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Original Article

Comparison of 25- Hydroxy Vitamin D Levels in Premature Infants with and without Respiratory Distress

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ABSTRACT

Background: The 25-hydroxyvitamin D3(25-OH D3)deficiency is a common problem worldwide, and it is aprevalent incidence in neonates. Different studies investigated the relationship of vitamin D deficiency with neonatal mortality and morbidity. This study aimed to evaluate the relationship between vitamin D deficiency and respiratory distress in preterm neonates.

Methods: A prospective cohort study was conducted in Alzahra Hospital affiliated to Isfahan University of Medical Sciences, Isfahan, Iran. In total, 160 preterm neonates with>1000 g birth weight were evaluated for the manifestation of respiratory distress during the first 6 h of life. The neonates were divided into two groups of A (n=80) with respiratory symptoms and B (n=80) without respiratory symptoms. The level of 25-OH D3 was measured in the first h of the neonate's life. All neonates were followed to reach 36 weeks of gestational age or 28th day of life. Subsequently, the two groups were compared in terms of vitamin D levels. There was a relationship between vitamin D deficiency and respiratory morbidities in group A.

Results: The mean vitamin D level was obtained at 27.42±11.25 ng/mL, and it was categorized into adequate level (n=53, 33.1%), inadequate level (n=62,38.8%), and vitamin D deficiency (n=45, 28.1%).According to the results, vitamin D level correlated significantly with birth weight and gestational age (P<0.05). Moreover, respiratory distress correlated with birth weight, gestational age, and the use of corticosteroids during pregnancy (P<0.001). The mean vitamin D level in group A (with respiratory distress syndrome [RDS]) was significantly lower than that in group B (without RDS, P<0.001).Furthermore, vitamin Dcorrelated with RDS, a need for intubation surfactant extubation, and duration of continuous positive airway pressure (P<0.05).

Conclusion: Neonates with a low level of vitamin D are prone to manifest respiratory distress, and vitamin D deficiency is a risk factor for presenting RDS.

Keywords: Preterm neonate, Respiratory distress, Respiratory distress syndrome

Introduction

Vitamin D is a fat-soluble vitamin active form (1,25dihydroxyvitamin D3) which has a crucial role in calcium, phosphate, and bone metabolism with several biologic effects (1). It inhibits parathyroid hormone synthesis, adoptive immune, cell proliferation, and also increases insulin secretion, innate immunity, and stimulation of cell differentiation(2).

Vitamin D deficiency is a worldwide problem and the Middle East studies reported that 72.8% of the population had this type of deficiency (3, 4). Moreover, it is also common among neonates, especially those with very low birth weight (VLBW) and small gestational age(5, 6). Vitamin D deficiency is considereda risk factor for other diseases, such ascardiovascular, infectious, and bone diseases, as well as cancers (7, 8). Preterm neonates, especially those with VLBW are athigh

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risk for the nutritional deficiency that affects neonatal and infancy health and development. Preterm neonates have an inadequate level of vitamins that predispose them to increased mortality and morbidity (9, 10). The relationship between vitamin D deficiency and diseases of prematurityhas been investigated, and the results showed that it led to sepsis, necrotizing enterocolitis (NEC), respiratory distress syndrome (RDS) (11), and broncho-pulmonary dysplasia (BPD) (12-15).

The RDS is a common complication in prematurity, and around half of the VLBW neonates suffer from this situation (16). Some studies reported vitamin D hada role in lung development, and preterm neonates with vitamin D deficiency are more prone to manifest RDS signs and symptoms (17). Alveolar cells have vitamin D receptor that is involved in surfactant synthesis and secretion in response to vitamin D. Previously conducted studies reported the role of vitamin Don pulmonary development, maturation, and respiratory diseases (18).

The majorly of the previous studies on the relationship between vitamin D deficiency and respiratory diseases in preterm neonates were conducted in developed countries, and there are limited studies on this association in developing countries. According to the effect of climate and sunlight exposure in different countries, this study aimed to evaluate the relationship between vitamin D deficiency and respiratory distress in preterm neonates in Isfahan as the third populated city in Iran.

Methods

This prospective cohort study was conductedon preterm neonates who were born in Alzahra Hospital affiliated to Isfahan University of Medical Science (IUMS), Isfahan, Iran, during 2018. The inclusion criteria were: 1) preterm neonates with 28-37 weeks of gestation, 2) weight of ≥1000 g at birth, 3) five-minuteApgar score>4, and 4) parent's willingness to participate in this study. On the other hand, the neonates who had a major anomaly, history of chorioamnionitis during delivery or premature rupture of membrane > 18h, as well as clinical or laboratory diagnosis of sepsis, pneumonia, or congenital heart diseases were excluded from the study. The study protocol was approved by the Ethics Committee of IUMS (IR.MUI.REC.1396.3.585).

Blood samples (2 ml) were taken from the cords of the neonates immediately after birth or peripheral blood was taken during the first h of the neonate's life. Subsequently, the samples were referred to the laboratory of Alzahra Hospital, and the level of 25-hydroxycholecalciferol (25-OHD3) was measured by enzyme-linked immunosorbent assay (ELISA). The level of 25-OHD3 is reported with ng/mL and categorized into adequate (>30ng/mL), inadequate (20-30 ng/mL), deficient (10-20 ng/mL), and severely deficient (<10 ng/mL)(18).

All neonates were followed during the first 6 h of life for the presence of respiratory symptoms, including respiratory rate>60, grunting, retraction, nasal flaring, and the need for oxygen therapy. Therefore, neonates were divided into two groups of A and B with and without respiratory symptoms, respectively. Neonates in group A were followed to reach 36 weeks of gestational age or the 28th day of life. They were then evaluated regarding the duration of oxygen therapy, duration of treatment with mechanical ventilation or continuous positive airway pressure (CPAP), a need for intubation surfactant extubation (INSURE), presence of RDS, transient tachypnea of neonates (TTN), BPD, NEC, and intraventricularhemorrhage (IVH).

Other information extracted from each neonate medical record or using interviews with their parents included gestational age, gender, weight at birth, singleton or twin pregnancy, and use of vitamin D supplementations and corticosteroids during pregnancy.

Data were analyzed in SPSS software (version 24) (SPSS crop., Chicago, IL, USA). Moreover, the quantitative and qualitative data were analyzed by mean±SD as well as number and percent, respectively. Furthermore, the chi-square test, Fisher's Exact test, Mann Whitney U test, and General Linear Model were utilized to compare the groups in terms of variables. A p-value less than 0.05 was consideredstatistically significant.

Results

This study evaluated 160 neonates with the meangestationalage of 34.64±1.58 weeks and a mean weight of 2274.815±430.69 g. The majority of the neonates were female (n=84, 52.5%). The mean vitamin D level was obtained at 27.42±11.25 ng/mL and categorized into adequate level (n=53, 33.1%), inadequate level (n=62, 38.8%), and deficient (n=45, 28.1%). Vitamin D level did not correlate with gender (P=0.91) and twin pregnancy (P=0.24). However, vitamin D level correlated significantly with birth weight and gestational age (birth weight: P=0.03and gestational age: P=0.04).

According to the results, the mean birth weight and gestational age were significantly lower in neonates with respiratory symptoms ($P<0.001$ for both). In addition, the use of corticosteroids during pregnancy was significantly higher in neonates with respiratory symptoms ($P<0.001$).

There was no significant difference between the two groups regarding gender distribution, twin pregnancy, and use of vitamin D supplementation during pregnancy (P=0.21,0.08, 0.87, respectively). The mean values of vitamin D levels were 23.66±8.46 ng/mL and 31.18±12.44 ng/mL in neonates with and without respiratory distress, respectively. This indicates a significant difference between the groups in this regard. In other words, the mean vitamin D level in group A was significantly lower than that in group B ($P<0.001$).

Moreover, the results of the General Linear Model considering confounding variables (i.e., birth weight, gestational age, and use of corticosteroid) showed a statistically significant relationship between the mean level of vitamin D and the presence of respiratory symptoms in neonates (P=0.001, Table1).

The neonates in group A (with respiratory symptoms) were evaluated in terms of preterm morbidities, including RDS,TTN, a need for mechanical ventilation, a need for INSURE, duration of oxygen therapy, and duration of CPAP. The results revealed a significant relationship between vitamin D levels and RDS. In other words, the neonates with inadequate vitamin D obtained a higher frequency of RDS, compared to those with adequate vitamin D levels (P=0.004). Moreover, the frequency of a need for INSURE was significantly lower in new borns with inadequate vitamin D, compared to neonates with adequate vitamin D levels (P=0.03). The mean duration of CPAP in the group with an inadequate level of vitamin D was significantly higher than the group with an adequate vitamin D level (P=0.02). Additionally, vitamin D levels did not correlate with transient tachypnea, mechanical ventilation, and duration of oxygen therapy ($P>0.05$, Table 2).

Table1. Distribution of gender, number of fetuses, weight, gestational age, use of corticosteroids, and vitamin D supplementation during pregnancy in neonates with and without respiratory symptoms

Variable		With respiratory symptoms Number (%)	Without respiratory symptoms Number (%)	P-value
Gender	Male	35(43.8)	41(51.3)	0.21
	Female	45(56.3)	39(48.8)	
Number of fetuses	Singleton	73(91.3)	78(97.5)	0.08
	Multiple	7(8.8)	2(2.5)	
Weight	<1500	21(26.3)	0(0)	<0.001
	1500-2000	32 (40)	4(5)	
	2000-2500	19 (23.8)	21(26.3)	
	>2500	8 (10)	55(68.8)	
Gestational age	28-31	22(27.5)	0 (0)	<0.001
	32-33	21 (26.3)	5 (6.3)	
	>34	37(46.3)	75 (93.8)	
Use of corticosteroid during pregnancy	Yes	45(56.3)	14(17.5)	<0.001
	No	35(43.8)	66 (82.5)	
Use of vitamin D supplements during pregnancy	Yes	38 (47.5)	37(46.3)	0.87
	NO	42 (52.5)	43(53.8)	

Table 2. Distribution of RDS, transient tachypnea, a need for mechanical ventilation, a need for INSURE, as well as duration of oxygen therapy and CPAP in neonates with and without vitamin D deficiency

Variables		Vitamin D level <30 ng/mL	Vitamin D level >30 ng/mL	P-value
RDS[1]	Yes	45(63.4)	10(19.2)	0.004
	No	63(36.6)	42(80.8)	
Transient tachypnea[1]	Yes	6(5.6)	1 (1.9)	0.27
	No	102(94.4)	51(98.1)	
Mechanical ventilation[1]	Yes	2(1.9)	0(0)	0.45
	No	106(98.1)	52(100)	
Needs for INSURE[1]	Yes	44(40.7)	30(57.7)	0.03
	No	64(59.3)	22(42.3)	
Duration of oxygen therapy[2]		60.41(63.01)	57.91(46.68)	0.87
Duration of CPAP[2]		27.01(33.09)	12.01(9.35)	0.02

[1]Data are presented bynumber (%)
[2]Data are presented by mean (SD)

Discussion

The mean level of vitamin D was estimated at 27.42±11.25 ng/mL among preterm neonates in this study. This value was obtained at 18.1±11.6ng/mL in a study conducted on this population(19).Other studies showed that the mean values of vitamin D level in preterm neonates were 14.5 and 32 ng/mL in Arab countries and the Korean population, respectively(20, 21). In this study,28.1% and 38.8% of the neonates had vitamin D deficiency and inadequate levels of vitamin D, respectively. It should be noted that the prevalence rate of vitamin D deficiencyvaries in several studies and ranges from 65.2% to 89.9% (5, 21). Vitamin D deficiency is a worldwide problem, and there is evidence about the higher prevalence of this deficiency in Europe, the United States, and the Middle East (3, 11, 22).

The differences among the studies regarding the level of vitamin D and prevalence of vitamin D deficiency among preterm neonates is maybe due to different study population features including weight, gestational age, and mother's vitamin D status. One of the reasons for the lower level of vitamin D in Iranian neonates, compared to those in other communities is probably attributed to receiving vitamin D pearls during pregnancy in Iranian pregnant women (20).

The present study showed a significant relationship between the level of vitamin D and birth weight in preterm neonates. A study was conductedon 607 VLBW and 300 term neonates and compared these two groups in terms of vitamin D level. According to the results, vitamin D deficiency was more prevalent in neonates with lower weight (5). Similarly, a study was performedon 83 VLBW neonates and 301 newborns who were small for gestational age. The results of the aforementioned study revealed that the mean level of vitamin D<50 ng/mL was associated with a decreased risk of VLBW(23).

Our finding suggested a significant relationship between the low level of vitamin D and RDS. The results of this study are consistent with the findings of other studies. In a study conducted by Ataseven et.al (2013), it was investigated whether vitamin D deficiency was a risk factor for RDS or not. They evaluated 152 preterm neonates with 29-35 weeks of gestational age and reported that RDS was more prevalent in neonates with severe vitamin D deficiency, compared to those with mild vitamin D deficiency. Accordingly, it is suggested that the identification of vitamin D deficiency in pregnant women and prescription of appropriate supplementation has effects on reducing the risk of RDS in their neonates (12). In the same line, Kim etal. evaluated the association between vitamin D level at birth and respiratory morbidities in VLBW infants. They indicated that low serum vitamin D level was a risk factor for RDS (OR: 4.32) (18). A recently conducted study evaluated the level of vitamin D using the blood samples taken from the neonates' cord. The results showed that a lower level of vitamin D was associated with a higher risk of respiratory tract infection during the first 3 months of life and wheezing in early childhood (24). A similar study revealed that subclinical vitamin D deficiency was associated with frequent development of acute respiratory tract infection (25).

There is evidence about the role of vitamin D in lung development. The effect of an active form of vitamin D (1,25(OH)D3) is through the vitamin D receptors (VDR) which are nuclear receptors. The VDR with 25(OH) D3 binds to the vitamin D response element (VDRE) and regulates the expression of the vitamin D target gene (26). Around 3000 genes have VDRE, and groups of them are involved in lung development (27, 28). Vitamin D pathway gene is up-regulated during the pseudoglandular and saccular stage of lung development, and proximal and distal airways are generatedin this stage (28). Vitamin D hasalso effects on alveolar epithelial-mesenchymal interaction. There is evidence that shows the alveolar type II cells have a specific binding site for vitamin D and its active metabolite. Moreover, it stimulates the production of surfactant, protein and phospholipid, alveolar type II cells, as well as fibroblast proliferation and differentiation (29-31).

Vitamin D has a role in the function of the innate immune system by induction of antimicrobial peptides in epithelial cells, neutrophil, and macrophage (32, 33). An active form of vitamin D can maintain the integrity of the epithelial cell by encoding the proteins that are needed for several tight junctions (32, 34). It also affected T helper cells and has anti-inflammatory effects on neutrophils (35). It is involved in superoxide generation in monocytes and inhibits excessive production of inflammatory cytokines and facilitates neutrophil's phagocytosis and motility (36).

In a study performed by Boskabadi et al. in Iran, the association of vitamin D level was evaluated with respiratory complications on 160 preterm neonates weighing less than 2000 g. According to the results, the mean vitamin D level was significantly higher in the preterm newborns with distress, compared to those without distress. Moreover, vitamin D levels correlated significantly with the duration of hospitalization, gestational age, birth weight, one- and five-minute Apgar scores, and head circumference (37).

In the same vein, in a study, it was found that vitamin D deficiency was more common among preterm infants. Moreover, there was a significant relationship between vitamin D level in the infants and IVH. In other words, the mean vitamin D level was less than normal in the infants with IVH (38).Furthermore, according to the results of a study, level of vitamin D in the infants correlated with mortality and gestational age (39).

Among the strength of this study, one can name its appropriate sample size that is sufficient for generalizing the results to the Iranian population. On the other hand, one of the limitations of this study was the selection of neonates from a public hospital. Since pregnant women with a poor or intermediate level of nutrition generally refer to these hospitals, the mother's nutritional levelsmay have effects on the outcomes.

This study did not evaluate the mother's vitamin D level which may play a role in the level of neonate's vitamin D according to previous studies (14). The level of vitamin D was measured in participants at birth, and this variable was not assessed during hospitalization to detect the alteration of this vitamin level during hospitalization. Therefore, further studies are required to select the samples from all public and private hospitals considering the confounding factors, such as the mother's vitamin D level.

Conclusion

In conclusion, vitamin D deficiency in preterm neonates is considereda risk factor for developing respiratory diseases, such as RDS. Moreover, vitamin D level is associated with the cause of respiratory distress due to low birth weight, lower corticosteroids, and lower gestational age.

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Conflicts of interest

The authors declare that they have no conflict of interest.

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References

1. Sigmundsdottir H, Pan J, Debes GF, Alt C, Habtezion A, Soler D, et al. DCs metabolize sunlight-induced vitamin D3 to'program'T cell attraction to the epidermal chemokine CCL27. NatImmunol. 2007; 8(3):285-93.
2. Di Rosa M, Malaguarnera M, Nicoletti F, Malaguarnera L. Vitamin D3: a helpful immuno-modulator. Immunology. 2011;134(2):123-39.
3. Berry DJ, Vimaleswaran KS, Whittaker JC, Hingorani AD, Hyppönen E. Evaluation of genetic markers as instruments for Mendelian randomization studies on vitamin D. PloS One. 2012;7(5):e37465.
4. Kesby JP, Cui X, Ko P, McGrath JJ, Burne TH, Eyles DW. Developmental vitamin D deficiency alters dopamine turnover in neonatal rat forebrain. NeurosciLett. 2009;461(2):155-8.
5. Fares S, Sethom MM, Khouaja-Mokrani C, Jabnoun S, Feki M, Kaabachi N. Vitamin A, E, and D deficiencies in tunisian very low birth weight neonates: prevalence and risk factors. PediatrNeonatol. 2014;55(3):196-201.
6. Sachan A, Gupta R, Das V, Agarwal A, Awasthi PK, Bhatia V. High prevalence of vitamin D deficiency among pregnant women and their newborns in northern India. AmJClin Nutr. 2005;81(5):1060-4.
7. Newhook LA, Sloka S, Grant M, Randell E, Kovacs CS, Twells LK. Vitamin D insufficiency common in newborns, children and pregnant women living in Newfoundland and Labrador, Canada. MaternChild Nutr. 2009;5(2):186-91.
8. Brown AJ, Dusso AS, Slatopolsky E. Vitamin D analogues for secondary hyperparathyroidism. Nephrol DialTransplant. 2002;17(Suppl10):10-9.
9. Darlow BA, Graham P, Rojas-Reyes MX. Vitamin A supplementation to prevent mortality and short-and long-term morbidity in very low birth weight infants. Cochrane Database Syst Rev. 2016; 8:CD000501.
10. Karatekin G, Kaya A, Salihoğlu Ö, Balci H, Nuhoğlu A. Association of subclinical vitamin D deficiency in newborns with acute lower respiratory infection and their mothers. EurJClin Nutr. 2009;63(4):473-7.
11. Wang TJ, Zhang F, Richards JB, Kestenbaum B, Van Meurs JB, Berry D, et al. Common genetic determinants of vitamin D insufficiency: a genome-wide association study. Lancet. 2010;376(9736): 180-8.
12. Ataseven F, Aygün C, Okuyucu A, Bedir A, Kücük Y, Kücüködük S. Is vitamin D deficiency a risk factor for respiratory distress syndrome. Int J Vitam Nutr Res. 2013;83(4):232-7.
13. Cetinkaya M, Cekmez F, Buyukkale G, Erener-Ercan T, Demir F, Tunc T, et al. Lower vitamin D levels are associated with increased risk of early-onset neonatal sepsis in term infants. JPerinatol. 2015;35(1):39-45.
14. Cetinkaya M, Erener-Ercan T, Kalayci-Oral T, Babayiğit A, Cebeci B, Semerci S, et al.

Maternal/neonatal vitamin D deficiency: a new risk factor for necrotizing enterocolitis in preterm infants? J Perinatol. 2017;37(6):673-8.
15. Joung KE, Burris HH, Van Marter LJ, McElrath TF, Michael Z, Tabatabai P, et al. Vitamin D and bronchopulmonary dysplasia in preterm infants. JPerinatol. 2016;36(10):878-82.
16. Levine CR, Gewolb IH, Allen K, Welch RW, Melby JM, Pollack S, et al. Safety, pharmacokinetics, and anti-inflammatory effects of intratracheal recombinant human Clara cell protein in premature infants with respiratory distress syndrome. PediatrRes. 2005; 58(1):15-21.
17. Cetinkaya M, Cekmez F, Erener-Ercan T, Buyukkale G, Demirhan A, Aydemir G, et al. Maternal/neonatal vitamin D deficiency: a risk factor for bronchopulmonary dysplasia in preterms? J Perinatol. 2015;35(10):813-7.
18. Kim I, Kim SS, Song JI, Yoon SH, Park GY, Lee YW. Association between vitamin D level at birth and respiratory morbidities in very-low-birth-weight infants. J Korean Pediatr. 2019;62(5):166-72.
19. Maghbooli Z, Hossein-Nezhad A, Shafaei AR, Karimi F, Madani FS, Larijani B. Vitamin D status in mothers and their newborns in Iran. BMC Pregnancy Childbirth. 2007;7(1):1.
20. De-Regil LM, Palacios C, Lombardo LK, Peña-Rosas JP. Vitamin D supplementation for women during pregnancy. Sao Paulo Med J. 2016; 134(3):274-5.
21. Shin YH, Yu J, Kim KW, Ahn K, Hong SA, Lee E, et al. Association between cord blood 25-hydroxyvitamin D concentrations and respiratory tract infections in the first 6 months of age in a Korean population: a birth cohort study (COCOA). Korean J Pediatr. 2013;56(10):439-45.
22. de Haan K, Groeneveld AJ, de Geus HR, Egal M, Struijs A. Vitamin D deficiency as a risk factor for infection, sepsis and mortality in the critically ill: systematic review and meta-analysis. CritCare. 2014;18(6):660.
23. Morgan C, Dodds L, Langille DB, Weiler HA, Armson BA, Forest JC, et al. Cord blood vitamin D status and neonatal outcomes in a birth cohort in Quebec, Canada. ArchGynecolObstet. 2016;293(4):731-8.
24. Camargo CA, Ingham T, Wickens K, Thadhani R, Silvers KM, Epton MJ, et al. Cord-blood 25-hydroxyvitamin D levels and risk of respiratory infection, wheezing, and asthma. Pediatrics. 2011;127(1):e180-7.
25. Marshall I, Mehta R, Petrova A. Vitamin D in the maternal–fetal–neonatal interface: clinical implications and requirements for supplementation. J Matern Fetal Neonatal Med. 2013;26(7):633-8.
26. Torday JS, Rehan VK. A cell–molecular approach predicts vertebrate evolution. MolBiolEvol. 2011; 28(11):2973-81.
27. Bossé Y, Lemire M, Poon AH, Daley D, He JQ, Sandford A, et al. Asthma and genes encoding components of the vitamin D pathway. RespirRes. 2009;10(1):98.
28. Kho AT, Bhattacharya S, Tantisira KG, Carey VJ, Gaedigk R, Leeder JS, et al. Transcriptomic analysis of human lung development. AmJRespirCrit Care Med. 2010;181(1):54-63.
29. Marin L, Dufour M, Tordet C, Nguyen M. 1, 25 (OH) 2D3 stimulates phospholipid biosynthesis and surfactant release in fetal rat lung explants. Biol Neonatol. 1990;57(3-4):257-60.
30. Nguyen M, Trubert C, Rizk-Rabin M, Rehan V, Besancon F, Cayre Y, et al. 1, 25-Dihydroxyvitamin D3 and fetal lung maturation: immunogold detection of VDR expression in pneumocytes type II cells and effect on fructose 1, 6 bisphosphatase. JSteroid BiochemMol Biol. 2004;89-90(1-5):93-7.
31. Sakurai R, Shin E, Fonseca S, Sakurai T, Litonjua AA, Weiss ST, et al. 1α, 25 (OH) 2D3 and its 3-epimer promote rat lung alveolar epithelial-mesenchymal interactions and inhibit lipofibroblast apoptosis. Am JPhysiol Lung CellMol Physiol. 2009;297(3):L496-505.
32. Clancy N, Onwuneme C, Carroll A, McCarthy R, McKenna MJ, Murphy N, et al. Vitamin D and neonatal immune function. J Matern Fetal Neonatal Med. 2013; 26(7):639-46.
33. Kempker JA, Han JE, Tangpricha V, Ziegler TR, Martin GS. Vitamin D and sepsis: an emerging relationship. Dermatoendocrinol. 2012;4(2):101-8.
34. Gniadecki R, Gajkowska B, Hansen M. 1,25-dihydroxyvitamin D3 stimulates the assembly of adherens junctions in keratinocytes: involvement of protein kinase C. Endocrinology. 1997;138(6):2241-8.
35. Sadeghi K, Wessner B, Laggner U, Ploder M, Tamandl D, Friedl J, et al. Vitamin D3 down-regulates monocyte TLR expression and triggers hyporesponsiveness to pathogen-associated molecular patterns. Eur J Immunol. 2006;36(2):361-70.
36. Youssef DA, Miller CW, El-Abbassi AM, Cutchins DC, Cutchins C, Grant WB, et al. Antimicrobial implications of vitamin D. Dermatoendocrinol. 2011;3(4):220-9.
37. Boskabadi H, Mamoori G, Khatami SF, Faramarzi R. Serum level of vitamin D in preterm infants and its association with premature-related respiratory complications: a case-control study. Electron Physician. 2018;10(1):6208-14.
38. Boskabadi H, Zakerihamidi M, Faramarzi R. The vitamin D level in umbilical cord blood in premature infants with or without intra-ventricular hemorrhage: a cross-sectional study. Int J Reprod Biomed. 2018;16(7):429-34.
39. Boskabadi H, Maamouri G, Hemmatipour A, Parvini Z, Ramazani A, Bagheri F. Comparison of serum vitamin D in the umbilical cord of survived with not survived premature infants. Iran J Pediatr. 2019; 29(3):e84798.