# Vitamin D Deficiency

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## Risk

- High prevalence of deficiency (much more than previously recognized).
- At risk: Dietary insufficiency, breastfed infants, inadequate sun exposure, elderly, nursing home residents, institutionalized, dark skinned individuals, obese, post gastric bypass, IBD.
- Genetically predisposed: Rickets, osteomalacia.

## Worry About

- Hypocalcemia; vitamin D promotes calcium absorption in the gut and aids in maintenance of calcium and phosphorus levels. Without vitamin D, only 10–15% of dietary calcium and approx 60% of phosphorous is absorbed. Low total body magnesium is also likely.
- Calcitriol influences muscle function, CV homeostasis, and immune response.
- Deficiency associated with Htn, MI, CHF, and calcific aortic stenosis.
- Ample evidence to connect adequacy to risk and/or severity of certain cancers (colorectal, prostate, breast, leukemia) and autoimmune diseases (RA, MS, type 1 DM).
- Chronic vitamin D deficiency may lead to impaired mineralization of cervical spine (increased incidence of abn neck mobility). Pediatric pts with deformed chest wall may experience lowered FRC and increased incidence of respiratory infections.

## Overview/Pharmacology

- Fat soluble vitamin and biologically inert. Amount obtained through food sources is minimal compared to that from sun exposure.
- There are two main forms. Vitamin $D_3$ (cholecalciferol) is synthesized in the skin by exposure to ultraviolet (UVB) radiation. Vitamin $D_2$ (ergocalciferol) is obtained through irradiation of ergosterol in plants and subsequent dietary intake.
- Intake involves two hydroxylations. Vitamins $D_2$ and $D_3$ are hydroxylated in the liver to 25 vitamin D (calcidiol), the major circulating form. Further hydroxylation in the kidney produces the active metabolite 1,25 vitamin D (calcitriol). Calcitriol is the physiologically active form.
- Involved in functioning of hemopoietic cells, skin cells, cancer cells of various origins, islet cells of the pancreas, immune response, as well as CV function (via serum $Ca^{2+}$).

## Etiology

- Inadequate sun exposure, dietary insufficiency.
- There are two types of vitamin D-dependent rickets: Type I: Inherited autosomal recessive trait (defect in the 25OH-$D_3$ conversion into calciferol [true vitamin D]); type II: Autosomal dominant disorder, where single amino acid change in vitamin D receptor results in nonfunctional state.
- Osteomalacia is a metabolic disease with inadequate and/or delayed mineralization of osteoids in mature bone.

## Usual Treatment

- Now recognized as an essential supplement for most adults, especially ages >50.
- Dose: Ages 1–70 recommendation, 600 IU/d in normal children/adults. Ages 71 and greater, 800 IU/d.
- Occurs in few food sources in nature. Fatty fish and fish liver oils are best source. Other sources in USA diet are from fortified foods such as milk, breakfast cereals, yogurt, and orange juice.
- Toxicity: Margin of safety is large. Prolonged intake of doses >40,000 IU/d promotes bone demineralization, leads to hypercalcemia, and enhances CV calcification.
- Prescribed for rickets, osteomalacia.
- Vitamin D insufficiency: Vitamin D 800–2000 IU/d + elemental calcium 1200 mg/d.
- Vitamin D deficiency: Elemental calcium 1200 mg/d plus ergocalciferol 50,000 IU/wk for 8–12 wk, then 2000 IU/d vitamin $D_3$.

## Assessment Points

| System | Effect | Assessment by Hx | PE | Test |
|---|---|---|---|---|
| MS | Impaired mineralization<br>Increased arthritis due to bone spur formation<br>Osteomalacia<br>Osteoporosis | Bone pain, fracture<br>Joint pain<br>Weak antigravity muscles | Dry, scaly skin<br>Brittle nails<br>Coarse hair<br>Neck immobility<br>Osteoarthritis | Bone density<br>X-ray |
| CV | CHD<br>CHF<br>Irregular heart beat<br>Orthostatic hypotension<br>Htn<br>Cardiac hypertrophy<br>Vascular calcification<br>Stroke | Angina<br>Dyspnea<br>Palpitations<br>Fatigue | Auscultation | ECG<br>BP<br>Stress test<br>Cardiac ECHO |
| CNS/PNS | NM irritability | Muscle stiffness, rigidity<br>Numbness, paresthesias<br>Muscle cramps<br>Persistent, nonspecific musculoskeletal pain | Seizure, tetany | Calcium levels<br>PTH (if severe) |

**Key References:** Stechschulte S, Kirsner R, Federman D: Vitamin D: Bone and beyond, rationale and recommendations for supplementation. *Am J Med* 122(9):793–802, 2009; Akhtar S: Diseases of the endocrine system. In Fleisher LA editor: *Anesthesia and uncommon diseases,* ed 6, Philadelphia, PA, 2012, Elsevier, pp 406–408.

## Perioperative Implications

### Preoperative Preparation

- Both PTH and vit $D_3$ (calcitriol) work to keep the level of ionized $Ca^{2+}$ within tight range (±0.1 mg/dL).
- Periop considerations are related to:
  - Level of ionized $Ca^{2+}$ (regulation of muscle contraction)
  - Neurotransmitter release
  - Blood coagulation

### Monitoring

- ECG changes: Compare to previous tracing. Prolonged QT interval (adjusted to R-R interval; 2:1 intraventricular heart block).
- Easy availability of blood sample for immediate serum calcium assessment (art catheter vs. vein stick).

### Maintenance

- $ETCO_2$: Avoid hyperventilation (alkalosis shifts ionized $Ca^{2+}$ into the cells). Acute hypocalcemia increases chance of tetany.
- Monitor/replete calcium, phosphate, and magnesium.

### Extubation

- Laryngeal spasm on extubation in fully awake pt is also likely. Predictor may be distal extremity paresthesia.

### Management

- Acute treatment (laryngospasm, seizure, tetany): Initial IV bolus 10–20 mL 10% calcium gluconate over 10 min followed by infusion over 6–24 h if needed.
- Monitor calcium, magnesium, phosphate, potassium, and creatinine.

## Anticipated Problems/Concerns

- Chronic anticonvulsant Rx (phenobarbital/phenytoin) may lead to hypocalcemia (decreased $Ca^{2+}$ absorption from the intestine) and diminished vitamin D biosynthesis in the liver.
- Vitamin D serum concentration is decreased when PTH is decreased (may occur with thiazide medications).
- Deficiency can be a result of deficient production of vitamin D in the skin, lack of dietary intake, impaired vitamin D activation, or resistance to the biological effects of calcitriol.
- Disorders of small bowel, hepatobiliary system, and pancreas (bile salt deficiency, pancreas insufficiency, poor intestinal absorption of fat-soluble vitamins [A, D, K, E]) may cause maldigestion and/or malabsorption.
- Liver disease can impact CRI/ESRD (GFR <25% of nml), with moderate to severe impairment of renal phase synthesis of vitamin D with reduction of serum albumin.
- Uremia, CRF, and nephritic syndrome suppress vitamin D action on gut.
- Nephrotic syndrome causes vitamin D deficiency related to chronic proteinuria (loss of circulating 25 vitamin $D_3$–binding globulin). Symptoms present are 2° hyperparathyroidism, low serum $Ca^{2+}$, osteomalacia.
- Vitamin $D_3$ (1,25 dihydroxycholecalciferol) directly facilitates $Ca^{2+}$, $Mg^{2+}$, and $(PO_4)^{3-}$ uptake by intestinal mucosa, their transport through intestinal cells and efflux.