Maternal and neonatal umbilical cord serum levels of 25-hydroxy vitamin D among Sudanese women with normal pregnancy: a cross-sectional study

Mohamed A Ahmed
University of Khartoum

Abdelmageed Elmugabil
University of Khartoum

Ashwaq AlEed
Qassim University

Abdullah Al-Nafeesah (✉ a.alnafeesah@qu.edu.sa)
Qassim University

Ishag Adam
Qassim University

Research Article

Keywords: mothers, neonates, umbilical cord, vit D deficiency, 25-(OH)D

Posted Date: January 12th, 2023

DOI: https://doi.org/10.21203/rs.3.rs-2446154/v1

License: ☺️ ① This work is licensed under a Creative Commons Attribution 4.0 International License.
Read Full License
Abstract

There are few published studies on the association between maternal and umbilical cord serum vitamin D concentrations in Sub-Saharan Africans. Therefore, the aim of this study was to assess the association between mothers and umbilical cord 25-hydroxyvitamin D (25-[OH]D) levels. A cross-sectional study was conducted at the Saad Abuelela Maternity Hospital in Khartoum, Sudan. 90 pairs of mothers and neonates (umbilical cords) were enrolled. The median (IQR) mother’s age and gestational age were 28.5 (26.0–30.0) years and 38.0 (37.5–38.2) weeks, respectively. The median (IQR) umbilical cord level of 25-(OH)D was significantly higher than the median maternal level of 25-(OH)D (30.3 [18.2–38.4] vs. 20.2 [17.5], ng/mL, P = 0.011). Moreover, compared to the maternal samples, a significantly low number of umbilical cord samples had a vitamin D deficiency (≤ 20; 25/90 [27.8%] vs. 42/90 [46.7%], P = 0.013). The umbilical cord 25-(OH)D levels were positively correlated with and significantly higher than the maternal 25-(OH)D levels (r = 0.401).

Introduction

Vitamin D is a fat-soluble vitamin and a steroid hormone precursor that is primarily involved in the homeostasis of calcium, bone health, immune function, cell proliferation and gene expression regulations [1, 2]. Vitamin D is mainly synthesized in the skin, and the 25-hydroxyvitamin D (25-(OH)D) form is found in the liver but continues on to the kidneys to produce the active form 1, 25-dihydroxy vitamin D (1, 25-(OH)2D) [3, 4]. Vitamin D deficiency during pregnancy is a health problem worldwide, and it can lead to several adverse pregnancy outcomes such as anemia [5], preeclampsia, preterm birth, gestational diabetes and gestational hypertension [6, 7]. The literature contains recent reports on the maternal and umbilical cord levels of 25-(OH)D [8–10]. While some of these studies have shown a higher level of umbilical cord 25-(OH)D than maternal 25-(OH)D [8–10], others have shown the opposite (lower level of umbilical cord 25-(OH)D) than maternal 25-(OH)D) [11–13]. A few studies have been conducted in Sub-Saharan Africa [14]. Notably, recent reports have shown that a high rate of umbilical cord blood vitamin D deficiency is associated with adverse effects, such as eczema, in infants [15].

There is a high prevalence (93.9%) of vitamin D deficiency among pregnant women in Sudan [16], and low 25-(OH)D levels have been associated with gestational diabetes mellitus [17], preeclampsia [18] and preterm birth [7]. The present study was conducted to investigate maternal and umbilical 25-(OH)D levels in Sudan. Investigating the maternal and umbilical 25-(OH)D levels and generating the data necessary for evidence-based interventions would be useful for physicians and health planners.

Methods

This cross-sectional study was conducted at the Saad Abuelela Maternity Hospital in Khartoum, Sudan, from October 15 to 30, 2021.

Inclusion Criteria
Women presented to the labor room with a term birth (37–41 weeks of gestation) of a single, alive newborn were included in the study.

**Exclusion Criteria**

Women with uncertain dates, preterm birth (<37 weeks of gestation), multiple pregnancies, intra-uterine fetal death, a baby with one or more congenital anomalies, diseases such as hypertension, diabetes mellitus and antepartum hemorrhage or any other chronic disease and those taking any drugs were excluded.

After obtaining their informed consent, the sociodemographic, medical and obstetric data of the subjects were gathered and recorded via a questionnaire (age, parity, gestational age, antenatal attendance, education level and employment). Gestational age was calculated using a combination of the dates of the subject’s last menstrual period and the early pregnancy ultrasound.

Following this, five milliliters of blood were taken from the maternal subjects and umbilical cords and collected in plain tubes. These were immediately labeled and allowed to clot at room temperature. The blood samples were then centrifuged and stored at -20°C before being assessed for 25-(OH)D levels using an enzyme-linked immunosorbent assay as per the manufacturer’s instructions (Euroimmun, Lubeck, Germany).

**Sample Size Calculation**

The sample size (90 samples from the mothers and umbilical cords) was calculated based on our previous report regarding the desired level of serum 25-(OH)D (15.0 ng/mL) in pregnant Sudanese women [7]. We assumed that the umbilical cord level of 25-(OH)D would be higher (18.0 ng/mL) than the maternal level based on recent reports about the maternal and umbilical cord levels of 25-(OH)D [8, 9]. We assumed a mean difference of 3 ng/mL between the maternal and umbilical serum 25-(OH)D concentrations. The sample size (90 samples) was determined to achieve a power of 80% and a precision of 5%.

**Statistics**

All statistical analyses were performed using the Statistical Package for the Social Sciences for Windows version 22.0 (SPSS Inc., Chicago, Illinois, USA). Continuous data (25-(OH)D) were checked for normality using the Shapiro–Wilk test. The 25-(OH)D levels of the two groups (maternal and umbilical cord) were compared using the Mann–Whitney U test. Spearman’s correlations were performed between the maternal and umbilical cord 25-(OH)D levels. P-values < 0.05 were considered significant.

**Results**

90 pairs of maternal and neonatal (umbilical cord) blood samples were used in this study. The median (IQR) values of mother’s age, parity and gestational age were 28.5 years (26.0–30.0), 3 (2–5) and 38.0
weeks (37.5–38.2), respectively. The education levels of 32 women (35.6%) were below the secondary level, and 81 women (90.0%) were housewives (Table 1).

### Table 1

Characteristics of the enrolled maternal and newborn in Khartoum, Sudan, 2021

<table>
<thead>
<tr>
<th>Variables</th>
<th>Median</th>
<th>Interquartile range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, years</td>
<td>28.5</td>
<td>26.0 – 30.0</td>
</tr>
<tr>
<td>Parity</td>
<td>3</td>
<td>2 – 5</td>
</tr>
<tr>
<td>Gestational age, weeks</td>
<td>38.0</td>
<td>37.5 – 38.2</td>
</tr>
<tr>
<td>Body mass index, kg/m²</td>
<td>26.4</td>
<td>24.2 – 29.4</td>
</tr>
</tbody>
</table>

The median (IQR) umbilical cord 25-(OH)D level was significantly higher than the maternal 25-(OH)D level (30.3 [18.2–38.4] vs. 20.2 [17.5] ng/ml, P = 0.011], Fig. 1). Moreover, compared to the maternal samples, a significantly low number of umbilical cord samples were found to have a vitamin D deficiency (≤ 20; 25/90 [27.8%] vs. 42/90 [46.7%], P = 0.013). The umbilical cord 25-(OH)D levels were positively correlated with the maternal 25-(OH)D levels (r = 0.401, P < 0.001, Fig. 2).

**Discussion**

The findings of the present study showed that the umbilical cord 25-(OH)D levels were significantly higher than and positively correlated with the maternal 25-(OH)D levels. The prevalence (46.7%) of vitamin D deficiency in this study was lower than the prevalence (93.9%) reported in our previous study involving pregnant women in Central Sudan [16]. The present study’s finding of the umbilical cord 25-(OH)D levels being higher than the maternal 25-(OH)D levels is in line with the reports of previous studies. For instance, based on samples from 103 pregnant women and their newborns in China, Luo et al. reported that the mean serum vitamin D level was higher in the umbilical cords (16.2 ng/mL) than in mothers (15.1 ng/mL) [8]. Likewise, Yu et al. considered 295 neonates and 225 mothers in China and reported that the mean (25-(OH)D) level was higher in the neonates than in the mothers (10.17 vs. 8.49 ng/mL) [9]. Moreover, Sideri et al. considered 81 healthy women in Greece and reported that the umbilical 25-(OH)D levels (21.3 ng/ml) were higher than the maternal 25-(OH)D levels at delivery (19.2 ng/ml) [10].

However, several studies have reported lower 25-(OH)D levels in umbilical cords than in maternal samples. Wang et al. conducted a study in Shanghai, China, and reported that the mean 25-(OH)D concentrations in maternal blood samples and newborn umbilical cord blood samples were 35.62 ng/mL and 19.77 ng/mL, respectively [11]. In a cohort of 116 mother–infant pairs in Indonesia, the mean 25-(OH)D level was lower in the umbilical cord blood (16.27 ng/mL) than in the maternal serum (17.55 ng/mL) [12]. In a sample of 100 mothers in Poland, the mean maternal 25-(OH)D level was 22.2 ng/mL, whereas the mean umbilical cord of 25-(OH)D level was 1.3 ng/mL [13]. Interestingly, the prevalence of vitamin D deficiency (< 20 ng/mL) in mothers and newborns was reported to be 4.8% and 29.5%,
respectively, upon considering 166 pregnant women in Lagos, Nigeria [14]. In contrast, low prevalence rates of vitamin D deficiency in both mothers and newborns were reported in Iran (1.1% and 2.5%, respectively) [11].

In the present study, the umbilical cord 25-(OH)D levels were positively correlated with the maternal 25-(OH)D levels \( (r = 0.401) \). The data align with those of previous studies. For instance, in a study of 295 neonates and 225 mothers in China, the 25-hydroxy vitamin D levels were positively correlated with the 25-(OH)D levels in maternal serum \( (r = 0.75) \) [9]. In Poland, Zasimovich et al. found a positive correlation between maternal serum and umbilical cord blood 25-(OH)D \( (r = 0.74) \) [19]. Moreover, a positive correlation between maternal and neonatal 25-(OH) vitamin D levels \( (r = 0.874) \) was reported [20]. On the other hand, a weak correlation between maternal serum and cord blood 25-(OD)D \( (r = 0.12) \) was reported in Iran [21]. It is worth noting that our results and the results of the other studies should be compared with caution because of differences in the characteristics of the enrolled women and newborns and in the methods used to measure 25-(OH)D levels.

Several vitamin D biomarkers were higher in the pregnant women compared to their nonpregnant peers, which suggests that metabolic adaptations such as involving the placenta to enhance optimum vitamin D supply during pregnancy [22, 23]. The vitamin D binding protein has been reported to increase during pregnancy with high variations; this increase might influence the active form of vitamin D [22, 23]. It has previously been reported that the vitamin D binding protein level is lower in the cord serum than in the mother [24], which may lead to an increase in free 25-(OH)D to maintain its high level in the fetus.

**Limitations**

The 25-OHD levels were measured at the time of delivery in this study, which means that the data obtained do not reflect the whole picture throughout the course of the pregnancy. A longitudinal study that assesses the 25-OHD levels in the early and mid-pregnancy stages as well as in the later weeks of gestation is needed. Further, several factors that might affect pregnancy, such as infection and nutrient levels, were not measured. The birth outcomes, namely the birth weight, head circumference and length of the newborns, were not assessed. Consequently, larger longitudinal studies are needed to obtain more evidence to support the findings.

**Conclusion**

The neonatal umbilical cord levels of 25-(OH)D were significantly higher than the maternal levels of 25-(OH)D, and the umbilical cord and maternal levels of 25-(OH)D were positively correlated.

**Declarations**

**Author Contributions**
Conceptualization, M.A.A., AA and I.A; Methodology, A.E., A.A. and I.A.; Validation, M.A.A. and I.A.; Investigation, A.E. and A.A.; Statistical Analysis, A.A. and I.A.; Writing—Original Draft Preparation, M.A.A., AA and I.A.; Writing—Review & Editing, A.E., A.A. and I.A.; Supervision, I.A. and MAA. All authors have read and agreed to the publishable version of the manuscript.

**Funding**

There was no funding for this study.

**Institutional Review Board Statement**

The study was conducted in accordance with the Declaration of Helsinki and approved by the ethical committee of the Department of Obstetrics and Gynaecology, University of Khartoum, Sudan (2021, 07).

**Informed Consent Statement**

Informed consent was obtained from all subjects involved in the study.

**Data Availability Statement**

The data presented in this study are available on request from the last author.

**Conflicts of Interest**

The authors declare no conflict of interest.

**References**


**Figures**
Figure 1

Comparing maternal and umbilical cord level of 25-(OH)D in Khartoum Sudan, 2021
Figure 2

Correlations between maternal and umbilical cord level of 25-(OH)D in Khartoum Sudan, 2021