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The Effect of Vitamin D Administration on Blood Levels*Malondialdehyde*(MDA) Blood in Male White Mice (*Rattus Norvegicus*) With Chronic Kidney Failure (CKF)

Mazirul Agung Santara[1], Darmawan Ismail[2], Ida Bagus Budhi Surya Adnyana[3]

[1,2.3] Department of Surgery, Faculty of Medicine, Sebelas Maret University, Surakarta, Dr. Moewardi Regional Hospital

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Author correspondence:
***Correspondence of the author:**
Name: Mazirul Agung Santara
Institution: Departemen Bedah, Faculty Fakultas Kedokteran Universitas Sebelas Maret, Surakarta, RSUD Dr. Moewardi
Address: Jl. Kolonel Sutarto No. 132, Jebres, Surakarta, Jawa Tengah
Email: (aduntsantara91@gmail.com)

ABSTRACT

Chronic renal failure is a progressive and irreversible structural or functional disorder of the kidneys that causes a decline in kidney function. Oxidative stress in CKD occurs due to decreased expression of 25-hydroxyvitamin D-1α-hydroxylase (1αOHase) which causes impaired regulation of calcitriol or the active metabolite of renal vitamin D. Malondialdehyde (MDA) is the end product of polyunsaturated lipid peroxidation or can be called polyunsaturated fatty acids that occur due to increased oxidative stress in the body. Based on this, researchers are interested in examining the effect of vitamin D administration on blood MDA levels in chronic renal failure conducted in male rats. This study was an experimental study with a post-test only control group design. The subjects were male Wistar rats, 2 months old, weighing 150-300 grams, with inclusion criteria. Exclusion criteria included rats with physical disabilities and visibly ill. This study used 24 white mice. Data were analyzed using one-way ANOVA mean difference test and Tukey's post hoc test to determine differences between test groups according to the measurement time, which showed significant differences in mean body weight, mean blood pressure, and MDA levels with a p value <0.05. Vitamin D administration can reduce MDA levels in male rats (Rattus norvegicus) with CKD.
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Introduction

Chronic Kidney Failure (CKD) is a progressive and irreversible structural or functional disorder of the kidneys that can lead to decreased kidney function, leading to electrolyte and metabolic imbalances in the body. The incidence of CKD is quite high worldwide. There are 20 million people with CKD in the United States (CDC, 2010). Based on data from*United States Renal Data System (USRDS)*(2014) there was an increase every year, as many as 2.7 million people were recorded in 2011 and became as many as 2.8 million people in 2012. The prevalence in Indonesia according to Riskesdas (2013) was 0.2% while in Central Java it was 0.3% and in Riskesdas (2018) the prevalence in Indonesia was 0.38%.

Chronic kidney disease (CKD) is a global health problem associated with an increased risk of cardiovascular disease, which is a leading cause of premature death in patients with CKD. Several factors contributing to cardiovascular morbidity in CKD include oxidative stress, inflammation, dyslipidemia, hypertension, atherosclerosis, vascular calcification, left ventricular dysfunction, and calcification of the aortic and mitral valves.[1,2]

Oxidative stress that occurs in CKD is caused by various mechanisms. In CKD, there is a decrease in expression.*25-hydroxyvitamin D-*

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1α-hydroxylase(1αOHase) which disrupts the regulation of calcitriol, the active renal metabolite of vitamin D, leading to deficiency. This can result in decreased blood calcitriol and increased parathyroid hormone, leading to mineral imbalance in the blood.

Malondialdehyde(MDA) is the end product of polyunsaturated lipid peroxidation or can be called*polyunsaturated fatty acid*Normally, humans have a defense system against free radicals in the body. However, in chronic kidney disease (CKD), the body fails to maintain the balance of free radicals, resulting in an increase in free radicals. This increase in free radicals affects systemic MDA levels. Increased blood MDA levels can be caused by increased lipid peroxidation, which is a result of increased oxidative stress in the body. This increase in blood MDA levels can be used as an indicator to assess oxidative stress.

Vitamin D deficiency often occurs in CKD, which is exacerbated by a decreased ability of the kidneys to convert 25(OH)D into its active metabolite, 1,25(OH)D. Therefore, supplemental vitamin D is necessary to improve CKD. Several recent studies have shown that vitamin D supplementation can improve the condition of CKD. Vitamin D has been shown to increase calcium absorption from the intestine and has a regulatory function in inflammation in the body's immune cells by binding to*vitamin D receptor*which results in reduced expression of genes that can secrete pro-inflammatory cytokines.[3,4,5]

Based on this, researchers are interested in further researching the effect of administering Vitamin D on blood MDA levels in chronic kidney failure, which was carried out on male rats (*Rattus Norvegicus)*.

Methodology

The research design used was a completely randomized design with*post-test only control group design*. The treatment consisted of: (KKN) Normal control group, (KK-) GGK group and (KP) GGK group treated with Vitamin D. This research was conducted at the Laboratory of the Center for Food and Nutrition Studies - Postgraduate Program, Gajah Mada University, Yogyakarta. The research was conducted over a three-month period with an estimated total sampling time of one month. The population in this study was mice (*Rattus norvegicus)* The inclusion criteria were male, Wistar strain, 2 months old, and weighing 150-300 grams. The exclusion criteria for the study subjects were rats with physical disabilities and visibly ill rats. The dependent variable in this study was MDA levels, and the independent variable was vitamin D.

Data were analyzed using the test*One Way*ANOVA if the data is normally distributed is continued with analysis*after this multiple comparison*with Tukey HSD test (*Honest Significant Differences*) and test*Kruskal-Wallis* if the distribution is not normal, then it is continued with analysis*after this*Mann-Whitney. If the analysis results show a significant difference if $p<0.05$ is obtained.

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Results and Discussion

Characteristics of Research Subjects

This research was conducted at the Laboratory of the Center for Food and Nutrition Studies-Postgraduate Program, Gajah Mada University, Yogyakarta from August to September 2022. This research used 24 white mice (*Ratus norvegicus)*, male, Wistar strain, body weight 150-300 grams, 2 months old. The research subjects were randomly divided into three groups and acclimatized for seven days. The subjects were divided into a normal group without treatment (KKN), a CKD group (KK-), and a CKD group with Vitamin D administration (KP). In the KK- and KP groups, chronic renal failure was induced by unilateral ureteral ligation, then observed for ten days. After the CKK induction observation was completed, Vitamin D was administered 0.0252 mcg/200gBW orally every day to the KP group with the aim of suppressing oxidative activity and chronic inflammation in the CKD rat model. In all three groups, body weight, blood pressure, and MDA levels were measured. Blood samples for MDA levels were taken in the 1st, 2nd, 3rd, and 4th weeks after ten days of ureteral ligation observation. After the data were collected, they were analyzed descriptively to determine the characteristics of the research subjects. Then, a mean difference test was performed.*one way ANOVA*and test*post hoc Tukey*to determine the differences between test groups according to the measurement time.

Characteristics of Research Subjects

The sample characteristics measured during the study were body weight (BW), blood pressure (BP) and MDA levels.

Table 1. Characteristics of Research Subjects

Characteristics	KKN Group			KK Group-			KP Group		
	Rerata	SD	*p*	Rerata	SD	*p*	Rerata	SD	*p*
Body Weight (Grams)									
Baseline	179,75	4,773	0,496	183,87	3,758	0,856	188,25	3,195	0,711
0	189,75	3,012	0,366	178,87	3,642	0,923	183	3,779	0,535
Week 1	197,25	1,034	0,408	175,5	3,586	0,840	186,63	3,503	0,260
Week 2	200,13	3,314	0,913	171,38	3,420	0,770	189,88	3,944	0,347
Week 3	210,13	3,44	0,386	167,25	3,77	0,898	193,86	3,87	0,440
Week 4	218,13	4,05	0,330	163,75	3,61	0,942	199,75	4,17	0,434
Blood Pressure (mmHg)									

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0	86,37	1,767	0,078	148,50	4,629	0,380	155,75	4,301	0,613
Week 1	84,25	1,832	0,828	161,50	4,629	0,380	158,13	4,580	0,805
Week 2	87,75	1,282	0,592	172	4,659	0,422	152,12	4,734	0,977
Week 3	87,5	1,511	0,239	178,13	4,45	0,554	144,25	5,52	0,250
Week 4	87	1,309	0,857	181,37	3,66	0,795	140,75	3,80	0,961
As much as MDA									
Week 1	1,38	0,115	0,791	9,79	0,278	0,948	9,65	0,417	0,374
Week 2	1,36	0,072	0,146	9,83	0,179	0,371	6,94	0,343	0,106
Week 3	1,40	0,079	0,608	9,87	0,260	0,530	4,66	0,281	0,377
Week 4	1,39	0,091	0,992	9,88	0,285	0,826	3,79	0,380	0,645

In this study, a normality test was carried out*Shapiro-Wilk*on the variables of body weight, blood pressure and MDA levels. Based on table 4, the values obtained*p*>0.05 in the normality test*Shapiro-Wilk*so it can be said that all data is normally distributed. Next, an analysis was carried out*One Way ANOVA*and test*post hoc Tukey*

Statistical Analysis

Table 2. Average Body Weight

Weight	KKN	KK-	KP	*p*
n	8	8	8	
Baseline	179,75	183,87	188,25	0,001
0	189,75	178,87	183	0,000
Week 1	197,25	175,5	186,63	0,000
Week 2	200,13	171,38	189,88	0,000
Week 3	210,13	167,25	193,86	0,000
Week 4	218,13	163,75	199,75	0,000

Table 2 shows the results of body weight measurements taken on subjects throughout the research period.*baseline*is the measurement of body weight in all

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groups before ureteral ligation in the KK- and KP groups. Then, measurements were taken on day 0, namely measurements taken 10 days after CKD induction with ureteral ligation, week 1, week 2, week 3, and week 4 after induction. In the test*One Way Anova*obtained value*p* <0.05 which indicates a significant difference between the three groups at each measurement time.

Table 3. Average Blood Pressure

Blood Pressure	KKN	KK-	KP	*p*
n	8	8	8	
0	86,37	148,50	155,75	0,000
Week 1	84,25	161,50	158,13	0,000
Week 2	87,75	172	152,12	0,000
Week 3	87,5	178,13	144,25	0,000
Week 4	87	181,37	140,75	0,000

Table 3 shows the results of blood pressure measurements in the KKN, KK-, and KP groups on day 0, week 1, and week 2 after CKD induction with ureteral ligation was performed on the subjects. Based on the test results*One Way Anova*p<0.05 was obtained, which means there was a significant difference between the three groups at three measurement times.

Table 4. Average MDA Levels

As much as MDA	KKN	KK-	KP	*p*
n	8	8	8	
Week 1	1,38	9,79	9,65	0,000
Week 2	1,36	9,83	6,94	0,000
Week 3	1,40	9,87	4,66	0,000
Week 4	1,39	9,88	3,79	0,000

Blood MDA levels were measured in this study in the first, second, third, and fourth weeks after CKD induction with ureteral ligation for 10 days. Normality and difference tests were then performed.*One way Anova*, and test*after this Tukey*.

Based on the difference test*One Way Anova*In Table 4, a p value of <0.05 was obtained, which means there was a significant difference in the average MDA levels between groups in week 1, week 2, week 3, and week 4. Then a test was carried

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out*post hoc Tukey*to find out the differences between each group.

Table 5. Tukey's post hoc test of blood MDA levels

Parameter	Time	Group		Average Difference	P
MDA	Week 1	KKN	KK-	-8,403	<0,001
		KKN	KP	-8,270	<0,001
		KK-	KP	0,143	0,646
	Week 2	KKN	KK-	-8,464	<0,001
		KKN	KP	-5,578	<0,001
		KK-	KP	2,885	<0,001
	Week 3	KKN	KK-	-8,467	<0,001
		KKN	KP	-3,26	<0,001
		KK-	KP	5,207	<0,001
	Week 4	KKN	KK-	-8,5	<0,001
		KKN	KP	-2,403	<0,001
		KK-	KP	6,097	<0,001

Based on the test*post hoc Tukey*Table 5 shows a p-value of <0.05, indicating a difference between the three groups at each measurement time. In the KK- and KP groups, the measurement in week 1 obtained a p-value of >0.05, indicating an insignificant difference.
Based on the results of the mean difference test*one way Anova* And *post hoc Tukey*This study found significant differences between the KK- and KP groups in terms of body weight, blood pressure, and blood MDA levels. The KP group had higher body weight, lower blood pressure, and lower blood MDA levels than the KK- group in the 2nd, 3rd, and 4th weeks of measurement. It can be concluded that vitamin D administration in the KP group resulted in significant differences in the study subjects.

Discussion

Chronic kidney disease (CKD) is a progressive and irreversible disease characterized by damage to the structure or function of the kidneys, which can lead to metabolic imbalances, increasing morbidity and mortality in patients. The incidence of CKD increases annually. CKD is a global health problem associated with an increased risk of cardiovascular disease. This increased risk of cardiovascular disease is a cause of premature death in CKD patients. Patients with CKD have a 10-30 times higher risk of developing cardiovascular disorders compared to those with normal kidney function. Contributing factors in CKD patients include oxidative stress, inflammation, dyslipidemia, hypertension, atherosclerosis, vascular calcification, left ventricular dysfunction, and heart valve calcification. These factors can lead to arterial calcification and vascular stiffness, which are key factors in the onset of cardiovascular complications.

Oxidative stress in people with CKD is caused by various mechanisms. An imbalance between free radical production and antioxidant protection is the cause of oxidative stress.*reactive oxygen species* Excessive (ROS) formation in CKD patients is caused by upregulation of NADPH oxidase and decreased activity.*superoxide dismutase* (SOD).

ROS can affect cell function, damage proteins, lipids, and nucleic acids, and can also inhibit enzymatic activity in cellular respiratory function. In CKD conditions, increasingly severe conditions

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are associated with increased ROS formation. Oxidative stress is associated with decreased NO activity produced by the endothelium, which is an early stage in the formation of atherosclerosis.

In chronic kidney disease (CKD), urea accumulates in the blood. This leads to various conditions that increase pro-inflammatory cytokines, leading to chronic inflammation. Furthermore, this toxic condition disrupts the endothelium of blood vessels. This decreases the amount of NOS in the blood, causing blood vessels to become stiff and difficult to vasodilate. The effects of uremia toxins, decreased NO production due to impaired endothelial function, hypertension, and angiotensin II activity also contribute to increased ROS formation in the body.

ROS are chemical molecules formed as a result of oxygen metabolism in cells. They are highly reactive and can cause damage to cellular components such as DNA, proteins, and lipids. Although ROS are natural byproducts of cellular respiration, increased ROS production can result from oxidative stress, which can play a role in the aging process, degenerative diseases, and even cancer. Oxidants are highly reactive compounds with half-lives of only seconds, making it difficult to measure free oxidants (ROS) in clinical settings. Another way to assess ROS activity is by measuring more stable markers with longer half-lives that are modified by their interaction with ROS. One such marker is MDA, which represents lipid peroxidation by ROS.[6]

MDA is a marker of oxidative stress which is a product of peroxidation of*polyunsaturated fatty acid*(PUFA) by free radicals. MDA formation occurs due to increased systemic oxidative stress. This oxidative stress process causes the decomposition of arachidonic acid and PUFA, which are normally found in cell membranes, resulting in the formation of MDA. MDA is a mutagenic, tumorigenic, and 3-hydroxylase compound.*carbondialdehyde*which is highly reactive. Measuring MDA levels in blood or affected tissues is a very useful method for predicting the level of oxidative stress.[7] MDA is a biomarker that is closely related to kidney health. Patients who have undergone kidney transplants have lower MDA levels than patients who are still on dialysis.[6]

Increased blood MDA has been reported in various studies, which can cause problems. In the study conducted by Montesa*et al.*(2009) who found higher levels of the oxidative stress biomarker MDA in CKD patients compared to the control group. Then, research conducted by Sagar*et al.*(2023) in patients with CKD, serum MDA levels showed an increase.[8,9]High serum MDA levels are also influenced by the grade of CKD. The higher the CKD grade, the higher the serum MDA levels. Another study conducted by Tomás-Simó*et al.*(2021) who studied the oxidation process in various molecular compounds (proteins, lipids and genetic material) showed that MDA content in patients with grade 3-5 CKD increased with increasing severity.[10]These studies are in accordance with this study where blood MDA levels in the treatment group experienced an increase in MDA levels after 10 days of ureteral ligation.

Vitamin D is a fat-soluble vitamin which is a pleiotropic hormone that regulates homeostasis of calcium regulation in organisms, induces differentiation and inhibits proliferation of various normal cells or cancer cells.[11]In addition to its function of regulating calcium and phosphate, Vitamin D also has anti-inflammatory properties. This anti-inflammatory effect affects innate immune cells such as macrophages. In macrophages, Vitamin D can regulate*toll like receptor*(TLR) by reducing the regulation of mIR-155 so that it occurs*feedback* negative, reducing the expression of MCP-1 and IL-6 through NF-kB inhibition.[12,13]In addition, vitamin D also

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plays a role in the regulation of dendritic cells and T lymphocytes.

People with chronic kidney disease (CKD) are prone to vitamin D deficiency. The prevalence of vitamin D deficiency in CKD patients is 70-80%. This is due to decreased cholecalciferol production in CKD, decreased calcifediol reuptake, and uremia, which leads to decreased calcifediol formation. The active form of vitamin D is calcitriol [1.25$(OH)_2$D] also decreased due to decreased expression of 1α-hydroxylase, which catalyzes the synthesis of calcitriol from its previous form, calcifediol [25(OH)D]. The decrease in 1α-hydroxylase expression occurred due to increased FGF-23, which compensates for phosphate retention.[14]Vitamin D deficiency is defined as blood calcidiol levels below 20 ng/ml. It is considered insufficient at 21-29 ng/ml and sufficient at >39 ng/ml. Excessive levels are considered excessive at >150 ng/ml.

In research conducted by Zhang*et al.*(2014), blood vitamin D levels influence oxidative stress biomarkers. Samples with vitamin D deficiency showed lower SOD levels, an antioxidant that functions to break down ROS in the body. Consequently, samples with low SOD levels showed an increase in oxidative stress biomarkers.[15]Then another study was conducted by Codoner-Franch*et al.*(2012), regarding vitamin D deficiency in obese patients, showed that low vitamin D levels can cause increased MDA levels when compared with samples that have normal serum vitamin D levels.[16]

Vitamin D supplementation has been shown in several studies to be beneficial for people with CKD. In the study conducted by Kandula*et al.*(2011) administration of 50,000 IU of vitamin D per week with a reduced dose can increase 25(OH)D levels without hypercalcemia, hyperphosphatemia and with a decrease in serum PTH.[17]These results are also similar to research conducted by Cupisti*et al.*(2015) and Alvarez*et al.*(2012) which showed that vitamin D supplementation reduced serum PTH.[18,19]In patients with CKD with diabetes mellitus, vitamin D supplementation can also reduce albuminuria. Furthermore, vitamin D administration can improve vascular endothelial function and reduce various inflammatory markers in the body. Vitamin D receptors are present in the endothelium and vascular smooth muscle; stimulation of these receptors can increase the production of vasodilatory compounds such as prostacyclin from the smooth muscle. Concentrations of proinflammatory cytokines such as interleukin-6 and CRP have been shown to decrease after supplementation. This can improve endothelial function and also reduce chronic inflammation in the body.[20,18,21]

In this study, vitamin D supplementation was conducted on experimental animal subjects who had been induced with chronic kidney failure. In the treatment group given supplementation, there was a significant decrease in MDA levels after administering vitamin D supplementation. In this study, evaluations were carried out four times, namely in week 1, week 2, week 3, and week 4. With assessment indicators based on blood pressure, body weight, and blood MDA levels. The results obtained the most significant decrease in blood pressure in weeks 2 to 3. For the body weight indicator, there was the most significant increase in body weight from week 3 to week 4 and for MDA levels, there was the most significant decrease from week 1 to week 2. This is in accordance with research conducted by Amani*et al.*(2018), where providing Vitamin D supplementation can reduce IL-17 and MDA levels.[22]Other studies also show that administering Vitamin D can prevent free oxidants by activating*signalling* WnT/b-catenin.[23]This study shows that vitamin D supplementation can reduce MDA biomarkers, indicating that supplementation can reduce oxidative stress that occurs in CKD conditions.

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Conclusion

Vitamin D administration effectively lowers Malondialdehyde (MDA) levels in male white mice models of Chronic Kidney Disease (CKD), indicating a significant reduction in systemic oxidative stress. In the context of CKD, the kidneys fail to activate vitamin D (25-hydroxyvitamin D-1α-hydroxylase deficiency), leading to a state of chronic inflammation and the accumulation of free radicals that cause lipid peroxidation, measured by MDA. By supplementing Vitamin D, the physiological antioxidant pathways are bolstered, which mitigates the oxidative damage to cellular membranes typically seen in progressive renal failure. This suggests that Vitamin D serves not only a metabolic role in bone health but also acts as a protective agent against the oxidative complications that exacerbate the progression of chronic kidney failure.

Acknowledgments

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References

1. Go, A. S., Chertow, G. M., Fan, D., McCulloch, C. E. and Hsu, C. (2004) 'Chronic Kidney Disease and the Risks of Death, Cardiovascular Events, and Hospitalization', *New England Journal of Medicine*, 351(13), pp. 1296–1305. doi: 10.1056/nejmoa041031.
2. Rattazzi, M., Bertacco, E., Del Vecchio, A., Puato, M., Faggin, E. and Pauletto, P. (2013) 'Aortic valve calcification in chronic kidney disease', *Nephrology Dialysis Transplantation*, 28(12), pp. 2968–2976. doi: 10.1093/ndt/gft310.
3. Xu, G., Luo, K., Liu, H., Huang, T., Fang, X. and Tu, W. (2015) 'The progress of inflammation and oxidative stress in patients with chronic kidney disease', *Renal Failure*, 37(1), pp. 45–49. doi: 10.3109/0886022X.2014.964141.
4. Xu, S., Chen, Y. H., Tan, Z. X., Xie, D. D., Zhang, C., Xia, M. Z., Wang, H., Zhao, H., Xu, D. X. and Yu, D. X. (2015) 'Vitamin D pretreatment alleviates renal oxidative stress in lipopolysaccharide-induced acute kidney injury', *Journal of Steroid Biochemistry and Molecular Biology*, 152, pp. 133–141. doi: 10.1016/j.jsbmb.2015.05.009.
5. Šimoliūnas, E., Rinkūnaitė, I., Bukelskienė, Ž. and Bukelskienė, V. (2019) 'Bioavailability of different vitamin D oral supplements in laboratory animal model', *Medicina (Lithuania)*, 55(6), pp. 1–7. doi: 10.3390/medicina55060265.
6. Tucker, P. S., Dalbo, V. J., Han, T., & Kingsley, M. I. (2013). Clinical and research markers of oxidative stress in chronic kidney disease. Biomarkers, 18(2), 103–115. https://doi.org/10.3109/1354750X.2012.749302
7. Singh, Z., Karthigesu, I. P., Singh, P. and Kaur, R. (2014) 'Use of malondialdehyde as a biomarker for assessing oxidative stress in different disease pathologies: A review', *Iranian Journal of Public Health*, 43(3), pp. 7–16.
8. Sagar, P., Pranay, K., Shekhar, R., Singh, P. P., & Kumar, P. (2023). Serum malondialdehyde in different stages of chronic renal disorader. Asian Journal of Medical Sciences, 14(6), 113–118.
9. Montesa, P. M. J., Gonzalez Rico, M. A., Solis Salguero, M. A., Torregrosa Maicas, I., Tormos Munoz, M. C., Saez Tormo, G., Juan Garcia, I., & Miguel Carrasco, A. (2009). [Study of

oxidative stress in advanced kidney disease]. Nefrologia, 29(5), 463–473. https://doi.org/DOI: 10.3265/Nefrologia.2009.29.5.5493.en.full

10. Tomás-Simó, P., D'Marco, L., Romero-Parra, M., Tormos-Munoz, M. C., Saez, G., Torregrosa, I., Estan-Capell, N., Miguel, A., Gorriz, J. L., & Purchades, M. J. (2021). Oxidative Stress in Non-Dialysis-Dependent Chronic Kidney Disease Patients. International Journal of Environmental Research and Public Health, 18. https://doi.org/10.3390/ijerph2004010001
11. Pfotenhauer, K. M. and Shubrook, J. H. (2017) 'Vitamin D deficiency, its role in health and disease, and current supplementation recommendations', *Journal of the American Osteopathic Association*, 117(5), pp. 301–305. doi: 10.7556/jaoa.2017.055.
12. Chen, Y., Liu, W., Sun, T., Huang, Y., Wang, Y., Deb, D. K., Yoon, D., Kong, J., Thadhani, R. and Li, Y. C. (2013) '1,25-Dihydroxyvitamin D Promotes Negative Feedback Regulation of TLR Signaling via Targeting MicroRNA-155–SOCS1 in Macrophages', *The Journal of Immunology*, 190(7), pp. 3687–3695. doi: 10.4049/jimmunol.1203273.
13. Yin, K. and Agrawal, D. K. (2014) 'Vitamin D and inflammatory diseases', *Journal of Inflammation Research*, 7(1), pp. 69–87. doi: 10.2147/JIR.S63898.
14. Jean, G., Souberbielle, J., & Chazot, C. (2017). Vitamin D in Chronic Kidney Disease and Dialysis Patients. Nutrients, 9(4), 328. https://doi.org/10.3390/nu9040328
15. Zhang, H., Teng, J., Li, Y., He, Y., & He, X. (2014). Vitamin D status and its association with adiposity and oxidative stress in schoolchildren. Nutrition, 30(9), 1040–1044. https://doi.org/doi: 10.1016/j.nut.2014.02.024
16. Codoñer-Franch P, Tavárez-Alonso S, Simó-Jordá R, Laporta-Martín P, Carratalá-Calvo A, Alonso-Iglesias E. (2012). Vitamin D status is linked to biomarkers of oxidative stress, inflammation, and endothelial activation in obese children. J Pediatr. 2012 Nov;161(5):848-54. doi: 10.1016/j.jpeds.2012.04.046. Epub 2012 Jun 5. PMID: 22677566.
17. Kandula, P., Dobre, M., Schold, J. D., Schreiber, M. J., Mehrotra, R., & Navaneethan, S. D. (2011). Vitamin D Supplementation in Chronic Kidney Disease: A Systematic Review and Meta-Analysis of Observational Studies and Randomized Controlled Trials. Clinical Journal of the American Society of Nephrology, 6(1), 50–62. https://doi.org/10.2215/CJN.03940510
18. Cupisti, A., Egidi, M. F., Vigo, V., Baronti, M. E., D'Alessandro, C., & Ghiadoni, L. (2015). Vitamin D status and cholecalciferol supplementation in chronic kidney disease patients: An Italian cohort report. International Journal of Nephrology and Renovascular Disease, 151. https://doi.org/10.2147/IJNRD.S90968
19. Alvarez, J. A., Law, J., Coakley, K. E., Zughaier, S. M., Hao, L., Shahid Salles, K., Wasse, H., Gutiérrez, O. M., Ziegler, T. R. and Tangpricha, V. (2012) 'High-dose cholecalciferol reduces parathyroid hormone in patients with early chronic kidney disease: a pilot, randomized, double-blind, placebo-controlled trial.', *The American journal*

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p-ISSN 2723-097X

of clinical nutrition, 96(3), pp. 672–679. doi: 10.3945/ajcn.112.040642.

20. Aytaç, M. B., Deveci, M., Bek, K., Kayabey, Ö., & Ekinci, Z. (2016). Effect of cholecalciferol on local arterial stiffness and endothelial dysfunction in children with chronic kidney disease. Pediatric Nephrology, 31(2), 267–277. https://doi.org/10.1007/s00467-015-3220-5
21. Meireles, M. S., Kamimura, M. A., Dalboni, M. A., Giffoni De Carvalho, J. T., Aoike, D. T., & Cuppari, L. (2016). Effect of cholecalciferol on vitamin D-regulatory proteins in monocytes and on inflammatory markers in dialysis patients: A randomized controlled trial. Clinical Nutrition, 35(6), 1251–1258. https://doi.org/10.1016/j.clnu.2016.04.014
22. Amani, R., Abbasnezhad, A., Hajiani, E., Cheraghian, B., Abdoli, Z. and Choghakhori, R. (2018) 'Vitamin D induced decrease in il-17 and malondialdehyde, and increase in il-10 and total antioxidant capacity levels in patients with irritable bowel syndrome', *Iranian Journal of Immunology*, 15(3), pp. 186–196. doi: 10.22034/IJI.2018.39388.
23. Tang, L., Fang, W., Lin, J., Li, J., Wu, W., & Xu, J. (2018). Vitamin D protects human melanocytes against oxidative damage by activation of Wnt/β-catenin signaling. Laboratory Investigation, 98(12), 1527–1537. https://doi.org/10.1038/s41374-018-0126-4