Biochemistry and Biotechnology Research
Vol. 9(1), pp.8-13, September 2021
DOI: 10.30918/BBR.91.21.018
ISSN: 2354-2136
Full Length Research Paper

Retrospective evaluation of the serum level of Vitamin D among COVID-19 patients in Al Madinah, Saudi Arabia

Sultan Siaf Al-Harbi[1], Yasmine Amaier Al-Harbi[1], Amal Ezzat Abdellatif[2], Ziab Zakey Al-Ahmadey[1]* and Sultan Saud Alahmadi[2]

[1]Ohud Hospital, Ministry of Health, Medina, Saudi Arabia.
[2]Clinical Laboratory Sciences Department, College of Applied Medical Sciences, Umm-Qura University, Kingdom of Saudi Arabia.

Accepted 3 September, 2021

ABSTRACT

Coronavirus disease (COVID-19) is a new viral illness that affects not only the respiratory system but also leads to multiorgan involvement. Till now, no curative treatment is available; prevention is the only way to reduce the number of infected cases. Low serum level of vitamin D has been implicated in increased susceptibility to coronavirus infection and disease severity. However, there is no conclusive evidence as regards the role of vitamin D in COVID-19 infection and outcome. This study aimed to evaluate the serum level of Vit D in patients with COVID-19 and highlights its prognostic significance. A total of 109 COVID-19 patients' medical records were selected and retrospectively analyzed from Ohoud Hospital in Medina. Data collection was done in the period between 1/4/2020 and 22/2/2021 followed by statistical analysis. The median age for COVID-19 patients was 54 years old. The level of Vit-D was low in patients with COVID-19 with a median of 15.2 ng/ml. Serum ferritin was high in all COVID-19 patients with a median of 720.9 ng/ml. There was a significantly higher rate of developing severe forms of COVID-19 in males compared to females, P-value < 0.001. Serum vitamin D level was significantly lower in patients with COVID-19 compared to control with P-value < 0.001. More reduction in Vit-D level was detected in the severe form of COVID-19 (P-value 0.042). There were significantly lower levels of vitamin D and higher levels of ferritin in the server covid-19 cases, P-values of 0.018 and 0.001, respectively. Low serum Vitamin-D level was significantly associated with a higher risk of COVID-19 infection and a more severe form of the disease that may end by death. Vitamin D supplementation will provide a sufficient serum level of the vitamin that can prevent infection and or minimize COVID-19 severity.

Keywords: COVID-19, vitamin D deficiency.

*Corresponding author. E-mail zal-ahmadey@gmail.com.

INTRODUCTION

By the end of 2019, one of the very serious viral illnesses emerged in Wuhan, China. This acute respiratory distress syndrome was caused by one of the novel coronaviruses, SARS-CoV2, and the resulting disease was named Covid-19 by the WHO (Ouassou et al., 2020). Clinically, it was manifested as atypical pneumonia (Zhu et al., 2020). Based on the genomic structure, there are 4 groups of the Coronaviridae subfamily, alpha (α), beta (β), gamma (γ), and delta (δ). Alpha and beta coronaviruses are the most important in human infection (Cui et al., 2019). Sars-cov2 is positive-stranded and enveloped RNA viruses. The viral genome is 27–32 kb in size and is capped and polyadenylated (Alrasheed et al., 2020).

The causative agent has been identified as a novel

coronavirus and was named (SARS-CoV-2) and the resulting disease was named coronavirus disease 2019 (COVID-19) (Ouassou et al., 2020).

SARS-CoV2 uses the angiotensin-converting enzyme 2 (ACE2) receptors to enter human cells, these receptors are highly expressed in the lung alveolar cells, cardiac myocytes, the vascular endothelium, and other cells. Once inhaled, SARS-CoV2 viral particles travel through the respiratory tract. The affinity of SARS-CoV2 to ACE2 receptors is higher than that of SARS-CoV. Many human organs can be affected by COVID-19 such as the lungs, heart, spleen, lymph nodes, liver, brain, gastrointestinal tract, and blood vessels, but the most affected organs are the respiratory system and heart (Bikdeli et al., 2020).

RT-PCR is a gold standard diagnostic test for COVID-19. Specimens used are nasal swab, tracheal aspirate or bronchoalveolar lavage (BAL). Respiratory secretions could be collected through nasopharyngeal and oropharyngeal swabs which are the preferred methods. Sample collection by bronchoscopy is not recommended as the generated aerosol carries the risk of infection transmission for the health care workers; this method can be used in intubated patients (Wang et al., 2020).

Leucopenia, leukocytosis, lymphopenia and sometimes thrombocytopenia elevated liver enzymes, LDH, CRP, serum ferritin and D-dimer are present in most of the patients (Belmehdi et al., 2021; Adhikari et al., 2020). Typical chest CT shows ground-glass opacities. The degree of lung involvement correlates with the disease severity. Other nonspecific findings like pleural effusion and lymphadenopathy could be found (Adhikari et al., 2020).

Vitamin D is a steroid-related hormone; it can be synthesized under the effect of ultraviolet light in the skin or supplied from food (Ali, 2020). Dihydroxy vitamin D (1,25(OH)2D) is the active form of vitamin D, its synthesis is completed in both liver and kidney following 2 hydroxylation steps by 1-hydroxylase (Bishop et al., 2020).

There are two forms of Vitamin D, D2 (ergocalciferol) and D3 (cholecalciferol). Vitamin D3 is of animal origin like oily fish and synthesized in human skin. It is exceedingly difficult to obtain your needs of vitamin D from food only 20% of our needs, the main source is synthesis in the skin under the effect of UVB (80%). Vitamin D plays a major role in calcium homeostasis and bone health (Wacker and Holick, 2013).

Vitamin D Receptors are expressed by many other cells than the intestine and bone including cells in the bone marrow, brain tissue, breast and some malignant cells B, T lymphocytes and antigen-presenting cells. There are many vitamin D-responsive genes (Rhodes et al., 2021). Vitamin D deficiency has been associated with autoimmune disorders and various infections especially those of the respiratory tract (Urashima et al., 2010).

This study aimed to evaluate the serum level of Vit D and serum ferritin in patients with COVID-19 and highlights its prognostic significance.

MATERIALS AND METHODS

Subjects

This retrospective study involved a total of 109 COVID-19 patients divided into 3 groups. Group 1 is the control. Group 2 included 35 COVID-19 patients admitted to the ICU, 30 males and 5 females. Group 3 included 74 COVID-19 patients in the non-ICU section, 36 males and 38 females. Those patients were selected from the Ohoud Hospital, in Madinah, KSA from April 2020 to February 2021.

- **Inclusion criteria:** Newly diagnosed Covid-19 patients.
- **Exclusion criteria:** Patients with viral infection other than Coronavirus.

The study was performed in accordance with the declaration of Helsinki 1964. The protocol was approved by the Ministry of Health, KSA.

Patients were subjected to the following:

- Nasopharyngeal swab for detection of Coronavirus by PCR. In which RNA is separated and prepared using Magna pure 96 instruments (Roche Diagnostic-Germany).
- Serum Vit D level using COBAS e analyzer (Roche Diagnostics-Germany).
- Serum Ferritin level, LDH and CRP using COBAS e analyzer (Roche Diagnostics-Germany).
- Routine laboratory tests (renal and liver function) were done as baseline testing before any treatment.

Statistical analysis

The collected information was analyzed using SPSS program version 20. Quantitative data were presented as the mean ± SD or median (min - max) as appropriate. Qualitative data were presented as frequency and percentage. Comparison between two groups was conducted using the nonparametric Mann–Whitney U and Kruskal–Wallis tests as the data were not normally distributed. For all comparisons, a two-sided alpha value was set at 0.05. Probability (P-value) < 0.05 and < 0.001 were considered significant and highly significant, respectively.

RESULTS

Demographic data of the studied patients

This study included 129 cases; 20 cases were normal control that have no suspicious symptoms or contact with known COVID19 cases (Group I) and 109 cases were proved to be infected with COVID-19. Out of the COVID-19 cases, 35 cases (Group II) needed ICU admission due to severe symptoms and signs of ARD and 74 cases (Group III) were isolated kept under medical supervision receiving the ordinary treatment till convalescence. COVID-19 cases were selected from those who were

represented to Ohoud Hospital in Medina, Saudi Arabia in the period from 1/4/2020 to 22/2/2021. The COVID-19 cases included 66 (60.6%) males and 43 (39.4%) females. The control group included 12 (60%) males and 8 (40%) females (Table 1).

Basic statistics of the studied patients

The median age for COVID-19 patients was 54 years old. The level of Vit-D was low in patients with COVID-19 with a median 15.2 ng/ml. Serum ferritin was high in all COVID-19 patients with a median 720.9 ng/ml (Table 2).

Age and sex in relation to the severity of COVID-19 infection

There was a significantly higher rate of developing severe forms of COVID-19 in males compared to females, P-value < 0.001. On the other hand, there was no significant difference regarding the age of the patients whether above or equal to 60 years or below 60, P-value 1.00. Data are shown in Table 3.

Vitamin D level and COVID-19 cases

There was a significant difference regarding vitamin D level in the normal control cases and the COVID-19 infected cases, P-value < 0.001. Data are shown in Table 4.

Comparison between studied groups as regards vitamin D level

ANOVA test was used to compare the 3 groups: Group I (control), group II (severe) and group III (moderate) COVID 19 cases. There was a significant difference between the control group and both COVID-19 groups (Severe and Moderate), P-value < 0.001 Also, a significant difference was detected between severe (GII) and moderate (GIII), P-value 0.042. Data are shown in Table 5.

There were significantly lower levels of vitamin D and higher levels of ferritin in the severe Covid cases, P-values 0.018 and 0.001, respectively. Data are shown in Table 6.

Table 1. Demographics of the study groups.

	Age	Sex
Group I	48-67 years	60% M, 40% F
Group II	14-70 years	30 M, 5 F
Group III	25-100 years	36 M, 38 F

M; Male, F; Female.

Table 2. Baseline characteristics of study populations.

	Mean	Median
Age	54.88 ± 15.91	54.00 (20-100)
Ferritin	1039.39 ± 971.99	720.90 (5267.00-23.21)
Vit-D	18.35 ± 11.16	15.25 (3.00-49.55)

Table 3. Age and sex in relation to the severity of COVID-19 infection.

		Group II	Group III	P-value
Sex	Males	30 (85.7%)	36 (48.6%)	0.000
	Females	5 (14.3%)	38 (51.4%)	
Age	Above 60	25(71.4%)	52 (70.3%)	1.00
	60 and below	10 (28.6%)	22 (29.7%)	

Table 4. Vitamin D level and COVID-19 cases.

	Control cases (n = 20)	COVID-19 cases (n = 109)	P-value
Vitamin D level	44.65 ± 9.45	18.35 ± 11.16	<0.001

Table 5. Vitamin D level among different groups.

	Group I (n = 20)	Group II (n = 35)	Group III (n = 74)	P-value
Vitamin D level	44.65 ± 9.45	14.70 ± 9.34	20.08 ± 11.59	<0.001

Table 6. Vitamin D and ferritin levels in COVID 19 cases.

	Group II (n = 35)	Group III (n = 74)	P-value
Vitamin D level	14.70 ± 9.34	20.08 ± 11.59	0.018*
Ferritin	1444.89 ± 1104.62	585.23 ± 517.31	0.001**

DISCUSSION

The SARS-COV2 pandemic started by the end of 2019, and till the moment it continues to be a public health crisis. The actual cause that leads to more severe even fatal disease in one person and a mild form in another is still unknown. Many researchers tried to investigate the effects of some risk factors like age, sex, and the presence of comorbidity on the severity and disease outcome and to decide prevention and treatment strategies.

COVID-19 is a multi-system disease that can cause multiple organ failures ending in death. The total infected case as announced by the WHO till May 2021 is 162,535,713 and 3,371,407 deaths. To date no curative treatment is available; prevention is the only way to reduce the number of infected cases and overcome severity and mortality.

Vitamin D is one of the fat-soluble vitamins that can be supplied in food or synthesized in our body under the effect of UVB. Vitamin D plays an important role in immune defense against viruses and other respiratory infections.

Vitamin D can modify both innate and adaptive immune mechanisms. Also, it has anti-inflammatory and antiviral effects (Hribar et al., 2020)**.**

Vitamin D can positively affect the expression of genes involved in the antioxidant pathways and hence improve the immune system performance (Lei et al., 2017).

The present study aimed to evaluate the serum level of Vit D in covid-19 patients and the correction between its serum level with COVID-19 severity and ICU admission.

This study was carried out on 129 subjects, 20 individuals of matched age and sex used as a control group and 109 COVID-19 patients. 35 patients out of the 109 were admitted to the ICU and 74 out of the 109 patients did not need ICU admission. COVID-19 showed a higher incidence in males compared to females (P-value < 0.000). These data agreed with Kopel et al. (2020) and Jin et al. (2020). They reported a higher rate of infection and more severe disease in men than women. This difference could be explained by the variability in the immune response in women and men. Women have more potent innate immunity, production of more cytotoxic molecules and inflammatory markers like interferon-gamma, interleukin-12 receptor b2 (IL12Rb2), lymphotoxin beta and granulysin (GNLY). Also, female patients produce more immunosuppressive molecules than men, helping to reduce systemic inflammation. Estrogen in females can affect both humoral and cellular immune responses; it increases the number of antibodies produced by the B -Lymphocytes and at the same time increases activity and number of T-lymphocytes. Estrogen decreases IL-1β, IL-6, and TNF production from the monocytes which help reduce the severity of cytokine storms (Kopel et al., 2020; Kramer et al., 2007).

The serum ferritin level was significantly high in COVID-19 patients with a mean value (1039.39 ± 971.99); more than triple the reference range. This finding agrees with (Banchini et al., 2021) who reported high serum ferritin in patients with COVID-19. Patients with COVID -19 showed marked elevation of serum ferritin when compared with other patients having acute surgical disorders. Ferritin is an acute-phase reactant and has been used as a marker of prognosis in many disorders. Serum ferritin has been used as a marker of mortality in COVID-19 patients (Vargas-Vargas and Cortés-Rojo, 2020).

In this study, we found that the serum ferritin level was significantly higher in severe COVID-19 cases when compared with less severe or moderate cases. These findings agreed with Colafrancesco et al. (2020), Zhou et al. (2020) and Taneri et al. (2020).

The inflammation scenario in COVID 19 patients is different from other inflammatory processes, like acute abdomen, in the latter conditions; the severity of inflammation is correlated well with inflammatory markers like CRP and LDH but not with serum ferritin. The situation is the opposite in COVID-19 patients where serum ferritin is immediately elevated and is correlated with disease severity and outcome (Banchini et al., 2021).

As regards vitamin D level, in this study serum level of Vit-D was significantly lower in patients with COVID-19

when compared with the control group (18.35 ± 11.16 ng/ml vs 44.65 ± 9.45 ng/ml). These findings were reported by Vyas et al. (2020), Baktash et al. (2020) and Sulli et al. (2021).

Meltzer et al. (2020) investigated the relation between COVID-19 infection in 489 individuals and their serum vitamin D levels and concluded that COVID-19 infection was statistically associated with vitamin D deficiency. This indicated a strong association between low serum vitamin D levels and the chance of acquiring COVID-19 infection.

In this study, we observed an association between the level of vitamin D and the severity of COVID-19, being lower in more severe cases. These findings were reported by Ye et al. (2020) who found more vitamin D reduction in severe cases of COVID-19. Maghbooli et al. (2020) reported a similar finding.

Vitamin D can affect many aspects of the immune defense against viral and respiratory infections. It can modulate cytokine production, B-lymphocyte function and T-lymphocyte subsets and proliferation. These immune modulations done by vitamin D deficiency greatly raise our attention towards the importance of vitamin D supplementation in preventing and minimizing side effects and severity of viral infections including COVID-19.

CONCLUSION AND RECOMMENDATION

From the above-mentioned data, we could conclude that low serum Vitamin-D level was significantly associated with a higher risk of COVID-19 infection and a more severe form of the disease that may end in death. Vitamin D supplementation will provide a sufficient serum level of the vitamin that can prevent infection and or minimize COVID-19 severity.

More studies about the outcome of COVID-19 patients with deficient vitamin D and the efficacy of vitamin D supplementation during the treatment are required.

REFERENCES

Adhikari SP, Meng S, Wu Y-J, Mao Y-P, Ye R-X, Wang Q-Z, Sun C, Sylvia S, Rozelle S, Raat H, Zhou H, **2020**. Epidemiology, causes, clinical manifestation and diagnosis, prevention and control of coronavirus disease (COVID-19) during the early outbreak period: a scoping review. Infect Dis Poverty, 9(1): 1–12.

Ali N, **2020**. Role of vitamin D in preventing of COVID-19 infection, progression and severity. J Infect Public Health, 13(10): 1373-1380.

Alrasheed H, Althnian A, Kurdi H, Al-Mgren H, Alharbi S, **2020**. COVID-19 Spread in Saudi Arabia: Modeling, Simulation and Analysis. Int J Environ Res Public Health, 17(21): 7744. doi: 10.3390/ijerph17217744.

Baktash V, Hosack T, Patel N, Shah S, Kandiah P, Van den Abbeele K, Mandal AKJ, Missouris CG, **2020**. Vitamin D status and outcomes for hospitalised older patients with COVID-19. Postgrad Med J, 97(1149): 442-447. doi: 10.1136/postgradmedj-2020-138712.

Banchini F, Cattaneo GM, Capelli P, **2021**. Serum ferritin levels in inflammation: a retrospective comparative analysis between COVID-19 and emergency surgical non-COVID-19 patients. World J Emerg Surg, 16(1): 9. doi: 10.1186/s13017-021-00354-3.

Belmehdi O, Hakkour M, Omari N, Balahbib A, Guaouguaou F-E, Benali T, El Baaboua A, Lahmoud M, el Menyiy N, Bouyahya A, **2021**. Molecular Structure, Pathophysiology, and Diagnosis of COVID-19. Biointerface Res Appl Chem, 11: 10215–10237. DOI: 10215-10237. 10.33263/BRIAC113.1021510237.

Bikdeli B, Madhavan MV, Jimenez D, Chuich T, Dreyfus I, Driggin E, Nigoghossian C, Ageno W, Madjid M, Guo Y, Tang LV, Hu Y, Giri J, Cushman M, Quéré I, Dimakakos EP, Gibson CM, Lippi G, Favaloro EJ, Fareed J, Caprini JA, Tafur AJ, Burton JR, Francese DP, Wang EY, Falanga A, McLintock C, Hunt BJ, Spyropoulos AC, Barnes GD, Eikelboom JW, Weinberg I, Schulman S, Carrier M, Piazza G, Beckman JA, Steg PG, Stone GW, Rosenkranz S, Goldhaber SZ, Parikh SA, Monreal M, Krumholz HM, Konstantinides SV, Weitz JI, Lip GYH, Global COVID-19 Thrombosis Collaborative Group, Endorsed by the ISTH, NATF, ESVM, and the IUA, Supported by the ESC Working Group on Pulmonary Circulation and Right Ventricular Function, **2020**. COVID-19 and Thrombotic or Thromboembolic Disease: Implications for Prevention, Antithrombotic Therapy, and Follow-Up: JACC State-of-the-Art Review. J Am Coll Cardiol, 16;75(23): 2950-2973. doi: 10.1016/j.jacc.2020.04.031.

Colafrancesco S, Alessandri C, Conti F, Priori R, **2020**. COVID-19 gone bad: A new character in the spectrum of the hyperferritinemic syndrome? Autoimmun Rev, 19(7): 102573. doi: 10.1016/j.autrev.2020.102573.

Cui J, Li F, Shi Z.-L, 2019. Origin and evolution of pathogenic coronaviruses. Nature Rev Microbiol, 17(3): 181–192.

Hribar CA, Cobbold PH, Church FC, **2020**. Potential role of vitamin D in the elderly to resist COVID-19 and to slow progression of Parkinson's disease. Brain Sci, 10(5): 284.

Kopel J, Perisetti A, Roghani A, Aziz M, Gajendran M, Goyal H, **2020**. Racial and Gender-Based Differences in COVID-19. Front Public Health, 8: 418. doi: 10.3389/fpubh.2020.00418.

Kramer PR, Winger V, Kramer, S. F, **2007**. 17β-Estradiol utilizes the estrogen receptor to regulate CD16 expression in monocytes. Mol Cell Endocrinol, 279(1–2): 16–25. doi: 10.1016/j.mce.2007.08.014.

Bishop E, Ismailova A, Dimeloe SK, Hewison M, White JH, **2020**. Vitamin D and immune regulation: antibacterial, antiviral, anti-inflammatory. JBMR Plus. 5(1): e10405. doi: 10.1002/jbm4.10405.

Lei GS, Zhang C, Cheng BH, Lee CH, **2017**. Mechanisms of Action of Vitamin D as Supplemental Therapy for Pneumocystis Pneumonia. Antimicrob Agents Chemother, 61(10): e01226-17. doi: 10.1128/AAC.01226-17.

Maghbooli Z, Sahraian MA, Ebrahimi M, Pazoki M, Kafan S, Tabriz HM, Hadadi A, Montazeri M, Nasiri M, Shirvani A, Holick MF, **2020**. Vitamin D sufficiency, a serum 25-hydroxyvitamin D at least 30 ng/mL reduced risk for adverse clinical outcomes in patients with COVID-19 infection. PLoS One, 15(9): e0239799. doi: 10.1371/journal.pone.0239799.

Meltzer DO, Best TJ, Zhang H, Vokes T, Arora V, Solway J, **2020**. Association of Vitamin D Status and Other Clinical Characteristics With COVID-19 Test Results. JAMA Netw Open. 3(9):e2019722. doi: 10.1001/jamanetworkopen.2020.19722.

Ouassou H, Kharchoufa L, Bouhrim M, Daoudi NE, Imtara H, Bencheikh N, ELbouzidi A, Bnouham M, **2020**. 'The Pathogenesis of coronavirus disease 2019 (COVID-19): Evaluation and prevention. J Immunol Res, Article ID 1357983 | https://doi.org/10.1155/2020/1357983.

Rhodes JM, Subramanian S, Laird E, Griffin G, Kenny RA, **2021**. Perspective: Vitamin D deficiency and COVID-19 severity - plausibly linked by latitude, ethnicity, impacts on cytokines, ACE2 and thrombosis. J Intern Med, 289(1):97-115. doi: 10.1111/joim.13149.

Sulli A, Gotelli E, Casabella A, Paolino S, Pizzorni C, Alessandri E, Grosso M, Ferone D, Smith V, Cutolo M, **2021**. Vitamin D and Lung Outcomes in Elderly COVID-19 Patients. Nutrients, 13(3): 717. doi: 10.3390/nu13030717.

Taneri PE, Gómez-Ochoa SA, Llanaj E, Raguindin PF, Rojas LZ, Roa-

Díaz ZM, Salvador D Jr, Groothof D, Minder B, Kopp-Heim D, Hautz WE, Eisenga MF, Franco OH, Glisic M, Muka T, **2020**. Anemia and iron metabolism in COVID-19: a systematic review and meta-analysis. Eur J Epidemiol, 35(8): 763-773. doi: 10.1007/s10654-020-00678-5.

Urashima M, Segawa T, Okazaki M, Kurihara M, Wada Y, Ida H, **2010**. Randomized trial of vitamin D supplementation to prevent seasonal influenza A in schoolchildren. Am J Clin Nutr, 91(5): 1255 - 1260. doi: 10.3945/ajcn.2009.29094.

Vargas-Vargas M, **Cortés-Rojo** C, **2020**. Ferritin levels and COVID-19. Rev Panam Salud Publica, 44:e72. doi: 10.26633/RPSP.2020.72.

Vyas N, Kurian SJ, Bagchi D, Manu MK, Saravu K, Unnikrishnan MK, Mukhopadhyay C, Rao M, Miraj SS, **2020**. Vitamin D in Prevention and Treatment of COVID-19: Current Perspective and Future Prospects. J Am Coll Nutr, 1: 1-14. doi: 10.1080/07315724.2020.1806758.

Wacker M, **Holick** MF, **2013**. Sunlight and Vitamin D: A global perspective for health. Dermato-endocrinol, 5(1): 51–108.

Wang W, Xu Y, Gao R, Lu R, Han K, Wu G, Tan W, **2020**. Detection of SARS-CoV-2 in Different Types of Clinical Specimens. JAMA, 323(18): 1843-1844. doi: 10.1001/jama.2020.3786.

Ye K, Tang F, Liao X, Shaw BA, Deng M, Huang G, Qin Z, Peng X, Xiao H, Chen C, Liu X, Ning L, Wang B, Tang N, Li M, Xu F, Lin S, Yang J, 2020. Does Serum Vitamin D Level Affect COVID-19 Infection and Its Severity?-A Case-Control Study. J Am Coll Nutr, 13:1-8. doi: 10.1080/07315724.2020.1826005.

Zhou, B, She J, Wang Y, Ma X, **2020**. Utility of ferritin, procalcitonin, and C-reactive protein in severe patients with 2019 novel coronavirus disease. Research Square Preprint.

Zhu N, Zhang D, Wang W, Li X, Yang B, Song J, Zhao X, Huang B, Shi W, Lu R, Niu P, Zhan F, Ma X, Wang D, Xu W, Wu G, Gao GF, Tan W, China Novel Coronavirus Investigating and Research Team, **2020**. A Novel Coronavirus from Patients with Pneumonia in China, 2019. N Engl J Med, 382(8): 727-733. doi: 10.1056/NEJMoa2001017.

Citation: Al-Harbi SS, Al-Harbi YA, Abdellatif AE, Al-Ahmadey ZZ, Alahmadi SS, 2021. Retrospective evaluation of the serum level of Vitamin D among COVID-19 patients in Al Madinah, Saudi Arabia. Biochem Biotechnol Res, 9(1): 8-13.