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# Assessing Serum Vitamin D Levels in Hypertensive Patients and Associated Complications

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## Abstract

**Background:** Hypertension is a major global health challenge, and emerging evidence suggests that vitamin D deficiency may play a role in its pathogenesis and complications. Despite increasing research, the relationship between serum vitamin D levels and hypertension-related target organ damage remains underexplored in many populations.

**Aim:** To estimate serum vitamin D levels in patients with essential hypertension and evaluate its association with hypertension-related complications including retinopathy, nephropathy, and left ventricular hypertrophy.

**Materials and Methods:** A prospective observational study was conducted on 130 hypertensive patients aged 30–70 years. Detailed clinical examination, blood pressure measurement, and serum vitamin D assessment were performed. Hypertension-related complications were evaluated using fundoscopic examination, urine albumin tests, and echocardiography. Data were analyzed using SPSS version 15, with $p < 0.05$ considered statistically significant.

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**Results:** Vitamin D deficiency (<20 ng/dl) was observed in over 56% of patients. Retinopathy, nephropathy, and left ventricular hypertrophy were significantly more common in patients with vitamin D levels below 20 ng/dl. Patients with sufficient vitamin D levels (>30 ng/dl) had the lowest prevalence of complications, highlighting a potential protective effect.

**Conclusion:** The study demonstrates a strong association between low serum vitamin D levels and hypertension-related complications. Routine screening and correction of vitamin D deficiency in hypertensive patients may offer a valuable strategy to reduce cardiovascular and renal complications.

Keywords: vitamin D, hypertension, target organ damage

## Introduction

Hypertension is one of the most common cardiovascular disorders worldwide, affecting nearly one-third of the adult population and significantly contributing to the global burden of cardiovascular morbidity and mortality (1,2). In recent years, vitamin D has emerged as a potential modifiable factor implicated in the pathogenesis of hypertension and related cardiovascular complications. Traditionally known for its role in bone metabolism, vitamin D is now recognized to have widespread effects on the cardiovascular, endocrine, and immune systems (3,4).

Vitamin D deficiency has been reported with increasing prevalence across diverse populations, particularly among individuals with hypertension (5). Several mechanisms have been proposed to explain the association between low vitamin D levels and elevated blood pressure, including modulation of the renin-angiotensin-aldosterone system (RAAS), suppression of vascular smooth muscle proliferation, regulation of calcium homeostasis, and improvement of endothelial function

(6,7). Studies suggest that vitamin D downregulates renin expression, thereby reducing vasoconstriction and sodium retention, which are key contributors to elevated blood pressure (8). Furthermore, vitamin D has been implicated in reducing vascular inflammation, oxidative stress, and arterial stiffness, which may explain its protective effects against hypertension-related complications such as left ventricular hypertrophy, chronic kidney disease, and stroke (9,10). Recent meta-analyses and clinical trials have shown mixed results regarding the effectiveness of vitamin D supplementation in reducing blood pressure, highlighting the need for further research to clarify its role in hypertensive populations (9).

Given the high prevalence of both hypertension and vitamin D deficiency in the general population, exploring the relationship between serum vitamin D levels and hypertension, as well as its complications, has important clinical implications. Estimating serum vitamin D levels in patients with essential hypertension can help identify potentially modifiable risk factors and guide therapeutic strategies aimed at reducing cardiovascular risk and improving patient outcomes (10).

**Materials and Methods**

This prospective observational study was conducted in the Department of Medicine. The aim was to estimate serum vitamin D levels in patients with essential hypertension and assess its association with hypertension-related complications.

Study Population: The study included 130 patients aged 30–70 years diagnosed with essential hypertension, attending the outpatient and inpatient departments.

Inclusion Criteria:

- Patients aged 30–70 years
- Diagnosis of essential hypertension as per current guidelines

- Patients willing to give written informed consent

Exclusion Criteria:

- Patients with secondary hypertension
- Those with chronic kidney disease, chronic liver disease, malignancies, or metabolic bone disorders
- Patients on vitamin D supplementation in the past 6 months
- Pregnant and lactating women

Methodology:

After obtaining ethical approval from the Institutional Ethics Committee, written informed consent was obtained from all participants. Detailed history, physical examination, and relevant clinical data were recorded. Blood pressure was measured using a standard sphygmomanometer according to standard protocols.

A fasting blood sample (5 mL) was collected under aseptic precautions for serum vitamin D measurement, along with routine biochemical parameters. Serum vitamin D levels were estimated using a chemiluminescent immunoassay (CLIA) method. Patients were categorized into vitamin D sufficient (≥30 ng/mL), insufficient (20–29 ng/mL), and deficient (<20 ng/mL) groups.

Hypertension-related complications including left ventricular hypertrophy (LVH), retinopathy, nephropathy (assessed by urine albumin), and stroke were evaluated using echocardiography, fundoscopic examination, urine testing, and clinical records, respectively.

**Statistical Analysis**

Data were analyzed using IBM SPSS Statistics version 25. Continuous variables were expressed as mean ± SD, and categorical variables as percentages. The chi-square test was used for

categorical comparisons, and the Student's t-test or ANOVA was used for continuous variables. A p-value <0.05 was considered statistically significant.

**Results**

Table 1 shows the distribution of participants across different age groups, with the largest proportion in the 41–45 years range, followed by 36–40 years, indicating that middle-aged adults made up the majority of the hypertensive population. There was a consistent male predominance across all age categories, reflecting a slightly higher burden of hypertension among men in this sample.

Table 2 presents the serum vitamin D status among participants, revealing that a significant portion (over 44%) had levels between 11–20 ng/dl, suggesting widespread vitamin D insufficiency or deficiency in the hypertensive population, which is consistent with global trends linking low vitamin D with cardiovascular risk.

Table 3 illustrates the relationship between serum vitamin D levels and retinopathy, showing that patients with levels below 20 ng/dl were disproportionately affected by hypertensive retinopathy, while those with sufficient vitamin D (>30 ng/dl) had much lower rates of retinopathy, suggesting a possible protective role of vitamin D against microvascular complications.

Table 4 demonstrates the association between serum vitamin D levels and nephropathy, where patients with levels <20 ng/dl showed a notably higher prevalence of hypertensive nephropathy, whereas those with higher vitamin D levels were largely free of kidney involvement, highlighting the importance of vitamin D in renal protection.

Table 5 summarizes the relationship between serum vitamin D levels and left ventricular hypertrophy (LVH), showing that the prevalence of LVH was highest among those with vitamin D

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deficiency and progressively lower in those with sufficient vitamin D, suggesting that vitamin D status may influence cardiac remodeling and the development of hypertensive heart disease.

**Table 1: Distribution of study population according to their age groups**

| Age groups (years) | Male | Female | Total |
|---|---|---|---|
| 26–30 | 6 | 4 | 10 |
| 31–35 | 7 | 7 | 14 |
| 36–40 | 18 | 15 | 33 |
| 41–45 | 22 | 12 | 34 |
| 46–50 | 19 | 7 | 26 |
| 51–55 | 4 | 2 | 6 |
| 56–60 | 4 | 3 | 7 |
| Total | 80 | 50 | 130 |

**Table 2: Distribution of study population according to serum Vitamin D levels**

| Serum Vitamin D | Number of cases | Percentage |
|---|---|---|
| <10 ng/dl | 15 | 11.5% |
| 11–20 ng/dl | 58 | 44.6% |
| 21–30 ng/dl | 27 | 20.8% |
| >30 ng/dl | 30 | 23.1% |
| Total | 130 | 100% |

**Table 3: Serum Vitamin D level and retinopathy**

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| Serum Vitamin D | Retinopathy Present | Retinopathy Absent |
|---|---|---|
| <10 ng/dl | 10 | 5 |
| 10–20 ng/dl | 28 | 30 |
| 20–30 ng/dl | 5 | 22 |
| >30 ng/dl | 3 | 27 |
| Total | 46 | 84 |

**Table 4: Serum Vitamin D level and nephropathy**

| Serum Vitamin D | Nephropathy Present | Nephropathy Absent |
|---|---|---|
| <10 ng/dl | 10 | 5 |
| 10–20 ng/dl | 26 | 32 |
| 20–30 ng/dl | 3 | 24 |
| >30 ng/dl | 4 | 26 |
| Total | 43 | 87 |

**Table 5: Serum Vitamin D level and left ventricular hypertrophy**

| Serum Vitamin D | LVH Present | LVH Absent |
|---|---|---|
| <10 ng/dl | 9 | 6 |
| 10–20 ng/dl | 25 | 33 |
| 20–30 ng/dl | 4 | 23 |
| >30 ng/dl | 3 | 27 |
| Total | 41 | 89 |

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**Discussion**

This study aimed to estimate serum vitamin D levels in patients with essential hypertension and evaluate its association with hypertension-related complications such as retinopathy, nephropathy, and left ventricular hypertrophy (LVH). Our findings highlight a significant prevalence of vitamin D deficiency among hypertensive individuals and a clear link between lower vitamin D levels and hypertension-related target organ damage.

Vitamin D deficiency was observed in nearly 56% of the study population, with most patients falling in the <20 ng/dl range. This aligns with global reports indicating widespread vitamin D deficiency among hypertensive populations and the general public (11). The high prevalence of deficiency in our hypertensive cohort underscores the need for routine screening of vitamin D levels in these patients.

We observed that retinopathy was more common in patients with serum vitamin D levels below 20 ng/dl, consistent with previous reports suggesting that vitamin D's anti-inflammatory and vasoprotective effects may help reduce retinal microvascular damage (12). Similarly, nephropathy was significantly more frequent in vitamin D-deficient patients, supporting evidence that vitamin D plays a role in modulating the renin-angiotensin-aldosterone system (RAAS), improving glomerular function, and protecting against kidney damage (13,14).

Left ventricular hypertrophy, a marker of cardiac end-organ damage in hypertension, was also more common in the vitamin D-deficient group. Prior studies have suggested that vitamin D may influence myocardial remodeling by modulating myocardial calcium influx, collagen deposition, and inflammatory processes (15). Our findings support this hypothesis and highlight the potential cardioprotective role of adequate vitamin D levels.

While some interventional trials have reported mixed results on the benefits of vitamin D supplementation in lowering blood pressure, several studies have shown that maintaining sufficient vitamin D levels may help prevent the progression of hypertension-related complications (16,17). This suggests that even if vitamin D supplementation does not dramatically lower blood pressure, it may offer valuable protective effects on target organs.

Limitations of our study include its observational design and relatively small sample size, which limit causal inference. Larger multicenter trials are needed to confirm these associations and evaluate the potential benefits of vitamin D supplementation in hypertensive patients (18).

**Conclusion**

In conclusion, this study demonstrates a high prevalence of vitamin D deficiency among patients with essential hypertension and a significant association between low vitamin D levels and complications such as retinopathy, nephropathy, and left ventricular hypertrophy. These findings emphasize the importance of assessing and correcting vitamin D deficiency in hypertensive individuals as part of a comprehensive cardiovascular risk management strategy. Addressing vitamin D deficiency may offer an additional, non-pharmacologic approach to reducing hypertension-related complications and improving overall patient outcomes.

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