Disorders of Vitamin Metabolism

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Learning Objective

Identify the RDA range, dietary sources, roles in metabolism, clinical manifestations, related disorders, relationship to other conditions, diagnosis, treatment, and toxicity of Vitamins B1, B2, B3, B6 and A,C, D, E, and K.

Learning Objective

Recognize the RDA range and dietary sources of Vitamin B12 and Folate and their relationships to other medical conditions.

Case #1

- **Joe, a 56-year-old homeless man, is brought to your Emergency Department by the police because he was wandering aimlessly through the streets and could not answer their questions coherently.**
- **He tells you that he is healthy but does admit to drinking daily. His last drink was yesterday.**

Case #1 (cont')

- On exam, he is unkempt and appears older than 56. He is thin and his mouth is dry.
- His vital signs are all within normal limits.
- His neurologic exam reveals confusion, poor memory, confabulation, decreased sensation in his legs, and absent lower extremity reflexes.
- He denies auditory or visual hallucinations.

Case #1(cont')

- **Lab results are significant for negative drug screen and blood alcohol level of 0; CBC and chemistries within normal limits.**

- **Joe is suffering from a deficiency of which vitamin?**

Case #1(cont’)

- **Diagnosis: Thiamin Deficiency (Dry Beriberi)**
- **Clues:**
  - **Homeless & Alcoholic (at risk for malnutrition)**
  - **Confusion & Amnesia**
  - **Confabulation**
  - **Decreased sensation and loss of reflexes in lower extremities**

Disorders of Vitamin Metabolism

- General Principles
- Specific Vitamin Disorders
- Case Studies
- Questions

Disorders of Vitamin Metabolism – General Principles

Usually a patient will have multiple vitamin deficiencies, not just one

Disorders of Vitamin Metabolism – General Principles (cont')

- Common causes for vitamin deficiencies
  - Malabsorption
  - Alcoholism
  - Hemodialysis
  - Inborn errors of metabolism

Disorders of Vitamin Metabolism – General Principles (cont')

- Medications
- Total Parenteral Nutrition
- Unusual food intake (fad diet)

Disorders of Vitamin Metabolism – General Principles (cont’)

- Symptoms associated with vitamin deficiencies develop gradually
- Physical exam findings are not observed until late in the course of the disorder

Vitamins

- Thiamin (B1)
- Riboflavin (B2)
- Niacin (B3)
- Pyridoxine (B6)
- Vitamin C
- Vitamin A
- Vitamin E
- Vitamin D
- Vitamin K
- Vitamin B12
- Folate

Thiamin (B1)

- **RDA Range**
  - **Adult males: 1.2 - 1.5 mg/day**
  - **Adult females: 1.0 - 1.6 mg/day**

Thiamin (B1) (Cont’)

- Dietary Sources of Thiamin
  - Cereals
  - Fortified bread/rice
  - Nuts
  - Meats
  - Legumes

Thiamin (B1) (cont’)

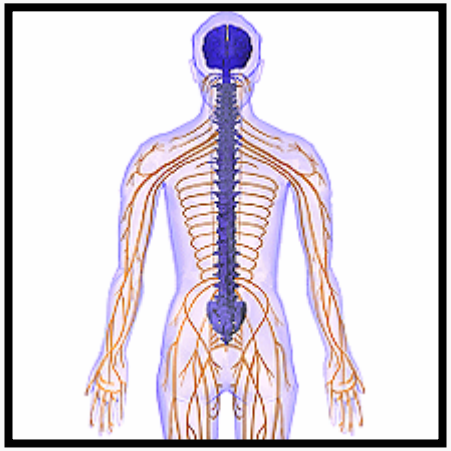
- Role of Thiamin
  - Precursor of thiamin pyrophosphate, an important coexzyme utilized in biochemical reactions for carbohydrate oxidation
  - Involved in peripheral nerve conduction

Thiamin (B1) Deficiency

- Secondary to
  - Alcoholism (due to poor dietary intake, absorption, metabolism, storage)
  - Malabsorption
  - Dialysis
  - Chronic malnutrition

Thiamin (B1) Deficiency – Clinical Manifestations

- Early
  - Anorexia
  - Muscle cramps
  - Paresthesias
  - Irritability



- Advanced
  - Wet beriberi – cardiovascular system
  - Dry beriberi – nervous system

Thiamin (B1) Deficiency – Wet Beriberi

- Occurs when thiamin deficiency is exacerbated by extreme physical exertion and high carbohydrate intake
  - Marked peripheral vasodilation occurs
  - High output cardiac failure develops

Thiamin (B1) Deficiency – Wet Beriberi

- **Dyspnea, tachycardia, pulmonary edema, cardiomegaly, peripheral edema present**

Thiamin (B1) Deficiency – Dry Beriberi

- Occurs when thiamin deficiency is accompanied by inactivity and low caloric intake
- Clinical manifestations
  - Peripheral nervous system
  - Central nervous system

Thiamin (B1) Deficiency – Dry Beriberi

- **Peripheral nervous system manifestations:**
  - **Symmetric motor and sensory neuropathy (legs affected more than arms)**
  - **Decreased position and vibration sense**

Thiamin (B1) Deficiency – Dry Beriberi

- **Peripheral nervous system manifestations (cont’):**
  - **Pain**
  - **Paresthesias**
  - **Hyporeflexia**

Thiamin (B1) Deficiency – Dry Beriberi (cont')

- **Central nervous system manifestations:**
  - **Wernicke's Encephalopathy**
    - **Triad of confusion, ataxia, ophthalmoplegia (6th nerve most common)**

Thiamin (B1) Deficiency – Dry Beriberi (cont')

- Central nervous system manifestations:
  - Korsakoff's Syndrome
    - Psychosis with antegrade and retrograde amnesia and confabulation

Thiamin (B1) Deficiency – Dry Beriberi (cont')

- Central nervous system manifestations (cont'):
  - Confabulation is unconsciously filling in memory gaps with facts that are imagined or untrue

Thiamin (B1) Deficiency – Diagnosis

- **Diagnostic tests:**
  - **Erythrocyte transketolase activity coefficient (positive if > 15-25%)**
  - **Urinary thiamin excretion**
- **Testing not always done – patient's response to thiamin replacement is diagnostic**

Thiamin (B1) Deficiency – Treatment

- **50-100 mg of parenteral Thiamin/day, for several days, followed by**
- **5-10 mg of oral Thiamin/day**
- **Treatment is successful in about 50% of patients**
- **Replacement of other vitamins as needed**

Thiamin (B1) Toxicity

- None known

Riboflavin (B2)

- RDA Range
  - Adult males: 1.4 – 1.8 mg/day
  - Adult females: 1.2 – 1.8 mg/day
- Dietary sources of Riboflavin
  - Meat
  - Fish
  - Dairy products

Riboflavin (B2) (cont’)

- Role of Riboflavin
  - Riboflavin coenzymes, flavin mononucleotide and flavin adenine dinucleotide, are critical for oxidation-reduction reactions
  - Essential building block of other enzymes

Riboflavin (B2) Deficiency

- Secondary to
  - Dietary insufficiency
  - Chronic malnutrition
  - Alcoholism
  - Medications (Phenobarbital [generic], Phenothiazines, tricyclic antidepressants, Adriamycin®, Chloramphenicol [generic])

Riboflavin (B2) Deficiency – Clinical Manifestations

- Cheilosis
- Angular stomatitis
- Bleeding gums
- Glossitis
- Conjunctival irritation
- Corneal vascularization

Glossitis

Riboflavin (B2) Deficiency – Clinical Manifestations

- **Weakness**
- **Anemia**
- **Seborrheic dermatitis**
- **Scrotal/vulvar dermatoses**

Riboflavin (B2) Deficiency – Diagnosis

- **Diagnostic tests:**
  - **Measurement of erythrocyte glutathione reductase (a riboflavin-dependent enzyme) – if > 1.2 – 1.3, riboflavin deficiency is suggested**

Riboflavin (B2) Deficiency – Diagnosis (Cont’)

- **Diagnostic tests (cont’):**
  - **Urinary riboflavin excretion**
  - **Serum levels of plasma, red cell flavins**

- **Testing not always done**

Riboflavin (B2) Deficiency - Treatment

- **5-15 mg of oral riboflavin/day**
- **Riboflavin rarely given parenterally**
- **Increase dietary intake of meat, fish, dairy products**

Riboflavin (B2) Toxicity

- None known

Niacin (B3)

- RDA Range
  - Adult males: 15 – 20 mg/day
  - Adult females: 13 – 20 mg/day
- Dietary sources of niacin:
  - Proteins containing tryptophan
  - Cereals
  - Vegetables
  - Dairy products

Niacin (B3) (cont')

- Niacin is a term for nicotinic acid and other similar compounds
- Niacin can be synthesized from the amino acid tryptophan

Niacin (B3) (cont’)

- **Role of Niacin**
  - **Essential component of 2 coenzymes (nicotinamide adenine dinucleotide & nicotinamide adenine dinucleotide phosphate) utilized in oxidation-reduction reactions**

Niacin (B3) (cont’)

- **Role of Niacin (cont’)**
  - **Nicotinic acid is used therapeutically to treat hypercholesterolemia and hypertriglyceridemia**

Niacin (B3) Deficiency

- Secondary to
  - Alcoholism
  - Nutrient-drug interactions (e.g., Isoniazid [generic] interacts with Niacin to alter body Niacin levels)
  - Inborn errors of metabolism

B3

Niacin (B3) Deficiency – Clinical Manifestations

- Early
  - Anorexia
  - Weight loss
  - Fatigue
  - Stomatitis
  - Glossitis
  - Loss of papillae on tongue

Niacin (B3) Deficiency – Clinical Manifestations (cont’)

- **Advanced**
  - **Pellagra: classic triad of dermatitis, diarrhea, and dementia**

Niacin (B3) Deficiency – Clinical Manifestations (cont')

- Pellagra
  - Dermatitis
    - Symmetric, in sun-exposed skin
    - Lesions are dark, dry, scaly
  - Diarrhea
    - Can be severe
    - Atrophy of the intestinal villi can occur resulting in malabsorption

Niacin (B3) Deficiency – Clinical Manifestations (cont')

- Pellagra (cont')
  - Dementia
    - Early: irritability, insomnia, apathy
    - Late: confusion, memory loss, hallucinations, psychosis
  - Pellagra can be fatal

Niacin (B3) Deficiency – Diagnosis

- **Low urinary N-methylnicotinamide (a metabolite of niacin) level**
- **Low serum and red blood cell levels of nicotinamide adenine dinucleotide & nicotinamide adenine dinucleotide phosphate**

Niacin (B3) Deficiency – Treatment

10 – 150 mg of oral nicotinamide/day

Niacin (B3) Toxicity

- Seen in patients taking Niacin for hypercholesterolemia or hypertriglyceridemia
  - Cutaneous flushing
  - Gastric irritation
  - Elevated liver enzymes
  - Hyperglycemia
  - Gout

Pyridoxine (B6)

- RDA Range
  - Adult males: 2.0 mg/day
  - Adult females: 1.5 – 2.2 mg/day
- Dietary sources of Pyridoxine
  - Fruits and vegetables
  - Meats
  - Fortified cereals and breads

Pyridoxine (B6) (cont’)

- Pyridoxine is a group of related substances
- Role of Pyridoxine substances
  - Pyridoxal 5-phosphate is a coenzyme involved in amino acid metabolism
  - Pyridoxal phosphate is involved in heme synthesis

Pyridoxine (B6) Deficiency

- Secondary to
  - Alcoholism
  - Medications (oral contraceptives and diuretics, and generics such as Penicillamine, Isoniazid, Cycloserine, Primidone, Chloramphenicol, Hydralazine)
  - Inborn errors of metabolism

Pyridoxine (B6) Deficiency – Clinical Manifestations

- Mild deficiency
  - Cheilosis
  - Mouth soreness
  - Glossitis
  - Seborrhea
  - Weakness
  - Irritability

Severe Angular Cheilosis

Pyridoxine (B6) Deficiency – Clinical Manifestations (cont’)

- Severe deficiency
  - Peripheral neuropathy
  - Seizures
  - Anemia

Pyridoxine (B6) Deficiency – Diagnosis

Blood pyridoxal phosphate level less than 50 ng/mL

Pyridoxine (B6) Deficiency – Treatment

- 10 – 20 mg of oral Vitamin B6/day
- Higher doses, up to 100mg/day, for patients taking medications that interfere with pyridoxine metabolism
  - Vitamin B6 should be given to these patients prophylactically
- 600 mg/day for patients with inborn errors of pyridoxine metabolism

Pyridoxine (B6) Toxicity

- **Sensory neuropathy can develop, and may be irreversible**
- **Doses as low as 200 mg/day can precipitate toxicity**
- **Doses of 2 gm/day or more are most likely to cause toxicity**

Vitamin C (Ascorbic Acid)

- RDA Range
  - Adult males: 60 mg/day
  - Adult females: 60 – 95 mg/day
- Dietary sources
  - Fresh fruits and vegetables

Vitamin C (cont’)

- Role of Vitamin C
  - Potent anti-oxidant
  - Important for oxidation-reduction reactions
  - Utilized in collagen synthesis
  - Plays a role in wound healing
  - Increases iron absorption
  - Involved in tyrosine metabolism

Vitamin C (cont’)

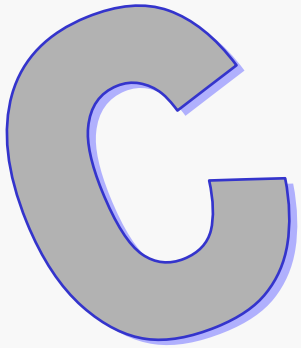
- Role of Vitamin C (cont’)
  - Involved in drug metabolism
  - Studies have suggested that high intake of vitamin C may:
    - Reduce cancer risk
    - Prevent coronary artery disease by preventing oxidation of LDL cholesterol

Vitamin C Deficiency

- Secondary to
  - Poor dietary intake
  - Alcoholism
  - Chronic disease (chronic renal failure, cancer)
  - Smokers
  - Salicylates

Vitamin C Deficiency – Clinical Manifestations

- Early
  - Nonspecific –
    - Weakness
    - Malaise
    - Muscle aches and pains
- Late
  - Scurvy



Vitamin C Deficiency – Clinical Manifestations (cont')

- Scurvy
  - Poor wound healing
  - Perifollicular hemorrhages & hyperkeratotic papules
  - Bleeding gums
  - Petechiae

Scorbutic Gingivitis in Scurvy

Vitamin C Deficiency – Clinical Manifestations (cont’)

- Scurvy
  - Purpura
  - Splinter hemorrhages
  - Hemarthroses
  - Subperiosteal hemorrhages
  - Anemia

Vitamin C Deficiency – Clinical Manifestations (cont’)

- Advanced scurvy
  - Oliguria
  - Edema
  - Neuropathy
  - Intracerebral hemorrhage
  - Death

Vitamin C Deficiency - Diagnosis

- **Scurvy can be diagnosed clinically**
- **Hemarthrosis without history of trauma is an important clue**
- **Plasma ascorbic acid levels less than 0.1 mg/dL**

Vitamin C Deficiency - Treatment

300 – 1000 mg of oral ascorbic acid/day

Vitamin C Toxicity

- Very high doses may cause
  - Gastric irritation
  - Diarrhea
  - Flatulence

Vitamin C Toxicity (cont’)

- Vitamin C can cause
  - False negative fecal occult blood tests
  - False negative and false positive tests for glucose in the urine

Vitamin C Toxicity (cont’)

Vitamin C has not been proven to cause kidney stones, although ascorbic acid is metabolized into oxalate

Vitamin A (Retinol)

- RDA Range
  - Adult males: 1000 mg RE/day
  - Adult females: 800 – 1300 mg RE/day
- Dietary sources of Vitamin A
  - Dark and brightly colored vegetables

Vitamin A (Retinol) (cont’)

- Can be synthesized from Beta-carotene
- Role of Vitamin A
  - Essential for retinal function
  - Plays a role in cell growth/differentiation
  - Involved in wound healing

Vitamin A (Retinol) (cont')

- **Vitamin A derivatives can be used therapeutically:**
  - **Isotretinoin [generic] for acne**
  - **Tretinoin [generic] for acne, wrinkles**

Vitamin A Deficiency

- **Secondary to:**
  - **Fat malabsorption syndromes**
  - **Mineral oil laxative abuse**
  - **Malnutrition**
  - **Medications (aluminum antacids, and generics Neomycin and Cholestyramine)**

Vitamin A Deficiency – Clinical Manifestations

- **Early**
  - **Night blindness**
  - **Xerosis (dry conjunctiva)**
  - **Bitot’s Spots (white patches on conjunctiva)**
  - **Dry, scaly skin**
  - **Poor wound healing**

Vitamin A Deficiency – Clinical Manifestations (cont’)

- Advanced
  - Keratomalacia (ulceration and necrosis of cornea)
  - Endophthalmitis
  - Blindness
  - Hyperkeratization of skin
  - Loss of taste

Vitamin A Deficiency - Diagnosis

Serum Vitamin A levels less than 30 – 65 mg/dL

Vitamin A Deficiency - Treatment

- For early disease
  - 30,000 IU mg of Vitamin A/day for one week
- For advanced disease
  - 20,000 IU/kg/day for 5 days minimum

Vitamin A Toxicity

- **Beta-carotene toxicity – essentially benign**
  - **Skin discoloration (yellow, orange), especially palms and soles**

Vitamin A Toxicity (cont’)

- Vitamin A toxicity
  - Early manifestations
    - Dry, scaly skin
    - Hair loss
    - Mouth sores
    - Anorexia
    - Vomiting

Vitamin A Toxicity (cont’)

- Vitamin A toxicity (cont’)
  - Late manifestations
    - Hypercalcemia
    - Increased intra-cranial pressure
    - Hepatomegaly
    - Cirrhosis

Vitamin A Toxicity (cont')

- Vitamin A toxicity (cont')
  - Acute toxicity (secondary to consuming excessive doses of Vitamin A or consuming polar bear liver)

Vitamin A Toxicity (cont’)

- **Vitamin A Toxicity Symptoms:**
  - **Nausea and Vomiting**
  - **Abdominal pain**
  - **Headache**
  - **Papilledema**
  - **Lethargy**

Vitamin A Toxicity (cont’)

- **Teratogenicity**
  - **Isotretinoin is absolutely contraindicated in pregnancy as it can cause severe fetal defects**

Vitamin E

- RDA Range
  - Adult males: 10 mg alpha-tocopherol/day
  - Adult females: 8 - 12 mg alpha-tocopherol/day
- Dietary sources of Vitamin E
  - Vegetable seed oil
  - Nuts

Vitamin E (cont’)

- Role of Vitamin E
  - Functions as an antioxidant
  - Protects cell membranes from free radicals
  - May help to prevent cancer, Alzheimer’s Disease, coronary artery disease, and cataracts

Vitamin E Deficiency

- **Secondary to:**
  - **Malabsorption**
  - **Abetalipoproteinemia (a genetic disorder)**
  - **Cystic fibrosis**
  - **Children with chronic cholestatic liver disease or biliary atresia**

Vitamin E Deficiency – Clinical Manifestations

- Decreased vibration sensation
- Impaired propioception
- Loss of reflexes
- Gait disturbances
- Ophthalmoplegia

Vitamin E Deficiency - Diagnosis

- **Plasma Vitamin E level below 0.5 – 0.7 mg/dL**
- **Vitamin E is transported in lipoproteins, so circulating lipid levels can affect Vitamin E level**

Vitamin E Deficiency - Treatment

- **Parenteral Vitamin E in large doses is used for severe deficiency**
- **Optimum dose has not been established**
- **Antioxidant dosage is 100 – 400 units/day taken by mouth**

Vitamin E Toxicity

- Large doses of Vitamin E can increase the Vitamin K requirement
- Large doses for patients on anticoagulants can increase the risk of bleeding
- Large doses can cause
  - Nausea, Diarrhea
  - Flatulence

Vitamin D

- RDA Range
  - Adult males: 5 – 10 mg/day
  - Adult females: 5 – 10 mg/da
- Primary source of Vitamin D
  - Sunlight
- Dietary source of Vitamin D
  - Fortified milk

Biochemistry of Vitamin D3 – Brief Review

- **Vitamin D3 (cholecalciferol) is synthesized in the skin, with UV light, from 7-dehydrocholesterol**
- **Vitamin D3 is hydroxylated twice – first in the liver, to 25-hydroxycholecalciferol, then in the kidney, to 1, 25-dihydroxycholecalciferol, the most potent form of Vitamin D**

Vitamin D (cont’)

- Primary role of Vitamin D
  - Increase calcium and phosphate absorption from the intestines
- Other tissues that Vitamin D acts on
  - Parathyroid glands
  - Bone, Kidneys
  - Skin, Brain, Pituitary
  - Lymphocytes,Tumors

Vitamin D Deficiency

- Secondary to
  - Insufficient sun exposure
  - Malabsorption, Malnutrition
  - Liver disease
  - Renal disease, nephrotic syndrome
  - Anticonvulsants (generics Phenytoin, Carbamazepine, Valproate, Phenobarbital) can inhibit hepatic hydroxylation of Vitamin D

Vitamin D Deficiency (cont’)

- Vitamin D deficiency can cause
  - Osteoporosis
  - Osteomalacia and Rickets

Vitamin D Deficiency
Osteomalacia & Rickets

- **Osteomalacia occurs in adults**
- **Rickets occurs in children**
- **Defective mineralization of the skeleton**

Vitamin D Deficiency Osteomalacia & Rickets (cont')

- Secondary to many things, including
  - Vitamin D deficiency as discussed above
  - Dietary calcium deficiency
  - Phosphorus deficiency
  - Aluminum toxicity
  - Hypophosphatasia
  - Fibrogenesis imperfecta ossium

Osteomalacia & Rickets – Clinical Manifestations

- Asymptomatic at onset
- Muscle weakness, especially of pelvic girdle
- Bone pain
- Atraumatic fractures
- X-rays assist in diagnosis

Osteomalacia & Rickets - Diagnosis

- **Bone biopsy is diagnostic**
- **Serum 25-hydroxycholecalciferol <50nmol/L indicates Vitamin D deficiency**

Osteomalacia & Rickets - Diagnosis

- Other laboratory abnormalities may include
  - Hypocalcemia
  - Hypophosphatemia
  - Elevated serum alkaline phosphatase

Vitamin D Deficiency - Treatment

- **50,000 IU of oral Vitamin D2, once or twice weekly for 6 – 12 months, followed by 1000 IU/day**
- **Appropriate exposure to sunlight**
- **Phosphate and Calcium replacement, if needed**

Vitamin D Toxicity

Vitamin D excess can cause hypercalcemia

Vitamin D Toxicity - Hypercalcemia

- **Clinical Manifestations of hypercalcemia:**
  - **Early**
    - **Constipation**
    - **Polyuria (nephrogenic diabetes insipidus)**
  - **Advanced**
    - **Stupor, Coma, Azotemia**

Vitamin D Toxicity – Hypercalcemia (cont’)

- **Laboratory findings:**
  - **Serum calcium >10.3 mg/dL**
  - **Short QT interval on ECG**

Vitamin D Toxicity – Hypercalcemia Treatment

- **Depends on underlying cause of hypercalcemia**
- **IV Furosemide [generic] or Lasix® with normal saline promotes calcium excretion (when sodium is excreted, calcium is also excreted)**
- **Renal dialysis may be indicated**

Vitamin K

- RDA Range
  - Adult males: 65 – 80 mg/day
  - Adult females: 55 – 65 mg/day
  - Body stores only about one week's worth of Vitamin K
- Sources of Vitamin K
  - Synthesis by intestinal bacteria
  - Leafy vegetables

Vitamin K (cont’)

- **Role of Vitamin K**
  - **Needed for the synthesis of coagulation factors II, VII, IX, and X**

Vitamin K Deficiency

- Secondary to
  - Malnutrition
  - Malabsorption
  - Broad spectrum antibiotics which suppress colonic flora
  - Medications (generics Phenobarbital, Phenytoin, Primidone and Cholestyramine, and mineral oil)

Vitamin K Deficiency – Clinical Manifestations

- Bleeding at any site
- Prothrombin time prolonged
- PTT may be prolonged to lesser degree
- Fibrinogen, thrombin time, platelet count are unaffected

Vitamin K Deficiency - Diagnosis

- **Decreased levels of Vitamin K**
- **Decreased levels of coagulation factors II, VII, IX, and X**
- **Patient’s response to Vitamin K replacement can be diagnostic**

Vitamin K Deficiency - Treatment

- **15 mg of subcutaneous Vitamin K**
- **A single dose will correct laboratory abnormalities within 12 – 24 hours**
- **Fresh frozen plasma is used to treat hemorrhage**

Vitamin K Toxicity

- **No known toxicity**
- **Patients on Warfarin [generic] should not take an excess of Vitamin K as it may decrease the anticoagulant effect of Warfarin**

Vitamin B12

- RDA Range
  - Adult males: 2.0 micrograms/day
  - Adult females: 2.0 – 2.6 micrograms/day
- Dietary Sources of B12
  - Meat
  - Dairy products

Vitamin B12 (cont')

- **Role of B12**
  - **Serves as a co-factor for conversion of homocysteine to methionine, and of methylmalonyl-CoA to succinyl-CoA**

Vitamin B12 Deficiency

- Secondary to
  - Hereditary pernicious anemia
  - Vegan diet
  - Fish tapeworm parasitosis
  - Pancreatic insufficiency
  - Gastric surgery (due to removal of site of intrinsic factor production)

Vitamin B12 Deficiency

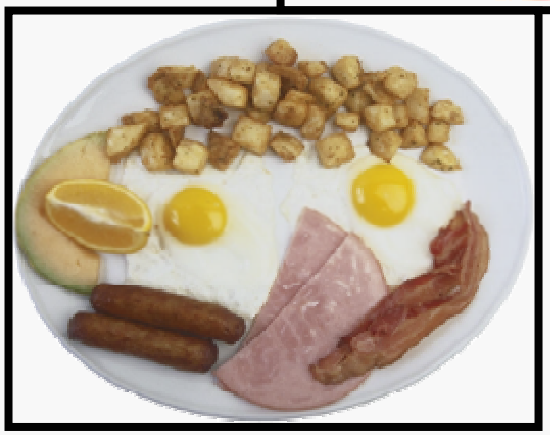
- **Secondary to**
  - **Medications (H2 blockers, generics Primidone, Neomycin, Chloramphenicol, Cycloserine, Colchicine, Clofibrate)**
  - **Severe Crohn’s Disease (due to destruction of the ileum where B12 is absorbed)**

Vitamin B12 Deficiency

Vitamin B12 deficiency anemia will be discussed in another lecture

Folate

- RDA Range
  - Adult males: 200 micrograms/day
  - Adult females: 160 - 400 micrograms/day
- Dietary Sources of Folate
  - Fresh fruits and vegetables
  - Meat
  - Eggs



Folate (cont’)

- **Role of Folate**
  - **Vital to DNA synthesis**
  - **In pregnancy, Folate deficiency can cause fetal neural tube defects**

Folate Deficiency

- Secondary to
  - Inadequate dietary intake
  - Alcoholism
  - Anorexia nervosa
  - Renal dialysis
  - Certain conditions can increase Folate requirements (pregnancy, hemolytic anemia, exfoliative skin disorders)

Folate Deficiency (cont’)

- **Secondary:**
  - **Medications can interfere with Folate absorption (generics Phenobarbital, Phenytoin, Primidone, Cycloserine, Sulfonamide, Sulfasalazine, Trimethoprim-sulfamethoxazole, Nitrofurantoin, Methotrexate and Cholestyramine, and oral contraceptives)**

Case #2

You are on a medical mission trip taking care of children in South America. Maria is a 16-year-old patient who presents with left knee pain. She denies any trauma, and states her knee has been swollen and painful for about a week. Her mother states she has always been a very tired and weak child. Her diet, like that of the rest of her community, is poor.

Case #2 (cont')

- On exam, Maria is a thin female with petechaie and purpura on her extremities.
- Her left knee is swollen with a palpable effusion and limited range of motion.
- Her vital signs are all within normal limits.

Case #2 (cont)

- **Arthrocentesis reveals grossly bloody fluid, with less than 200 WBCs and few neutrophils.**

- **Which vitamin deficiency is the cause of Maria's illness?**

Case #2 (con’t)

- **Diagnosis: Vitamin C Deficiency (Scurvy)**

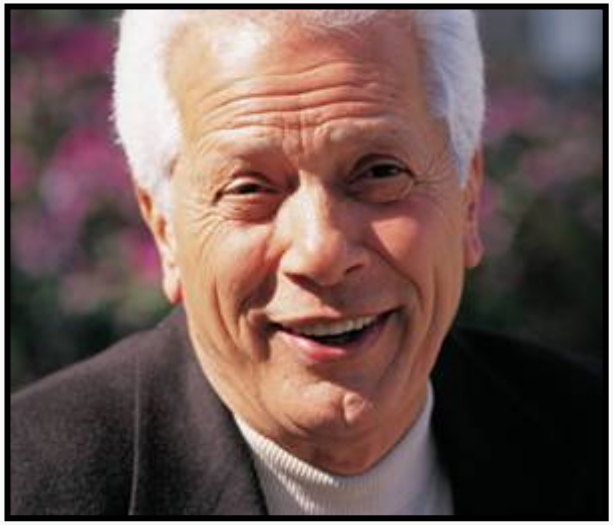
- **Clues:**
  - **Poor diet**
  - **Petechaie, purpura**
  - **Spontaneous hemarthrosis**

Case #3

- **A 62-year-old male patient, 10 days status post colon resection, develops oozing at the site of his IV.**
- **He has a history of colon cancer and seizure disorder. His medications include generics Phenytoin and Gentamycin, and parenteral nutrition.**

Case #3 (cont')

- **Lab studies reveal a normal CBC, a prolonged PT and PTT, normal liver function tests, normal platelet count, and normal fibrinogen level.**
- **With which vitamin would you treat this patient?**



Case #3 (cont')

- **Treatment: Vitamin K, 15 mg subcutaneously**
- **Clues:**
  - **Poor nutrition for at least past 10 days**
  - **Broad spectrum antibiotic use, Phenytoin [generic] use**
  - **Bleeding**
  - **Prolonged PTT/PT, other coagulation labs normal**

Summary

- **RDA range, dietary sources, roles in metabolism, clinical manifestations, related disorders, relationship to other conditions, diagnosis, treatment, and toxicity of Vitamins B1, B2, B3, B6, A,C, D, E, & K**
- **RDA range, dietary sources of Vitamin B12 and Folate, their relationships to other medical conditions**