

Rickets, Nutritional

Description/Etiology

Rickets is a disorder in growing children characterized by defective bone and cartilage mineralization secondary to abnormal calcium, phosphorus, and/or vitamin D metabolism. Rickets is defined as failure of osteoid (i.e., noncalcified matrix of young bone) to calcify in a growing person or animal. Rickets can cause bone pain, long bone deformity, fractures, and other skeletal deformities.

Nutritional rickets is caused by calcium and/or vitamin D deficiency. Vitamin D deficiency, which can be caused by inadequate dietary intake and/or insufficient exposure to ultraviolet (UV) light, causes impaired intestinal absorption of calcium and its deposition in bone. Without sufficient calcium, proper bone mineralization cannot occur and excess bone osteoid can accumulate, leaving bones soft and susceptible to fractures.

Treatment consists of dietary changes and supplements to correct nutritional deficiency, analgesia for discomfort, moderate sun exposure, careful supportive positioning, and braces in some cases.

Facts and Figures

Nutritional rickets can occur in infants aged 6 months to 1 year but is rarely seen in newborns. Rickets is relatively uncommon in developed countries because dietary intake regularly includes milk and green vegetables, which contain phosphorus and calcium. Nutritional deficiencies still cause severe rickets in Africa. The estimated incidence of rickets in White children in the U.K. is 3.16 per 100,000 children < 15 years of age. In Turkey, 3.1% of children aged 3 months -15 years have clinical and biochemical changes consistent with rickets. Over 90% of vitamin D is synthesized in the skin after exposure to UV radiation; the remainder is obtained from dietary sources. Nutritional rickets does not occur in formula-fed infants in the United States; formula contains 400 IU/L of vitamin D. In the U.S., nearly all cases of nutritional rickets occur in breastfed infants with darker skin who do not receive vitamin D supplementation. (WHO)

ICD-9
275.3

ICD-10
E55.0

Authors

Tanja Schub, BS

Cinahl Information Systems, Glendale, CA

Cherie Marcel, BS

Cinahl Information Systems, Glendale, CA

Reviewers

Kathleen Walsh, RN, MSN, CCRN

Cinahl Information Systems, Glendale, CA

Alexia Beauregard, RD, MS, CSP, LD

Cinahl Information Systems, Glendale, CA

Nursing Executive Practice Council

Glendale Adventist Medical Center,

Glendale, CA

Editor

Diane Pravikoff, RN, PhD, FAAN

Cinahl Information Systems, Glendale, CA

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Risk Factors

Risk factors include darker skin pigmentation, poverty, poor nutrition, and insufficient sunlight exposure. Factors that contribute to inadequate UV exposure include sunscreens, industrial pollution, and dress codes/customs that encourage covering infants and children. Severe nutritional rickets has become rare in the U.S. and Europe, although darker-skinned inner-city children are at risk for mild disease. Children born to mothers with low vitamin D, calcium, and phosphorus levels can be prone to rickets during infancy, especially when breastfed because breast milk is a poor source of vitamin D; formula-fed infants usually get sufficient calcium and vitamin D.

Signs and Symptoms/Clinical Presentation

Failure to grow, lethargy, and increased irritability can be signs that an infant is deficient in vitamin D. Chvostek sign (i.e., spasm of facial muscles when the facial nerve is tapped) can be present, indicating low serum calcium; tetany and/or seizures can also occur. Bone pain/tenderness in arms, legs, spine, or pelvis and skeletal/dental deformities are significant signs. For other physical findings, see below.

Nutritional Assessment

› Patient Medical History

- Obtain patient history, including assessing for/asking about
 - signs and symptoms (e.g., pain, fatigue, headaches), if any, that can indicate inadequate nutrient consumption and can negatively affect dietary intake
 - level and type of regular physical activity

› Physical Findings of Particular Interest

- Failure to grow can cause short adult stature
- Delayed tooth eruption, greater susceptibility to cavities in deciduous teeth
- Delayed fontanelle closure
- Pigeon chest (pectus carinatum; i.e., protruding sternum/ribs)
- Oddly shaped skull caused by cranial bones growing faster than facial bones
- Limb pain, tenderness, or slight ache
- Muscle cramps, reduced muscle tone
- Deformity of long bones (bowlegs)
- Rachitic rosary (i.e., knob-like swellings where ribs and cartilage join)
- Unsteady gait—can present as limping or waddling
- Wrist enlargement (i.e., bracelet-like appearance of bone around the wrist)

› Patient Dietary History

- A 24-hour dietary recall can be used to assess individual usual intake. Evaluate usual nutrition intake by asking the patient/patient's family to complete a 24-hour dietary recall identifying foods generally consumed, food preferences, cultural/religious beliefs, and medically prescribed dietary interventions
 - In the outpatient setting, a 24-hour dietary recall combined with a 3-day diet history may be useful for evaluating the patient's dietary strengths and weaknesses (i.e., patient recalls all foods and beverages consumed in a 3-day period that includes 1 weekend day)
- Ask about personal habits, including caffeine and soda consumption and use of any herbal or over-the-counter supplements (e.g., fish oil caps, cranberry caps, ginger, etc.) as well as prescription medications

› Anthropometric Data and Calculations

- Anthropometric tools are available for the measurement of adequate nutrition in children
 - The Centers for Disease Control and Prevention (CDC) has established references for weight and growth patterns, which can be tracked on weight-for-age/height-for-age/weight-for-height age-based growth charts, as well as body mass index (BMI) for age charts which assist in the calculation of BMI for ages 2 to 20 years

› Laboratory Tests and Diagnostic Tests of Particular Interest to the Nutritionist

- Serum chemistry can reflect abnormal levels of calcium, phosphate, alkaline phosphatase, parathyroid hormone, and vitamin D
- ABGs can show metabolic acidosis
- UA can show low excretion of calcium and creatinine

› Other Diagnostic Tests/Studies

- Although rarely performed, bone biopsy (usually taken from the iliac crest) can confirm rickets when special stains (e.g., von Kossa stain) show excessive osteoid formation
- X-rays, particularly of knee joint, can show evidence of decalcification of bone at the epiphyseal plate junction (i.e., growth plate seam)

Treatment Goals

› Correct Nutritional Deficiency and Provide Symptomatic Relief

- Review results of laboratory tests and diagnostic studies related to nutritional status and evaluate for deficiencies in nutrition; report findings to the treating clinician
- Clinician may prescribe vitamin D and calcium supplements if levels are low
 - American Academy of Pediatrics (AAP) guidelines (Misra et al., 2008):
 - Vitamin D (cholecalciferol): Infants < 1 month: 1,000 IU/day; 1–12 months: 1,000–5,000 IU/day; > 12 months: > 5,000 IU/day
 - Calcium (elemental): 30–75 mg/kg/day in 3 divided doses; start with high-end doses and titrate downward over 2–4 weeks

- Monitor bone biochemistry results until symptom reversal is observed
- Determine dietary preferences and provide information about a healthy diet high in necessary vitamins and minerals
- › **Provide Emotional/Psychosocial Support and Educate**
- Assess parental anxiety level and emotional status; provide emotional support, educate, and encourage discussion about nutritional rickets pathophysiology, potential complications, treatment risks and benefits, the importance of continued medical surveillance, and individualized prognosis
- Review diet history information to assess dietary intake and patterns and provide detailed patient/family education regarding importance of following a calorie-appropriate and nutrient-dense diet; the effect of diet, exercise, and other lifestyle factors on nutritional status; and strategies for meal planning, grocery shopping, and food preparation. (For more information, see *What Do I Need to Tell the Patient/Patient's Family?* and *Discharge Planning*, below)
- Educate about the benefit of sun exposure (i.e., sun conversion of skin cholesterol substance to vitamin D) and encourage routine sun exposure protected by sunscreen

Food for Thought

- › Rickets was endemic during the Industrial Revolution in temperate zones where air pollution blocked the sun's UV rays
- › Rare forms of inherited rickets also occur

Red Flags

- › If rickets is not corrected during infancy, small stature and skeletal deformities can be irreversible; severe rickets can cause respiratory failure and pelvic distortion in females can cause problems with vaginal delivery in adulthood

What Do I Need to Tell the Patient's Family?

- › Provide instructions and written information, if possible, for
 - Eating a calorie-appropriate diet that includes fish and other lean proteins, unsaturated fats (including omega-3), complex carbohydrates (e.g., whole unrefined grains), legumes, nuts and seeds, and a variety of fruits and vegetables. (For more information on eating a balanced diet, see the USDA food guidance system, ChooseMyPlate, at <http://www.choosemyplate.gov/>)
 - Consume meals containing a variety of at least 5 fruits and vegetables a day in order to supply ample vitamins, minerals, phytonutrients (i.e., beneficial plant-derived nutrients), and fiber. Eating a variety of deeply colored fruits and vegetables (e.g., spinach, carrots, berries) should be emphasized
 - Eat 25–30 g of fiber/day (food sources: oat bran, barley, nuts, seeds, beans, lentils, peas, and fruits and vegetables). At least half of all grains consumed should be whole grains
 - Consume fish, especially oily fish, at least twice a week, along with fortified milk daily, and eggs. All are sources of vitamin D.
 - Ingest adequate calcium (at least 1,200 mg/day) to reduce risk of rickets; good calcium sources are dairy products, fish with bones, broccoli, and legumes
 - Reduce risk for CVD, cancer, stroke, and diabetes mellitus, type 2 (DM2) by choosing unsaturated fats (including omega-3 fatty acid) and by limiting total fat intake to 30% or less of daily calories, limiting saturated fat (found in meat, whole milk, cream, butter, and cheese) to less than 10% of daily calories, and consuming less than 200 mg of cholesterol per day
 - Drink adequate water to prevent or relieve constipation (if medically appropriate)
 - Refrain from consuming sugar-sweetened beverages
 - appropriate portion sizes
 - taking a vitamin and mineral supplement as prescribed
 - participating in regular moderate physical activity of at least 150 minutes each week, including strength training at least 2 days each week, if medically appropriate
 - healthy sun exposure; 20 minutes/day of sunlight to the face of a light-skinned baby is sufficient, with longer durations needed for adequate vitamin D production in babies with darker pigmentation
- › Recruit the help of family and friends to assist in meal planning, grocery shopping, and food preparation
- › Assess for possibility of affected siblings

Related Guidelines

- › For guidelines on determining nutrient needs, see *Nutritional Assessment and Treatment Goals*, above

References

1. Giustina, A., Adler, R. A., Binkley, N., Bollerslev, J., Bouillon, R., Dawson-Hughes, B., & Bilezikian, J. P. (2020). Consensus statement from 2nd International Conference on Controversies in Vitamin D. *Reviews in Endocrine and Metabolic Disorders*, 21(1), 1-28. doi:10.1007/s11154-019-09532-w
2. Mazur, E., & Litch, A. (2019). Vitamins. In *Lutz's Nutrition & diet therapy* (7th ed., pp. 75-78). Philadelphia: F.A. Davis Company.
3. Misra, M., Pacaud, D., Petryk, A., Collett-Solberg, P. F., & Kappy, M. (2008). Vitamin D deficiency in children and its management: Review of current knowledge and recommendations. *Pediatrics*, 122(2), 398-417.
4. Schlenker, E. D. (2019). Vitamins. E. D. Schlenker & S. L. Roth (Eds.), *Williams' essentials of nutrition and diet therapy* (12th ed.). St. Louis, MO: Elsevier Mosby.
5. Shore, R. M., & Chesney, R. W. (2013). Rickets: Part I. *Pediatric Radiology*, 43(2), 140-151. doi:10.1007/s00247-012-2532-x
6. Shore, R. M., & Chesney, R. W. (2013). Rickets: Part II. *Pediatric Radiology*, 43(2), 152-172. doi:10.1007/s00247-012-2536-6
7. Simon, A. E., & Ahrens, K. A. (2020). Adherence to vitamin D intake guidelines in the United States. *Pediatrics*, 145(6), e20193574. doi:https://doi.org/10.1542/peds.2019-3574
8. Tanna, N., Alexander, E. C., Lee, C., Lakhanpaul, M., Popat, R., Almeida-Meza, P., ... Blair, M. (2021). Interventions to improve vitamin D status in at-risk ethnic groups during pregnancy and early childhood-a systematic review. *Public Health Nutrition*, 24, 11. doi:10.1017/S1368980021000756
9. Uday, S., & Höglér, W. (2017). Nutritional rickets and osteomalacia in the twenty-first century: Revised concepts, public health, and prevention strategies. *Current Osteoporosis Reports*, 15(4), 293-302. doi:10.1007/s11914-017-0383-y
10. Woodruff, K. (2019). Nutrition for normal growth and development. E. D. Schlenker & J. Gilbert (Eds.), *Williams' essentials of nutrition and diet therapy* (12th ed.). St. Louis, MO: Mosby, Inc, an affiliate of Elsevier Inc.
11. World Health Organization. (2019, November 6). Nutritional rickets: a review of disease burden, causes, diagnosis, prevention and treatment. Retrieved May 29, 2021, from <https://www.who.int/publications/i/item/9789241516587>