

Vitamins and Minerals for the Gastroenterologist

Amy Tiu, MD

Feb. 9, 2006

7:00AM conference

Objectives

- Description fat-soluble and water soluble vitamins
- Trace minerals (zinc, selenium, iodide, copper, chromium)
- Deficiency and Toxicity
- Sources and Recommendations
- Clinical implication

History

- 1835 British Parliament passed the Merchant Seaman's Act that required lemon juice to be included in the rations of sailors to prevent scurvy
- 1912 Casimir Funk coined the term *vitamine*
- *Daily Values (DV was RDA)* established by the National Academy of Sciences and National Research Council as the amount to prevent gross deficiency syndromes

Which food has the most vitamin A?



Sweet potatoes



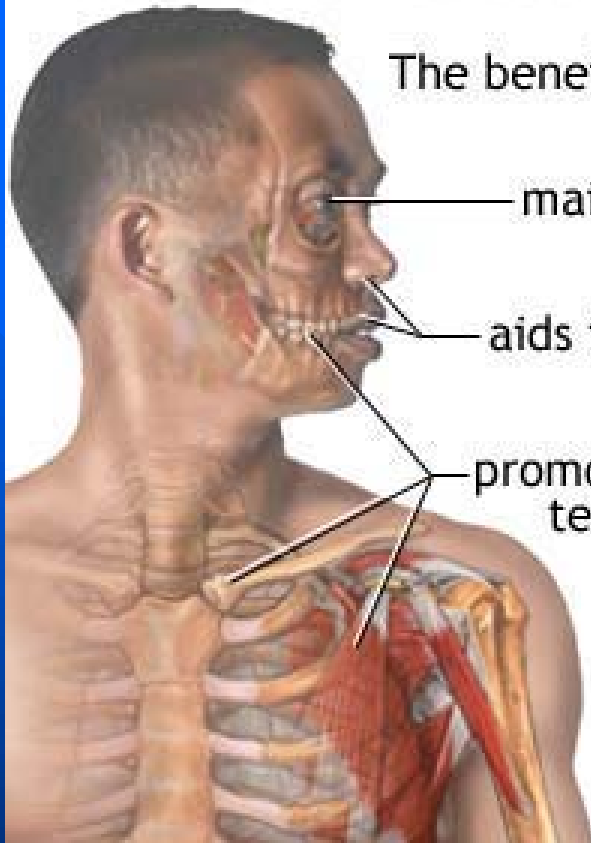
Beef liver



Cantaloupe

Vitamin A


The benefits of vitamin A:



- maintains health of specialized tissues such as the retina
- aids in growth and health of skin and mucous membranes
- promotes normal development of teeth, soft and skeletal tissue

Adult RDA: 1000 μ g RE

Fat-soluble

 ADAM.

1 RE = 10 IU

MVI = 3500 IU

TPN = 3300 IU

Vitamin A

- Prevents xerophthalmia (abnormalities in corneal and conjunctival development)
- Phototransduction
- Cellular differentiation and integrity of the eye
- Ancient Egyptians used liver to treat night blindness



Vitamin A Deficiency

- Main feature (nyctalopia)

Night blindness

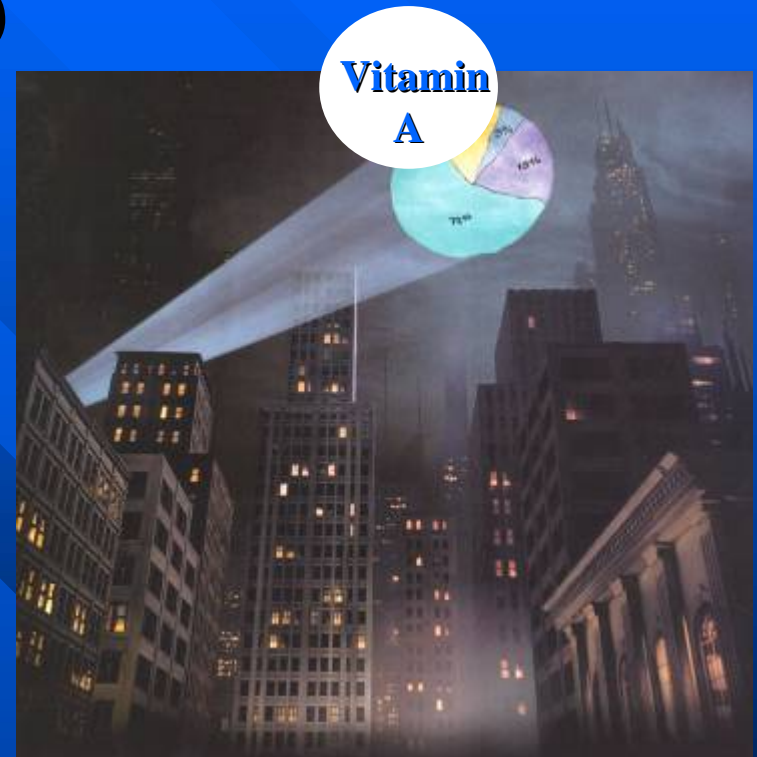
- Issues

Retinal formation
of rhodopsin

- Other features

Corneal, conjunctiva

Dermatitis, keratomalacia



Phrynoderma (follicular hyperkeratosis)

- Blockage of hair follicles with plugs of keratin
- Dry, scaly, rough
- Forearms and thighs



GI patients at risk of Vitamin A deficiency

- Crohn's (small bowel)
- Celiac sprue
- Cholestatic liver disease
- Pancreatic deficiency
- Short gut
- Cystic fibrosis

Vitamin A toxicity

- Arctic explorers who feasted on polar bear liver (10 million IU/lb) acute overdose with n/v; fatigue, weakness, headache, anorexia
- Dermatitis, xerosis, hair loss, joint pain, hyperostosis, hepatomegaly, pseudotumor



Vitamin A toxicity: 3 syndromes

- **Acute** (>660,000 units): n/v; vertigo; blurry vision; drowsiness, malaise
- **Chronic** (higher than 10X daily values): ataxia; alopecia; hyperlipidemia; hepatotoxicity, bone and msk pain; visual impairments; increase risk osteoporotic fractures (need to avoid >5000 units)
- **Teratogenic**: first trimester; spontaneous abortion; fetal anomalies

What vitamin was added in this experiment to make the rats fertile?

- 1922 Evans and Bishop discovered a substance that was deficient in rats fed a diet that contained lard and that resulted in infertility
- When they added a lipid extract the rats became sterile.



Vitamin E (Tocopherol)

- Eight naturally occurring compounds (alpha, beta, gamma, and delta)
- Free radical scavenger, protecting polyunsaturated fatty acids (PUFA), a major structural component of cell membranes from peroxidation

Vitamin E

Tocopherol



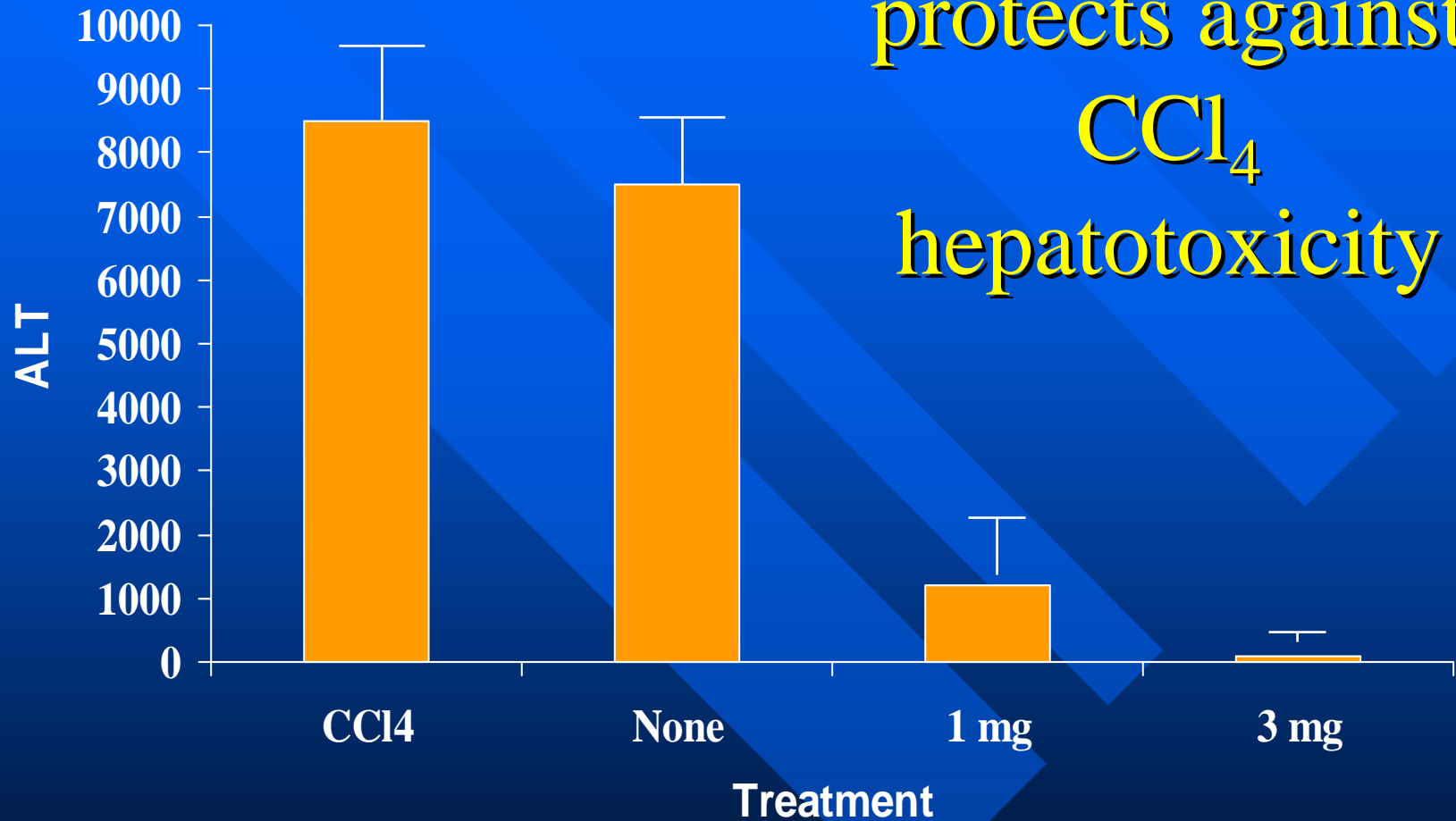
Vitamin E is found in corn, nuts, olives, green, leafy vegetables, vegetable oils and wheat germ, but food alone cannot provide a beneficial amount of vitamin E, and supplements may be helpful

 ADAM.

Vitamin E

- Reduced plasma and hepatic vitamin E levels have been reported in liver disease
- Vitamin E has antioxidant/anti-inflammatory properties

Vitamin E protects against CCl_4 hepatotoxicity



Zern's lab, Am. J Physiol 267, 1994

Vitamin E deficiency: RARE

- At risk: cirrhosis, cholestatic liver disease, cystic fibrosis, small bowel bacterial overgrowth, pancreatic insufficiency, gluten sensitive enteropathy, regional enteritis
- Deficiency proportional to magnitude and duration of steatorrhea
- Skeletal myopathy, spinocerebellar ataxia, pigmented retinopathy; hemolytic anemia (G-6-PD) deficiency; areflexia

Vitamin E toxicity: Unusual

- May interfere with vitamin K, arachidonic acid metabolism
- Large oral supplements associated with necrotizing enterocolitis in infants
- Headache, Myopathy

Vitamin E

- Vitamin E supplementation with a dose ≥ 400 IU/day was associated with a significantly increased risk of all-cause mortality (95% CI 3-74 per 10,000 persons); (meta analysis of 19 RCTs)
- Note 1 mg (alpha tocopherol equivalent) equals 1.49 IU
- Rec: 10 mg/day for men; 8 mg/day for women
- MVI = 30 IU; TPN = 10 IU

Vitamin K

- 1930 Isolated by Doisy and colleagues
- “antihemorrhagic factor”
- Henrick Dam found it capable of reversing dietary induced bleeding disorders in chicks



Vitamin K: 3 forms

- **Phylloquinone**: green plants
- **Menaquinone**: formed as the results of bacterial action in the intestinal tract
- Water-soluble form (K1 and K2)
- None of the forms are stored in appreciable amounts
- Destroyed by alkali and light

Vitamin K metabolism

- Requires pancreatic and biliary function for intact absorption
- Protein bound and requires pancreatic enzymes in the small intestine for liberation

Vitamin K function

- Cofactor for carboxylase
- Vitamin K essential for activity of clotting factors 7,9,10 prothrombin, and anticoagulant protein C and S

Vitamin K deficiency

- Risk: TPN, long term antibiotics
- Easy bruisability, mucosal bleeding, splinter hemorrhages, melena, hematuria
- Hemorrhagic disease of the newborn: develops within the first week of life
- DV is 65 to 80 micrograms/day which can be achieved with dietary intake
- TPN = 150 micrograms
- MVI = 25 micrograms

Vitamin K Toxicity

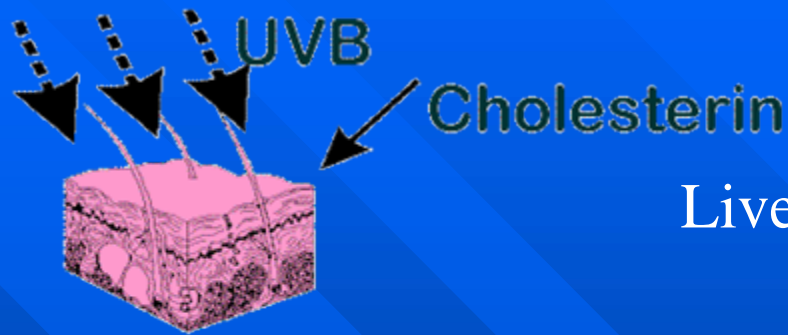
- Infants: hemolytic anemia; hyperbilirubinemia, jaundice, and kernicterus
- With rapid IV infusion possible flushing and cardiovascular collapse

Vitamin D (calciferol)

- First recognized by McCollum as the component of cod liver oil that was cable of curing rickets
- Role in calcium homeostasis and bone metabolism
- May have a role in inhibiting the carcinogenic effects of bile acids through calcium binding in the bowel lumen

Metabolism

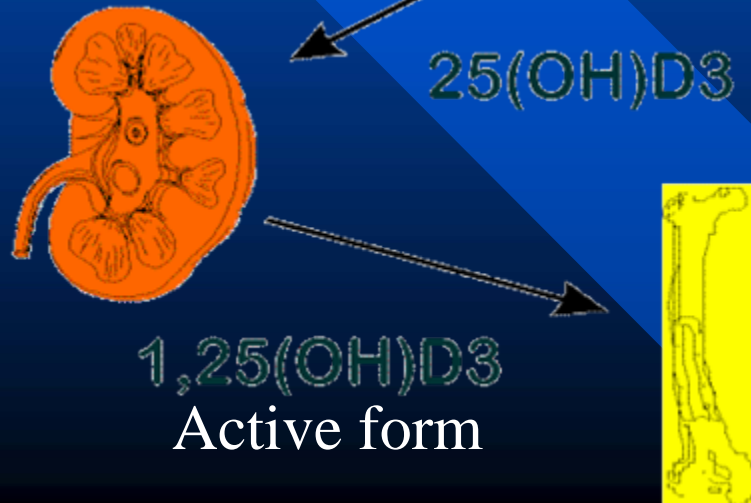
Skin photoisomerization from D to D3



Liver hydroxylates vitamin D



Kidney further hydroxylates



Vitamin D



The body itself makes vitamin D when it is exposed to the sun

Cheese, butter, margarine, fortified milk, fish and fortified cereals are food sources of vitamin D



Causes of Vitamin D deficiency

- Decreased intake/ Insufficiency sunlight
- Fat malabsorption (celiac disease, pancreatic insufficiency, IBD, cystic fibrosis, post-gastrectomy states, and small bowel resection)
- Impaired liver/kidney
- Symptoms: Rickets, osteomalacia, hypophosphatemia (more than hypocalcemia), muscle weakness, phosphaturia

Bone Mineral Abnormalities in IBD

- Studies estimating BMD prevalence vary widely
- 45% IBD patients have decreased BMD
 - » 40% increase risk of fracture in IBD pts¹
 - » 2.5 fold increased risk in women with CD²
- Multiple factors contribute to increased risk
 - » Lifetime steroid use
 - » BMI
 - » Calcium/vitamin D deficiency

1. Bernstein Ann Int Med 2000; 133: 795-9

2. Verstergaard Gut 2000; 46:176-81

Vitamin D Toxicity

- Minimum 200 IU/day; Pregnancy 400 IU/day;
Must be with calcium to prevent fracture
- If children >1,800 IU or adults >2,000 IU toxic
- Excessive calcification of bone, kidney stones, metastatic calcification of soft tissues (kidney and lung) headache, weakness, n/v, constipation, polyuria, polydipsia
- TPN = 200 IU
- MVI = 400 IU

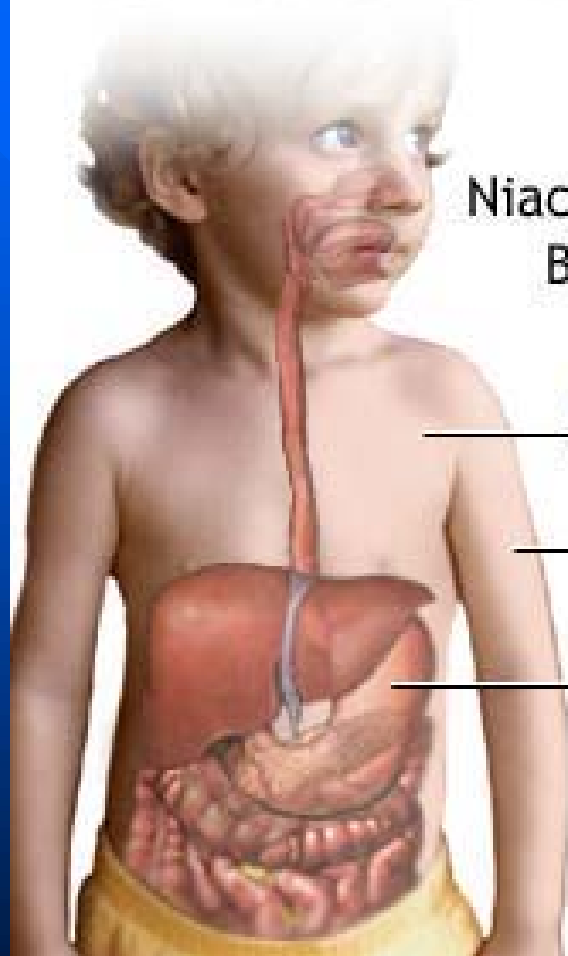
What is this vitamin?

- Epidemic amongst corn eating population of the United States
- Hopi Indians were spared of this because they would cook the mature corn in alkaline wood ash that would release this substance

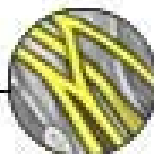


Deficiency causes this

Vitamin B₃



Niacin (vitamin B₃) works with other B vitamins to help release energy from carbohydrates



Healthy nerves

Healthy skin

Healthy digestive system

Adult RDA: 19 mg

Water-soluble

ADAM.

Vitamin B₃



Food sources of Niacin (vitamin B₃) include dairy, poultry, fish, lean meat, nuts and eggs

Vitamin B3



An inability to absorb niacin (vitamin B3) or the amino acid tryptophan may cause pellagra, a disease characterized by scaly sores, mucosal changes and mental symptoms

Niacin deficiency (B3)

- **Carcinoid syndrome** because tryptophan is metabolized to 5-OH tryptophan and serotonin rather than to nicotinic acid
- Prolonged use of **isoniazid** since isoniazid depletes stores of pyridoxal phosphate, which enhances the production of tryptophan, a precursor of niacin

Hartnup disease

- Autosomal recessive congenital disorder
- Defect in transport of tryptophan
- Diagnosis by detecting a number of neutral amino acids in the urine (not seen with dietary pellagra)

Niacin toxicity

- Flushing, n/v/pruritus, hives, elevation in serum aminotranferases and constipation; myopathy (doses of 1000-3000 mg/day) Note: to treat dyslipidemia 1 to 3 grams/day
- Hyperglycemia, hyperuricemia (caution in those with gout)
- DV: 15-20 NE males; 13-15 NE for females
- 60 mg tryptophan = 1 mg niacin
- TPN = 40 mg
- MVI = 20 mg

What vitamin causes “burning feet syndrome”?

- Human volunteers fed an antimetabolite for three months developed burning, distal paresthesias, and gastrointestinal distress
- Found in egg yolk, liver, kidney, broccoli, and milk

Vitamin B5 (Pantothenic Acid)

- 1947, Coenzyme A (CoA)
- Essential in first step of the tricarboxylic acid cycle, crucial role in the synthesis of many molecules (A,D, cholesterol, steroids, heme A, FA, AA, and proteins)
- No known toxicity
- No DV but 10 mg considered 100 % DV
- TPN = 15 mg
- MVI = 10 mg

Biotin

- 1942 Sydenstricketer et al first induced deficiency in adult volunteers by feeding them a diet to which 200 g of dehydrated egg white.
- Biotin acts as CO₂ carrier on the surface of enzymes (carboxylases); essential role in protein in DNA synthesis and cell replication
- Gut bacteria produces it; mostly absorbed in small intestine
- MVI = 30 micrograms (10% of DV)
- TPN = 60 micrograms

Biotin Deficiency

- May occur in patients on Chronic TPN
- Conjunctivitis, **Dermatitis** around the eyes, nose and mouth, **alopecia** with loss of normal hair coloring, skin infections, and **neurologic symptoms** such as ataxia, hypotonia, increase cholesterol, and severe lethargy, depression, and possibly parasthesia and hallucinations



Before

After

Vitamin B₂

Food sources of Riboflavin (vitamin B2):

Cereal, nuts, milk,
eggs, green leafy
vegetables
and lean meat



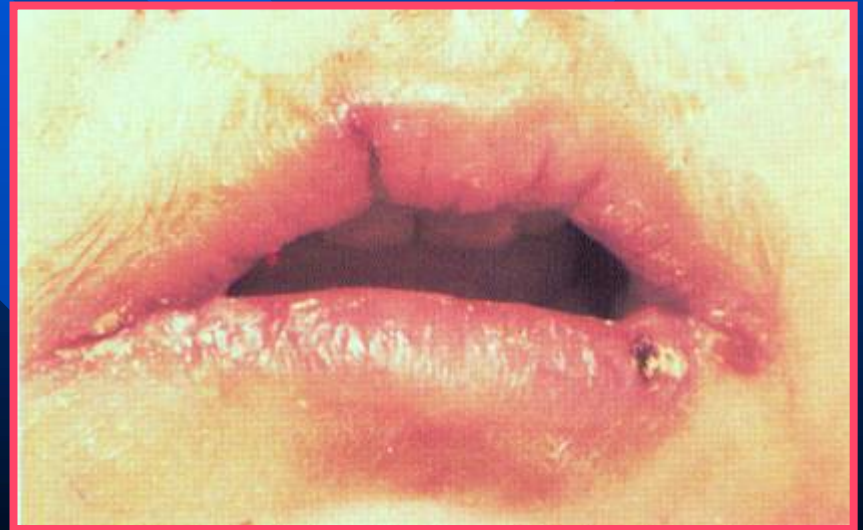
ADAM.

Vitamin B2 (Riboflavin)

- Primarily as a component of coenzymes flavin adenine dinucleotide (FAD) and flavin adenine mononucleotide (FMN)
- Catalyze oxidation-reduction reactions in cells and are hydrogen carriers in the mitochondrial system
- Actively absorbed from the proximal small intestine; absorption increased by the presence of food

Vitamin B2 Riboflavin deficiency

- Intake must be low for several months to develop
- Photophobia, lacrimation, eye irritation, loss of visual acuity, sore lips, mouth, tongue
- Ariboflavinosis
- Seborrheic dermatitis
- Angular stomatitis; cheilosis (may be in naicin, folic acid, thiamin, B6, B12 deficiency too)



Riboflavin deficiency

- More common than generally appreciated
- Urinary riboflavin excretion and the erythrocyte glutathione reductase assay are better functional indices of riboflavin deficiency
- At risk: anorexia; lactose intolerant, celiac sprue, short bowel, rare inborn errors of metabolism, long term use of phenobarbital and other barbiturates (these oxidate riboflavin and impair function)
- DV: 0.6 mg per 1000 kcal
- MVI = 1.7 mg
- TPN = 3.6 mg

Riboflavin and HIV

- Patients with HIV who develop lactic acidosis (zidovudine or stavudine) may be treated with riboflavin.
- Some intramitochondrial beta-oxidation defects may respond to riboflavin therapy

Vitamin B1 (thiamine)

- Antiberiberi factor
- Absorption is in the small intestine
- Pyrophosphate (TPP) or the triphosphate (TTP)
- Catalyst for conversion of pyruvate to acetyl CoA
- Involved in initiation of nerve impulse
- Transketolation of the pentose phosphate pathway



Thiamine Deficiency



- Main features

Beriberi (peripheral neuropathy, CHF, muscle weakness)

Wernicke's Encephalopathy (ataxia, nystagmus, confusion)

Korsakoff's Syndrome (loss of memory, confabulation)

- Issues

Chronic EtoH abuse

Glucose infusion precipitates deficiency

Differentiating EtoH related problems, trauma

- Diagnosis - clinical suspicion

- Treatment - Intravenous, intramuscular, then oral

Often empiric. Need 0.5 mg per 1000 Kcal

TPN = 6 mg; MVI = 1.5 mg

Wet Berberi

- Precipitated by a high carbohydrate intake along with strenuous physical exertion with edema due to biventricular heart failure and pulmonary congestion
- Tense calf muscles, fast pulse, distended neck veins, increased BP, decrease UOP
- Administration of glucose in TPN with less than the requirement of thiamine can result in the rapid development of wet beriberi

Dry Beriberi

- Worsening of polyneuritis of early stage
- Loss of function or paralysis of lower extremities
- Wernicke-Korsakoff (need 50 mg per day to treat)
- To treat beriberi (50-100 mg IV per day for 7-14 days) or po 10 mg per day

What is Leigh's syndrome?

- Condition seen in thiamine deficiency
- Subacute necrotizing encephalomyopathy
- Sporadic mitochondrial disorder
- Ataxia, dysarthria, movement disorders, areflexia, muscle atrophy, and weakness

Name the vitamin

- 15 to 20% of women taking oral steroid contraceptives may have this deficiency
- Infants who were fed formula missing this vitamin developed convulsions
- Children with an inborn error of metabolism of this vitamin require large dose in the neonatal period to avoid convulsions and MR
- Patients treated with isoniazid develop peripheral neuritis

Vitamin B6



Vitamin B6 (pyridoxine) is important for maintaining healthy brain function, the formation of red blood cells, the breakdown of protein and the synthesis of antibodies in support of the immune system

Adult RDA: 2 mg

Water-soluble

 ADAM.

Not found in typical MVI (centrum)
TPN = 6 mg

Vitamin B6

Food sources of vitamin B6 (pyridoxine) include beans, legumes, nuts, eggs, meats, fish breads and cereals



Vitamin B6 deficiency

- Nonspecific stomatitis, glossitis, cheilosis, irritability, confusion, and depression
- Genetic syndromes affecting PLP dependent enzyme mimic deficiency (homocystinuria, cystathioninuria)

Vitamin B6 toxicity

- Requires long term megadoses 250 mg/day
- Peripheral neuropathy
- Dermatoses
- Photosensitivity
- Dizziness
- Nausea

What vitamin deficiency was the major cause of death during the great potato famine?



Vitamin C

- Ascorbic acid absorbed in the distal small intestine
- Provides electrons needed to reduce molecular oxygen
- Greatest concentrations are found in the pituitary, adrenal, brain, leukocytes, and the eye

Vitamin C

- Fatty acid transport (long chain fatty acids)
- Collagen synthesis
- Neurotransmitters
- Prostaglandin metabolism

Scurvy

- Impaired collagen synthesis
- Occur as early as three months
- Ecchymoses
- Bleeding gums
- Petechiae
- Hyperkeratosis
- Sjogren's syndrome
- Arthralgias
- Impaired wound healing
- Weakness
- Joint swelling
- Coiled hair
- Neuropathy
- Vasomotor instability
- Need 10 mg to prevent

Vitamin C



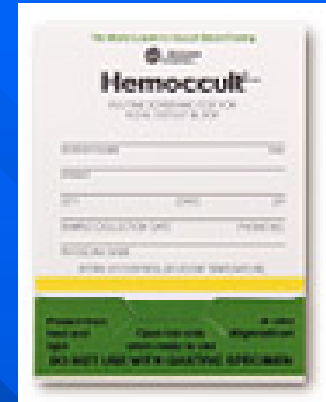
Scurvy

Vitamin C deficiency

- Drug and alcohol abusers
- Low intake associated with gastric cancer; but supplementation has not been studied
- Note breast milk provides ADEQUATE source
- Elderly, institutionalized, or chronically ill patients at risk
- DV: 60 mg/day non pregnant; 125 mg/day in elderly
- MVI = 60 mg
- TPN = 200 mg ascorbic acid

Vitamin C Toxicity

- Requires one gram quantities
- False negative stool guaiac
- Diarrhea and abdominal bloating
- Fatal cardiac arrhythmias in patients with iron overload (due to oxidative injury)
- Controversy: risk factor for calcium oxalate stones (patients who predisposition or on hemodialysis should avoid excessive)



Vitamin B₁₂

Food sources of
vitamin B₁₂:

Eggs, meat, poultry,
shellfish, milk and
milk products



Vitamin B12

- Isolated in 1948
- Required for DNA synthesis (transfers methyl group)
- Meat and dairy products are the only source for humans

Vitamin B12 absorption

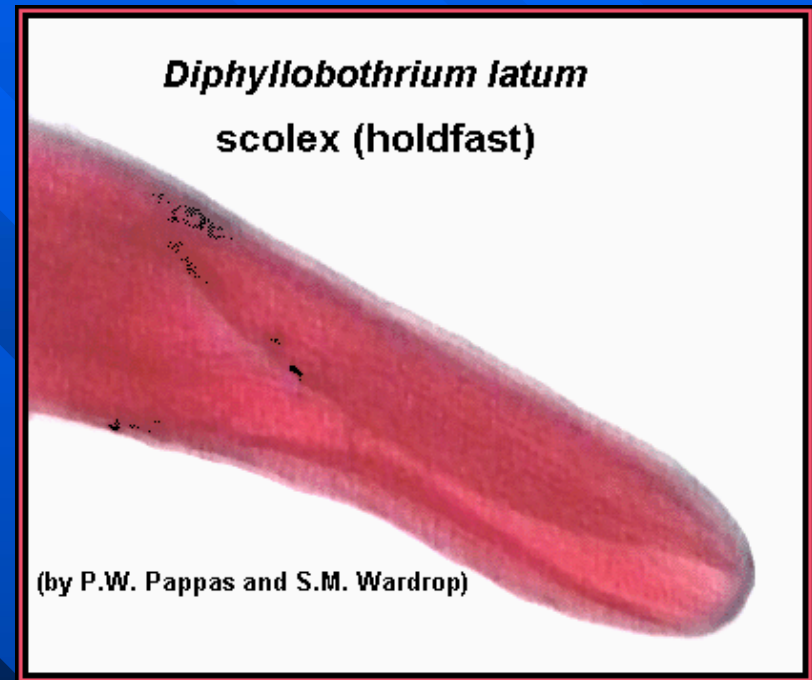
- Gastric acid/pepsin releases it from food protein
- B12 binds to R protein (from salivary gland and gastric mucosa)
- B12-R requires pancreatic proteases to release B12; need acid environment
- B12 then binds to intrinsic factor (parietal cells) to facilitate absorption in the ileum

Causes of B12 deficiency

- Gastric abnormalities (gastrectomy)
- Pernicious anemia (autoimmune attack on IF)
- H.Pylori infection
- Small bowel disease (ileal resection/bypass; crohn's)
- Pancreatitis (pancreatic insufficiency)
- Diet (vegan, chronic alcoholism)
- Agents that block absorption
 - Neomycin
 - Biguanides (eg, metformin)
 - PPI
 - N2O anesthesia inhibits methionin synthase

Causes of vitamin B12 deficiency

- **Diphyllobothrium Latum**
- 10 to 20% of people taking metformin (reversed with calcium)
- **Imerslund Grasbeck's** disease or juvenile megaloblastic anemia



Vitamin B12 deficiency

- Megaloblastic anemia
- Neurologic abnormalities
- Demyelinating disorder
- Painful paresthesias and loss of proprioception (symmetrical Legs > arms)
- Hypospermia
- Glossitis
- DV 2 microgram per day (western diet 5-7) Body store (2,000 micrograms) may take 5-6 years for deficiency to appear if from restriction alone_
- TPN = 5 mcg
- MVI = 6 mcg

Folic acid

- Established as essential in 1946
- Nurses' Health Study found that women who consumed folate-containing supplements daily for 15 years were 75% less likely to develop colorectal cancer
- The Health Professionals Follow-up study showed a moderate risk reduction in men receiving folate for more than 10 years

Vitamin B9

Folate

Food sources of folate include beans and legumes, citrus fruits and juices, whole grains, dark green leafy vegetables, poultry, pork, shellfish and liver



 ADAM.

Causes of Folate Deficiency

- Nutritional deficiency (substance abuse, etoh, poor diet, overcooked foods, depressed patient, nursing home)
- Malabsorption (sprue, IBD, infiltrative bowel disease, short bowel syndrome)
- Drugs (methotrexate, trimethoprim, ethanol, phenytoin, sulfasalazine)
- Increased requirements (pregnancy, lactation, chronic hemolysis, exfoliative dermatitis)
- Need: 200-400 micrograms/day
- TPN = 600
- MVI = 400

Folate deficiency

- Alcohol abuse on low folate intake can develop megaloblastosis within 5 to 10 weeks (impairs enterohepatic cycle and inhibits its absorption)
- Glossitis, intestinal mucosal dysfunction, megaloblastic anemia (no neurologic abnormalities)

Selected Trace Microminerals

Zinc, Copper, Selenium, Iodide,
Chromium, Manganese, Molybdenum

Zinc

- Required for zinc metalloenzymes and zinc finger proteins
- 1/3 of ingested zinc absorbed
- Acrodermatitis enteropathica: hereditary disease of impaired zinc absorption
- TPN = 2.5 to 4 mg
- MVI = 15 mg

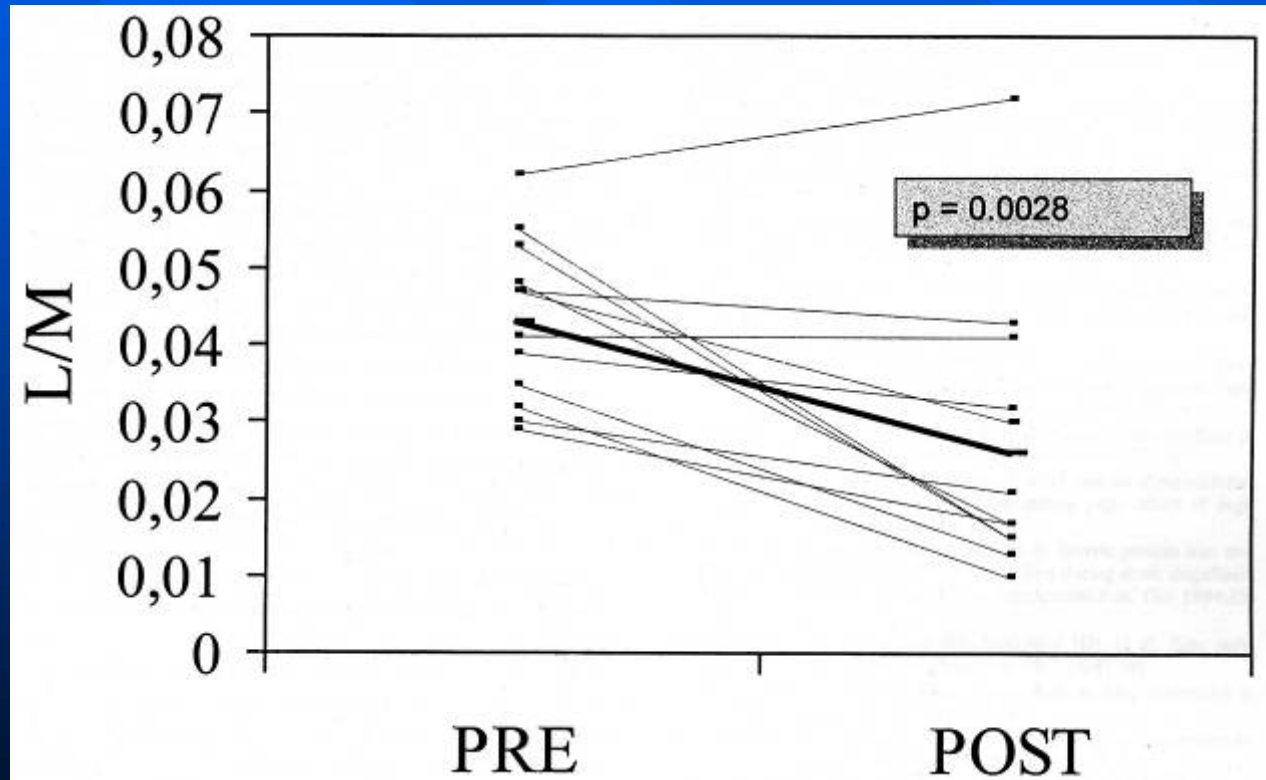
Zinc

Zinc supplementation tightens "leaky gut" in Crohn's disease.

Sturniolo GC, Di Leo V, Ferronato A, D'Odorico A, D'Inca R.

Inflamm Bowel Dis 2001 May;7(2):94-8

Intestinal Permeability before and after 8 weeks zinc therapy



Conditions that alter Zinc Metabolism

■ Intestinal Processes

- IBD
- Short bowel
- Jejunioileal bypass
- Sprue
- Diarrhea

■ Pancreatic disease

- Schwachman's syndrome
- CF

■ Liver disease

- ETOH
- PBC
- Viral hepatitis

■ TPN

■ Sepsis/trauma

■ Eating disorders

■ Aging

Zinc deficiency: Two categories

■ True deficiency

- Poor intake
- Mucosal problems leading to decreased absorption
- Dietary **phytate** inhibition (vegetarians)
- Dietary fiber and **oxalate** (vegetarians)

■ Redistribution

- Mediated by IL-1, TNF, IL-6,

Zinc Deficiency

- Skin lesions
- Anorexia (alter taste and smell acuity)
- Growth retardation
- Depressed wound healing
- Hypogonadism
- Altered immune function
- Impaired night vision, altered vitamin A metabolism
- Diarrhea
- Depressed mental function
- Teratogenesis



Copper

- Cofactor for several oxidoreductases
- Aceruloplasminemia: low plasma copper; increased iron deposits in the liver, pancreas, and brain; dementia, neurologic problems, type I diabetes
- Risk of deficiency: CF; Crohn's disease, malabsorptive disorders; patients taking excess zinc
- Was not in TPN formulas prior to 1979; TPN = 0.3 – 1.2 mg
- MVI = 2 mg

Copper Deficiency

- Main feature
Iron deficiency anemia
- Issues
Coenzyme for oxidation
of ferrous → ferric iron
Impaired iron absorption,
marrow utilization
- Other features - leukopenia
ageusia (taste)
- Diagnosis - clinical suspicion, serum copper, ceruloplasmin
- Toxicity – hepatic necrosis, coma, ARF; hypotension



Copper

- **Zinc** induces metallothionein and IMPAIRS copper absorption; excess zinc may lead to deficiency
- Copper deficiency results in **anemia** NOT responsive to iron supplementation, **neutropenia**, and **less often hypopigmentation**, immune dysfunction and skeletal abnormalities

Selenium Deficiency

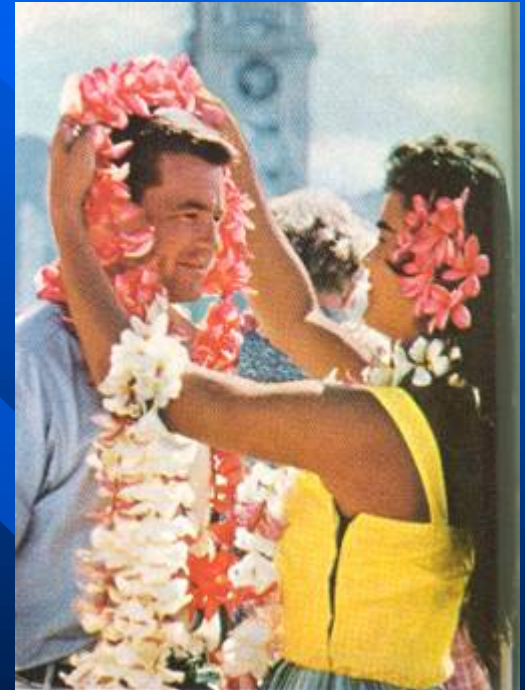
Who is at risk?



South Dakota



Keshan China



Hawaii

Selenium

- Selenomethionine
- Required cofactor for protein and DNA synthesis
- Deficiency was seen in chronic TPN users with **cardiomyopathy** and skeletal muscle dysfunction
- **Keshan disease:** endemic cardiomyopathy that effects children and women of childbearing age in areas of China
- MVI = 20 mcg
- TPN = 20 to 80 mcg

Selenium Deficiency

- Main features

 - Congestive heart failure
(Keshan syndrome)

 - Muscle weakness

- Issues

 - Related to soil content (mainland)

 - Not included in most MVI

 - Key component of glutathione peroxidase
(anti-oxidant free radical scavenger)

 - Complements anti-oxidant properties of Vit E

- Diagnosis - clinical suspicion only

- Treatment - Reported in U.S. from supplement 180 fold the amount labeled: nausea, emesis, hair loss, nail changes, mental status changes, and peripheral neuropathy



Iodine

- Used for synthesis of triiodotyrosine (T3) and thyroxine (T4)
- Deficiency: Goiter and hypothyroidism
- Cretinism: mental deficiency, spastic diplegia or quadriplegia, deaf mutism, dysarthria, shuffling gait, shortened stature, and hypothyroidism
- Toxicity: Goiter, hypo or hyperthyroidism
- TPN = 70-140 mcg
- MVI = 150 mcg



Chromium

- 1957 extracted from pork kidney termed “glucose tolerance factor”) corrected hyperglycemia in rats
- In patients with diabetes requiring TPN, chromium deficiency was indicated by **increased** insulin requirements
- Required for normal lipid and carbohydrate metabolism
- TPN = 10-20 mcg
- MVI = 120 mcg

Chromium Deficiency

- Main feature - Glucose intolerance

Insulin resistance

- Issues

Cofactor to insulin for cellular glucose absorption

Glucose Tolerance Factor (GTF)

- Other features

Poor wound healing

Neurologic - peripheral neuropathy, ataxia

Manganese

- Deficiency first reported 1972
- Component of several enzymes; requires bile for absorption
- Deficiency: weight loss, transient dermatitis, n/v; **changes in color**, and slow growth of hair; sterility
- Striking skeletal abnormalities and ataxia in offspring in deficient mothers

Manganese toxicity

- Miners
- Accumulates in liver
- Accumulates in CNS
- Parkinson-like symptoms
- Iron deficiency enhances absorption
- In TPN (0.2-0.8 mg) but reported toxicity with long term use so now some clinicians < 0.1 mg or eliminate it
- MVI = 2 mg

Molybdenum

- Required for several enzymes (xanthine oxidase and flavoproteins)
- Deficiency in long term TPN: mental changes and abnormalities in sulfur and purine metabolism
- Toxicity: gout like syndrome
- TPN = 100 – 200 mcg
- MVI = 75 mcg

What vitamins are in TPN?

- Vitamin A, D, E
- Ascorbic acid, folacin, niacin, riboflavin, thiamin, pyridoxine, B12, pantothenic acid, biotin
- Trace minerals: zinc, copper, chromium, and manganese
- Single minerals: selenium and molybdenum separate

Bariatric surgery

- RYGB: iron, B12, vitamin D, Calcium
- Biliopancreatic diversion: protein and fat soluble vitamins
- 4 years post op: 44% had low hemoglobin, iron, and ferritin; 33% had B12 deficiency
- 4 years after diversion deficiency: 69% vitamin K; 63% vitamin D; 4% vitamin E
- Thiamine also deficient (hyperemesis)

Bariatric surgery

- Monitor: calcium, phosphorus, alkaline phosphatase, parathyroid hormone, and 25 hydroxyvitamin D
- Use Calcium citrate (need low acid for carbonate)
- Need 2000 mg of calcium and 400 IU vitamin D
- Need 350 micrograms B12/day (note DV=2); Few require monthly parenteral administration
- Thiamine 50-100 mg/day

Conclusions

- RDA now DV (Daily Values)
- Need to be aware of increased needs in patients on chronic TPN or changes in gut anatomy
- Increased role in vitamins and minerals in altering disease process and immune system (another talk all together) rather than sustaining daily metabolism

Special thanks

- Dr. McClain and Steve Mahanes
- Dr. Dryden
- Dr. McClave
- Dr. Jabbar