Vitamin D deficiency in Egyptian mothers and their neonates and possible related factors

Nihal Mohamed El Rifai¹, Ghada Abdel Fattah Abdel Moety², Hassan Mostafa Gaafar², and Dalia Ahmed Hamed³

¹Pediatrics Department, ²Obstetrics and Gynecology Department, and ³Chemical Pathology Department, Faculty of Medicine, Cairo University, Cairo, Egypt

Abstract

Objective: To correlate vitamin D level in Egyptian mothers with that of their newborns, and examine risk factors related to maternal vitamin D deficiency.

Methods: A cross-sectional study was carried out at the university teaching hospital in Cairo, Egypt. Serum 25(OH) D levels were measured by enzyme-linked immunosorbent assay in 135 pregnant women at ≥37 weeks’ gestation immediately before delivery and in cord blood of their newborns.

Results: The levels of serum 25(OH) D were 32.6 ± 21.4 ng/ml in mothers and 16.7 ± 10 ng/ml in their newborns. Maternal vitamin D level was strongly correlated with that of the newborns (r = 0.7, p < 0.0001). Maternal vitamin D deficiency/insufficiency and neonatal vitamin D deficiency/insufficiency were encountered in (40%, 28.9% and 60%, 32.6% respectively). Maternal vitamin D levels showed significant correlations with maternal body mass index (BMI; r = 0.201, p = 0.021), gestational age at delivery (r = 0.315, p < 0.0001), fish consumption (r = 0.185, p = 0.032), educational level (r = 0.29, p = 0.001), and skin exposure (r = 0.247, p = 0.004).

Conclusion: Maternal vitamin D levels strongly correlate with neonatal levels. Maternal vitamin D deficiency is a real problem in Egypt; this is generally related to high BMI, low fish consumption, low educational level, and limited skin exposure.

Keywords

Mothers, neonates, vitamin D

Introduction

Maternal vitamin D deficiency is a common public-health problem [1]. Staggering rates of poor vitamin D status are found among pregnant mothers throughout the world [2–5].

Vitamin D deficiency is defined as serum 25(OH) D of less than 25–50 nmol/l (10–20 ng/ml). Approximately one billion people worldwide are estimated to be vitamin D deficient with people living in Europe, the Middle East, China and Japan at particular risk [6]. Deficiency is more common in women than men, and pregnancy is known to represent a particularly high-risk situation [7].

Vitamin D deficiency in pregnancy has been shown to lead to significant complications. Maternal complications include decreased weight gain [8], gestational diabetes, preeclampsia, infections, and caesarean section [9]. In the newborn, maternal vitamin D deficiency has been linked to hypocalcemia, low birth weight [10], wheezing, type I diabetes, eczema [11,12], poor weight gain, impaired development and rickets [13].

Vitamin D deficiency rickets occurs more commonly during infancy, starting in the early months of life. 25-Hydroxyvitamin D₃ crossing the placenta during the last months of gestation furnishes the main vitamin D requirement of the newborn during the first few months of life [14].

Women, including pregnant women, with a body mass index (BMI) greater than 30 are at increased risk of vitamin D deficiency [15]. Ethno-cultural factors; dark skin or concealing clothing, which may lead to limited exposure even though living in tropical areas where sun-exposure is adequate, can cause vitamin D deficiency [16].

Several studies have identified a surprisingly high prevalence of vitamin D deficiency in pregnant women in temperate regions such as the United Kingdom [17], the United States [12] and Norway [18], and even in sunny countries such as India [19], Turkey [4], Saudi Arabia [20] and Iran [21].

In this study, we aimed to correlate the level of 25(OH) vitamin D in Egyptian mothers with that of their neonates. Besides, we tried to find out some possible risk factors of maternal vitamin D deficiency.

Methods

The current study was a prospective cross-sectional observational study held from September 2012 to May 2013. A total
of 135 pregnant women attending the delivery unit of Kasr Al Aini teaching hospital, Cairo University, Egypt, and their newborns were included in the study.

Eligible women were healthy pregnant women carrying a singleton full-term newborn (≥ 37 weeks’ gestation) who did not receive any form of calcium or vitamin D supplementation during the last 3 months of pregnancy. Exclusion criteria were women with a known history or evidence of chronic disease as heart, liver, kidney, thyroid, parathyroid or adrenal diseases, diabetes mellitus, malabsorption or psychiatric diseases. Neonates born with congenital anomalies were also excluded.

An informed written consent was obtained from each participant after full explanation of the aim and the nature of the procedure. The study was approved by the local ethical committee of the hospital.

A detailed history was obtained from each woman including age, number of pregnancies, clothing style (veiled or not), diet (especially eggs, dairy products and fish), and educational status. Physical examination was performed and abdominal ultrasound was carried out to each mother for the estimation of gestational age and confirmation of fetal viability.

Maternal weight and height were measured and BMI was calculated as BMI equals to the weight in kilograms divided by height in meters squared. Season of delivery was recorded for each woman. Season was defined as winter (December, January, February), spring (March, April, May) and fall (September, October, November).

All neonates were subjected to complete physical examination immediately after resuscitation with emphasis on gestational age at delivery, neonatal sex, anthropometric measures and the presence of any signs of hypocalcemia in the form of seizures, apnea, cyanosis and/or cardiac rhythm disturbances. Blood culture, cerebrospinal fluid analyses were performed for neonates presenting with seizures to rule out the presence of seizures secondary to serious neonatal infections.

Venous samples were collected from mothers immediately before delivery for determination of 25(OH) D, calcium and alkaline phosphatase levels. Neonatal umbilical cord blood samples were also collected at birth to represent the neonatal values of the same biochemical parameters.

Maternal and neonatal vitamin D status was classified into: vitamin D deficiency [25(OH)D <20 ng/ml], vitamin D insufficiency [20 ng/ml ≤ 25(OH)D <32 ng/ml], and vitamin D sufficiency [25(OH) D ≥32 ng/ml] [22]. The same cutoffs were used for both women and neonates, because experts contend that the ideal healthy of 25(OH) D is the same in infants as adults [22].

Biochemical analysis
All samples were allowed to clot, and sera were separated by centrifugation at room temperature. Sera were stored at −20°C until they were analyzed at the end of the study. Quantification of 25(OH) D was performed using the solid phase enzyme-linked immunosorbent assay (ELISA) (DRG 25(OH) vitamin D ELISA kit, DRG Instrument GmbH, Germany). The test was performed according to the manufacturer’s instructions. Intra- and inter-assay coefficients of variation (CV) were 4.4 and 9.9, respectively.

Sample size calculation
Sample size was calculated by a priori power analysis, aiming at a power of 0.80 to all for determination of a difference between vitamin D level in mothers and neonates. As a difference of 30% was reported previously [5], thus a minimal sample size of 122 with a power of 0.80 and α = 0.05 was calculated. We found that 135 participants will be appropriate.

Statistical analysis
Data were presented as mean ± standard deviation (μ ± SD) or frequency and percentage (%) unless otherwise stated. The coefficients of determination for vitamin D status were calculated using Spearman's bivariate analysis. Student's t test was used to compare two means between groups. While comparing subgroups of maternal vitamin D (Deficient, insufficient and sufficient), means between groups were compared using ANOVA and post hoc Bonferroni test. A two-tailed p value of 0.05 was considered statistically significant. All statistical analyses were performed using statistical software SPSS version 19.0 (IBM SPSS Statistics, SPSS Inc., Chicago, IL).

Results
In total, 135 mothers participated in the study. Baseline characteristics of mothers and their neonates are listed in Table 1. More than 50% of the study participants had a low educational level. Most of the study participants were veiled (86.7%). More than 50% of women included in the study were consuming fish infrequently, and more than 75% were not consuming eggs regularly. Also, 42.2% of the study participants were overweight and 48% were obese.

The mean maternal serum 25(OH) D was 32.6 ± 21.4 ng/ml (range 3–82 ng/ml). The mean neonatal 25(OH) D was 16.7 ± 10 ng/ml with about 50% difference between maternal and neonatal values. The mean maternal and neonatal serum calcium levels were similar (8.46 mg/dl ± 1.5). The mean serum alkaline phosphatase level was 346 IU/l ± 195.9 for mothers and 343.1 IU/l ± 135.9 for neonates.

Of all women, 54 (40%) were vitamin D deficient (serum 25(OH) D <20 ng/ml), 39 (28.9%) were vitamin D insufficient (20 ng/ml ≤ serum 25(OH) D <32 ng/ml), and only less than one-third (31.1%) had sufficient vitamin D levels (serum 25(OH) D ≥32 ng/ml). Of note, 81 neonates (60%) had vitamin D deficiency, 44 neonates (32.6%) had vitamin D insufficiency, and only 10 neonates (7.4%) had sufficient vitamin D levels.

In 12 mothers (8.9%) and 24 neonates (17.8%), hypocalcemia was encountered. The median serum calcium level of the hypocalcemic newborns was 6.3 mg/dl. Of the hypocalcemic newborns, 9 (37.5%) presented with symptoms of hypocalcemia in the form of seizures (3 neonates), apnea and cyanosis (6 neonates).

Maternal serum vitamin D strongly correlated with neonatal vitamin D levels (r = 0.7, p < 0.0001). Maternal serum calcium also showed a significant correlation with neonatal serum calcium (r = 0.68, p < 0.0001).

Also, maternal vitamin D levels strongly correlated with both maternal and neonatal calcium levels (r = 0.967, p ≤ 0.0001, and r = 0.705, p ≤ 0.0001, respectively).
Vitamin D deficiency in mothers and neonates

Importantly, neonatal vitamin D was strongly correlated with neonatal calcium level ($r = 0.919$, $p \leq 0.0001$).

Moreover, maternal vitamin D levels showed strong inverse correlations with both maternal and neonatal alkaline phosphatase levels ($r = -0.794$, $p \leq 0.0001$, and $r = -0.655$, $p \leq 0.0001$, respectively).

Among the newborns of mothers who had vitamin D deficiency, vitamin D concentrations were significantly lower than newborns of mothers with vitamin D sufficient levels ($8.55 \pm 9.7 \text{ ng/ml versus } 24.3 \pm 5.7 \text{ ng/ml, } p \leq 0.0001$).

Maternal vitamin D levels showed significant correlations with maternal BMI, gestational age at delivery, fish consumption, educational level, and skin exposure. However, maternal vitamin D levels were not significantly correlated with maternal age, parity, eggs and dairy products consumption, or neonatal birth weight (Table 2).

The highest prevalence of vitamin D deficiency was encountered in winter (43%) followed by spring (36%), while the least was in fall (33.3%), however, the difference was not significant ($p = 0.75$). Maternal vitamin D deficiency was significantly more prevalent among pregnant women residing in rural areas (61.8%) than among those residing in urban areas (17.9%) ($p = 0.024$). Also, maternal vitamin D deficiency was significantly higher in women pregnant in a male fetus than in those pregnant in a female fetus (50% versus 28.57%, $p = 0.004$) (Table 3).

Discussion

The current study revealed that over two-thirds (68.9%) of mothers and 92.6% of their neonates had vitamin D deficiency or insufficiency. To our knowledge, this is the first study that examined vitamin D status of Egyptian pregnant women and their neonates. The study highlighted the presence of a real problem of vitamin D deficiency among Egyptian mothers and its great impact on neonatal vitamin D level and the later process of skeletal development to the magnitude of which warrants public health intervention.

Our results support the evidence that neonatal serum 25(OH) D strongly correlates with maternal values, as reported previously by many studies [2,5,17,19,23]. There was also a strong inverse correlation between maternal serum alkaline phosphatase and maternal vitamin D level, which supports the results of other studies [4,17].

The study results revealed a strong correlation between neonatal vitamin D and calcium levels. Maternal vitamin D status may influence placental calcium transfer [24]. Paunier et al. [23] have pointed to the important role of maternal
vitamin D concentration in neonatal and maternal calcium homeostasis; they also reported that neonates born to mothers with low vitamin D intake during pregnancy had low serum calcium concentration in cord blood or during the first week of life [23].

We studied some risk factors that may be related to vitamin D deficiency among pregnant women.

A significant moderate inverse correlation was detected between BMI and maternal vitamin D level. Obesity is a notable risk factor for vitamin D deficiency that may be related to a sequestering of vitamin D3 in adipose tissue [25]. One study has examined the relation between obesity and vitamin D deficiency among pregnant women [1]. In concordance with our results, the authors have found that compared with lean women, pre gravid obese women had lower adjusted mean serum 25(OH) D concentrations and a higher prevalence of vitamin D deficiency. Also, Vandevijvere et al. [26] have reported that the risk of vitamin D deficiency increased significantly with BMI.

In the current study, vitamin D level correlated significantly with gestational age at delivery. Dunlop et al. [27] performed MEDLINE search to identify observational and experimental studies that evaluated the relation between nutrient intake and/or supplementation and preterm birth. They found varying levels of evidence for an association between preterm birth and nutrient deficiency of iron, folic acid, zinc, vitamin D, calcium and magnesium.

There are very few dietary sources of vitamin D. Oily fish such as herring, mackerel, pilchards, sardines and tuna are rich sources but their consumption in some countries is low. The only other useful sources are eggs, fortified margarines and some fortified yogurts and breakfast cereals [28]. The current study showed a significant correlation between maternal vitamin D level and fish intake. In Egypt, as a developing country, there is no mandatory staple food fortification; moreover, Egyptian population does not consume fish regularly. This may account for the high prevalence of vitamin D deficiency.

Our results have shown a significant correlation between vitamin D level and educational level; this is mostly related to better knowledge of vitamin D-rich diet in highly educated women. This is supported by Vandevijvere et al. [26].

The current study showed a significant correlation between maternal vitamin D level and skin exposure. Vitamin D is obtained either through photosynthesis in the skin with exposure to ultraviolet B radiation or through dietary sources. Avoidance of sun exposure reduces dermal synthesis of vitamin D [29]. Egypt is an Islamic country, where most females wear the traditional clothes that cover the whole body apart from face and hands. Clothing habits have accounted for the high prevalence of vitamin D deficiency among our study participants.

A cross-sectional study including 50 women in labor with a singleton term pregnancy in Pakistan measured vitamin D status in maternal blood before delivery and cord blood at delivery. They stated that vitamin D levels were significantly affected by sunlight exposure [30]. Also, Halicioglu et al., 2012, conducted a study in Turkey examining vitamin D deficiency in pregnant women and their neonates. They reported that maternal serum 25(OH) D concentrations related strongly to the dressing style [2]. Moreover, wearing a veil was reported to be one of the factors associated with maternal vitamin D deficiency in a study done by Bowyer et al. [3].

In our study, maternal vitamin D deficiency was highest in winter compared to spring and fall most probably because of limited sun exposure in winter. This was supported by the results of previous studies [4,26].

In addition to the above-studied factors related to vitamin D deficiency, this study has revealed significantly higher proportion of vitamin D deficiency among women living in rural areas compared to those living in urban areas. This can be related to the educational level difference.

The limitation of the current study is the relatively small sample size. Larger sample size would have declared the extent of vitamin D deficiency in Egypt more properly. Actually, the sample size was limited by the financial ability of the authors. Nevertheless, the study results highlighted the presence of a real problem of vitamin D deficiency in Egyptian mothers that requires attention to prevent the later development of neonatal hypovitaminosis D, rickets, tetany, and infantile rickets.

In conclusion, our results have shown that despite of the tropical climate, vitamin D deficiency and insufficiency are highly prevalent among Egyptian mothers and their neonates. Maternal vitamin D levels were strongly correlated with that of the newborn. Maternal vitamin D level was related to maternal BMI, gestational age at delivery, fish consumption, residency, educational level, skin exposure, and fetal gender.

Declaration of interest

The authors report no conflicts of interests. The authors alone are responsible for the content and writing of this article.

References