ACID–BASE DISORDERS
Definitions

- What are the definitions of:
  - Acidemia
  - Alkalemia
Definitions

- **Acidemia**
  - The condition of increased [H+] in blood
  - Low blood pH

- **Alkalemia**
  - The condition of decreased [H+] in blood
  - High blood pH
Definitions

- What are the definitions of:
  - Acidosis
  - Alkalosis
Definitions

- **Acidosis**
  - The disease process which increases \([\text{H}^+]\)

- **Alkalosis**
  - The disease process which decreases \([\text{H}^+]\)
Can these 4 conditions coexist?

- Acidemia
- Alkalemia
- Acidosis
- Alkalosis
Definitions

- Acidemia and alkalemia
  - Generally does not coexist.

- Acidosis and alkalosis
  - More than one etiology may be simultaneously present.
Introduction

- Severe acidemia
- pH < 7.0

- What are 5 effects of severe acidemia?
Severe Acidemia

- Impairs enzyme function
- Interferes with electrophysiology
- Disturbs electrolyte balance
- Blocks calcium influx into cells
- Inhibits catecholamine action
Basic Principles

- Aerobic cellular metabolism
  - Produces energy

- Carbohydrate + Fat $\Rightarrow$ ATP + CO2

- $\text{CO}_2 + \text{H}_2\text{O} \Leftrightarrow \text{H}_2\text{CO}_3 \Leftrightarrow \text{H}^+\text{HCO}_3^-$
Basic Principles

- Acid–base disorders
- Alterations in hydrogen ion activity

- \[ \text{pH} = - \log [\text{H}^+] \]

- In extracellular fluid,
- what is the normal pH and [H+]?
Basic Principles

- In extracellular fluid:
  - Normal pH = 7.40
  - Normal [H+] = 40 nEq/L
Basic Principles

- What is
- the Henderson–Hasselbalch equation?
Basic Principles

- Henderson–Hasselbalch equation
- Under equilibrium conditions
- pH is related to the molar concentrations of bicarbonate and carbonic acid
Basic Principles

- $\text{pH} = \text{pK}' + \log \left( \frac{\text{HCO}_3^-}{\text{H}_2\text{CO}_3} \right)$
- $\text{pH} = \text{pK}' + \log \left( \frac{\text{HCO}_3^-}{[\text{PCO}_2 \times 0.03]} \right)$

- $\text{pK}' = 6.1$
- $= -\log \text{ of dissociation constant for H}_2\text{CO}_3$

What is total CO2?
Basic Principles

- \( tCO2 = [HCO3^-] + \text{dissolved CO2} \)
- \( tCO2 = [HCO3^-] + [H2CO3] \)
- \( tCO2 = [HCO3^-] + 0.03 \times PCO2 \)

- What are normal values for:
  - pH, PCO2, PO2, [HCO3^-]?
Basic Principles

- pH 7.35 – 7.45
- PCO2 35 – 45 mmHg
- PO2 80 – 100 mmHg
- \([\text{HCO}_3^-]\) 22 – 26 mmol/L
Derangements

- Respiratory
  - Net gain or loss of CO2

- Metabolic
  - Net gain or loss of HCO3⁻
Simple Disturbances

- Primary Disorder / Compensation

- Respiratory acidosis HCO3– retention (renal)
- Respiratory alkalosis HCO3– elimination (renal)
- Metabolic acidosis CO2 elimination (respiratory)
- Metabolic alkalosis CO2 retention (respiratory)
Respiratory Derangements

- How do kidneys compensate?
Respiratory Derangements

- Kidneys adjust HCO3\(^-\) reabsorption in the proximal tubules.

- The effect appears in 6 to 12 hours and slowly increases to a steady-state response over days.

- What is the relationship between pH and pCO2 in acute renal compensation?
Respiratory Derangements

- In acute respiratory derangement:
  - If pCO2 changes 10 mmHg, what is the acute change in pH?
  - If pCO2 changes 10 mmHg, what is the compensatory change in [HCO3]?
Respiratory Derangements

- Acute renal compensation
  - Change in pH = 0.008 x change in pCO2

- Partial compensation
  - change in pH < 0.008 x change in pCO2

- Superimposed acid–base disorder
  - change in pH > 0.008 x change in pCO2
Respiratory Derangements

- Acute hypercapnia: $PCO_2 = 50 \text{ mmHg}$
  - Alteration: $pH$ decreases 0.08
  - Compensation: $HCO_3$ increases 2 mM

- Acute hypocapnia: $PCO_2 = 30 \text{ mmHg}$
  - Alteration: $pH$ increases 0.08
  - Compensation: $HCO_3$ decreases 2 mM
Respiratory Derangements

- Chronic hypercapnia: $PCO2 = 50$ mmHg
  - Alteration: $pH$ decreased $0.03$
  - Compensation: $HCO3$ increases $4$ mM

- Chronic hypocapnia: $PCO2 = 30$ mmHg
  - Alteration: $pH$ increased $0.02$
  - Compensation: $HCO3$ decreases $5$ mM
Respiratory Acidosis

- pH < 7.35 and PCO2 > 45

- Causes
  - Decreased alveolar ventilation
  - Increased CO2 production
Respiratory Acidosis

- Decreased alveolar ventilation
  - Neuromuscular etiologies?
  - CNS etiologies?
  - Pulmonary etiologies?
  - Mechanical ventilator
Respiratory Acidosis

- Neuromuscular etiologies
- Disorders of nerve, muscle, or neuromuscular junction
- Drugs / toxins
- Hypokalemia
Respiratory Acidosis

- CNS etiologies
  - CNS injury, ischemia, hemorrhage, tumor
  - CNS depression
  - Narcotics, sedatives, anesthetics
Respiratory Acidosis

- Pulmonary etiologies
- Restrictive disease (fibrosis)
- Obstructive disease
- Pulmonary edema
- Severe pneumonia
- Impaired diaphragmatic excursion
- Hemothorax, pneumothorax, flail chest
- Obesity – hypoventilation
- Mechanical Ventilator

- Increased CO2 Production?
Respiratory Acidosis

- Increased CO2 production
- High carbohydrate diet
- Hypermetabolism
- Fever
- Shivering
Respiratory Acidosis

- What is treatment?
Respiratory Acidosis

- Correct underlying cause
- Bronchospasm
- Pulmonary edema
- Reverse depressed ventilatory drive
- Sedation
- Narcotics
- Mechanical ventilation
Severe Alkalemia

- What are some effects of severe alkalemia?
Severe Alkalemia

- Cerebral vasoconstriction
- Seizures
- Confusion
- Coma
- Hypoventilation
- Arrhythmias
- Electrolyte disorder
Respiratory Alkalosis

- pH > 7.45 and PCO2 < 35
- Caused by increased alveolar ventilation
Respiratory Alkalosis

- Causes
  - CNS etiologies?
  - Pulmonary etiologies?
  - Pregnancy
  - Thyrotoxicosis
  - Hypoxemia
  - Salicylates
  - Sepsis
  - Mechanical ventilation
  - Burns
  - Hepatic failure
  - Severe anemia
  - Carbon monoxide poisoning
Respiratory Alkalosis

- CNS etiologies
  - Hyperventilation syndromes
  - Anxiety
  - Pain
  - Tumor
  - Trauma
  - Infection
  - Encephalopathy
Respiratory Alkalosis

- Pulmonary etiologies
- Pulmonary edema
- Pneumonia
- ARDS
- Pulmonary embolism
- Asthma
- Secretions
Respiratory Alkalosis

- What is treatment?
Respiratory Alkalosis

- Correct underlying cause
  - Anxiety
  - Infection
  - Fever
  - Pain
  - Hypovolemia
How can we estimate the quantity of metabolic acids?
Metabolic Derangements

- What is anion gap?
- What is normal anion gap?
Metabolic Derangements

- Anion gap = Na – (Cl + HCO3)

- Principle of electroneutrality
  - Total serum cations = total serum anions
  - Na + UC = (Cl + HCO3) + UA
  - UC = K + Ca + Mg
  - UA = PO4 + SO4 + protein + organic acids

- Normal AG ≤ 12 mEq/L
Metabolic Derangements

- What is the relationship between hypoalbuminemia and anion gap?
Plasma proteins are the major source of UA. Decrease in plasma proteins decreases UA,
- Results in relative increase in measured anions.
- Results in decreased AG.
The AG decreases 2.5 mEq/L for every 1 g/dL decrease in albumin.

Is the AG a sensitive marker of lactic acidosis?
Anion Gap

- What is the Delta AG?
Anion Gap

- Delta AG = Measured AG – Normal AG
Pre-acidosis HCO3

- What is the pre-acidosis HCO3?
Pre-acidosis HCO₃

- Pre-acidosis HCO₃ =
  Delta AG + Measured HCO₃
Decreased AG

- Hypoalbuminemia
- Renal anion excretion
- Paraproteinemia
- Hyponatremia
- Hyperosmolar states
- Hypercalcemia
- Hypermagnesemia
- Halide poisoning (Br, I; false elevation in Cl)
- Lithium intoxication (cation)
- Polymyxin B (cation)
Increased AG

- Carbenicillin (anion)
- Exposure of sample to air
Metabolic Acidosis

- pH < 7.35 and normal PCO2

Causes

- Increased acids – AG acidosis
- Decreased HCO3 – normal AG acidosis
- Increased Cl – normal AG acidosis
Metabolic Acidosis

- Increased acids – AG acidosis
- Lactic acidosis
- Renal failure (impaired excretion)
- Ketoacidosis
- Diabetic, alcoholic
- Rhabdomyolysis
- Toxins
  - Salicylates, methanol, paraldehyde,
  - ethylene glycol, propylene glycol, toluene
Metabolic Acidosis

- Decreased HCO3 – normal AG acidosis
- Renal tubular acidosis
- Tubulointerstitial disease
- Acetazolamide therapy
- Hyperchloremic acidosis
- NaCl, NH4Cl, HCl, arginine Cl
- Renal failure
- Dilutional acidosis
- GI HCO3 loss
- Biliary or pancreatic drainage, diarrhea, fistula
- Ureteral diversions
- Adrenal insufficiency
Renal Tubular Acidosis

- Kidneys unable to account for normal acid production
- 4 Types
I. Proximal H+ secretion, normal GFR
   TX: NaHco3

II. Classical distal, normal GFR
   TX: NaHCO3

III. Buffer deficiency distal, Low GFR
   TX: NaHCO3

IV. Generalized distal, Low GFR
   TX: NaHCO3, K restriction, furosemide, fludrocortisone
Metabolic Acidosis

- What causes respiratory compensation?
- Rule of sevens?
Metabolic Acidosis

- H+ sensitive chemoreceptors located in the carotid body and in the brainstem modulates respiratory drive.

- Rule of sevens

- With pH decrease of 0.1
- PCO2 decreases 7 mmHg
Respiratory Compensation

- What is the expected PCO2 in respiratory compensation of metabolic acidosis?
Respiratory Compensation

- Expected PCO2 = 1.5 x HCO3 + 8 ± 2
Metabolic Acidosis

- What is treatment?
Metabolic Acidosis

- Correct underlying cause
- Shock, DKA, toxin
- Administer NaHCO3
- HCO3 deficit =
  - Weight x 0.2 x (24 mM – actual HCO3)
- 0.2 = 20% extracellular fluid
Metabolic Alkalosis

- Adverse effects?
Metabolic Alkalosis

- Neurologic
- Depressed consciousness
- Seizures
- Carpopedal spasms
- Hypoventilation
- Tissue oxygenation?
- Increases calcium binding to albumin – decreased ionized (free) calcium impairs myocardial contractility.
- Shifts oxyhemoglobin dissociation curve to the left, decreasing oxygen release in tissues.
Metabolic Acidosis

- Excessive use of NaHCO3

- Increased Na load

  - Shifts oxyhemoglobin distribution curve to the left
  - compromising O2 delivery
Metabolic Alkalosis

- pH > 7.45 and HCO₃ > 26

- Causes
  - Cl–responsive?
  - Cl–resistant?
Metabolic Alkalosis

- Cl-responsive – Urine Cl < 10 mM
- Reduced ECF volume (contraction)
- Vomiting
- Nasogastric suction
- Diuretics
- Diarrhea
- Posthypercapnia
- Carbenicillin
- Penicillin
- Villous adenoma
Metabolic Alkalosis

- Cl–resistant – Urine Cl > 20 mM
- Normal ECF volume
- Hyperaldosteronism
- Cushing’s disease
- Glucocorticoids
- Refeeding alkalosis
- K depletion
- Excess alkali (HCO3, citrate, lactate)
- Mg depletion
Metabolic Alkalosis

- What is treatment?
Metabolic Alkalosis

- Correct underlying cause
- NG suction, diarrhea, diuretics
- Life-threatening alkalosis
- 0.1 N HCl infusion
- Restoration of intravascular volume
- 0.9 NaCl
- Correction of electrolyte abnormalities
- K and Mg
- Carbonic anhydrase inhibitor
- Acetazolamide (carbonic anhydrase inhibitor)
- Blocks HCO₃⁻ reabsorptiton in the proximal tubules.
Key Points

- In primary acid–base disorders:
  - the process that caused the pH shift is the primary disorder
  - compensation cannot overcorrect the pH derangement
- A mixed disorder is present when:
  - Unexpected pH for a given PCO2 change
  - Unexpected pH for a given HCO3 change
True or False?

- The bicarbonate–carbonic acid system is the primary intracellular buffering system.
True or False?

- False

- Important intracellular buffers include proteins and phosphates.
The ratio of the base bicarbonate to carbonic acid determines the extracellular fluid pH.
True or False?

- True
The functions of the extracellular buffering system are expressed in the Henderson–Hasselbalch equation:

\[ \text{pH} = pK + \log \left( \frac{[\text{H}_2\text{CO}_3]}{[\text{HCO}_3^-]} \right) \]
True or False?

- False

- \( \text{pH} = \text{pK} + \log \left( \frac{[\text{HCO}_3^-]}{[\text{H}_2\text{CO}_3]} \right) \)
True or False?

- A bicarbonate–carbonic acid ratio of 10:1 is associated with a normal pH (7.4).
True or False?

- False
- 20:1
True or False?

- Hyperkalemia is a frequent complication of respiratory alkalosis.
True or False?

- False

- In alkalosis, preferential excretion of potassium, rather than hydrogen ion, in exchange for sodium occurs at the level of the distal convoluted tubule.
True or False?

- Potassium restriction is an important adjunct in the treatment of respiratory alkalosis.
False

Hypokalemia contributes to alkalosis because hydrogen ion rather than potassium is excreted for sodium resorption.
True or False?

- The most common cause of acid excess in the critical care patient is prolonged NG suction.
True or False?

- False

- Shock and lactic acidosis.
True or False?

- Restoration of blood pressure with vasopressors corrects the metabolic acidosis with circulatory failure.
Volume replacement results in the restoration of circulation.
Stepwise Analysis

1. Does the patient have an acidemia or alkalemia?
2. Is the primary disturbance respiratory or metabolic?
3. Is the compensation appropriate?
4. Is the anion gap elevated?
5. Determine whether an additional disorder is present.
Problem #1

- 22M w/ DM develops a severe URI.
  - Na = 128
  - K = 5.9
  - Cl = 94
  - HCO3 = 6
  - PCO2 = 15
  - PO2 = 102
  - pH = 7.19
  - Glucose = 324

- A. What is the acid–base disorder?
Problem #1

- 22M w/ DM develops a severe URI.
  - Na = 128
  - K = 5.9
  - Cl = 94
  - HCO3 = 6
  - PCO2 = 15
  - PO2 = 102
  - pH = 7.19
  - Glucose = 324

A. Is the patient acidemic or alkalemic?
- Acidemic, pH < 7.4
22M w/ DM develops a severe URI.
- Na = 128
- K = 5.9
- Cl = 94
- HCO3 = 6
- PCO2 = 15
- PO2 = 102
- pH = 7.19
- Glucose = 324

B. Is the primary disorder respiratory or metabolic?
22M w/ DM develops a severe URI.

- Na = 128
- K = 5.9
- Cl = 94
- HCO3 = 6
- PCO2 = 15
- PO2 = 102
- pH = 7.19
- Glucose = 324

B. Is the primary disorder respiratory or metabolic?

Metabolic, PCO2 < 40
22M w/ DM develops a severe URI.

- Na = 128
- K = 5.9
- Cl = 94
- HCO3 = 6
- PCO2 = 15
- PO2 = 102
- pH = 7.19
- Glucose = 324

C. What is this patient’s anion gap?
**Problem #1**

- 22M w/ DM develops a severe URI.
  - Na = 128
  - K = 5.9
  - Cl = 94
  - HCO3 = 6
  - PCO2 = 15
  - PO2 = 102
  - pH = 7.19
  - Glucose = 324

- C. What is this patient’s anion gap?
  - \( AG = 128 - (94 + 6) = 28 \)
  - High AG metabolic acidosis
Problem #1

- 22M w/ DM develops a severe URI.
  - Na = 128
  - K = 5.9
  - Cl = 94
  - HCO3 = 6
  - PCO2 = 15
  - PO2 = 102
  - pH = 7.19
  - Glucose = 324

- D. Is there a mixed metabolic acidosis and alkalosis?
- Delta AG = 28 – 12 = 16
22M w/ DM develops a severe URI.
- Na = 128
- K = 5.9
- Cl = 94
- HCO3 = 6
- PCO2 = 15
- PO2 = 102
- pH = 7.19
- Glucose = 324

D. Is there a mixed metabolic acidosis and alkalosis?
- Pre–acidosis HCO3 = 16 + 6 = 22
- No underlying metabolic alkalosis
Problem #1

- 22M w/ DM develops a severe URI.
  - Na = 128
  - K = 5.9
  - Cl = 94
  - HCO3 = 6
  - PCO2 = 15
  - PO2 = 102
  - pH = 7.19
  - Glucose = 324

- E. Is the compensation for metabolic acidosis appropriate?
22M w/ DM develops a severe URI.
- Na = 128
- K = 5.9
- Cl = 94
- HCO3 = 6
- PCO2 = 15
- PO2 = 102
- pH = 7.19
- Glucose = 324

E. Is the compensation for metabolic acidosis appropriate?
- Expected PCO2 = 1.5 \times 6 + 8 \pm 2
- Expected PCO2 = 17 \pm 2
- Simple compensated metabolic acidosis
Problem #1

- What is the cause of this patient’s increase in anion gap?
Problem #1

- Diabetic ketoacidosis
Problem # 2

- 47F w/ CRF & severe alcohol intoxication.
  - Na = 134
  - K = 6.1
  - Cl = 112
  - HCO3 = 10
  - PCO2 = 30
  - PO2 = 52
  - pH = 7.10
  - Creatinine = 3.7

- A. What is the acid–base disorder?
Problem # 2

- 47F w/ CRF & severe alcohol intoxication.
  - Na = 134
  - K = 6.1
  - Cl = 112
  - HCO3 = 10
  - PCO2 = 30
  - PO2 = 52
  - pH = 7.10
  - Creatinine = 3.7

- A. Is the patient acidemic or alkalemic?
  - Acidemic, pH < 7.4
Problem # 2

- 47F w/ CRF & severe alcohol intoxication.
  - Na = 134
  - K = 6.1
  - Cl = 112
  - HCO3 = 10
  - PCO2 = 30
  - PO2 = 52
  - pH = 7.10
  - Creatinine = 3.7

- B. Is the primary disorder respiratory or metabolic?
Problem # 2

- 47F w/ CRF & severe alcohol intoxication.
  - Na = 134
  - K = 6.1
  - Cl = 112
  - HCO3 = 10
  - PCO2 = 30
  - PO2 = 52
  - pH = 7.10
  - Creatinine = 3.7

- B. Is the primary disorder respiratory or metabolic?
  - Metabolic, pCO2 < 40
Problem # 2

- 47F w/ CRF & severe alcohol intoxication. RR = 10.
  - Na = 134
  - K = 6.1
  - Cl = 112
  - HCO3 = 10
  - PCO2 = 30
  - PO2 = 52
  - pH = 7.10
  - Creatinine = 3.7

  C. What is the AG?
Problem # 2

- 47F w/ CRF & severe alcohol intoxication. RR = 10.
  - Na = 134
  - K = 6.1
  - Cl = 112
  - HCO3 = 10
  - PCO2 = 30
  - PO2 = 52
  - pH = 7.10
  - Creatinine = 3.7

- C. What is the AG?
- AG = 134 – (112 + 10) = 12
- Normal AG metabolic acidosis
Problem # 2

- 47F w/ CRF & severe alcohol intoxication. RR = 10.
  - Na = 134
  - K = 6.1
  - Cl = 112
  - HCO3 = 10
  - PCO2 = 30
  - PO2 = 52
  - pH = 7.10
  - Creatinine = 3.7

- D. Is the compensation for the metabolic acidosis appropriate?
Problem # 2

- 47F w/ CRF & severe alcohol intoxication. RR = 10.
  - Na = 134
  - K = 6.1
  - Cl = 112
  - HCO3 = 10
  - PCO2 = 30
  - PO2 = 52
  - pH = 7.10
  - Creatinine = 3.7

- D. Is the compensation for the metabolic acidosis appropriate?
  - Expected PCO2 = 1.5 x 10 + 8 ± 2
  - Expected PCO2 = 23 ± 2
  - Mixed metabolic and respiratory acidosis.
Problem # 2

- What could cause this patient’s mixed metabolic and respiratory acidosis?
Problem # 2

- Metabolic acidosis may be related to CRF.
- Respiratory acidosis may be related to alcohol intoxication with reduced respiratory drive.
Problem # 3

- 47F w/ binge drinking, N/V, fever.
  - Na = 140
  - K = 2.9
  - Cl = 96
  - HCO3 = 18
  - PCO2 = 49
  - PO2 = 45
  - pH = 7.15
  - Glucose = 96
  - UA: 4+ ketones
  - CXR: infiltrates

A. What is the acid–base disorder?
Problem # 3

- 47F w/ binge drinking, N/V, fever.
  - Na = 140
  - K = 2.9
  - Cl = 96
  - HCO3 = 18
  - PCO2 = 49
  - PO2 = 45
  - pH = 7.15
  - Glucose = 96
  - UA: 4+ ketones
  - CXR: infiltrates

- A. Is the patient acidemic or alkalemic?
  - Acidemic, pH < 7.4
Problem # 3

- 47F w/ binge drinking, N/V, fever.
  - Na = 140
  - K = 2.9
  - Cl = 96
  - HCO3 = 18
  - PCO2 = 49
  - PO2 = 45
  - pH = 7.15
  - Glucose = 96
  - UA: 4+ ketones
  - CXR: infiltrates

- B. Is the primary disorder respiratory or metabolic?
Problem # 3

- 47F w/ binge drinking, N/V, fever.
  - Na = 140
  - K = 2.9
  - Cl = 96
  - HCO3 = 18
  - PCO2 = 49
  - PO2 = 45
  - pH = 7.15
  - Glucose = 96
  - UA: 4+ ketones
  - CXR: infiltrates

- B. Is the primary disorder respiratory or metabolic?
- Respiratory, PCO2 > 40
Problem # 3

- What is the expected HCO3 in metabolic compensation for acute respiratory acidosis?
Problem # 3

- Expected HCO₃ = 24 + (PCO₂ – 40) / 10
Problem # 3

- 47F w/ binge drinking, N/V, fever.
  - Na = 140
  - K = 2.9
  - Cl = 96
  - HCO3 = 18
  - PCO2 = 49
  - PO2 = 45
  - pH = 7.15
  - Glucose = 96
  - UA: 4+ ketones
  - CXR: infiltrates

- C. Is the compensation for the respiratory acidosis appropriate?
Problem # 3

- 47F w/ binge drinking, N/V, fever.
  - Na = 140
  - K = 2.9
  - Cl = 96
  - HCO3 = 18
  - PCO2 = 49
  - PO2 = 45
  - pH = 7.15
  - Glucose = 96
  - UA: 4+ ketones
  - CXR: infiltrates

C. Is the compensation for the respiratory acidosis appropriate?
- Expected HCO3 = 24 + (49 – 40) / 10
- Expected HCO3 = 25
- Mixed respiratory and metabolic acidosis
Problem # 3

- 47F w/ binge drinking, N/V, fever.
  - Na = 140
  - K = 2.9
  - Cl = 96
  - HCO3 = 18
  - PCO2 = 49
  - PO2 = 45
  - pH = 7.15
  - Glucose = 96
  - UA: 4+ ketones
  - CXR: infiltrates

D. What is the AG?
Problem # 3

- 47F w/ binge drinking, N/V, fever.
  - Na = 140
  - K = 2.9
  - Cl = 96
  - HCO3 = 18
  - PCO2 = 49
  - PO2 = 45
  - pH = 7.15
  - Glucose = 96
  - UA: 4+ ketones
  - CXR: infiltrates

D. What is the AG?

AG = 140 – (96 + 18) = 26

High AG metabolic acidosis
Problem # 3

- 47F w/ binge drinking, N/V, fever.
  - Na = 140
  - K = 2.9
  - Cl = 96
  - HCO3 = 18
  - PCO2 = 49
  - PO2 = 45
  - pH = 7.15
  - Glucose = 96
  - UA: 4+ ketones
  - CXR: infiltrates

- E. Is there a mixed metabolic acidosis and alkalosis?
Problem # 3

- 47F w/ binge drinking, N/V, fever.
  - Na = 140
  - K = 2.9
  - Cl = 96
  - HCO3 = 18
  - PCO2 = 49
  - PO2 = 45
  - pH = 7.15
  - Glucose = 96
  - UA: 4+ ketones
  - CXR: infiltrates

- E. Is there a mixed metabolic acidosis and alkalosis?
  - Delta AG = 26 - 12 = 14
  - Pre–acidosis HCO3 = 14 + 18 = 32
  - Mixed respiratory acidosis, metabolic acidosis, and metabolic alkalosis.
Problem # 3

- What is the explanation for this patient’s triple acid–base disturbance?
Problem # 3

- Chronic alcoholic
  - Metabolic acidosis
    - Alcoholic ketoacidosis
      - UA w/ 4+ ketones
  - Respiratory acidosis
    - Pneumonia
      - CXR w/ infiltrates
  - Metabolic alkalosis
    - Nausea / vomiting