Objectives

- Review the emergent management of severe electrolyte disturbances
- Recognize manifestations of adrenal insufficiency in the critically ill patient and initiate appropriate treatment
- Describe the management of severe hyperglycemic syndromes

Case Study 1

- 78-year-old woman with diabetes, heart failure, and chronic renal insufficiency
- Confusion, lethargy, poor oral intake for 1 week
- BP 98/52 mm Hg, HR 110 beats/min, RR 18 breaths/min
- Frequent premature ventricular contractions on cardiac monitor

What risk factors does this patient have for electrolyte disturbances?

What electrolyte disorders might contribute to her presentation?

What electrolyte disorders might contribute to her presentation? (Select all that apply)

A. Hyponatremia
B. Hypernatremia
C. Hyperkalemia
D. Hypercalcemia

Case Study 1

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What electrolyte disorders might contribute to her presentation?

Principles of Electrolyte Disturbances

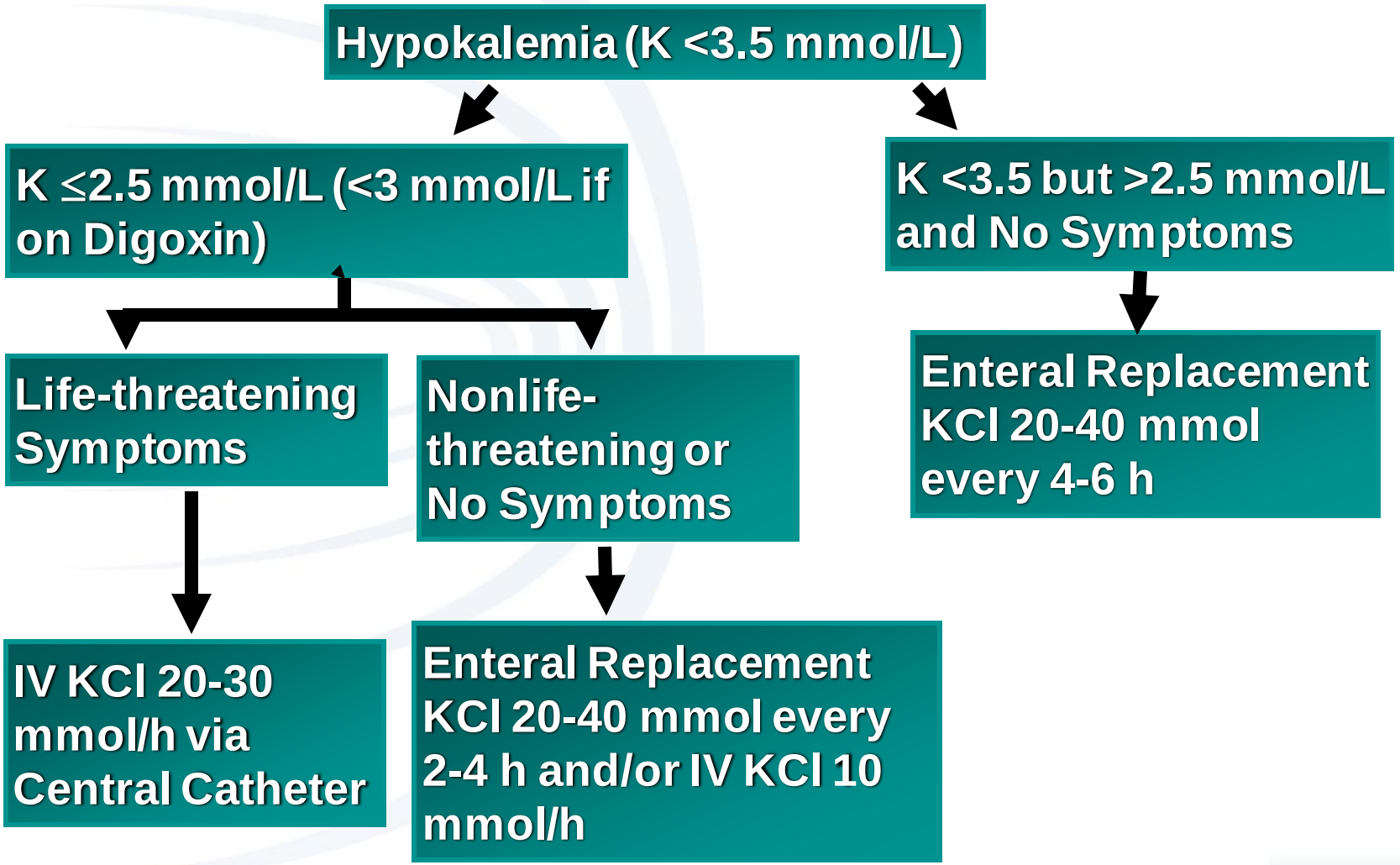
- Treat the electrolyte change, but search for the cause
- Clinical manifestations are usually not specific to a particular electrolyte change
- Clinical circumstances determine urgency of treatment rather than electrolyte concentration
- Frequent reassessment of electrolyte abnormalities required

Case Study 1

- 78-year-old woman with diabetes, heart failure, and chronic renal insufficiency
- Confusion, lethargy, poor oral intake for 1 week
- Frequent premature ventricular contractions on cardiac monitor
- Laboratory value: potassium 2.5 mmol/L

How would you initiate evaluation and treatment of this patient?

Treatment of Hypokalemia



Case Study 1

- 78-year-old woman with hypertension and heart failure
- ECG

- Laboratory value: K 7.8 mmol/L

How would you initiate urgent/emergent treatment of this patient?

How would you initiate urgent/emergent treatment of this patient? (Select all that apply)

A. Administer IV calcium chloride

B. Use glucose and insulin to redistribute potassium intracellularly

C. Use sodium bicarbonate to redistribute potassium intracellularly

D. Use dialysis to decrease body potassium

Treatment of Hyperkalemia

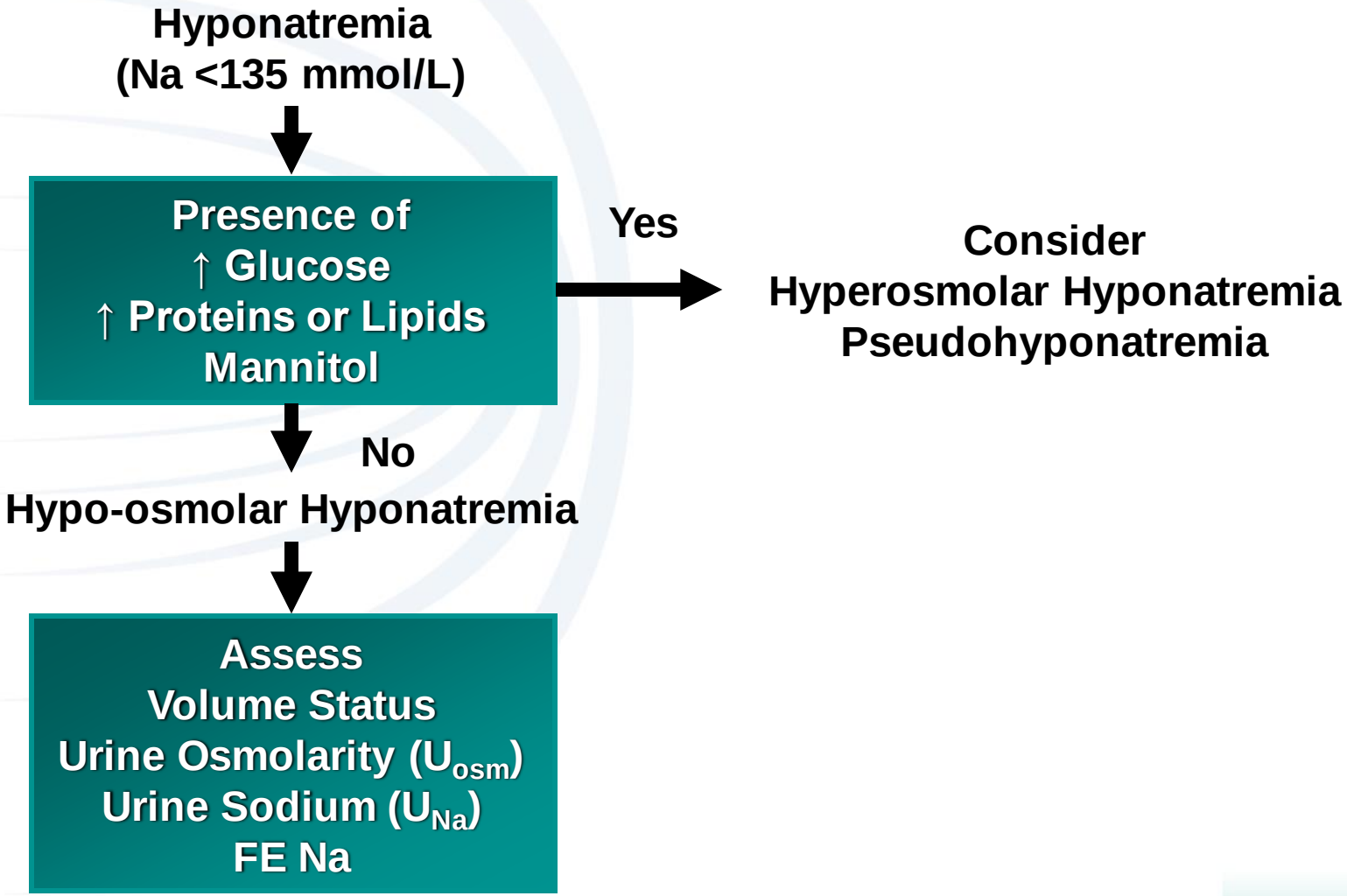
- Calcium for cardiac toxicity (ECG abnormalities)
- Redistribute potassium
  - Insulin and glucose
  - Sodium bicarbonate
  - Inhaled β_2-agonists
- Remove potassium
  - Loop diuretic
  - Sodium polystyrene sulfonate
  - Dialysis

Case Study 1

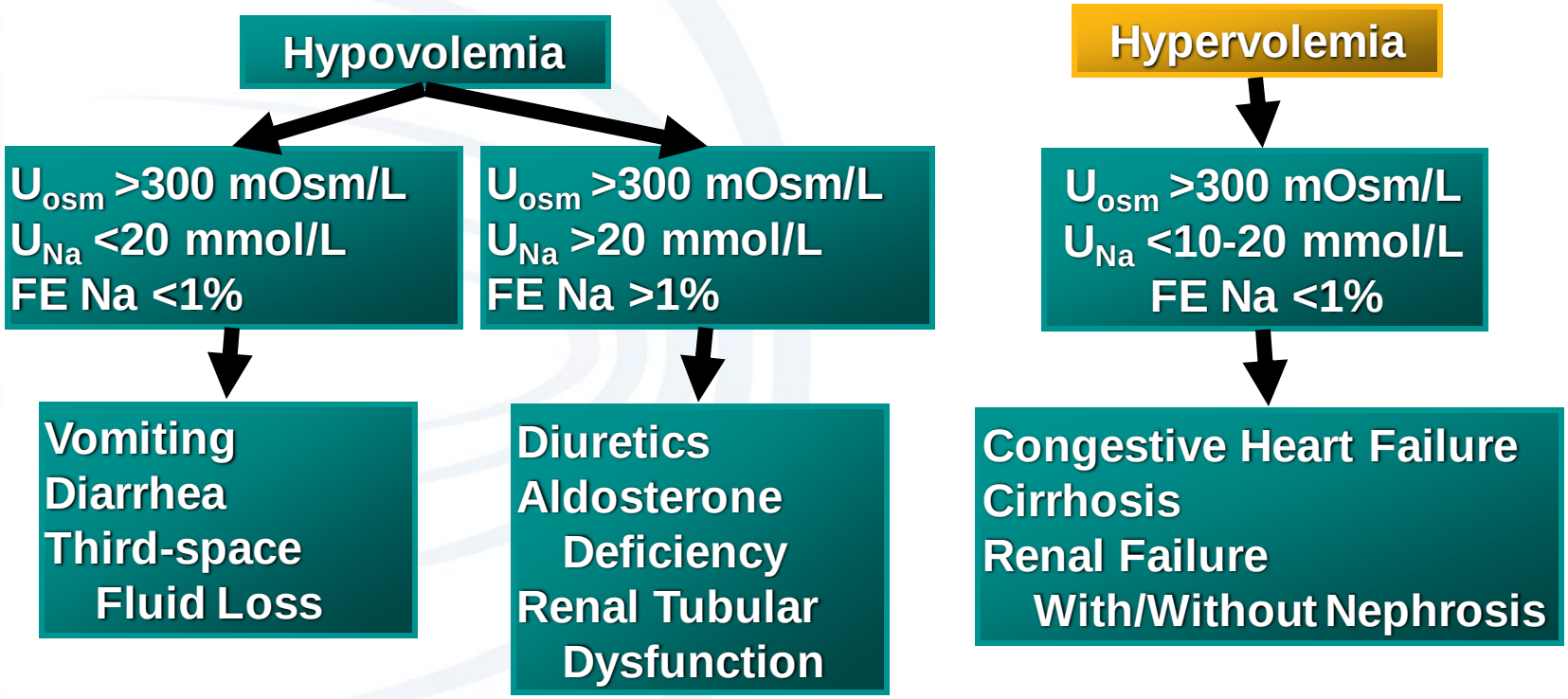
- 78-year-old woman with diabetes, heart failure, and chronic renal insufficiency
- Confusion, lethargy, poor oral intake for 1 week
- Frequent premature ventricular contractions on cardiac monitor
- Laboratory value: Na 118 mmol/L

How would you initiate evaluation of this patient to determine the etiology?

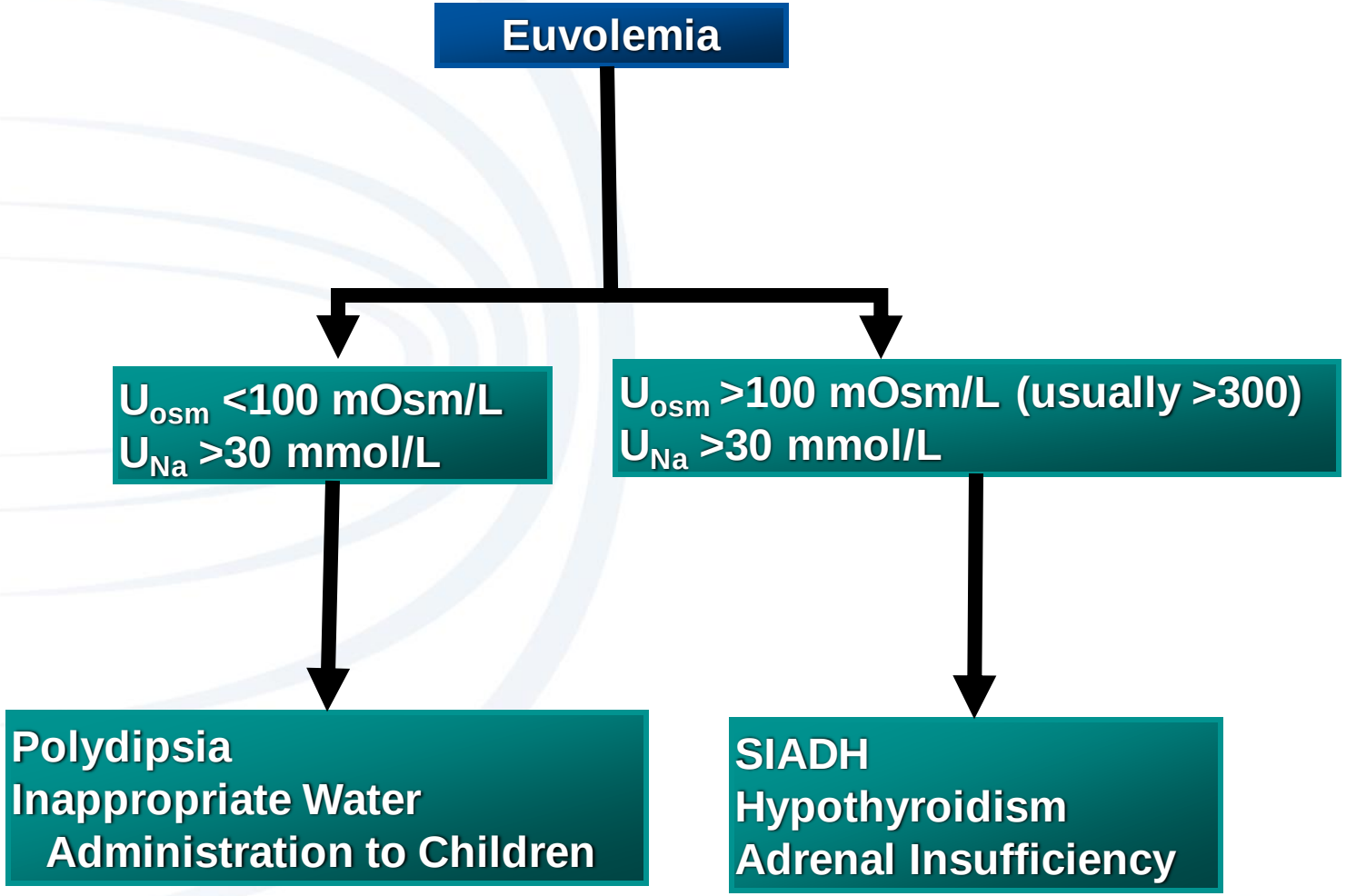
Etiology of Hyponatremia



Etiology of Hyponatremia



Etiology of Hyponatremia



Management of Hyponatremia

- Hypovolemic
- Hypervolemic
- Euvolemic
  - Restrict free water intake - Increase free water loss
  - Replace intravascular volume with normal saline or hypertonic saline
  - Vasopressin receptor antagonists (VRAs)

How fast would you correct the sodium concentration?

When would you use hypertonic saline?

When would you use hypertonic saline? (Select all that apply)

A. Symptomatic hypotension
B. Seizures
C. Decline in mental status

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When would you use hypertonic saline?

Vasopressin Receptor Antagonists

- **Special considerations when using VRAs:**
  - **Not for symptomatic acute hyponatremia**
    - Avoid in patients with severe neurologic symptoms
  - **Discuss with appropriate consultant**
  - **Do not use in hypovolemia**
  - **Do not use with hypertonic saline**
  - **Frequently monitor sodium levels**

Case Study 1

- 78-year-old woman with diabetes, heart failure, and chronic renal insufficiency
- Confusion, lethargy, poor oral intake for 1 week
- Frequent premature ventricular contractions on cardiac monitor
- Laboratory value: Na 168 mmol/L

How would you treat this patient?

Treatment of Hypernatremia

- Normal saline if hemodynamically unstable
- Hypotonic fluid when stable
  - Intravenous fluids
  - Enteral free water
- Quantity
  - H_2O deficit (L) =
  - $[0.6 \times \text{wt (kg)}] \times \left[\frac{\text{Measured Na}}{140} - 1\right]$
- Rate of correction

Case Study 2

- 21-year-old HIV+ man with flulike symptoms
- Febrile, tachycardic, and hypotensive
- Antibiotics and volume initiated
- Admitted to floor
- 2 hours later, systolic BP 60 mm Hg
- Hypotensive in ICU after 40 mL/kg fluids and norepinephrine 10 μg/min

What testing is needed?

Adrenal Insufficiency in Critical Illness

- Support blood pressure with fluids and vasopressors
- Treat precipitating conditions
- Administer IV hydrocortisone at a dose of 200 mg/24 h for vasopressor-resistant septic shock
- Clinical decision to treat (checking a cortisol value is not necessary)

Hyperglycemic Syndromes

Is this diabetic ketoacidosis (DKA) or hyperglycemic hyperosmolar state (HHS)?

- **22-year-old patient with type 1 diabetes: venous pH 7.16, glucose 240 mg/dL, HCO_3 12 mmol/L, anion gap 20 mmol/L, urine ketones (+)**
- **58 year-old patient with no chronic illness: Na 141 mmol/L, Cl 98 mmol/L, HCO_3 13 mmol/L, glucose 1,640 mg/dL, BUN 70 mg/dL, urine ketones (+)**

Hyperglycemic Syndromes

Is this diabetic ketoacidosis (DKA) or hyperglycemic hyperosmolar state (HHS)?

- **73-year-old patient with type 2 diabetes: Na 163 mmol/L, Cl 134 mmol/L, HCO_3 21 mmol/L, glucose 1,282 mg/dL, BUN 62 mg/dL, urine ketones (-)**

Hyperglycemic Syndromes

Characteristics of Hyperglycemic Syndromes		
	DKA	HHS
Glucose	>250 mg/dL	>600 mg/dL
Arterial/venous pH	≤7.3	>7.3
Anion gap	Increased	Variable
Serum/urine ketones	Positive	Negative or small
Serum osmolarity	Normal	Increased

Initial Evaluation

- Mental status
- Degree of dehydration
- Presence of infection or other precipitating condition
- Laboratory studies
  - Glucose
  - Venous or arterial pH
  - Electrolytes, renal function
  - Urine or serum ketones
  - Complete blood count
  - ECG

Management of Hyperglycemic Syndromes

- **Fluids**
  - Crystalloids
  - Add glucose to fluids when glucose 250-300 mg/dL
- **Insulin**
  - Regular insulin loading dose (0.1-0.15 U/kg)
  - Regular insulin infusion (0.1U/kg/h)
- **Electrolytes**
  - Add K to fluids if K >3.3 but <5 mmol/L
  - If K <3.3 mmol/L, hold insulin and replace K

Hyperglycemia of Critical Illness

- Continuous insulin infusion
- Goal:

  140-180 mg/dL (7.8-10 mmol/L)
- Patient selection
- Protocol important to optimal outcomes

Questions

Key Points

- Give KCl through a central venous catheter for life-threatening hypokalemia
- Consider calcium administration for hyperkalemia with ECG changes, followed by interventions to shift K intracellularly
- Limit the increase in serum Na to 6-8 mmol/L in the first 24 h in symptomatic euvolemic hyponatremia
- Administer normal saline to patients with hypernatremia and hemodynamic instability

Key Points

- Patients with possible adrenal insufficiency should have emergent treatment with a glucocorticoid
- Treatment goals for hyperglycemic syndromes are to restore fluid and electrolyte balance, provide insulin, and identify precipitants
- In DKA, insulin infusion should be continued until anion gap acidosis and ketosis have resolved

Key Points

- Maintain glucose 250-300 mg/dL in HHS until plasma osmolality ≤315 mOsm/L.
- Choose a protocol for glycemic control to avoid hyperglycemia and minimize hypoglycemia in critically ill patients.
- Add potassium to the intravenous fluids being administered once the serum potassium has fallen below 5 mmol/L