



School of Continuous
Professional Development

31ST ANNUAL

INTERNAL MEDICINE BOARD REVIEW





School of Continuous
Professional Development

NEPHROLOGY: ACID-BASE CASES

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DISCLOSURE OF RELEVANT FINANCIAL RELATIONSHIP(S) WITH INELIGIBLE COMPANIES

- Nothing to disclose

REFERENCES TO OFF-LABEL USAGE(S) OF PHARMACEUTICALS OR INSTRUMENTS

- Nothing to disclose

All relevant financial relationships have been mitigated.

LEARNING OBJECTIVE

- Apply an algorithm to diagnose acid-base disorders

SESSION PLAN

- Review cases:
 - Read case
 - Work on answer with neighbor
 - Key in answer when prompted
 - Expert discussion
- Worksheets at your desks
- Experts and facilitators available for questions
- Slides available online on portal after session

PRESENTERS

- **Facilitators:**

- Christopher Aakre, MD
- April Christensen, MD

- **Content experts:**

- LaTonya J Hickson, MD
- Matthew R D'Costa, MD

APPROACH TO ACID BASE QUESTIONS

- Acidemia or alkalemia?
- Primary metabolic or respiratory?
- Compensation adequate or mixed disorder?
- Is there an anion gap?
- Based on the Δ in anion gap is there a secondary metabolic disorder?

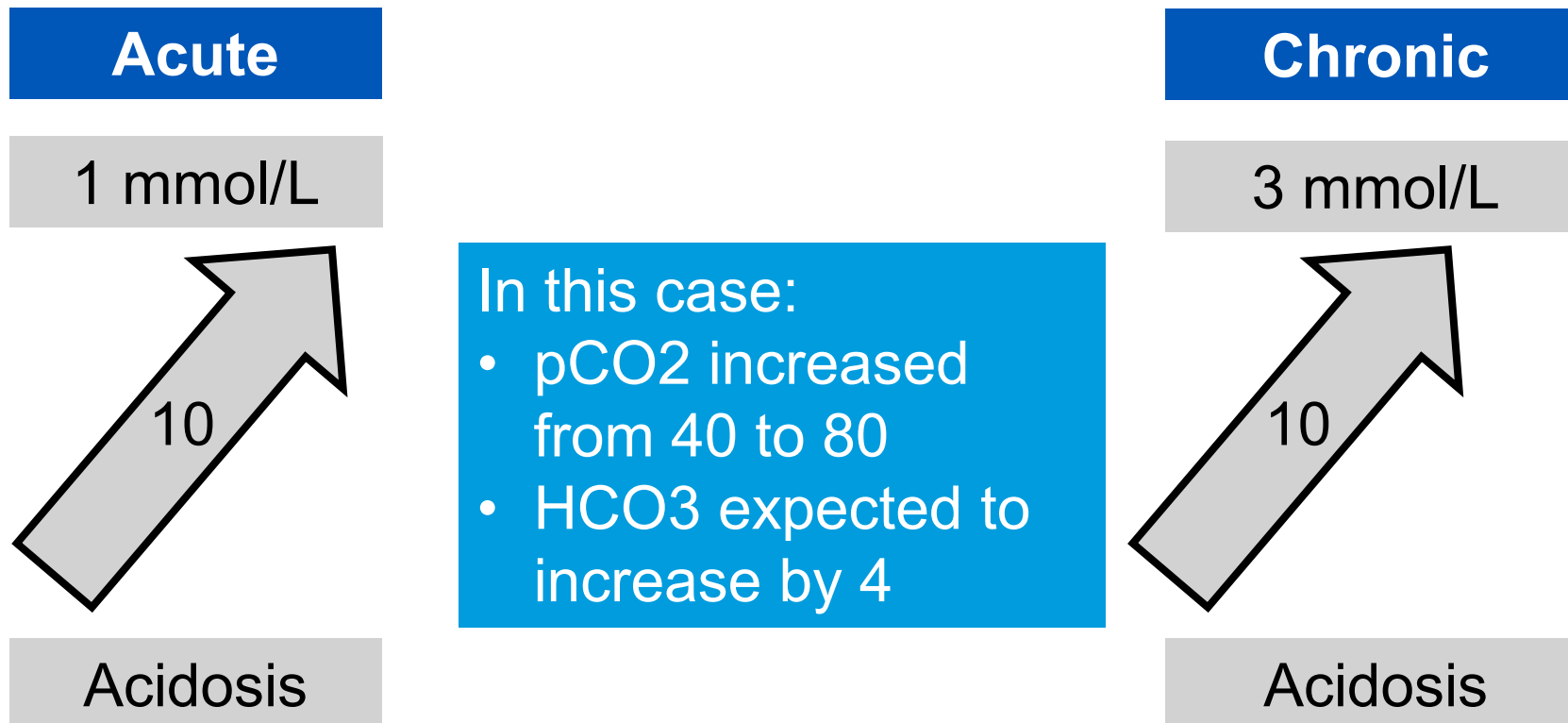
CASE 1

- A 59-year-old male with past history significant for COPD, CHF, HTN, and obesity (BMI 41kg/m²) is admitted to the hospital for total knee replacement. Medication list includes acetaminophen, albuterol/ipratropium inhaler, atorvastatin & metoprolol. On post-op day 2, he is found to be somnolent and difficult to arouse
- On exam: BP:136/86 mmHg, HR: 90b/min, RR 8/min, Temp 37.5° C, SpO₂ 91% on 6 L. Patient is unresponsive to verbal stimuli and lung exam reveals decreased breath sounds bilaterally. Chest x-ray shows new small bilateral pleural effusions
- **ABG: pH: 7.24, pO₂: 96 mmHg, pCO₂: 80 mmHg**
- Sodium is 140meq/L, potassium is 4.6meq/L, chloride 101meq/L, HCO₃ is 28meq/L, creatinine of 1.5mg/dL and BUN of 34mg/dL

WHAT IS THE ACID-BASE ABNORMALITY?

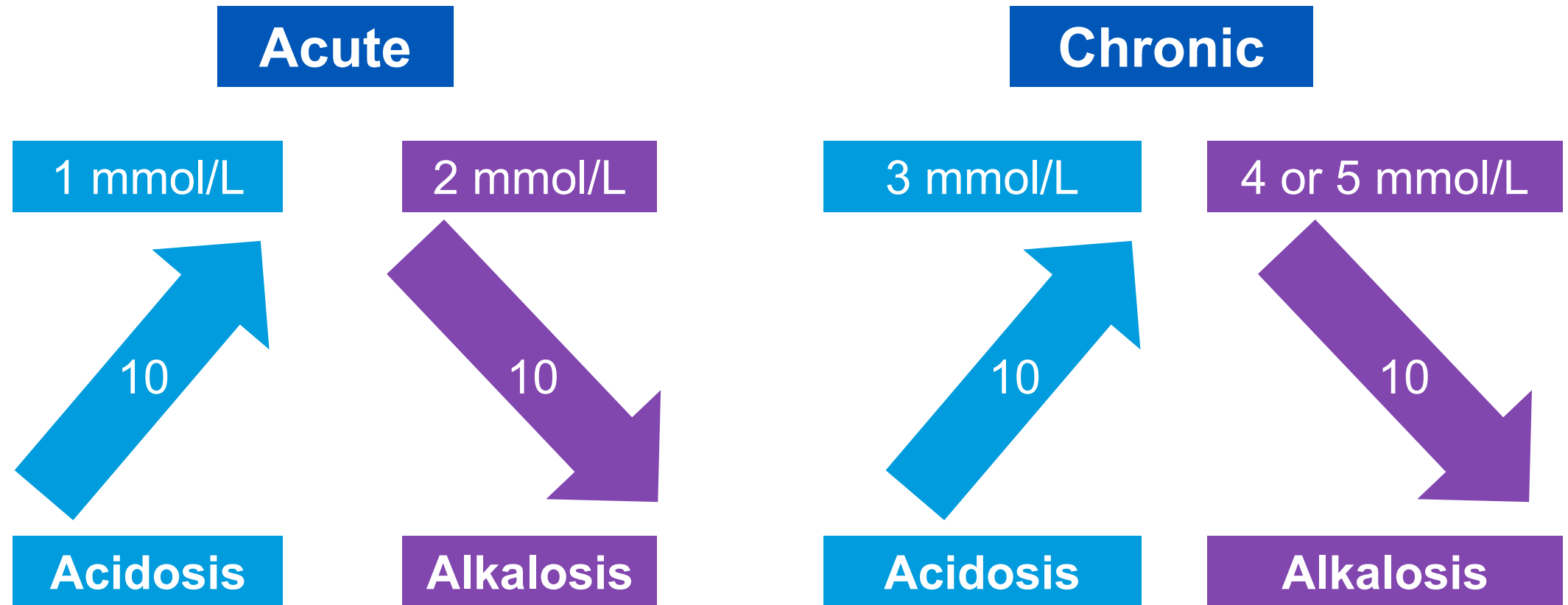
- A. Metabolic alkalosis
- B. Acute respiratory acidosis
- C. Chronic respiratory acidosis
- D. Acute respiratory acidosis and non-gap metabolic acidosis
- E. Chronic respiratory alkalosis

EXPECTED BICARBONATE COMPENSATION FOR RESPIRATORY ACIDOSIS



For every 10 mmHg ↑ in pCO₂: HCO₃ should ↑ by 1 (Acute) or 3 (Chronic) Respiratory Acidosis

EXPECTED BICARBONATE COMPENSATION FOR RESPIRATORY ACIDOSIS/ RESPIRATORY ALKALOSIS



For every 10 mmHg ↑ in pCO₂: HCO₃ should ↑ by 1 (Acute) or 3 (Chronic) Respiratory Acidosis

For every 10 mmHg ↓ in pCO₂: HCO₃ should ↓ by 2 (Acute) or 4/5 (Chronic) Respiratory Alkalosis

CASE 1 (CONTINUED)

- Patient is transferred to the ICU and intubated
- ABG: pH 7.4, pO₂ 105mmHg, pCO₂ 42mmHg
- Sodium: 135meq/L, potassium: 3.7meq/L, chloride 96meq/L, Bicarb: 27meq/L, Creatinine: 1.6mg/dL, BUN: 42mg/dL
- In the next 3 days, he is diuresed with intravenous furosemide. He is extubated and transferred to the Medicine Floor. Patient is alert and oriented and repeat chest x-ray shows clear lung fields.
- **ABG: pH 7.50, pO₂ 88mmHg, pCO₂ 48mmHg**
- Sodium: 140meq/L, potassium: 3.5meq/L, Chloride: 94meq/L, Bicarb: 35meq/L, creatinine: 1.7mg/dL, BUN: 50mg/dL

WHAT IS THE ACID-BASE DISORDER?

- A. Metabolic alkalosis
- B. Metabolic alkalosis and respiratory alkalosis
- C. Metabolic alkalosis and respiratory acidosis
- D. Respiratory alkalosis
- E. Respiratory alkalosis and metabolic acidosis

PEARL

- Overdiuresis, vomiting, and nasogastric suction are common causes of Metabolic alkalosis

CASE 2

- A 61-year-old female with past-history significant for DM 2, hypertension, hyperlipidemia and alcoholism is admitted to the hospital for management of back pain. Her medication includes amlodipine 5mg daily, atorvastatin 40mg daily, metformin 1000mg twice daily, and acetaminophen 1000mg four times daily
- On exam: BP: 103/64mmHg, HR: 95b/min, alert and oriented x 3 in moderate pain, lungs clear to auscultation, Heart: tachycardic no lower extremity edema
- Sodium: 140meq/L, potassium: 4.2meq/L, Bicarb: 10meq/L, Chloride: 104meq/L, Creatinine: 1.4 mg/dL, BUN: 8mg/dL, lactate: 1.0mmol/L, glucose: 100mg/dL, serum osm: 295mosm/Kg
- **ABG: pH: 7.25, PCO2: 25mmHg, PO2: 95mmHg**

WHAT IS THE MOST LIKELY CAUSE OF METABOLIC ACIDOSIS?

- A. Renal failure
- B. Metformin
- C. 5-Oxoproline
- D. D-lactic acidosis
- E. Alcohol poisoning

EXPECTED PCO₂ (COMPENSATION) IN METABOLIC ACIDOSIS

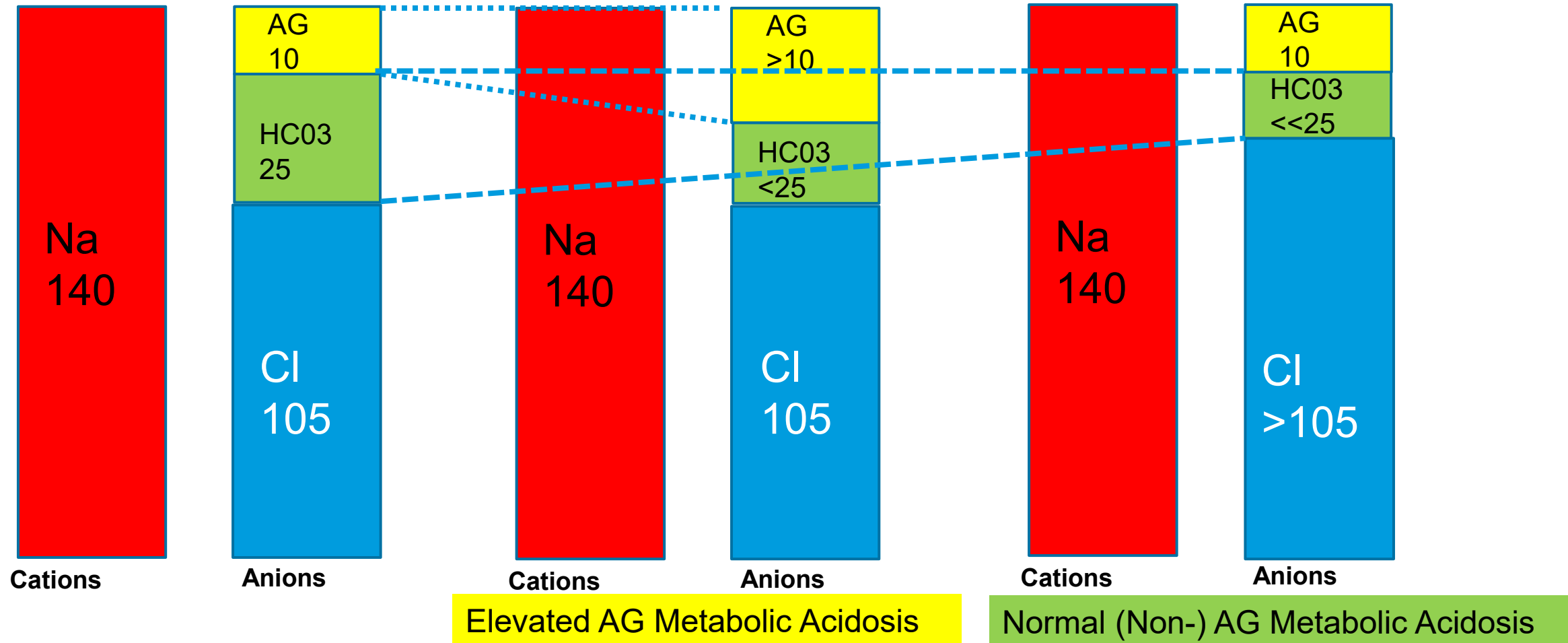
Winter's Formula

$$\text{Expected pCO}_2 = [1.5 (\text{HCO}_3) + 8] \pm 2$$

-Or another method-

$$\text{Expected pCO}_2 = \text{HCO}_3 + 15$$

$$\text{ANION GAP} = \text{NA} - (\text{CL} + \text{HCO}_3)$$



ELEVATED ANION GAP METABOLIC ACIDOSIS

Glycols

Oxoproline

Lactic acidosis

D-lactic acidosis

Methanol

Aspirin

Renal failure

Ketoacidosis

CASE 3

- A 56-year-old female with past-history significant for relapsing Hodgkin's lymphoma, hypertension, and nephrolithiasis is admitted to the hospital and started on chemotherapy with ifosfamide, carboplatin, and etoposide. On day 5 of chemotherapy labs are obtained as shown below. Patient is clinically stable with no symptoms
- **ABG: pH: 7.25, pCO₂ 25mmHg, pO₂ 80mmHg**
- Sodium: 135meq/L, potassium: 3.0meq/L, Chloride: 114meq/L, Bicarbonate: 10meq/L, creatinine: 0.9mg/dL, BUN: 14mg/dL, glucose: 98mg/dL
- Serum calcium: 9.2mg/dL, phosphorous: 1.8mg/dL, uric acid: 2.0mg/dL
- UA with microscopy: pH: 5.2, glucose: 310, protein/creatinine ratio: 0.3, 1-3 WBC

WHAT IS THE MOST LIKELY CAUSE OF METABOLIC ACIDOSIS?

- A. Lactic acidosis
- B. Ketoacidosis
- C. Diarrhea
- D. Distal renal tubular acidosis
- E. Proximal renal tubular acidosis

PEARL

- Urinary electrolyte loss is a clue to proximal tubular dysfunction (Fanconi Syndrome)

CASE 4

- A 47-year-old female with depression, anxiety, and history of alcohol abuse is admitted to the ICU after being found unresponsive on the floor by her husband. Her home medications include Ibuprofen, fluoxetine, and trazodone. During transfer to the ED, she has a seizure. On arrival, she is intubated. Lorazepam and fosphenytoin are initiated
- Vital signs: Temp 34.8°C, BP 100/70mmHg, HR: 111b/min, SpO₂ 97% on ventilator. She is unresponsive, has occasional muscle twitches, lung fields clear, bowel sounds diminished and no skin rash

CASE 4

- **ABG: pH <6.8, PO₂ 195mmHg, PCO₂ 32mmHg**
- Sodium: 145meq/L, potassium: 5.1meq/L, chloride: 109meq/L, bicarbonate: 6meq/L, BUN: 58mg/dL, creatinine: 1.2mg/dL, glucose: 89mg/dL
- Serum osmolality: 361mosm/Kg
- Lactate: 6.94mmol/L
- Ethanol: negative
- Drug screen: negative
- CT head negative

WHAT IS THE MOST LIKELY ETIOLOGY FOR HER OVERALL PRESENTATION?

- A. Acetaminophen overdose
- B. Methanol toxicity
- C. Isopropyl alcohol toxicity
- D. Lactic acidosis
- E. Starvation ketoacidosis

DIFFERENTIAL DIAGNOSIS OF INCREASED OSMOLAR GAP

- Increased Serum Osmolar Gap
 - Ethylene glycol
 - Methanol
 - Ethanol
 - Isopropyl alcohol (rubbing alcohol)*
 - Propylene glycol
 - Diethylene glycol

*Unique: Isopropyl alcohol has increased osmolar gap ***without*** metabolic acidosis

PEARL

- Check osmolar gap when there is a change in mental status

REVIEW: APPROACH TO ACID BASE QUESTIONS

- Acidemia or alkalemia?
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SUMMARY – CLINICAL PEARLS

- Overdiuresis, vomiting, and nasogastric suction are common causes of Metabolic alkalosis
- Urinary electrolyte loss is a clue to proximal tubular dysfunction (Fanconi Syndrome)
- Check osmolar gap when there is a change in mental status



THANK YOU!

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