



**ILLINOIS**  
**EMSC**  
Emergency Medical  
Services for Children

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# Pediatric Hyperglycemia and Diabetic Ketoacidosis (DKA)

**5<sup>th</sup> Edition, 2019**



Illinois EMSC is a collaborative program between the Illinois Department of Public Health and the Ann & Robert H. Lurie Children's Hospital of Chicago. Revision of this presentation was supported in part by: Grant 6 H33 MC 31621 from the Department of Health and Human Services Administration, Maternal and Child Health Bureau





Today, almost a century after the discovery of insulin, the most common cause of death in a child with diabetes, from a global perspective, is lack of access to insulin or improper use of insulin.

Many children die even before their diabetes is diagnosed. Around the world, forces have united to make it come true that no child should die from diabetes or its complications.



# Illinois Emergency Medical Services for Children (EMSC)

- Illinois EMSC is a collaborative program between the [Illinois Department of Public Health](#) and [Lurie Children's Hospital of Chicago](#), aimed at improving pediatric emergency care within our state.
- Since 1994, [Illinois EMSC](#) has worked to enhance and integrate:
  - Pediatric education
  - Practice standards
  - Injury prevention
  - Data initiatives



**This educational activity is being presented without the provision of commercial support and without bias or conflict of interest from the planners and presenters.**

# Goals

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- Define and explain pediatric hyperglycemia and DKA
- Highlight current standards of care regarding pediatric hyperglycemia and DKA management
- Provide educational resources to health care professionals to share with pediatric patients and families dealing with issues related to pediatric hyperglycemia and DKA

# Acknowledgements

## EMSC Facility Recognition & Quality Improvement Committee

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The Illinois EMSC Advisory Board gratefully acknowledges the commitment and dedication of the *EMSC Facility Recognition & Quality Improvement Committee* in revising this educational module (which was originally published in October 2012). Their contributions have led to this valuable resource and assists Illinois EMSC in striving toward the goal of improving pediatric emergency care within our state.

To access a list of the committee members, click [here](#).

**Suggested Citation: Illinois Emergency Medical Services for Children (EMSC), *Pediatric Hyperglycemia and DKA*, December 2018**

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# INTRODUCTION

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# Purpose

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The purpose of this educational module is to enhance the care of pediatric patients who present with hyperglycemia and diabetic ketoacidosis (DKA) through appropriate:

- **ASSESSMENT**
- **MANAGEMENT**
- **PREVENTION OF COMPLICATIONS**
- **DISPOSITION**
- **PATIENT & PARENT/CAREGIVER EDUCATION**



# Objectives

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**At the end of this module you will be able to:**

- Describe the mechanisms of hyperglycemia and DKA
- Perform an initial assessment on a child who is experiencing hyperglycemia and DKA
- Describe the clinical presentation of a pediatric patient with DKA
- Understand the physiologic changes taking place in a pediatric patient with DKA
- Develop an effective management plan
- Discuss cerebral edema as a complication of pediatric DKA
- Develop a plan for appropriate admission, transfer or referral
- Formulate appropriate discharge instructions

# Main Resources

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**The following publications were the primary sources of information for this module, and will be referenced throughout:**

**The American Diabetes Association (ADA)<sup>1</sup>**

**Diabetic Ketoacidosis in Infants, Children, and Adolescents**

A consensus statement from the American Diabetes Association

**European Society for Paediatric Endocrinology (ESPE)<sup>2</sup>**

**Lawson Wilkins Pediatric Endocrine Society (LWPES)<sup>2</sup>**

**European Society for Paediatric Endocrinology / Lawson Wilkins Pediatric Endocrine Society Consensus Statement on Diabetic Ketoacidosis in Children and Adolescents**

**International Society for Pediatric and Adolescent Diabetes (ISPAD)<sup>3</sup>**

**Diabetic Ketoacidosis in Children and Adolescents with Diabetes**

ISPAD Clinical Practice Consensus Guidelines 2009 Compendium

# Frequency of DKA

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## **DKA occurs in children with:**

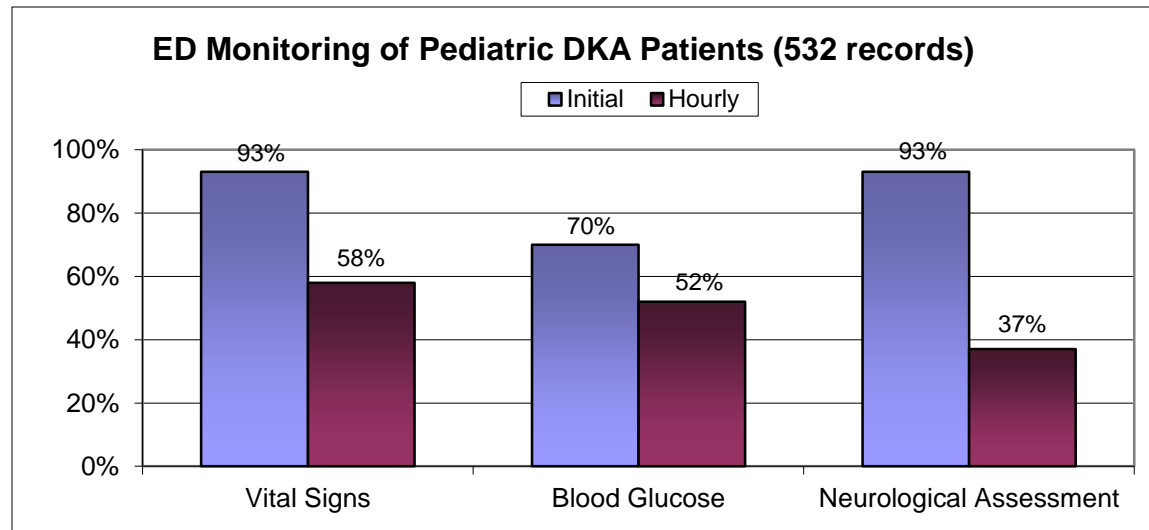
- New-onset of type 1 diabetes mellitus
- Established type 1 diabetes mellitus during risk episodes
- May occur in children with type 2 diabetes mellitus

# DKA Risk Factors

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- Young children
- Poor diabetes control
- Previous episodes of DKA
- Missed insulin injections
- Insulin pump failure
- Infection or other illnesses
- Low socioeconomic status
- Lack of adequate health insurance
- Psychiatric disorders (i.e., eating disorders)





# Illinois EMSC Statewide DKA QI



- DKA record review (532 records total) - high percentage of cases reported documentation of: full set of vital signs, blood glucose level, and neurological status during *initial* assessment
- However, documentation of *ongoing/hourly* ED monitoring for same indicators was much less consistent
  - Percentage of documentation *even lower* for hospitals that (on survey) reported ED ongoing monitoring was "not defined in policy" or performed "per physician decision"

# Illinois EMSC Statewide DKA QI

\*\* Additional findings from the statewide QI project (responses to survey and case scenarios) seem to indicate concerning deviations from the current treatment guidelines for pediatric DKA patients *within the first hour of treatment*\*\*

Practice Deviations (within 1 <sup>st</sup> hour of treatment)		Guideline Recommendations
	Administer an IV fluid bolus 15-20 mL/kg 0.45% NaCl over the first hour	The recommended fluid course is <u>10-20 mL/kg 0.9% NaCl</u> over the first hour
	Administer an IV insulin drip of 0.1 units/kg/hour	Current guidelines recommend administering insulin <u>after</u> the initial fluid resuscitation, not concurrently
	Administer an IV insulin bolus of 0.1 units/kg	Current guidelines suggest IV insulin bolus may <u>increase</u> the risk of cerebral edema, and should <u>not</u> be used at the start of therapy
	Wait for more laboratory results before giving any fluids	Current guidelines recommend initial IV fluid administration should begin <u>immediately</u>

# Understanding Diabetes

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Diabetes mellitus, often referred to simply as **diabetes**.

Diabetes is a condition in which the body:

- Does not produce enough insulin, and/or
- Does not properly respond to insulin

**Insulin is a hormone produced in the pancreas. Insulin enables cells to absorb glucose in order to turn it into energy.**

# Diabetes: An Epidemic

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**The cause of diabetes in children continues to be a mystery.**

- Genetics
- Environmental factors
- Obesity
- Lack of exercise





# Type 1 vs. Type 2

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<b>Type 1 diabetes</b>	<b>Type 2 diabetes</b>
<b>Diagnosed in children and young adults</b>	<b>Typically diagnosed in adulthood</b>
<b>Previously known as Juvenile Diabetes</b>	<b>Also found in overweight children</b>
<b>Insulin-dependent</b>	<b>Non-insulin-dependent</b>
<b>Body does not produce insulin</b>	<b>Body fails to produce and properly use insulin</b>

# Diabetes: Warning Signs

**KNOW THE DIABETES WARNING SIGNS!**



**Urinating a lot**      **Losing weight**      **Lacking energy**      **Drinking a lot**

**If your child shows these signs,  
seek immediate medical attention.**

Diabetes can affect children at any age.  
If left untreated, diabetes is deadly.

# Blood Glucose Alterations

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## Complications of blood glucose alterations

- Hypoglycemia
- Hyperglycemia
- Ketosis
- Acidosis
- DKA (Hyperglycemia + Ketosis + Acidosis)

**Normal fasting blood glucose level 80 - 120 mg/dL**

# Hypoglycemia

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- **Low** blood glucose: **treated when less than 70 mg/dL<sup>4</sup>**  
Develops because the body doesn't have enough glucose to burn energy
- Can happen suddenly
- Can be treated quickly and easily by eating or drinking a small amount of glucose rich food

The signs and symptoms include:

***Low blood glucose***

***Hunger***

***Headache***

***Confusion, shakiness, dizziness***

***Sweating***

**If hypoglycemia is suspected, check the blood glucose concentration**

# Hyperglycemia

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- **High** blood glucose: **treated when greater than 200 mg/dL**
- Develops when the body has too much glucose in the blood
- Serious problem if not treated
- A major cause of many of the complications in children with diabetes

The signs and symptoms include:

***High blood glucose***

***High levels of glucose in the urine***

***Frequent urination***

***Increased thirst***

**If hyperglycemia is suspected, check the blood glucose concentration**

# Hypoglycemia vs. Hyperglycemia

## Low blood glucose

(less than 70 mg/dL)

### Signs and symptoms include:

- Shakiness
- Dizziness
- Sweating
- Hunger
- Headache
- Pale skin color
- Mental or behavior changes
- Lethargy
- Clumsy or jerky movements
- Seizure
- Difficulty concentrating
- Tingling sensations around the mouth

## High blood glucose

(greater than 200 mg/dL)

### Signs and symptoms include:

#### Classic symptoms:

- **Polyphagia** (excessive hunger)
- **Polyuria** (excessive urine/urination)
- **Polydipsia** (excessive thirst)

#### Other symptoms might include:

- Blurred vision
- Fatigue
- Weight loss
- Slow-healing cuts and sores
- Headaches
- Difficulty concentrating
- Vaginal and skin infections

# Ketosis

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## **Ketones**

- Acidic substances that are made when the body breaks down fat for energy

## **Ketosis**

- Presence of excess ketones in the body
- Blood ketone concentration between 0.3 and 7.0 mmol/L

## **Ketoacidosis**

- Severe form of ketosis
- Reflects levels of 7.0 mmol/L or higher
- Lowers the pH to 7.3 or lower

# Acidosis

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- Increased acidity of the blood
- Acidemia is a pH below 7.35

## ***Signs & Symptoms***

- *Deep, rapid breathing (known as Kussmaul's respirations)*
- *confusion or lethargy*
- *abdominal pain*
- Blood tests to diagnose metabolic acidosis may include:
  - Arterial or venous blood gas
  - Electrolytes: Na<sup>+</sup> (sodium), K<sup>+</sup> (potassium), Cl<sup>-</sup> (chloride) and HCO<sub>3</sub><sup>-</sup> (bicarbonate) (total CO<sub>2</sub> content)





**DKA is a complex metabolic state of:**  
***hyperglycemia, ketosis, and acidosis***

Symptoms include:

- Deep, rapid breathing
- Fruity breath odor
- Very dry mouth
- Nausea and vomiting
- Lethargy/drowsiness

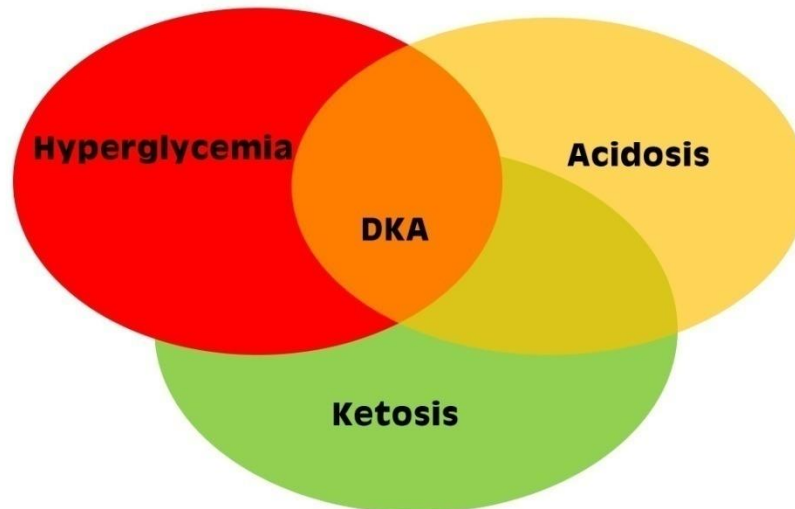
**DKA is life-threatening and needs immediate treatment**

# Classic Triad of DKA

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The biochemical criteria for the diagnosis of DKA<sup>2,3</sup>

- **Hyperglycemia** - blood glucose greater than 200 mg/dL
- **Ketosis** - ketones present in blood and/or urine
- **Acidosis** - pH less than 7.3 and/or bicarbonate less than 15 mmol/L



# Classification of DKA

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DKA is generally categorized by the severity of the acidosis\*.

- **MILD** – Venous pH less than 7.3 and/or bicarbonate concentration less than 15 mmol/L
- **MODERATE** – Venous pH less than 7.2 and/or bicarbonate concentration less than 10 mmol/L
- **SEVERE** – Venous pH less than 7.1 and/or bicarbonate concentration less than 5 mmol/L

\*Severity of acidosis has no relation to the degree of hyperglycemia.

# Two Emergencies of Diabetes

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	<b>Hypoglycemia</b>	<b>Hyperglycemia Ketoacidosis/DKA</b>
<b>Due to:</b>	<ul style="list-style-type: none"><li>● Low blood glucose</li></ul>	<ul style="list-style-type: none"><li>● Presence of ketones</li></ul>
<b>Time of onset:</b>	<ul style="list-style-type: none"><li>● Fast – within seconds</li></ul>	<ul style="list-style-type: none"><li>● Slow - within hours or days</li></ul>
<b>Causes:</b>	<ul style="list-style-type: none"><li>● Too much insulin</li><li>● Too little food</li><li>● Too much exercise without food</li><li>● Missing or delayed meals/snacks</li><li>● Stress/overexcitement in young children</li></ul>	<ul style="list-style-type: none"><li>● Insufficient insulin</li><li>● Missed insulin dose(s)</li><li>● Infections/illness</li><li>● Stress response</li></ul>
<b>Blood glucose:</b>	<ul style="list-style-type: none"><li>● Low (less than 70 mg/dL)</li></ul>	<ul style="list-style-type: none"><li>● High (greater than 200 mg/dL)</li></ul>
<b>Ketones:</b>	<ul style="list-style-type: none"><li>● None in urine or blood</li></ul>	<ul style="list-style-type: none"><li>● Moderate/large in urine or blood</li></ul>

# New Emerging Third Emergency: Hyperglycemic Hyperosmolar Syndrome (**HHS**)

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## Similar symptoms to DKA

- Elevated blood glucose
- Dehydration
- Altered mental status

## HHS<sup>5,6</sup>

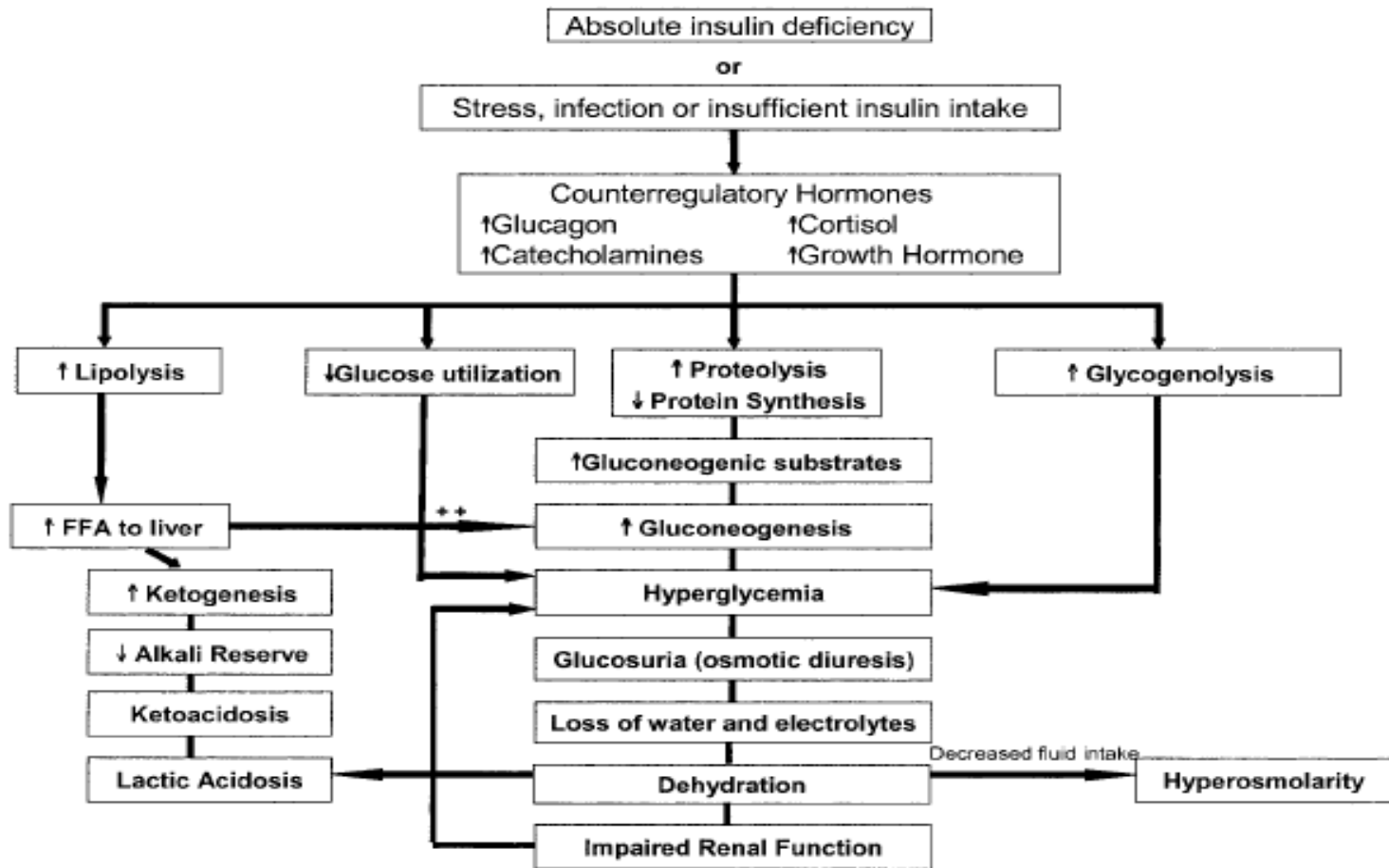
- Severe dehydration
- Little or no ketone accumulation
- Elevated blood glucose levels greater than 600 mg/dL, frequently exceeds 1000 mg/dL
- Elevated serum osmolality (over 320 mOsm/kg H<sub>2</sub>O)
- Children with type 2 diabetes may be at greatest risk
- Occurs infrequently in children, so data regarding the optimal approach to treatment are lacking

# Classifications of DKA

## Diagnostic Criteria for Diabetic Ketoacidosis and Hyperosmolar Hyperglycemic State

	Mild DKA	Moderate DKA	Severe DKA	HHS
Blood glucose	>200 mg/dL	>200 mg/dL	>200 mg/dL	>600 mg/dL
Venous pH	< 7.3	< 7.2	< 7.1	> 7.3
Serum bicarbonate	< 15 mEq/L	< 10 mEq/L	< 5 mEq/L	> 15 mEq/L
Urine ketones	Positive	Positive	Positive	Small or none
Blood ketones	Positive	Positive	Positive	Small or none
Beta-hydroxybutyrate	High	High	High	Normal or elevated
Serum osmolality	Variable	Variable	Variable	> 320 mOsm/kg H <sub>2</sub> O
Alteration in mental status	Alert	Alert/drowsy	Stupor/coma	Stupor/coma

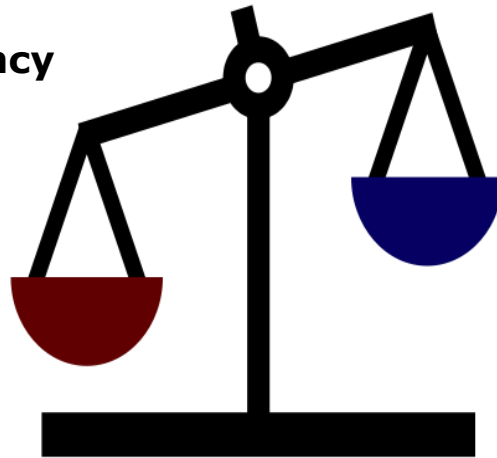
# Pathophysiology of DKA



Wolfsdorf J, Glaser N, Sperling MA; American Diabetes Association. Diabetic ketoacidosis in infants, children, and adolescents: A consensus statement from the American Diabetes Association. *Diabetes Care*. 2006;29(5):1150-1159. Reprinted with permission from The American Diabetes Association.

# Pathophysiology of DKA

**Insulin deficiency**



**hyperglycemia**



**glucosuria**



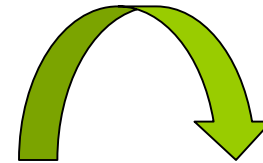
**osmotic diuresis**



**dehydration**

**Excess counter-regulator hormones**

glucagon, cortisol, catecholamines  
and growth hormone



**ketogenesis**



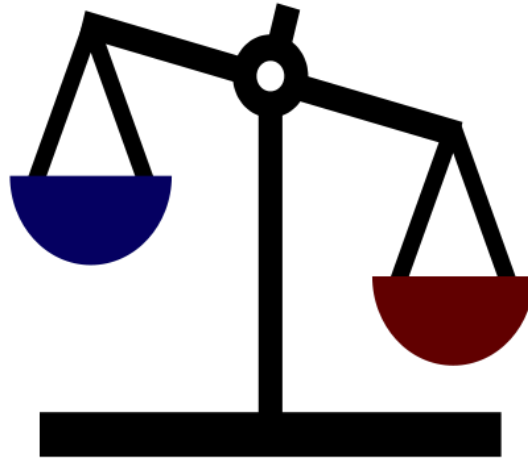
**acidosis**



# Pathophysiology of DKA

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**Dehydration**



**Depletion of electrolytes**

sodium, potassium, chloride,  
phosphate and magnesium

**osmotic diuresis + acidosis**



**DKA**



# ASSESSMENT

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# Clinical Presentation

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- Nausea, vomiting
- Polyuria
- Polydipsia
- Weight loss
- Fruity breath odor
- Abdominal pain
- Lethargy/drowsiness
- Confusion
- Coma

# Thorough History is Imperative!

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## New diabetic

### Recent history of

- Polyuria
- Polydipsia
- Polyphagia
- Weight loss

### Past medical history

- Family history of diabetes

### History/duration of symptoms

- Headache
- Blurry vision
- Nausea/vomiting/ abdominal pain
- Difficulty in breathing
- Changes in behavior

### Precipitating factors

- Concurrent illness or infection

## Known diabetic

### History of diabetes and duration

- Last meal/carbohydrate intake
- Current and routine blood glucose levels

### Standard insulin regimen

- Last insulin dose
- Type of insulin and route

### Past hospitalization history

### Duration of symptoms

- Nausea/vomiting/abdominal pain

### Precipitating factors

- Physical exertion
- Change in eating habits/diets
- Stress
- Missed insulin dose
- Illness

# Physical Assessment

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- Assess for dehydration
  - Vital signs, mucous membranes, capillary refill, skin (color, temperature and turgor)
- Assess for acidosis
  - Fruity breath odor
  - Deep, rapid breathing → Kussmaul's respirations
- Assess mental status → watch for cerebral edema!
  - AVPU
  - Pediatric GCS (PGCS)
- Assess for signs/symptoms of possible infection

# Assessment Resources

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- [Systematic Assessment](#)
- [Pediatric Assessment Triangle \(PAT\)](#)
- [Initial Assessment \(ABCDE\)](#)
- [Focused Physical Examination \(FGHI\)](#)
- [Triage \(E-U-N\)](#)
- [Emergency Severity Index \(ESI\)](#)
- [AVPU Scale](#)
- [Pediatric Glasgow Coma Scale \(PGCS\)](#)

For more information, click on these links or proceed to [Appendix A](#)

# Normal Pediatric Vital Sign Values by Age

Age	Respiratory Rate (breaths/minute)	Heart Rate (beats/minute)	Systolic Blood Pressure (mmHg)
Newborn	30 - 60	100 - 180	> 60
3 months	30 - 60	110 - 160	> 70
6 months	30 - 60	110 - 160	> 70
9 months	30 - 60	110 - 160	> 70
12 months	30 - 60	110 - 160	> 70
2 years	24 - 40	90 - 150	> 70
4 years	22 - 34	90 - 150	> 75
6 years	18 - 30	70 - 120	> 80
8 years	18 - 30	70 - 120	> 80
10 years	18 - 30	70 - 120	> 80
12 years	12 - 16	60 - 110	> 90

Source: Illinois EMSC *Pediatric Pocket Reference Card*, 2013

# Initial Assessment

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- **Assess Airway, Breathing, and Circulation**
- Perform a clinical evaluation
- Obtain vital signs and weight (kg)
- Assess clinical severity of dehydration
- Assess neurological status
  - AVPU
  - Pediatric GCS
- Apply cardiac monitor



# Laboratory Evaluation

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- **Initial Labs**

- **Blood glucose**
- **Urine ketones**
- **Venous blood gas**
- **Basic blood chemistry**
  - Electrolytes
  - BUN, creatinine
  - Magnesium, calcium, phosphorus

- **Additional labs**

- CBC
- Osmolality
- Serum beta-hydroxybutyrate ( $\beta$ -OH)
- Hemoglobin A1c (HgbA1c)
- Pancreatic antibodies
- Additional testing as indicated
  - CXR, non-contrast Head CT, Cultures (blood, urine, throat)

# Blood Glucose Testing

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- A blood glucose test measures the amount of glucose in the blood
- Blood glucose tests are done to screen and monitor treatment
- Normal glucose range is between 80 and 120 mg/dL



# Ketone Testing

## Blood Ketone Reading Indications

### Above 1.5 mmol/L

Readings above 1.5 mmol/L in the presence of hyperglycemia indicate the child may be at risk for developing diabetic ketoacidosis (DKA).

### 0.6 to 1.5 mmol/L

Readings between 0.6 and 1.5 mmol/L may indicate the development of a problem that may require medical assistance.

### Below 0.6 mmol/L

Readings below 0.6 mmol/L are in the normal range.

## Urine Ketone Testing



Out-dated or expired test strips may cause a false-positive reading.

# Blood Gases

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**ABG** arterial blood sample or **VBG** venous blood sample are both adequate to determine blood pH.

**VBG is sufficient unless altered level of consciousness**

- *Remember: arterial puncture is a painful procedure; consider using topical anesthetic as a pain reducing therapy*
- An ABG provides a snapshot of the blood's pH + PO<sub>2</sub> + PCO<sub>2</sub> = HCO<sub>3</sub>
  - pH – indicates if acidotic or alkalemic
  - PO<sub>2</sub> – the amount of oxygen dissolved in the blood
  - PCO<sub>2</sub> – the amount of carbon dioxide dissolved in the blood
  - HCO<sub>3</sub> – the amount of bicarbonate in the blood
- **Metabolic acidosis** is defined as a low pH and decreased HCO<sub>3</sub>
- **Metabolic alkalosis** is defined as a high pH and increased HCO<sub>3</sub>





# MANAGEMENT

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# Not All Children Are The Same!

**Be prepared to make adjustments frequently!**

## **Goals Of Therapy**

- **Correct dehydration**
- **Correct acidosis and reverse ketosis**
- **Restore normal blood glucose levels**
- **Avoid complications of therapy**



# Treatment Overview

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- Follow established guidelines
- Consider consultation with intensivist and transfer to higher level of care
- Recognize and prevent serious complications such as cerebral edema
- Maintain strict NPO
- IV fluids
  - Phase I
    - Initial volume expansion
  - Phase II
    - Replacement of fluid deficit
    - Maintenance fluids
- Insulin administration (begins after the initial fluid resuscitation)
  - Continuous IV insulin infusion
  - Subcutaneous/Intramuscular (notify intensivist if administered)
- Electrolyte replacement
- Reassessment and ongoing monitoring

# Management of Pediatric Patients with DKA

Complete initial evaluation



Initial hour - start IV fluids



IV Fluids



Insulin



Potassium



Dextrose



[Advance to slide 49](#)



[Advance to slide 51](#)



[Advance to slide 54](#)



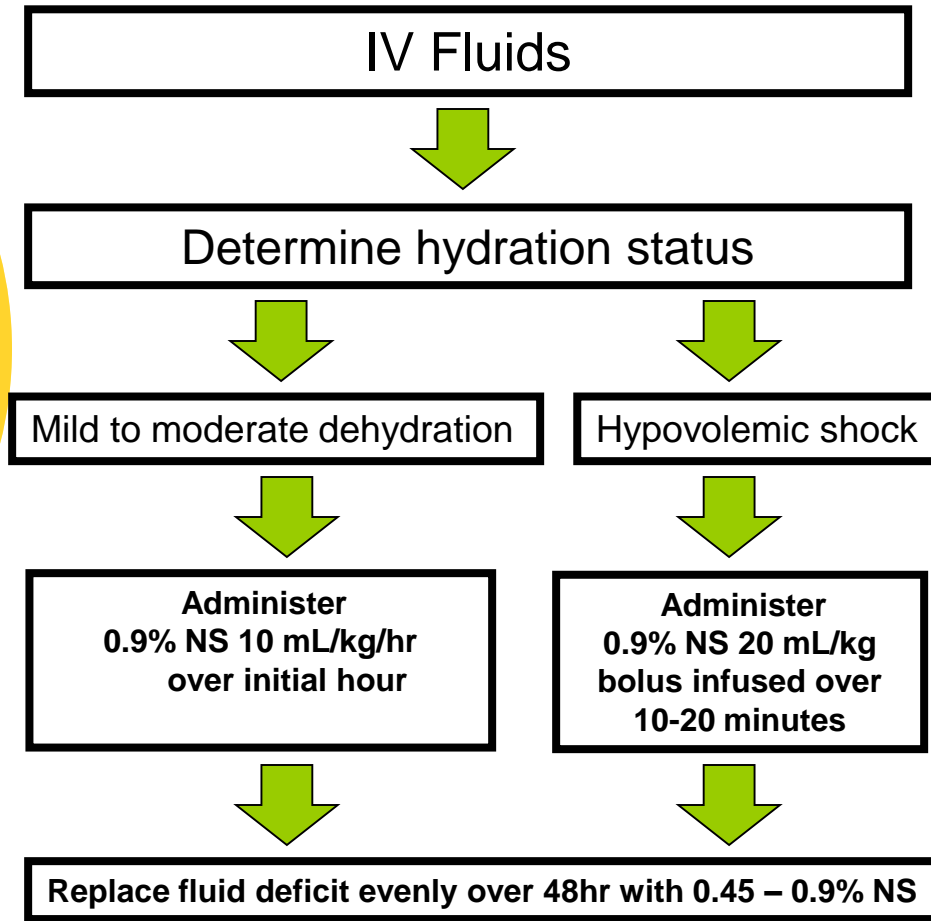
[Advance to slide 61](#)

Adapted from:

Kitabchi AE, Umpierrez GE, Murphy MB, et al; American Diabetes Association. Hyperglycemic crises in diabetes. *Diabetes Care*. 2004;27(Suppl. 1):S94-S102



# IV Fluid Administration



## The goal of the first hour of treatment

- fluid resuscitation
- confirmation of DKA by laboratory studies

## The goals of the second and succeeding hours

- slow correction of hyperglycemia, metabolic acidosis and ketosis
- continued volume replacement

**This usually requires several hours and meticulous attention to the patient's response to therapy**

Adapted from:

Kitabchi AE, Umpierrez GE, Murphy MB, et al; American Diabetes Association. Hyperglycemic crises in diabetes. *Diabetes Care*. 2004;27(Suppl. 1):S94-S102

# IV Fluid Key Points

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- **Start IV fluids: 10-20 mL/kg of 0.9%NS over the first hour**
  - In a severely dehydrated patient, this may need to be repeated
  - Fluids should not exceed 50 mL/kg over first 4 hours of therapy
- **Clinical assessment of dehydration to determine fluid volume**
  - Children with DKA have a fluid deficit in the range of 5-10%
    - Mild DKA 3-4% dehydration
    - Moderate DKA 5-7% dehydration
    - Severe DKA 10% dehydration
  - Shock is rare in pediatric DKA
- **Replace fluid deficit evenly over 48 hours**
- **REMINDER:** Serum sodium decreases by 1.6mEq/L for every 100-mg/dl increase in serum glucose concentration above 100mg/dl, therefore no electrolyte correction is needed

**ALL PATIENTS WITH DKA REQUIRE SUPPLEMENTAL FLUIDS**

# Insulin Administration

## **Insulin treatment is begun after the initial fluid resuscitation**

- Insulin dose
  - IV insulin infusion (regular insulin)
  - 0.05 – 0.1 units/kg/hr
- Insulin therapy
  - Turns off the production of ketones
  - Decreases blood glucose
- Low-dose insulin infusion
  - Decreases risk of hypoglycemia or hypokalemia
  - Goal is to decrease blood glucose by 100mg/dL/hour

**Do not reduce or discontinue the insulin infusion based solely upon the blood glucose, but may need to begin a dextrose infusion when glucose level <250**

**The insulin infusion should be continued until the pH >7.30 and/or the  $\text{HCO}_3^- >15$  mEq/L and the serum ketones have cleared**

# Insulin Key Points

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- Prior to insulin administration, reassess vital signs, blood glucose level and neurological status
- Insulin is administered as a continuous intravenous infusion of **regular insulin** at a rate of 0.05-0.1 units/kg per hour (**prepared by pharmacy**)

**Do not give insulin as a bolus**

- Insulin is a "High-Alert" medication, therefore two nurses should verify the insulin order, dose, and volume prior to administration
- IV tubing should be primed with the insulin solution before administration

**At the time of insulin infusion, make sure any indwelling insulin pump has been *disconnected and/or stopped***

# Insulin Key Points (cont.)

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- The dose of insulin should remain at 0.05-0.1 units/kg/hour
- Do not decrease rate or stop the insulin administration based solely on glucose values
- Once blood glucose reaches 250 mg/dL, maintain insulin and begin dextrose infusion
- If the acidosis is not improving, consult with a Pediatric Endocrinologist or Intensivist.
- If IV infusion is not possible, insulin injected intramuscularly or subcutaneously every 1 or 2 hours can be effective

# Potassium Administration: General Guidelines

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**Consult with your Pharmacist before administering potassium**

- Start replacing potassium after initial fluid resuscitation and concurrent with starting insulin therapy
- **MONITOR CLOSELY!!!**
- In general, in patients with DKA, there is a significant potassium deficit that must be replaced
- Potassium replacement should continue throughout IV fluid therapy
- The maximum recommended rate of IV potassium replacement is institution specific

## Potassium Administration (cont.)

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- **When initial serum potassium is  $<2.5$  mmol/L (hypokalemia)**
  - Administer 0.5-1 mEq/kg of potassium chloride in IV over 1-2 hours
  - Administer at rates specified by your institutional protocol or utilize a standard pediatric reference
  - Start potassium replacement early, *even before* starting insulin therapy

## Potassium Administration (cont.)

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- **When initial serum potassium is 2.5 - 3.5 mmol/L**
  - Administer potassium 40 mEq/L in IV solution until serum potassium > 3.5 mmol/L
  - Monitor serum potassium hourly
  - Administer potassium 30 – 40 mEq/L in IV solution to maintain serum potassium at 3.5 – 5.0 mmol/L



## Potassium Administration (cont.)

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- **When initial serum potassium is 3.5 - 5.0 mmol/L**
  - Administer potassium 30 – 40 mEq/L in IV solution to maintain serum potassium at 3.5 – 5.0 mmol/L
  - Monitor serum potassium hourly

Normal serum potassium level ranges between 3.5 to 5.0 mmol/L

## Potassium Administration (cont.)

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- **When initial serum potassium is > 5.0 mmol/L (hyperkalemia)**
  - Do not give IV potassium in initial fluids
  - Monitor serum potassium hourly until < 5.0 mmol/L
  - Then begin IV fluids with potassium to maintain serum potassium at 3.5 – 5.0 mmol/L

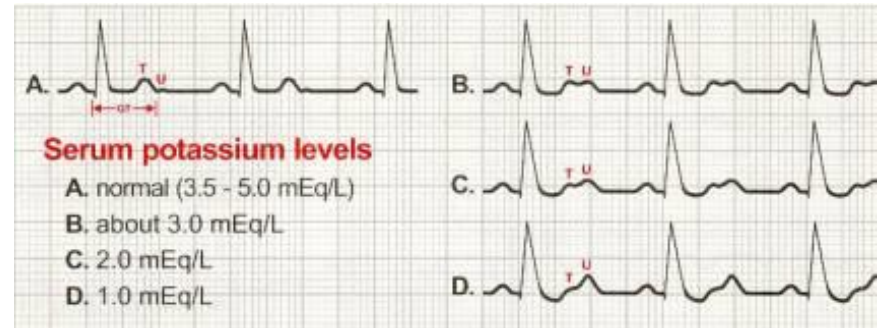
**Defer potassium replacement therapy  
until child has voided**

# EKG

**Normal serum potassium level ranges between 3.5 to 5.0 mmol/L**

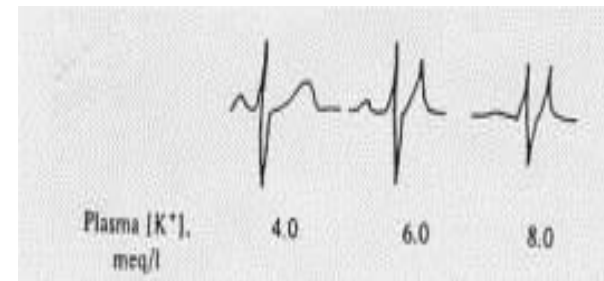
## Hypokalemia

Flattening T wave, widening of the QT interval, and appearance of U waves



## Hyperkalemia

Tall, peaked symmetrical, T waves and shortening of QT intervals



# Potassium Key Points

---

- Potassium loss in DKA due to:
  - vomiting
  - osmotic diuresis
- Potassium levels should be maintained at 3.5 – 5.0 mmol/L
  - Abnormal or critical values require hourly potassium checks
  - Consult with a Pediatric Endocrinologist or Intensivist about abnormal values
- Suggested potassium replacement can be administered as follows:
  - Potassium phosphate with potassium chloride
  - Potassium phosphate with potassium acetate

**Suggested administration:  
Potassium Phosphate 20mEq + Potassium Acetate 20mEq  
(unless hypophosphatemia develops)**

# Dextrose Administration

Dextrose



Add to IV fluids when the blood glucose concentration reaches 250 mg/dL



Change to 5% dextrose with 0.45 NaCl at a rate to complete rehydration in 48 hr



Check glucose hourly and electrolytes every 2-4 hr until stable



After resolution of DKA, initiate SQ insulin 0.5 – 1.0 units/kg/day (or according to insulin dosing guidelines per institution or physician policy)

- Maintain glucose between 150 to 250 mg/dL to prevent hypoglycemia
- Check glucose hourly until stable
- Check electrolytes every 2-4 hrs until stable

Adapted from:  
Kitabchi AE, Umpierrez GE, Murphy MB, et al; American Diabetes Association. Hyperglycemic crises in diabetes. *Diabetes Care*. 2004;27(Suppl. 1):S94-S102

# Bicarbonate

---

**Bicarbonate therapy is generally contraindicated in Pediatric DKA due to increased risk of cerebral edema.<sup>7,8,9,10</sup>**

**Consult with a Pediatric Endocrinologist and/or Intensivist prior to initiating bicarbonate!**

- Bicarbonate therapy should only be considered in cases of:
  - CPR
  - Life-threatening hyperkalemia with EKG changes<sup>10</sup>

# Monitoring

---

**Children presenting with DKA must be monitored closely**

- Hourly assessments:
  - Vital signs
    - pulse, respiratory rate, B/P, oxygen saturation, temperature, and pain level (as applicable)
  - Neurological status
  - Accurate fluid intake/output
  - Point-of-care-testing blood glucose level
  - Potassium level

**A flow sheet is invaluable for monitoring and documentation**

**Notify the treating physician immediately with any critical lab values or change in mental status.**

# Monitoring (cont.)

---

- Every 2 hours:
  - Urine ketones
  - Serum  $\beta$ -OH
  - Labs (repeated every 2– 4 hours or more frequently, as indicated in more severe cases)
    - serum glucose, electrolytes, BUN, calcium, magnesium, phosphorus, hematocrit, and blood gases
- Continuous cardiac monitoring
- Amount of administered insulin

**All insulin rate/dose changes should be double checked by two nurses and documented on the flow sheet.**



# Additional Measures

---

- Administer oxygen
  - Circulatory impairment
  - Shock



- Insert additional peripheral intravenous catheter
  - for repetitive blood sampling, and/or
  - if insulin drip is initiated



## **Children with altered mental status or consciousness, consider:**

- Secure the airway
- Nasogastric suction
- Bladder catheterization

# Introduction of Oral Fluids

---

Oral fluids should be introduced:

- only when substantial clinical improvement has occurred – note that mild acidosis/ketosis may still be present

**When oral fluid is tolerated, IV fluid should be reduced**

**If continuing fluids for hydration, remove dextrose from the IV.**

**Ketoacidosis is resolved when:**

- blood glucose is  $< 200$  mg/dL
- serum bicarbonate is  $\geq 15$  mEq/L and/or venous pH  $> 7.3$
- oral intake is tolerated



# Transition to Subcutaneous Insulin Injections

- **Typically occurs in the inpatient setting**
- **Transition to subcutaneous insulin when:**
  - Ketoacidosis has resolved, and
  - Oral intake is tolerated



**Do not stop** the insulin infusion before the first injection

- **Initiate subcutaneous insulin 0.5-1.0 unit/kg/day**
  - Before a mealtime
  - Before stopping the insulin infusion

**The dose and type of subcutaneous insulin given should be based on hospital or physician guidelines**

**After transitioning to subcutaneous insulin, frequent blood glucose monitoring is required to avoid marked hyperglycemia and hypoglycemia**

# High-Risk Patients

---

- New-onset diabetes
- Severe DKA (including long duration of symptoms)
- Compromised circulation
- Depressed level of consciousness
- Increased risk for cerebral edema
  - children less than 5 years of age
- Any child who might benefit from consultation with pediatric critical care specialists and transfer to specialized pediatric critical care centers

**Consult with a Pediatric Endocrinologist/Intensivist as soon as DKA is suspected**

# Inter-facility Pediatric Transfer Guideline

---

## **Inter-facility transfer guideline is defined as:<sup>12</sup>**

hospital-to-hospital (including out of State/Territory) procedural and administrative policies for transferring critically ill children to facilities that provide specialized pediatric care, or pediatric services not available at the referring facility

## **Components of a Pediatric Inter-facility transfer guidelines should include:**

- Process for initiating a transfer
  - the roles and responsibilities of the referring facility
  - the roles and responsibilities of the referral center
  - responsibilities for requesting transfer and communication
- Process for selecting an appropriate facility
- Process for selecting an appropriately staffed transport service
- Process for patient transfer

# Transport: Selecting a Facility

---

## **Factors to consider when selecting the appropriate facility:**

- PICU or pediatric unit specializing in diabetes care with:
  - Written guidelines for DKA management in children
  - A specialist with training and expertise in the management of DKA
  - Experienced nursing staff trained in monitoring and management of DKA
  - Access to laboratories for frequent and timely evaluation of critical labs

**Timely transfer to a specialty care center is essential**

# Transport: Mode of Transport

---

## **Process for selecting appropriate method of transport:**

- The referring physician, in consultation with the receiving center, should:
  - Determine the method of transport
  - Use appropriate personnel to accompany the child
    - Critical care transport team
    - Transport staff matches child's acuity
- Utilize appropriate sized equipment and medication

**Use a specialized transport team for any child already started on an insulin infusion**

# Transport: Patient Transfer

---

## Process for patient transfer:

- Obtain informed consent
- Plan transfer of:
  - Medical record
  - Copy of signed transport consent
  - Personal belongings
- Provide family with receiving institution information and directions



**The overall goal is to expedite safe transport of the child using trained staff with appropriate equipment and medications**





# COMPLICATIONS

# DKA Management: Common Complications

- Inadequate rehydration
- Hypoglycemia
- Hypokalemia

# DKA Management: Serious Complications

---

- **Cerebral Edema**
- Pulmonary Edema
- CNS Hemorrhage or Thrombosis
- Cardiac Arrhythmias
- Pancreatitis
- Renal Failure

**Cerebral edema due to DKA is almost exclusively a pediatric condition**

# Unclear Pathogenesis

---

## **DKA-related cerebral edema remains poorly understood**

- Many theories proposed<sup>13,14,15,16</sup>
- Data from literature has not clearly supported any particular theory
- Treatment causing or exacerbating cerebral edema has been particularly controversial
- Continues to be a topic of current review<sup>19,20</sup>

# Cerebral Edema: Facts

---

- Occurs in less than 1% of Pediatric DKA episodes
- Accounts for 60% to 90% of all DKA deaths
- 10% to 25% of survivors have permanent neurological injury



# Cerebral Edema: Presentation

---

- May develop without warning symptoms
- Asymptomatic cerebral swelling is believed to occur more frequently
- Occurs most frequently 4-12 hours after therapy initiation
- May occur before treatment is initiated.



# Cerebral Edema: Risk Factors

---

- Younger age (e.g., infants and children < 5 yrs)
- New-onset diabetes
- High glucose levels
- Severe dehydration (elevated BUN/creatinine)
- Severe acidosis (lower pH,  $\text{HCO}_3^-$ ,  $\text{pCO}_2$ )
- Treatment with bicarbonate

# Cerebral Edema: Rate of Fluid Rehydration?

---

## *Controversial Issue*

*Does a faster rate of rehydration increase risk of cerebral edema? 19,20*

*Should there be gradual, even fluid replacement during treatment? 19,20*



# Cerebral Edema: Warning Signs & Symptoms

---

- **Major criteria:**<sup>14</sup>

- Altered mental status/fluctuating LOC
- Sustained HR deceleration (not due to sleep or improved intravascular volume)
- Age-inappropriate incontinence

- **Minor criteria:**

- Vomiting
- Headache
- Lethargy
- Diastolic B/P > 90 bpm
- Age < 5 years



# Cerebral Edema: Treatment

- Reduce rate of intravenous fluids
- Elevate head of bed to at least a 30° angle
- Give Mannitol 0.25 - 1 gram/kg IV over 10-15 minutes<sup>21</sup>
  - May repeat if no initial response in 30 minutes to 2 hours
  - Have Mannitol ready at bedside and calculate dose beforehand



*And/Or*

- Give 3% Hypertonic Saline - 5 mL/kg IV over 10-15 minutes<sup>21, 22</sup>
  - Can be given instead or in conjunction with Mannitol.

**Initiate treatment as soon as cerebral edema is suspected**



# Cerebral Edema: Treatment (cont.)

---

- Intubation for impending herniation, PGCS < 8, apnea
- CNS imaging studies (non-contrast CT scan)
  - **treatment should not be delayed while waiting results.**
- Transfer and or admit to PICU.

**These measures may be life-saving when initiated promptly (before coma) and may prevent neurologic sequelae.**

# Key Points of Cerebral Edema

---

- Cerebral edema as a complication of DKA is almost exclusively a condition of childhood
- The pathophysiology is still not completely understood
- Occurs most frequently 4-12 hours after therapy initiation
- May occur even with improvement in blood chemistries
- Clinical diagnosis is based on major and minor criteria
- The clinical course is variable

# Key Points of Cerebral Edema (cont.)

---

- Requires urgent recognition and intervention
- Treatment of choice is Mannitol (0.25 - 1 gram/kg) and/or 3% Hypertonic saline (5 mL/kg)
- Requires admission to a PICU
- Intubation may be required
- A non-contrast CT scan is needed to confirm the diagnosis of cerebral edema and to rule out other causes



# PATIENT EDUCATION

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# DKA Can Be Prevented!

---

Management of an episode of DKA is not complete until the cause has been identified and an attempt made to prevent it.

- Better access to medical care
- Proper education
- Effective communication with health care provider



# How To Reduce Episodes Of DKA

**All children and families with diabetes should receive comprehensive diabetes health care and education.**

- Recognize the early warning signs and symptoms of ketoacidosis
- Take home measurements of blood ketone levels for earlier diagnosis



- Frequent insulin pump checks for blockages, kinks, or disconnections



- Have access to a 24-hour diabetes telephone help-line





# Diabetic Education

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- How to use a glucose monitoring device to check glucose levels
- How to draw up insulin and give injections
- How to recognize and treat hypoglycemia, including administration of glucagon
- Understand the **basic** principles of diet in terms of both content and timing of meals and snacks



# Discharge Instructions

---

## **Before discharge:**

- Meet with diabetes provider/educator and arrange follow-up
- Ensure child and family know when and where they are to return for follow-up care



# Sick Day Management: Overview

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- When to contact PCP/Endocrinologist/Diabetic Educator
- Blood glucose goals
- Use of supplemental insulin during illness
- Medications to suppress fever and treat infections
- Initiation of an easily digestible liquid diet containing carbohydrates and salt

## **MOST IMPORTANT**

- **Never discontinue or withhold insulin**
- **Seek professional advice early in the course of illness**

# Sick Day Management: Basics

## Successful sick day management must include:

- Involvement of the child
- Involvement of parent and family members
- The ability to measure blood glucose
- The ability to measure urine and/or blood ketones
- Knowledge of insulin administration
- Know how to take a temperature, respirations and pulse
- Know current weight
- Able to communicate signs and symptoms to health care professionals



# Effective School-based Diabetes Management

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- Basic diabetes training for all staff
- Shared responsibilities for care, with leadership by school nurse
- Self management is allowed in all school settings for students with capacity



These principles have been endorsed by the American Academy of Pediatrics, American Association of Clinical Endocrinologists, American Association of Diabetes Educators, American Dietetic Association, Children with Diabetes Disability Rights Education Defense Fund, Juvenile Diabetes Research Foundation, Lawson Wilkins Pediatric Endocrine Society, and Pediatric Endocrine Nursing Society.



# RESOURCES

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# Resources



## American Diabetes Association

[www.diabetes.org](http://www.diabetes.org)



[www.diabetes.org/living-with-diabetes/parents-and-kids/diabetes-care-at-school/](http://www.diabetes.org/living-with-diabetes/parents-and-kids/diabetes-care-at-school/)



[www.diabetes.org/in-my-community/](http://www.diabetes.org/in-my-community/)



## Children with Diabetes

[www.childrenwithdiabetes.com](http://www.childrenwithdiabetes.com)



# Resources

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## **Children with Diabetes Foundation**

[www.childrensdiabetesfoundation.org](http://www.childrensdiabetesfoundation.org)



## **European Society for Pediatric Endocrinology**

[www.eurospe.org](http://www.eurospe.org)



## **Lawson Wilkins Pediatric Endocrine Society**

[www.lwpes.org](http://www.lwpes.org)

LAWSON WILKINS PEDIATRIC ENDOCRINE SOCIETY





# Resources

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## International Diabetes Federation

[www.idf.org](http://www.idf.org)



International Diabetes Federation

## International Society for Pediatric and Adolescent Diabetes

[www.ispad.org](http://www.ispad.org)



## Juvenile Diabetes Research Foundation

[www.jdrf.org](http://www.jdrf.org)



# American Diabetes Alert Day

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Observed on the fourth Tuesday in March:

## ***American Diabetes Alert Day***

The **American Diabetes Alert Day** is a one-day, “wake-up” call to inform the American public about the seriousness of diabetes.



# American Diabetes Month

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**November is American Diabetes Month**



A time to communicate the seriousness of diabetes and the importance of diabetes prevention and control.

**1 out of every 3 children born today will face a future with diabetes if current trends continue.**

# World Diabetes Day

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world diabetes day

14 November

World Diabetes Day is celebrated worldwide to increase diabetes awareness and advocacy



# Test Your Knowledge

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# Test Your Knowledge: School Nurse



*You are a School Nurse at a local Elementary School. You are called to the classroom of a 10 year old female student. She is sitting at her desk slumped over the desktop, awake but drowsy. She feels nauseated and weak. She complains of abdominal pain and states that she hasn't felt well for a few days. Respirations are deep and rapid and she has a fruity odor to her breath.*

***Based on your assessment thus far which action should you choose?***

- (1)** The student's breathing pattern and odor indicates a possible toxic ingestion, you call the poison center
- (2)** The student's breathing pattern and breath odor indicates a metabolic problem such as hyperglycemia, you check her blood glucose level
- (3)** The student's breathing pattern indicates an foreign body airway obstruction , you apply abdominal thrusts (Heimlich Maneuver)
- (4)** The student's breathing pattern along with abdominal pain indicates an acutely inflamed abdomen, you perform an abdominal assessment

**For answer, proceed to next slide**

# The Correct Answer is....

---

**(2)** The student's breathing patterns indicates a metabolic problem such as hyperglycemia. You should check her blood glucose level.

## **Question Review**

If hyperglycemia is suspected, check the blood glucose level.

Hyperglycemia is high blood glucose levels defined as greater than 200 mg/dL. It develops when the body has too much glucose in the blood. If left untreated can lead to complications such as DKA. Clinical presentation of DKA include: deep and rapid respirations, nausea, vomiting, fruity breath odor, abdominal pain, lethargy/drowsiness, and confusion.

# Test Your Knowledge (cont.)

---

*You have obtained base line vital signs: pulse 120, respirations 42, B/P 92/58 and a blood glucose level of 340 mg/dL. As you continue your assessment you notice further increase in respiratory rate and a deterioration in mental status.*

***Based on this information, what would your next course of action be?***

- (1)** Contact parent or guardian to pick up child and seek medical advice
- (2)** Continue to monitor vital signs and neurological status in nurses' office
- (3)** Activate EMS
- (4)** Provide student with something to drink

**For answer, proceed to next slide**



# The Correct Answer is....

---

## **(3)** Activate *EMS*

### **Question Review**

You have identified a life-threatening problem and the need to activate EMS. As you await EMS arrival:

- Support airway, breathing and circulation as indicated
- Monitor vital signs and neurological status
- Repeat glucose level as necessary
- Give nothing by mouth
- Place in left lateral recovery position to prevent aspiration
- Prepare for transport and notify parent or guardian

# Quiz

---

**1. The most common symptom(s) of diabetes mellitus is (are):**

- (a) headache, chest pain
- (b) frequent urination, hunger, thirst
- (c) craving for sweets
- (d) sweaty, nervous

**2. The normal fasting blood glucose level is:**

- (a) 40-70 mg/dL
- (b) 160-240 mg/dL
- (c) 80-120 mg/dL
- (d) > 250 mg/dL

**3. Which of the following is not an indicator of diabetic ketoacidosis:**

- (a) very dry mouth
- (b) nausea/vomiting
- (c) slow and shallow breathing
- (d) lethargy/drowsiness

**4. Precipitating factors in the development of DKA include:**

- (a) missed insulin dose(s)
- (b) change in eating habits/diet
- (c) Stress and illness
- (d) all of the above

**5. A Individualized Health Care Plan (IHP) is required for all students with diabetes in the school setting.**

- (a) true
- (b) false

**For answers, proceed to next slide**

# Quiz

---

**1. The most common symptom(s) of diabetes mellitus is (are):**

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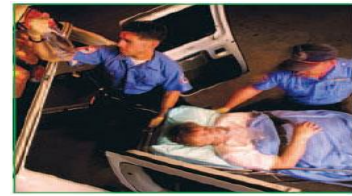
- (a) true**
- (b) false

**Answer Key:**

- 1. (b)**
- 2. (c)**
- 3. (c)**
- 4. (d)**
- 5. (a) TRUE**

# Test Your Knowledge:

## Pre-hospital Professional



*You are a pre-hospital professional dispatched to the home of a 6 year old male with sudden onset of lethargy and vomiting. You are advised that the child is conscious and breathing. According to the mother, "He suddenly became ill several hours ago and has gotten worse since then." He has a known history of diabetes and recently was placed on a insulin pump for insulin administration.*

***While enroute to the scene, you review the complications of diabetes with your partner. Which of the following statements are true?***

- (1)** Diabetic emergencies are generally related to extremely high or low blood glucose levels
- (2)** Diabetic emergencies may occur with no identifiable predisposing factor
- (3)** Altered mental status is often caused by complications of diabetes
- (4)** All of the above

**For answer, proceed to next slide**

# The Correct Answer is....

---

## (4) All of the above

Diabetic emergencies are generally related to extremely high or low blood glucose levels

Children at risk for diabetic emergencies are those lacking medical supervision and/or insufficient insulin administration

Diabetic emergencies may occur with no identifiable predisposing factor

Altered mental status is often caused by complications of diabetes

## Question Review

Most emergencies in children with established diabetes are related to events of hypoglycemia or hyperglycemia. Risk factors include: younger children, improper medical supervision or poor diabetes control. These emergencies are generally due to missed insulin injections and insulin pump failures. There may be no identifiable predisposing factor. It is not uncommon for children with complications of diabetes to present with symptoms of altered mental status.

# Test your Knowledge (cont.)

*On arrival the child is conscious but clearly appears ill. Upon assessment you determine he is tachycardic, has deep rapid respirations, signs of dehydration and an altered level of responsiveness. The mother states the blood glucose pump recordings have indicated normal values.*

***What intervention would you do next?***

- (1)** Apply C-spine immobilization
- (2)** Place on cardiac monitor
- (3)** Obtain blood glucose level
- (4)** Administer glucagon



**For answer, proceed to next slide**

# The Correct Answer is....

---

**(3)** Obtain blood glucose level

## **Question Review**

Although the mother has indicated normal blood glucose values, it is best to obtain a blood glucose level upon arrival to determine an accurate baseline level. This will allow you to determine, in an instant, if your interventions will be based on either hypoglycemia or hyperglycemia.

# Test your Knowledge (cont.)

---

*The blood glucose level obtained is 420 mg/dL. You have determined this child to have severe hyperglycemia. Because of his signs of dehydration, deep, rapid respirations and altered mental status, you are concerned that he is progressing into DKA.*

***What further management is indicated now?***

***Remember, treatment priorities will depend on the pre-hospital professional level. Choose the answer(s) that best match the level of the pre-hospital professional.***

**The treatment priorities for this patient are:**

- (1)** Support airway, breathing and circulation if indicated
- (2)** Give nothing by mouth and apply O<sub>2</sub>
- (3)** Transport immediately to appropriate hospital per medical control and continue to monitor vital signs and mental status
- (4)** All of the above

**For answer, proceed to next slide**



# The Correct Answer is....

---

## (4) All of the above

Support airway, breathing and circulation if indicated

Give nothing by mouth and apply O<sub>2</sub>

Transport immediately to appropriate hospital per medical control and continue to monitor vital signs and mental status

### **Question Review**

Children presenting in DKA are a medical emergency, therefore the goal of the pre-hospital professional is to safely transport to the closest appropriate care center in a timely fashion. The level of the pre-hospital professional will determine the type of care that can be provided. Always perform ongoing assessments to observe the response to interventions and to guide changes in treatment, transport and triage. Maintain contact with medical control, which allows for complete and concise transmission of vital data. In turn this allows the ED team to best prepare for the child's arrival.

# Quiz

---

**1. Which statement is not correct when defining Type 1 diabetes:**

- (a) non-insulin dependent
- (b) body does not produce insulin
- (c) diagnosed in children and young adults
- (d) insulin dependent

**2. Which of the following signs and symptoms are associated with DKA:**

- (a) decreased LOC, recent seizure, normal vital signs
- (b) dry skin, slow respirations, normal heart rate
- (c) decreased LOC, tachycardia, deep and rapid respirations
- (d) sweaty skin, tachycardia, rapid respirations

**3. Prolonged and exceptionally high hyperglycemia may lead to:**

- (a) ketosis
- (b) acidosis
- (c) DKA
- (d) all of the above

**4. Signs of dehydration may include:**

- (a) prolonged capillary refill and poor skin turgor
- (b) abnormal breathing and altered mental status
- (c) Dry mucus membranes and warm skin
- (d) all of the above

**5. All children and families with diabetes should receive comprehensive diabetes health care and education:**

- (a) true
- (b) false

For answers, proceed to next slide

# Quiz

---

**1. Which statement is not correct when defining Type 1 diabetes:**

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- (c) **decreased LOC, tachycardia, deep and rapid respirations**
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- (c) DKA
- (d) **all of the above**

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- (a) prolonged capillary refill and poor skin turgor
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- (c) Dry mucus membranes and warm skin
- (d) **all of the above**

**5. All children and families with diabetes should receive comprehensive diabetes health care and education:**

- (a) true
- (b) false

**Answer Key: 1. (a)  
2. (c)  
3. (d)  
4. (d)  
5. (a) TRUE**

# Test Your Knowledge:

## Emergency Department



*A lethargic child is rushed into the emergency department by her mother who states that she was unable to arouse her four-year-old from bed this morning. She reports that her child had appeared "totally fine" until last evening when her daughter complained of some "belly pain" and experienced several episodes of vomiting. The mother denies a history of trauma and states that her child has no medical problems. The child is not taking any medications, has no known allergies, and has had no recent contact with any communicable diseases.*

### ***Components of your assessment should include ?***

- (1)** Evaluate the ABC's; airway, breathing and circulation
- (2)** Obtain vital signs, weight (kg), and point-of-care testing (BGL/urine ketones)
- (3)** Assess clinical severity of dehydration
- (4)** Assess neurological status
- (5)** Place child on cardiac monitor
- (6)** All of the above



**For answer, proceed to next slide**

# The Correct Answer is....

---

## (6) All of the above

Evaluate the ABC's; airway, breathing and circulation

Obtain vital signs, weight (kg), and point-of-care testing (BGL/urine ketones)

Assess clinical severity of dehydration

Assess neurological status

Place on cardiac monitor

## Question Review

DKA is a medical emergency, and as in common with all emergencies:

- Resuscitation should follow the "ABC" pattern (airway, breathing and circulation).
- Obtain vital signs
  - Weigh the patient, in kilograms. If body surface area is used for fluid therapy calculations, measure height or length to determine surface area. This weight should be used for calculations and not a weight from a previous office visit or hospital record.
- Obtain point-of-care testing
  - Blood glucose and urine ketones
- Assess clinical severity of dehydration
  - All children with DKA require supplemental fluids due to dehydration. DKA fluid deficit is usually in the range of 5-10%
- Assess neurological status
  - Utilizing assessment tools such as AVPU or the Pediatric Glasgow Coma Scale (PGCS) may help to detect early signs of cerebral edema
- Assess cardiac rhythm
  - Monitoring to assess for arrhythmias and for presence of abnormal T waves, which would indicate hypokalemia or hyperkalemia..

# Test Your Knowledge (cont.)

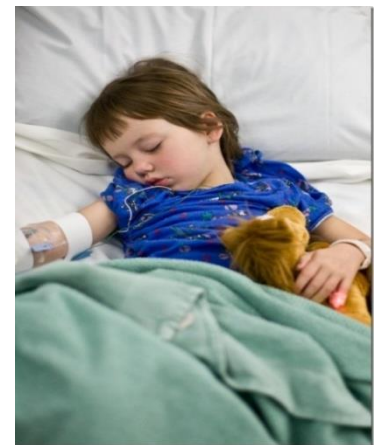
---

***The child is presumed to be in DKA, the following is initiated:***

- *Non-rebreather mask at 12 - 15L/minute*
- *Continuous cardiac monitor*
- *Pulse oximeter*
- *A peripheral venous catheter access*
  - *Initial labs*
  - *Fluid resuscitation*

***What is the goal of the first hour of treatment for DKA?***

- (1)** Replace potassium deficits
- (2)** Volume resuscitation and confirmation of DKA by laboratory studies
- (3)** Initiation of an insulin drip
- (4)** All of the above



**For answer, proceed to next slide**

# The Correct Answer is....

---

**(2)** Volume resuscitation and confirmation of DKA by laboratory studies

## **Question Review**

Management of DKA starts with intravenous fluid replacement. The goal of the first hour of treatment is volume resuscitation and confirmation of DKA by results of laboratory studies. Insulin treatment is begun after the initial fluid resuscitation; that is, at the beginning of the second hour of therapy. Beginning insulin treatment at the same time as fluid resuscitation increases the risks of severe hypokalemia, and of rapidly and excessively decreasing the serum glucose.

# Test Your Knowledge (cont.)

---

*The child is confirmed to be in DKA. Phase I, initial volume expansion has been initiated. The clinical status of the child appears to be deteriorating.*

***Continued ED management of a child in DKA would include?***

- (1)** Continue to monitor and follow your hospital DKA protocol
- (2)** Consult with Pediatric Endocrinologist and/or Intensivist for treatment options
- (3)** Begin admission process to your hospital's PICU or transfer to a receiving hospital with a higher level of care
- (4)** All of the above



**For answer, proceed to next slide**



# The Correct Answer is....

---

## **(4)** All of the above

Continue to monitor and follow your hospital DKA protocol

Consult with Pediatric Endocrinologist and/or Intensivist for treatment options

Begin admission process to your hospital's PICU or transfer to a receiving hospital with a higher level of care

## **Question Review**

Once DKA is suspected and/or confirmed, early consultation with a Pediatric Endocrinologist and/or Intensivist regarding management and treatment is strongly recommended. Severely ill children, those in DKA may require specialized pediatric critical care services that may not be available in the ED. For those reasons, begin admission process to your hospital's PICU or transfer to a receiving hospital with a higher level of care. In addition, it is important to continue to monitor the child based on your hospital's DKA protocol and guidelines.

# Quiz

---

**1. The biochemical criteria for the diagnosis of DKA is defined as:**

- (a) blood glucose greater than 200 mg/dl
- (b) ketones present in blood and/or urine
- (c) ph less than 7.3 and/or bicarbonate less than 15 mmol/L
- (d) all of the above

**2. Blood test used to diagnose the presence and severity of acidosis include:**

- (a) only arterial blood gases
- (b) arterial blood gas or venous blood gas and electrolytes
- (c) electrolytes and serum  $\beta$ -hydroxybutyrate
- (d) blood glucose, urine ketones and electrolytes

**3. Complications of DKA management are:**

- (a) inadequate rehydration
- (b) hypoglycemia
- (c) cerebral edema
- (d) all of the above

**4. First hour management of a child suspected of DKA would be:**

- (a) give IV fluid of 0.9% NS at maintenance
- (b) give an IV bolus of 0.9% NS 10-20-mL/kg over the first hour
- (c) administer insulin bolus
- (d) wait for more laboratory results before giving any fluids or insulin

**5. Pediatric Glasgow Coma Scale (PGCS) is an accurate measure to document level of consciousness over a period of time**

- (a) true
- (b) false

**For answers, proceed to next slide**

# Quiz

---

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- (d) wait for more laboratory results before giving any fluids or insulin

**5. Pediatric Glasgow Coma Scale (PGCS) is an accurate measure to document level of consciousness over a period of time**

- (a) true
- (b) false

**Answer Key:** 1. (d)  
2. (b)  
3. (d)  
4. (b)  
5. (a) TRUE



# REFERENCES

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# APPENDIX A: ASSESSMENT TOOLS

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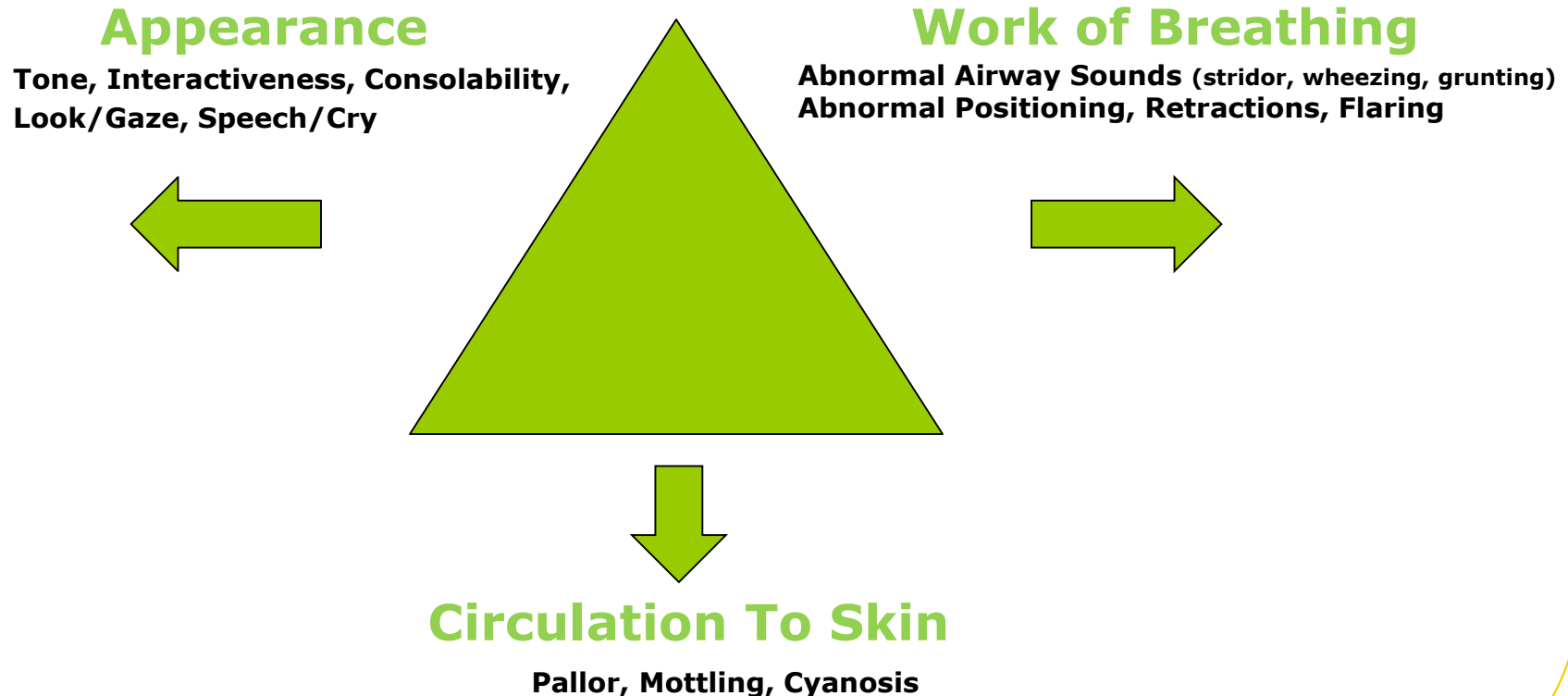
# Systematic Assessment

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- **Scene safety assessment**
  - Ensure that it's safe to approach, or call for backup assistance as necessary.
- **Pediatric Assessment Triangle (PAT)**
  - Immediately activate EMS if the situation is obviously emergent.
- **Initial assessment (ABCDE)**
  - Identify and treat problems that threaten life.
- **History**
  - Gather background information essential to your triage decision.
- **Focused physical examination (FGHI)**
  - Measure and record vital signs, inspect, auscultate, and palpate to identify or investigate additional problems.

# Pediatric Assessment Triangle

A quick overall appraisal of the child's condition based on appearance, breathing and circulation



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# Initial **ABCDE** Assessment

<b>Assessment</b>	
<b>A</b>	<b>Airway</b> <i>Position, sounds, obstruction</i>
<b>B</b>	<b>Breathing</b> <i>Rate, depth/pattern, symmetry, sounds, work of breathing, odors, injuries</i>
<b>C</b>	<b>Circulation</b> <i>Heart rate and quality of pulses, capillary refill time, skin color, temperature, and moisture, bleeding</i>
<b>D</b>	<b>Disability (neurologic status)</b> <i>Level of consciousness via AVPU; pupillary response</i>
<b>E</b>	<b>Exposure with Environmental control to prevent heat loss</b> <i>Observe and inspect for additional emergent problems</i>

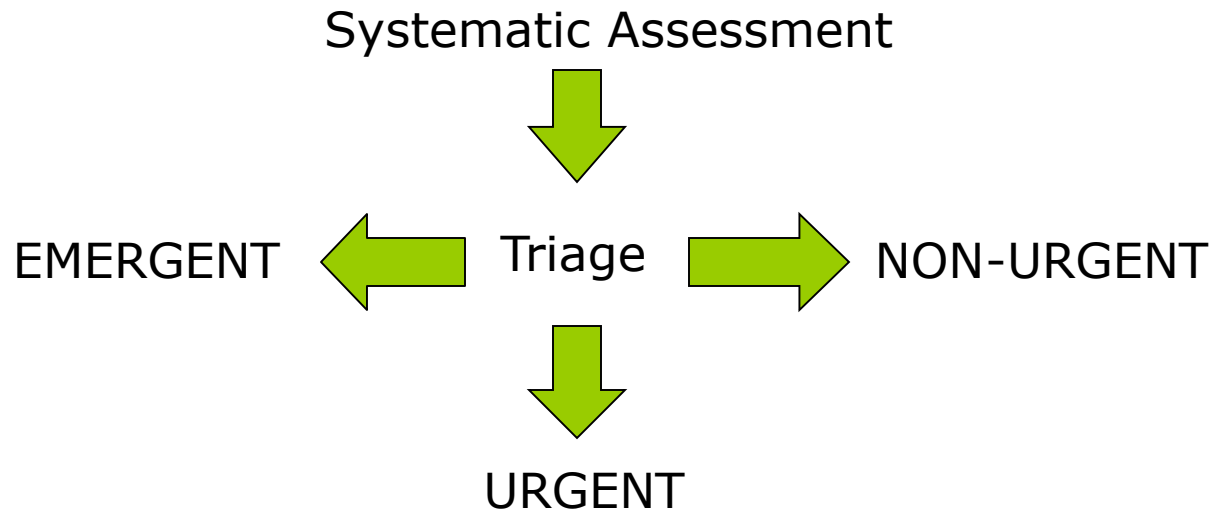
# Focused Physical Examination FGHI

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<b>Assessment</b>	
<b>F</b>	Full set of vital signs
<b>G</b>	Give comfort measures
<b>H</b>	Head-to-toe assessment <i>Inspect, palpate, auscultate— limited or complete</i>
<b>I</b>	Isolate; Injuries; additional Interventions

# Triage (E-U-N)

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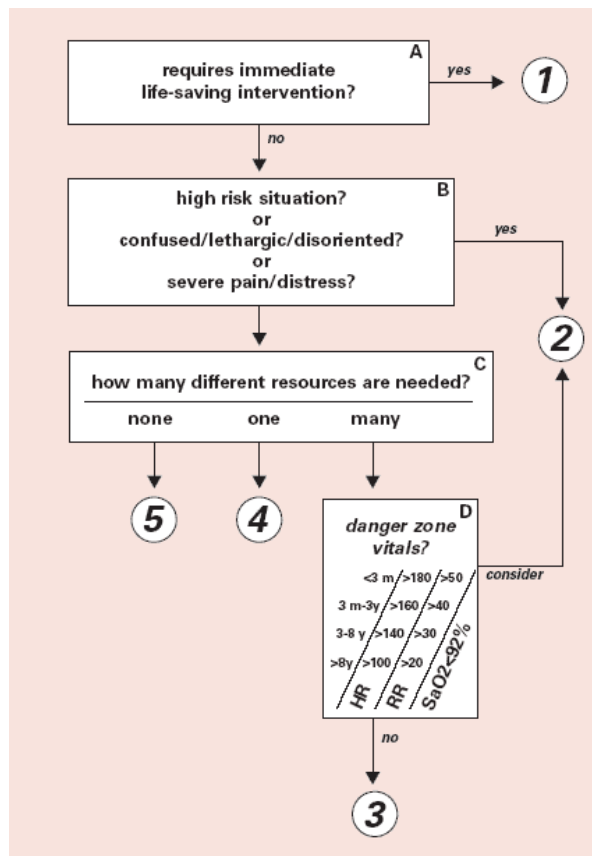


**Emergent** – child requires immediate medical attention. Condition is acute and has the potential to threaten life.

**Urgent** – child requires additional medical intervention within 2 hours. Condition is acute but not severe or life threatening.

**Non-urgent** – child may require referral for routine medical care. Minor or non-acute condition.

# Emergency Severity Index (ESI)



Source: ©ESI Triage Research Team, 2004

## Emergency Severity Index (ESI)

- Five-level triage instrument
- Categorizes emergency department patients by
  - **patient acuity**
  - **resources**

**ESI 1** requires immediate life-saving intervention

**ESI 2** high risk situation:  
should the patient wait?

**ESI 3** vital signs:  
vital signs outside accepted parameters?

**ESI 4** resources prediction:  
how many resources are needed?

**ESI 5** no resources needed

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# AVPU

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The AVPU scale should be assessed using these identifiable traits, looking for the best response of each

- A** ***Alert*** - the child is lucid and fully responsive, can answer questions and see what you're doing. Infants – active, responsive to parents and interacts appropriately with surroundings
- V** ***Voice*** - the child or infant is not looking around; responds to your voice, but may be drowsy, keeps eyes closed and may not speak coherently, or make sounds.
- P** ***Pain*** - the child or infant is not alert and does not respond to your voice. Responds to a painful stimulus, e.g., shaking the shoulders or possibly applying nailbed pressure.
- U** ***Unresponsive*** - the child or infant is unresponsive to any of the above; unconscious.

**The AVPU scale is not suitable for long-term neurological observation of the child. In this situation, the Pediatric Glasgow Coma Scale is more appropriate**



# Pediatric Glasgow Coma Scale (PGCS)



Illinois Emergency Medical Services for Children

Pediatric Glasgow Coma Scale (PGCS)		
	<2 Years Old	>2 Years Old
<b>Eye Opening (E)</b>	(4) Spontaneous (3) To speech (2) To pain (1) None	(4) Spontaneous (3) To speech (2) To pain (1) None
<b>Verbal Response (V)</b>	(5) Coos, babbles, appropriate words (4) Irritable, cries but consolable (3) Cries to pain, inconsolable (2) Moans to pain (1) None	(5) Oriented/appropriate words (4) Confused (3) Inappropriate words/persistent cry (2) Incomprehensible sounds (1) None
<b>Motor Response (M)</b>	(6) Normal spontaneous movements (5) Withdraws from touch (4) Withdraws from pain (3) Abnormal flexion (decorticate) (2) Abnormal extension (decerebrate) (1) None	(6) Obeys commands (5) Localizes to pain (4) Withdraws from pain (3) Abnormal flexion (decorticate) (2) Abnormal extension (decerebrate) (1) None
Total Pediatric Glasgow Response: 3-15		

**PGCS is an accurate measure to document level of consciousness over a period of time.**

**Frequent assessment will indicate the progression of illness and determine it's severity.**

**The lower the score the more severe the illness.**

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## APPENDIX B: “Two-Bag System”

NOTE: The “two-bag system” should be used **with caution** and utilized only in tertiary care centers that have the necessary resources, including a Pediatric Endocrinologist on staff. The “two-bag system” should only be administered by staff who have been trained and have demonstrated competency. All IV fluids used in this method should be prepared by trained pharmacy personnel.

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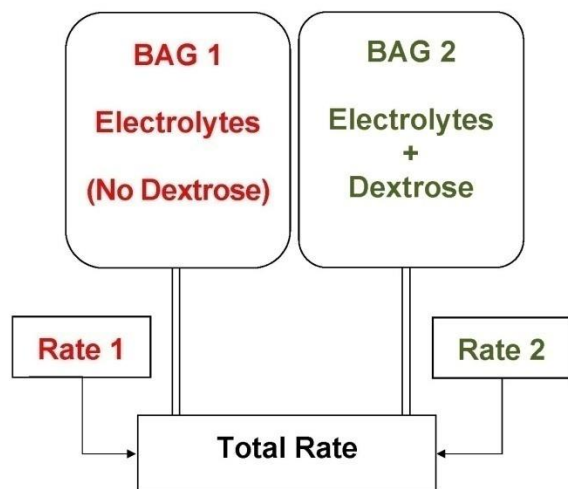
# Alternative Method to Administer Dextrose in Pediatric Tertiary Care Centers

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NOTE: The “two-bag system” should be used **with caution** and utilized only in tertiary care centers that have the necessary resources, including a Pediatric Endocrinologist on staff. The “two-bag system” should only be administered by staff who have been trained and have demonstrated competency. All IV fluids used in this method should be prepared by trained pharmacy personnel.

- The **“two-bag system”** is an alternate method for administering dextrose in tertiary care centers
- Consists of simultaneous administration of two IV fluids of differing dextrose concentrations
- Allows a more rapid response to changes in blood glucose concentration<sup>16</sup>
- Rates of administration of the two bags of fluid can be adjusted to vary the dextrose concentration while maintaining a constant overall rate of fluid and other electrolyte administration

# "Two-Bag System" EXAMPLE<sup>17</sup>



- Two IV fluid bags are ordered **from the pharmacy** with identical electrolyte concentration
- **Bag 1 will contain no dextrose**
- **Bag 2 will contain D10**
- Begin the initial infusion with **Bag 1** only. IV fluid administration will initially contain no dextrose. Then adjust each bag accordingly.
- **Increase** dextrose by increasing the rate of **Bag 2** and decreasing the rate of **Bag 1**
- **Decrease** dextrose by decreasing the rate of **Bag 2** and increasing the rate of **Bag 1**
- The relative rates of administration of the two IV fluid bags are adjusted to change the dextrose concentration delivered to the patient while keeping fluid and electrolyte replacement constant

# “Two-Bag System” Key Points

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- Use **with caution** in tertiary care center settings with specialty resources
  - Pediatric Endocrinologist on staff
  - Pediatric Intensivist
  - Trained staff with ongoing competency demonstration
  - Trained pharmacy staff
- Provides more precise control of total fluid, electrolyte, and dextrose
- Tailors the IV fluids to meet the child’s individual needs
- Decreases time to institute ordered changes in fluid therapy
- Cost-effective
  - “Two-bag system” costs less per DKA admission than one bag system



# **APPENDIX C: Treatment Guidelines**

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# Treatment Guidelines

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**Below are examples of Pediatric DKA guidelines that can be used as templates as you develop your own ED guidelines. Please give appropriate credit to any resource you utilize.**

Advocate Children's Hospital (Oak Lawn, IL)

Suspected Diabetic Ketoacidosis

<http://www.advocatedocs.com/wp-content/uploads/2018/11/Diabetic-Ketoacidosis.pdf>

Northwest Community Hospital (Arlington Heights, IL)

Pediatric DKA Guideline

<https://www.luriechildrens.org/globalassets/documents/emsc/education/northwestcommunityhospitaldkapedsedpolicy.pdf>

OSF St. Francis Hospital (Peoria, IL)

DKA Nursing Care Guidelines

<https://www.luriechildrens.org/globalassets/documents/emsc/education/osfstfrancischildrenshospitalpedaitricdkanursingcareguidelines.pdf>

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**THE END**