Rickets: Not Just a Disease Caused by Vitamin D Deficiency

Lauren Head Zauche, BSN, RN

KEY WORDS
Case study, hypophosphatemia, rickets

CASE PRESENTATION

A 2-year, 10-month-old White girl presented to a pediatric clinic with an abnormal wide gait and genu varum. She had been an established patient at the clinic since her 4-month well-child visit. Concerns regarding her motor development were noted at her 6-month well-child visit, when she presented with generalized muscle hypotonia, was unable to roll supine to prone or prone to supine, and was unable to sit unassisted. Additionally, the patient had dropped to the 5th to 10th percentile for weight at 6 months from the 25th percentile at her 4-month visit. At her 6-month visit, the patient was referred to a statewide program for infants and toddlers with developmental delays for nutritional support and physical therapy. After 1 month in this program, the patient's development significantly improved, and she was able to roll over in each direction and was able to sit unsupported at 12 months. Although she was making progress, she had not begun to crawl or pull to a stand by 12 months, and both weight and length dropped to the 5th percentile.

The patient was referred to a neurology specialist at her 12-month visit to rule out a neurologic cause for her symptoms. A complete neurologic examination, including magnetic resonance imaging of the brain and spine failed to support a neurologic cause. There was a considerable gap in care between the ages of 12 months and 24 months. At the patient's 24-month visit, she was unable to walk, and her weight had both fallen below the 5th percentile and her length below the 10th percentile. Although the patient was referred to an orthopedic specialist during her 24-month well-child visit, the visit did not take place because of the family's loss of medical insurance. The patient was lost to follow-up between her 24-month visit and her visit at 2 years 10 months.

Medical History

The patient was born via a spontaneous vaginal delivery at 37 gestational weeks with no prenatal or postnatal complications. Her birth weight was 3.2 kg. The standard 48-hour hospitalization after birth was uneventful, and her newborn screening result was normal.

Family Medical History

The family history was negative for any childhood diseases, including genetic, endocrine, and metabolic abnormalities. However, the patient's mother reported that as a child, she was also delayed in meeting milestones in the gross motor developmental domain, and she had short stature, at a height of 4 feet 10 inches. No other pertinent family history was noted.

Social History

The patient lived at home in a one-bedroom apartment with her mother and two older siblings in a rural area. The patient and her siblings had recently returned

Lauren Head Zauche, Doctoral Student and Pediatric Nurse Practitioner Student, Emory University Nell Hodgson Woodruff School of Nursing, Atlanta, GA.

Conflicts of interest: None to report.

Correspondence: Lauren Head Zauche, BSN, RN, Emory University Nell Hodgson Woodruff School of Nursing, 1520 Clifton Rd NE, Atlanta, GA 30329; e-mail: lmhead@emory.edu.

J Pediatr Health Care. (2016) ■, ■-■.

0891-5245/$36.00

http://dx.doi.org/10.1016/j.pedhc.2016.11.005

from a 2-month stay in foster care because of domestic violence, for which her mother obtained a restraining order against the father. At the time of the visit, the mother had no support or help from any other relatives. The patient attended daycare 3 days a week and stayed at home with her mother the remaining time.

Review of Systems

According to the mother, the patient was not in any pain while standing, walking, or moving her lower extremities, and she had not experienced muscle spasms or tremors. The patient was fatigued often, sleeping 8 to 10 hours at night with a 2-hour nap during the day. The patient ate a well-balanced diet, including fruits and vegetables and sources of iron and calcium. All other developmental domains except gross motor were normal, and the remainder of the review of systems results were negative.

Physical Examination

The patient, who was 2 years and 10 months old, weighed 10.0 kg (<3rd percentile), with a height of 81 cm (<3rd percentile) according to a standardized growth chart. Her vital signs were normal. The patient's gait was wide and showed waddling. Decreased strength and range of motion were noted bilaterally in the lower extremities, but normal strength and full range of motion were observed in the upper extremities. Significant genu varum was noted. No scoliosis or widening of the ribs was present. The remainder of the physical examination findings were normal.

Diagnostic Tests

A pediatric nurse practitioner ordered a comprehensive metabolic panel, along with serum phosphate and 1,25-dihydroxyvitamin D tests. Serum 1,25-dihydroxyvitamin D level was 45 pmol/L (reference range = 36–108 pmol/L), and serum phosphate level was 1.7 mg/dl (reference range = 2.5–4.6 mg/dl). All results from the comprehensive metabolic panel were normal, including serum calcium level. Full-length leg, hip, and tibia/fibula radiologic films were also ordered. The patient's bones appeared osteopenic, with cupping of metaphyses at the tibia, fibula, and knees and with evidence of subperiosteal bone resorption.

CASE STUDY QUESTIONS

1. What is the etiology and pathophysiology of X-linked hypophosphatemic (XLH) rickets, and how does its pathology differ from other forms of rickets?
2. What are differential diagnoses for XLH rickets, and what is the clinical presentation of XLH rickets?
3. How is XLH rickets diagnosed and treated?
4. What are challenges associated with caring for a patient with XLH rickets in a rural setting?

CASE STUDY ANSWERS

1. What is the etiology and pathophysiology of XLH rickets, and how does its pathology differ from other forms of rickets?

Rickets refers to a disease in children in which growing bones fail to mineralize or ossify as a result of a deficiency in calcium, phosphorus, or vitamin D (Greenbaum, 2011). In normal bone metabolism, bone is formed through the mineralization of calcium and phosphate as hydroxyapatite crystals and is influenced by vitamin D and the parathyroid hormone (PTH; Penido & Alon, 2012). Rickets can be caused by a variety of different factors that affect the levels of calcium, phosphate, and vitamin D, including nutritional causes, kidney disorders, and genetic abnormalities (Greenbaum, 2011; Holm, 2008).

The most commonly recognized form of rickets is referred to as *nutritional rickets,* or *vitamin D-deficient rickets*. Although prevalent in the United States in the early 20th century, public health measures to ensure that children receive an adequate vitamin D intake have drastically reduced the prevalence of vitamin-D deficient rickets, although breastfed infants who do not receive vitamin D supplementation are at risk (Holm, 2008). In vitamin D-deficient rickets, decreased vitamin D intake impairs calcium and phosphate absorption from the intestines (Penido & Alon, 2012). As hypocalcemia develops, compensatory mechanisms occur, including elevation in PTH and mobilization of calcium from the bone, resulting in decreased bone density (Holm, 2008; Penido & Alon, 2012). Furthermore, kidney disorders that can result in hypophosphatemia and rickets include Fanconi syndrome, which involves defects in the proximal renal tubule, and renal tubular acidosis, both of which lead to increased phosphate excretion (Holm, 2008).

Rickets may also result from genetic abnormalities that control the response of the body to 25-hydroxy vitamin D (25[OH]D), 1,25-dihydroxyvitamin D (1,25 $[OH]_2D$), and phosphate. Vitamin D 1α-hydroxylase deficiency is a genetic form of rickets in which a loss-of-function mutation occurs in the gene that encodes 1α-hydroxylase enzyme, preventing 25(OH)D from being converted into the active form, $1,25(OH)_2D$ (Holm, 2008). Another genetic form of rickets is