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Nutritional rickets in vegetarian children

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Vitamin-D-deficiency rickets, once the most common metabolic bone disease, is now rare in North America.[1] However, this decade has seen a resurgence of the problem.

For many years much of the reported nutritional rickets has occurred in infants who did not receive vitamin D supplementation.[2] Whether human breast milk contains sufficient vitamin D for normal term infants has recently been a controversial issue.[3-6]

Vegetarian children are susceptible to vitamin D deficiency. In its extreme form vegetarianism is often motivated by cultural convention or religious dictates, and vegetarian parents frequently apply their dietary rules to their children. The omission of vitamin-D-fortified milk from the infant's diet, coupled with failure to provide vitamin D supplements, has resulted in an increase in the number of reported cases of nutritional rickets in infants and children.[7-10] We describe three children in whom rickets developed after prolonged periods of strict vegetarian diets. One of the children also had anemia due to vitamin B_{12} deficiency.

Case reports

Case 1

A 3½-year-old black boy of Jamaican parents was referred to the outpatient department of our hospital because of genu valgum, first noted by his mother 6 months previously. She had delayed seeking medical advice until the child's gait became awkward and he began to fall frequently.

The boy had been born at term after an uneventful gestation, and the developmental milestones had been normal. Tooth eruption had started at 9 months of age. His mother, who was a strict vegetarian, breast-fed him for 1 year and then started giving him a purely vegetarian diet,* excluding milk and milk products, meat, fish and eggs. He had never been given vitamin supplements.

The child's height was 98.5 cm (50th percentile), weight 15.5 kg (50th percentile) and head circumference 53.5 cm (98th percentile). He had normal teeth with no enamel hypoplasia. The fontanelles were closed and there was frontal bossing. The child had enlarged costochondral junctions and wrists, and marked genu valgum, with an 11-cm separation of the medial tibial malleoli. Pertinent laboratory and roentgenologic data are given in Table I.

*A typical daily diet was as follows: *breakfast*, bitter or mint tea, orange or fruit juice, and rice or vegetable soup; *lunch*, potatoes or plantain, and coconut "milk"; *dinner*, green leafy vegetables, green beans or carrots or cabbage, and rice or potatoes or yams.

Case 2

A 1½-year-old black girl of Jamaican origin was seen in the outpatient department of our hospital because of vomiting. She was admitted for investigation when pallor of the mucous membranes was noted and a blood count confirmed the presence of anemia.

The patient had been born at term after a normal gestation, and the developmental milestones were within normal limits. She had started walking at 13 months of age. In

Table I—Laboratory and roentgenologic data for three patients with rickets due to vegetarian diets

Finding	Normal values	Case 1	Case 2	Case 3
Plasma level				
Calcium (mg/dl)	**9.5–10.5**	**7.0**	**8.8**	**7.5**
Inorganic phosphate (mg/dl)	**3.7–6.5**	**2.1**	**1.1**	**2.2**
Alkaline phosphatase (IU/l)	**154–341**	**852**	**1408**	**1018**
Immunoreactive parathyroid hormone (ng/dl)	**< 0.30**	**0.75**	**0.70**	**0.67**
25-hydroxycholecalciferol (ng/dl)	**8.1–33.2**	**< 3.0**	**< 3.0**	**< 3.0**
Generalized aminoaciduria		**Present**	**Absent**	**Present**
Roentgenographic		**Normal**	**Signs of rickets**	**Signs of rickets**

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recent months, however, she had become progressively weaker, and by the time of her admission she was no longer making any effort to walk.

The child had been breast-fed from birth. In addition, from the age of 9 months she had been receiving a restricted vegetarian diet (generally similar to that in case 1), with wheat, milk and milk products, meat, fish and eggs excluded. She had never been given vitamin supplements. Both parents were strict vegetarians.

She was pale and lethargic. Her length was 73 cm (3rd percentile), weight 8 kg (3rd percentile) and head circumference 45 cm (25th percentile). The conjunctivas were pale. None of her seven erupted teeth had enamel hypoplasia. The anterior fontanelle was closed and there was frontal bossing. The costochondral junctions, wrists, knees and ankles were enlarged, and she had genu valgum, with a 6-cm separation of the medial tibial malleoli. The abdomen was protuberant and the liver edge soft and smooth, extending 4 cm below the right costal margin. The spleen was enlarged 3 cm below the left costal margin. The hemoglobin level was 6.3 g/dl. The erythrocytes in a smear of peripheral blood showed an abnormal variation in shape and size, some being unusually large, and a bone marrow aspirate contained megaloblasts. The serum vitamin B_{12} level was 248 (normally 200 to 900) pg/ml; the serum folate level was normal. Other pertinent laboratory and roentgenologic data are shown in Table I.

Case 3

A 2¾-year-old girl, the only sibling of the patient in case 2, was seen because of genu valgum within a few days of her sister's admission. Her parents indicated that she had had an episode of tetany within the previous week.

The child has been born at term after a normal gestation. She had been breast-fed and given vitamin supplements for 1 year, and then had begun receiving a strictly vegetarian diet (generally similar to that in case 1), consisting of legumes, nuts and fruit juices and excluding wheat, milk and milk products, meat, fish and eggs. The diet was not supplemented with vitamin preparations.

She was thin and had severe genu valgum. Her height was 91 cm (25th percentile), weight 12.3 kg (10th percentile) and head circumference 48.5 cm (50th percentile). There was no enamel hypoplasia. The anterior fontanelle was closed. The costochondral junctions and wrists were enlarged, and the distance between the medial tibial malleoli was 11 cm. Pertinent laboratory and roentgenologic data are reported in Table I.

Treatment and outcome

All the children responded to therapy with vitamin D_3 (2000 or 3000 IU/d for 3 months) and the addition of milk to their diet: the plasma levels of calcium, inorganic phosphate, alkaline phosphatase, immunoreactive parathyroid hormone and 25-hydroxycholecalciferol became normal, and the aminoaciduria and rachitic lesions disappeared. In case 2 vitamin B_{12} therapy (500 μg of the vitamin given intramuscularly) corrected the megaloblastic anemia.

Discussion

A balanced diet denotes the intake of a variety of food containing proteins, minerals and vitamins in sufficient quantity to meet daily nutrient needs for growth and metabolism. The minimum intake of vitamin D necessary to prevent rickets may be about 100 IU/d.[11] Some studies have suggested that breast milk contains more than 400 IU/l of vitamin D in water-soluble form.[12,13] However, more recent reports refute claims that significant amounts of biologically active vitamin D are present.[14-18] Indeed, bioassays of the lipid extract of human milk show that it contains only about 20 IU/l of antirachitic activity.[14-19] We consider it important to give vitamin D supplements to all breast-fed infants during the first year of life, during which exposure to sunlight is unreliable in temperate regions of the world such as Canada.

Infants of vegetarian parents are at even greater risk of rickets. Although plant foods in appropriate combinations may be a good source of protein, individual vegetables do not provide an adequate blend of amino acids for long-term nutrition in the human.[7] Pure vegetable diets — those excluding legumes, nuts and grains — are nutritionally inadequate in vitamins B_{12} and D, calcium and iron,[8,20] and sometimes in protein.[7] Newborn infants of vegetarian mothers may be poorly endowed with vitamin D, and by the time of weaning they may already have covert vitamin D deficiency. The institution at that stage of a purely vegetarian diet, itself deficient in vitamin D and calcium, will exacerbate the condition and lead rapidly to overt rickets.

In our three patients rickets resulted from multifactorial nutritional deprivation, possibly extending back to fetal life. Since the mothers adhered to strict vegetarian regimens they were probably deficient in both vitamin D and calcium during pregnancy, giving birth to offspring with low stores of vitamin D.[21] Evidence of rickets appeared in the children after prolonged feeding of breast milk and foods devoid of vitamin D, unaccompanied by vitamin supplements.

Rickets might still have been prevented in these children with adequate exposure to sunlight. However, the long winters in our area and the patients' dark skin may have reduced their own production of vitamin D.[22]

Another factor that probably contributed to the development of rickets in these children was their low calcium intake.[23] Although some vegetables contain significant amounts of calcium, many purely vegetarian diets fall short of the recommended dietary intake of this element from vegetables alone.[24] Thus, children following a strictly vegetarian diet are at risk of a combined deficiency of vitamin D and calcium.[25]

As in case 2, a vegetarian diet may also lead to clinically manifest vitamin B_{12} deficiency. The infant breast-fed by a strict vegetarian who herself may have vitamin B_{12} deficiency can show the consequences of such nutritional deprivation at an early age.[26-28]

Vegetarians can ensure a nutritionally adequate diet by using proper combinations of vegetables, cereals and vitamin-D-enriched milk.[29,30] The advocates of strict veg-

etarian regimens expose themselves and their offspring to the risk of multiple nutritional deficiencies. The parents of our patients were amenable to making minor but essential modifications to their children's diet once the necessity was understood. Others have reported similar responses to their advice.[9]

The responsibility for preventing dietary-induced nutritional deficiencies lies with the physicians and other health care personnel who see parents and their infants at well-baby clinics. They should emphasize the need for vitamin D supplementation for any breast-fed baby who is sheltered from sunlight, and they should caution parents against the exclusive use of any vegetable diet that does not contain vitamins D and B_{12}, nutrients that are provided by vitamin-D-enriched milk and such fermented dairy products as yogurt and cheese.

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