Fluid,Electrolytes, &

Acid-Base Balance Review

NURS 380

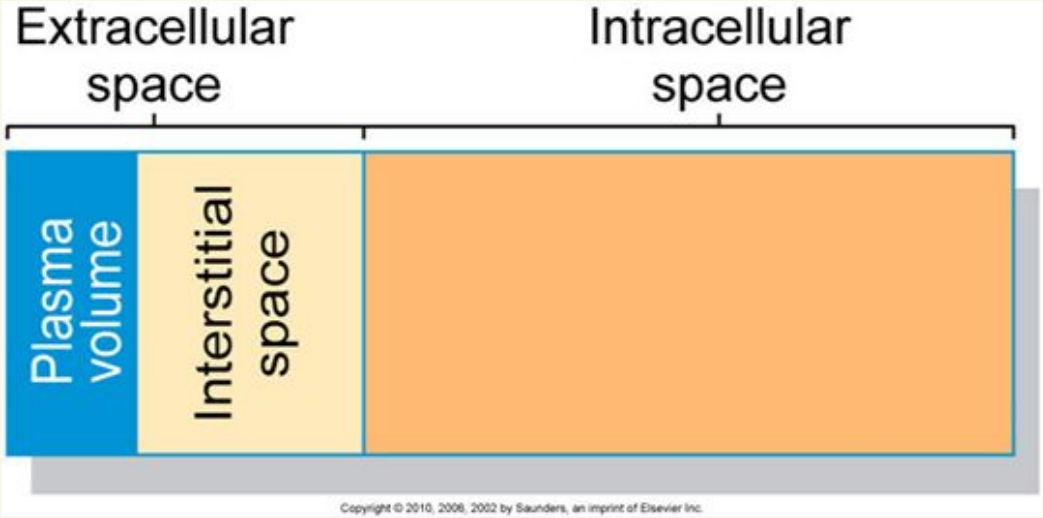
Objectives

At the conclusion of this presentation and learning activities, learners will be able to:

- Describe types of fluids based on tonicity
- Calculate fluid replacement for adults and children
- Differentiate between hyper/hypovolemia as well as their treatments
- Identify major electrolytes in the body
- Analyze signs and symptoms of increased/decreased electrolytes in the body
- Analyze and interpret arterial blood gases
- Distinguish between causes and treatments for acid/base imbalances

Fluid Distribution

- TBW is 60% of body weight
- 2 compartments: intracellular fluid and extracellular fluid



Intracellular

Main electrolytes:
potassium, phosphate, sulfate

Extracellular

Main electrolytes:
sodium, chloride, bicarbonate

Fluid Types

Hypertonic

Higher solute concentration than another solution

Hypotonic

Lower solute concentration than another solution

Isotonic

Has same solute concentration as another solution

Fluid Shifts

Hypertonic

Fluid shifts into higher solute solution/area (3% saline, D10)

Hypotonic

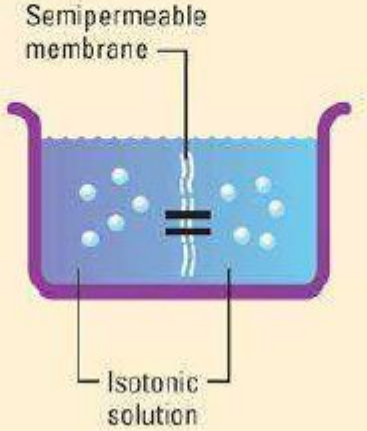
Fluid shifts from low solute solution to higher solute solution (0.45% NS, dextrose solutions)

Isotonic

No net change in fluid movement (0.9% NS, LR, D5W, 5% dextrose in 0.2% saline)

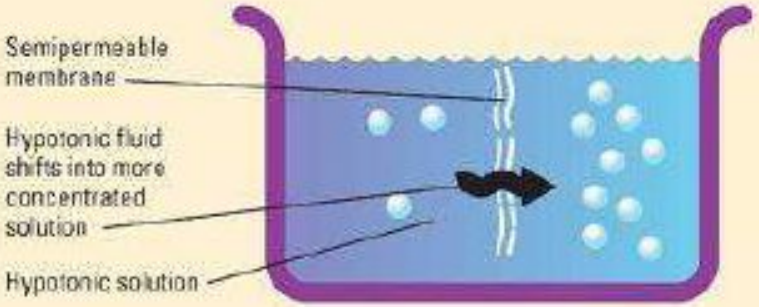
Understanding isotonic fluids

No net fluid shifts occur between isotonic solutions because the solutions are equally concentrated.



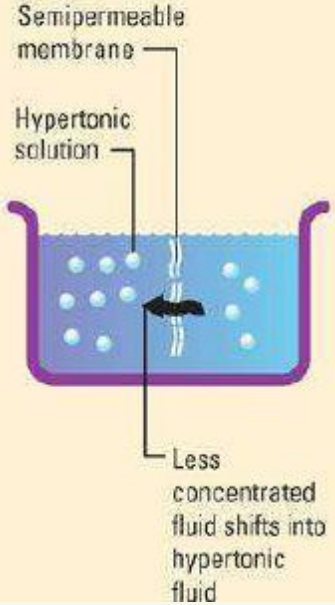
Understanding hypotonic fluids

When a less concentrated, or hypotonic, solution is placed next to a more concentrated solution, fluid shifts from the hypotonic solution into the more concentrated compartment to equalize concentrations.



Understanding hypertonic fluids

If one solution has more solutes than an adjacent solution, it has less fluid relative to the adjacent solution. Fluid will move out of the less concentrated solution into the more concentrated, or hypertonic, solution until both solutions have the same amount of solutes and fluid.



Fluid Movement

Diffusion

Movement of molecules from area of higher concentration to an area of lower concentration

Osmosis

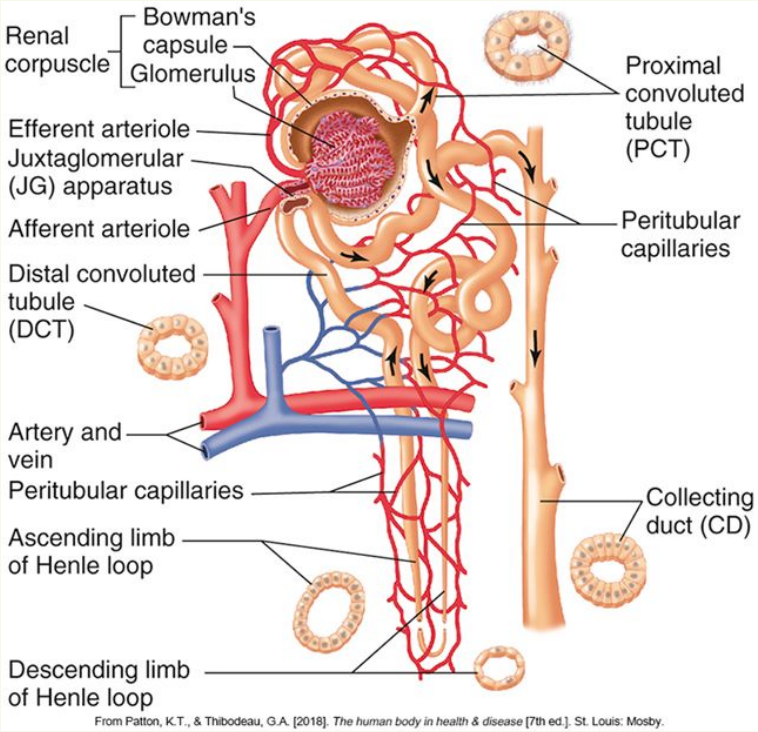
Movement through a semipermeable membrane

Active Transport

Energy used to move molecules from lesser concentration to higher concentration

Filtration

Transfer of water and dissolved substances through a permeable membrane from high pressure to low pressure

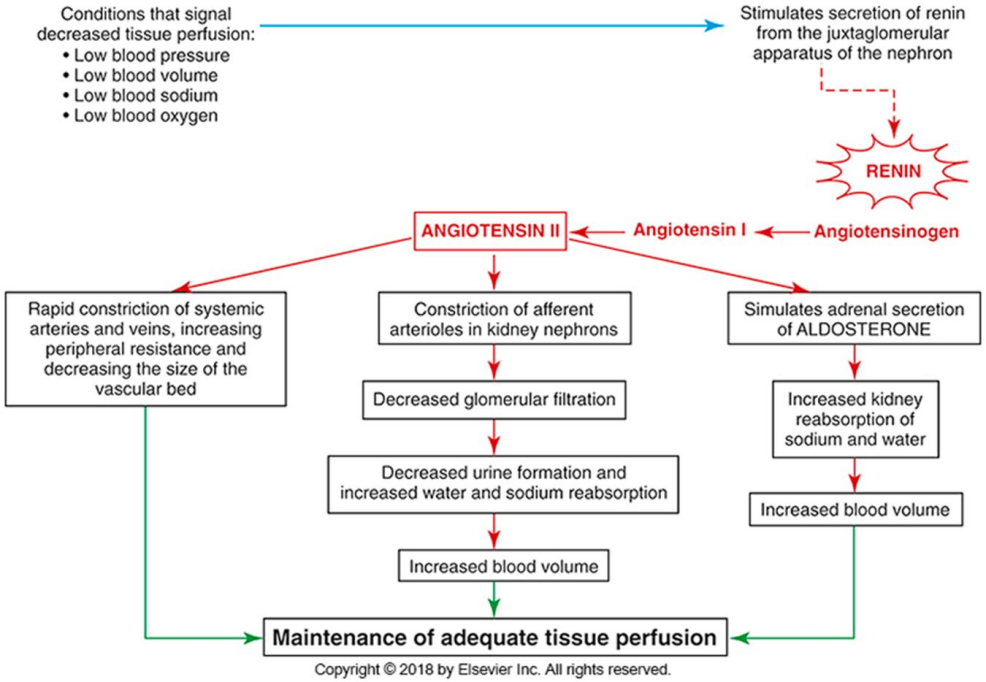


From Patton, K.T., & Thibodeau, G.A. [2018]. *The human body in health & disease* [7th ed.]. St. Louis: Mosby.

Renal Regulation

Nephron function:

- Filter blood plasma
- Reabsorbs water and solutes as needed
- Maintain fluid and electrolyte balance


Conditions that signal decreased tissue perfusion:
• Low blood pressure
• Low blood volume
• Low blood sodium
• Low blood oxygen
Stimulates secretion of renin from the juxtaglomerular apparatus of the nephron
RENIN
ANGIOTENSIN II
Angiotensin I
Angiotensinogen
Rapid constriction of systemic arteries and veins, increasing peripheral resistance and decreasing the size of the vascular bed
Constriction of afferent arterioles in kidney nephrons
Simulates adrenal secretion of ALDOSTERONE
Decreased glomerular filtration
Increased kidney reabsorption of sodium and water
Decreased urine formation and increased water and sodium reabsorption
Increased blood volume
Increased blood volume
Maintenance of adequate tissue perfusion
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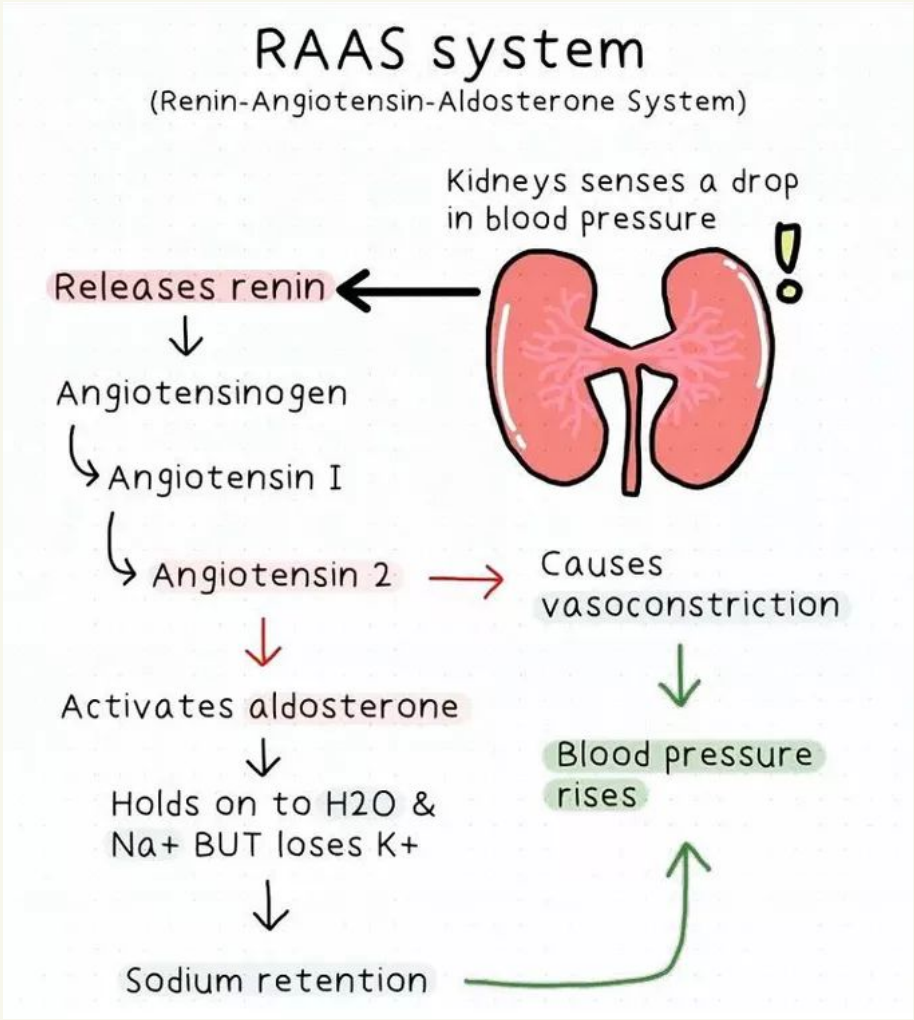

RAAS system
(Renin-Angiotensin-Aldosterone System)
Kidneys senses a drop in blood pressure
Releases renin
Angiotensinogen
Angiotensin I
Angiotensin 2
Causes vasoconstriction
Activates aldosterone
Blood pressure rises
Holds on to H2O & Na+ BUT loses K+
Sodium retention

Assessing Fluid Balance

- Intake and output
  - “adequate “ urine output
- Influencing factors?
- Adult vs pediatric patients

Pediatric Daily Fluid Needs

- 100/50/20 rule
- 4/2/1 formula (more convenient for hourly rates)

- 100 ml/kg/24 hours = 4 ml/kg/hour for the 1st 10kg
- 50 ml/kg/24 hours = 2 ml/kg/hr for the 2nd 10kg
- 20 ml/kg/24 hours = 1 ml/kg/hr for remaining weight

Based on the formula above, how much fluid should a child weighing 23 kilograms receive in 24 hours? How would you program your pump for an hourly rate?

Fluid Labs

Serum Osmolarity/Osmolality

Measure of different solutes in plasma

BUN & Creatinine

Used to determine kidney function

Specific Gravity

Measure of concentration of particles in urine and density of urine compared to water

GFR

Measure of flow rate of filtered fluid through the glomeruli in kidneys

Fluid Labs

Serum Osmolarity

275-300 mOsm/L
270-290 mOsm/L (Ped)

BUN & Creatinine

BUN: 6-20 mg/dL
Creatinine: 0.6-1.2 mg/dL (M), 0.5-1.1 mg/dL (W)

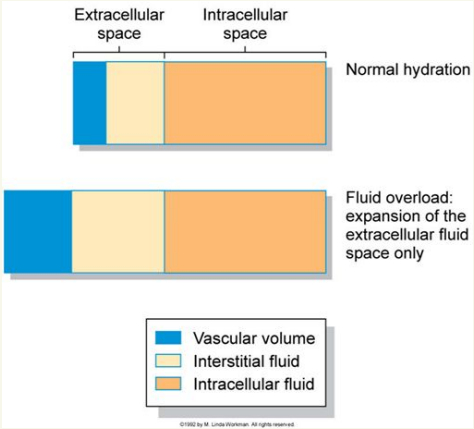
Specific Gravity

1.010 - 1.025

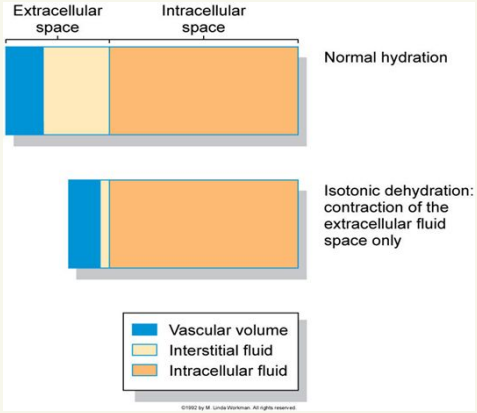
GFR

>90 (adult)
40-60 (newborn/child)

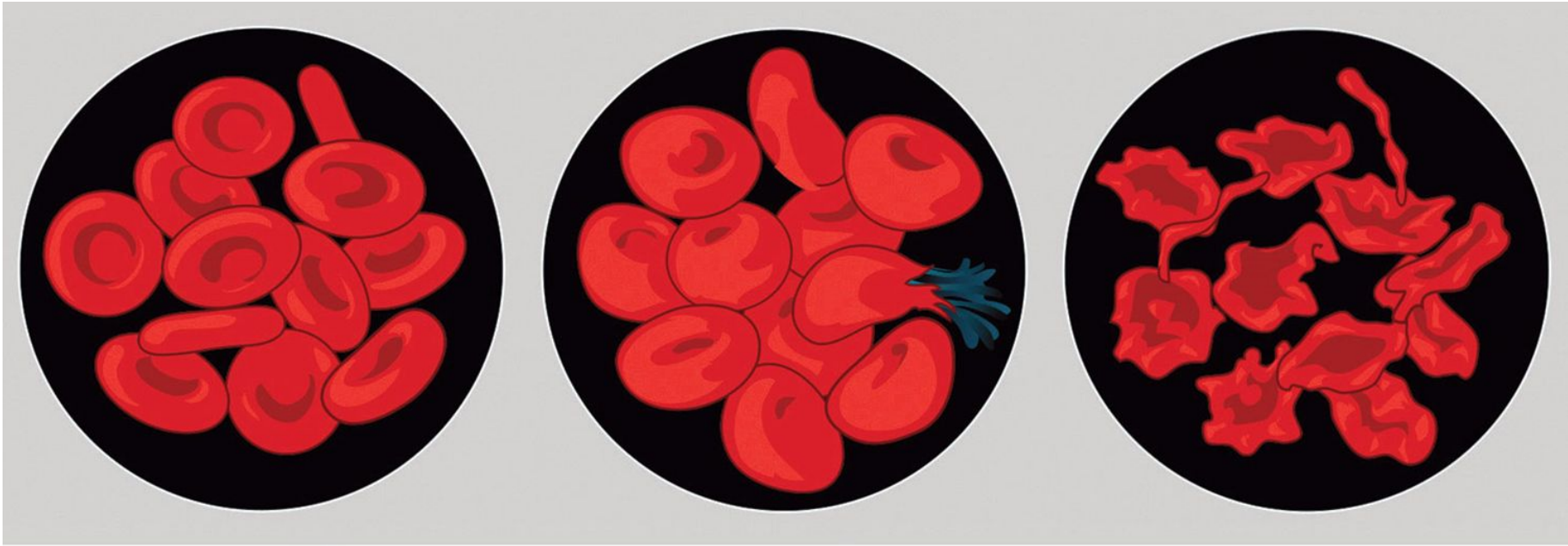
Volume Excess

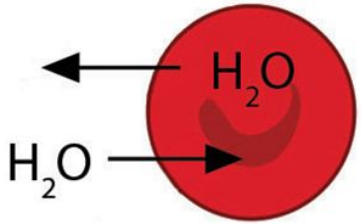


Volume Depletion

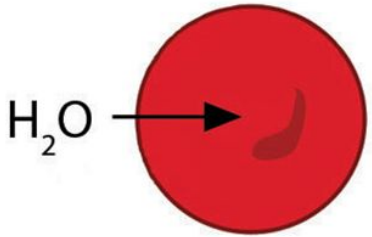


Fluid Maintenance & Replacement

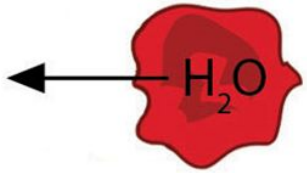




(a) Isotonic



(b) Hypotonic



(c) Hypertonic

Crystalloids

- Solutions with small molecules that flow easily from the bloodstream into cells and tissues
- Can be isotonic, hypertonic, or hypotonic
  - Isotonic have few shifts between ECF and ICF
  - Hypotonic move from bloodstream into cells
  - Hypertonic pull fluid into bloodstream from cells (cell shrinkage)
- Mainly used to increase intravascular volume
  - First choice for fluid resuscitation
  - Typically solution for other IV meds
  - Maintenance fluids
- Ex: **NS, LR, D5W, D10W, 0.45% NaCl, 3% NaCl**

Colloids

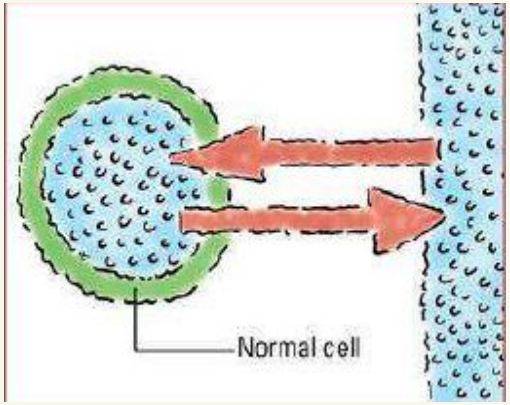
- Plasma expanders - pull fluid into bloodstream
- Monitor closely for signs of hypervolemia
- Ex: **dextran, hetastarch, 5% albumin, 25% albumin**

When to use? What vital signs/labs/hemodynamic values will increase? What will decrease?

Isotonic Fluids

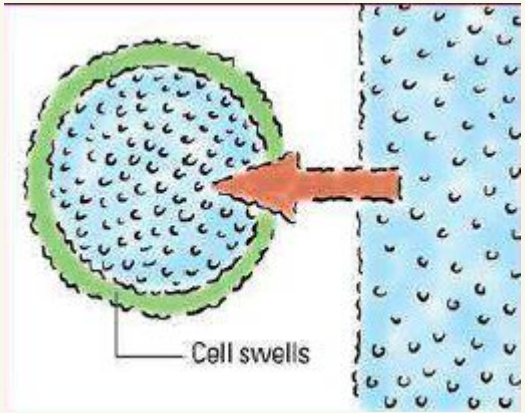
0.9% NaCl

- When to use?
- Differences in LR and normal saline?



Hypotonic Fluids

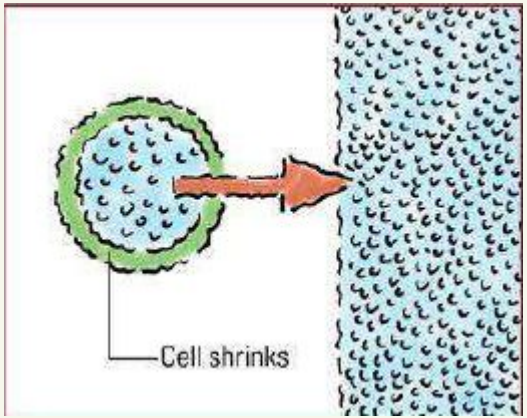
0.45% NaCl



- Provide free water and sodium and chloride
- Used as a maintenance fluid
- When to use?
- What would happen if patient is hypovolemic and/or hypotensive?
- What would happen if patient has cerebral edema?

Hypertonic Fluids

3% NaCl



- Provide solutes (dextrose, sodium, chloride, etc.)
- When to use?
- Would they cause hypovolemia or fluid overload?

Nursing Responsibilities

- Know your orders
- Be aware of fluid overload signs/symptoms
  - What to do if you suspect overload?
- Monitor intake/output
- Monitor electrolytes

Blood Transfusions

- RBCs (PRBCs)
  - Restore or maintain oxygen carrying capacity, correct anemia, increase RBC mass
  - A: receives A or O; B: receives B or O, AB: AB, A, B, or O; O; receives O
  - Nursing considerations?
- Platelets
  - Treat bleeding, improve platelet counts preop
  - ABO compatibility identical, RH negative should receive Rh negative products
  - Nursing considerations?
- Fresh frozen plasma (FFP)
  - Treat postop hemorrhage, correct coagulation factor deficiency, coumadin reversal
  - ABO compatibility required, Rh match not required
  - Nursing considerations?
- Cryoprecipitate
  - Treat factor VIII deficiency and fibrinogen disorders, hemophilia A
  - ABO compatibility required, Rh match not required

Knowledge Check

A 65-kg, 42 year old patient is traveling on business. She presents to the local ED with a 3-day history of fever, chills, and a productive cough with decreased oral intake. On physical examination, she appears ill, is tachypneic, and is mildly dehydrated. A chest xray reveals bilateral lower lobe pneumonia. Her blood work is unremarkable. She is give a 0.9% NaCl fluid bolus, feels improved, and urinates. She is not deemed well enough to return alone to her hotel room and is admitted for IVF therapy and IV antibiotics.

What would be the most appropriate fluid type for this patient?

Knowledge Check

A 28 year old patient undergoes an appendectomy. Postoperatively, she is placed on 0.45% NaCl at 120 mL/h. Twelve hours later she develops a headache, nausea, and vomiting and is treated with narcotic analgesics. Twenty four hours later she is confused and combative and taken for an emergent head CT. En route to head CT, she suffers generalized tonic-clonic seizures. Rapid bedside testing reveals a serum sodium of 122 mEq/L.

What would be the most appropriate fluid type for this patient?

Knowledge Check

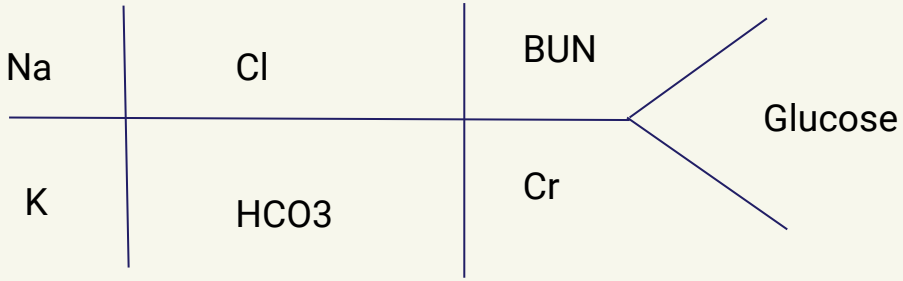
A 7 year old, 25 kg patient with cerebral palsy (CP) who is fed via gastrostomy tube presents to the ED with a 5 day history of fever, cough, and irritability. She is diagnosed with pneumonia, but has otherwise been tolerating feeds and is not experiencing vomiting or diarrhea. Lab work reveals:

Serum sodium 184 mEq/L
BUN 60 mg/dL
Creatinine 1.4 mg/dL
Urine osmolality 1200 mOsm/kg

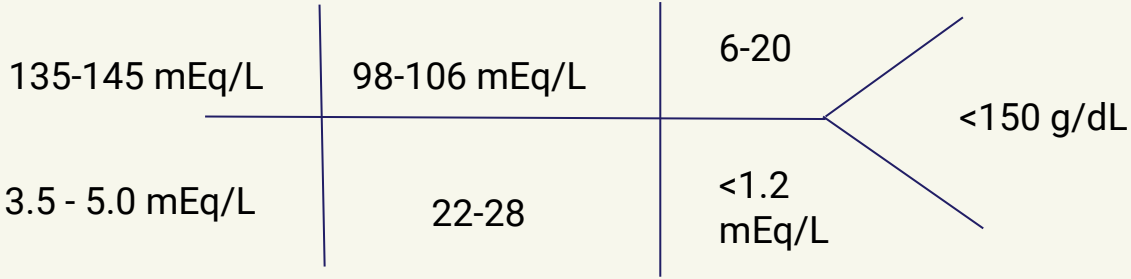
With a chart review, her baseline sodium levels are found to be, at baseline, 145-150 mEq/L.

What fluid orders would you anticipate for this patient?

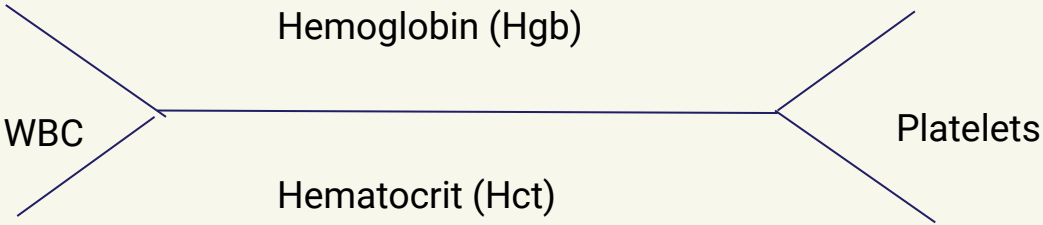
Electrolytes



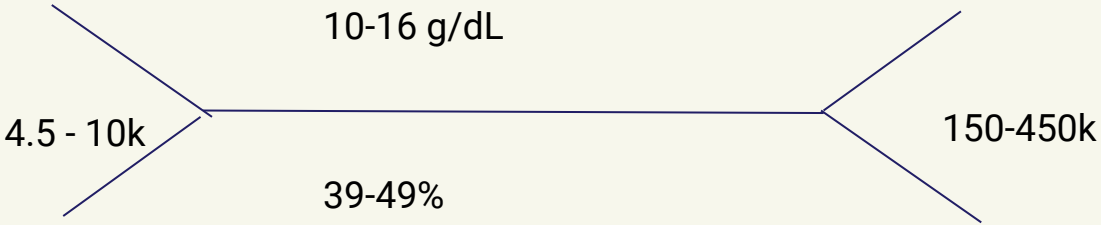
Normal Values?



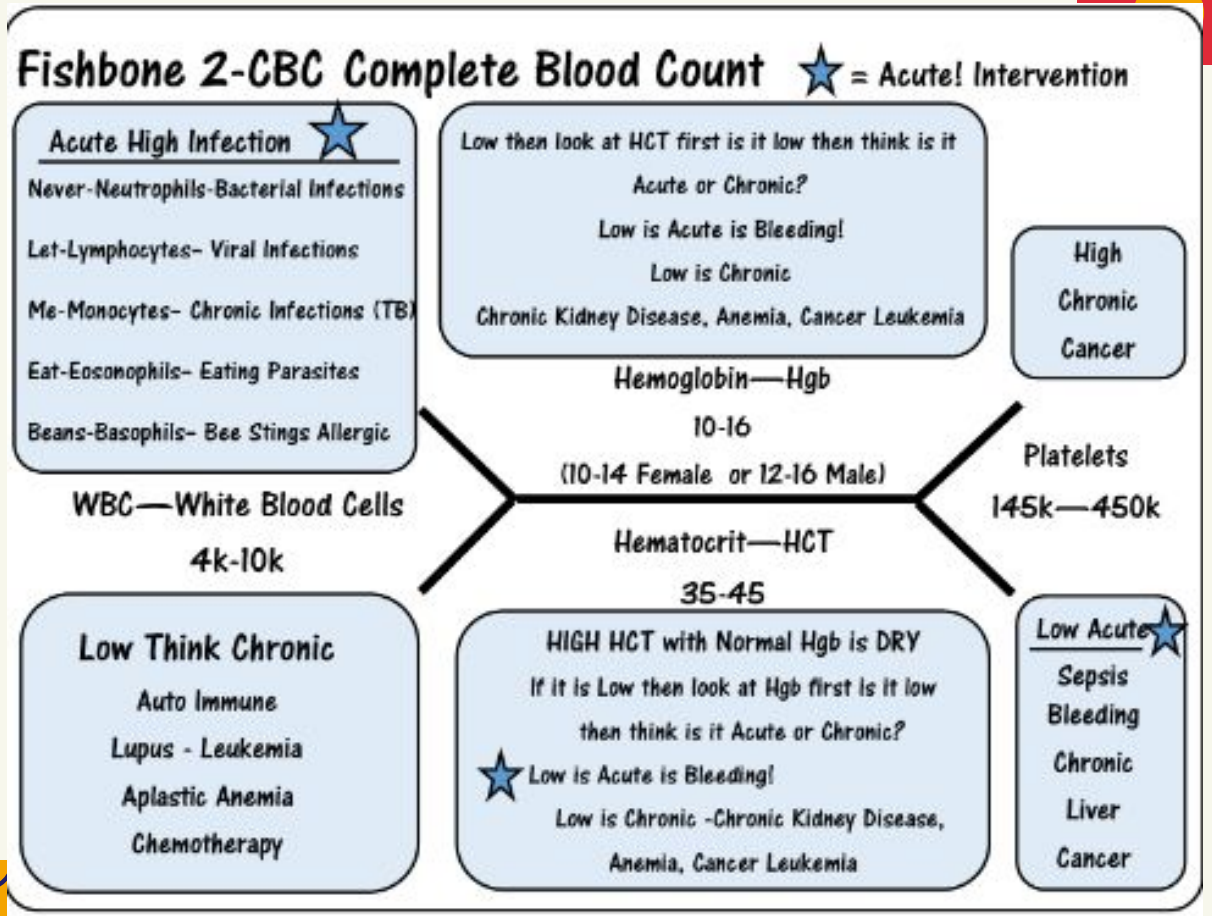
Normal Values



Normal Values?



Normal Values


Fishbone 2-CBC Complete Blood Count
= Acute! Intervention
Acute High Infection
Never-Neutrophils-Bacterial Infections
Let-Lymphocytes- Viral Infections
Me-Monocytes- Chronic Infections (TB)
Eat-Eosonophils- Eating Parasites
Beans-Basophils- Bee Stings Allergic
WBC—White Blood Cells
4k-10k
Low then look at HCT first is it low then think is it
Acute or Chronic?
Low is Acute is Bleeding!
Low is Chronic
Chronic Kidney Disease, Anemia, Cancer Leukemia
Hemoglobin—Hgb
10-16
(10-14 Female or 12-16 Male)
Hematocrit—HCT
35-45
High
Chronic
Cancer
Platelets
145k—450k
Low Think Chronic
Auto Immune
Lupus - Leukemia
Aplastic Anemia
Chemotherapy
HIGH HCT with Normal Hgb is DRY
If it is Low then look at Hgb first is it low
then think is it Acute or Chronic?
Low is Acute is Bleeding!
Low is Chronic -Chronic Kidney Disease,
Anemia, Cancer Leukemia
Low Acute
Sepsis
Bleeding
Chronic
Liver
Cancer

Sodium

- behavioral/LOC changes

Muscle weakness/diminished DTRs
Hyperactive bowel sounds, N, D, abd cramping
Seizures
Hypovolemic - postural hypotension, decreased UOP, tachycardia, thirst, dry mouth, azotemia
Hypervolemic - HA, confusion, N, V, D, muscle cramps, muscle spasms

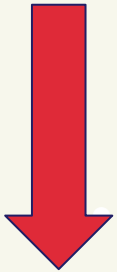
twitching/irregular contractions
Progressive muscle weakness
Hypovolemic - extreme thirst, short attention span, agitated/confused, tachycardia, hypotension
Hypervolemic - lethargy, coma, distended neck veins, increased BP

Potassium

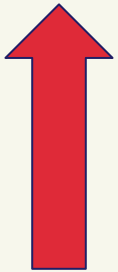
- Arrhythmias
- EKG changes (PVCs, T wave changes, ST depression)
- Respiratory muscle weakness
- Muscle weakness
- Paralysis
- N, V, constipation, dec bowel sounds, abd distention

- Bradycardia
- EKG changes (tall T waves, prolonged PR, flat or absent P waves, wide QRS)
- Muscle twitching, paresthesia (early)
- Muscle weakness, paralysis (late)

Magnesium



- Hypocalcemia
- Arrhythmias (complete heart block)
- Tremors
- Tetany (Chvostek's & Trousseau's signs)
- EKG changes (widened QRS, peaked T waves, prolonged PR, Torsades)



- Weakness
- Nausea
- Dizziness
- Confusion
- Decreased reflexes
- Bladder paralysis
- Seizures
- Hypotension, bradycardia, AV blocks

Pediatric Considerations

Common Imbalances (Peds)

- Hypervolemia
  - Renal failure, HF, cirrhosis, increased oral or IV sodium intake
  - S/S: edema, weight gain, JVD, crackles, shortness of breath, increased CVP and BP
  - Tx: diuretics, fluid restriction, sodium restriction, HD if renal failure
- Hypovolemia
  - Dehydration, DM, diuretic usage, hot weather, decreased oral intake
  - S/S: dry mucous membranes, oliguria, dizziness, weakness, AMS, hypotension, inc H/H
  - Tx: oral/IV fluids
- Hypernatremia
- Hyponatremia
- Hypokalemia
- Hyperkalemia

Acid-Base Imbalances

ABG Analysis

	acidotic	normal	alkalosis
pH	<7.35	7.35-7.45	>7.45
CO_2	>45	35-45	<35
HCO_3	<22	22-26	>26

1. Check the pH
   - Determine if acidotic (<7.35) or alkalotic (>7.45)
2. Determine the PaCO2
   - Provides information about the respiratory component of acid-base balance
   - Low or high?
3. Determine the bicarbonate
   - Provides information about the metabolic aspect of acid-base balance
   - High or low?
4. ROME (respiratory opposite, metabolic equal)
   - inc CO2 and dec ph = resp acidosis
   - dec CO2 and inc pH = resp alkalosis
   - dec HCO3 and pH = metabolic acidosis
   - inc HCO3 and pH = metabolic alkalosis
5. Compensation

acidic

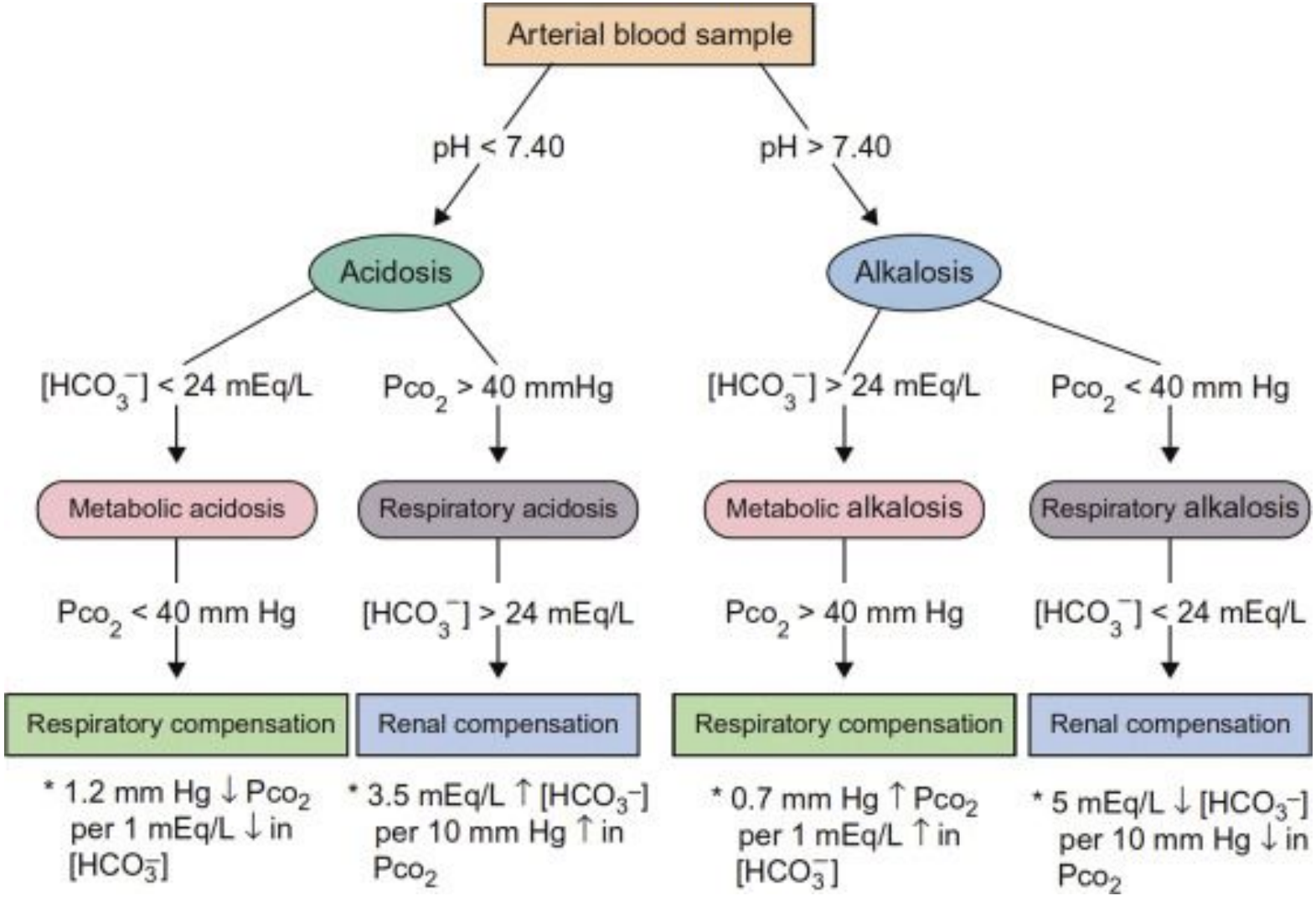
7.40

basic

pH < 7.35
PaCO2 >45
HCO3 <22

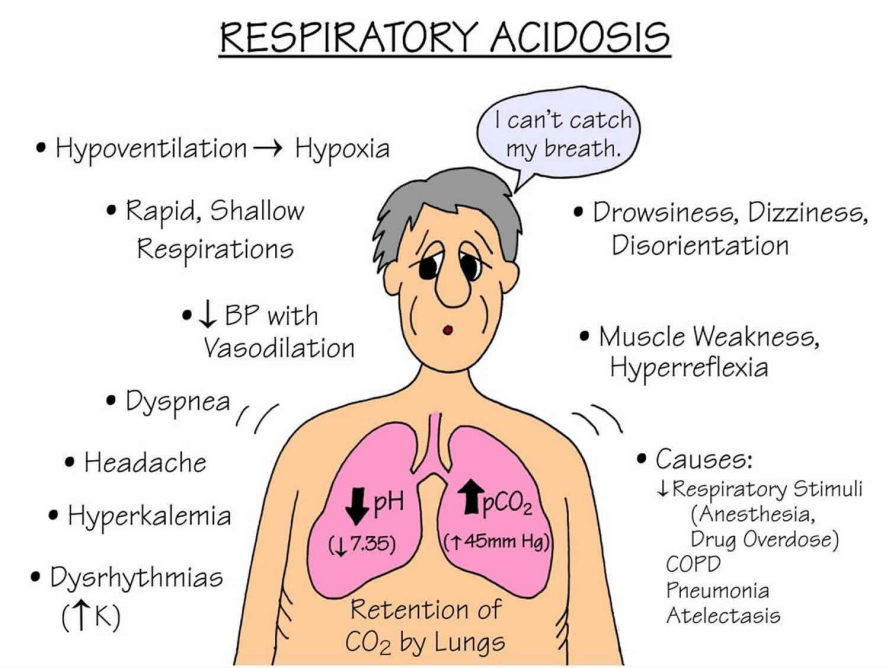
pH > 7.45
PaCO2 <35
HCO3 >26

1. pH 7.22, CO2 65, HCO3 25
2. pH 7.22 CO2 65, HCO3 33
3. pH 7.36, CO2 65, HCO3 33


Arterial blood sample
pH < 7.40
pH > 7.40
Acidosis
Alkalosis
[HCO3−] < 24 mEq/L
Pco2 > 40 mmHg
[HCO3−] > 24 mEq/L
Pco2 < 40 mm Hg
Metabolic acidosis
Respiratory acidosis
Metabolic alkalosis
Respiratory alkalosis
Pco2 < 40 mm Hg
[HCO3−] > 24 mEq/L
Pco2 > 40 mm Hg
[HCO3−] < 24 mEq/L
Respiratory compensation
Renal compensation
Respiratory compensation
Renal compensation
* 1.2 mm Hg ↓ Pco2 per 1 mEq/L ↓ in [HCO3−]
* 3.5 mEq/L ↑ [HCO3−] per 10 mm Hg ↑ in Pco2
* 0.7 mm Hg ↑ Pco2 per 1 mEq/L ↑ in [HCO3−]
* 5 mEq/L ↓ [HCO3−] per 10 mm Hg ↓ in Pco2

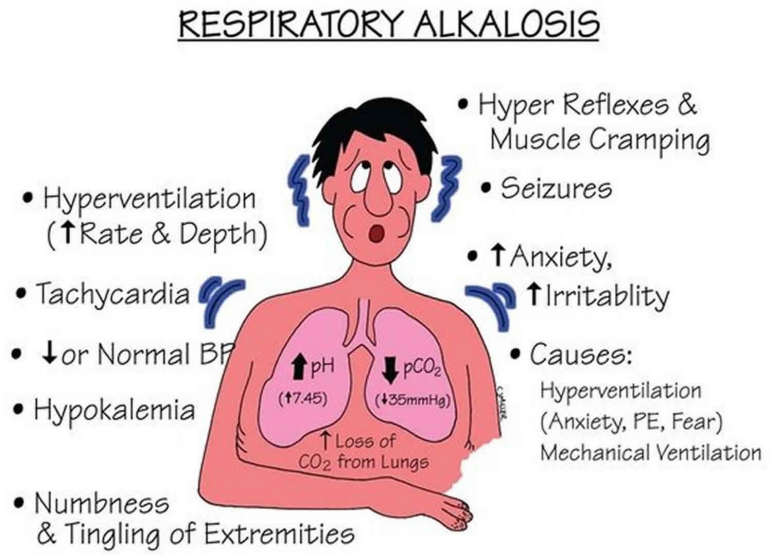
Respiratory Acidosis

- Disruption in any component of breathing (ventilation, perfusion, or diffusion)
- Characterized by alveolar hypoventilation
- Acute vs chronic respiratory acidosis
- Signs and symptoms?
- Treatment?
- Nursing considerations?

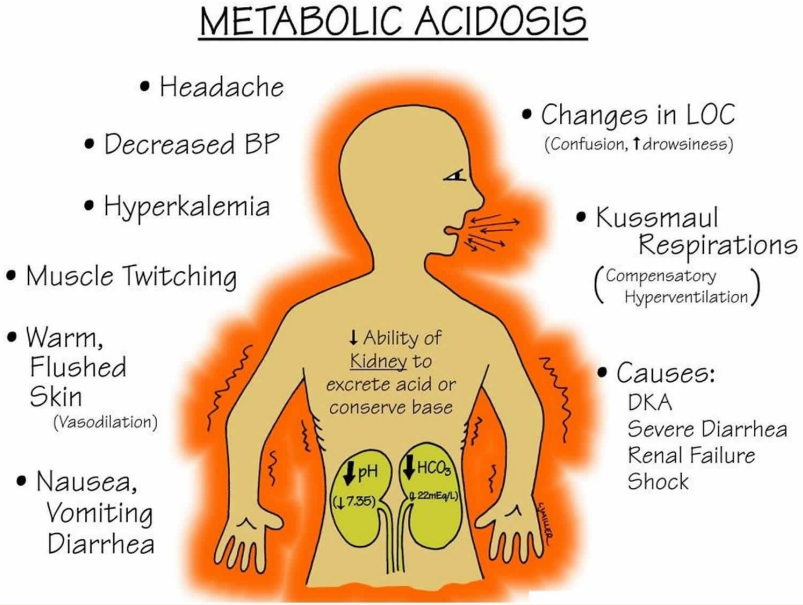


Respiratory Alkalosis

- Results from alveolar hyperventilation and hypocapnia
- Causes?
- Signs and symptoms?
- Treatment?
- Nursing considerations?

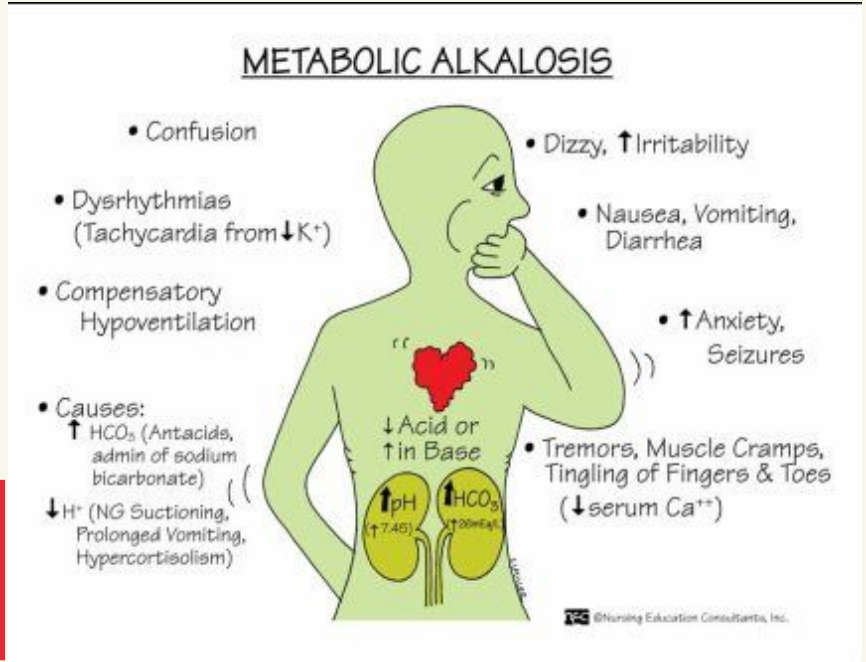


Metabolic Acidosis



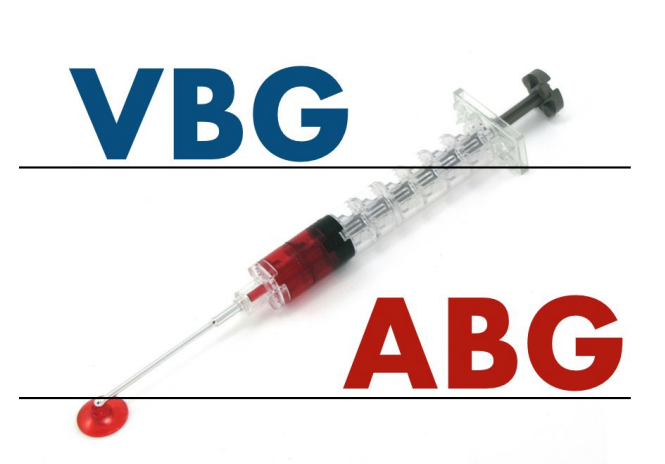
- Due to loss of bicarb from ECF, an accumulation of metabolic acids, or both
- Anion gap (Na - HCO3)
- Causes?
- Signs and symptoms?
- Treatment?
- Nursing considerations?

Metabolic Alkalosis



- Loss of hydrogen ions, gain in bicarb, or both
- If PaCO2 is >45, typically means lungs are compensating for alkalosis
- Commonly associated with hypokalemia
- Causes?
- Signs and symptoms?
- Treatment?
- Nursing considerations?

Venous Blood Gas (VBG)



Differences?

Values?

VBG vs ABG