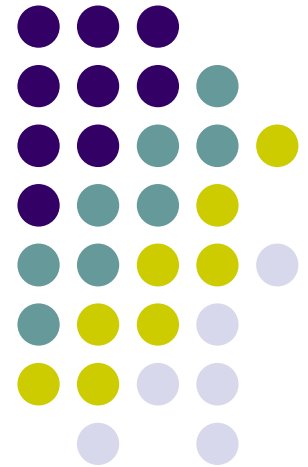
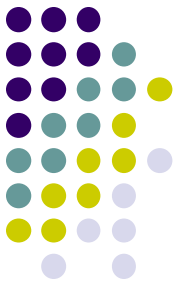


Highs & Lows of Electrolytes Management

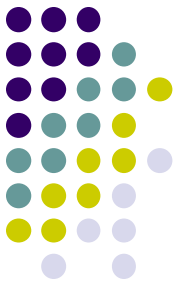
Lisa Burry
Mount Sinai Hospital
November 2016



Electrolytes

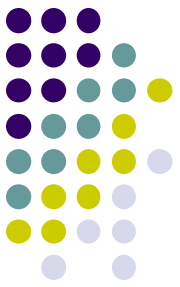


- Potassium
- Calcium
- Phosphate
- Magnesium



Potassium

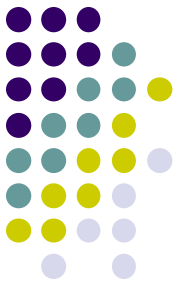
- Serum range 3.5 – 5.5 mmol/L
- Functions:
 - Protein and Glycogen Synthesis
 - Cell Metabolism and Growth
 - Electrical Action Across the Cell Membrane



Potassium - Hypokalemia

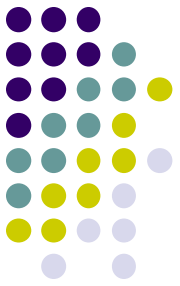
- The body has no method for storing potassium
- For every 1mmol/L decrease from 3.5mmol/L the corresponding body loss is 100 – 150mmol/L
- Drugs cause loss by intracellular shifting, increased renal excretion and stool loss
- Drugs
 - Epinephrine, Salbutamol, Pseudoephedrine, Theophylline, Diuretics, High-dose Penicillins, Aminoglycosides, Sodium Polystyrene Sulfonate and Corticosteroids with Mineralocorticoid properties (including hydrocortisone)

Potassium - Hypokalemia



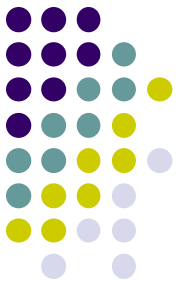
- Symptoms
 - Mild Hypokalemia is Asymptomatic
 - Hypertension, Cardiac Arrhythmias
 - Impaired Muscular Activity
 - Muscle Weakness, Cramping, Easily Fatigued, Myalgias

Potassium - Hypokalemia

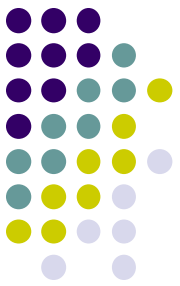


- Treatment
 - If concomitant hypomagnesemia, treat first to prevent refractory hypokalemia
 - Potassium Chloride is supplied as
 - Elixir 20mEq/15mL or 40mEq/30mL
 - Slow K Tablets 8mEq/tablet
 - Oral supplementation
 - If potassium >2.5 mmol/L give 60 – 80 mEq/day in divided doses
 - If potassium < 2.5 mmol/L give 40 – 60 mEq now and monitor serum levels to adjust dose

Potassium - Hypokalemia



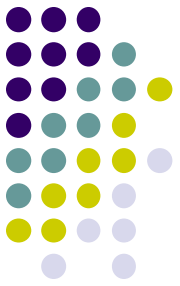
- Treatment
 - IV Supplementation if potassium 2.5 – 3 mmol/L
 - Potassium Chloride 10 mEq/100 ml sterile water over one hour can be given on all units
 - IV Supplementation if potassium <2.5 mmol/L
 - Potassium Chloride 20 mEq/100ml sterile water over one hour in a central line with ECG monitoring normally in ICU or SDU where telemetry is available



Potassium - Hyperkalemia

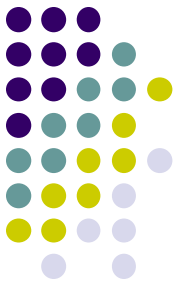
- Common in
 - Renal Failure
 - Adrenal Insufficiency
 - Addison's Disease
 - Hypoaldosteronism
- Drugs
 - ACE Inhibitors, Angiotensin II Receptor Blockers, Potassium Sparing Diuretics, Prostaglandin Inhibitors (NSAIDs), Trimethoprim-Sulfamethoxazole, Heparin, Pentamidine

Potassium - Hyperkalemia



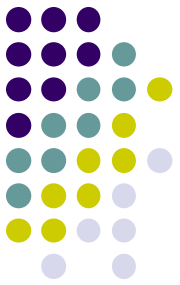
- Symptoms
 - Weakness
 - Irritable/Twitchy Muscles
 - Fearfulness and Parasthesiae
 - Cardiac Arrhythmias – Ventricular Fibrillation
 - Cardiac Standstill

Potassium - Hyperkalemia

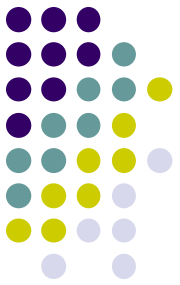


- Asymptomatic Treatment
 - Ion Exchange Resins remove potassium over several hours
 - Sodium Polystyrene Sulfonate (Kayexalate) is available as 15g powder to be given as a suspension up to four times daily
 - Close monitoring of electrolytes is necessary
 - Loop Diuretics promote renal excretion
 - Furosemide 20 – 40mg orally is a starting dose
 - The duration of activity is about 4 – 6 hours

Potassium - Hyperkalemia

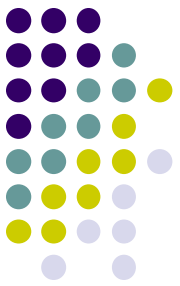


- Symptomatic Treatment
 - Calcium 2 – 4 mg/kg elemental calcium
 - Calcium is available as
 - Calcium Chloride (1g/10mL) IV where 1g = 270mg elemental calcium
 - Calcium Gluconate (1g/10ml) IV where 1g = 93mg elemental calcium
 - Supplementation
 - Calcium Chloride (1g/10ml) 5-10mL over 2 – 4 min
 - Calcium Gluconate (1g/10ml) 10-20mL over 2 – 4 min



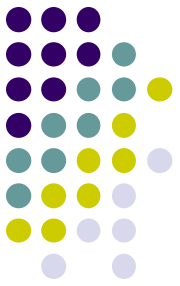
Calcium

- Serum range 2.2 – 2.55 mmol/L
- Functions
 - Propagation of Neuromuscular Activity
 - Regulation of Endocrine and Exocrine Secretory Functions
 - Coagulation Cascade and Platelet Adhesion
 - Bone Metabolism
 - Muscle Cell Contraction
 - Mediation of Electrophysiologic slow channel response in Cardiac and Smooth Muscle



Calcium - Hypocalcemia

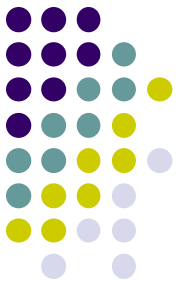
- Causes
 - Postoperative Hypoparathyroidism
 - Vitamin D Deficiency
 - Magnesium Deficiency
 - Hypoalbuminemia
- Drugs
 - Furosemide, Calcitonin, Bisphosphonates, Gallium Nitrate, Oral Phosphorus, Phenobarbital, Phenytoin, Chelating agents, Fluoride, Ketoconazole, Pentamidine



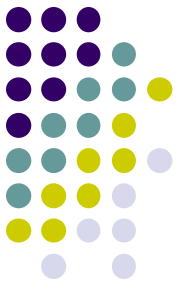
Calcium - Hypocalcemia

- Symptoms
 - Muscle Cramping and Spasms
 - Paresthesias
 - Hair Loss
 - Memory Loss, Confusion
 - Seizures
 - Arrhythmias

Calcium - Hypocalcemia

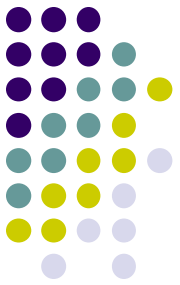


- Treatment
 - Calcium is available as
 - Calcium Chloride (1g/10mL) IV where 1g = 270mg elemental calcium
 - Calcium Gluconate (1g/10ml) IV where 1g = 93mg elemental calcium
 - 100 – 300mg elemental calcium over 5 – 10 minutes followed by continuous infusion of elemental calcium at a rate of 0.5 – 2.0 mg/kg/h



Calcium - Hypercalcemia

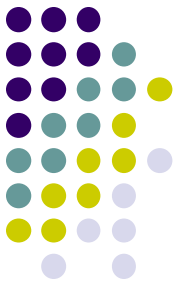
- Mechanisms
 - Increased Bone Resorption
 - Increased GI Absorption
 - Decreased Renal Elimination
- Drugs
 - Thiazide diuretics, Lithium, Vitamin D, Vitamin A, Calcium, Aluminum/Magnesium antacids, Theophylline, Tamoxifene, Gancyclovir



Calcium - Hypercalcemia

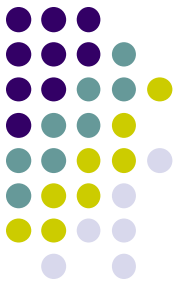
- Symptoms and Complications
 - Anorexia
 - Nausea and Vomiting
 - Constipation
 - Polyuria, Polydipsia, Nocturia
 - Calcium Deposition in Blood Vessels and Organs
 - Kidney stones
 - Hypertension
 - Cardiac Arrhythmias

Calcium - Hypercalcemia

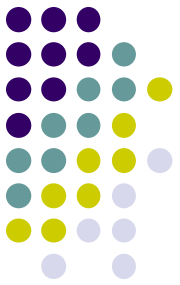


- Treatment
 - Rehydration with Normal Saline
 - Calcitonin if Saline Hydration is Contraindicated
 - 4 IU/kg every 12 hours SC or IM
 - Promote Urinary Excretion with Loop Diuretics as additional therapy

Calcium - Hypercalcemia



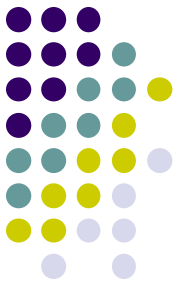
- Treatment
 - Pamidronate
 - If calcium <3.0 mmol/L give 30mg/250mL over 2 hours
 - If calcium 3.0 - 3.5 mmol/L give 30mg or 60mg /250mL over 2 – 4 hours
 - If calcium 3.5 - 4.0 mmol/L give 60mg/250mL or 90mg/500mL over 4 hours
 - If calcium >4.0 mmol/L give 90mg/500mL over 4 hours
 - Infusion rate should not exceed 22.5mg/hour
 - Gallium Nitrate
 - 200mg/m² for 5 consecutive days in 1L of NS or D5W



Phosphorus

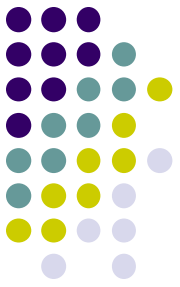
- Serum range 0.8 – 1.6 mmol/L
- Functions
 - Part of phospholipid cell membranes, nucleic acids and phosphoproteins
 - Source of high energy bonds in ATP
 - Regulates intermediary metabolism of carbohydrates, fats and proteins
 - Regulates glycolysis, ammoniogenesis, and 1-hydroxylation of 2,5-hydroxyvitamin D₃

Phosphorus - Hypophosphatemia



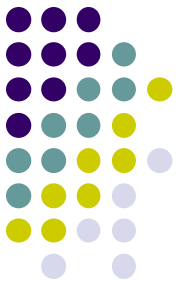
- Patients at risk include those with peptic ulcer disease, hyperparathyroidism, renal insufficiency, alcoholics and patients recovering from third degree burns
- Drugs
 - Dextrose solutions, glucagon, insulin, catecholamines, calcitonin, erythropoietin and anabolic steroids, acetazolamide, osmotic diuretics, glucocorticoids, sodium bicarbonate

Phosphorus - Hypophosphatemia



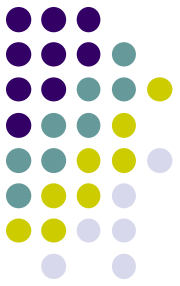
- Symptoms
 - Irritability
 - Weakness
 - Numbness
 - Confusion
 - Hallucinations
 - Seizures
 - Coma

Phosphorus - Hypophosphatemia



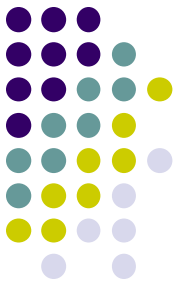
- Treatment
 - Phosphorus is available as
 - Phosphate Effervescent (500 mg tablet)
 - Potassium Phosphate (3 mmol phosphate and 4.4 mEq potassium /5mL)
 - Sodium Phosphate (3 mmol phosphate and 44 mEq sodium /mL)

Phosphorus - Hypophosphatemia



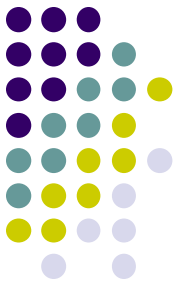
- Treatment
 - 1.5 – 2g phosphorus orally daily in divided doses
 - 15 mmol phosphorus in 250 mL in D5W or NS over 3 hours
 - When supplementing with potassium phosphate run 10 mEq potassium over 1 hour and 20 mEq potassium over 1 hour in a central line with ECG monitoring

Phosphorus - Hyperphosphatemia



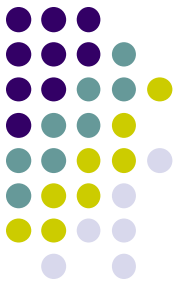
- Unusual condition as phosphorus is closely regulated by the kidneys
- Found in
 - Renal Disease
 - Hypoparathyroidism
 - Lactic Acidosis and Diabetic Ketoacidosis
 - Rhabdomyolysis
 - Tumor Lysis Syndrome
 - Excessive Phosphorus and Vitamin D Intake

Phosphorus - Hyperphosphatemia



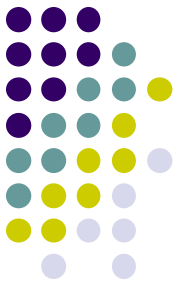
- Symptoms are the result of calcium and phosphorus complexation
 - Pruritus
 - Effects of concomittant hypocalcemia
 - Soft tissue calcification
 - Conjunctiva, Skin, Heart, Cornea, Lung, Gastric Mucosa, Kidney

Phosphorus - Hyperphosphatemia



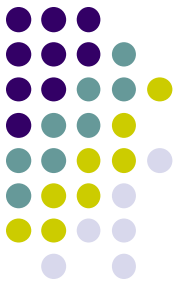
- Treatment
 - Calcium Carbonate Tablets (40% Elemental Calcium) 500 – 100mg three times daily
 - Aluminum Hydroxide Tablets 500-1800mg 3 – 6 times a day
 - Sevelamer (400 and 800mg tablets) in divided doses given with meals
 - If serum phosphorus >1.9 and <2.4 mmol/L give 2.4g
 - If serum phosphorus ≥ 2.4 and <2.9 mmol/L give 3.6 – 4.8g
 - If serum phosphorus ≥ 2.9 give 4.8g

Magnesium



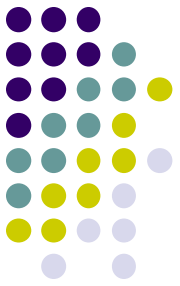
- Serum range 0.8 – 1.2 mmol/L
- There is no hormonal regulation of the distribution between bone and circulating and intracellular
- Functions
 - Cofactor for enzymes and receptors, especially systems dependent on ATP
 - Mitochondrial function
 - Protein Synthesis
 - Cell Membrane Function
 - Parathyroid Hormone Secretion

Magnesium - Hypomagnesemia



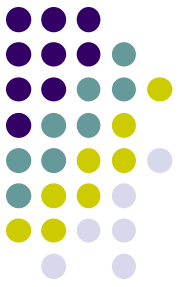
- Often seen concomitantly with hypokalemia and hypocalcemia
- Associated with disorders of the intestines and kidney
 - Enteritis, Ulcerative Colitis, Acute and Chronic Diarrhea, Pancreatic Insufficiency
- Drugs causes include
 - Aminoglycosides, Amphotericin B, Cyclosporine, Diuretics, Digoxin, Cisplatin, Alcohol and Chronic Laxative Abuse

Magnesium - Hypomagnesemia



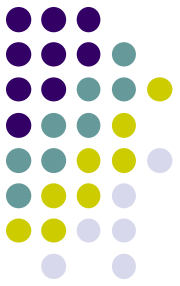
- Symptoms
 - Tremor and Neuromuscular Irritability
 - Hypertension
 - Tetany
 - Generalized Convulsions
 - Cardiac Arrhythmias

Magnesium - Hypomagnesemia



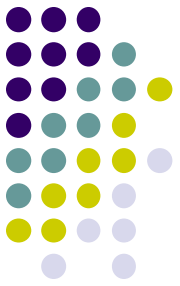
- Treatment
 - Magnesium is supplied as
 - Magnesium Oxide Tablets (100mg elemental)
 - Magnesium Glucoheptonate (Magnesium Rougier) 5mg/ml
 - Magnesium Sulfate IV (500mg/mL)
 - Supplementation
 - If magnesium >1 mEq/L give 300mg elemental magnesium orally four times a day
 - If magnesium <1 mEq/L give up to 250mg/kg or 5 g IV over 3 hours

Magnesium - Hypermagnesemia



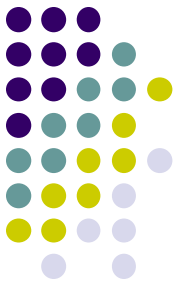
- Very rare
- Seen in Acute Kidney Failure
 - Decreased excretion with decreased filtration rate
- Drugs
 - Magnesium Containing Antacids and Lithium

Magnesium - Hypermagnesemia



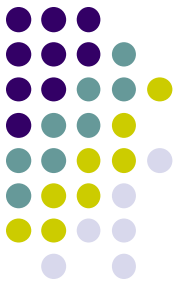
- Symptoms
 - Deep Tendon Reflexes Lost
 - CNS Depression
 - Hypotension
 - Drowsiness
 - Lethargy
 - Somnolence
 - Respiratory Paralysis

Magnesium - Hypermagnesemia



- Treatment
 - IV Elemental Calcium available as
 - Calcium Chloride (1g/10mL) IV where 1g = 270mg elemental calcium
 - Calcium Gluconate (1g/10ml) IV where 1g = 93mg elemental calcium
 - Supplement 100 – 200 mg elemental calcium hourly until symptom relief
 - Diuresis using saline and loop diuretics
 - Furosemide 40mg IV

Electrolytes



- Questions?