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Short communication

Case report of nutritional rickets in an infant following a vegan diet

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ABSTRACT

We report the case of a 13-month-old infant who was referred to the pediatric emergency department because of psychomotor regression with four bone fractures due to nutritional rickets. The reason was prolonged breastfeeding from a vegetarian mother followed by a vegan diet for the infant after weaning. Rickets is one of the many nutritional deficiencies that could affect infants fed vegan or vegetarian diets. These diets are a public health concern requiring adapted information that suggests alternative formulas made from rice or soy proteins and adapted supplementation after weaning.

1. Introduction

Nutritional rickets due to low calcium intake and/or vitamin D deficiency was a common disease in Europe until the mid-20th century [1]. Vitamin D enrichment of infant formulas and systematic supplementation during pregnancy and infancy have decreased the occurrence of this disease significantly. Currently, affected children are more likely to be dark-skinned, receive limited exposure to sunshine on their skin, lack recommended daily supplementation, and/or be exclusively breastfed for a long period by mothers who have had low calcium intake and/or poor vitamin D status during pregnancy (not receiving the recommended supplementation during the third trimester of gestation [1,2]).

Vegetarian diets exclude all types of meats, fish, shellfish, and crustaceans, but in lacto-ovo vegetarian diets, dairy products, eggs, and honey are tolerated. Vegan diets avoid all animal products such as meat, fish, shellfish, insects, dairy, eggs, and honey. A macrobiotic diet is a vegan diet where only cereals, pulses, vegetables, seaweed, soy, and occasionally fish are consumed. Meats, dairy products, eggs, and some vegetables are usually avoided. The number of infants following these alternative dietary patterns has increased dramatically during the past few decades [3,4]. This is becoming a real public health concern since vegetarian and vegan diets can induce many nutritional deficiencies in infants including iron, calcium, vitamins D and B_{12}, docosahexaenoic acid (DHA), zinc, and proteins [3,4]. Nutritional deficiencies are more frequent and severe in young infants fed a non-dairy drink made with almonds, chestnuts, rice, or soya [4].

In this article, we describe a 13-month-old infant on a vegan diet who developed rickets and bone fractures.

2. Case report

A 13-month-old Eurasian infant was referred to the pediatric emergency department for 1-month psychomotor regression and apathy.

He had no significant neonatal history with a term birth at home. He was seen by a pediatrician on day 12, and then missed all further check-ups, including vaccinations, until the age of 12 months when his parents became worried about a decrease in appetite and weight loss that had begun at 10 months of age. These symptoms were associated with psychomotor regression since he crawled at 8 months, took a few steps at 10 months, and then struggled to hold an upright position and no longer got up at 11 months.

His weight was at −2.7 SD (standard deviation), his height at −1.4 SD, the Waterlow score was 78%, and the cranial circumference at −1.0 SD. An assessment of the infant's growth rate was not

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possible because of the lack of check-ups in his health record. The panniculus adiposus was thin, and he was apathetic, but there was no abdominal bloating. A widening of the wrists was clearly visible, as well as a bilateral costal rosary. There was no pain when the limbs were palpated, and the limbs were not deformed or unequal in length. Sitting was difficult without support and hypotonia was observed. There was delayed eruption of the teeth: at 13 months of age, the child had only primary teeth 71 and 81. The rest of the clinical examination, including exploration of cardiorespiratory and ganglionic areas, revealed no additional anomalies.

He was exclusively breastfed up to the age of 7–8 months, when complementary feeding was introduced consisting of a vegan diet that included rice flour, fruits, vegetables, legumes, oatmeal, algae powders, black sesame, and almonds on the advice of the Asian-born maternal family, with the addition of a spoonful of olive, peanut, and fish oils twice a day, but without any pharmaceutical vitamin D supplementation. Before hospitalization, the retrospective estimation of energy intake was about 950 kcal/day. The mother was following a vegetarian diet herself, without meat or fish, but with a few dairy products and eggs. The parents had many beliefs and misconceptions about food and thought that they should limit the amount of animal products (meat, fish, eggs, and dairy products) in their child's diet.

An initial blood test revealed a normal calcium level (2.21 mmol/L; normal values [N]: 2.1–2.6) and hypophosphatemia (0.64 mmol/L; *N*: 1.3–1.8) with elevated alkaline phosphatase (ALP; (1066 IU/L; $N < 35$). There was vitamin D deficiency (25-hydroxy-cholecalciferol: 22.6 nmol/L; N: 75–250) and secondary hyperparathyroidism (21.2 pmol/L; N: 0.8–5.2). Urinary analysis performed before vitamin D supplementation but after a calcium-enriched diet showed a urinary calcium/creatinine ratio of 0.62 mmol/mmol. At that time, the phosphate reabsorption rate was decreased at 44% and C terminal fibroblast growth factor 23 (FGF-23) was normal (165 RU/mL). The rest of the nutritional assessment showed deficiencies in vitamins A, B_6, and C, but normal levels of vitamins B_1, B_9, B_{12}, and E. The anemia was probably due to glucose 6 phosphate dehydrogenase deficiency because the ferritin level was normal. Albumin levels were normal, with a decreased prealbumin level (0.110 g/L). Celiac serology yielded negative results and thyroid function was normal.

Bone X-rays revealed diffuse osteopenia with bone hypertransparency and fine cortical, consolidated left ulnar and bilateral peroneal diaphyseal fractures, enlargement, cupping, splaying, fraying and a coarse trabecular pattern in the metaphysis, with widening of the growth plate (Figs. 1 and 2), and an enlargement of the anterior costochondral joints (Fig. 3).

The case pointed to calcium and vitamin D deficiency rickets, with no basis for hereditary rickets or other risk factors for developing rickets apart from diet.

This infant's diet was supplemented with vitamin D (100,000 IU/month for 3 months) and calcium (500 mg/day for 15 days). Because of severe rickets with fractures, malnutrition, and absence of medical check-ups, this child was initially separated from his parents and placed in a tertiary care unit. After discussion with the parents, a diversified diet was started with the introduction of infant formula containing cow's milk proteins and animal proteins along with close medical check-ups.

Fig. 1. X-ray of the right arm: enlargement of the wrist, cupping, splaying and fraying of humerus and ulna–radius metaphysis, widened growth plates (a): enlargement of the wrist, cupping, splaying and fraying of humerus and ulna-radius metaphysis, widened growth plates; (b): consolidated diaphyseal ulna fracture; diffuse osteopenia.

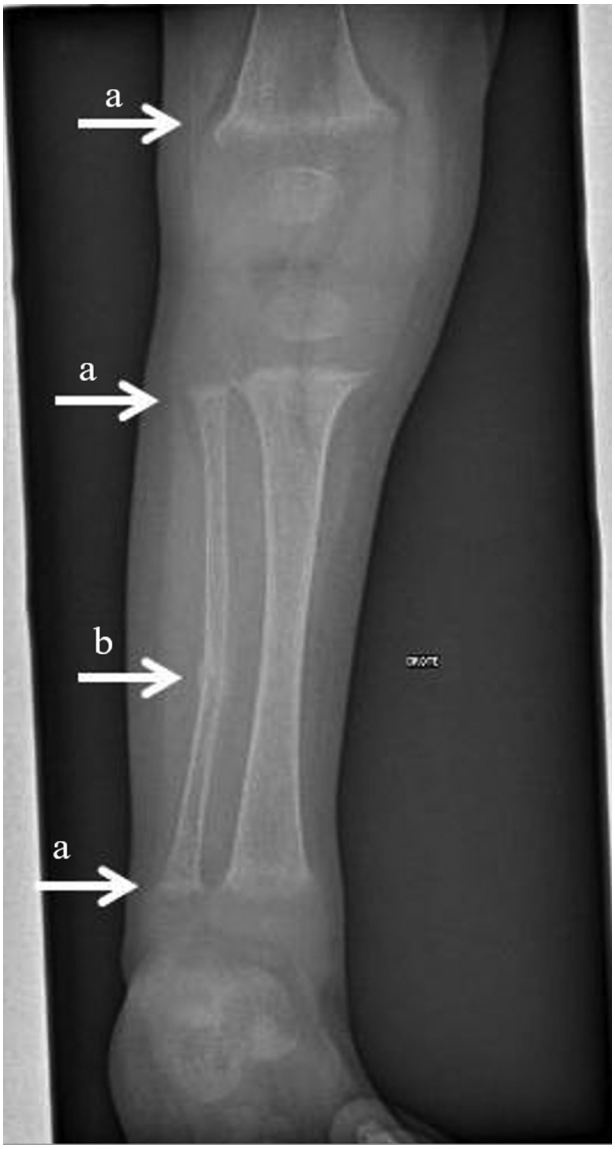

Fig. 2. X-ray of the right leg: cupping, splaying, and fraying of metaphysis, widened growth plates (a); cupping, splaying and fraying of metaphysis, widened growth plates; (b): diaphyseal peroneal fracture with continuous periosteal appositions and rough of bony callus; diffuse osteopenia.

Fig. 3. X-ray of the chest and abdomen: enlargement of anterior costochondral junctions (c): enlargement of anterior costochondral junctions; scapula hypertransparency.

Subsequently, the child's general condition quickly improved, with a gradual recovery of sitting and standing within 1 month, and he was able to walk within 3 months. Phosphoremia levels normalized, followed by vitamin D levels, and finally ALP. Recovery in weight began gradually over time (Fig. 4), in parallel with a spontaneous increase in energy intake up to 1100 kcal/day. Moreover, regarding vaccination, the parents agreed to participate in the catch-up vaccination program and to provide their child with an omnivore diet. A few months later, the child was able to rejoin his family at home and is now developing well. The child's growth has caught up to normal rates and he is regularly taken to medical check-ups.

3. Discussion

This case report describes nutritional rickets due to parental ignorance of their child's dietary needs, associated with psychomotor regression and four peripheral fractures. Unfortunately, this infant was not reached by existing prevention measures because of a home birth, refusal of neonatal screening on blotting paper, and a lack of medical check-ups.

Rickets in children is prevented by a vitamin D load in the pregnant woman in the seventh month of pregnancy, and by a systematic supplementation from birth to the age of 12–18 months [5]. All countries in Europe have established this policy for supplementation in infancy and childhood, but in five out of 29 countries, this supplementation only involves breastfed infants [5]. In the majority of European countries (24/28), the information given concerning the value of vitamin D supplementation is provided in maternity wards [5]. In our case, because of the home birth and the lack of check-ups, such information could not be given. In the case of nutritional rickets, consensus recommends a minimum dose of 2000 IU/day of vitamin D_2 or D_3 or a single large dose of vitamin D_3, preferably via oral administration rather than intramuscular, for a minimum of 3 months in conjunction with oral calcium (500 mg/day), either through dietary intake or as a supplement [6].

In addition to the vitamin D deficiency, the quantity and quality of calcium consumption are important. Despite the fact that nuts such as almonds, leafy vegetables, and pulses are high in calcium, the bioavailability of this source of calcium is negatively correlated with the amounts of oxalate and phytate [7]. Therefore one must consume tofu or mineral water fortified with calcium in the absence of dairy products [8]. The milk of breastfeeding women who are vegetarian or follow a macrobiotic diet is usually rich enough in calcium as a result of maternal bone demineralization and higher parathyroid hormone, leading to an increase in 1,25-dihydroxy vitamin D conversion enhancing calcium absorption [7,8].

Rickets affects up to 55% of infants on a macrobiotic diet [9], but it is not the only disease linked to a lack of nutrients that may affect vegetarian or vegan children [8]. When the child is exclusively or partially breastfed, nutritional deficiencies may also occur, depending on the quality of the vegetarian or vegan mother's supplementation. Several European societies of nutrition and/or pediatrics do not recommend a vegan diet in children or they state that it is possible only when dietary and medical treatments are provided [7,10]. It is therefore necessary to give advice to parents who want a vegan diet for their children, offering them alternatives in order to avoid potentially irreversible consequences. Today, it is obvious that non-dairy drinks are inappropriate for infants [4]. Hydrolyzed rice protein-based formulas are the best alternative in respecting a family's choice of vegetarian or vegan diet. Soy formulas can also be suggested but they have now been replaced in many countries by rice formulas.

Concerning growth, the birthweight of babies born to women on a macrobiotic diet are lower than expected, unlike to those of vegan or vegetarian women [7]. During breastfeeding, the milk of vegetarian mothers is usually nutritionally adapted, and the growth of infants is normal during the first 6 months of life. This is not the case for mothers on a macrobiotic diet because of a significantly lower protein content than omnivore mothers [7]. When breastfeeding occurs for longer than 6 months for infants of vegetarian mothers, the growth rate reaches the lower end of normal [7].

Vitamin B_{12} deficiency in breastfed children occurs more frequently when mothers are on a lacto-ovo vegetarian diet than on an omnivore diet [7]. There is a good correlation between vitamin B_{12} levels in breast milk and serum concentrations in infants [8]. In most cases, the discovery of a vitamin B_{12} deficiency in a breastfed infant is due to a vegetarian diet in the mothers [7]. Vitamin B_{12} deficiency results in anemia and neurodevelopmental delay in the first year of life [8]. In non-breastfed vegetarian children, rice- or soy-based infant formula contains enough vitamin B_{12} to prevent the deficiency [8]. In our case, the infant did not have a vitamin B_{12} deficiency because his mother ate some eggs and fish during pregnancy and breastfeeding.

Iron levels in the milk of lacto-ovo vegetarian and vegan women are identical to those of non-vegetarian women and, therefore, there is no difference in the incidence of iron-deficiency anemia during weaning [7]. During infancy, children on macrobiotic diets are often affected by iron deficiency [7].

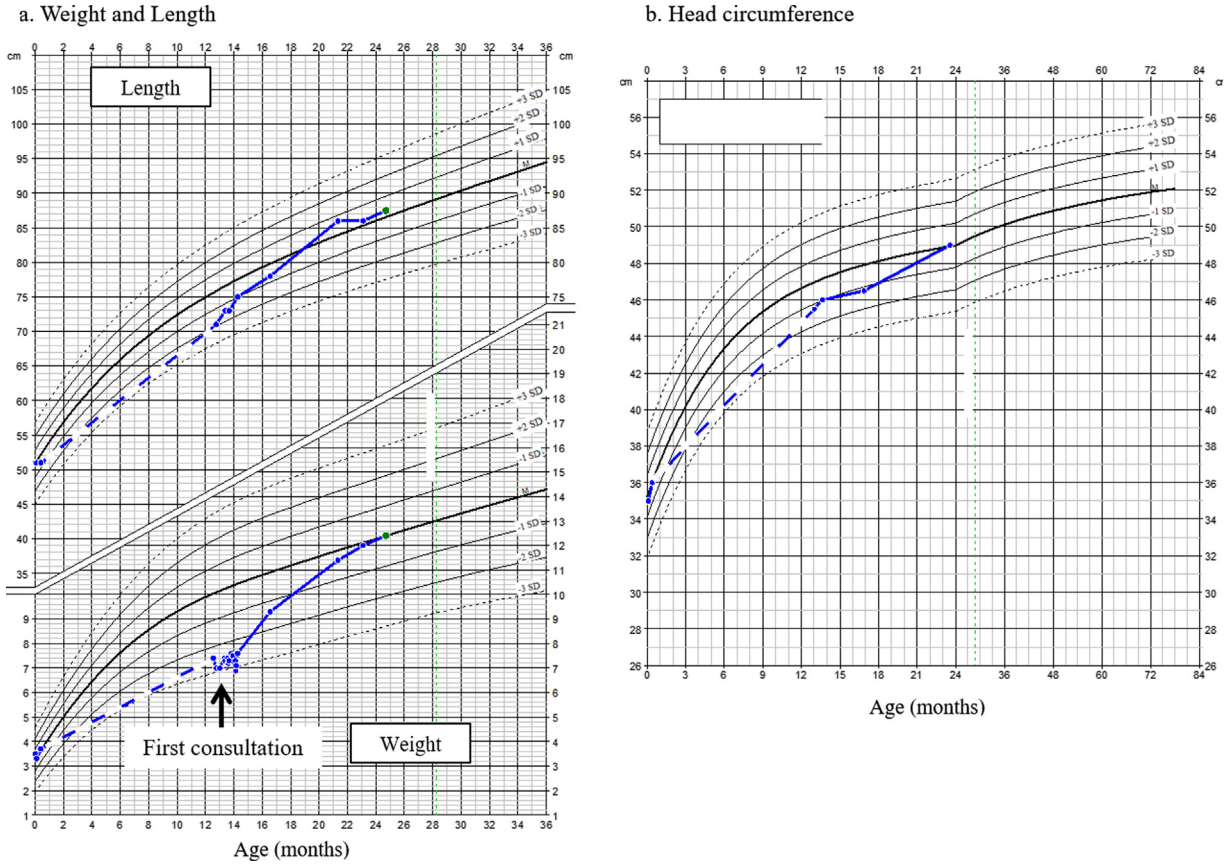

Fig. 4. a and b: Weight, length and head circumference charts. No data from 12 days to 13 months. Omnivore diet was started right after the first consultation. SD: standard deviation.

Because the main sources of eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) are seafood products, breast milk from vegetarian women is poorer in DHA than that of *omnivorous* women [7,8]. To prevent these deficiencies, recommendations are to consume DHA-enriched rice-based infant formula, add omega-3 rich vegetable oils (colza, walnut, soy) to savory meals, and/or to eat algae [8].

From a practical point of view, vegan parents who want a vegan diet for their child should be encouraged to breastfeed or give their children a rice-based formula and/or a soy-based formula after the age of 6 months, and ideally up to at least 6 years of age. After diversification onset, supplementation in calcium may be required, according to the consumption of infant formula and other calcium intake (mineral water, calcium-rich vegetables). Vitamin D supplementation is the same for vegan infants as for other children up to 18 months of age, and should be continued after the age of 18 months. For iron, supplementation might be required if the systematic serum ferritin dosage is low, when the consumption of plant-based formula decreases. And when the child is no longer consuming rice- or soy-based formulas, there must be systematic vitamin B_{12} supplementation. DHA supplementation is recommended from the age of 1 year with omega-3-rich vegetable oils (rapeseed, walnut, soybean) and/or with algae-based supplements [8]. In all cases, a close follow-up with a pediatrician trained in nutrition is recommended.

4. Conclusion

Vegetarian and vegan diets in infants and children have become a public health concern in many European countries [3]. They lead to severe nutritional deficiencies that could irreversibly harm neurologic development or bone mineralization, especially in young infants. Pediatricians must campaign for information to be provided about health risks associated with these alternative diets.

Disclosure of interest

The authors declare that they have no competing interest.

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