# Vitamins and Minerals

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# Vitamins

- Organic molecules needed in small quantities for normal metabolism and other biochemical functions, such as growth or repair of tissue
- Attach to enzymes or coenzymes and help them activate anabolic (tissue-building) processes

# Vitamins

- Essential part of enzymatic reactions
- Natural sources from both plants and animals
- Insufficient amounts result in various deficiencies

# Vitamins (cont'd)

- Vitamin K and vitamin B complex vitamins obtained by synthesis in the small intestine
- Vitamin D can be synthesized by the skin when exposed to sunlight

# Water-Soluble Vitamins

- B-complex group and vitamin C
- Can be dissolved in water
- Cannot be stored by the body in large amounts
- Daily intake required to prevent deficiencies

# Fat-Soluble Vitamins

- Vitamins A, D, E, K
- Present in both plant and animal foods
- Stored in the liver and fatty tissues
- Daily intake not required

# Fat-Soluble Vitamins (cont'd)

- Deficiency occurs only after prolonged deprivation
- Can become toxic if excessive amounts are consumed

# Vitamins:  Other Issues

- Nutrient megadosing
- Toxic hypervitaminosis
- RDAs

# Vitamin A

- Fat soluble
- Vitamin A (retinol) derived from animal fats (butter and milk), eggs, meat, liver, fish liver oils
- The vitamin A in animal tissues is derived from carotenes, which are found in plants (green and yellow vegetables and yellow fruits)

# Vitamin A

- Required for growth and development of bones and teeth
- Necessary for other processes
  - Reproduction
  - Integrity of mucosal and epithelial surfaces
  - Cholesterol and steroid synthesis
  - Essential for night vision

# Vitamin A: Indications

- Dietary supplement
  - Infants and pregnant and nursing women
- Deficiency states
  - Hyperkeratosis of the skin
  - Night blindness
  - Other conditions
- Skin conditions
  - Acne, psoriasis, keratosis follicularis

# Vitamin A: Toxicity

- Ingestion of excessive amounts causes toxicity
  - Irritability, drowsiness, vertigo, delirium, other symptoms
  - Increased intracranial pressure in infants
  - Generalized peeling of the skin and erythema over several weeks

# Vitamin D

- Fat soluble
- “Sunshine vitamin”
- Responsible for proper utilization of calcium and phosphorus
- Actually a group of analog steroid chemicals

# Vitamin D (Fat Soluble)

- Different chemicals, produce same effect
- Vitamin $D_2$ (ergocalciferol)
  - Plant vitamin D
  - Obtained through dietary sources
- Vitamin $D_3$ (cholecalciferol)
  - Produced in the skin by ultraviolet irradiation (sunshine)

# Vitamin D (cont'd)

- Vitamin $D_2$-containing foods
  - Fish oils, salmon, sardines, herring
  - Fortified milk, breads, cereals
  - Animal livers, tuna fish, eggs, butter
- Endogenous synthesis in the skin

# Vitamin D: Function

- Regulates absorption of and use of calcium and phosphorus
- Necessary for normal calcification of bone and teeth

# Vitamin D: Indications

- Dietary supplement
- Treatment of vitamin D deficiency
- Treatment and correction of conditions related to long-term deficiency: rickets, tetany, osteomalacia
- Prevention of osteoporosis

# Vitamin D: Toxicity

- Long-term ingestion of excessive amounts causes toxicity
  - Hypertension, weakness, fatigue, headache, many others
  - GI tract effects
  - CNS effects

# Forms of Vitamin D

- calcifediol (Calderol)
- calcitriol (Rocaltrol)
- dihydrotachysterol (Hytakerol, DHT)
- ergocalciferol (Calciferol)

# Vitamin E

- Fat soluble
- Tocopherols
- Dietary plant sources
  - Fruits, grains, cereals, vegetables, oils, wheat germ
- Animal sources
  - Eggs, chicken, meats, fish

# Vitamin E: Function

- Exact biologic function of vitamin E is unknown
- Believed to act as an antioxidant

# Vitamin E: Indications

- Dietary supplement
- Antioxidant
- Treatment of deficiency
  - Highest risk of deficiency in premature infants

# Vitamin E: Side Effects

- Very few acute side effects
  - GI tract
  - CNS effects

# Vitamin K

- Fat soluble
- Three types: $K_1$, $K_2$, $K_3$
- Dietary sources of $K_1$
  - Green leafy vegetables (cabbage, spinach), meats, milk
- Vitamin $K_2$ synthesized by intestinal flora

# Vitamin K: Functions

- Essential for synthesis of blood coagulation factors in the liver
- Vitamin K–dependent clotting factors
  - II
  - VII
  - IX
  - X

# Vitamin K: Indications

- Dietary supplementation
- Treatment of deficiency states (rare)
  - Antibiotic therapy
  - Newborn infants
  - Malabsorption
- Reverse the effects of certain anticoagulants (warfarin)

# Vitamin K Agent

- Vitamin $K_1$ (AquaMEPHYTON)

# Water-Soluble Vitamins

- Vitamin B complex
  - thiamine ($B_1$) – pyridoxine ($B_6$)
  - riboflavin ($B_2$) – folic acid ($B_9$)
  - niacin ($B_3$) – cyanocobalamin ($B_{12}$)
  - pantothenic acid ($B_5$)
- Vitamin C
  - ascorbic acid

# Water-Soluble Vitamins (cont'd)

- Can dissolve in water
- Excessive amounts excreted in the urine, not stored in the body
- Toxic reactions are very rare

# Vitamin $B_1$ (Thiamine)

- Water soluble
- Food sources
  - Whole grains, liver, beans
- Deficiencies
  - Beriberi
  - Wernicke's encephalopathy

# Vitamin $B_1$ (Thiamine) Deficiencies

- Beriberi
  - Brain lesions, polyneuropathy of peripheral nerves, serous effusions, cardiac anatomic changes
- Wernicke's encephalopathy
  - Cerebral beriberi

# Vitamin $B_1$ (Thiamine): Causes of Deficiencies

- Poor diet
- Extended fever
- Hyperthyroidism
- Liver disease
- Alcoholism
- Malabsorption
- Pregnancy and breast-feeding

# Vitamin $B_1$ (Thiamine) Functions

- Essential for:
  - Carbohydrate metabolism
  - Many metabolic pathways, including Krebs' cycle
- Maintains integrity of:
  - Peripheral nervous system
  - Cardiovascular system
  - GI tract

# Vitamin $B_1$ (Thiamine): Indications

- Treatment of thiamine deficiency
  - Beriberi
  - Wernicke's encephalopathy
  - Peripheral neuritis associated with pellagra
- Metabolic disorders

# Vitamin $B_1$ (Thiamine): Indications (cont'd)

- Dietary supplement
  - Malabsorption induced by alcoholism, cirrhosis, GI disease
- Oral insect repellant
- Other uses

# Vitamin $B_2$ (Riboflavin)

- Water soluble
- Food sources
  - Leafy green vegetables
  - Eggs
  - Nuts
  - Meats
  - Yeast

# Vitamin $B_2$ (Riboflavin) Causes of Deficiency

- Alcoholism is a major cause
- Deficiency also caused by:
  - Intestinal malabsorption
  - Long-term infections
  - Liver disease
  - Malignancy
  - Probenecid therapy

# Vitamin $B_2$ (Riboflavin) Functions

- Converted into enzymes essential for tissue respiration
- Required to activate vitamin $B_6$ (pyridoxine)
- Converts tryptophan into niacin
- Maintains erythrocyte integrity

# Vitamin $B_2$ (Riboflavin) Deficiency

- Deficiency results in:
  - Cutaneous, oral, and corneal changes
  - Cheilosis
  - Seborrheic dermatitis
  - Keratitis

# Vitamin $B_2$ (Riboflavin): Indications

- Dietary supplement
- Treatment of deficiency
- Microcytic anemia
- Acne
- Migraine headaches
- Many other uses

# Vitamin $B_2$ (Riboflavin): Side Effects

- No side effects or toxic effects
- Large doses will discolor urine to a yellow-orange

# Vitamin $B_3$ (Niacin)

- Water soluble
- Food sources
  - Meats, beans, liver, yeast, wheat
- Also synthesized from tryptophan (an essential amino acid obtained from protein digestion)

# Vitamin $B_3$ (Niacin): Functions

- Once ingested, converted to nicotinamide
- Nicotinamide is converted to two coenzymes
- These enzymes are required for:
  - Glycogenolysis, tissue respiration
  - Lipid, protein, and purine metabolism

# Vitamin $B_3$ (Niacin): Indications

- Antihyperlipidemic agent
  - Lowers serum cholesterol and triglyceride levels by reducing VLDL synthesis
  - Doses required for this effect are higher than than those required for its nutritional and metabolic effects

# Vitamin $B_3$ (Niacin): Deficiency

- Pellagra: niacin deficiency
  - Mental: various psychotic symptoms
  - Neurologic: neurasthenic syndrome
  - Cutaneous: crusting, erythema
  - Mucous membrane: oral, vaginal, and urethral lesions
  - GI: diarrhea or bloody diarrhea

# Vitamin $B_3$ (Niacin): Side Effects

- Side effects seen when higher doses are used in the treatment of hyperlipidemia
  - Flushing
  - Pruritus
  - GI distress

# Vitamin $B_6$ (Pyridoxine)

- Water soluble
- Sources
  - Whole grains, wheat germ, nuts, yeast
  - Fish and organ meats

# Vitamin $B_6$ (Pyridoxine) (cont'd)

- Composed of three compounds
  - Pyridoxine
  - Pyridoxal
  - Pyridoxamine

# Vitamin $B_6$ (Pyridoxine): Function

- Necessary for many metabolic functions
  - Protein, lipid, and carbohydrate utilization
  - Conversion of tryptophan to niacin
- Necessary for integrity of peripheral nerves, skin, mucous membranes, hematopoietic system

# Vitamin $B_6$ (Pyridoxine) (cont'd)

- Signs and symptoms of deficiency
  - Sideroblastic anemia
  - Neurologic disturbances
  - Seborrheic dermatitis
  - Cheilosis (chapped, fissured lips)
  - Xanthurenic aciduria (“stones” in the urine)
  - Glossitis and stomatitis
  - Epileptiform convulsions

# Vitamin $B_6$ (Pyridoxine): Causes of Deficiency

- Inadequate intake
- Poor absorption
- Uremia, alcoholism, cirrhosis, hyperthyroidism, malabsorption, heart failure
- Drug induced (isoniazid, hydralazine, others)

# Vitamin $B_6$ (Pyridoxine): Indications

Used to prevent and treat deficiency

# Vitamin $B_6$ (Pyridoxine) Toxicity

Toxic effects occur with large doses, especially neurotoxicity

# Vitamin $B_{12}$ (Cyanocobalamin)

- Water soluble
- Synthesized by microorganisms present in the body
- Food sources
  - Liver, kidney, fish, shellfish, meat, dairy foods
- Contained in minimal amounts in plants

# Vitamin $B_{12}$ (Cyanocobalamin): Function

- Present as two different coenzymes
- Required for many metabolic pathways
  - Fat and carbohydrate metabolism
  - Protein synthesis
  - Growth, cell replication
  - Hematopoiesis
  - Nucleoprotein and myelin synthesis

# Vitamin $B_{12}$ (Cyanocobalamin): Deficiency

- Deficiency leads to:
  - Neurologic damage
  - Pernicious anemia
- Deficiency states caused by:
  - Malabsorption
  - Poor dietary intake (vegetarians)

# Vitamin $B_{12}$ (Cyanocobalamin): Oral Absorption

- Oral absorption of vitamin $B_{12}$ (extrinsic factor) required presence of the intrinsic factor
- The intrinsic factor is a glycoprotein secreted from the gastric parietal cells

# Vitamin $B_{12}$ (Cyanocobalamin): Oral Absorption (cont'd)

The extrinsic and intrinsic factors form a complex that is then absorbed by the intestines

# Vitamin C (Ascorbic Acid)

- Water soluble
- Natural sources
  - Citrus fruits and juices
  - Tomatoes
  - Cabbage
  - Cherries
  - Liver
- Can also be synthesized

# Vitamin C (Ascorbic Acid): Functions

- Acts in oxidation-reduction reactions
- Required for several metabolic activities
  - Collagen synthesis
  - Maintenance of connective tissue
  - Tissue repair
  - Maintenance of bone, teeth, and capillaries
  - Folic acid metabolism
  - Erythropoiesis

# Vitamin C (Ascorbic Acid): Functions (cont'd)

- Enhances absorption of iron
- Required for the synthesis of:
  - Lipids
  - Proteins
  - Steroids
- Aids in cellular respiration
- Aids in resistance to infections

# Vitamin C (Ascorbic Acid): Deficiency

- Prolonged deficiency results in scurvy
  - Gingivitis and bleeding gums
  - Loss of teeth
  - Anemia
  - Subcutaneous hemorrhage
  - Bone lesions
  - Delayed healing of soft tissues and bones

# Vitamin C (Ascorbic Acid): Indications

- Dietary supplement
- Prevention and treatment of scurvy
- Urinary acidifier

# Vitamin C (Ascorbic Acid): Megadoses

- Megadoses may cause:
  - Nausea, vomiting, headache, abdominal cramps
  - Acidified urine, with possible stone formation
- Discontinuing megadoses may result in scurvy-like symptoms

# Minerals

- Inorganic elements or salts
- Bind with enzymes or other organic molecules
- Help to regulate many body functions

# Minerals

- Building blocks for many body structures
- Required for intracellular and extracellular body fluid electrolytes
- Macrominerals
- Microminerals, or trace elements

# Calcium

- Most abundant mineral element in the body
- Accounts for 2% of body weight
- Highest concentration in bones and teeth
- Efficient absorption requires adequate amounts of vitamin D

# Calcium: Food Sources

- Found in many foods
- Especially milk and dairy products

# Calcium Requirements

- Calcium requirements high for
  - Growing children
  - Women who are pregnant or breast-feeding

# Calcium: Function

- Essential for normal maintenance and function of:
  - Nervous, muscular, skeletal systems
  - Cell membrane and capillary permeability
- Catalyst in many enzymatic reactions

# Calcium: Function (cont'd)

- Essential in many physiologic processes
  - Transmission of nerve impulses
  - Contraction of cardiac, smooth, and skeletal muscles
  - Renal function, respiration, and blood coagulation
- Several other functions

# Calcium Deficiency

- Calcium deficiency: hypocalcemia
  - Infantile rickets
  - Adult osteomalacia
  - Osteoporosis
  - Many other conditions associated with calcium deficiency

# Calcium
# Causes of Deficiency

- Inadequate intake of calcium or vitamin D
- Hypoparathyroidism
- Malabsorption syndrome
- Many other causes

# Calcium: Indications

- Used to treat various deficiency states
- Dietary supplement for women during pregnancy and lactation

# Calcium: Toxicity

- Hypercalcemia may occur with therapy
  - Anorexia, nausea, vomiting, constipation

# Calcium: Drug Interactions

Chelation

- Calcium salts will bind (chelate) with tetracyclines to produce an insoluble complex

# Magnesium

- One of the principal cations of intracellular fluid
- Essential for enzyme systems associated with energy metabolism
- Required for:
  - Nerve physiology
  - Muscle contraction

# Magnesium (cont'd)

- Dietary sources
  - Vegetables and other foods
- Required in higher amounts in those with diets high in protein-rich foods, calcium, and phosphorus

# Magnesium: Causes of Deficiency

- Hypomagnesemia
  - Malabsorption
  - Alcoholism
  - Long-term IV feedings
  - Diuretics
  - Metabolic disorders (hyperthyroidism, diabetic ketoacidosis)

# Magnesium: Indications

- Nutritional supplement
- Treatment of magnesium deficiency
- Anticonvulsant in magnesium deficiency
- Preeclampsia and eclampsia
- Tocolytic agent for inhibition of uterine contractions in premature labor
- Many other uses

# Magnesium: Adverse Effects

- Adverse effects are due to hypermagnesia
  - Tendon reflex loss
  - Difficult bowel movements
  - CNS depression
  - Respiratory distress
  - Heart block
  - Hypothermia

# Phosphorus

- Widely distributed in foods
- Dietary deficiency is rare

# Phosphorus Deficiency

- Deficiency due to nondietary causes
  - Malabsorption
  - Extensive diarrhea or vomiting
  - Hyperthyroidism
  - Long-term use of aluminum or calcium antacids
  - Hepatic disease

# Phosphorus: Functions

- Required precursor for the synthesis of essential body chemicals
- Building block for body structures
- Required for the synthesis of:
  - Nucleic acid
  - AMP
  - ADP
  - ATP

# Phosphorus: Functions (cont'd)

- Responsible for cellular energy transfer
- Necessary for the development and maintenance of the skeletal system and teeth
- Several other functions

# Phosphorus: Indications

- Treatment of deficiency states
- Dietary supplement

# Phosphorus: Side Effects

- Diarrhea
- Nausea and vomiting
- Other GI disturbances
- Confusion
- Weakness
- Breathing difficulties

# Zinc

- Trace element
- Essential in metabolic reactions of proteins and carbohydrates
- Important for normal tissue growth and repair, especially wound repair

# Vitamins and Minerals: clinical Implications

- Assess nutritional status
- Assess baseline lab values (H&H, WBC, RBC, protein, albumin levels)
- Assess history and medication history
- Assess for contraindications

# clinical Implications

- Follow specific guidelines for administration, especially if parenteral
- Provide nutritional counseling about necessary foods to include in the diet

# clinical Implications

- Monitor for therapeutic responses
  - Will vary for each vitamin and mineral
- Monitor for side effects and adverse effects

# Know About Diseases or Conditions Associated with:

Fat soluble Vitamins
A, D, E, K

- B complex vitamins
- Vitamin C
- calcitriol (Rocaltrol)

- Calcium
- Magnesium
- Phosphorus
- Zinc