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CORRELATION OF BIOCHEMICAL PARAMETERS AND BMI WITH FRACTURES IN CHILDREN

Orthopedics

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ABSTRACT

Background : Our aim is to find out the correlation of serum levels of calcium, phosphorus and Alkaline phosphatase and Body Mass Index with occurrence of fractures in children.

Methods : Study included total of 200 children between 2-14 years of age. Of these, 100 had sustained fractures and 100 were control samples. Study compared four parameters i.e serum calcium, phosphorus, alkaline phosphatase and body mass index to find out whether there is any correlation of these parameters with fractures.

Results : Higher levels of Alkaline Phosphatase were found in children with fractures and lower levels of calcium and phosphorus were found in children with fractures than the control group. Body Mass Index of both the groups were similar.

Conclusion : Significant correlation has been found between serum levels of calcium, phosphorus and alkaline phosphatase with fractures. But, no correlation between fractures and BMI has been found.

KEYWORDS

Serum calcium, Phosphorus, Alkaline Phosphatase, Body Mass Index

INTRODUCTION

Knowledge of epidemiology of fractures is crucially important for implementation of prevention strategies for target population.

Most of the fractures in children occur in the first decade of their life. The incidence of these fractures is higher in boys than in girls because of the increased physical activity in them. Around two-thirds of all fractures occur in the upper limb because of fall on the stretched hand and the remaining third include the lower limbs and other fractures. The most common pediatric fractures are the radius ulna fractures specially the distal end followed by supracondylar humerus fractures.

Contributing factors in our country include poor nutritional status and poor socio-economic conditions with lack of proper diet. Proper nutrition is an essential parameter of skeletal health, participating in both the prevention and the treatment of bone diseases(1). Among dietary factors, Calcium plays an important role in bone health and remodelling. An adequate calcium dietary intake, the principal component of bone, can significantly reduce the loss of bone(2). Optimal bioavailability of calcium is achieved through concomitant intake of vitamin D(3). Vitamin D deficiency decreases calcium absorption from the intestinal tract and the kidneys, increases parathyroid hormone (PTH) concentration, and leads to osteolysis, which over time may lead to fracture(4).

Low body mass index is a well-documented risk factor for future fracture. When compared with a Body Mass Index of 25 kg/m^2, a Body Mass Index of 20 kg/m^2 is associated with a nearly twofold increase in risk ratio for fractures. Low Body Mass Index confers a risk of substantial importance for all fractures that is largely independent of age and sex. The significance of Body Mass Index as a risk factor varies according to the level of Body Mass Index.

Multiple studies have demonstrated an association between vitamin D deficiency and fracture risk in children. However, few studies have correlated vitamin D deficiency with Bone Mineral Density, fracture risk, and laboratory markers of bone health. To our knowledge, no study has evaluated serum Calcium, Phosphorus and Alkaline Phosphatase levels and Body Mass Index in relation with fractures and no such comparative study has been performed in children with and without fractures.

So in the given study, we will have studied the correlation of serum calcium and Alkaline Phosphatase levels and also Body Mass Index which have an impact on bone health and subsequently on the risk of fractures in children.

MATERIALS AND METHODS / STUDY DESCRIPTION:

The study was a single centre, prospective case control study held in tertiary care hospital. The sample size was 200 out of which 100 had sustained fractures and 100 were control samples. All the patients presenting to tertiary care hospital with traumatic fractures were included. Serum levels of the children were sent for Calcium, phosphorus and Alkaline Phosphatase. Also, Body Mass Index of all the children was calculated for comparison. Children between 2 to 12 years of age with traumatic fractures were included. Children less than 2 years of age and children with pathological fractures were excluded from the study.

RESULTS

Data Analysis and Interpretation:

Descriptive statistics such as mean and standard deviation (SD) for continuous variables, frequencies and percentages were calculated for categorical Variables were determined. Association between Study group and other variables was done by using Chi-Square test for categorical variables and unpaired t test for quantitative variable. Level of significance was set at 0.05.

From the study, we got to know that there is a significant correlation between Serum Calcium, Serum Phosphorus and Serum Alkaline Phosphatase with fractures in Children aged 2-12 years which is the sample age group of the study.

1) Serum Calcium levels

Table 1 : Comparison of Serum Calcium between Cases and Controls

(N = 100)

Serum Calcium	Fracture n (%)	No Fracture n (%)
<8.4	44 (74.6)	15 (25.4)
8.4-11.0	56 (39.7)	85 (60.3)
>11.0	-	-
Chi-Square Test, P Value <0.001, Significant		

Low serum levels of calcium were been found to be associated with increased risk of fractures in children.(P value <0.001, Significant)

2. Serum Phosphorus levels

Table 2 : Comparison of Serum Phosphorous between Cases and Controls (N=100)

Serum Phosphorous	Fracture n (%)	No Fracture n (%)
<2.5	88(83.0)	18(17.0)
2.5-4.5	12 (12.8)	82 (87.2)
>4.5	-	-
Chi-Square Test, P Value <0.001, Significant		

Low serum levels of phosphorus were been found to be associated with increased risk of fractures in children. (P value <0.001, Significant)

3. Serum Alkaline Phosphatase levels

Table 3 : Comparison of Alkaline Phosphatase between Cases and Controls (N = 100)

Alkaline phosphatase	Fracture n (%)	No Fracture n (%)
100-325	55 (42.0)	76 (58.0)
>325	45 (77.6)	13 (22.4)
Chi-Square Test, P Value <0.001, Significant		

High serum levels of Alkaline Phosphatase were been found to be associated with increased risk of fractures in children. (P value <0.001, Significant)

4. Body Mass Index

Table 4 : Comparison of Body Mass Index between Cases and Controls (N = 100)

Body Mass Index	Fracture n (%)	No Fracture n (%)
<18.5	6 (60.0)	4 (40.0)
18.5-23.0	73 (46.5)	84 (53.5)
>23.0	21 (63.6)	12 (36.4)
Chi-Square Test, P Value = 0.163, Not Significant		

According to the results, Body Mass Index did not have a significant correlation with Fractures in children. (P value=0.163, Not Significant)

Lower serum Calcium levels and Phosphorus levels were associated with increased fractures in children and higher Alkaline Phosphatase levels were associated with increased fractures in children.

Around 45-50 % of all fractures occurred between the ages of 2-6 and most of the fractures were of upper limb contributing about 65% of all fractures. Distal end radius were the commonest of all with majority of cases affecting males.

As calcium levels were found to be significantly low in majority of cases, improving the nutritional status with appropriate Calcium intake can help reduce the risk of fractures in children. Alkaline Phosphatase values can help serve as an indicator of underlying bone disease as almost 80% cases had high serum Alkaline Phosphatase levels.

DISCUSSION

Calcium and vitamin-D deficiency is a major risk factor for rickets. It may also contribute to the compromised bone healing frequently observed in these patients, since calcium is essential for fracture callus mineralization. Additionally, clinical data suggest systemic bone loss following fracture, which may aggravate rickets and thus increase the risk for fractures in these patients further, highlighting the importance of proper diet and nutrition for bone health and subsequent healing in fracture cases.

There has been one study by Kulak et al where correlation of Body Mass Index and urinary Calcium with Fractures in children suffering from Meningomyelocoele was studied. They found that BMI was directly correlated with the risk of fractures and calciuria was found in most of the patients of MMC who sustained fractures(6).

Another study by Marcus Pauly et al studied the correlation of urinary Calcium excretion and risk of fractures in children suffering from spina bifida. They could not find a correlation between the urinary calcium excretion, the level of lesion, the mobility parameters (ability to stand upright, gait distance) and the frequency of fractures but there was a positive correlation between the serum calcium level, gait distance and the ability to stand upright in patients with spina bifida(7).

Some have correlated the levels of vitamin D and Bone Mineral Density with the frequency of fractures in which a positive correlation was found between vitamin D and Bone Mineral Density with the frequency of fractures. According to Van der Velde et al, the combined daily administration of calcium and vitamin D in elderly women led to a reduction in all fracture incidence by 30%, including hip fracture(5).

So our study has similar results when serum calcium levels are taken into account. Our study has also found out a correlation of serum phosphorus levels and Alkaline Phosphatase levels with the risk of fractures in children. In fact, Alkaline Phosphatase levels are found to have a strong correlation with the frequency of fractures in children. However, no correlation is seen between Body Mass Index and fracture risk in children.

Bone health and nutrition has an important role to play in the epidemiology of fractures. Among dietary factors, Calcium plays an important role in bone health and remodelling.

Approximately 99% of body Calcium is found in bone, where it serves a key structural role as a component of hydroxyapatite. Dietary requirements for Calcium are determined by the needs for bone development and maintenance, which vary throughout the life stage, with greater needs during the periods of rapid growth in childhood and adolescence, during pregnancy and lactation, and in later life. As peak bone mass is an important determinant of future fracture risk, the goal of the current calcium recommended dietary allowance during youth is to provide a calcium intake that allows individuals to reach their full genetic potential for acquiring skeletal mass. The current Recommended Dietary Allowances (RDA) are insufficient to support optimal bone mass gain during growth and development. Based on the recent intervention trials, recommendations are made for an RDA of 1250 mg during childhood and 1450 mg during adolescence. These values are consistent with established calcium balance intake thresholds for growth during pre-adolescence and adolescence. Inadequate dietary Calcium in early life impairs bone development and Calcium supplementation of the usual diet has been shown to enhance bone mineral status in children and adolescents. In later years, inadequate dietary Calcium accelerates bone loss and may contribute to osteoporosis. So, Calcium levels and its metabolism have a big influence in the epidemiology of fractures and improving the nutrition and calcium supplementation can play a major role in preventing fractures and decreasing its incidence and associated morbidities especially in developing countries.

A study by P.Dimitri and N.Bishop shows paradoxical relation of obesity with fractures. In children, obesity has been found to be a risk factor for fractures. On the other hand, they have found it to be protective against fractures in adults. They concluded that obesity may be associated with a low bone mass in obese children particularly in adolescence(8).

According to recent study published in Diabetes Care (2015), one more interesting factor found to increase the risk of fractures in children and that was type 1 Diabetes Mellitus. To clarify, in participants with type 1 diabetes and participants without diabetes, they found that fracture incidence was highest in the 10–20 year age group for males only; the highest incidence in females occurred in those aged 80–90 years. In summary, they found that both adults and children with type 1 diabetes were at increased risk of fractures.

Apart from Vitamin D, Vitamin K2 levels were found to strongly correlate with fractures with lower levels increasing the incidence of fractures according to a study. In a cross-sectional study by Booth et al, low plasma vitamin K levels were associated with low bone mineral density at the femoral neck in men and at the spine in women without using estrogen replacements(9). According to Vik, MenaQ7 Vitamin K2 increases the activation of osteocalcin, the K-dependent protein responsible for binding calcium to the bone mineral matrix, therefore improving bone health. Children with bone fractures had two times lower vitamin K status than healthy controls. In addition, Torbergsen et al showed that low plasma vitamin K level was associated with increased hip fracture risk(10). More specifically for vitamin K2 supplement, a meta-analysis confirmed that its consumption can ameliorate the vertebral bone mineral density(12). Moreover, higher levels of vitamin K are associated with elevated levels of osteocalcin; therefore, vitamin K helps the body produce osteocalcin, a protein that helps to improve bone density and reduce fracture risk(13). Finally, data from a recent meta-analysis point out that daily intake of vitamin K is significantly associated with reduced risk of fractures(14).

Apart from Vitamin D and K, Vitamin B12 has also been to affect bone health. Vitamin B12 deficiency has been associated with osteoporosis in the past. Indeed, there is currently a good level of evidence that low levels of vitamin B12 could have a significant negative impact on bones mineral density. A recent study by Roman-Garcia et al showed that vitamin B12 deficiency negatively affects bone development and maintenance, a finding in line with other studies(15).

Administration of calcium and vitamin D supplements is now the main diet intervention against rickets and osteoporosis based on their correlation with decrease bone loss (associated with advanced age) and reduced risk of fracture. A meta-analysis by Boonen et al suggested that oral vitamin D supplementation can reduce the risk of hip fractures only in combination with calcium supplementation(11). Calcium and Vitamin D deficiency continues to be a problem in paediatrics, especially in the developing countries. Improving the nutritional and health care facilities could mitigate the overall health related issues in children including bone health and reduce the incidence of fractures in children.

In our future studies, we also plan to correlate Vitamin D levels and the incidence of fractures in children which was not done in this study due to financial constraints.

Abbreviations

Sr. ALP	Serum Alkaline phosphatase
Sr. Ca	Serum Calcium
Sr. Po4	Serum Phosphorus
BMI	Body Mass Index
Vit D	Vitamin D
MMC	Meningomyelocele
BMD	Bone Mineral Density
RDA	Recommended Dietary Allowance

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