Fluid, Electrolyte, & Acid-Base Balance

1. Body Fluids
    1. water content
        1. infant- 73%
        2. young male 60%
        3. young female 50% (greater lipid, less muscle mass)
        4. elderly- 45%
    2. compartments
        1. intracellular
        2. extracellular
            1. plasma
            2. interstitial fluid
    3. composition
        1. recall water as universal solvent
        2. solutes
            1. electrolytes
                1. dissociate (ionize)
                2. inorganic salts
                3. inorganic & organic acids & bases
                4. some proteins
            2. nonelectrolytes
                1. do not dissociate
                2. tend to be organics
                    1. glucose
                    2. lipids
                    3. creatinine
                    4. urea
            3. electrolytes have greater osmotic power because they dissociate into more ions
        3. water follows osmotic gradients
        4. intra vs. extracellular fluids
            1. extracellular similar except for protein in plasma
            2. intracellular high in K^+ and phosphate
            3. intracellular & extracellular nearly opposite
                1. reflects Na^+/K^+ pumps (driven by ATP)
    4. movement among compartments
2. Water Balance
    1. overview
        1. intake 2500 ml/ day
            1. 60% ingested liquid
            2. 30% solid food
            3. 10% metabolic water/ water of oxidation
        2. output
            1. 28% lost from lungs & skin
            2. 8% perspiration
            3. 4% feces
            4. 60% urine
        3. figure
        4. osmolarity maintained at 285 - 300 mOsm/L
    2. intake regulation
        1. thirst
            1. triggered by 10% decrease in plasma volume
            2. 1 - 2% increase in plasma osmolarity
            3. hypothalamic thirst center has osmoreceptors
    3. output regulation
        1. obligatory water loss: lungs, skin, kidneys
        2. fluid intake, diet, & water loss
    4. disorders
        1. dehydration
        2. hypotonic hydration
            1. ecstasy breakdown product is stronger than ADH, causes water to accumulate in brain,.... death
        3. edema
            1. accumulation of fluid in interstitial space
            2. can result from hypoproteinemia
                1. protein malnutrition
                2. liver disease
                3. glomerulonephritis
3. Electrolyte Balance
    1. Sodium Regulation
        1. background
            1. receptors have yet to be found (!)
            2. 65% of Na^+ in renal filtrate is reabsorbed in proximal tubule
            3. 25% reclaimed in loops of Henle
            4. Aldosterone controls fate of remaining 10%
        2. Aldosterone
            1. if Aldosterone high all Na^+ is reabsorbed in:
                1. distal convoluted tubules
                2. collecting ducts

2. Aldosterone release controlled by JGA
    1. responds to:
        1. sympathetic nervous system
        2. decreased filtrate osmolarity
        3. decreased stretch
    2. releases:
        1. renin
        2. angiotensin II
        3. aldosterone release
        4. time course: hours to days
        5. figure
3. Cardiovascular Baroreceptors
    1. in heart, aorta, & carotids
    2. when stretched, alert brain stem
    3. sends sympathetic signals to kidney decline
    4. afferent arterioles relax
    5. increased filtration
    6. reduced blood pressure
    7. vice versa
4. ADH
    1. release increases water reabsorbtion in collecting ducts
    2. osmoreceptors in hypothalamus sense ECF osmolarity & trigger release of ADH from posterior pituitary
    3. figure
5. ANP- atrial natriuretic peptide
    1. inhibits
        1. vasoconstriction
        2. Na^+ retention
        3. water retention

2. Potassium is also regulated

4. Acid-Base Balance
1. intro
    1. typically narrow range pH = 7.35 - 7.45
    2. acidosis pH < 7.35
    3. alkalosis pH > 7.45
2. blood buffers
    1. chemical, very rapid
    2. bind hydrogen when pH drops & vice versa
    3. recall strong acids & bases dissociate completely
    4. weak acids & bases are slower to dissociate
    5. figure
    6. bicarbonate buffer system
        1. carbonic acid (H_2CO_3) & its salt, sodium bicarbonate ($NaHCO_3$)
            1. HCl + $NaHCO_3$ goes to H_2CO_3 + NaCl
            2. strong acid & weak base goes to weak acid & salt
            3. NaOH + H_2CO_3 goes to $NaHCO_3$ + H_2O
            4. strong base & weak acid goes to weak base and water
        2. strongs replaced by weaks, thus pH changes slowly
3. respiratory system
    1. $CO_2 + H_2O \Leftrightarrow H_2CO_3 \Leftrightarrow H^+ + HCO_3^-$ (bicarbonate ion)
    2. if CO_2 accumulates or H^+ released, then breathing rate increases to blow off CO_2
    3. if alkalosis, respiratory centers slow
    4. quick response
4. renal mechanisms
    1. can excrete bicarbonate
    2. can conserve bicarbonate
        1. reabsorbtion of filtered HCO_3^- is coupled to H^+ secretion
    3. can generate new bicarbonate
    4. renal pH can vary between 4.5 to 8.0 !
    5. slower, long term response

5. Summary
1. big variables
    1. blood volume
    2. ion concentration
2. big control issues
    1. intrinsic vs. extrinsic control
    2. fast vs. slow responses