Chapter 12: Vitamins and Minerals

Measurements of Vitamin Needs

- The original recommended daily allowance (RDA) was designed with the goal of preventing the diseases produced by a deficiency of a certain nutrient. These values were meant to be used to make recommendations for populations rather than specific people. During subsequent years, the RDAs began to be used (inappropriately) to address specific patient needs.

Vitamins and Minerals

- Haveles (pp. 148-149)
  - Vitamins are essential in small quantities for maintenance of cell structure and metabolism
  - In normal quantities, a vitamin is used to replace the specific vitamin that is deficient
  - When vitamins are used to treat problems not associated with vitamin deficiency, they are regarded as drugs
  - Few situations exist for which proof has been found that vitamins are useful for the treatment of any condition except vitamin deficiency

- Haveles (pp. 148-149) (Table 12-1)
  - Vitamins are classified into two large groups: water soluble and fat soluble
  - Water-soluble vitamins include B vitamins and vitamin C
  - Fat-soluble vitamins are vitamins A, D, E, and K
  - Vitamins act in three different ways: coenzymes, antioxidants, or hormones
  - Water-soluble vitamins act as coenzymes, acting with a specific enzyme that catalyzes a specific reaction
  - Vitamin C and E act as antioxidants
  - Vitamin A and D act as hormones

- Haveles (pp. 148-149) (Box 12-1)
  - In 1993 the Food and Nutrition Board initiated a review process, beginning with a symposium
  - The new RDAs are designed not only to prevent deficiency diseases, but also to minimize chronic diseases such as heart disease
  - The original term RDAs has been divided into different, more specific recommendations
Terminology

- Dietary reference intakes (DRIs)
- Estimated average requirement (EAR)
- Recommended dietary allowance (RDA)
- Adequate intake (AI)
- Tolerable upper intake level (UL)

Water-Soluble Vitamins

- Ascorbic acid (vitamin C)
  - A sugar acid that readily undergoes oxidation to form dehydroascorbic acid
  - Ascorbic acid is an effective reducing agent

Water-Soluble Vitamins

- Ascorbic acid (vitamin C): sources
  - Good natural sources include citrus fruits, green peppers, tomatoes, strawberries, broccoli, raw cabbage, baked potatoes, and papaya
  - Ascorbic acid is readily destroyed through cooking, and as much as 50% of the ascorbic acid content of foods can be lost in this manner

Water-Soluble Vitamins

- Ascorbic acid (vitamin C): RDA
  - The RDA of ascorbic acid for a healthy female adult is 75 mg and 90 mg for a healthy male adult
  - During pregnancy and lactation, stress, or tobacco smoking, the need for this vitamin increases

Water-Soluble Vitamins

- Ascorbic acid (vitamin C): role
  - The metabolic role of ascorbic acid is probably related to the fact that ascorbic acid and dehydroascorbic acid form a readily reversible oxidation-reduction system
  - The belief is that this vitamin plays a role in biologic oxidations and reductions in cellular respirations
  - Ascorbic acid also plays a definite role in connective-tissue metabolism because it is required for the formation of collagen

Water-Soluble Vitamins

- Ascorbic acid (vitamin C): deficiency
  - Deficiency of ascorbic acid produces scurvy
  - Manifestations occur because of the inability of the connective tissue to produce and maintain intercellular substances such as collagen, bone matrix, dentin, cartilage, and vascular endothelium
  - Because humans and other primates cannot synthesize vitamin C, they must obtain it daily from their diet
Water-Soluble Vitamins

- Ascorbic acid (vitamin C): adverse reactions
  - Untoward effects have been reported with use of megadoses of vitamin C
  - Daily intake of 1 gram of vitamin C may cause precipitation of oxalate stones in the urinary tract

- Ascorbic acid (vitamin C): clinical considerations
  - As long ago as 1942, the suggestion was made that vitamin C could be therapeutically beneficial in preventing the common cold
  - Based on current evidence, unrestricted use of ascorbic acid for these purposes cannot be advanced

- Water-soluble vitamins, except for vitamin C, are known as B-complex vitamins
  - These vitamins can be subdivided into the following three classes
    - Those that primarily release energy from carbohydrates and fats
    - Those that, among other functions, catalyze the formation of red blood cells
    - Those that have not been shown to be required in human nutrition

Water-Soluble Vitamins

- Thiamine (vitamin B1)
  - Source: abundant in foods of both animal and vegetable origin
  - RDA: 1.2 mg for adult men and 1.1 mg for adult women
  - Role: thiamine pyrophosphate (TPP) plays a principal role in intermediary metabolism
  - Deficiency: severe deficiency leads to beriberi
  - Adverse reactions: usually nontoxic; some patients are hypersensitive
  - Clinical considerations: used for treatment of a variety of manifestations of deficiencies

- Riboflavin (vitamin B2)
  - Source: abundant in both plants and animals
  - RDA ranges from 1.1 (adult women) to 1.2 mg (adult men)
  - Role: functions as two flavoprotein enzymes
  - Deficiency: symptoms usually involve the lips, tongue, and skin
  - Adverse reactions: not associated with any toxicity

- Niacin or nicotinic acid (vitamin B3)
  - Source: lean meats, fish, liver, poultry, legumes, and whole grains
  - Role: plays a key role in metabolism by participating in a variety of oxidation-reduction reactions
  - Deficiency: clinical syndrome is pellagra
  - Adverse reactions: side effects from large doses include cutaneous flushing, pruritus, GI distress
  - Clinical considerations: used as a vitamin in treatment of pellagra
Water-Soluble Vitamins

Haveles (p. 154) (Table 12-2)

- B-complex vitamins: pyridoxine (vitamin B₆)
  - Pyridoxine is one of three different pyridoxine derivatives
  - Source: present in most foods of both plant and animal origin
  - RDA: varies from 1.0 to 1.7 mg daily for men and women ages 9 to older than 70 years
  - Deficiency: rare because of widespread distribution in food
  - Adverse reactions: usually nontoxic
  - Clinical considerations: can interact with isoniazid (INH); can cancel the therapeutic and side effects of levodopa; certain other drugs may produce a pyridoxine deficiency

Water-Soluble Vitamins

Haveles (pp. 154-155) (Table 12-4)

- B-complex vitamins: folic acid
  - A form of water-soluble vitamin B₉
  - Sources: include glandular meats such as liver, some fruits and vegetables, wheat germ, and yeasts
  - RDA is 400 µg daily for healthy, nonpregnant, or nonlactating adults
  - Role: tetrahydrofolic acid functions primarily in the transfer and utilization of one-carbon groups
  - Deficiency: produces megaloblastic anemia, the most common deficiency in the United States
  - Adverse reactions: relatively nontoxic
  - Clinical considerations: will cause remission of hematologic effects of pernicious anemia; will not prevent neurologic effects caused by deficiency of vitamin B₁₂

Water-Soluble Vitamins

Haveles (p. 155)

- B-complex vitamins: cyanocobalamin (vitamin B₁₂)
  - A chemically complex substance that contains four extensively substituted pyrrole rings surrounding an atom of cobalt
  - Source: the only sources in nature are certain microorganisms that synthesize the vitamin
  - RDA is 2.4 µg, with an additional 2.6 µg and 2.8 µg during pregnancy and lactation respectively
  - Role: a coenzyme required in conversion of methylmalonyl-CoA to succinyl-CoA
  - Deficiency: symptoms include inadequate hematopoiesis, GI disturbances, inadequate myelin synthesis, and generalized debility, most common cause is pernicious anemia
  - Adverse reactions: even large doses are usually nontoxic
  - Clinical considerations: patients who are vegetarians or who have had a gastrectomy can exhibit symptoms of deficiency

Water-Soluble Vitamins

Haveles (p. 155)

- B-complex vitamins: pantothenic acid
  - Pantothenic acid is another compound required to form acetyl-CoA
  - Source: a part of all living material
  - RDA: suggested daily dietary intake of 5 to 7 mg
  - Role: incorporated into coenzyme-A, essential for normal epithelial function
  - Deficiency: clinical deficiencies are extremely rare in humans
  - Clinical considerations: apparently promotes GI motility

Water-Soluble Vitamins

Haveles (pp. 155-156)

- B-complex vitamins: biotin
  - Initially demonstrated to be an essential growth factor for yeast
  - Source: present in almost all foods, synthesized by microflora in the intestinal tract
  - RDA: suggested daily dietary intake is 25 to 35 mg
  - Role: a coenzyme required in metabolism in carbon dioxide fixation reactions
  - Deficiency: can occur with long-term parenteral nutrition
  - Clinical considerations: antimetabolite agents can produce a biotin deficiency

Water-Soluble Vitamins

Haveles (pp. 156-157)

- B-complex vitamins: other B vitamins
  - Vitamin B₅ and B₁₇, also known as pangamic acid and amygdalin (Laetrile), have been shown to be neither vitamins nor important in human nutrition
  - Neither choline nor inositol has been demonstrated to be required in the human diet
Fat-Soluble Vitamins

- Haveles (p. 157)
  - Vitamin A
  - Necessary for normal growth and for maintaining health and integrity of certain epithelial tissues
    - The term vitamin A represents a group of retinoids and carotenoids
    - Source: vitamin A occurs naturally in saltwater fish and animal tissues
      - Vitamin A₁ is found in freshwater fish
      - Preformed vitamin A is found in milk, liver, and some cheeses
    - Carotenes provide the greatest source of vitamin A in most diets
      - Carotenes are found in pigmented fruit and in vegetables

- Vitamin A analogs
  - Tretinoin is a topical product used to treat acne
  - Isotretinoin is used orally for treatment of severe cystic acne

Fat-Soluble Vitamins

- Haveles (pp. 157-158)
  - Vitamin A
    - Adult RDA is 700 to 1300 retinol equivalents (REs)
    - Role: essential for maintenance of photoreceptor mechanism of the retina; the integrity of the epithelia, and the mucosa of the respiratory, GI, and genitourinary tracts; and lysosome stability
    - Deficiency: leads to impaired vision in dim light, nystagmus
    - Toxicity: characteristics include itching skin, desquamation, coarse or absent hair, painful subcutaneous swellings, gingivitis, hyperirritability, and limitation of motion
      - When the Vikings landed in Iceland, they ingested polar bear liver and died from acute poisoning

Fat-Soluble Vitamins

- Haveles (p. 158)
  - Vitamin A
    - Deficiency: produces inadequate absorption of calcium and phosphate with a decrease in plasma calcium
      - Parathyroid hormone secretion is stimulated, which removes calcium from the bone to restore plasma levels
      - In children, this results in rickets
      - During pregnancy or in young children, deficiency may result in enamel hypoplasia
      - In adults, it produces a disease state called osteomalacia
    - Toxicity: symptoms of hypervitaminosis D are caused by abnormal calcium metabolism

Fat-Soluble Vitamins

- Haveles (pp. 158-159)
  - Vitamin D
    - Source: vitamin D₃ is produced in the skin of mammals by the action of sunlight on its precursor
      - Cholecalciferol (vitamin D₃) is also present in some foods and is added to dairy products
      - Ergocalciferol (vitamin D₂) is the vitamin D found in plants and is the form of vitamin D used in vitamin supplements
    - RDA: adequate daily dietary intake of vitamin D is 5 µg/day for children and 5 to 15 µg/day for adults
    - Role: promotes normal mineralization of bone by stimulating intestinal absorption of calcium and decreasing excretion from the kidney

Fat-Soluble Vitamins

- Haveles (pp. 158-159)
  - Vitamin D
    - Clinical considerations: used to prevent and treat rickets, chronic hypocalcemia, hypophosphatemia, osteodystrophy, and osteomalacia
    - Osteoporosis: occurs when the equilibrium between resorption and formation of bone becomes negative
      - Most likely the thin, Caucasian, or Asian woman who smokes
      - Bisphosphonates are indicated for management of osteoporosis
Fat-Soluble Vitamins

- Haveles (p. 159)
  - Vitamin E
    - There are eight naturally occurring tocopherols possessing vitamin E activity
      - Source: best sources are vegetable oils
      - RDA: estimated that a daily intake of 10 to 20 mg will keep serum level within a normal range
      - Role: action is probably exerted via its antioxidant effect
      - Deficiency: can occur in malabsorption syndromes and in premature infants with impaired absorption ability
      - Toxicity: thought to have low toxicity
  - Source: best sources are vegetable oils
  - RDA: estimated that a daily intake of 10 to 20 mg will keep serum level within a normal range
  - Role: action is probably exerted via its antioxidant effect
  - Deficiency: can occur in malabsorption syndromes and in premature infants with impaired absorption ability
  - Toxicity: thought to have low toxicity

Fat-Soluble Vitamins

- Haveles (p. 160)
  - Vitamin E
    - Clinical considerations: recommended for treatment of a wide variety of human diseases similar to conditions of vitamin E deficiency
      - At present, no therapeutic use of vitamin E has been proved by controlled scientific studies, with the exception of hemolytic anemia of the newborn
  - Source: occurs in green vegetables, such as alfalfa, cabbage, and spinach, and in egg yolk, soybean oil, and liver
  - Role: essential for hepatic synthesis of four of the clotting factors
  - Deficiency: can produce hypoprothrombinemia

Fat-Soluble Vitamins

- Haveles (p. 160)
  - Vitamin K
    - Originally found to be a fat-soluble substance present in hog liver fat and alfalfa
    - Vitamin K consists of several substances, with menaquinone-4 being the most active form
      - It is synthesized by gram-positive bacteria present in the gastrointestinal tract
    - Vitamin K is found in plants
    - Source: occurs in green vegetables, such as alfalfa, cabbage, and spinach, and in egg yolk, soybean oil, and liver
    - Role: essential for hepatic synthesis of four of the clotting factors
    - Deficiency: can produce hypoprothrombinemia
    - Toxicity: vitamins K1 and K2 are essentially nontoxic in massive doses; vitamin K must be administered in large doses before toxicity can be demonstrated
    - Clinical considerations: anticoagulant drugs such as warfarin competitively antagonize vitamin K and interfere with the production of prothrombin (II) and factors VII, IX, and X
      - Vitamin K can be used to treat excessive hypoprothrombinemia caused by warfarin toxicity

Selected Minerals

- Haveles (pp. 160-161)
  - Iron
    - Widely distributed throughout the human body, principally found in hemoglobin
      - Source: good sources include organ meats, wheat germ, brewer's yeast, egg yolks, oysters, red meats, and dried beans
      - RDA: the body carefully conserves iron; no mechanism for its excretion exists
      - Role: basic function is to allow for the movement of oxygen and carbon dioxide from one tissue to another
Selected Minerals

- HAVELES (pp. 161-162)
  - Iron
    - Deficiency: can only occur with growth, blood loss, or inadequate intake during pregnancy or lactation
      - Produces microcytic and hypochromic anemia
      - Toxicity: bleeding into the intestine can occur with acute overdose, resulting in shock or even death

- ZINC
  - Only recently recognized as a mineral the body requires
  - Source: best sources are seafood and meat
  - RDA for adults is 11 mg for men and 8 mg for women
  - Role: required to transport carbon dioxide in the blood and eliminate it in the lungs
  - Deficiency: associated with delay in sexual maturity, slow healing of wounds, and slowed growth
  - Toxicity: excessive intake has impaired lymphocyte and polymorphonuclear leukocyte functions in healthy persons
  - Clinical considerations: long known to participate in wound healing, no known advantage to administration of zinc in patients who have no zinc deficiency

- CALCIUM
  - The level of calcium in the serum must be maintained within a narrow concentration to prevent serious problems
  - Source: dairy products are the best source in the diet
  - RDA: adequate daily dietary intake is from 1000 to 1300 mg for the adult
  - Role: essential for function of nervous, muscular, and skeletal systems and for cell membrane and capillary permeability
  - Deficiency: tetany, paresthesia, muscle cramps, and convulsions can result if blood levels fall
  - Adverse reactions: hypocalcemia can result if large doses are given to patients with chronic renal failure
  - Clinical considerations: calcium is used to treat a deficiency of calcium and secondary to low calcium levels

Drug-Induced Vitamin Deficiencies

- HAVELES (p. 163) (Table 12-4)
  - Drugs from a large variety of drug groups have the ability to produce vitamin deficiency
    - Some actually produce a deficiency, whereas others tend to lower the levels of some vitamins
      - INH can produce a neuropathy resulting from vitamin B6 deficiency
      - Patients taking phenytoin may exhibit vitamin D deficiency because phenytoin stimulates the liver microsomal enzymes
      - Certain drugs, such as oral contraceptives tend to induce a deficiency of vitamins B12, B6, and folic acid