

# **ACUTE METABOLIC COMPLICATIONS OF DIABETES MELLITUS**

# COMPLICATIONS OF DM

## Acute Metabolic Complications

- Diabetic Ketoacidosis (DKA)
- Nonketotic Hyperosmolar State (NKHS)

## Diabetic Ketoacidosis (DKA)

- a fatal complication
- may be initial symptom complex of type 1 DM
- early diagnosis & efficient management : ↓ mortality
- in experienced centers : mortality not > 5%

# COMPLICATIONS OF DM

## Diabetic Ketoacidosis (DKA)

### Pathophysiology

*insulin deficiency with counterregulatory hormone excess precipitated when insulin relatively insufficient & insulin requirements ↑ during a concurrent illness*

**↓ ratio of insulin to glucagon promotes**

- ↑ glucose production & ↓ peripheral glucose utilization
- *Ketosis* from ↑ free fatty acid released from adipocytes, shift toward ketone body synthesis in liver
- acidosis from ketone bodies & ↑ lactic acid
- pancreatitis from ↑ free fatty acids → hypertriglyceridemia

## **Table 333-5. Manifestations of Diabetic Ketoacidosis**

### Symptoms

Nausea/vomiting

Thirst/polyuria

Abdominal pain

Altered mental function

Shortness of breath

### Physical findings

Tachycardia

Dry mucous membranes/reduced skin turgor

Dehydration / hypotension

Tachypnea / Kussmaul respirations/respiratory distress

Abdominal tenderness (may resemble acute pancreatitis or surgical abdomen)

Fever

Lethargy / obtundation / cerebral edema / possibly coma

### Precipitating events

Inadequate insulin administration

Infection (pneumonia/UTI/gastroenteritis/sepsis)

Infarction (cerebral, coronary, mesenteric, peripheral)

Drugs (cocaine)

**Table 3334. Laboratory Values in Diabetic Ketoacidosis (DKA) and Nonketotic Hyperosmolar States (NKHS) (Representative Ranges at Presentation)**

	DKA	NKHS
Glucose, <sup>a</sup> mmol/L (mg/dL)	16.7-33.3 (300-600)	33.3-66.6 (600-1200)
Sodium, meq/L	125-135	135-145
Potassium, <sup>a</sup> meq/L	Normal to ↑ <sup>b</sup>	Normal
Magnesium <sup>a</sup>	Normal <sup>b</sup>	Normal
Chloride <sup>a</sup>	Normal	Normal
Phosphate <sup>a</sup>	↓	Normal
Creatinine, μmol/L (mg/dL)	Slightly ↑	Moderately ↑
Osmolality, mOsm/mL	300-320	330-380
Plasma ketones <sup>a</sup>	++++	+/-
Serum bicarbonate, <sup>a</sup> meq/L	<15 meq/L	Normal to slightly ↓
Arterial pH	6.8-7.3	>7.3
Arterial PCO <sub>2</sub> , mmHg	20-30	Normal
Anion gap <sup>a</sup> [Na - (Cl + HCO <sub>3</sub> )], meq/L	↑	Normal to slightly ↑

<sup>a</sup> Large changes occur during treatment of DKA.

<sup>b</sup> Although plasma levels may be normal or high at presentation, total-body stores are usually depleted.

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	DKA			NKHS
	mild	moderate	severe	
Plasma glucose(mg/dl)	>250	>250	>250	>600
Arterial pH	7.25-7.30	7.00-7.24	<7.00	>7.30
Serum bicarbonate(mEq/l)	15-18	10 - <15	<10	>15
Urine ketones	+++	+++	+++	small
Serum ketones	+++	+++	+++	small
Effective serum osmolality (mOsm/kg)	variable	variable	variable	>320
Anion gap	>10	>12	>12	variable
Alteration in sensorium	alert	alert/drowsy	stupor/coma	stupor/coma

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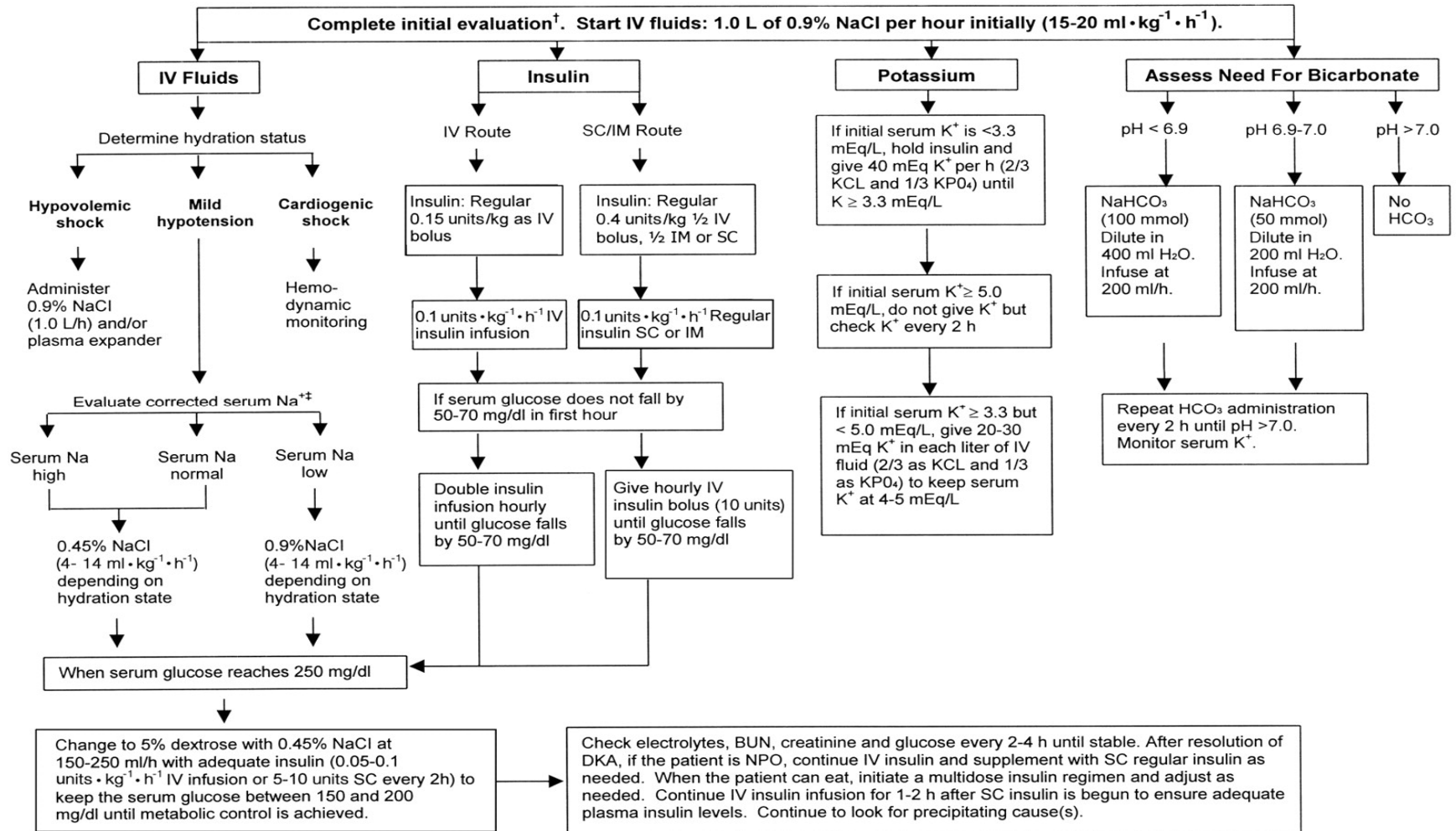
Diabetic Ketoacidosis (DKA)

Treatment

Successful treatment requires correction of

- Dehydration
- Hyperglycemia
- Electrolyte imbalance
- Identification of comorbid precipitating events
- Above all patient monitoring

## Management of Adult Patients with DKA\*



Protocol for the management of adult patients with DKA. \*DKA diagnostic criteria: blood glucose >250 mg/dl, arterial pH <7.3, bicarbonate <15 mEq/l, and moderate ketonuria or ketonemia. Normal ranges vary by lab; check local lab normal ranges for all electrolytes. After history and physical examination, obtain arterial blood gases, complete blood count with differential, urinalysis, blood glucose, blood urea nitrogen (BUN), electrolytes, chemistry profile, and creatinine levels STAT as well as an electrocardiogram. Obtain chest X-ray and cultures as needed. Serum Na should be corrected for hyperglycemia (for each 100 mg/dl glucose >100 mg/dl, add 1.6 mEq to sodium value for corrected serum sodium value). IM, intramuscular; IV, intravenous; SC subcutaneous.



### Table 333-6. Management of Diabetic Ketoacidosis

1. Confirm diagnosis ( $\uparrow$  plasma glucose, positive serum ketones, metabolic acidosis).
2. Admit to hospital; intensive-care setting may be necessary for frequent monitoring or if pH < 7.00 or unconscious.
3. Assess: Serum electrolytes ( $K^+$ ,  $Na^+$ ,  $Mg^{2+}$ ,  $Cl^-$ , bicarbonate, phosphate)  
Acid-base status—pH,  $HCO_3^-$ ,  $PCO_2$   
Renal function (creatinine, urine output)
4. Replace fluids: 2-3 L 0.9% saline over first 1-3 h (5-10 mL/kg per hour); subsequently, 0.45% saline at 150-300 mL/h; change to 5% glucose and 0.45% saline at 100-200 mL/h when plasma glucose reaches 14 mmol/L (250 mg/dL).
5. Administer regular insulin: 10-20 units IV or IM, then 5-10 units/h by continuous IV infusion; increase 2- to 10-fold if no response by 2-4 h.
6. Assess patient: What precipitated the episode (noncompliance, infection, trauma, infarction, cocaine)?  
Initiate appropriate workup for precipitating event [cultures, chest x-ray, electrocardiogram (ECG)]
7. Measure capillary glucose every 1-2 h; measure electrolytes (especially  $K^+$ , bicarbonate, phosphate) and anion gap every 4 h for first 24 h.
8. Monitor blood pressure, pulse, respirations, mental status, fluid intake and output every 1-4 h.
9. Replace  $K^+$ : 10 meq/h when plasma  $K^+$  < 5.5 meq/L, ECG normal, urine flow, and normal creatinine documented; administer 40-80 meq/h when plasma  $K^+$  < 3.5 meq/L or if bicarbonate is given.
10. Continue above until patient is stable; glucose goal is 8.3-13.9 mmol/L (150-250 mg/dL), until acidosis is resolved. Insulin infusion may be decreased to 1-4 units/h.
11. Administer intermediate or long-acting insulin as soon as patient is eating. Allow for overlap in insulin infusion and subcutaneous insulin injection.

# COMPLICATIONS OF DM

## Diabetic Ketoacidosis (DKA)

### Prevention

- review sequence of events that led to DKA
- patient education about
  - ✍ symptoms of DKA
  - ✍ its precipitating factors
  - ✍ management of diabetes during a concurrent illness

# COMPLICATIONS OF DM

## Diabetic Ketoacidosis (DKA)

### Prevention

During illness or when oral intake is compromised

- (1) frequently measure capillary blood glucose
- (2) measure urinary ketones when serum glucose  $>300$  mg/dl
- (3) drink fluids to maintain hydration
- (4) continue or increase insulin
- (5) seek medical attention if dehydration, persistent vomiting, or uncontrolled hyperglycemia develop

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## Diabetic Ketoacidosis (DKA)

### Differential diagnosis

- Starvation ketosis ( bicarbonate not lower than 18 mEq/l )
- Alcoholic ketoacidosis ( glucose mildly elevated to hypoglycemia )
- Lactic acidosis ( blood lactate )
- Ingestion of drugs such as
  - salicylate ( serum salicylate )
  - methanol ( blood methanol )
  - ethylene glycol ( ca oxalate & hippurate crystals )
  - paraldehyde ( characteristic strong odor )
- Chronic renal failure ( typically hyperchloremic acidosis )

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## NonKetotic Hyperosmolar State ( NKHS )

### Clinical Features

MC type 2 DM

*the prototypical patient*

- a mildly diabetic
- elderly individual
- weeks history of polyuria, weight loss, and ↓ oral intake
- leading to mental confusion, lethargy, or coma

*the physical examination*

- profound dehydration
- hyperosmolality
- hypertension
- tachycardia
- altered mental status

# COMPLICATIONS OF DM

## NonKetotic Hyperosmolar State ( NKHS )

*precipitated by*

a serious, concurrent illness ( MI,stroke ,sepsis, pneumonia )  
with use of thiazide diuretics, glucocorticoids, phenytoin

## Pathophysiology

Insulin deficiency and inadequate fluid intake

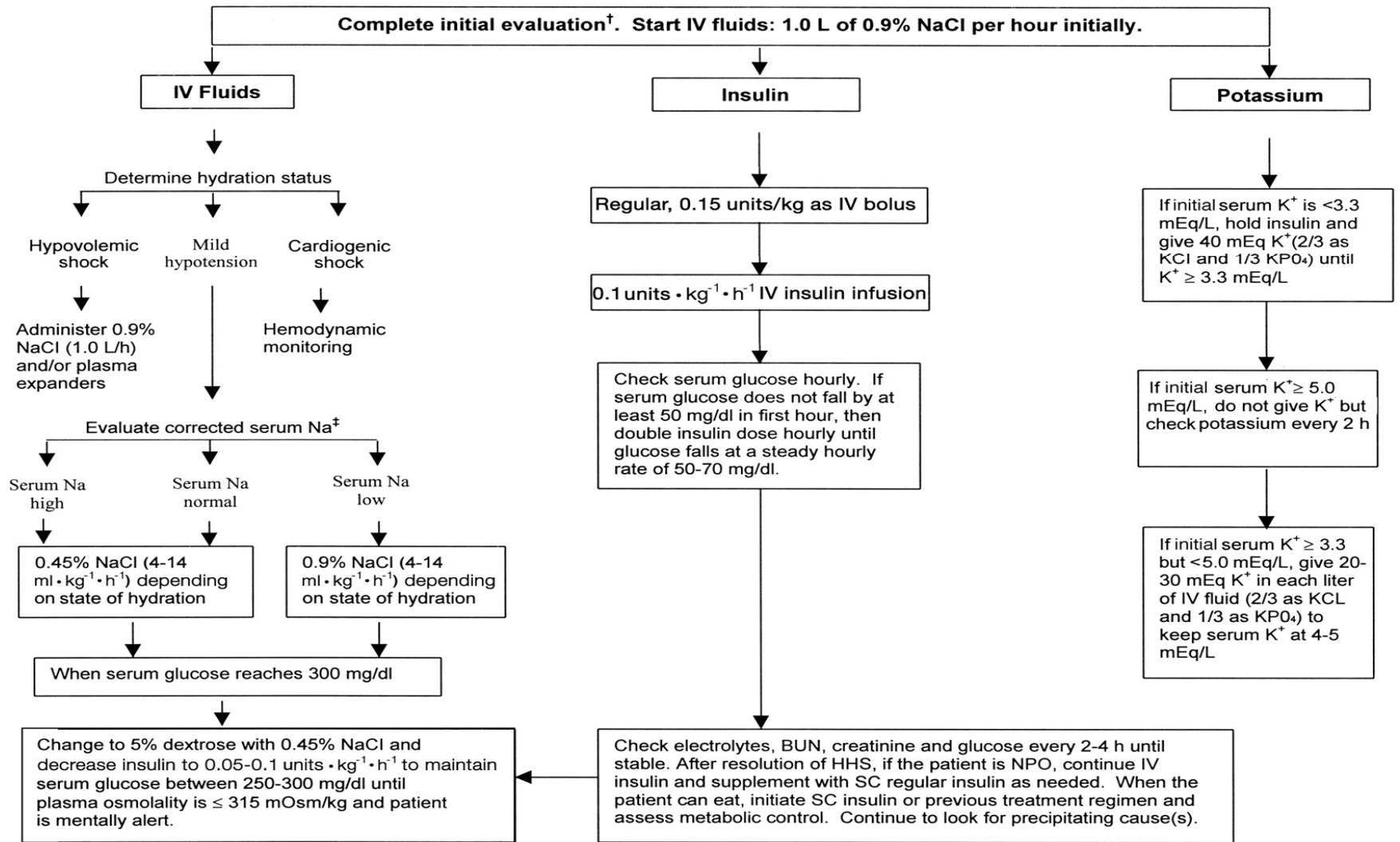
Hyperglycemia → osmotic diuresis → intravascular volume depletion, exacerbated by inadequate fluid replacement

the absence of ketosis not understood

insulin deficiency only relative and less severe

lower levels of counterregulatory hormones and FFA

## Management of Adult Patients with HHS\*



Protocol for the management of adult patients with HHS. \*Diagnostic criteria: blood glucose >600 mg/dl, arterial pH >7.3, bicarbonate >15 mEq/l, mild ketonuria or ketonemia, and effective serum osmolality >320 mOsm/kg H<sub>2</sub>O. This protocol is for patients admitted with mental status change or severe dehydration who require admission to an intensive care unit. For less severe cases, see text for management guidelines. Normal ranges vary by lab; check local lab normal ranges for all electrolytes. Effective serum osmolality calculation:  $2[\text{measured Na (mEq/l)}] + \text{glucose (mg/dl)}/18$ . After history and physical examination, obtain arterial blood gases, complete blood count with differential, urinalysis, plasma glucose, blood urea nitrogen (BUN), electrolytes, chemistry profile, and creatinine levels STAT as well as an electrocardiogram. Obtain chest X-ray and cultures as needed. Serum Na should be corrected for hyperglycemia (for each 100 mg/dl glucose >100 mg/dl, add 1.6 mEq to sodium value for corrected serum value). IV, intravenous; SC subcutaneous.

All the best..