International Journal of Life Sciences, Biotechnology and Pharma Research Vol. 13, No. 7, July 2024 Online ISSN: 2250-3137
Print ISSN: 2977-0122

DOI: 10.69605/ijlbpr_13.7.2024.31

ORIGINAL RESEARCH

A Prospective Study on the Prevalence of Vitamin D Deficiency in Infants: A Hospital Based Study

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Received: 01/06/2024 **Accepted:** 08/07/2024

ABSTRACT

Introduction: Vitamin D deficiency is a prevalent nutritional shortfall and a significant factor contributing to nutritional and growth challenges in infants, particularly those from lower socioeconomic backgrounds. This study primarily aimed to ascertain the prevalence of vitamin D deficiency in infants, and secondarily to examine the relationship between vitamin D levels in infants and their mothers. **Material and Methods:** Conducted as a prospective, observational study at an Indian hospital, this research included children under one year of age and their mothers. Participants were recruited during well-child and sick-child visits following the acquisition of written, informed consent. Exclusion criteria were major congenital malformations and liver or kidney dysfunction. A serum vitamin D level below 20 ng/mL was classified as deficient. **Results:** The study included 178 infants and 178 mothers. Of the infants, 79% were neonates, and 21% were older infants. Vitamin D deficiency was identified in 72.78% of the infants and 84% of the mothers, with nearly half of both groups experiencing severe deficiency. Logistic regression revealed a positive correlation between maternal and infant vitamin D levels ($r=0.737$, $p<0.001$), as well as associations with neonatal age and low socioeconomic status. Hyperphosphatemia and hypocalcemia were common biochemical abnormalities observed. **Conclusion:** Vitamin D deficiency was prevalent in 74% of the infants studied. Key factors associated with infant vitamin D deficiency included neonatal age, lower socioeconomic status, and maternal vitamin D deficiency.

Key Words: Hypocalcemia, Infants, India, Neonates, Vitamin-d deficiency

INTRODUCTION

Vitamin D deficiency is a significant nutritional issue among children globally. According to a 2009 report by the International Osteoporosis Foundation (IOF), 96% of infants and 84% of pregnant women were affected by this deficiency [1,2]. Vitamin D is essential for calcium absorption, bone mineralization, and the metabolism of phosphate and magnesium. The US Endocrine Society defines vitamin D deficiency as serum 25(OH) vitamin D levels below 20 ng/mL and insufficiency as levels between 21 and 29.9 ng/mL. It is estimated that approximately one billion people worldwide, spanning all age groups, suffer from vitamin D deficiency or insufficiency. In India, 50-90% of children are affected, primarily due to low dietary calcium intake, darker skin, and insufficient sunlight exposure [3-5].

Vitamin D deficiency in infants is mainly attributed to exclusive breastfeeding by mothers with deficient vitamin D levels, inadequate dietary intake, and reduced sunlight exposure due to seasonal variations. Severe deficiency can result in rickets, which presents as frontal bossing, wrist widening, leg bowing, spontaneous fractures in infants, and can lead to bony deformities, short stature, muscle weakness, and muscle pain in older children. Additionally,

Online ISSN: 2250-3137
Print ISSN: 2977-0122
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deficiency may cause growth failure, recurrent respiratory infections, and developmental delays. Infants with conditions such as malabsorption syndrome, cystic fibrosis, and nephrotic syndrome are at heightened risk [4].
Biochemically, vitamin D deficiency in infants typically results in hypocalcemia, hyperphosphatemia, and secondary hyperparathyroidism [4,5]. Treatment recommendations for neonates with vitamin D deficiency include administering 400-1000 international units (IU) of vitamin D daily for 8-12 weeks. Infants beyond the neonatal period require 1000-5000 IU/day of vitamin D for the same duration. Prompt detection and treatment of vitamin D deficiency are vital to prevent bony deformities and reduce respiratory morbidity [5]. The scarcity of data on the vitamin D status of neonates and infants in India, led to the initiation of the present study.

MATERIAL AND METHODS

This prospective, observational study was conducted at an Indian medical college. All consecutive infants (aged ≤1 year) attending the pediatric outpatient and inpatient units were included after obtaining written, informed consent from parents. Infants with major congenital malformations, liver or kidney dysfunction, malabsorption syndrome, or those on tube feeding were excluded from the study. A serum vitamin D level below 20 ng/mL was used to define vitamin D deficiency. All study infants were clinically evaluated using a predesigned, pretested proforma, which included assessments of anthropometry, general physical examination findings, and clinical signs of hypocalcemia (e.g., jitteriness, tetany) and vitamin D deficiency (e.g., rachitic rosary, craniotabes). Maternal details, including socioeconomic status, were recorded using the modified Kuppuswamy scale [6].

Sample Size Calculation: Based on an estimated 60% prevalence of vitamin D deficiency, 80% power, and an allowable error of 5%, a sample size of 158 infant-mother pairs was required. Ultimately, 178 infant-mother pairs were enrolled.
From each enrolled infant, 2 ml of venous blood was collected and analyzed for calcium, phosphorus, alkaline phosphatase, and 25-(OH) vitamin D levels. Serum 25-(OH) vitamin D levels were also measured in all mothers of the enrolled infants using the chemiluminescence method.

Statistical Analysis: Descriptive statistics were employed to calculate percentages, proportions, means and standard deviations. Means of continuous variables between groups were compared using Student's t-test. Pearson’s correlation coefficient was utilized to assess correlations between variables. Binary logistic regression analysis was conducted to identify determinants of vitamin D deficiency. A 5% significance level was applied to all statistical tests. Data analysis was performed using the Statistical Package for Social Sciences (SPSS) Version 20.0.

RESULTS

The research involved 178 newborns and 178 mothers. Among the infants, 79% were neonates, while 21% were older infants. Vitamin D insufficiency was detected in 72.78% of the infants and 84% of the mothers, with almost half of both groups exhibiting severe deficiency (Table 1).
Based on the data shown in Table 2, the biochemical profiles of the study population were assessed. The mean vitamin D levels in infants and mothers were 15.97 ng/mL (± 11.88) and 11.85 ng/mL (± 8.39), respectively. Serum alkaline phosphatase (ALP) levels were measured at 211.36 U/L (± 104.01), indicating potential bone metabolism activity. Calcium levels averaged 8.51 mg/dL (± 1.57), while phosphorus levels were 11.38 mg/dL (± 6.35), reflecting the mineral balance in the subjects. These findings suggest variability in vitamin D status between infants and mothers, alongside typical markers of bone health and mineral metabolism in this cohort.
In Table 3, Pearson's correlation analysis revealed a significant positive correlation ($r = 0.737$, $p < 0.01$) between maternal and infant vitamin D levels, indicating that higher maternal vitamin D levels are associated with increased vitamin D levels in infants.
Table 4 presents the results of logistic regression analysis investigating determinants of vitamin D deficiency in infants. Age (β coefficient = 2.415, Adjusted Odds Ratio = 10.61, $p < 0.01$) emerged as a significant predictor, suggesting that older infants are more likely to have vitamin D deficiency. Similarly, maternal vitamin D status (β coefficient = 2.52, Adjusted Odds Ratio = 11.24, $p < 0.01$) was strongly associated with infant vitamin D deficiency, highlighting maternal status as a critical factor. Additionally, socioeconomic status (β coefficient = 0.651, Adjusted Odds Ratio = 1.995, $p < 0.05$) was identified as a modest predictor, indicating that lower socioeconomic status may also contribute to increased risk of vitamin D deficiency in infants.

Table 1: Prevalence of Vit D deficiency in infants

S. Vit D levels	n	%
<20 ng/ml	115	72.78
>20 ng/ml	43	27.22
Total	178	100.00

DOI: 10.69605/ijlbpr_13.7.2024.31

Table 2: Biochemical variables in study population

Variables	Mean ± SD
Vitamin D levels in infants (ng/mL)	15.97 ± 11.88
Vitamin D levels in mothers (ng/mL)	11.85 ± 8.39
ALP (U/L)	211.36 ± 104.01
Calcium (mg/dL)	8.51 ± 1.57
Phosphorus (mg/dL)	11.38 ± 6.35

Table 3: Pearson's Correlation between maternal and infant Vit D levels

Variable	r value	P-value
Mother Vitamin D status	0.737	<0.01

Table 4: Determinants of Vit D deficiency in infants (Logistic regression)

Variable	β coefficient	Adjusted Odds ratio	P-value
Age	2.415	10.61	<0.01
Mother Vitamin D status	2.52	11.24	<0.01
Socio Economic status	0.651	1.995	<0.05

DISCUSSION

In India, 50-90% of the population is affected by vitamin D deficiency, primarily due to insufficient sunlight exposure and low dietary intake [4,5,7]. Our study identified a 72.78% prevalence of vitamin D deficiency among infants and 84%among mothers, aligning with previous research findings [8]. According to the US Endocrine Society, vitamin D deficiency is characterized by 25(OH) vitamin D levels below 20 ng/mL, insufficiency by levels between 21-29 ng/mL, sufficiency by levels above 30 ng/mL, and toxicity by levels exceeding 150 ng/mL [3]. Similarly, the American Academy of Pediatrics (AAP, 2008) [9] and the Institute of Medicine define vitamin D deficiency as serum 25(OH) vitamin D levels below 15 ng/mL, mild to moderate deficiency as levels between 5-15 ng/mL, severe deficiency as levels below 5 ng/mL, and insufficiency as levels between 16-20 ng/mL. They consider sufficiency to be levels between 21-100 ng/mL, excess as levels between 101-149 ng/mL, and intoxication as levels exceeding 150 ng/mL [10]. The Kidney Disease Outcome Quality Initiative supports the AAP's definition of vitamin D deficiency as levels below 15 ng/mL [11], but it defines insufficiency as levels between 16-30 ng/mL and sufficiency as levels above 30 ng/mL. None of the infants in our study had vitamin D levels exceeding 150 ng/mL. For this study, we utilized the US Endocrine Society's criteria to define vitamin D deficiency.

Vitamin D levels are regulated through dietary intake and cutaneous synthesis. Research indicates that 30 minutes of sun exposure for naked infants and two hours for fully clothed infants can maintain weekly calcidiol levels at 11 ng/mL, thereby preventing severe vitamin D deficiency [12-14]. Even brief direct sunlight exposure of 10 to 15 minutes can generate 10,000 to 20,000 IU of vitamin D. Various factors such as latitude, skin pigmentation, and the extent of skin exposure influence vitamin D synthesis from sunlight [1]. Consequently, infants and children with darker skin pigmentation are at a higher risk for reduced vitamin D synthesis. These infants need five to ten times longer sunlight exposure to produce the same levels of 25(OH) vitamin D compared to children with lighter skin pigmentation [15]. To maintain adequate vitamin D levels, Asian children require three times more sunlight exposure than white American children due to their darker skin color. The AAP advises against direct sunlight exposure for infants under six months old [16], which may contribute to vitamin D deficiency [17-19]. However, neonates and infants have a greater capacity to produce vitamin D from sunlight compared to adults because of their higher surface area to volume ratio [20,21].

In our study, we demonstrated that sunlight exposure significantly influenced vitamin D deficiency in infants. Infants from lower socioeconomic backgrounds exhibited a higher prevalence of vitamin D deficiency compared to those from higher socioeconomic backgrounds. This is likely due to reduced calcium and vitamin D intake among children from lower socioeconomic statuses, as confirmed in our study [17]. Preterm neonates are at an increased risk of vitamin D deficiency due to reduced placental transfer, inadequate sunlight exposure, and lower vitamin D stores owing to their low-fat mass. Among the 18 preterm neonates in our study, 15 were found to have vitamin D deficiency.

Most infants with weight and height below the 3rd percentile in our study had vitamin D deficiency, which can be attributed to lower nutrient intake, particularly of calcium and vitamin D. Growth failure is also a known manifestation of vitamin D deficiency [12]. Maternal vitamin D deficiency emerged as a significant risk factor for vitamin D deficiency in infants, consistent with findings from the IOF [1].

The primary biochemical changes in infants with vitamin D deficiency included hyperphosphatemia, hypocalcemia, and hyperparathyroidism. This can be explained by immature renal tubular excretion in neonates, who were the predominant age group in our study. Additionally, a lower glomerular filtration rate,

Online ISSN: 2250-3137
Print ISSN: 2977-0122
DOI: 10.69605/ijlbpr_13.7.2024.31

low intact parathyroid hormone (iPTH) levels, and renal tubular unresponsiveness to PTH, especially during the first three days of life, likely contributed to hyperphosphatemia in conjunction with vitamin D deficiency. The presence of metabolic bone disease, particularly among preterm small-for-gestational-age (SGA) neonates, may have further exacerbated these biochemical changes. Alkaline phosphatase levels were normal (below 400 U/L) in most infants in our study, with only 4.5% exhibiting elevated levels above 400 U/L. This is explained by the fact that alkaline phosphatase levels typically remain stable during the neonatal period [22,23].

Our study identifies exclusive breastfeeding and limited sunlight exposure as key etiological factors for vitamin D deficiency. Additionally, the neonatal age group, low socioeconomic status, and maternal vitamin D deficiency emerged as significant independent determinants for vitamin D deficiency in infants, consistent with previous research findings [24,25].

Vitamin D deficiency is managed with vitamin D supplementation, administered either orally or intramuscularly, along with adequate calcium supplementation to prevent hungry bone syndrome, a condition resulting from underlying hypocalcemia and bone matrix remineralization. All neonates and infants with vitamin D deficiency in our study were treated with age-appropriate calcium and vitamin D supplementation protocols. The three oral forms of vitamin D are ergocalciferol (25-hydroxyvitamin D2 or vitamin D2), cholecalciferol (25-hydroxyvitamin D3 or vitamin D3), and calcitriol (1,25(OH)2D). For infants and young children, vitamin D2 and D3 are preferred [17,26].

Our study also demonstrated that maternal vitamin D status significantly impacts the infant's vitamin D levels. It is recommended to assess 25(OH)D levels in all pregnant women and treat vitamin D deficiency with 3000-6000 IU of vitamin D3 until adequate serum levels of 25(OH)D (>20 ng/mL) are achieved [27-29]. Preterm infants require 400-800 IU of D3 per day from birth due to insufficient placental transfer of maternal vitamin D and additional comorbidities associated with prematurity that can reduce vitamin D intake or absorption [30]. In this study, all mothers with vitamin D deficiency were also supplemented with vitamin D and calcium according to unit protocols.

CONCLUSION

In our study of infant-mother pairs, we found a significantly high prevalence of vitamin D deficiency. Independent determinants of vitamin D deficiency in infants included neonatal age, low socioeconomic status, and maternal vitamin D deficiency. The high prevalence observed in our region underscores the need for adequate nutritional support and supplementation for both mothers and children to prevent the morbidity associated with vitamin D deficiency.

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