Diabetic Ketoacidosis in Youth

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Objectives

- Discuss the etiology of type 1 diabetes in children and the differences from type 2 diabetes
- Review the signs and symptoms of Diabetic Ketoacidosis (DKA) in children with and without the diagnosis of type 1 diabetes
- Describe the basic treatment of DKA and the potential complications during treatment of DKA

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Overview

- Diagnosis of type 1 diabetes
- Recognition of the child in DKA
- Evaluation
- Treatment
- When is DKA life threatening?
- Summary
- Q&A

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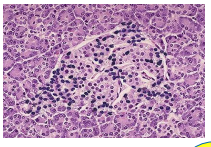
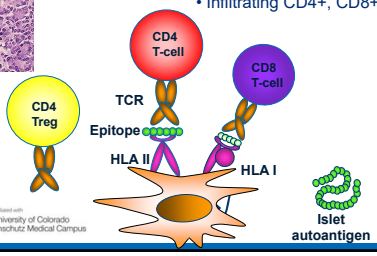
Type 1 diabetes is an autoimmune disease



- T cell mediated
- Occurs in 1 in 300 children
- Infiltrating CD4+, CD8+ T cells



Peakman, 2023. Type 1 diabetes free download ID: 3354199

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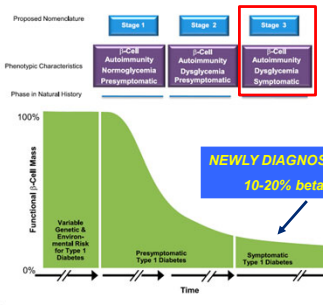

Figure 1—Early stages of type 1 diabetes.

Jacobsen LM, Haller MJ and Schatz DA (2018) Understanding Pre-Type 1 Diabetes: The Key to Prevention. Front. Endocrinol. 9:70. doi: 10.3389/fendo.2018.00070

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Type 1 Diabetes

How often does new onset diabetes present with DKA?

- In Colorado: increased from 41% in 2010 to **58%** in 2017* (15-83% globally); ***up to 60% in 2020***
- Others may present with non-acidotic ketosis or just with hyperglycemia and no ketosis
- 23% of new onset patients not diagnosed at first visit with symptoms of diabetes (patient survey)

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Alonso GT, Rewers A et al, *Diabetes Care* Jan 2020
Baldelli L, Flitter B, Alonso GT et al, *Pediatr Diabetes* 2016

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- New onset T1D may present with:
  - Polyuria
  - Polydipsia
  - Fatigue
  - Weight loss
  - Blurry vision
  - Enuresis
  - Detection at well check/ sports physical

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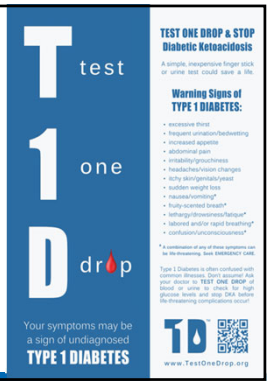

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Type 1 vs. Type 2 Diabetes

- Over 90% of diabetes in pediatrics (< 18 yrs old) is type 1 diabetes
- Type 2 diabetes (T2D) rarely diagnosed before start of puberty (or < 10 yrs old*)
- Pediatric T2D patients tend to have:
  - Obesity
  - Family history of T2D
  - more likely to be minority race/ethnicity than T1D pts
- BUT T2D *can* present with DKA, especially in adolescents (6-11%; higher in 2020)

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Definition of Diabetic Ketoacidosis

- Hyperglycemia (glucose > 200 mg/dl)
- Evidence of significant ketosis
  (urine acetoacetate, blood beta-hydroxybutyrate)
- Acidosis (pH < 7.30 or HCO_3 < 15)

	Mild	Moderate	Severe
Venous pH	<7.3	<7.2	<7.1
Bicarbonate	<15	<10	<5

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ISPAD Consensus Guidelines, Wolfsdorf J et al, *Pediatric Diabetes* 2018

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Risk factors for DKA

- In <u>new onset</u> patients:
  - Age < 5 years old
  - Difficult access to medical care
  - Lower income, lower parental education
  - Lack of insurance/ under-insured

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Risk factors for DKA

- In children with known diabetes
  - Risk 1-10%/patient per year
    - Poor metabolic control/history of DKA
    - Mental health history (ex: major depression)
    - Peripubertal and adolescent females
    - Unstable family situation

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Morbidity & Mortality of DKA

- DKA can be life threatening
- Mortality rate in U.S. is 0.1-0.3%
  - higher in other countries where T1D less common
- Causes of mortality
  - Failure to make the diagnosis
  - **Cerebral Edema (60-70% of DKA mortality)**
  - Hypokalemia/ Hyperkalemia
  - Hypoglycemia
  - Hypovolemia

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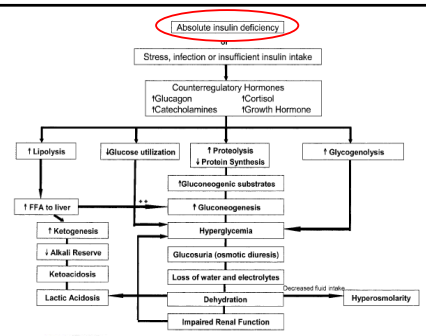

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Diabetes Care 2006 29:1150-1159

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Compensation for the acidosis

- Acidosis drives the reaction:

$H^+ + HCO_3^- \rightleftharpoons H_2CO_3 \rightleftharpoons H_2O + CO_2$

- Excess CO_2 is eliminated through the lungs
  - Kussmaul respirations

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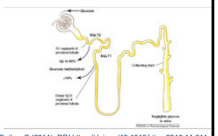
Dehydration

- Excess glucose cannot be reabsorbed from the glomerular filtrate
  - Large amounts of glucose in the filtrate pull water into the urine
    - Large volumes of urine
    - Dehydration
    - Weight loss
    - Electrolyte imbalances



Bailey, C (2011). DOI:https://doi.org/10.1016/j.tips.2010.11.011

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DKA

How does the child in DKA present?

- "gastroenteritis" with vomiting
  - But no diarrhea
- Dehydration
  - But excessive urine output!
- "Respiratory distress"
  - But no wheezing

**** Diagnosis is made largely on history and physical exam**

Confirmed with labs

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Physical Exam

- Perfusion (capillary refill)
- Vital Signs
  - including weight, respiratory rate
- Hydration
- Mental Status

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Initial Laboratory Evaluation

- Glucose*
- Ketones*
- Sodium
- Potassium
- Chloride
- HCO3
- Venous pH
- BUN
- Serum Osmolality
- Phosphorus
- Calcium

- **Outpt: UA, fingerstick quick and inexpensive**
- **ED/ Inpt: See DKA order set for baseline labs at CHCO**

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Ketone Testing

- Fingerstick blood ketone testing (β-hydroxybuterate)
- Many families now use at home
- Allows real time assessment of blood ketone level
- Urine testing – a simpler, cheaper option (acetoacetate)

https://www.co.grand.co.us/DocumentCenter/View/14622/art24315_rev-b-web_compressed?bidId=

https://www.dreamstime.com/illustration/urine-test-strip.html

https://together.stjude.org/en-us/patient-education-resources/tests-procedures/check-urine-for-glucose-and-ketones.html

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Rewers A, McFann K, Chase HP. *Diabetes Technol Ther*. 2006 Dec

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DKA : Treatment

- DKA protocol or Clinical Care Guidelines should be used
- At CHCO, use DKA order sets
- Call BDC / local ped endo on call *early* for assistance
  (303) 724-2323 or One Call in Colorado
  - Medical management
  - Logistics
    - New onset patient
    - Known patient with known history

Children's Hospital Colorado DKA Clinical Pathway

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DKA : Treatment

Goals:

1. Correct dehydration
2. Correct acidosis and reverse ketosis
3. Slowly correct hyperosmolality and hyperglycemia
4. Monitor for complications
5. Transition to sc insulin after resolution of DKA

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DKA : Treatment

Correct dehydration:

- Start with 10-20 cc/kg NS bolus
- Do not give more than 40 cc/kg as bolus
- Goal is to replace deficits over 48 hours
- Continually re-evaluate status of hydration

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DKA : Treatment

Hydration (cont'd)

- Replacement therapy
  - Will need 3,000 mL/m^2/ 24 hrs (usually aprox 1.5 x Maintenance)
- Add dextrose when BG < 250 mg/dl OR decrease in glucose is too rapid
- Goal: decrease BG by 50-100 mg/dl/ hour
- Continually re-evaluate status of hydration

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NEW changes this year

Bag 1: NS + 20 mEq K Phosphate + 20 mEq K Acetate

OR

NS + 40 mEq KCl

If K Phos and K Acetate not available

Bag 2: D10 NS + 20 mEq K Phosphate + 20 mEq K Acetate

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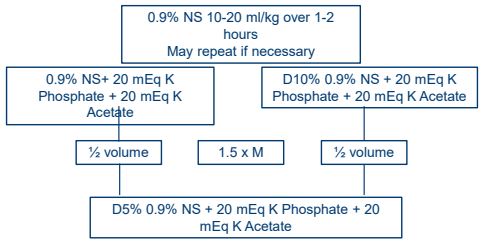
Fluid therapy: 2 bag system



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DKA : Treatment

Insulin

(#2, #3: correct acidosis, ketosis hyperglycemia)

- IV Regular insulin drip at 0.1 units/ kg/ hour
- Do NOT give initial bolus of insulin
- May decrease to 0.05 u/kg/hr if BG decreasing too quickly
  - To get control of balance with IV fluids
  - Prevent hypoglycemia
- Monitor BG at least every 1 hour

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DKA : Treatment

Monitoring

- Consider ICU admission with:
  - Severe DKA (pH < 7.1)
  - Altered level of consciousness
  - Under age of 5 years
  - Increased risk for cerebral edema
- **Caution with meds that may alter mental status**

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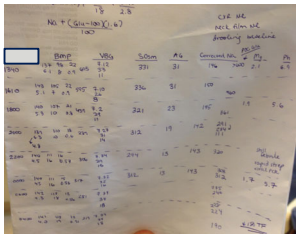
DKA : Treatment

Monitoring (cont'd)

- Management requires close attention to detail
- Track labs, rates of insulin, fluids (I&O), dextrose
  - *(Epic/ EMR vs. paper charting)*
- Neurological status
  - consider neuro checks q1 hr
  - How does the patient look TO YOU?
- Assess and re-assess; then re-assess again



Personal photo

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Causes of Mortality

- Delay or Failure to make the diagnosis
- Cerebral Edema
- Hypokalemia/ Hyperkalemia
- Hypoglycemia
- Hypovolemia

ASSESS
REASSESS
ASSESS AGAIN
FLOWSHEETS
CONSIDER CVP MONITORING

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Causes of Mortality

- Delay or Failure to make the diagnosis
- **Cerebral Edema**
- Hypokalemia/ Hyperkalemia
- Hypoglycemia
- Hypovolemia

Is the most common cause of DKA related mortality

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Cerebral Edema

- Major cause of death in childhood DKA
  - 20% with cerebral edema die
  - 20% with mild to severe neurologic outcomes
- At risk:
  - Initial pH < 7.1
  - Newly diagnosed, < 5 years old
  - Rapid rehydration (> 50cc/ kg in first 4 hrs)
  - Hypernatremia/ persistent hyponatremia

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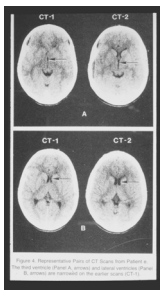
Cerebral Edema

Know what to look for

- Altered mental status/ severe headache
- Clinical worsening despite improving lab values
- Changes in pupil size, seizures, bradycardia
- CT/ MRI changes may not be seen in early cerebral edema



https://www.nejm.org/doi/full/10.1056/NEJM198505023121803

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Cerebral Edema

Treatment

Mannitol: 1 gram/ kg IV over 30 minutes

OR

3% NaCl in certain settings

(not in ADA consensus statement)

- Consider intubation/ hyperventilation to lower pCO_2
- ICU management
- Do not delay treatment until radiographic evidence

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DKA: Resolution

Transition off IV insulin

- pH > 7.30 and $HCO_3 \geq 18$* and patient able to eat
- (may transition with bicarb <18 if β-hydroxybutyrate normal and approved by diabetes physician on call)

- Electrolytes (Na, K) improved/ improving
- Subcutaneous insulin:
  - **Discuss regimen with Diabetes provider**
  - Give sc injection, D/C IV insulin / **IV dextrose**, feed patient

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Transition to sc insulin

New patient

- 0.5 – 1.0 units/kg/ day
  - Adolescent/ pubertal patient – insulin resistant
- Regimen:
  - Multiple Daily Injections (MDI)
    - Long acting + Rapid acting analogs
      = Lantus (glargine) + Humalog (lispro) at CHCO
    - Use insulin order set (EMR)
- Make plan with on call diabetes team:
  - Discharge
  - Family education (At BDC, outpatient, 2 days)
  - Follow up

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DKA: Summary

Successful Management:

- Making the diagnosis is critical
- Initial evaluation:
  - Assessment of hydration status, degree of acidosis, hyperglycemia and hyperosmolarity
- Treatment:
  - IV fluids and IV insulin to correct dehydration, ketoacidosis, hyperglycemia, electrolyte abnormalities
  - Transition to sc insulin when DKA resolved and patient clinically ready
- Call Diabetes on call team for assistance and coordination of care

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Questions?

https://lifeforachild.org/education/t1d-warning-signs-posters/

www.barbaradaviscenter.org
(303) 724-2323 (office/after hours)
(720) 777-3999 (One Call)

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Reference List

ISPAD Clinical Practice Consensus Guidelines
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2022 guidelines – now on ISPAD website (ISPAD.org)

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