VERSITA

ARS Medica Tomitana - 2013; 4(75): 212 -217
DOI: 10.2478/arsm-2013-0038

Chircor Lidia, Iordan G., Surdu Loredana

Morphological features of bone in calcium and vitamin D deficiency

Department of Anatomy, Faculty of Medicine, University "Ovidius" Constanţa, România

ABSTRACT

The authors aim to identify morphological features of the bone abnormal development caused by calcium and vitamin D deficiency (CDD) and possible risk factors in the occurrence of these changes. The study is conducted on a selected group of 102 children aged 10-12 years with bone changes due to CDD, diagnosed and treated in Constanţa City from 2000 - 2010. For cases where the same child presented several bone deformities, we considered every bone deformity as an independent entity. In this study we observed deformation of the bones of the skull, prominent frontal bone 62 cases (60.78%); "beads rib" 49 cases (48.03%) sub mammary grooves 31 cases (30.32%), increasing the volume of knee joint 75 cases (73.52%) and wrist 68 cases (66.66%). The changes visible under direct examination are accompanied by structural changes visible by radiological exam, so the epiphysis plate has an irregular appearance (35 cases), serrated (35 cases), are enlarged (34 cases) or cup (31 cases). Analysis of sex distribution shows higher involvement of male children, sex ratio 3/1. Age group most affected in the studied group is 3-36 months. Skeletal deformities in CDD conditions are associated with peculiar situations of risk: monthly income below Average 72 cases (70.5%), increased pigmentation of the skin 61 (59.8%), prematurity 20 (19.6%). Increased incidence of developmental abnormalities of the bones due to CDD in the studied group and in different regions (England, Turkey, USA, etc) in recent years coincides with modern life style, which involves skin protection against solar radiation and a lack of exposure to sunlight.

Keywords: bones' abnormalities, calcium deficiency, vitamin D deficiency.

Lidia Chircor

Department of Anatomy
Faculty of Medicine, University "Ovidius" Constanţa
Aleea Universităţii Nr. 1, Campus B, Constanţa, Romania
e-mail: lidia_chircor@yahoo.com

Introduction

The Department of Health from England announced in 2008 that the incidence of bone abnormalities caused by deficiency of D vitamin and calcium (CDD) is increasing. In fact, the incidence of CDD accompanied by bone changes is increasing worldwide, especially in the United States and northern Europe, where 15 years ago was extremely rare, and is a common disease for children in Middle East [1], Africa with 10% prevalence, and Asia with 25% prevalence in China. In Romania, the frequency of CDD remains high; an incidence of 40 cases per thousand inhabitants in last years [2] with higher values in Suceava, Sibiu, Olt, Hunedoara counties represents a major risk factor in infant mortality and morbidity.

The authors aim to identify morphological aspects of the bone caused by CDD and possible risk factors in the occurrence of CDD.

Materials and Methods

The study is conducted on a sample of 102 children aged 0-12 years with developmental abnormalities of the skeleton due to CDD diagnosed with common rickets, takes out and treated in ConstanţaCounty between 2000 to 2010.

Inclusion criteria in the studied group includes children who presented simultaneously: bone deformities, low calcium levels for both total and for the calcium ion, history suggestive of low dietary calcium and vitamin D.

Exclusion criteria in the studied group does not includes cases of primary vitamin D-resistant rickets, cases of secondary vitamin D-resistant rickets as caused by malabsorption (cystic fibrosis, celiakie, chronic cholestasis, large bowel resection), congenital metabolic diseases (secondary tubulopathy characterized the tubular reabsorption of PO4 disorder), hepatic metabolism disorders (idiopathic anomalies of 25-hydroxylase, cirrhosis, liver failure), impaired renal hydroxylase (hypoparathyroidism, chronic renal failure, proximal tubulopathy) receptor abnormalities (pseudo-Deficiency rickets), oncogenic factors (vitamin D-resistant oncogenic rickets, neurofibromatosis syndrome, epidemic moles, fibroimatosis tumors), corticosteroids, iatrogenic rickets (prolonged treatment with anticonvulsants).

For each case study, we made history, clinical examination and radiological (including data on skeletal development, bone age assessment) to record data in such files.

Based on age at first changes occurring bone we established 10 chronological categories in who framed the 102 cases of the studied group.

Results

The analysis by gender distribution of the bone changes occurring in the CDD (Table I) show higher net impairment of male children, sex ratio 3:1.

Table I - Distribution of bone changes by gender

Gender	Number of cases (%)
Male children	79 (77.45 (%)
Female children	23 (22.5%)

Distribution by sex and age categories of developmental abnormalities of the skeleton in the studied group (Table II) reveals that 98% of the total of 102 cases - were diagnosed in the first 3 years of life, 1.96% (2 cases) after age of 4 years, no cases in the first 3 months of life.

Table II - Distribution of bone changes by chronological age criterion

Age of the first bone changes	Number of cases (%)	Number of cases (% of 102 cases)	
		Male	Female
0 – 3 month	-	-	-
3 - 6 month	72(70.5%)	59(57.8%)	13(12.7%)
6 – 12 month	9(8.8%)	6(5.9%)	3(2.9%)
12 – 24 month	12(11.76%)	7(6.86%)	5(4.9%)
24 – 36 month	7(6.86%)	6(5.88%)	1(0.98%)
3 – 4 years	-	-	-
4 – 6 years	1(0.98%)	1(0.98%)	-
6 – 8 years	-	-	-
8 - 10 years	-	-	-
10 - 12 years	1(0.98%)	-	1(0.98%)

In the studied group, the skeletal developmental abnormalities due to CDD are associated with particular situations of risk: dystrophy, prematurity, twins, vitamin D restricted diet, dark skin as “screen” against UV rays (Table III).

Table III - Risk factors for skeletal developmental abnormalities due to DCD

Risk factors	Number of cases (%)
Protein caloric malnutrition	18 (17.64%)*
Prematurity	20 (19.6%)*
Twins	4 (3.9%)*
Restricted diet / D vitamin	3 (2.9%)*
Monthly income below average	72 (70.5%)*
Families with more than 3 children in care	1 (0.98%)*
Children with dark skin "screen" against UV rays.	61 (59.8%)*

The studied Lot has changes in bone development expressed by the deformation of the spine, skull cap, chest bone, long bones of the legs (Table IV); these results are comparable to those reported in the U.S. [2].

Table IV - Distribution of the skeletal developmental abnormalities by location

The location of the skeletal developmental abnormalities		Number of cases (%)
The skull	Prominent frontal bones	62 (60.78%)*
	Plagiocephaly	16 (15.68%)*
Vertebral Column	Thoracic kyphosis	10 (9.8%)*
Bony thorax	Submammary grooves	31 (30.32%)*
	Clogging sternum	18 (17.6%)*
	"Beads cost"	49 (48.03%)*
Long bones of the legs	Genum valgum	36 (35.29%)*
	Genum varum	38 (37.25%)*
Joints	Enlargement of the knee joint	75 (73.52%)*
	Enlargement of the fist joint	68 (66.66%)*
Foot bones	Foot in abduction	29 (28.43%)*
	Reduced plantar curvature	12 (11.76%)*
	Metatars adduction	29 (28.43%)*

** for cases where the same child presented several changes we considered every aspect of bone disease as an independent entity*

In our study the CDD during skeletal growth and development causes enlargement of the knee joint and the wrist as well as deformities of the limbs' long bones.

Our results also reveals the fact that the CDD modify the normal development of the axial skeleton, causes the chest bone - most commonly affecting the ribs.

In the studied group, the localization of bone changes is mainly bilateral (> 75% of cases)

The most common changes of the foot shape consist of the abduction of the foot and metatars adduction (Table IV).

Of the 29 cases of foot positioned in abduction, 12 cases (more than one third) associated reduction of the plantar curvature.

Changes in shape of the bones caused by CDD are accompanied by structural changes such as: reduced bone density, poorly mineralized subperiosteal bone deposition, which gives a double contour of the shaft (Table V).

Calcium and vitamin D deficiency during childhood mainly affects long bones. Reduced mineralization of the long bones causes deformation of the long bones of the legs, increases the knees' volume due to hypertrophy of the growth cartilage. Epiphyseal long bone deformity occurs after structural changes of the growth cartilage.

Discussions

Regarding risk factors for CDD with bone changes, our study shows that prematurity, age 0-3 years, skin hyperpigmentation are major risk factors.

Similar results to those obtained in the studied group are presented in a study conducted in the Asian side of Turkey, between the years 2007 - 2008 on a sample of 391 333 children aged 0-3 years, which highlights that the most common bone changes found

Table V - Bones structural changes caused by CDD

Knee joint	Location of the Bones structural changes	Total NR of cases	Bilateral location Number of cases
Changes visible by direct exam	Increase the volume	75*	75*
Structural changes visible by X-ray exam	Expanded Metaphysis	34*	34*
	Cup shape Metaphysis	31*	31*
	Irregular appearance of the Metaphysis	35*	35*
	Fine fringe Metaphysis	24*	25*
	Serrated Metaphysis	35*	35*
	Epiphyses with irregular contour	16*	16*
	Epiphyses with deleted contour	18*	18*
	Epiphyses with cup-shaped contour	21*	21*
	Epiphyses looking "moth eaten"	18*	18*
	Shaft with double periosteal contour	12*	12*

* for cases where the same child presented several changes we considered every aspect of bone disease as an independent entity

in CDD are chest deformity "beads rib" epiphyseal long bone deformity, craniotabes [3].

Recent communications of prestigious research teams highlights similar results. Thus dark skin as a risk factor of CDD is emphasized along with an increased incidence of CDD in the U.S. and U.K. The study conducted over a period of 10 years of Wake Forest University and University of North Carolina in North Carolina, led by Kreiter suggest that the heavily pigmented skin children are prone to CDD with bone manifestations [4,5].

Regarding risk factors for CDD with bone changes, our study shows that prematurity, age 0-3 years, skin hyperpigmentation are major risk factors. Recent communications of prestigious research teams highlights similar results. Thus dark skin as a risk factor of CDD is emphasized along with an increased incidence of CDD in the U.S. and U.K. The study conducted over a period of 10 years of Wake Forest University and University of North Carolina in North Carolina, led by Kreiter suggest that the heavily pigmented skin children are prone to CDD with bone manifestations [4, 5]. Thomas R. Welch associate chief editor of the Journal of Pediatrics at Cincinnati Children's Hospital Medical Center noted an increase in cases of bone deformities caused by the CDD in the U.S. in the last years [6, 7].

Studies conducted in 2000 - 2001 in North Carolina, Texas, Georgia states confirm the existence of cases with bone deformities due to CDD and emphasizes the importance of the dark skin as a sunscreen that decreases the activation of provitamin D [8].

The study managed by Pearce and Cheetham from Newcastle University and Royal Victoria Infirmary, published in England by the British Medical Journal notice skin dark skin, the use of chemicals to protect against solar radiation and the insufficient exposure to sunlight (institutionalized children, children who spend their free time exclusively to computer or TV) as risk factors for the occurrence of CDD with bone changes [9]. Scientific Advisory Committee on Nutrition in a study led by Kreiter [10] in 2000 suggests as risk factors for CDD the reduced exposure to sunlight, skin dark skin, breast-feeding without vitamin D supplement. Decreased levels of 25-hydroxy vitamin D in children with skin dark skin (Asians) was noticed in a study led by Awumey in

1998.

Intensive research reported by Holick in 2002 reveals the same risk factors of the CDD accompanied by bone structural changes as the risk factors arising from the results obtained in our this study: the intense demand periods during the growing body as in the first three years of life, male gender and dark skin [11]. The importance of these risk factors is supported by a study in Birmingham demonstrating increased incidence of CDD in Asian male children [12,13,14].

Conclusions

In our study CDD causes a variety of skeletal developmental abnormalities, mainly of the long bones. Children with CDD have asymmetric skulls and/or plagiocephaly with prominent frontal bone; they have different degrees of emphasis on the spine curvature, including thoracic kyphosis, deformation of the chest bones, most commonly affecting chondrocostale cartilage.

The substrate of bones deformation due to CDD is the inadequate and irregular mineralization of the organic matrix. Changes in the shape of the bones caused by CDD is accompanied by structural changes as: reduced bone density, poorly mineralized subperiosteal bone deposition which gives a double contour of the shaft.

Risk factors in the occurrence of bone changes caused by the CDD are: male gender, prematurity, monthly income below average and increased pigmentation of the skin. Increased incidence of developmental abnormalities of the bones due to CDD in the studied group and also in different regions (England, Turkey, USA, etc) in recent years coincides with modern life style, which involves skin protection against solar radiation and a lack of exposure to sunlight.

References

1. Baroncelli G.I., Bereket A., El Kholy M., Audì L., Cesur Y., Ozkan B. & Rashad M. (2008). Rickets in the Middle East: Role of Environment and Genetic Predisposition. *Journal of Clinical Endocrinology and Metabolism.* 93(5), 1743
2. Georgescu A. & Ciofu E.P. (2008). *Ghiduri si protocoale în pediatrie: volum de ghiduri si rezumate,* Bucureşti: Ed. Amalteea
3. Ozkan B., Doneray H., Karacan M., Vancelik S., Yildirim Z.K., Ozkan A., Kosan C. & Aydin K. (2009). European Prevalence of vitamin D deficiency rickets in the eastern part of Turkey. *Journal of Pediatrics*. 168, 95-100
4. Petifos J.M. (2004). Deficiency of vitamin D, calcium or both. *Am. J. Clin Nutr.* 80(suppl), 17255-17295
5. Yasuda T. (2009). Rickets Imaging. *Clin Calcium*. 19(1), 109-16
6. Wagner C.L. & Greer F.R. (2008). Prevention of rickets and vitamin D deficiency in infants, children, and adolescents. *Pediatrics*. 122(5), 1142-52
7. Welch T.R., Bergstrom W.H. & Tsang R.C. (2000). Vitamin D-deficient rickets: the re-emergence of a once-conquered disease. *J Pediatr.* 137, 143–5
8. Weisberg P., Scanlon K.S, Li R. & Cogswell M.E. (2004). Nutritional rickets among children in the United States: review of cases reported between 1986 and 2003. *American Journal of Clinical Nutrition.* 80(6), 1697S-1705S
9. Pearce S. & Cheetham T. (2010). Diagnosis and management of vitamin D deficiency. *British Medical Journal.* 340, b5664
10. Kreiter S.R.**,** Schwartz R.P., Kirkman H.N. Jr, Charlton P.A., Calikoglu A.S. & Davenport M.L. (2000). Nutritional rickets in African American breast-fed infants. *J Pediatr.* 137, 153-157
11. Holick M.F. (2002). Vitamin D: the underappreciated D-lightful hormone that is important for skeletal and cellular health. *Curr Opin Endocrinol Diabetes.* 9, 87-98

12. Shaw N.J. & Pal B.R. (2002). Vitamin D deficiency in UK Asian families: activating a new concern. *Arch Dis Child*. 86, 147-149
13. Datta S., Alfaham M., Davies D.P., Dunstan F., Woodhead S., Evans J. & Richards B. (2002). Vitamin Ddeficiency in pregnant women from a non-European ethnic minority population—an interventional study. *BJOG*. 109, 905-908
14. Ashraf S. & Mughal M.Z. (2002). The prevalence of rickets among non-Caucasian children. *Arch Dis Child.* 87, 263-265