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Original Article

The effect of vitamin D levels on clinical outcomes after pediatric open-heart surgery

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Abstract

Objectives: Congenital heart disease is a massive structural abnormality in the heart or large vessels inside the chest that is potentially important. Vitamin D is essential for the recovery of organs. This study aimed to evaluate the effect of serum vitamin D levels on clinical outcomes after pediatric open-heart surgery. Recent studies in infants have shown that vitamin D deficiency and hypocalcemia are associated with heart shock.

Methods: The following descriptive cross-sectional study was conducted in the Cardiology Unit of Shahid Faghihi Hospital in Shiraz from April 2021 to October 2022, involving 115 patients aged one to seven years old. Serum levels of vitamin D were measured to evaluate the correlation between vitamin D levels and postoperative clinical outcomes. Data was gathered using SPSS.v16 software and analyzed through statistical tests.

Results: The mean age of the patients in this study was 29.20± 53.10 months. The average vitamin D level of the patients was 24.52± 10.3 ng/ml. The study's findings indicated that infants eligible for heart surgery with normal vitamin D levels had significantly shorter durations of Inotropes, ventilators, chest tubes, and Intensive Care Unit (ICU) stay (P<0.001).

Conclusions: Decreased vitamin D levels in children with abnormal vitamin D can delay the improvement of heart and myocardial function and increase the use of inotropes, ventilators, and chest tubes. It also increases the number of days hospitalized in the ICU after Cardio Pulmonary Bypass (CPB) surgery.

Keywords: Pediatrics, Vitamin D, Heart Diseases

Introduction

Congenital heart disease (CHD) is structural or functional abnormalities and defects that occur in the first trimester of pregnancy during the fetal heart development process. The estimated prevalence of this disease is 1 in 100 in the general population (1). A significant proportion of these pediatric patients require one or more corrective surgeries throughout their lives. Postoperative complications in these patients include pronounced systemic inflammatory response, multiple organ

failure, electrolyte disturbances, arrhythmia, infection, and endocrine imbalance. Interventions that prevent postoperative issues can be crucial in enhancing recovery, speeding up healing, and minimizing long-term complications (2, 3).Ultrasound during pregnancy can detect CHD. If the disease is not detected during pregnancy, symptoms such as dizziness, shortness of breath, fainting, impaired growth of organs and muscles, swelling, respiratory infections, and fatigue may appear after birth or in childhood (4, 5).The cause of CHD is not well understood. It is obvious that changes in intracellular ionized calcium ($Ca2^{+}$) levels can play an important role in myocardial contractility. Accordingly, in recent studies in patients with CHD, vitamin D deficiency has been considered (6). Vitamin D plays a crucial role in heart function, being recognized as a significant pleiotropic hormone for various central organ systems and vital diseases like electrolyte balance, cardiovascular health, inflammation, and immunity. Myocardial cells contain a vitamin D receptor and a calcitriol-dependent Ca2+ binding protein (7, 8).
Recent studies in infants have shown that vitamin D deficiency and hypocalcemia are associated with heart shock (9). Vitamin D, through its receptors in the cardiovascular system, plays a vital role in controlling hypertrophy and cardiac fibrosis and regulating blood pressure (10). Vitamin D deficiency can be associated with an increased risk of heart failure and myocardial infarction. Accordingly, suppression of the renin-angiotensin system of the heart and natriuretic peptides may be due to the anti-hypertrophic effects of vitamin D additionally, numerous studies have shown that vitamin D plays a crucial role in regulating the immune-inflammatory system by regulating the production of inflammatory cytokines and inhibiting the proliferation of pro-inflammatory cells (8, 11). On the basis of these preliminary data, it can be hypothesized that low circulating levels of vitamin D metabolites are contributing to the pathogenesis of CHD. To support this postulate, we performed a study to evaluate the effect of vitamin D levels on the clinical results of patients after open heart surgery in children.

Materials and Methods

Participants and study design

The current study was a descriptive cross-sectional study performed in the Cardiology Unit of the Shahid Faghihi Hospital in Shiraz from April 2021 to October 2022. The target sample comprised 115 infants selected from patients between 1-7 years of age with congenital heart disease and candidates for open heart surgery with CPB. Exclusion criteria involved lung, kidney, and liver disease, as well as the use of drugs such as corticosteroids, cholestyramine, barbiturates, and phenytoin. Following protocol approval from the Ethics Committee and written parental consent, the study collected the following information from all participating patients: (1) comprehensive demographic history. This included vitamin D levels, age, inotrope use duration, chest tube duration, intubation duration, ventilator use, and ICU hospitalization duration. (2) Thorough physical examination.

Laboratory Investigations

Whole blood samples were obtained 24 hours before the surgery. Levels of 25(OH) D were assessed using radioimmunoassay (Novartis, USA). According to additional data analyses, the reference range for 25(OH) D deficiency is <20 ng/ml. Subsequently, patients were categorized into two groups based on their vitamin D levels: normal and below-normal.

Surgical Conditions

A surgical team performed operations on the patients, and conventional ultrafiltration (CUF) was carried out during the surgery to prevent substantial fluid displacement. Following the surgery, all patients were closely monitored in a specialized Pediatric Cardiac Intensive Care Unit (PCICU).

Statistical Analysis

The collected data in this study were statistically presented and analyzed using SPSS software version 16 (SPSS, Chicago, IL.) Quantitative data is expressed as mean and SD (X±SD). Student t-test and Mann-Whitney were used to compare two groups of normally distributed data. Qualitative data was tested by Pearson chi-squared tests. A p-value<0.05 was considered significant.

Results

In this study, 115 infants, including 62 boy infants (53.9%) and 53 girl infants (46.1%), with a mean age of 20.29 months participated. Table 1 shows the Demographic and clinical characteristics of infants.

Table1. Descriptive Indices of Quantitative Variables of Patients

Variables	Mean	Standard deviation	Minimum	Maximum
Age (months)	20.29	10.53	12	84
Pump time (minutes)	100.49	24.57	60	170
Aortic clamp (minutes)	86.72	25.09	52	158
Ventilator (hours)	11.66	3.21	7	20
Inotrope (hours)	38.68	11.49	20	60
Chest tube (hours)	55.4	13.4	35	90
Hospitalization in the ICU (hours)	95.46	12.03	70	114
Vit D level	24.52	10.3	11.5	43.20

As the results reveal, the mean age of infants with normal vitamin D levels was lower than infants with abnormal vitamin D levels, but the difference was not statistically significant (*P*=0.37). Also, the mean pump time and aortic clamp duration in patients with low vitamin D levels were slightly higher compared to patients with normal vitamin D levels. Nevertheless, no significant differences were observed between the two groups (*P*=0.39, P=0.38).According to Table 2, the average hours of ventilator use in infants with normal vitamin D levels were nearly 1.5 hours less than those with low vitamin D levels, which was statistically significant (*P*=0.02). The duration of use of inotrope, chest tube, and ICU hospitalization was higher in patients with abnormal vitamin D levels than in infants with normal vitamin D levels, and this difference was significant (*P*<0.001).23 of the girls studied (43.4%) had normal vitamin D levels, while 30 (56.6%) had abnormal levels. 36 boys (58.1%) had normal vitamin D levels, and 23 infant boys had abnormal levels (42%). Thus, there was no significant correlation between gender and vitamin D levels (*P* = 0.08).

Table2. Comparison of Studied Variables between Normal and Abnormal Groups in Terms of Vitamin D Levels

Variables/Groups		Mean±SD	P Value
Age (months)	Normal	19.22±7.92	=0.37
	Abnormal	12.69±21.42	
Pump time (minutes)	Normal	23.05±98.4	=0.39
	Abnormal	26.1±102.69	
Aortic clamp (minutes)	Normal	24.85±85.49	=0.38
	Abnormal	25.51±88.01	
Ventilator (hours)	Normal	3.03±10.98	
	Abnormal	3.28±12.37	=0.02
Inotrope (hours)	Normal	7.09±31.94	<0.001
	Abnormal	10.97±45.78	
Chest tube (hours)	Normal	4.99±48.5	<0.001
	Abnormal	15.53±62.67	
Hospitalization in the ICU (hours)	Normal	13.66±90.55	<0.001
	Abnormal	7.09±100.64	

Discussion

The role of vitamin D in maintaining electrolyte homeostasis, cardiovascular health, inflammation, and innate immunity has led many research groups to investigate the prevalence of vitamin D deficiency in CHD children and the general population (9, 12). Therefore, in this study, we analyzed the effect of serum vitamin D levels on clinical outcomes after pediatric open- heart surgery. The findings of the current study revealed that in infants undergoing heart surgery, vitamin D levels did not show a significant correlation with age, gender, duration of bypass pump usage, and aortic clamping. Nevertheless, patients with adequate vitamin D levels exhibited notably reduced durations of Inotropes, ventilator use, chest tube placement, and ICU stay.

Consistent with this, Ebenezer et al. (2016) demonstrated in their research that vitamin D

insufficiency is prevalent among pediatric patients hospitalized in the PICU in southern India.Low serum (OH) D 25 levels were linked to increased disease severity, requirement for mechanical ventilation, higher vasopressor usage, and decreased serum calcium levels (13). In this study, a longer duration of mechanical ventilation and extended ICU stay were noted, consistent with Ebenezer et al.'s research in 2016.In a different study, Abou Zahr et al.'s research (2017) indicated that CPB correlates with reduced levels of total and free vitamin D in pediatric patients. This impact is noticeable in patients with sufficient vitamin D levels during surgery but not in those deficient in vitamin D (14). This study aligns with prior research and the current study's findings. Tasdighi et al. (2020) showed that the apoptosis rate after CPB can be reduced with vitamin D. Vitamin D treatment may improve the inflammatory condition before and after surgery. Accordingly, it is recommended that patients' vitamin D levels be adjusted as much as possible before surgery to reduce treatment costs and other risks (15).

Kendrick et al.'s study (2008) showed in that the risk of developing angina, myocardial infarction, and heart failure is higher in people with vitamin D levels< 20 ng/ml (16) additionally, a study by Kim et al. (2008) also showed that reducing vitamin D levels<20 ng/ml increased the incidence of coronary heart disease, heart failure, and peripheral vascular disease (17). Kendrick et al.'s study (2008) showed in that the risk of developing angina, myocardial infarction, and heart failure is higher in people with vitamin D levels< 20 ng/ml (16) additionally, a study by Kim et al. (2008) also showed that reducing vitamin D levels<20 ng/ml increased the incidence of coronary heart disease, heart failure, and peripheral vascular diseass.

The findings of these studies confirm the vital role of vitamin D and the need to address its deficiency to improve public health and reduce treatment costs.In conclusion, decreased levels of vitamin D in children with abnormal vitamin D levels can delay the improvement of heart and myocardial function and increase the duration of use of inotropes, ventilators, chest tubes, and the ICU hospitalization after CPB surgery, so correcting levels it is necessary before heart surgery. Furthermore, it is recommended that another study be conducted on a larger patient population and on patients undergoing different surgeries to assess the risk of cardiovascular disease. Additionally, a study should be planned to examine the long-term impacts of low vitamin D levels for better understanding.

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Author Contributions

All authors significantly contributed to designing the study, collecting and analyzing data, and drafting the manuscript. ASh, SJM, AT, HF, and MK were involved in drafting or revising the article. ASh, SJM, AT, HF, and MK approved the revised version for submission. All authors have reviewed and accepted the manuscript.

Conflicts of Interest

There is no conflict of interest.

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Ethics declarations

The research protocol was approved by the Research Council and the Ethics Committee of Shahid Sadoughi University of Medical Sciences (IR.SSU.MEDICINE.REC.1400.124). All methods were conducted according to the appropriate guidelines and regulations. Informed consent was obtained from all subjects or their legal guardian(s).

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