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Measurement of bone mineral density by dual energy X-ray absorptiometry in preterm infants fed human milk or formula

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Abstract Bone mineralization of healthy preterm infants fed human milk were compared with that of similar fed preterm formula. Bone mineralization was studied by dual energy X-ray absorptiometry in 43 preterm infants divided into two groups; 21 preterm infants were fed with maternal breast milk and 22 preterm infants with a preterm formula containing 70 mg calcium and 35 mg phosphorus per decilitre.

Conclusion Preterm infants fed breast milk had lower bone mineral density than the preterm formula-fed group. Fortifying preterm human milk with calcium and phosphorus will improve bone mineralization in preterm infants.

Key words Bone mineralization · Dual energy X-ray absorptiometry · Prematurity

Abbreviations *DXA* dual energy X-ray absorptiometry · *BMD* bone mineral density · *ALP* Alkaline phosphatase

Introduction

Preterm infants require more calcium (Ca) and phosphorus (P) for bone mineralization than term infants [15]. Inadequate mineralization of osteoid in the growing preterm infant may cause osteopenia of prematurity [6, 10].

It has been shown that preterm human milk may not supply sufficient Ca and P for adequate bone mineralization in preterm infants [1]. Adequate postnatal bone mineralization is observed in preterm infants fed a supply of Ca and P or with enriched preterm human milk [3, 5, 8, 14]. Dual energy X-ray absorptiometry (DXA) measurements of the lumbar spine allows non-invasive evaluation of the osteopenia of prematurity [7, 11, 16]. The main advantages of this new technique are its accuracy, speed of scanning and lower radiation exposure [4].

Subjects and methods

Forty-three healthy preterm infants from the Neonatal Intensive Care Unit of Gülhane Military Medical Faculty Hospital were selected for the study from January 1994 to August 1995. Exclusion criteria included intracranial haemorrhage, respiratory distress syndrome, major congenital anomalies and total parenteral nutrition for more than 5 days. The infants were studied in two groups. Group 1, consisted of 21 infants (11 boys, 10 girls) of gestational ages less than 37 weeks and birth weights less than 2500 g. Infants fed breast milk from their mothers with oral daily supplement of 400 IU vitamin D beginning at the 2nd week of life. Group 2, consisted of 22 infants (11 boys, 11 girls) of gestational ages less than 37 weeks and birth weights less than 2500 g, fed with a commercial preterm formula (Prematil-Milupa Co. Ltd.) containing 70 kcal, 2 g protein, 7.7 g carbohydrate, 3.5 g fat, 70 mg Ca, 35 mg P and 85 IU vitamin D per decilitre. Oral feedings were started within 24 h after birth and increased to full enteral feedings within 4–6 days as tolerated. Infants were weighed daily, length and head circumference were determined weekly. All infants had serum Ca, P, alkaline phosphatase (ALP), albumin values and bone mineral density (BMD) determinations at the 2nd and 10th postnatal weeks.

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Table 1 Data on the two groups

	Group 1 (preterm milk)	Group 2 (preterm formula)
No	21	22
Male/female	11/10	11/11
Birth weight (g)	1673 ± 215	1765 ± 235
Gestational age (weeks)	33.2 ± 1.1	33.4 ± 1.2

Table 2 Data on both groups at the postnatal 2nd week of life

	Group 1	Group 2
Weight (g)	1893 ± 239	1989 ± 241
Length (cm)	46.4 ± 1.6	46.7 ± 0.6
Head circumference (cm)	33.5 ± 0.7	33.8 ± 0.9
Calcium (mg/dl)	9.4 ± 0.6	9.3 ± 0.6
Phosphorus (mg/dl)	7.5 ± 0.5	7.6 ± 0.6
ALP (mU/ml)	187 ± 21	179 ± 25
Albumin (g/dl)	3.7 ± 0.3	3.8 ± 0.3
BMD (g/cm^2)	0.145 ± 0.010	0.149 ± 0.083

Table 3 Data on both groups at the 10th week of life

	Group 1	Group 2	P
Weigth (g)	2978 ± 336	3089 ± 431	> 0.05
Length (cm)	50.0 ± 1.6	50.7 ± 0.8	> 0.05
Head circumference (cm)	35.6 ± 0.7	35.8 ± 1.1	> 0.05
Calcium (mg/dl)	9.2 ± 0.5	9.5 ± 0.6	> 0.06
Phosphorus (mg/dl)	7.3 ± 0.6	7.7 ± 0.6	> 0.05
ALP (mU/ml)	213 ± 22	206 ± 31	> 0.05
Albumin (g/dl)	3.9 ± 0.3	4.0 ± 0.3	> 0.05
BMD (g/cm^2)	0.144 ± 0.013	0.198 ± 0.018	< 0.001

BMD was determined by DXA (Norland XR-36 densitometer). Spinal BMD of the L1-L4 region was measured in the supine position and the scan time ranged 3–5 min. Results for spinal BMD of L1 to L4 were expressed in g/cm^2.

In the statistical analysis we used Wilcoxon-Z test and Student's *t*-test, for the comparison of two groups Mann-Whitney U test is used. Statistically significant differences were obtained at $P < 0.05$.

Results

Data on 43 preterm infants are summarized in Table 1. The birth weights and gestational ages of both groups were similar. There were no differences among the two groups for weight, length, head circumference measurements and Ca, P, ALP, albumin values at the 2nd postnatal week (Table 2). BMD values were also similar in the two groups.

At the 10th week of life all the anthropometric measurements and biochemical values were similar (Table 3). ALP in the group 1 was slightly elevated but this was not significant ($P > 0.05$). BMD differences were not noticed among the two groups during the first 2 weeks of life but group 1 had significantly decreased BMD by 10 weeks ($P < 0.001$).

Discussion

Rapid bone mineralization occurs during the last trimester of gestation. In utero, the fetus requires 100–140 mg/kg per day Ca and 60–75 mg/kg per day (P). The Ca content of human milk is approximately 30–40 mg/dl and for P it is 15–20 mg/dl [9]. This amount of Ca and P cannot provide sufficient minerals to achieve adequate bone mineralization for premature infants. Ca and P values were lower in group 1 than in group 2 but this was not significant. Although the serum Ca and P values were normal in our study, human milk may not provide sufficient Ca and P for adequate bone mineralization in preterm infants [2, 12].

The bone mineralization of preterm infants fed breast milk was lower than that of those fed with preterm formula. Other investigators have shown that preterm infants receiving breast milk had a lower bone mineral status than those infants receiving preterm formula [13, 15, 16]. In our study, preterm infants received a formula containing 70 mg Ca and 35 mg P per decilitre. This may still be inadequate for bone mineralization when compared with the in utero mineral requirements of the fetus. This study suggests that fortifying preterm human milk with Ca and P will improve bone mineralization in preterm infants.

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