ORIGINAL ARTICLE ASIAN JOURNAL OF MEDICAL SCIENCES

Prevalence of Vitamin D3 deficiency in patients undergoing elective neurosurgical procedures and its effects on morbidity and mortality

Jasima Javeed[1], Zoya Sehar[2], Aymen Masood[3], Shahid Ahmad Mir[4], Eman Aftab[5]

[1,2,5]DNB Scholar, Department of Neuroanesthesia and Neurocritical Care, Sher-i-Kashmir Institute of Medical Sciences, Srinagar, [3]Assistant Professor, Department of Anesthesiology, Government Medical College, Anantnag, Jammu and Kashmir, [4]Assistant Professor, Department of Neuroanesthesia, Paras Hospital, Gurgaon, Haryana, India

Submission: 16-08-2025 Revision: 29-09-2025 Publication: 01-11-2025

ABSTRACT

Background: Vitamin D3 plays a crucial role in calcium homeostasis, bone metabolism, muscle strength, and immune modulation. Its deficiency has been linked to increased postoperative complications, impaired wound healing, and higher mortality risk. However, data on Vitamin D3 status among neurosurgical patients remain limited. **Aims and Objectives:** The aim of the study was to determine the prevalence of Vitamin D3 deficiency in patients undergoing elective neurosurgical procedures and evaluate its association with post-operative morbidity and mortality. **Materials and Methods:** In this hospital-based prospective observational study 170 adult patients who were admitted for elective neurosurgical procedures during the study period were enrolled. Blood samples were collected within 48 h of admission and Vitamin D3 levels were measured using a chemiluminescence immunoassay in the central biochemistry laboratory at Sher-i-Kashmir Institute of Medical Sciences. The primary outcomes assessed were the prevalence of Vitamin D3 deficiency in the study population and its association with post-operative morbidity and mortality. Secondary outcomes included length of hospital stay, requirement of intensive care unit care, and readmission rates. **Results:** Vitamin D3 deficiency was observed in 54 patients (31.8%), while 46 patients (27.1%) had insufficient levels. Multivariate logistic regression analysis identified Vitamin D_3 deficiency as an independent predictor of prolonged hospital stay, with an adjusted odds ratio of 2.15 (95% confidence interval: 1.12–4.21, P=0.02). **Conclusion:** Vitamin D3 deficiency is highly prevalent among elective neurosurgical patients and is independently associated with increased hospital stay. Pre-operative screening and correction may be a simple, cost-effective strategy to improve surgical outcomes.

Key words: Vitamin D3 deficiency; Prevalence; Neurosurgery; Elective neurosurgical procedures; Morbidity; Mortality; Hypovitaminosis D; Surgical outcomes

Access this article online

Website:

https://ajmsjournal.info/index.php/AJMS/index

DOI: 10.71152/ajms.v16i11.4818

E-ISSN: 2091-0576

P-ISSN: 2467-9100

INTRODUCTION

Vitamin D deficiency has been very commonly encountered in neurosurgical population with a prevalence of 40–60%.[1] Association of admission serum levels of Vitamin D, calcium, phosphate, magnesium and parathormone with clinical outcomes in neurosurgical intensive care unit (ICU) patients. Various risk factors associated with hypovitaminosis D are age over 65 years old, frailty, systemic comorbidities, skin pigmentation and reduced sun exposure.[2,3] The patients may present to neurosurgical units with cranial pathology or a spinal pathology.

Address for Correspondence:
Dr. Jasima Javeed, Department of Neuroanesthesia and Neurocritical Care, Sher-i-Kashmir Institute of Medical Sciences, Soura, Srinagar - 190011, Jammu and Kashmir, India. **Mobile:** +91-6006330461. **E-mail:** drjjaveed.858@gmail.com

Hypovitaminosis of Vitamin D deficiency leads to adverse outcomes in neurocritical care unit.[1,4] Association of admission serum levels of Vitamin D, calcium, Phosphate, magnesium, and parathormone with clinical outcomes in neurosurgical ICU patients. Adverse outcomes have also been observed after spinal surgery due to Vitamin D deficiency.[5] It has been seen that hypovitaminosis D may lead to altered tissue homeostasis, impaired wound healing, poor neuronal function increasing the neuroinflammation.[6,7] Diet, environmental factors, and lifestyle underlie the high prevalence of Vitamin D deficiency in healthy adults in Scotland, and supplementation reduces the proportion that is severely deficient.[7]

Literature is sparse about the prevalence of hypovitaminosis D in cranial neurosurgical patients undergoing elective surgery. There is no evidence whether low Vitamin D levels will lead to an increase in mortality, morbidity. In this prospective study, we assessed the prevalence of hypovitaminosis D in elective neurosurgical patients undergoing cranial neurosurgical procedures. We studied whether Vitamin D levels in such patients were associated with an increase in the mortality, morbidity, increase in perioperative adverse events, length of hospital stay, and length of ICU stay.

Aims and objectives

Our study was single-center and observational, limiting generalizability and leaving open the possibility of unmeasured confounding. We focused on short-term outcomes; long-term functional recovery, quality of life, and cognitive trajectories were not assessed. We did not analyze post-operative Vitamin D levels nor implement supplementation protocols. Cost-effectiveness analyses, as well as explorations of optimal dosing (e.g., loading vs. daily supplementation) and timing (weeks prior vs. immediate pre-operative period), remain uncharted in our patients.

MATERIALS AND METHODS

This hospital-based prospective observational study was conducted in the Department of Neurosurgery at Sher-i-Kashmir Institute of Medical Sciences (SKIMS), Srinagar, over a period of 18 months. The study was approved by the Institutional Ethics Committee of SKIMS, Srinagar. In this study 170 adult patients who were admitted for elective neurosurgical procedures during the study period were enrolled. The study was conducted in accordance with the ethical standards of the Institutional Ethics Committee of SKIMS, and with the principles of the Helsinki Declaration of 1975, as revised in 1983.

A consecutive sampling technique was adopted, and informed consent was obtained from all eligible participants. The sample size was calculated using the standard formula $n=Z^2\times p\times(1-p)/d^2$, assuming a prevalence of 40%, a 95% confidence level (CI), and a margin of error of ±7.5%. Substituting values (Z=1.96, P=0.40, d=0.075), the minimum required sample size was estimated to be 164 patients. To enhance statistical power and account for potential dropouts, protocol deviations, or missing data, the final sample size was increased to 170 participants.

The inclusion criteria were: Patients aged ≥18 years, patients undergoing elective neurosurgical procedures, and patients who gave written informed consent for participation in the study. Patients undergoing emergency neurosurgical procedures (e.g., trauma, acute hemorrhage), patients with known chronic kidney disease, hepatic dysfunction, parathyroid disorders, or active malignancy, and patients already receiving Vitamin D supplementation within the past 3 months were excluded from the study.

The eligible subjects underwent a detailed pre-operative assessment according to a pre-formulated pro forma. After enrollment, demographic details including age and sex were recorded, along with clinical history such as comorbid conditions including hypertension, diabetes mellitus, and hypothyroidism.

Blood samples were collected within 48 h of admission and Vitamin D3 levels were measured using a chemiluminescence immunoassay in the central biochemistry laboratory at SKIMS. Vitamin D3 status was categorized as per guidelines laid down by IOM (institute of medicine, USA) as:

- Deficient if levels were <20 ng/mL
- Insufficient if between 20 and 29 ng/mL
- Sufficient if equal to or >30 ng/mL.

Intraoperative and post-operative data were collected prospectively, including duration of surgery, estimated blood loss, duration of ICU stay, total hospital stay, and occurrence of any complications such as wound infections, delayed healing, pneumonia, urinary tract infection, cerebrospinal fluid leak, or need for reoperation. Mortality was assessed in-hospital or within 30 days postoperatively. The primary outcomes assessed were the prevalence of Vitamin D3 deficiency in the study population and its association with post-operative morbidity and mortality. Secondary outcomes included length of hospital stay, requirement of ICU care, and readmission rates.

Data were entered into Microsoft Excel and analyzed using the Statistical Package for the Social Sciences software version 25. Continuous variables were expressed as mean±standard deviation. Categorical variables were presented as frequencies and percentages. Comparisons between groups (vitamin D deficient versus sufficient) were done using the Chi-square test for categorical variables, and independent *t*-test or Mann–Whitney U-test for continuous variables, as appropriate. A multivariate logistic regression model was used to identify independent predictors of post-operative morbidity and mortality after adjusting for confounding variables such as age, comorbidities. A P<0.05 was considered statistically significant.

RESULTS

The study included 170 patients with a mean age of 48.2±13.6 years (range 18–78 years). There was a slight female predominance, with 89 (52.4%) females compared to 81 (47.6%) males. Regarding body mass index (BMI), 72 (42.4%) patients had a normal BMI (<25 kg/m^2). Comorbidities were present in a considerable proportion of patients, with hypertension in 56 (32.9%). The majority of patients, 126 (74.1%), were classified as American Society of Anesthesiologists (ASA) Grade I. Socioeconomic and lifestyle parameters showed that nearly half of the study population (46.5%) belonged to the lower socioeconomic class, 39.4% reported daily sunlight exposure of <30 min, and 28.8% followed a vegetarian diet (Table 1).

In the study population, biochemical assessment revealed a mean serum calcium of 8.7±0.6 mg/dL, with 14.1% showing hypocalcemia, while hypomagnesemia was identified in 11.8% of patients. Vitamin K deficiency was documented in 9.4%, and suboptimal protein intake, based on dietary history and serum albumin, was present in 18.2%. Vitamin D3 deficiency (<20 ng/mL) was observed in 54 patients (31.8%), while 46 patients (27.1%) had insufficient levels (20–29 ng/mL). Sufficient Vitamin D3 levels (≥30 ng/mL) were recorded in 70 patients, accounting for 41.1% of the participants (Figure 1). Seasonal analysis demonstrated significantly reduced Vitamin D levels in patients recruited during winter months compared to those enrolled in summer (P=0.02) (Table 2).

In the study population, Vitamin D3 deficiency was most prevalent among individuals aged 41–60 years, accounting for 34 patients (63.0%) in the deficient group, 29 patients (63.0%) in the insufficient group, and 44 patients (62.9%) in the sufficient group. In this study, majority of patients were females (Table 3).

Perioperative assessment showed that mean surgery duration was comparable across groups, with 5.44±0.8 h in the deficient, 5.42±0.9 h in the insufficient, and 5.40±0.8 h in the sufficient category. Vasopressor use was required in 38%, 37%, and 36% of patients, respectively. The incidence

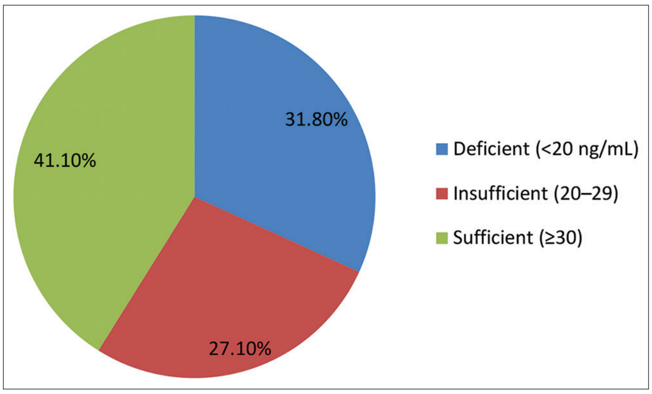

Figure 1: Distribution of Vitamin D3 status in study population

Table 1: Demographic and baseline clinical characteristics of the study population

Characteristic	No. of patients	Percentage
Age group (years)		
≤40	51	30.0
41–60	107	62.9
>60	12	7.1
Gender		
Male	81	47.6
Female	89	52.4
BMI (kg/m^2)		
<25 (Normal)	72	42.4
25–29.9 (Overweight)	81	47.6
≥30 (Obese)	17	10.0
Comorbidities		
None	78	45.9
Hypertension	56	32.9
Diabetes mellitus	37	21.8
Hypothyroidism	22	12.9
ASA Grade		
I	126	74.1
II	44	25.9
III	0	0.0
Lower socioeconomic status	79	46.5%
Sunlight exposure<30 min/day	67	39.4%
Vegetarian diet	27	10.0%

BMI: Body mass index, ASA: American Society of Anesthesiologists

Table 2: Distribution of Vitamin D3 status in study population

Parameters	Values (%)
Biochemical	
Mean serum calcium (mg/dL)	8.7±0.6
Mean serum magnesium (mg/dL)	1.9±0.3
Nutritional	
Vitamin K deficiency (No./%)	16 (9.4)
Suboptimal protein intake (No./%)	31 (18.2)
Vitamin D3 status	
Deficient (<20 ng/mL) (No./%)	54 (31.8)
Insufficient (20–29) (No./%)	46 (27.1)
Sufficient (≥30) (No./%)	70 (41.1)
Seasonal Vitamin D3 status	
Winter (Mean±SD)	18.4±6.2
Summer (Mean±SD)	24.6±7.1

SD: Standard deviation

of respiratory tract infection was low and similar (4%, 4%, and 3%), as was the occurrence of seizures (4%, 3%, and 4%). Blood transfusion was not required in the majority of patients (90%, 91%, and 90%), with only small proportions receiving 1 unit (8%, 7%, and 8%) or 2 units (2%, 2%, and 3%). Mean ICU stay was similar at 2.78±1.2, 2.80±1.3, and 2.76±1.2 days, respectively. However, hospital stay was significantly longer in the deficient group (18.4±4.1 days) compared to the insufficient (17.2±3.9 days) and sufficient groups (15.0±3.5 days, P=0.03). Mortality was recorded in 2 patients (3.7%) in the deficient group, 2 patients (4.3%) in the insufficient group, and 1 patient (1.4%) in the sufficient group (Table 4).

Multivariate logistic regression analysis identified Vitamin D3 deficiency as an independent predictor of prolonged hospital stay, with an adjusted odds ratio of 2.15 (95% CI: 1.12–4.21, P=0.02). Other variables, including age, gender, BMI, ASA grade, vasopressor use, surgery duration, and presence of comorbidities, did not show significant associations with prolonged hospitalization (Table 5).

DISCUSSION

The prevalence of Vitamin D deficiency seen in our elective cranial neurosurgical cohort (31.8% deficient, 27.1% insufficient) emphasizes the role of the physician in the detection and treatment of a modifiable pre-operative risk factor. Although the incidence of hypovitaminosis in our study is lower compared to reported deficiency rates of 40–60% in neurocritical care settings,[8] it reflects the need for immediate corrective measure, particularly in optimization of ASA II-IV patient populations.

Our study demonstrated that pre-operative Vitamin D deficiency was independently associated with prolonged hospital stay, with deficient patients having nearly double the odds (odds ratio 2.15) of extended hospitalization. Importantly, this association remained robust even after adjusting for potential confounders such as age, BMI, comorbidities, ASA status, surgical duration, and vasopressor use. This finding aligns with growing evidence in the literature that links hypovitaminosis D with adverse perioperative and postoperative outcomes. Ved et al., similarly observed that Vitamin D deficiency exerted a detrimental influence on clinical outcomes in neurosurgical patients. They reported that individuals with low Vitamin D levels were more vulnerable to post-operative complications and had significantly longer hospital stays compared to those with sufficient Vitamin D, underscoring its role as a potentially modifiable risk factor.[9]

Table 3: Association of Vitamin D3 levels with demographic and baseline variables

Variable	Deficient (n=54)	Insufficient (n=46)	Sufficient (n=70)	P-value
Age group (years)				
≤40	16 (29.6)	14 (30.4)	21 (30.0)	0.98
41–60	34 (63.0)	29 (63.0)	44 (62.9)	
>60	4 (7.4)	3 (6.5)	5 (7.1)	
Gender				
Male	26 (48.1)	22 (47.8)	33 (47.1)	0.94
Female	28 (51.9)	24 (52.2)	37 (52.9)	
BMI (kg/m^2)				
<25	23 (42.6)	19 (41.3)	30 (42.9)	0.98
25–29.9	26 (48.1)	22 (47.8)	33 (47.1)	
≥30	5 (9.3)	5 (10.9)	7 (10.0)	
ASA Grade				
I	40 (74.1)	34 (73.9)	52 (74.3)	0.97
II	14 (25.9)	12 (26.1)	18 (25.7)	
Comorbidities				
None	25 (46.3)	21 (45.7)	32 (45.7)	0.97
Hypertension	18 (33.3)	15 (32.6)	23 (32.9)	
Diabetes mellitus	12 (22.2)	10 (21.7)	15 (21.4)	
Hypothyroidism	7 (13.0)	6 (13.0)	9 (12.9)	
Season distribution				
Winter (n=94)	40 (42.5)	31 (33.0)	23 (24.5)	0.02
Summer (n=136)	34 (25.0)	40 (29.4)	62 (45.6)	

BMI: Body mass index, ASA: American Society of Anesthesiologists

Table 4: Perioperative variables and outcome by Vitamin D3 status

Variables	Deficient (n=54)	Insufficient (n=46)	Sufficient (n=70)	P-value
Mean surgery duration (hours)	5.44±0.8	5.42±0.9	5.40±0.8	0.95
Need for vasopressors (%)	38	37	36	0.98
RTI (%)	4	4	3	0.96
Seizures (%)	4	3	4	0.96
Blood transfusion				
Nil (%)	90	91	90	0.99
1 unit (%)	8	7	8	
2 units (%)	2	2	3	
Mean ICU stay (days)	2.78±1.2	2.80±1.3	2.76±1.2	0.98
Hospital stay (days)	18.4±4.1	17.2±3.9	15.0±3.5	0.03*
Mortality (n, %)	2 (3.7)	2 (4.3)	1 (1.4)	0.59

ICU: Intensive care unit, BMI: Body mass index, ASA: American Society of Anesthesiologists, *P < 0.05 considered statistically significant

Table 5: Multivariate logistic regression analysis for predictors of prolonged hospital stay (>median stay)

Predictor	Adjusted OR	95% confidence interval	P-value
Vitamin D3 deficiency	2.15	1.12–4.21	0.02*
Age	1.01	0.98–1.04	0.42
Gender	1.08	0.62–1.89	0.78
BMI	1.05	0.58–1.90	0.87
ASA Grade	1.18	0.64–2.18	0.60
Vasopressor use	1.25	0.68–2.32	0.47
Surgery duration	1.10	0.97–1.24	0.12
Any comorbidity	1.20	0.66–2.17	0.55

BMI: Body mass index, ASA: American Society of Anesthesiologists, OR: Odds ratio, CI: Confidence interval, *P < 0.05 considered statistically significant

In neurosurgical ICU patients, Ardehali et al., found that admission hypovitaminosis D was independently associated with prolonged ICU stay, even after accounting for other risk factors. Moreover, elevated admission parathormone levels were significantly correlated with ICU mortality, highlighting the importance of Vitamin D and parathyroid hormone status as prognostic markers in acute care settings.[1] Similarly, Flynn et al., reported that Vitamin D levels below 20 ng/mL were associated with adverse clinical outcomes, including prolonged hospitalization, greater organ dysfunction, and higher infection rates. While these findings reinforce the clinical significance of Vitamin D status in hospitalized patients, the authors emphasized the need for further research to evaluate whether supplementation could mitigate these risks and improve patient outcomes.[10]

However, it should be noted that the differences in perioperative outcomes across groups were relatively narrow, with hospital stay being the primary outcome significantly affected. This finding, though modest, may still have practical implications for resource utilization.

Taken together, these studies support our findings and strengthen the hypothesis that Vitamin D deficiency is not merely a biochemical abnormality but a clinically relevant factor that adversely affects recovery and prognosis. Addressing hypovitaminosis D in surgical and critically ill patients could therefore represent an important and cost-effective strategy to improve outcomes and reduce healthcare burden.

Vitamin D has an innate role in the surgical healing at various stages. At the cellular level, the active form, calcitriol, binds to the Vitamin D receptor (VDR), a nuclear hormone receptor expressed in numerous tissues, including immune cells, glial cells, endothelial cells, and neurons.[11] The VDR complex modulates gene transcription across a spectrum of processes: cytokine regulation (e.g., downregulating proinflammatory cytokines such as interleukin-17 and upregulating antimicrobial peptides like cathelicidin), cellular proliferation and differentiation (critical in tissue repair), blood coagulation, and barrier integrity.[12] These effects collectively support wound healing, immune competence, and neuroprotection.[13] Vitamin D's capacity to influence neurotrophic factor expression particularly nerve growth factor has implications for neuronal survival and synaptic plasticity, potentially affecting cognitive and functional outcomes after neurosurgery.[14,15]

In preclinical neurosurgical models, Vitamin D supplementation has attenuated surgery-induced neuroinflammation, preserved blood-brain barrier integrity, reduced cerebral edema, and modulated microglial phenotype shifting from proinflammatory (M1) to anti-inflammatory (M2) polarization. These findings suggest that adequate Vitamin D status may help in recovery from surgically induced brain stress. Moreover, Vitamin D enhances antioxidant capacity and reduces oxidative stress this may be particularly relevant in neurosurgical settings where neuronal tissue is vulnerable to ischemic and inflammatory injury.[14,15]

The lower levels of Vitamin D may lead to delayed wound healing, prolonged inflammation, slower mobilization, and, consequently, longer hospital stays. Yet our study did not demonstrate significant differences in morbidity, ICU stay, or mortality. A systematic review of perioperative studies showed that 84% of surgical cohorts with low Vitamin D status had at least one significantly worse outcome, most commonly wound complications, infections, and delayed recovery.[16]

Critical illness studies further demonstrate that high-dose Vitamin D may reduce ICU stays, mechanical ventilation duration, and mortality, although randomized controlled trials (RCTs) have produced mixed results. One large RCT of high-dose Vitamin D in critically ill patients did not show mortality benefit, but other trials observed improved antioxidant capacity and shortened ICU time with Vitamin D supplementation, highlighting the complexity of patient population, timing, and endpoints.[17]

In neurosurgical settings, one randomized clinical trial administered a single pre-operative intramuscular dose of 300,000 IU Vitamin D to Vitamin D – deficient brain tumor patients. While postoperative pain scores and analgesic requirements showed only non-significant trends toward improvement, the study raised the possibility that pre-operative Vitamin D may modulate neurophysiological recovery. Although limited by a small sample size, the trial underscores the feasibility of targeted pre-operative Vitamin D intervention.[18]

Despite mounting observational evidence, high-quality randomized trials of Vitamin D supplementation in surgical patients remain sparse and heterogenous varying in timing, dose, patient populations, and primary outcomes. A 2024 systematic review of RCTs found no clear benefit of supplementation on mortality or length of hospital stay across multiple surgical settings. However, these findings are tempered by marked heterogeneity and lack of subgroup analyses sensitivity to baseline deficiency status. When deficiencies are addressed in properly stratified trials, benefits may emerge creating a case for precision supplementation rather than blanket administration.[19]

Limitations of the study

To determine the prevalence of vitamin D3 deficiency in patients undergoing elective neurosurgical procedures. To evaluate its association with postoperative morbidity and mortality.

CONCLUSION

Our findings extend the growing body of evidence that Vitamin D deficiency is both prevalently unaddressed and potentially consequential in surgical patients. In elective cranial neurosurgery, deficiency was clearly linked to prolonged hospitalization. Optimizing Vitamin D status deserves consideration as a low-cost, high-impact strategy to enhance surgical recovery. Implementing routine screening and targeted supplementation, particularly for those at risk of deficiency, may represent an immediate, scalable improvement in neurosurgical care pending confirmation in robust interventional trials.

ACKNOWLEDGMENT

None.

AVAILABILITY OF DATA AND MATERIALS

The datasets generated and/or analyzed during the current study are available from the corresponding author upon reasonable request.

STATEMENT

Manuscript has been read and approved by all authors.

REFERENCES

1. Ardehali SH, Dehghan S, Baghestani AR, Velayati A and Shariatpanahi ZV. Association of admission serum levels of Vitamin D, calcium, phosphate, magnesium and parathormone with clinical outcomes in neurosurgical ICU patients. Sci Rep. 2018;8(1):2965.
   https://doi.org/10.1038/s41598-018-21177-4
2. Czernichow S, Fan T, Nocea G and Sen SS. Calcium and vitamin D intake by postmenopausal women with osteoporosis in France. Curr Med Res Opin. 2010;26(7):1667-1674.
   https://doi.org/10.1185/03007995.2010.483658
3. Thomas MK, Lloyd-Jones DM, Thadhani RI, Shaw AC, Deraska DJ, Kitch BT, et al. Hypovitaminosis D in medical inpatients. N Engl J Med. 1998;338(12):777-783.
   https://doi.org/10.1056/nejm199803193381201
4. Higgins DM, Wischmeyer PE, Queensland KM, Sillau SH, Sufit AJ and Heyland DK. Relationship of vitamin D deficiency to clinical outcomes in critically ill patients. JPEN J Parenter Enteral Nutr. 2012;36(6):713-720.
   https://doi.org/10.1177/0148607112444449
5. Mabey T, Singhatanadgige W, Yingsakmongkol W, Limthongkul W and Honsawek S. Vitamin D and spine surgery. World J Orthop. 2016;7(11):726-730.
   https://doi.org/10.5312/wjo.v7.i11.726
6. Grace C, Vincent R and Aylwin SJ. High prevalence of vitamin D insufficiency in a United Kingdom urban morbidly obese population: Implications for testing and treatment. Surg Obes Relat Dis. 2014;10(2):355-360.
   https://doi.org/10.1016/j.soard.2013.07.017
7. Zgaga L, Theodoratou E, Farrington SM, Agakov F, Tenesa A, Walker M, et al. Diet, environmental factors, and lifestyle underlie the high prevalence of vitamin D deficiency in healthy adults in Scotland, and supplementation reduces the proportion that are severely deficient. J Nutr. 2011;141(8):1535-1542.
   https://doi.org/10.3945/jn.111.140012
8. Chen KW, Chen CW, Yuan KC, Wang IT, Hung FM, Wang AY, et al. Prevalence of vitamin D deficiency and associated factors in critically ill patients: A multicenter observational study. Front Nutr. 2021;8:768804.
   https://doi.org/10.3389/fnut.2021.768804
9. Ved R, Taylor P, Stewart P, Foulkes J, Fields-Jewell W, Davies S, et al. Vitamin D deficiency is endemic in neurosurgical patients and is associated with a longer length of inpatient stay. Endocrinol Diabetes Metab. 2020;3(1):e00097.
   https://doi.org/10.1002/edm2.97
10. Flynn L, Zimmerman LH, McNorton K, Dolman M, Tyburski J, Baylor A, et al. Effects of vitamin D deficiency in critically ill surgical patients. Am J Surg. 2012;203(3):379-382; discussion 382.
    https://doi.org/10.1016/j.amjsurg.2011.09.012
11. Prietl B, Treiber G, Pieber TR and Amrein K. Vitamin D and immune function. Nutrients. 2013;5(7):2502-2521.
    https://doi.org/10.3390/nu5072502
12. Eyles DW, Smith S, Kinobe R, Hewison M and McGrath JJ. Distribution of the vitamin D receptor and 1 alpha-hydroxylase in human brain. J Chem Neuroanat. 2005;29(1):21-30.
    https://doi.org/10.1016/j.jchemneu.2004.08.006
13. De Freitas RP, Nunes FP, Dos Santos LM, Weckwerth PH, Silveira EM, Gulinelli JL, et al. Influence of vitamin D in bone healing. J Oral Diagn. 2017;2:1-8.
    https://doi.org/10.5935/2525-5711.20170014
14. Qiao J, Ma H, Chen M and Bai J. Vitamin D alleviates neuronal injury in cerebral ischemia-reperfusion via enhancing the Nrf2/HO-1 antioxidant pathway to counteract NLRP3-mediated pyroptosis. J Neuropathol Exp Neurol. 2023;82(8):722-733.
    https://doi.org/10.1093/jnen/nlad047
15. Gezen-Ak D, Dursun E and Yilmazer S. The effects of vitamin D receptor silencing on the expression of LVSCC-A1C and LVSCC-A1D and the release of NGF in cortical neurons. PloS One. 2011;6(3):e17553.
    https://doi.org/10.1371/journal.pone.0017553
16. McKinney TJ, Patel JJ, Benns MV, Nash NA and Miller KR. Vitamin D status and supplementation in the critically ill. Curr Gastroenterol Rep. 2016;18(4):18.
    https://doi.org/10.1007/s11894-016-0492-2
17. Gao Z, Xie J, Li C, Liu L and Yang Y. High dose vitamin D3 supplementation is not associated with lower mortality in critically ill patients: A meta-analysis of randomized control trials. Front Nutr. 2022;9:762316.
    https://doi.org/10.3389/fnut.2022.762316
18. Hajimohammadebrahim-Ketabforoush M, Shahmohammadi M,

Keikhaee M, Eslamian G and Vahdat Shariatpanahi Z. Single high-dose vitamin D3 injection and clinical outcomes in brain tumor resection: A randomized, controlled clinical trial. Clin Nutr ESPEN. 2021;41:153-159.

https://doi.org/10.1016/j.clnesp.2020.11.027

19. Patel A, Caruana EJ, Hodson J, Morrison R, Khor B, Gysling S, et al. Role of vitamin D supplementation in modifying outcomes after surgery: A systematic review of randomised controlled trials. BMJ Open. 2024;14(1):e073431.

https://doi.org/10.1136/bmjopen-2023-073431

Authors' Contributions:
JJ- Literature search, data acquisition, data analysis, manuscript review, manuscript preparation and submission; **ZS-** Manuscript preparation, literature search, data acquisition, data analysis, manuscript review; **AM-** Concept, data acquisition, manuscript review; **SAM-** Data acquisition, manuscript review, manuscript editing; **EA-** Manuscript preparation, literature search, data acquisition, data analysis, manuscript review.

Work attributed to:
Department of Neuroanesthesia and Neurocritical care, SKIMS, Soura, Srinagar Jammu and Kashmir, India.

Orcid ID:
Dr. Jasima Javeed- https://orcid.org/0009-0005-0263-655X
Dr. Zoya Sehar- https://orcid.org/0000-0001-6298-0022
Dr. Aymen Masood- https://orcid.org/0009-0003-3613-2785
Dr. Shahid Ahmad Mir- https://orcid.org/0009-0007-4138-2198
Dr. Eman Aftab- https://orcid.org/0009-0003-6592-217X

Source of Funding: None**, Conflicts of Interest:** None.