

**DIABETIC KETOACIDOSIS PATHWAY
EMERGENCY DEPARTMENT MANAGEMENT
GUIDELINES (This is NOT an order)**

2/2009

Note: this is only an outline. Please refer to "Guidelines for Management of Diabetic Ketoacidosis" for full details.

Definition of Diabetic Ketoacidosis (DKA):

Hyperglycemia (serum glucose >300 mg/dl)
Acidosis (bicarbonate <15 and arterial pH < 7.3)
Ketonemia (> or equal to 1:2 dilution)
Glucosuria
Ketonuria

Nursing to initiate the following immediately if DKA is suspected:

- 1) **DKA Flow Sheet (located at the end of DKA Pathway)**
- 2) **Order labs STAT: I stat, finger stick blood glucose**
- 3) **Obtain vital signs including Glasgow Coma Scale**
- 4) **If labs confirm DKA (see definition, above) then order from pharmacy**
 - a. **Insulin 1 unit/ml NS for drip**
 - b. **½ NS with 20 mEq KCl/L and 20 mEq KPO₄/L**
 - c. **D10 ½ NS with 20 mEq KCl/L and 20 mEq KPO₄/L**

Emergency Department physician should page either the hospitalist (if patient meets pathway inclusion criteria for floor admission) or the intensivist (if patient needs 1:1 nursing) ONLY AFTER the above information is available and fluids and insulin have been ordered. The discussion with the admitting physician should be documented and it should be clear who is assuming responsibility for management of the patient.

I. Additional labs which should be drawn in the Emergency Department

- A. All patients:
 1. Serum: glucose, lytes, phosphate, calcium, BUN, creatinine
 2. Urinalysis with microscopic, culture if indicated
 3. Bedside: finger stick glucose to correlate with serum, urine dip for glucose and ketones
 4. Consider: ABG or VBG if HCO₃ is low (<10), altered level of consciousness, or abnormal respiratory pattern
- B. All new diabetic patients:
 1. ICAB (islet cell antibody panel - includes GAD65, Insulin Autoantibody, and ICA512/IA-2), Anti-thyroid peroxidase (ANTIMAB) antibody, TSH, and anti-tissue transglutaminase (anti-TTG) antibody, serum IgA.
 2. If considering Type 2: serum insulin (if patient has not yet received insulin) or a C-peptide level, Comprehensive Metabolic Panel (for liver function and triglycerides).

II. Fluids (If blood sugar is greater than 800 mg/dl, consider diagnosis of nonketotic hyperosmolar coma and consult endocrinologist before giving fluids).

- A. Goal: **avoid excessive fluid administration or rapid osmotic shifts**
- B. Initial fluids: Normal Saline is the best initial fluid. Initial therapy is directed at treating hypovolemia IF PRESENT. Initial bolus 10-20 ml/kg. Over 20-30 minutes on a pump. No need to push fluids
- C. Change to ½ NS after the initial phase of rehydration. Rate should generally be 1.5 - 1.75 times maintenance
- D. In general, add D5 or D10 when blood glucose falls below 300 mg/dl.
- E. **Have a bag of ½ NS and D10½ NS at the bedside ready to be hung before transfer to floor.**
- F. Keep serum glucose > 200 mg/dl for the first 24 hours of therapy

III. Insulin

- A. Order insulin to be made up as soon as possible once the diagnosis of DKA has been established:
 1. Continuous IV infusion of regular insulin should be used in moderate-severe DKA.
 2. Insulin should be piggy-backed into hydration fluid
 3. Insulin concentration should be 1 unit/ml
 4. Initial rate is 0.05-0.1 unit/kg/hr

IV. Potassium

- A. Start K⁺ when serum K⁺ is <5.5 mEq/L and patient has urinated.
- B. Do not start K⁺ until insulin infusion has started
- C. K⁺ concentration: 20-40 mEq/L made up of KCl and KPO₄
- D. If using KPO₄, monitor Ca⁺⁺ levels to avoid hypocalcemia

V. Monitoring

- A. Finger stick blood sugar checks and neuro checks every hour, cardiac monitor while in the Emergency Department and while on insulin infusion. Check vital signs every hour while on insulin drip.

Diabetic Ketoacidosis Pathway - Admission to Floor

Diabetic Ketoacidosis (DKA) is a life-threatening condition caused by a lack of insulin. Uncomplicated DKA should resolve in 12-24 hours. Resolution is defined as correction of acidosis. The most serious complication of DKA in children is cerebral edema. The incidence of cerebral edema is 1:100 episodes of DKA. Cerebral edema is most likely to occur after initial fluid and insulin therapy has begun; usually 6-12 hours into the treatment of DKA. The mortality rate is at least 20% and the risk for morbidity from permanent neurologic impairment is even greater than this. The avoidance of cerebral edema and the correction of acidosis are the primary goals of the treatment of DKA in children.

Include in the pathway - patient is suitable for admission to the floor (Patients must be all of these to be put onto pathway):

- Hyperglycemia (serum glucose > 300 mg/dl on initial laboratories)*
- Acidosis ($\text{HCO}_3^- < 15$ mEq/L and pH < 7.30)
- Ketones present in serum or urine
- Anion gap > 12 mmol/L ($[\text{Na}^+] - [\text{HCO}_3^- + \text{Cl}^-]$)**
- pH > 7.1 and rising documented by repeat blood gas after 2 hours of resuscitation
- Mental status appropriate
- Glasgow Coma Scale > 12

Exclude from the pathway - patient requires 1:1 or 1:2 nursing and should be admitted to the PICU or, if appropriate, should be managed in the ED until an appropriate bed is available (Patients may be any of these):

- pH < 7.1
- Less than 2 years of age
- $\text{K}^+ < 3.5$ mEq/L on initial labs
- $\text{K}^+ > 6.0$ mEq/L
- Serum glucose > 1,000 mg/dl on initial labs
- Ketones absent
- Anion gap ≤ 12 mmol/L
- Glasgow Coma Scale < 12

Patients should be considered for removal from the pathway and evaluated for transfer to a higher level of care (PICU) if: (Nursing staff should contact physician if any of the following apply):

- Any deterioration in mental status or NEW complaint of headache or any other reason to suspect cerebral edema

Criteria for Diabetic Admission (not necessarily via this pathway)

- Vomiting or unable to take PO
- New diagnosis of diabetes and need education
- Dehydration

Criteria for Discharge - all of the following must be achieved prior to discharge

- $\text{HCO}_3^- > 15$ mmol/L
- Anion gap ≤ 12 mmol/L
- Tolerating PO
- Ambulating
- All teaching complete and documented by Diabetes Educator:
 - Use of blood glucose meter to test blood sugars
 - Ability to draw up and administer insulin
 - Ability to keep Diabetes Diary
 - Ability to demonstrate knowledge of carbohydrate counting
 - Ability to demonstrate knowledge of signs and symptoms of hypoglycemia and treatment of hypoglycemia, including when and how to administer glucagon
- Diabetes supplies in family possession
- Labs drawn (for NEWLY diagnosed patients only): ICAB, TSH, anti-TPO (ANTIMAB) antibody, anti-TTG antibody
- Safe and stable home situation

Background Information:

- * In rare cases, blood sugar may not be elevated.
- ** Need to exclude hyperchloremic metabolic acidosis

Note: Guidelines cannot be written for all circumstances and for rigid adherence. This pathway is not a substitute for clinical judgment.

References:

Dunger, DB 2004. "European Society for Pediatric Endocrinology/Lawson Wilkins Pediatric Endocrine Society Consensus Statement on Diabetic Ketoacidosis in Children and Adolescents" *Pediatrics* 113(2): e133-40

Sperling, Mark A. *Pediatric Endocrinology, Second Edition*. 2002 Elsevier Science (USA): 339-344

International Society for Pediatric and Adolescent Diabetes (ISPAD) 2002 Consensus guidelines.
www.ispad.org.

Weight:

Allergies:

Time/ Date: ----- Pharmacy Orders - Phase I

Insulin and Medications:

- 1) Flush new IV tubing with 50 mL of insulin drip solution **prior to connecting to patient** and starting insulin infusion. (Pharmacy to send flush solution)
- 2) Regular insulin 1 unit/mL NS
- 3) Begin infusion at 0.1 unit/kg/hour = _____ units per hour (**physician to determine rate, pharmacy to verify**)
- 4) Mannitol 25% vial: 0.25 g/kg IVSP via IV line with in-line filter (5 micron) PRN symptoms of cerebral edema - see Management of Suspected Cerebral Edema; **call physician before mannitol is given.**
[PYXIS REMOVAL]

Fluid Rates: (Physician to determine)

Maintenance: _____ mL/hr
 0.75 times maintenance: _____ mL/hr
 1.5 times maintenance: _____ mL/hr
 2 times maintenance: _____ mL/hr

Definition of maintenance fluids:	
1-10 kg	4 ml/kg/hr
11-20 kg	40 ml/hr + (2 ml/kg/hr for each kg >10)
>20 kg	60 ml/hr + (1 ml/kg/hr for each kg >20)

- 1) D10 ½ NS with 20 mEq KCl per liter AND 20 mEq KPhos per liter.
- 2) ½ NS with 20 mEq KCL per liter AND 20 mEq KPhos per liter.

Blood Glucose (mg/dL)	Fluid	Rate
> 300	½ NS + 20 mEq KCl/liter and 20 mEq KPhos/liter	1.5 times maintenance
201-300	½ NS + 20 mEq KCl/liter and 20 mEq KPhos/liter	0.75 times maintenance
	D10 ½ NS + 20 mEq KCl/liter and 20 mEq Kphos/liter	0.75 times maintenance
< 200	D10 ½ NS + 20 mEq KCl/liter and 20 mEq KPhos/liter	1.5 times maintenance

Physician's Signature/ID number : _____ Date: ____/____/____ Time: _____

DKA

Patient Label



- Time/Date:**
- 2) Regular insulin 1 unit/ml NS Send 2 (50 ml) syringes initially and upon RN request.
 - 3) Begin infusion at 0.1 unit/kg/hour
 - 4) Mannitol 25% vial 0.25 gm/kg IVSP via IV line with in-line filter (≤ 5 micron) PRN symptoms of cerebral edema - see Management of Suspected Cerebral Edema; **call physician before mannitol is given.**

Fluid Rates: (Physician to determine)

Maintenance: _____ ml/hour
 1.5 times maintenance: _____ ml/hour
 2 times maintenance: _____ ml/hour

Definition of maintenance fluids:

1-10 kg	4 ml/kg/hr
11-20 kg	40 ml/hr + (2 ml/kg/hr for each kg >10)
>20 kg	60 ml/hr + (1 ml/kg/hr for each kg >20)

Diet and Fluids For Insulin Drip

- 1) NPO except for ice chips while on insulin drip
- 2) Strict I's and O's
- 3) Calculate urine output every 4 hours and page MD on call for urine output > 4 ml/kg/hr or < 1 ml/kg/hr (MD may order fluid replacement of $\frac{1}{2}$ NS or NS for abnormal urinary losses).
- 4) Fluids:
 - a. D10 $\frac{1}{2}$ NS with 20 mEq KCl/liter and 20 mEq KPhos/liter
 - b. $\frac{1}{2}$ NS with 20 mEq KCl/liter and 20 mEq KPhos/liter
- 5) **Make sure that patient has voided and that K+ is < 5.5 before hanging any potassium-containing fluid**
- 6) If patient has not voided or if K+ > 5.5 page MD on-call for alternate fluid orders
- 7) Fluids and insulin should be "Y'd" together and should run through a single IV
- 8) Fluid rate: the following fluid rates assume that the patient is no more than 10% dehydrated and has received adequate fluid resuscitation prior to being placed on pathway.
 - a. Blood glucose > 300 mg/dl: $\frac{1}{2}$ NS with 20 mEq KCl/liter and 20 mEq KPhos/liter at 1.5 times maintenance
 - b. Blood glucose 201 - 300 mg/dl: $\frac{1}{2}$ NS with 20 mEq KCl/liter and 20 mEq KPhos/liter at 0.75 times maintenance plus D10 $\frac{1}{2}$ NS with 20 mEq KCl/liter and 20 mEq KPhos/liter at 0.75 times maintenance
 - c. Blood glucose < 200 mg/dl: D10 $\frac{1}{2}$ NS with 20 mEq KCl/liter and 20 mEq KPhos/liter at 1.5 times maintenance
- 9) Goal is to maintain **BLOOD GLUCOSE 200-300 mg/dl** during the first 24 hours of DKA treatment

Treatment of Hypoglycemia (Insulin Drip)

- 1) If blood glucose < 80 mg/dl decrease insulin drip to 0.05 unit/kg/hr and give a bolus of D10W 2 ml/kg IV. Increase IV fluid rate to 2 times maintenance. Page physician on-call. Re-check blood sugar in 15 minutes. If blood glucose still < 80 mg/dl give another bolus of D10W 2 ml/kg IV and recheck blood glucose in 15 minutes.
- 2) If blood glucose 81-100 mg/dl decrease rate of insulin drip to 0.05 unit/kg/hr and increase IV fluid rate to 2 times maintenance. Page physician on-call. Recheck blood glucose in 30 minutes.

Management of Suspected Cerebral Edema

- 1) Always keep mannitol 25% vial in or at nursing station
- 2) Page physician on-call for any of the following
 - a. Headache
 - b. Deterioration in consciousness level/response
 - c. Unequal dilated pupils
 - d. Delirium
 - e. Incontinence
 - f. Vomiting
 - g. Bradycardia
 - h. Hypertension
- 3) Contact PICU attending STAT

Transition from Insulin Drip to Subcutaneous Insulin

- 1) Check to make sure $\text{HCO}_3^- > 15$ mmol/L or pH > 7.3 ; anion gap ≤ 12 mmol/L
- 2) Start sugar-free oral fluids

Physician's Signature/ID number : _____ Date: ____/____/____ Time: _____

DKA

Patient Label



**Time/
Date:**

- 3) Make sure patient wants to eat
- 4) Order age appropriate meal according to the carb-counting meal plan recommended by the R.D. (if RD had not seen patient, use the following guide: < 2 years = 2 carbs, 3-5 years = 3 carbs, 5-12 years = 4 carbs, >12 years = 5 carbs. 1 carb = 15 grams of carbohydrates, so 2 carbs = 30 grams, 3 carbs = 45 grams, 4 carbs = 60 grams, and 5 carbs = 75 grams. Snacks are not recommended)
- 5) Check blood sugar and page physician with result to obtain subcutaneous insulin orders before giving patient meal tray. (Subcutaneous insulin orders should be determined with consultation from endocrinologist on-call after reviewing "Conversion from continuous insulin infusion to subcutaneous insulin" on page 6 of the "Guidelines for Management of Diabetic Ketoacidosis").
- 6) After meal tray is at bedside, give subcutaneous insulin as ordered by physician
- 7) After subcutaneous insulin has been given, turn off BOTH IV insulin infusion and IV fluids and heplock IVs
- 8) Page physician on-call if patient does not eat all carbohydrates on meal tray or if vomits

Once Patient is on Subcutaneous Insulin

- 1) Make sure endocrinologist has been consulted.
- 2) Check finger stick blood sugars using patient's own blood glucose meter before breakfast, lunch, dinner, 2100 and 0300.
- 3) Change vital signs to every 6 hours and cancel neuro checks.
- 4) Discontinue lab draws every 4 hours
- 5) Use insulin injection technique as described in "Guidelines for Management of Diabetic Ketoacidosis" p. 6. Section III H.
- 6) If blood sugar is **60 to 80 mg/dl**, give 4 oz (120 ml) of juice orally and retest blood sugar in 15 minutes. Repeat until blood sugar is greater than **100 mg/dl**. If necessary to repeat more than twice, page physician on-call.
- 7) If blood sugar is less than or equal to **60 mg/dl**, give 8 oz (240 ml) of juice orally and recheck blood sugar in 15 minutes. If blood sugar still less than 60 mg/dl, page MD on call. If blood sugar is 60-80 mg/dl, follow instructions above.
- 8) The 0300 blood sugar is to detect hypoglycemia. No action is needed if blood sugar is greater than 80 mg/dl.
- 9) Do not give insulin unless food tray is at the bedside
- 10) Glargine (Lantus) insulin **cannot be mixed** in the same syringe with any other insulin. It is a long-acting insulin given once every 24 hours.
- 11) Insulin Aspart (Novolog) is a rapid-acting insulin given before meals.
- 12) Page physician with pre-meal blood sugar for insulin orders, unless orders have already been written to cover that dose. Insulin orders should be reviewed and revised at least once every 24 hours.

Electrolytes:

Consider ordering BMP more frequently (ie every 1 to 2 hours instead of every 4 hours) if problems with any of the following electrolytes:

Na+: Na+ should always be rising. It is the best indicator of osmolality. A falling Na+ is a serious indication of over hydration and rate of fluid replacement must be decreased immediately in order to avoid possible cerebral edema.

HCO₃⁻ and anion gap: HCO₃⁻ should always be rising and anion gap falling. They are the best indicators of acid/base status (in addition to pH). A HCO₃⁻ that is falling or not rising indicates that the patient is not getting enough insulin or patient may be hyperchloremic if AG >=12. Consider increasing the concentration of dextrose in the IV fluid or the rate of fluid administration in order to maximize the rate of insulin administration.

K+: Diabetic ketoacidosis is a state of total body potassium depletion. As the acidosis corrects, potassium requirements will increase. Start K+ therapy as soon as possible: when serum K+ is < 5.5 and patient has urinated. Avoid both hypo- and hyperkalemia (either can be fatal).

Calcium: there is a risk for hypocalcemia when using phosphorous-containing fluids (ie KPhos). Monitor carefully.

Physician's Signature/ID number : _____ Date: ____/____/____ Time: _____

DKA

page 3 of 3



Patient Label

Physician's Order Sheet

GUIDELINES TO TRANSITION FROM IV TO SUBCUTANEOUS INSULIN

- A. Check to make sure $\text{HCO}_3 > 15$ or $\text{pH} > 7.3$; anion gap ≤ 12
- B. Make sure patient wants to eat and then start sugar-free oral fluids
- C. Order age appropriate meals according to the carb-counting meal plan (1 carb = 15 grams of carbohydrates, use the following guide: < 2 years = 30 grams, 3-5 years = 45 grams, 5-12 years = 60 grams, > 12 years = 75 grams) ie: in a 10 year old: Needs 60 grams for breakfast, lunch or dinner. (Snacks are not recommended)
- D. After meal tray is at bedside, give subcutaneous insulin: Calculate starting dose (new patients): most patients who have had DKA will need to start on **1 unit/kg/day (total daily dose/TDD) of SQ insulin**. (If not in DKA, can start with 0.5 units/kg/day and adjust as needed.) Determine the dose as follows:
- 10%** of TDD given as insulin Aspart (Novolog) insulin with breakfast
AND
 - 40%** of TDD given as **NPH** insulin with breakfast

 - 10%** of TDD given as insulin Aspart (Novolog) insulin with dinner
AND
 - 40%** of TDD given as **Glargine (Lantus)** insulin with dinner
- Note** If transitioning to SQ insulin **at lunch (only on day of transition)** give:
- 20%** TDD as NPH insulin with lunch
 - 10%** of TDD as novalog insulin with lunch
(**AND** skip breakfast doses that day)
- Previously diagnosed patients can resume their home dose. Some patients may go on a regimen of Novolog and Glargine without NPH insulin, based on the assessment done by the diabetic nurse educator. Obtain an endocrinology consult on thos patients.
- E. After subcutaneous insulin has been given, turn off **BOTH** IV insulin infusion and IV fluids and heplock IVs
- F. Change blood sugar checks to before each meal, at 2100, and at 0200.

	Outside Facility	CHCC ED	07	08	09	10	11	12	13	14	15	16	17	18	Total
Fluid ml/hr															
Fluid ml/hr															
Fluid ml/hr															
Insulin unit/kg/hr															
Urine Output															
HR															
RR															
BP															
Temp															
Blood Glucose	mg/dl	mg/dl	mg/dl	mg/dl	mg/dl	mg/dl	mg/dl	mg/dl	mg/dl	mg/dl	mg/dl	mg/dl	mg/dl	mg/dl	mg/dl
I.D. #															
Na															
K															
Cl															
CO ₂															
BUN/Cr															
Ca															
Phos															
pH															
Glascow Coma															

Date: _____

DKA



Patient Label

Flowsheet

	Outside Facility	CHCC ED	07	08	09	10	11	12	13	14	15	16	17	18	Total
Fluid ml/hr															
Fluid ml/hr															
Fluid ml/hr															
Insulin unit/kg/hr															
Urine Output															
HR															
RR															
BP															
Temp															
Blood Glucose	mg/dl	mg/dl	mg/dl	mg/dl	mg/dl	mg/dl	mg/dl	mg/dl	mg/dl	mg/dl	mg/dl	mg/dl	mg/dl	mg/dl	mg/dl
I.D. #															
Na															
K															
Cl															
CO ₂															
BUN/Cr															
Ca															
Phos															
pH															
Glasgow Coma															

Date: _____

DKA



Patient Label

Flowsheet

Diabetes Diary

INSULIN					BLOOD SUGAR TESTS							
Date	Brk	Lunch	Din	Bed	Brk		Lunch		Din	Bed	NT	Comments
1.												
2.												
3.												
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	Break	A.M.	Lunch	P.M.	Dinner	Bed Time
CARBS						

Carb = 15 grams of Carbohydrates

Diabetes Diary

INSULIN					BLOOD SUGAR TESTS							
Date	Brk	Lunch	Din	Bed	Brk		Lunch		Din	Bed	NT	Comments
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31.												

	Break	A.M.	Lunch	P.M.	Dinner	Bed Time
CARBS						

Carb = 15 grams of Carbohydrates

Diabetes Education Check-List

Must be completed prior to discharge of NEW patients

Initials

- _____ 1. Able to use blood glucose meter
- _____ 2. Able to correctly draw up and administer insulin
- _____ 3. Diabetes Diary filled out - parent understands how to keep
- _____ 4. Demonstration of carbohydrate counting knowledge (and ability to recite meal plan if appropriate)
- _____ 5. Ability to recognize signs and symptoms of hypoglycemia and able to demonstrate how to treat - including when and how to use glucagon

GUIDELINES FOR MANAGEMENT OF DIABETIC KETOACIDOSIS

The following represents a plan for the management of diabetic ketoacidosis (DKA) in children. The necessity for individualization of therapy in DKA (or any other life-threatening illness) is acknowledged and it is recognized that there are many acceptable methods for treating DKA. These guidelines are not meant to be static. Each case should be assessed individually and reassessed frequently. The Diabetes attending on-call should be notified for any patient admitted for DKA.

Definition of DKA:

Hyperglycemia (serum glucose >300 mg/dl)
Acidosis (bicarbonate <15 and arterial pH < 7.3)
Ketonemia (> or equal to 1:2 dilution)
Acetoacetate
B-hydroxy-butyrate

Other considerations:

Hyperglycemia (including nonketotic hyperglycemic coma)
Hyperglycemia with ketosis (glucose >300; pH >7.30; HCO₃⁻: >15)

Note: there can be a poor correlation between acidosis and level of glycemia. Remember that DKA is a state of insulin deficiency - whatever the cause.

Mainstays of therapy:

1. Fluids
2. Electrolytes (Na⁺, K⁺, HCO₃⁻, PO₄²⁻, Ca⁺⁺)
3. Insulin
4. Glucose
5. Monitoring

- I. **Initial Management** of DKA (usually in the ED): for either a newly diagnosed diabetic or established diabetic with an intercurrent problem:
- A. Careful history: search for any acute trigger for the DKA such as infection, trauma, or failure to take insulin.
 - B. Physical Examination: VS, weight, extent of dehydration, level of consciousness, focus of infection. Common physical findings: Kussmaul respirations (deep, rapid respirations resulting in elimination of CO₂), smell of acetone on breath, dehydration, glucosuria and ketonuria, often associated with changes in level of consciousness and vomiting.
 - C. Initial Laboratory Assessment:
 1. All patients: glucose, electrolytes, phosphate, calcium, BUN, creatinine, U/A with microscopic (send to lab - obtain STAT, if possible).
 2. All patients: finger stick glucose level to correlate with serum value and urine dip for glucose and ketones (do at bedside). Finger stick blood glucoses should continue to be obtained every 1 hr while in the ED.
 3. Consider ABG or VBG if HCO₃ low (< 10), altered level of consciousness, or abnormal respiratory pattern.
 4. All new diabetic patients: ICAB (islet cell antibody panel - includes GAD65, Insulin Autoantibody, and ICA512/IA-2), anti-thyroid peroxidase (TPO) antibody and TSH and anti-TTG antibody (for celiac disease).
 5. If considering Type 2 diabetes, obtain insulin level (if patient has not yet received insulin) or a C-peptide level and a comprehensive metabolic panel (for liver function and lipids).
 6. Appropriate cultures and CBC if an infection is suspected.
 - D. Expected initial laboratory results:
 1. Glucose high
 2. Sodium low
 - a. Sodium/glucose ratio: with hyperglycemia, measured Na⁺ decreases approximately 1.6 mEq/L per 100 mg/dl rise in glucose (Moran, West J Med 142:49; 1985).
 3. Potassium high, normal, or low

4. Acidosis variable
 5. Anion Gap > 12 mmol/L ($[\text{Na}^+] - [\text{HCO}_3^- + \text{Cl}^-]$).
 - a. Hyperchloremic metabolic acidosis can present with low bicarb and an anion gap < 12 mmol/L.
- E. Fluids: goal is to avoid excessive fluid administration or rapid osmotic shifts. Be gentle. Do not over hydrate.
1. General principles. Fluid therapy must be individualized. Good data are essential. Careful and accurate I/O and daily weights are indispensable. Use a flow sheet to record vital signs, fluid, laboratory, and therapeutic data. Evaluate/reevaluate progress frequently and readjust therapy as required.
 2. Patients should generally be kept NPO, especially if hyperventilating, vomiting, or having an altered state of consciousness (ice chips may be appropriate).
 3. Initial fluids: begin hydration immediately, while waiting for labs. Normal saline is the best initial fluid for all patients. Initial therapy should be directed at treating hypovolemia IF PRESENT. In order to restore appropriate intravascular volume, give 10-20 ml/kg of normal saline as a rapid infusion. If necessary, can give additional 10 ml/kg every hour until intravascular volume is restored.
 4. Initial rehydration can cause a significant drop in serum glucose. Need for hourly glucose monitoring.
- F. Insulin: Remember that DKA is a state of insulin deficiency. Insulin therapy in DKA is aimed at treating not only hyperglycemia, but also ketosis and acidosis.
1. A continuous IV infusion of regular insulin should be used in moderate-severe DKA.
 2. Begin piggyback solution of regular insulin 0.05-0.1 unit/kg/hr: CHCC standard insulin infusion solution is 1 unit/ml in normal saline. Insulin drip should be initiated at 0.05 /kg/hr if:
 - a. Patient has serum blood sugar >1,000 mg/dl.
 - b. Patient < 2 years old.
 - c. DKA is less severe or serum glucose is < 500 mg/dl.
 3. The infusion rate should be increased if blood glucose does not fall at least 50 mg/dl per hour, or the bicarbonate does not rise at least 0.5 mEq/L per hour.
 4. The infusion rate may be adjusted up or down, but should not be discontinued until you are ready to switch to subcutaneous therapy.
 5. Rate of fall in glucose should be 100 mg/dl per hour after initial drop associated with rehydration. There can, however, be significant interpatient variability (up to 400-500 mg/dl per hour drop). Therefore, monitor glucose frequently and adjust rate as needed.
 6. Practical aspects of insulin infusion therapy:
 - a. Insulin loss on polyvinylchloride and glass can be significant. Never use a concentration less than 0.1 unit/ml. Flush new IV tubing with 50 ml of insulin drip solution **prior to connecting to patient** and starting insulin infusion.
 - b. Make up fresh insulin solution at least every 24 hours.
 - c. Use a separate IV line and pump so the rate of insulin infusion can be adjusted independently of other fluids.
 - d. Because of adsorption, the actual amount of insulin being administered could be substantially less than the apparent (labeled) amount. Adjustment of the insulin infusion rate should be based on effect and not solely on the apparent insulin dose.

II. Ongoing Management

A. Monitoring:

1. Cardiac monitor should be used until metabolic status has normalized.
2. It is often necessary to treat moderate-severe DKA in the PICU because of the need for frequent blood draws, close monitoring of mental status, and 1:1 nursing (at least until the pH is > 7.25 and the serum bicarbonate is rising).
3. A heparin lock is a humane method for obtaining repeat blood samples.

B. Fluids:

1. Components:
 - a. Emergency rehydration (usually done in ED)
 - b. Established deficit
 - c. Maintenance
 - d. ABNORMAL ongoing losses
2. Determining fluid requirements:
 - a. Establish deficit - dehydration is commonly in the range of 5% (rarely more than 10%) and is frequently overestimated. Body weight before onset of DKA can help with calculation of deficit. Cap refill > 3 sec also helpful in establishing significant deficits. Urine output and urine specific gravity, in the face of heavy glucosuria and ketonuria, are not helpful.
 - b. Determine maintenance - based upon body weight (usual methods - see below if unsure). Adjust, if necessary, for fever or hyperventilation.

Definition of maintenance fluids:

1-10 kg	4ml/kg/hr
11-20 kg	40 ml/hr + (2ml/kg/hr for each kg >10)
>20 kg	60 ml/hr + (1ml/kg/hr for each kg>20)

- c. Calculate fluid requirement and replace evenly over 48 hours:
$$\frac{[(\text{Deficit} - \text{Emergency rehydration}) + \text{Maintenance}]}{48 \text{ hours}} = \text{ml/hr}$$
 - d. Replace ABNORMAL ongoing urinary losses in excess of 70% of maintenance (remember that 60% of maintenance fluids normally allocated to urine production) or other unexpected fluid losses (vomiting). Accurate I/O only way to determine this.
 - e. ½ NS is generally appropriate after the initial phase of rehydration. NS should be used if patient extremely hyperosmolar. 1/3 NS may be used if patient < 2 years.
 - f. Note: once patient is taking PO and is on subcutaneous insulin, they correct residual deficits on their own.
 3. Glucose:
 - a. Conventionally, glucose (D5 or D10) is added to IV fluids when blood glucose has fallen to 250-300 range. Glucose may be added sooner to avoid rapid falls in serum glucose once initial rehydration is completed and insulin is infusing. There should be a bag of 1/2NS and D10 ½ NS at the bedside ready to be hung. Can "Y" together the two fluids to achieve desired dextrose concentration.
 - b. **Keep serum glucose over 200 mg/dl in the first 24 hours of therapy** to avoid rapid osmotic shifts, which may contribute to development of cerebral edema, which is frequently fatal in this setting.
 - c. In general, 2 to 4 grams of glucose per unit of insulin (IV) will maintain stable blood glucose.
 4. Potassium:
 - a. Even if initial K⁺ levels are elevated, DKA is a state of total body potassium depletion. As acidosis improves, intracellular H⁺ is exchanged for extracellular K⁺, decreasing serum K⁺. Insulin drives K⁺ into cells; contributing to decreases in the serum K⁺. Potassium requirements are generally 1-5 mEq/kg in first 24 hours of therapy.
 - b. Start K⁺ therapy as soon as possible: when serum K⁺ is <5.5 mEq/L and patient has urinated. Potassium should not be started until after insulin infusion has started. A K⁺ level of < 4 mEq/L in an acidotic patient indicates severe depletion and K replacement should be started early as K requirements will increase as treatment progresses.
 - c. Potassium concentrations should generally be 20-40 mEq/L and may be made up of a

combination of KCl, and KPO_4 or KAcetate (another topic for debate). Generally, KCl is adequate, although there are theoretical reasons for using KPO_4 or KAcetate. Rate of administration should generally be < 0.5 mEq/kg per hour.

- d. If using phosphate, monitor Ca^{++} levels, as there is a risk of hypocalcemia.
- e. Monitor K every 1-2 hours. Avoid both hypo- and hyperkalemia (either can be fatal).

C. Insulin:

1. Follow serum glucose hourly while on continuous insulin infusion. Adjust rate to keep serum glucose **greater than 200 mg/dl for first 24 hours of therapy** to decrease risk of cerebral edema.
2. It is generally better to increase dextrose concentration rather than to decrease insulin infusion if blood sugar is falling too rapidly (although both may be necessary). Insulin is GOOD!

D. Laboratory:

1. ABG or VBG hourly if initial arterial pH is < 7.15 until pH $> 7.20-7.25$ and rising without use of bicarbonate. (VBG generally ok since O_2 problems are rare).
2. Follow electrolytes every 2-4 hours initially (depending upon severity of ketoacidosis), or hourly if:
 - a. Initial K < 5 or > 6.5 mEq/L
 - b. Not giving parenteral K
 - c. Giving > 40 mEq/L or > 0.5 mEq/kg/hr of KCl
 - d. Giving bicarbonate
 - e. Significant hyperosmolarity
 - f. ****Na⁺** or HCO_3 not rising appropriately
3. Glucose levels using bedside glucose meter initially hourly and every 1 to 2 hours until stable; one hour after any change in the insulin infusion rate.
4. Serum calcium if giving bicarbonate or phosphate.
5. Use a flowsheet to follow monitoring.

****Na⁺** should always be rising. It is the best indicator of osmolality. A falling Na⁺ is a serious indication of overhydration and adjustments in fluid management must be made immediately.

$$\text{Calculated Serum Osmolality: } [(Na^+ + K^+) \times 2] + \frac{\text{glucose}}{18} + \frac{BUN}{2.8}$$

Na⁺ is the big actor!

III. Conversion from continuous insulin infusion to subcutaneous insulin: Most cases of DKA are significantly improved within 24 hours. Because of adsorption of insulin to the infusion container and tubing, the apparent (labeled) dose should not be used solely as the basis for determining the subsequent insulin dose upon discontinuing the insulin infusion. Appropriate post-infusion insulin dosing requires close medical supervision.

IV.

- A. Glucose is in 200-250 range, HCO_3 is > 17 (or pH > 7.3), anion gap < 12 , urine ketones are largely cleared (ketones may persist even after acidosis is cleared), and patient has been started on PO clears and is taking them without difficulty.
- B. Make sure patient wants to eat and order a diabetic carb counting diet as recommended by R.D. based upon patients' home meal regimen.
- C. Calculate **starting** dose (new patients): most patients who have had DKA will need **1 unit/kg/day** (total daily dose, TDD) subcutaneous insulin. Determine the dose as follows:

10% of TDD given as **Aspart (Novolog)** insulin with breakfast

40% of TDD given as **NPH** insulin with breakfast

10% of TDD given as **Aspart (Novolog)** insulin with dinner

40% of TDD given as ***Glargine (Lantus)** insulin with dinner

***Glargine** insulin **CANNOT BE MIXED** with any other type of insulin; therefore, two separate shots must be given at dinner.

- D. A patient with established diabetes should usually return to their home insulin regimen once DKA has resolved.
 - E. Once food is at the bedside **and** patient wants to eat, give subcutaneous insulin and then turn off **both** IV insulin and IV fluids. Make sure patient eats.
 - F. Change blood sugar checks to before each meal, at 2100, and at 0300.
 - G. Adjust dose daily based upon the previous day's blood sugars. Do not write standing orders for subcutaneous insulin on a new patient.
 - H. Use subcutaneous insulin technique as follows:
 1. Use ultrafine II short needle syringes
 2. Choose injection site; use a good site rotation plan
 3. Make sure the site is clean
 4. Gently pinch up the skin and fat tissue
 5. Inject straight in, at a 90 degree angle, pushing the needle all the way into the skin. If the needle is not in far enough, the insulin may not be injected into the fatty layer. If it goes into the layer directly under the skin rather than into the fatty layer, it will sting and may cause a bump or redness and itching
 6. Release the pinch before injecting the insulin, or you will be squeezing the insulin out at the same time you are trying to inject it
 7. Push the insulin in SLOWLY and steadily
 8. After the insulin is in, wait five to ten seconds before removing the needle. COUNT TO FIVE SLOWLY to prevent insulin from leaking from injection site.
 - I. Once patient is on subcutaneous insulin, IVs should be discontinued.
- V. Starting insulin in a new patient who is not acidotic and has not had DKA. These patients are less glucose toxic and generally require less insulin.
- A. Start with 0.5 unit/kg/day for patients age 5 and under. Add 0.1 unit/kg/day for each year of age up to a maximum of 1 unit/kg/day (i.e. 0.6 unit/kg/day for a 6 year old, 0.7 unit/kg/day for a 7 year old, etc.).
 - B. Again, adjust dose daily based upon previous days blood sugars. Do not write standing insulin orders on new patients.

VI. Bicarbonate Therapy

- A. When to use bicarbonate in DKA remains controversial. Randomized studies in adults have shown no benefit when the pH is > 7. Studies involving children have actually shown longer hospital stays associated with bicarbonate therapy and increased risk for cerebral edema (Glaser, N. et al., Risk Factors for Cerebral Edema in Children with Diabetic Ketoacidosis. NEJM, 2001;344(4):264-269.

VII. Cerebral Edema - A MEDICAL EMERGENCY - usually occurs about six to 12 hours after initiation of therapy.

- A. Neurological checks should be done every 1-2 hours during correction of DKA.
- B. Mild cerebral edema (CE) occurs often in DKA. Clinically evident CE (brain swelling) occurs in 1-3% of cases and mortality is about 70%. The causes are not well understood, although osmotic shifts are felt to play a role (overhydration or too sudden a fall in glucose).
- C. More common in patients under the age of 5 years. Occurs in both first and subsequent DKA episodes
- D. Signs of CE include sudden headache, altered mental status, increasing lethargy, changes in vital signs (increased blood pressure, decreased heart rate) or any sudden worsening of neurological status in a patient whose metabolic status is improving (often 6-12 hours after onset of treatment). Risk is decreased after 24 hours.
- E. If CE is suspected, give MANNITOL 25% STAT (0.25 gm/kg IV push). Then reassess fluid status, ventilatory status (ABG).
- F. Contact Diabetes attending and PICU attending STAT.
- G. Head MRI or CT is often abnormal during DKA even without clinically apparent CE.
- H. Mannitol 25% should be kept at the bedside or should be available at the nursing station for all patients with DKA.

Discharge Sheet

For Hospital Use Only

Dictation: 1-800-411-1001 (#963)

D/S Job #: _____

Discharge sheet FAXed to PCP _____
initial/date

Follow-up appointment SCHEDULED with PCP _____
initial/date

Patient's Name: _____ Discharge Date: _____

Dx: 1) Diabetic Ketoacidosis 2) _____

Hospital Course

Complications during hospitalization: _____

Discharge Condition: _____ Discharge Weight: _____

Instruction to Patient

Activity: _____

Diet: Carb-counting diet

Medications: See Medication Reconciliation Form

Additional instructions:

Reference: Patient Education Sheet

Signed: _____ M.D. _____

Signature of Parent or Guardian

Attending Physician

Attending Resident

Primary Care Physician

City

DKA



Patient Label

Discharge Instructions