrected sodium
- Bun/Cr
- Serum Osmolarity (calculated)
- Later labs can include HgbA1C, new diagnosis tests for antibodies, blood culture if concern for infection
BOHB Testing

- BOHB levels rise and decrease quicker than the other ketone bodies
- BOHB is the best indicator of ketosis
- BOHB levels are not detected by urine ketone strips; that is acetoacetate
- BOHB meters are commercially available; meters are cheap ($40) but strips are about $4 each
DKA

MANAGEMENT
Management of DKA – goals of therapy

1. Correct dehydration
2. Correct acidosis and reverse ketosis
3. Normalize blood glucose
4. Minimize risk of DKA complications
5. Identify and treat any precipitating event
Goals of glucose-insulin –electrolyte replacement

Slow correction of glucose, fluid and electrolyte imbalances to prevent sudden changes in osmolarity which could result in intracellular fluid shifts
Initial fluid rehydration

- Give normal saline at 10 ml/kg bolus over 1 hour. **if hypotensive and poor pulses (very rare) can give fluid rapidly
- Can repeat up to 3 times, but often only 1 bolus is needed
- Consider what fluid patient has already had if referred in from an outside hospital/clinic
Insulin replacement

• If new arrival, insulin replacement is not recommended to begin within the first hour as the bolus is going so there is not rapid change of the fluid and glucose levels
• **Insulin drip should be ordered in the first hour so it is ready to be initiated at the 1 hour mark
• The recommended insulin replacement method is via insulin drip at 0.05-0.1 units/kg/hour
• DO NOT BOLUS INSULIN
Electrolyte replacement

- Even though the potassium may appear elevated (due to acidosis), there is a total body depletion
- Unless hyperkalemia (greater than 5.5), potassium replacement should begin
- **Ensure insulin is infusing when K begins**
- Do not routinely replace magnesium, phosphorus or calcium
We use the 2 bag system

• The 2 bag system was introduced in the 1990’s to facilitate rapid titration of the changing glucose levels in order to prevent high fluctuations in glucose level
• Other benefits include medication safety of not having numerous bags, timely titrations, possible infection prevention from less line opening, decreased cost
• Involves 2 bags with same concentration of electrolytes and sodium, but one has dextrose
• Isotonic fluids are given for first 6 hours depending on risk for cerebral edema
• If patient is tolerating fluids without neuro signs, fluids can be switched to hypotonic at 6 hours.
• ****1/4 NS should never be used; Only ½ NS should be given if no CE signs
• Potassium supplementation should be given
• KCL should be used with caution as it can increase hypochloremia and possibly prolong acidosis
PIV placement

- 2 larger bore PIV are recommended to facilitate the insulin and fluid infusions as well as obtain frequent blood draws
- PIV access may be difficult as the extremities are often cool and hypoperfused
- Warming with warm packs and a warm blanket may be helpful as long as access is not significantly delayed
- If altered LOC and PIV access not obtained rapidly, use intraosseous device
Fluid replacement

- Fluid replacement is recommended to occur over 48 hours until the DKA clears.
- The replacement rate is calculated based on the maintenance requirements over 48 hours plus the replacement based on the degree of dehydration (remember it is often 5-7%).
Clinical Standard Work

SEATTLE CHILDREN'S HOSPITAL DKA GUIDELINE
ICU Admission Criteria (if any of the following…)

**HIGH RISK: Admit to ICU**

ICU Admission Criteria: (Any of the following: [LOE: LC])

- Age ≤ 24 months
- Developmental delay or any condition that compromises communication
- GCS ≤ 13 after volume resuscitation
- Abnormal neurological exam after volume resuscitation
- Other organ system dysfunction
- Presenting pH ≤ 7.15
- Presenting HCO₃ ≤ 5 mEq/L
- Presenting PCO₂ < 10 mmHg
- Presenting BUN > 30 mg/dL
- Patient received IV bicarbonate or insulin bolus
- Calculated mOsm > 350
  \[2 \times Na + (\text{glucose}/18) + (\text{BUN}/2.8)\]
- Patient received > 40 mL/kg total initial volume replacement (include fluids received prior to arrival to SCH)
- Corrected Na < 140 mEq/L or decreasing at 2 hour labs
  \[\text{Corrected Na} = \text{Measured Na} + [(\text{Serum glucose} - 100)/100 \times 1.6]]

*If no ICU beds are available, admit to medical unit only if: 1:2 nurse to patient ratio, and after discussion with attending, charge RN and shift administrator*
## Lab Schedule

<table>
<thead>
<tr>
<th>Laboratory analysis</th>
<th>DKA confirmed</th>
<th>Hour 1</th>
<th>Hour 2</th>
<th>Hour 3</th>
<th>Hour 4</th>
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<td>Blood Gas (CBG, VBG, ABG)</td>
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<td>**β-hydroxybutyrate</td>
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<td>†Blood culture</td>
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</table>

* Repeat glucose every hour while on insulin drip, send first glucose to the lab as well for serum glucose

** Repeat sodium and BOHB every 2 hours while on insulin drip

*** May repeat these labs every 4 hours until normalized, especially while on insulin drip

† Only if febrile or concern for infection and do not repeat if done at referral hospital

‡ Repeat if done at referral hospital
Fluid management

- Every hour, the glucose is reobtained
- Based on the glucose we titrate the two bag system
- The glucose should not drop greater than 100 mg/dl per hour
- If there is a drop that exceeds 100 mg/dl per hour, the Provider is contacted who contacts Endocrine for further recommendations
- **Insulin is not titrated**
Transition to subcutaneous insulin

- The plan to transition to subcutaneous insulin is made when the ketosis is almost resolved
- At BOHB 3 mmol/L, the transition orders are written
- At BOHB 1 mmol/l, the patient is given subcutaneous insulin:
  - basal insulin
  - short acting if eating
- Drip turned off 30 min after sc insulin given
• **DKA:** Glucose > 200 **AND** pH < 7.30 or HCO3 < 15 **AND** ketonuria/ketonemia

• **Principles of Therapy**

  1. Treat dehydration without over-hydration as part of resuscitation.

  2. Minimize risk of and recognize cerebral edema. Too rapid correction of dehydration and hyperglycemia increases the risk of cerebral edema. Goal: glucose reduction at <100 mg/dL/hr at maximum
Transfer care

- 3. *Once initiated, maintain steady insulin rate.* Acidosis is primarily treated by insulin infusion and the hyperglycemia is primarily treated by volume restoration.
- 4. If the patient presents with a home insulin pump, turn it off and remove. Keep with patient.
- 5. Sodium bicarbonate, hypotonic fluid boluses, and insulin boluses are contraindicated.
Transport recommendations

- **Management prior to and during transport**

1st hour of care:
- Obtain glucose, electrolytes, urine ketones and venous blood gas
- NS bolus 10mL/kg over 1 hr

2nd hour and subsequent care:
- Re-check glucose and monitor glucose every 30 minutes
- Follow bolus with NS with potassium additives (if available) at maintenance rate
Cont. transport recommendations

- If glucose < 300 mg/dL, use D5NS instead of NS
- Begin insulin infusion at 0.05 unit/kg/hr
- **START** insulin infusion with maintenance fluids, typically with potassium
- **DO NOT** delay transport to wait for fluids or insulin drip. If unavailable, forego insulin, use NS at maintenance IV rate and expedite transfer to SCH
Cont. transport recommendations

• Ask referring facilities what they have available for potassium containing fluids.
• **Do not add potassium if $K > 5.5 \text{ meq/L x 2, sample not hemolyzed}**

OPTIONS:
• NS + 20meq/L K phos + 20 meq/L K acetate
• NS + 40 meq/L K acetate (if no K phos available)
• NS + 20 meq/L KCl (if only KCl available)
DKA

CASE REVIEWS
Case review #1

- An 18 month old sent from the PCP for vomiting and dehydration
- https://www.youtube.com/watch?v=j2MppcbXj70
Case review #1

- The Provider orders a PIV start, lytes, bedside glucose, Bun/Cr and a 20 ml/kg bolus
- The glucose is 550mg/dl
- What do you do? Do you start the 20 ml/kg bolus?
- What additional lab tests are needed?
- What are her risks?
Case review #1

- You and the Provider huddle about concern for DKA.
- She orders BOHB (or urine ketones) and a blood gas
- The BOHB is 9.6 (very large ketones) and the pH is 7.06, Na is 136 corrected Na is 141
- Hyperglycemia + ketosis + acidosis = DKA
- How much fluid should be given for a weight of 12 kg?
- Another PIV is placed
What assessments are done at 1 hour?

- Neuro check
- Repeat vitals
- Repeat glucose check
- Repeat corrected sodium
Case review #1 – 1 hour is complete

- Insulin arrives in standard concentration of 1 unit/1 ml
  - Order is for 0.05 units/kg/hr
  - 2 nurse independent check done
  - Smart pump used

- 2 bag system fluid is ordered:
  1. NS + 40 mEq/L K (Kacetate)
  2. D10 NS + 40 mEq/L K (K acetate)
    - calculate rate for 7% dehydration
### Case review #1 - 2 bag system rate

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight of patient</td>
<td>12 kg</td>
</tr>
<tr>
<td>Severity of Dehydration - assume:</td>
<td>7 percent</td>
</tr>
<tr>
<td>Fluid deficit = weight (max: 80 kg) * percentage dehydrated</td>
<td>840 ml</td>
</tr>
<tr>
<td>DKA Suspected - include all fluids administered at SCH and at other facilities</td>
<td>0 ml = 0 ml/kg</td>
</tr>
<tr>
<td>Maintenance fluids for one day</td>
<td>1100 ml</td>
</tr>
<tr>
<td>Total fluids to administer over 48 hours (maintenance * 2 + deficit - resuscitation)</td>
<td>3040 ml</td>
</tr>
<tr>
<td>NOTE: Formula is such that we never provide less than 1 x maintenance fluids.</td>
<td></td>
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<tr>
<td>TOTAL IV FLUID RATE:</td>
<td>63 ml/hr</td>
</tr>
</tbody>
</table>
2 bag system - what would rate be if BG was 510?

<table>
<thead>
<tr>
<th>Enter Total IV Fluid Rate:</th>
<th>63 ml/hr</th>
</tr>
</thead>
<tbody>
<tr>
<td>If Hourly Blood Glucose Falls &gt; 100 mg/dL/hr, call medical staff to guide management.</td>
<td></td>
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</tbody>
</table>

If hourly blood glucose falls 100 mg/dL/hr or less, use the following table:

<table>
<thead>
<tr>
<th>Two Bag System Table</th>
<th>Saline bag (ml/hr)</th>
<th>Dextrose-Saline bag (ml/hr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>For blood glucose values of</td>
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<tr>
<td>≥ 300</td>
<td>63</td>
<td>OFF</td>
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<td>250-299</td>
<td>47</td>
<td>16</td>
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<td>200-249</td>
<td>32</td>
<td>31</td>
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<td>150-199</td>
<td>16</td>
<td>47</td>
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<tr>
<td>100-149 (if &lt; 125, order D12.5-containing bag as below, but do not hang)</td>
<td>OFF</td>
<td>63</td>
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<tr>
<td>&lt; 100</td>
<td>Discontinue the two-bag system and instead use D12.5% concentration with identical saline and electrolyte content. <strong>Discuss with Attending.</strong> Check BOHB results and consider readiness to transition off insulin infusion.</td>
<td></td>
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</tbody>
</table>

Run at 63 ml/hr
Case review #2

- A 3 year old girl presents very sleepy who has been vomiting for 2 days
- GCS=13, HR 148, RR 40 (deep), 91/50-02 sat 96% on room air
- Glucose reads “Hi” on meter (> 599 mg/dl)
- pH 6.9, bicarb 10, anion gap 22
- What should happen next?
Case review #2

- Full monitors, (some use ETCO2), 2nd PIV
- 10 ml/kg bolus over 1 hour then start insulin at 0.05 units/kg/hr
- CR monitor with frequent vitals/neuro checks
- HOB elevated 30 degrees
- PICU consult
- *** if GCS decreases, Provider may consider mannitol, neurosurg consult
SUMMARY
• Do not overhydrate – give small amounts slow
• Do not cause rapid fluid shifts
  - do not titrate insulin
  - do not give insulin bolus
  - 2 bag system is optimal for glucose management
• Assess for cerebral edema at least for first 12 hours
• Consider using BOHB for an accurate assessment of ketosis
• Monitor corrected sodium levels
ISPAD Clinical Practice Consensus Guidelines 2009 Compendium

Diabetic ketoacidosis in children and adolescents with diabetes

Wolfsdorf J, Craig ME, Daneman D, Dunger D, Edge J, Lee W, Rosenbloom A, Sperling M, and Hanas R.
Diabetic ketoacidosis in children and adolescents with diabetes.
Pediatric Diabetes 2009: 10 (Suppl. 12): 118–133.

Joseph Wolfsdorf,
Maria E. Craig,
Denis Daneman,
David Dunger,
Julie Edge,
Warren Lee,
Arlan Rosenbloom,
Mark Sperling, and
Ragnar Hanas

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Pediatric Diabetes

118 articles
58 pages
Improving Care for Pediatric Diabetic Ketoacidosis

abstract

OBJECTIVE: We sought to create and implement recommendations from an evidence-based pathway for hospital management of pediatric diabetic ketoacidosis (DKA) and to sustain improvement. We hypothesized that development and utilization of standard work for inpatient care of DKA would lead to reduction in hypokalemia and improvement in outcome measures.

METHODS: Development involved systematic review of published literature by a multidisciplinary team. Implementation included multidisciplinary feedback, hospital-wide education, daily team huddles, and development of computer decision support and electronic order sets.

RESULTS: Pathway-based order sets forced clinical pathway adherence; yet, variations in care persisted, requiring ongoing iterative review and pathway tool adjustment. Quality improvement measures have identified barriers and informed subsequent adjustments to interventions. We compared 281 patients treated postimplementation with 172 treated preimplementation. Our most notable findings included the following: (1) monitoring of serum potassium concentrations identified unanticipated hypokalemia episodes, not recognized before standard work implementation, and earlier addition of potassium to fluids resulted in a notable reduction in hypokalemia; (2) improvements in insulin infusion management were associated with reduced duration of ICU stay; and (3) with overall improved DKA management and patient outcomes.

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KEY WORDS
pediatric diabetic ketoacidosis, electronic medical record, computerized physician order entry, standardization, quality improvement

ABBREVIATIONS
BHB=β-hydroxybutyrate
CI=confidence interval
CPOE=computerized provider order entry
D10=Dextrose 10%
DKA=diabetic ketoacidosis
ED=emergency department
ICD-9=International Classification of Diseases, Ninth Revision
IV=intravenous
LOS=length of stay
NS=normal saline
SCH=Seattle Children’s Hospital

Dr Kovos drafted, wrote, and submitted the manuscript; developed the design for manuscript and metrics data definitions; interpreted the data; formatted the manuscript; facilitated peer review; developed the figures, tables.

Diabetic ketoacidosis and hyperglycemic hyperosmolar state


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Key words: DKA – HHS – ISPAD consensus guidelines – pediatric diabetes

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+ 400 articles
Where should the child be managed?
Where Should the Child be Managed?

The child should receive care in a unit that has:

- Experienced nursing staff trained in monitoring and management
- Written guidelines for DKA management in children
- Access to laboratories that can provide frequent and timely measurements of biochemical variables
- A specialist/consultant pediatrician with training and expertise in the management of DKA should direct inpatient management.

Children with severe DKA (long duration of symptoms, compromised circulation, or depressed level of consciousness) or those who are at increased risk for cerebral edema (e.g., < 5 years of age, severe acidosis, low pCO₂, high blood urea nitrogen) should be considered for immediate treatment in an intensive care unit (pediatric, if available) or in a unit that has equivalent resources and supervision, such as a children's ward specializing in diabetes care (C.E) (5, 42).

Reference:
ISPAD International Consensus:
Thank you to the SCH DKA Team!!

- Elaine Beardsley MN RN CPEN
- Coral Ringer MN Medical CNS
- Jerry Zimmerman MD- PICU
- Elaine Albert MD-PICU
- Annie Slater MD- ED
- Micheal Leu MD- Medical Informaticist
- Jean Popalisky DNP- Clinical Effectiveness
- Gretchen Irby - Pharmacy
DRAFT:

• An initial blanket statement/recording identifying that this is an educational service to be heard when someone calls the Telephone Consult Service:

“Please note this is an educational service offered by Seattle Children’s Providers and not a consultation. Please use your clinical judgment regarding patient care or refer your patient to Seattle Children’s for further evaluation. Thank you.”

• Hypothetical or generic language during the encounter
  Example: “When I see a patient with this lab or that ECG finding, I would recommend a cardiology consult or echo. If you don’t have those resources, the patient should be sent here.”

Consult line should be for advice, not on-going care of patients.
Always consider patient safety and manage/transfer when necessary.
**IV Rate Calculator**

**DKA IV Rate Clinical Calculator** for patients in Diabetic Ketoacidosis

Select the link above, enter dose calc weight and total fluids received up to this point including those given before arrival. The calculator is designed only for weights up to 80 kg.
IV rate fluid calculator - Calculates rate based on how much fluid has already been obtained and degree of dehydration

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>IV fluid rate for patients with Diabetic Ketoacidosis</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fill in the yellow boxes and everything else will be calculated.</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Weight of patient</td>
<td></td>
<td><strong>40 kg</strong></td>
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<tr>
<td>Severity of Dehydration - assume:</td>
<td></td>
<td><strong>7 %</strong></td>
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<tr>
<td>Fluid deficit = weight (max: 80 kg) * percentage dehydrated</td>
<td></td>
<td><strong>2800 mL</strong></td>
<td></td>
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<tr>
<td><strong>PHASE 0: VOLUME RESUSCITATION</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TOTAL fluids administered during resuscitation phase</td>
<td><strong>8000 mL = 20 mL/kg</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maintenance fluids for one day:</td>
<td></td>
<td><strong>1900 mL</strong></td>
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</tr>
<tr>
<td>Total fluids to administer over 48 hours (maintenance * 2 + deficit - resuscitation)</td>
<td></td>
<td><strong>5000 mL</strong></td>
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<tr>
<td><strong>NOTE:</strong> Formula is such that we never provide less than 1 x maintenance fluids.</td>
<td></td>
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</tr>
<tr>
<td><strong>TOTAL IV FLUID RATE:</strong></td>
<td></td>
<td><strong>121 mL/hr</strong></td>
<td></td>
</tr>
</tbody>
</table>
The End Result is the table populates:

<table>
<thead>
<tr>
<th>ENTER TOTAL IV FLUID RATE:</th>
<th>110 ml/hr</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>TWO BAG SYSTEM TABLE</th>
<th>SALINE bag (ml/hr)</th>
<th>DEXTROSE-SALINE bag (ml/hr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Assuming that hourly blood glucose falls 100 mg/dL/hr or less)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>For blood glucose values of</td>
<td></td>
<td></td>
</tr>
<tr>
<td>≥ 300</td>
<td>110</td>
<td>OFF</td>
</tr>
<tr>
<td>250-299</td>
<td>83</td>
<td>27</td>
</tr>
<tr>
<td>200-249</td>
<td>55</td>
<td>55</td>
</tr>
<tr>
<td>150-199</td>
<td>28</td>
<td>82</td>
</tr>
<tr>
<td>100-149 (if &lt; 125, order D12.5-containing bag as below, but do not hang)</td>
<td>OFF</td>
<td>110</td>
</tr>
<tr>
<td>&lt; 100: Switch to one bag of D12.5-based fluid per orders and call Endocrinology.</td>
<td>run at 110 ml/hr</td>
<td></td>
</tr>
<tr>
<td>If remains &lt; 100 for &gt; 2 hrs and insulin currently at 0.1 units/kg/hr, Decrease insulin infusion to 0.075-0.05 units/kg/hr.</td>
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</tbody>
</table>