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Original Research Article

Role of maternal and neonatal plasma vitamin D levels on development of neonatal sepsis in term infants

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ABSTRACT

Background: Neonatal sepsis is characterized by signs and symptoms of infection with or without accompanying bacteremia in the first month of life and is an important cause of morbidity and mortality. There is overwhelming experimental evidence that vitamin D has an important role in the regulation of both the innate and acquired immune systems. Therefore, low vitamin D status is expected to be one of the risk factors for neonatal sepsis.
Methods: Between September 2016 and July 2018 term infants with clinical and laboratory findings of Neonatal Sepsis who were>37weeks of gestational age and were admitted to Neonatal Intensive Care Unit of Sheri-Kashmir Institute of Medical Sciences Soura, Srinagar and healthy infants (controls) who presented to our out-patient clinic for routine evaluation with no signs of clinical and laboratory infection were taken up for study. Blood for neonatal and maternal vitamin D levels was obtained from all infants and their mothers at the postpartum period at the time of hospital admission.
Results: A total of 92 mother-neonatal pairs (46 cases and 46 controls) were enrolled in the study. In the study group the mean neonatal vitamin D level was 12.90 ng/ml and the mean maternal vitamin D level was 22.90 ng/ml. In the control group the mean neonatal vitamin D level was 25.99 ng/ml and the mean maternal vitamin D level was 37 ng/ml. Mean maternal and neonatal vitamin D levels were significantly lower in the study group than in the control group.
Conclusions: There was a highly significant correlation between neonatal and maternal vitamin D levels in both study and control groups in our study. Thus, it was concluded that babies born to mothers with inadequate vitamin D levels have inadequate vitamin D levels.

Keywords: Immune system, Morbidity, Mortality, Neonatal sepsis, Vitamin D levels

INTRODUCTION

Neonatal sepsis is characterized by signs and symptoms of infection with or without accompanying bacteremia in the first month of life and is an important cause of morbidity and mortality.[1,2] The incidence of neonatal sepsis varies between 1 and 8 neonates per 1000 live births.[3] It is estimated to cause almost 1 million deaths that accounts for more than 2% of neonatal deaths worldwide.[4]

Sepsis related mortality is largely preventable with prevention of sepsis itself, timely recognition, rational antimicrobial therapy and aggressive supportive care. Neonatal sepsis can be classified into two major categories depending up on the onset of symptoms.[5]

Early onset sepsis

It presents within the first 72 hours of life. In severe cases, the neonate may be symptomatic at birth. Infants with EOS usually present with respiratory distress and pneumonia. The source of infection is generally the maternal genital tract. Some maternal/perinatal conditions have been associated with an increased risk of EOS. Knowledge about these potential risk factors would help in early diagnosis of sepsis. Based on the studies from India, the following risk factors seem to be associated with an increased risk of early onset sepsis.[5,6]

Low birth weight (<2500 grams) or prematurity. Febrile illness in the mother with evidence of bacterial infection within 2 weeks prior to delivery. Foul smelling and/or meconium-stained liquor. Rupture of membranes>24 hours. Single unclean or>3 sterile vaginal examination (s) during labor. Prolonged labor (sum of 1st and 2nd stage of labor>24 hours). Perinatal asphyxia (Apgar score<4 at 1 minute). Presence of foul-smelling liquor or three of the above-mentioned risk factors warrant initiation of antibiotic treatment. Infants with two risk factors should be investigated and then treated accordingly.

Late onset sepsis

It usually presents after 72 hours of age. The source of infection in LOS is either nosocomial (hospital acquired) or community-acquired and neonates usually present with septicaemia, pneumonia or meningitis.[7,8] Various factors that predispose to an increased risk of nosocomial sepsis include low birth weight, prematurity, admission in intensive care unit, mechanical ventilation, intensive procedures, administration of parenteral fluids and use of stock solutions. Factors that might increase the risk of community-acquired LOS include poor hygiene, poor cord care, bottle feeding and prelacteal feeds. In contrast, breastfeeding helps in prevention of infections.

Clinical features

Non-specific features

The earliest signs of sepsis are often subtle and non-specific, indeed a high index of suspicion is needed for early diagnosis. Neonates with sepsis may present with one or more symptoms and signs. Hypothermia or fever, lethargy, poor cry, refusal to suck, poor perfusion, prolonged capillary refill time, hypotonia, absent neonatal reflexes, brady/tachycardia, respiratory distress, apnea and gasping respiration, hypo/hyperglycemia, metabolic acidosis.

Vitamin D

Vitamin D is a fat-soluble steroid hormone that contributes to the maintenance of normal calcium homeostasis and skeletal mineralization.[9] Vitamin D also has immunomodulatory effects on immune function.10 It was suggested that it might have a role in the optimal functioning of the innate immune system by inducing antimicrobial peptides in epithelial cells, neutrophils and macrophages.[10,11] Vitamin D deficiency is now recognized as a pandemic. The major cause of vitamin D deficiency is the lack of appreciation that sun exposure in moderation is the major source of vitamin D for most humans. Very few foods naturally contain vitamin D and foods that are fortified with vitamin D are often inadequate to satisfy either a child's or an adult's vitamin D requirement. Vitamin D deficiency causes rickets in children and will precipitate and exacerbate osteopenia, osteoporosis and fractures in adults. Vitamin D deficiency has been associated with increased risk of common cancers, autoimmune diseases, hypertension and infectious diseases.

A circulating level of 25-hydroxyvitamin D of>75 nmol/L or 30 ng/mL, is required to maximize vitamin D's beneficial effects for health. In the absence of adequate sun exposure, at least 800–1000 IU vitamin D3/day may be needed to achieve this in children and adults. Vitamin D2 may be equally effective for maintaining circulating concentrations of 25-hydroxyvitamin D when given in physiologic concentrations. Newborns are more susceptible to infections as both innate and adaptive immune systems are not entirely developed. The relationship between vitamin D deficiency and infections, especially lower respiratory tract infections (RTls), has been demonstrated in children and newborns.[12] Low cord blood 25-hydroxyvitamin D (125-OHD) levels in healthy newborns were found to be associated with an increased risk of developing respiratory synctial virus infections during infancy.[13] Although some studies reported a link between vitamin D deficiency and critical illness in adults, a direct relationship has not as yet been shown.[11] Breast milk concentration of vitamin D is low (<20IU/l) and is inadequate for the needs of the growing infant.[14] Vitamin D in breast milk relates to mothers vitamin D intake, skin pigmentation and sunlight exposure.[15]

Vitamin D deficiency and insufficiency are common across the globe. Large epidemiological studies reveal the high prevalence of vitamin D in women, including antenatal and lactating mothers.[16] To avoid developing a vitamin D deficiency, the American Academy of Pediatrics recommends breastfed and partially breastfed infants be supplemented with 400 IU per day of vitamin D beginning in the first few days of life. Vitamin D supplementation should be continued unless the infant is weaned to at least 1 liter per day of vitamin-D fortified formula. Any infant who receives<1 liter or 1 quart of formula per day needs an alternative way to get 400 IU/day of vitamin D, such as through vitamin D supplementation. There is overwhelming experimental evidence that vitamin D has an important role in the regulation of both the innate and acquired immune systems.[17] Newborns are more susceptible to infections as both innate and acquired immune systems are not entirely developed.[18] Therefore, low vitamin D status is expected

to be one of the risk factors for neonatal sepsis and this study was conducted to understand role and relation of vitamin D status in neonatal sepsis.

METHODS

This prospective study was performed in term infants with clinical and laboratory findings of neonatal sepsis who were>37 weeks of gestational age, were admitted to neonatal intensive care unit.

Study place

The study was done at and of Sheri-Kashmir Institute of Medical Sciences Soura, Srinagar.

Study duration

The period of study was between September 2016 and July 2018.

Sample size

Total of 92 (46 cases and 46 controls) infant-mother pairs were included in the study. The study group consisted of term neonates clinically suspected to have an infection within the first 28 postnatal days of life. Blood for neonatal and maternal vitamin D levels was obtained from all infants and their mothers at the postpartum period at the time of hospital admission. The healthy infants who presented to our out-patient clinic for routine evaluation with no signs of clinical and laboratory infection and evaluated for hyperbilirubinemia were referred to as the control group.

The control group consisted of term infants with the same gestational and postnatal age of the infants in the study group. Analyses of 25-OHD levels in control group was performed from the same blood sample that was used for bilirubin detection. The maternal demographic features including age, educational level, socioeconomic status, presence of disease, mother's outdoor clothing status was recorded.

Gestational age, birth weight, sex, mode of delivery, Apgar scores, birth season of all infants was also recorded. Vitamin D deficiency was staged as deficiency (serum 25-OHD<2O ng/ml), Insufficiency (serum 25-OHD between 20 and 30 ng/ml) and Adequate (serum 25-OHD>30 ng/ml).[19] Maintenance of 25-OHD level of 40 to 60 ng/ml is ideal and that up to 100 ng/ml is safe.

A septic screen including total leukocyte count, absolute neutrophil count, immature to total neutrophil count, blood smear evaluation and C reactive protein (CRP) was performed in all neonates with suspected sepsis to corroborate diagnosis of Neonatal Sepsis. Blood samples for whole blood count, CRP and culture were obtained before initiating antimicrobial therapy. Plasmas of both maternal and neonatal blood samples were Separated and stored at -20ºC Levels of 25-OHD was determined using Chemiluminescence method. Whole blood count was performed using an automatic Beckman Coulter CBC analyzer. CRP was determined by LATEX agglutination method. Blood cultures were analysed using fully automatic BACTEC Method.

Selection of cases

The study group consisted of term infants admitted to NICU with clinical suspicion of Neonatal Sepsis. Only the following types of patients were selected as Cases.

Highly probable sepsis

According to sepsis criteria defined by Gitto et al.[20]

Sepsis-related clinical signs

Temperature instability, apnea, need for supplemented oxygen, need for ventilation, tachycardia, bradycardia, hypotension, feeding intolerance, abdominal distension, necrotizing enterocolitis. Probable/possible/no sepsis were not included in the study group.

Serum parameters other than C-reactive protein.

White blood cell count, absolute neutrophil count, Platelet count

Cases of neonatal meningitis

diagnosed by clinical, laboratory and radiological features. Cut-off values of the various CSF parameters, white cell count >30/ cu.mm with more than 60% polymorphonuclear cells, proteins>170 mg/dl, glucose<50% of serum glucose, determined just prior to lumbar tap.

In patients with CSF biochemistry consistent with meningitis, CSF samples were sent for Gram stain and Culture.

Cases of Pneumonia in neonatal age group

Diagnosed by clinical, laboratory and radiological features.

Cases of BLOOD/CSF/URINE culture positive sepsis

Cultures growing coagulase negative Staphylococus (CoNS) were taken as contamination and were treated as positive if repeat culture grow the same organism.

Cases of osteomyelitis and septic arthritis in the neonatal age group

Diagnosed by clinical, laboratory and radiological features.

Exclusion criteria

The group of patients were not included in the study group like maternal clinical/histological choroamnionitis, premature rupture of membrane, refusal of parental consent, lack of laboratory data, major congenital abnormality, babies on formulae feeds.

Selection of controls

The healthy infants who presented to our outpatient clinic for routine evaluation with no signs of clinical and laboratory infection and evaluated for neonatal hyperbilirubinemia were referred to as the control group. The control group consisted of term infants with the same gestational and postnatal age of the infants who were in the study group.

Statistical analysis

The recorded data was compiled and entered in a spreadsheet (Microsoft Excel) and then exported to data editor of SPSS Version 20.0 (SPSS Inc., Chicago, Illinois, USA). Continuous variables were expressed as Mean±SD and categorical variables were summarized as frequencies and percentages. Frequency distribution tables, bar and pie charts were used for data presentation. Karl Pearson's correlation coefficient and Scatter Plots were employed to establish correlation between various variables. Student's independent t-test and ANOVA were used for comparing various parametric data. A P-value of less than 0.05 was considered statistically significant. All P-values were two tailed.

RESULTS

A total of 92 (46 cases and 46 controls) mother-neonatal pairs were enrolled in the study for a period of 2 years. Study group consisted of neonates admitted for neonatal sepsis while as control group consisted of healthy neonates being evaluated for neonatal hyperbilirubinemia.

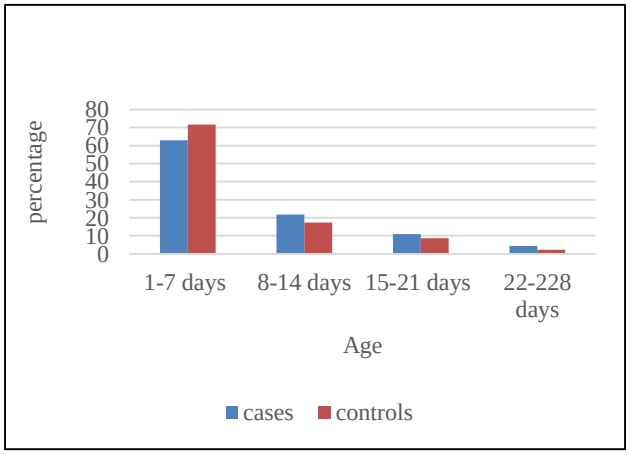

Figure 1: Age distribution of cases vs controls.

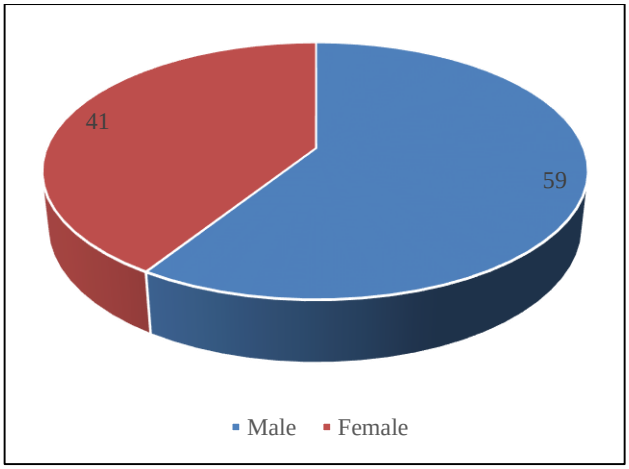

Figure 2: Gender distribution of cases.

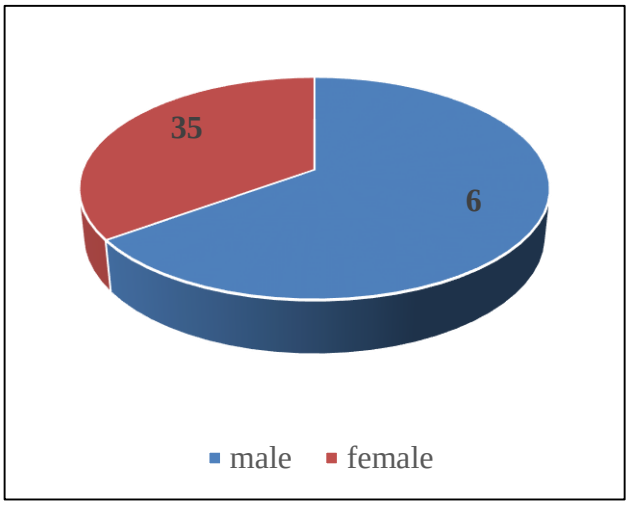

Figure 3: Gender distribution of controls.

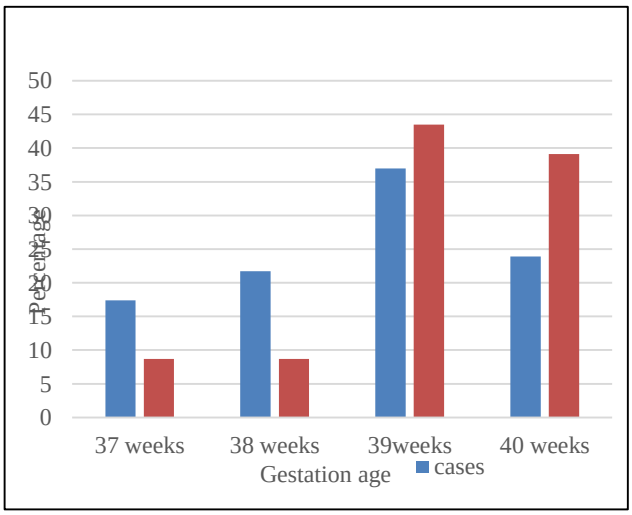

Figure 4: Gestation age distribution of neonates. Mean gestational age of neonates was 38.67 weeks in the study group and 39.13 weeks in the control group, the difference was statistically insignificant.

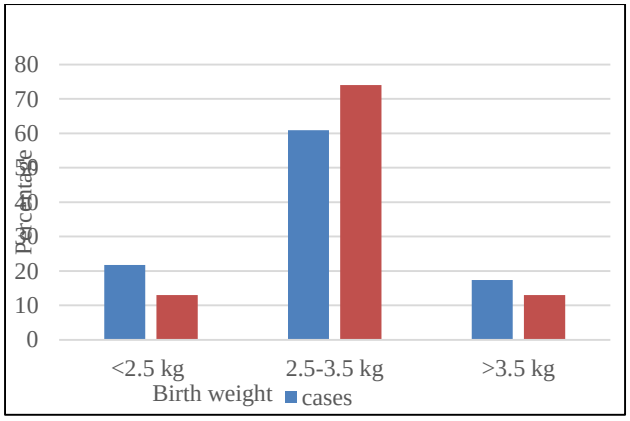

Figure 5: Birth weight distribution of neonates.

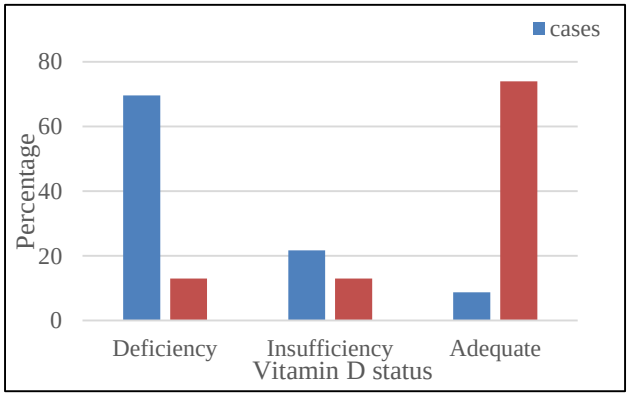

Figure 6: Maternal 25-hydroxyvitamin D (25-OHD) levels.

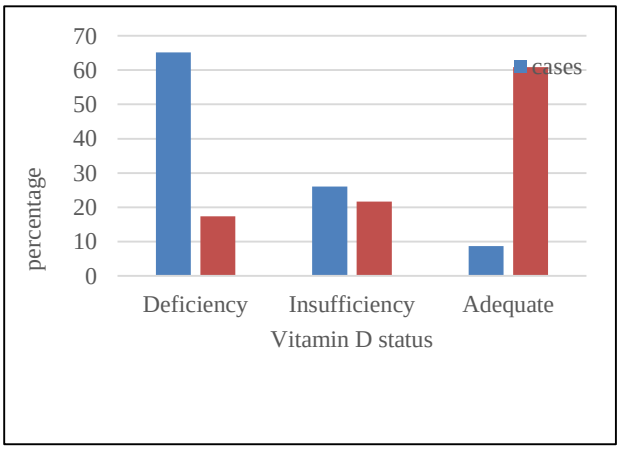

Figure 7: Neonatal 25-hydroxyvitamin D (25-OHD) levels where vitamin D deficiency was taken<20 ng/ml, insufficiency as 20-30 ng/ml and adequate>30 ng/ml.

Age distribution of neonates

In our study mean age of neonates was 7.13 days in study group and 6.59 days in control group. The difference in age between two groups was statistically insignificant (p-value=0.68).

Gender distribution of neonates

In our study 59% of neonates were males and 41% females in study group, whereas 65.2% of neonates were males and 34.8 % were females in the control group.

Gestational age distribution of neonates

Mean gestational age of neonates was 38.67 weeks in the study group and 39.13 weeks in the control group, the difference was statistically insignificant.

Birth weight distribution of neonates

Mean birth weight of neonates was 2.53 kg in the study group and 3 kg in the control group**.**

Maternal 25-hydroxyvitamin D (25-OHD) levels

Maternal 25-hydroxyvitamin D (25-OHD) levels where vitamin D deficiency was taken <20 ng/ml, insufficiency as 20-30 ng/ml and adequate >30 ng/ml.

Neonatal 25-hydroxyvitamin D (25-OHD) levels

Neonatal 25-hydroxyvitamin D (25-OHD) levels where vitamin D deficiency was taken <20ng/ml, insufficiency as 20-30 ng/ml and adequate >30n g/ml.

Mean neonatal vitamin D levels were 12.90 ng/ml in the study group and 25.99ng/ml in the control group.

Comparison of vitamin D levels between cases and controls

In our study mean neonatal 25-OHD levels in the study group (12.90 ng/ml) were lower than in the control group (25.99 ng/ml) and the difference was statistically significant (p<0.01).

Similarly mean maternal 25-OHD levels in the study group (22.97 ng/ml) were lower than in the control group (37 ng/ml) and the difference was statistically significant (p-value<0.001).

Correlation of maternal age with maternal and neonatal vitamin D, gestational age with neonatal vitamin D, neonatal birth weight with neonatal vitamin D

In our study none of the above parameters had statistically significant correlation in either of the groups.

Comparison of 25-hydroxyvitamin D levels of the study group in terms of culture positivity

In our study 11 out of 46 (23.9%) cases had positive blood culture, 3 had *Klebsella pneumonia*, 4 had *Eschersia coli*, 2 had *Pseudomonas aerogenosa* and 2 had *Staphylococcus aureus*.

Mean maternal 25-OHD levels in culture positive and culture negative cases were 23.24 ng/ml and 22.89 ng/ml respectively, the difference being statistically insignificant (p=0.92). Mean neonatal 25-OHD levels in culture positive and culture negative cases were 11.40 ng/ml and 13.37 ng/ml respectively, the difference again being statistically insignificant (p=0.49).

Table 1: The sepsis criteria used in the study defined by Gitto et al.[20]

Groups	Criteria
Highly probable sepsis	At least three sepsis-related clinical signs. CRP>1mg/dl. At least two other altered serum parameters in addition to CRP. Blood culture; positive or negative,
Probable sepsis	Less than 3 sepsis-related clinical signs. CRP>1mg/dl. At least two other altered serum parameters in addition to CRP. Blood culture, negative.
Possible sepsis	Less than 3 sepsis-related clinical signs CRP<1mg/dl. Less than 2 other altered serum parameters in addition to CRP. Blood culture, negative.
No sepsis	No sepsis-related clinical signs. CRP<1mg/dl. No altered serum parameters. Blood culture; negative.

Table 2: Comparison of vitamin D (25-OHD) levels between cases and controls.

Parameter	Mean		P value
	Cases (n=46)	Controls (n=46)	
Neonatal 25-OHD levels (ng/ml)	12.90	25.99	<0.01
Maternal 25-OHD levels (ng/ml)	22.97	37	<0.01

Table 2: Correlation of maternal age with maternal and neonatal vitamin D; gestational age with neonatal vitamin D, neonatal birth weight with neonatal vitamin D.

Parameter	Pearson correlation (r)		P value	
	Cases	Controls	Cases	Controls
Maternal vitamin D-mothers age	-0.008	-0.164	0.96	0.27
Neonatal vitamin D-mothers age	0.007	-0.157	0.96	0.29
Neonatal vitamin D-gestational age	0.004	0.068	0.98	0.65
Neonatal vitamin D-neonatal birth weight	0.168	-0.030	0.26	0.84

DISCUSSION

Vitamin D deficiency is pandemic, yet it is the most under diagnosed and under-treated nutritional deficiency in the world.[21] Vitamin D deficiency is widespread in individuals irrespective of their age, gender, race and geography. Indian socioreligious and cultural practices do not facilitate adequate sun exposure, thereby negating potential benefits of plentiful sunshine. Consequently, subclinical vitamin D deficiency is highly prevalent in both urban and rural settings and across all socioeconomic and geographic strata. Epidemiological support for skeletal benefits of vitamin D is well known.[22] Recent studies have linked vitamin D deficiency with increased risk of developing TB, otitis media, upper respiratory tract infections and influenza.[23-26] A total of 92 mother-neonatal pairs (46 cases and 46 controls) were enrolled in the study. Samples were taken from neonates and their mothers at the time of hospital admission in case of study group and at the time of evaluation of neonatal hyperbilirubinemia in case of control group. In our study mean maternal 25-OHD levels in the study and control groups were 22.98±10.22 ng/ml and 37±9.78 ng/ml respectively. Mean neonatal 25-OHD levels in the study and control groups were 12.90±8.12 ng/ml and 25.99±10.02 ng/ml respectively. In our study we find statistically significant difference in both maternal and neonatal 25 OHD levels between study and control groups (p<0.01).

A study was conducted by M Cetinkaya et al, in 2014 where mean maternal (22.2 ng/ml) and neonatal (8.6 ng/ml) 25-OHD levels were significantly lower in then septic group than mean maternal (36.2 ng/ml) and neonatal (19 ngml) 25-OHD levels in the non-septic group (p<0.01).[27] These results are consistent with our study. In our study we find significant positive correlation between maternal and neonatal 25-OHD levels in both study (r=0.839, p<0.01) and control groups (r=0.880, p<0.01). In our study mean maternal 25-OHD levels were 23.24 ng/ml and 22.89 ng/ml in culture positive and culture negative sepsis groups respectively, difference was statistically insignificant (p value=0.92). Mean neonatal 25-OHD were 11.40 ng/ml and 13.37

ng/ml in culture positive and culture negative sepsis groups respectively, difference was statistically insignificant (p value=0.49).

In our study there was no significant correlation between gestational age and neonatal vitamin D levels either in the study (r=0.004, p=0.98) or in the control group (r=0.068, p=0.65). As our study was restricted to infants ≥37 weeks of gestational age further study is required to see correlation between gestational age and neonatal vitamin D levels.

In our study no significant correlation was seen between birth weight of neonate and neonatal vitamin D level either in the study (p value=0.26) or in the control group (p value=0.84). This study has some limitations. The major limitation is the small number of patients. Exclusion of premature infants might have influenced maternal and newborn vitamin D levels. We measured maternal serum 25-OH vitamin D levels only at birth with no data regarding its serum levels during different trimesters.

The primary objective of this study was to determine the role of maternal and neonatal vitamin D deficiency on the development of neonatal sepsis The secondary objective was to determine the effect of maternal and neonatal vitamin D levels on culture results in neonatal sepsis and to ascertain whether supplementation of vitamin D is required in the pregnant and lactating mothers and their neonates or not. In the study group the mean neonatal vitamin D level was 12.90 ng/ml and the mean maternal vitamin D level was 22.90 ng/ml. In the control group the mean neonatal vitamin D level was 25.99 ng/ml and the mean maternal vitamin D level was 37 ng/ml. Mean maternal and neonatal vitamin D levels were significantly lower in the study group than in the control group. Thus, it was concluded that neonatal sepsis is more likely to develop in neonates with lower maternal and neonatal vitamin D levels.

Mean neonatal vitamin D levels were not significantly lower in the neonates with culture positive sepsis than in the neonates with culture negative sepsis. Thus, it was concluded that neonatal vitamin D level has no relation with culture positivity in neonatal sepsis. There was no significant between gestational age of neonate with neonatal vitamin D levels and Birth weight of neonate with neonatal vitamin D levels in either study or the control groups. In our study 58% (41.3% deficiency, 17.3% deficiency) of mothers and 65.2% (41.3% deficiency, 23.9% insufficiency) of neonates had inadequate vitamin D levels. Hence there is need for vitamin D supplementation of pregnant and lactating mothers and neonates who are on exclusive breastfeeding.

CONCLUSION

There is need for vitamin D supplementation of pregnant and lactating mothers and neonates who are on exclusive breastfeeding.

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Ethical approval: The study was approved by the Institutional Ethics Committee

REFERENCES

1. Shankar JM, Agarwal R, Deorari AK, Paul VK. Sepsis in the newborn. Indian J Pediatr. 2008;75:261-6.
2. Ng PC, Lam HS. Diagnostic markers foe neonatal sepsis.Curr Opin Pediatr. 2006;18:125-31.
3. Lawn JE, Cousens S. Zupan J. For the Lancet National Survival Steering Team. Neonatal survival 4 million neonatal deaths: When? Where? Why? Lancet. 2005;365:891-900.
4. Black RE, Cousens S, Johnson HL, Lawn JE, Rudan I, Bassani DG et al. Global, regional and national causes of child mortalityin 2008: a systemic analysis. Lancet. 2010;375:1969-87.
5. Singh M, Narang A, Bhakoo ON. Predictive prenatal scorein the diagnosis of neonatal sepsis. J Trop Pediatr. 1994;40(6):365-8.
6. Takkar VP, Bhakoo Indian Pediatr. 1974;1;l:597-600.
7. Baltimore RS. Neonatal nosocomial infections. Sernin Perinatol. 1998:22:25-32.
8. Wolach B. Neonatal sepsis: pathogenesis and supportive therapy. SeminPerinatol 1997;21:28-38
9. De Luca HF. Overview of general physiologic features and functions of vitamin D. Am J Clin Nutr 2004;80:1689-96.
10. 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;26:639-46.
11. Kempker Han JE Tangpricha V, Ziegler TR. Martin GS. Vitamin D and Sepsis: an emerging relationship lltlitirr'iri1. Dermato endocrinol. 2012;4:101-8.
12. Muhe L, Lulseged S, Mason KE, Simoes EA. Case control study of' the role of nutritional rickets in the risk of developing pneumonia in Ethiopian children. Lancet. 1997;349:1801-4.
13. Belderbos ME, Houben ML, WilbrinkB, Lentjes E, Bloemen EM, Kimpen JL, et al. Cord blood vitamin D deficiency is associated with respiratory syncthial virus bronchiolitis. Pediatrics 2011;2:1127-513.
14. Kamao M, Tsugawa N, Suhara Y, Wada A, Mori T, Murata K, et al. Quantification of fat-soluble vitamins in human breast milk by liquid chronratography-tandem mass spectrometry. J Chromotogr B Analyt Technol Biomed LifeSci 2007;859:192-200.

15. Specker BL. Do North American women need supplemental vitamin D during pregnancy or lactation? Am J Clin Nutr. 1994;59:84-490.
16. Mithal A, Wahl DA, Bonjour JP, Burckhardt P, Dawson-Hughes B, Eisman JA, et al. Global vitamin D status and determinants of hypovitaminosis D. Osteoporos Int. 2009;20:1807-20.
17. Hewison M. Vitamin D and the immune system: New perspectives on an old theme. Rheum Dis Clin North Am. 2021;8(1):125-39.
18. Cetinkaya M, Cekmez F, Buyukkale G, Erener-Ercan T, Demir F. Lower Vitamin D levels are associated with increased risk of early-onset neonatal sepsis in term infants. J Perinatol. 2014;35:39-45.
19. Holick MF, Bikley NC, Bischoff-Ferrari HF. Evaluation, treatment and prevention of vitamin D deficiency: an Endocrine Societyclinical practice guideline. J Clin Endocrinol Metab. 2011;96(7):l911-30.
20. Gitto E. Karbownik M. Reiter RJ. Tan DX. Cuzzocrea S. Chiurazzi P et al. Effects of melatonin treatment in septic newborns. Pediatr Res. 2001;50:756-60.
21. Van Schoor, N.M., Lips, P. Worldwide Vitamin D Status. Best Pract. Res. Clin. Endocrinol. Metab. 2011;25:671–80.
22. Holick, M.F. The role of vitamin D for bone health and fracture prevention. Curr. Osteoporos. Rep. 2006;4;96–102.
23. Nnoaham KE, Clarke A. Low serum vitamin D levels and tuberculosis: A systematic review and meta-analysis. Int. J. Epidemiol. 2008;37;113–9.
24. Linday LA, Shindledecke RD, Dolitsky JN, Chen TC, Holick MF. Plasma 25- hydroxyvitamin D levels in young children undergoing placement of tympanostomy tubes. Ann Otol Rhinol Laryngol. 2008;117:740–4.
25. Ginde AA, Mansbach JM, Camargo CA. Association between serum 25-hydroxyvitamin D level and upper respiratory tract infection in the Third National Health and Nutrition Examination Survey. Arch Intern Med. 2009;169;384–90.
26. Cannell JJ, Vieth R, Umhau JC, Holick MF, Grant WB, Madronich S, et al. Epidemic influenza and vitamin D. Epidemiol. Infect. 2006;134;1129–40.
27. M Cetinkaya, F Cekmez, G Bulzuk ale, TFrener-Ercan, F Demir, Tuno EN Aydin, et al. J Perinatol. 2015;35:39-45.

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