

Vitamin D: A Bridging Element for Wellness; A Case Study on Vitamin D Deficiency and its Association with Alopecia Areata and Other Conditions

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ABSTRACT

Vitamin D deficiency is a growing health concern linked to various conditions, including bone disorders, muscle weakness, and neuropsychiatric symptoms. Deficiency is also associated with dermatological conditions like alopecia areata. This study explores the connection between vitamin D deficiency and alopecia areata, while reviewing its broader health impact. This is a case about a 22-year-old female with sudden hair loss, fatigue, and widespread pain was diagnosed with alopecia areata after testing revealed a vitamin D level of 9.8 ng/mL. She was treated with corticosteroid ointments and monthly vitamin D injections. Vitamin D deficiency affects multiple body systems and is associated with conditions like alopecia areata. Early diagnosis and appropriate management, including supplementation and lifestyle changes, are crucial to prevent long-term health complications.

Keywords: vitamin D, alopecia areata, bone health, emotions.

INTRODUCTION

Vitamin D deficiency has been a rising issue in today's world driven by factors such as reduced sun exposure, age, dietary limitations and lifestyle changes. Vitamin D is vital for various bodily functions, particularly in bone health, immune function, and cellular processes. Many genes encoding proteins that regulate cell proliferation, differentiation, and apoptosis are modulated in part by vitamin D. The recommended daily intake of vitamin d varies by age and with general guidelines suggesting about 600 to 800 IU for most adults.[1] However some adults might need a higher dosage, especially those who are older, pregnant or have certain health conditions that impair the absorption of vitamin D. The deficiency has its

traditional range of symptoms such as osteoporosis in older adults condition where bones become weak and brittle or we have increased risk of infections , muscle weakness , some chronic conditions such as cardiovascular diseases and in children as a result of prolonged deficiency we can see rickets a condition that leads to weakening of bones[2].Some other rare and severe vitamin D deficiency can be manifested through a diverse range of symptoms that often remain unrecognised until substantial impairment occurs. Dermatological conditions such as hair loss and alopecia areata, systemic issues like fatigue, generalised body pain, and muscle weakness, and neuropsychiatric symptoms, including anxiety, depression, and lack of motivation, are increasingly

being linked to insufficient vitamin D levels.[1] Given the far-reaching effects of vitamin D deficiency, it is crucial to address this issue through early detection and management. The most common means of management of vitamin D are vitamin D supplementation, dietary modification and increased sun exposure. Taking prompt action or treatment is important to reduce the risks of more serious health problems.[2]

CASE PRESENTATION

A 22-year-old female presents to the outpatient clinic with a sudden onset of 5 well-defined patches of hair loss over the past 2 weeks (fig.1). The patches, which range in size from 1 to 3 cm in diameter, are located on the scalp but are not associated with any redness, scaling, or scarring. She notes the hair loss has been progressive, and she first noticed the patches without any preceding trauma or other obvious cause. She also reports feeling increasingly fatigued and "low," with a general lack of energy and motivation over the same time period. In addition to the hair loss, the patient describes widespread body pain, particularly in her back, shoulders, and legs. She was suggested to do CBC, thyroid function and Vitamin D analysis. Her reports showed a remarkably low Vitamin D of 9.8 ng/mL. She was diagnosed with Alopecia areata and was put on corticosteroid ointment on the bald patches and was given Vitamin D

(intramuscular once a month for 3 months and 50,000IU/month thereafter).

PATIENT HISTORY

The patient, a 22-year-old female, presents with sudden hair loss and body pain that have developed over the past two weeks. The pain is diffuse, non-specific, and does not seem to be related to any particular activity or injury. She notes that the discomfort is constant but worsens with stress. She also reports difficulty concentrating on her studies and says she feels emotionally "drained" and "empty." The patient's mood has been persistently low for several weeks, with anhedonia (loss of interest in previously enjoyable activities) and a sense of hopelessness. The patient denies any significant weight loss, appetite changes, or sleep disturbances, though she notes that the pain and emotional state make it difficult for her to rest fully at night. She denies any suicidal ideation or self-harm behaviors but mentions feeling "exhausted by life" and overwhelmed by daily tasks. Not currently taking any prescribed medications or over-the-counter supplements. No history of autoimmune diseases such as alopecia areata, lupus, or thyroid problems. The patient has a supportive group of friends but has been withdrawing socially due to her emotional and physical symptoms. She also has a supportive family but feels disconnected from them because of her current mood.



(Fig.1)

DISCUSSION

Vitamin D is obtained by the body in two primary ways: vitamin D3 (cholecalciferol), which is synthesized in the skin upon

exposure to ultraviolet B (UVB) radiation or obtained from animal-based dietary sources, and vitamin D2 (ergocalciferol), found in plant-based sources and fortified foods.[1][3]

When consumed through the diet, vitamin D is absorbed in the small intestine, primarily in the duodenum and jejunum. As a fat-soluble vitamin, its absorption is enhanced by the presence of dietary fat and bile acids, which emulsify fats and enable the formation of micelles.[4] Specialized intestinal cells, known as enterocytes, facilitate the incorporation of vitamin D into chylomicrons, which are then transported via the lymphatic system into the bloodstream. [6] Apart from dietary sources, vitamin D is synthesized in the skin when exposed to UVB radiation (290–315 nm). UVB rays convert 7-dehydrocholesterol, a precursor in the skin, into pre-vitamin D₃, which is then thermally isomerized into vitamin D₃. However, factors such as age, skin pigmentation, geographic latitude, and seasonal variation can significantly affect this synthesis.[1] Once in the bloodstream, vitamin D binds to vitamin D-binding protein for transport to the liver. In the liver, it undergoes hydroxylation by the enzyme 25-hydroxylase (CYP2R1), converting it to 25-hydroxyvitamin D (25(OH)D), also known as calcidiol. This is the main circulating form of vitamin D and a standard marker for assessing vitamin D status. [3] Subsequently, in the kidneys, 25(OH)D undergoes further hydroxylation by 1 α -hydroxylase (CYP27B1), producing 1,25-dihydroxyvitamin D (1,25(OH)₂D), also known as calcitriol, the biologically active form of vitamin D. This activation step is tightly regulated by parathyroid hormone (PTH), serum calcium, and phosphorus levels.[7] For instance, low calcium or phosphate levels stimulate 1 α -hydroxylase activity, while high levels inhibit it. Calcitriol exerts its effects by binding to the vitamin D receptor (VDR), a nuclear receptor present in various cells.[5] This interaction regulates gene expression, promoting the absorption of calcium and phosphorus in the intestine, enhancing renal calcium reabsorption, and mobilizing calcium from bones to maintain homeostasis. [8] Additionally, vitamin D influences immune modulation, supports muscle function, and

plays a role in cellular differentiation and proliferation.[1]

Vitamin D absorption is affected by several factors, both physiological and environmental.

Gastrointestinal disorders, such as celiac disease (a hypersensitivity of the small intestine lining leading to difficulty in digesting food), Crohn's disease (a type of inflammatory bowel disease that irritates and causes swelling in the digestive tract), and cystic fibrosis, can significantly impair the absorption of vitamin D. In these conditions, damage to the small intestine or impaired fat digestion reduces the body's ability to absorb fat-soluble vitamins, including vitamin D.[8]

Obesity is another key factor that affects vitamin D absorption. Since vitamin D is fat-soluble, it can become trapped in the adipose tissue of individuals with higher body fat percentages. This reduces the availability of vitamin D for physiological processes and makes it harder for obese individuals to maintain appropriate vitamin D levels.[2][8] As people age, their ability to produce vitamin D through sun exposure decreases due to changes in skin thickness and lower levels of 7-dehydrocholesterol, the precursor of vitamin D. Older adults also experience reduced renal function, which impairs the conversion of vitamin D into its active form, calcitriol. [8]

Liver and kidney diseases further complicate vitamin D metabolism. The liver is responsible for converting vitamin D into 25-hydroxyvitamin D, and the kidneys convert this form into its active metabolite, calcitriol. In cases of liver disease (e.g., cirrhosis) or chronic kidney disease (CKD), the ability of these organs to process vitamin D is impaired, resulting in low levels of the active form and, consequently, a higher risk of deficiency.[9]

Limited sun exposure remains one of the most common causes of vitamin D deficiency, particularly in individuals living at higher latitudes or those who spend extended periods indoors. Environmental factors such as air pollution and the use of sunscreen can also reduce UVB exposure,

further limiting the body's ability to produce vitamin D. [8][9].

Dietary insufficiency can contribute to inadequate vitamin D levels, particularly in populations that do not consume vitamin D-rich foods such as fortified dairy products, fatty fish, and eggs. Vitamin D is not abundant in many foods, and reliance on fortified foods or supplements is often necessary to meet daily requirements, especially for those who do not get adequate sunlight. [8]

Vitamin D deficiency can manifest through a wide range of symptoms, which vary in severity depending on the extent and duration of the deficiency. These symptoms are often related to its key functions in the body, including calcium regulation, bone health, immune function, and neuromuscular coordination.[8]

Hair Loss and Dermatological Issues

Vitamin D is important for regulating hair follicle cycling. Deficiency has been associated with hair loss, particularly in the form of alopecia areata, an autoimmune condition where the immune system attacks hair follicles, leading to patchy hair loss on the scalp or other parts of the body. Vitamin D plays a crucial role in transitioning hair follicles from the resting phase (telogen) to the growth phase (anagen). A deficiency disrupts this cycle, resulting in weakened or dormant hair follicles and subsequent hair thinning. In addition, vitamin D has immunomodulatory properties that help maintain immune system balance. In alopecia areata, an overactive immune response targets hair follicles, and insufficient vitamin D may exacerbate this immune dysregulation, intensifying hair loss. Furthermore, vitamin D deficiency is linked to increased inflammation and oxidative stress, both of which can damage the delicate hair follicle environment. Elevated inflammatory cytokines around hair follicles can impair their growth and sustainability. Beyond alopecia, vitamin D supports scalp health by promoting the production of antimicrobial peptides, which prevent infections and maintain a healthy scalp

environment. A deficiency in these peptides may compromise scalp integrity, exacerbating conditions like dandruff or folliculitis, which can impede hair growth.[10][11][12]

Bone Health and Osteomalacia

Vitamin D plays a crucial role in regulating calcium and phosphorus, the key minerals for bone health. A deficiency in vitamin D impairs calcium absorption in the intestine, leading to decreased blood calcium levels, which results in osteomalacia in adults - a condition where bones become soft, weak, and prone to fractures.[2] In children, prolonged vitamin D deficiency can cause rickets, characterised by bone deformities, particularly in the legs, spine, and chest.[10]

Muscle Weakness and Pain

Vitamin D deficiency affects muscle contraction, making muscles weaker and less efficient. This can lead to muscle weakness and pain. Individuals with low vitamin D levels are more likely to experience widespread musculoskeletal pain, which has been particularly noted in conditions like fibromyalgia, where vitamin D deficiency may exacerbate symptoms such as tenderness, pain, and stiffness.[2][8]

Fatigue and Generalised Weakness

Vitamin D plays a role in mitochondrial function, which is crucial for cellular energy production. Mitochondria are the energy powerhouses of cells, and vitamin D enhances their function. Low levels of vitamin D may reduce energy production, leading to fatigue. Deficiency also elevates pro-inflammatory cytokines, contributing to chronic fatigue.[8]

Increased Risk of Infection

Vitamin D is vital for the immune system, enhancing the pathogen-fighting effects of immune cells like macrophages and dendritic cells, which help defend the body against infections. Deficiency has been associated with an increased risk of chronic infections, such as respiratory infections, including the flu and pneumonia.[2] Individuals with low vitamin D levels are more susceptible to these infections, and their recovery may be slower. Vitamin D deficiency can also

exacerbate autoimmune conditions, such as rheumatoid arthritis.[9]

Cognitive and Psychiatric Symptoms

Research has established a link between vitamin D deficiency and neuropsychiatric symptoms, including depression, anxiety, and mood swings. The active form of vitamin D, calcitriol, influences brain function by regulating neurotransmitters and reducing inflammation in the brain. Deficiency disrupts these processes, leading to cognitive impairments such as difficulty concentrating, memory problems, and feelings of irritability or anxiety.[9] Vitamin D receptors are widespread in the brain, particularly in areas responsible for mood regulation, such as the hippocampus. Deficiency disrupts serotonin synthesis, a neurotransmitter key to mood stabilisation, and increases neuroinflammatory processes, both of which may contribute to depression and anxiety. Severe deficiency has even been linked to an increased risk of dementia and Alzheimer's disease, particularly in older adults.[8]

Management of Vitamin D Deficiency

The management of vitamin D deficiency primarily involves increasing vitamin D levels through supplementation, dietary changes, and sun exposure. Vitamin D supplements are commonly prescribed, especially for individuals with severe deficiency or those at higher risk, such as the elderly, pregnant women, and individuals with gastrointestinal disorders that impair absorption.[1] The typical dosage for supplementation ranges from 800 to 2,000 IU per day, depending on the severity of the deficiency and the individual's health status. [8] Dietary modifications are another key aspect of managing vitamin D deficiency. Foods rich in vitamin D, such as fatty fish (e.g., salmon, mackerel), fortified dairy products, eggs, and mushrooms, should be included in the diet to boost intake.[1] For those who have difficulty obtaining adequate amounts of vitamin D through food alone, supplementation is often recommended to fill the gap. In addition to dietary changes, sun exposure is a natural way to increase vitamin

D levels.[8] Spending time outdoors in direct sunlight for about 15 to 30 minutes a few times a week can significantly help. However, factors such as skin colour, geographical location, and seasonality can affect the body's ability to produce vitamin D through sunlight. [1] It is essential to regularly monitor vitamin D levels during treatment to avoid toxicity, which can lead to hypercalcemia (high calcium levels in the blood). Adjusting the dosage of supplements based on blood tests is crucial in the management process to ensure optimal levels without risking side effects.[8]

CONCLUSION

Vitamin D plays a critical role in maintaining numerous physiological functions, including calcium and phosphorus homeostasis, bone health, immune system modulation, muscle function, and mental health. Its absorption and metabolism are complex processes that depend on various factors, including dietary intake, sunlight exposure, skin characteristics, age, and the functionality of the liver and kidneys. Deficiencies in vitamin D can lead to a wide range of health problems, including hair loss (such as in alopecia areata), bone disorders (osteomalacia and rickets), muscle weakness, fatigue, increased susceptibility to infections, and cognitive and psychiatric issues like depression and anxiety.

Several conditions, such as gastrointestinal disorders, obesity, and age-related changes, can impair vitamin D absorption and activation, putting individuals at higher risk of deficiency. Additionally, environmental factors, such as limited sun exposure or inadequate dietary intake, contribute to widespread vitamin D deficiency across various populations.

The management of vitamin D deficiency involves a multifaceted approach, including supplementation, dietary adjustments, and adequate sun exposure. While supplementation with vitamin D is crucial for individuals with severe deficiency or those at risk, it is important to monitor levels regularly to prevent toxicity. A balanced

approach, involving both lifestyle modifications and medical intervention, can help restore optimal vitamin D levels, mitigating the potential health complications associated with deficiency.

Ultimately, addressing vitamin D deficiency is essential for promoting overall health, enhancing immune function, improving bone integrity, supporting muscle strength, and stabilising mood, thus contributing to a better quality of life.

Declaration by Authors

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