

World Journal of *Clinical Oncology*

World J Clin Oncol 2024 February 24; 15(2): 165-359



Contents

Monthly Volume 15 Number 2 February 24, 2024

EDITORIAL

- 165 Circulating tumor cells as prognostic marker in pancreatic cancer
Yakar M, Etiz D
- 169 Unlocking the potential-vitamin D in prostate cancer prevention
Cassell A, Konneh S
- 175 TM9SF1 is implicated in promoting the proliferation and invasion of bladder cancer cells
Zhou SQ, Luo LX

REVIEW

- 178 Updates on management of gliomas in the molecular age
Mohamed AA, Alshaibi R, Faragalla S, Mohamed Y, Lucke-Wold B

MINIREVIEWS

- 195 Deregulation of interferon-gamma receptor 1 expression and its implications for lung adenocarcinoma progression
Tecalco-Cruz AC, Medina-Abreu KH, Oropeza-Martínez E, Zepeda-Cervantes J, Vázquez-Macías A, Macías-Silva M

ORIGINAL ARTICLE

Clinical and Translational Research

- 208 Elucidating the molecular basis of ATP-induced cell death in breast cancer: Construction of a robust prognostic model
Zhang HL, Doblin S, Zhang ZW, Song ZJ, Dinesh B, Tabana Y, Saad DS, Adam Ahmed Adam M, Wang Y, Wang W, Zhang HL, Wu S, Zhao R, Khaled B
- 243 Identification of immune cell-related prognostic genes characterized by a distinct microenvironment in hepatocellular carcinoma
Li MT, Zheng KF, Qiu YE
- Retrospective Study
- 271 Population-based X-ray gastric cancer screening in Hiroshima prefecture, Japan
Vu NTH, Urabe Y, Quach DT, Oka S, Hiyama T
- 282 Endoscopic resection for calcifying fibrous tumors of the gastrointestinal tract
Geng ZH, Zhu Y, Fu PY, Qu YF, Chen SY, Zhong YS, Zhang YQ, Chen WF, Qin WZ, Hu JW, Cai MY, Yao LQ, Li QL, Zhou PH

Observational Study

- 290 Prevalence, risk factors, and BRAF mutation of colorectal sessile serrated lesions among Vietnamese patients
Vu NTH, Le HM, Vo DTN, Vu HA, Le NQ, Ho DDQ, Quach DT

Basic Study

- 302 TM9SF1 promotes bladder cancer cell growth and infiltration
Wei L, Wang SS, Huang ZG, He RQ, Luo JY, Li B, Cheng JW, Wu KJ, Zhou YH, Liu S, Li SH, Chen G
- 317 Limonin inhibits the stemness of cancer stem-like cells derived from colorectal carcinoma cells potentially via blocking STAT3 signaling
Zhang WF, Ruan CW, Wu JB, Wu GL, Wang XG, Chen HJ

META-ANALYSIS

- 329 Identification and validation of a pyroptosis-related prognostic model for colorectal cancer based on bulk and single-cell RNA sequencing data
Zhu LH, Yang J, Zhang YF, Yan L, Lin WR, Liu WQ

LETTER TO THE EDITOR

- 356 Bridging the gap: Predicting brain metastasis in breast cancer
Gonsalves D, Ciérvidé R, Couñago F

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The primary aim of *World Journal of Clinical Oncology* (WJCO, *World J Clin Oncol*) is to provide scholars and readers from various fields of oncology with a platform to publish high-quality basic and clinical research articles and communicate their research findings online.

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INDEXING/ABSTRACTING

The WJCO is now abstracted and indexed in PubMed, PubMed Central, Emerging Sources Citation Index (Web of Science), Reference Citation Analysis, China Science and Technology Journal Database, and Superstar Journals Database. The 2023 Edition of Journal Citation Reports® cites the 2022 impact factor (IF) for WJCO as 2.8; IF without journal self cites: 2.8; 5-year IF: 3.0; Journal Citation Indicator: 0.36.

RESPONSIBLE EDITORS FOR THIS ISSUE

Production Editor: Xiang-Di Zhang; Production Department Director: Xu Guo; Editorial Office Director: Xu Guo.

NAME OF JOURNAL

World Journal of Clinical Oncology

ISSN

ISSN 2218-4333 (online)

LAUNCH DATE

November 10, 2010

FREQUENCY

Monthly

EDITORS-IN-CHIEF

Hiten RH Patel, Stephen Safe, Jian-Hua Mao, Ken H Young

EDITORIAL BOARD MEMBERS

<https://www.wjgnet.com/2218-4333/editorialboard.htm>

PUBLICATION DATE

February 24, 2024

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INSTRUCTIONS TO AUTHORS

<https://www.wjgnet.com/bpg/gerinfo/204>

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PUBLICATION ETHICS

<https://www.wjgnet.com/bpg/GerInfo/288>

PUBLICATION MISCONDUCT

<https://www.wjgnet.com/bpg/gerinfo/208>

ARTICLE PROCESSING CHARGE

<https://www.wjgnet.com/bpg/gerinfo/242>

STEPS FOR SUBMITTING MANUSCRIPTS

<https://www.wjgnet.com/bpg/GerInfo/239>

ONLINE SUBMISSION

<https://www.f6publishing.com>



Unlocking the potential-vitamin D in prostate cancer prevention

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Specialty type: Oncology

Provenance and peer review:

Invited article; Externally peer reviewed.

Peer-review model: Single blind

Peer-review report's scientific quality classification

Grade A (Excellent): 0

Grade B (Very good): B

Grade C (Good): 0

Grade D (Fair): 0

Grade E (Poor): 0

P-Reviewer: Liu XL, China

Received: December 3, 2023

Peer-review started: December 3, 2023

First decision: December 18, 2023

Revised: December 19, 2023

Accepted: January 24, 2024

Article in press: January 24, 2024

Published online: February 24, 2024



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Abstract

Prostate cancer poses a significant health challenge globally, demanding proactive prevention strategies. This editorial explores the emerging role of vitamin D in prostate cancer prevention. While traditionally associated with bone health, vitamin D is increasingly recognized for its broader impact on immune function, cellular signaling, and cancer prevention. Epidemiological studies suggest an intriguing link between vitamin D deficiency and elevated prostate cancer risk, particularly in regions with limited sunlight exposure. Mechanistically, vitamin D regulates cellular processes, inhibiting unchecked cancer cell growth and bolstering immune surveillance. Personalized prevention strategies, considering individual factors, are deemed essential for harnessing the full potential of vitamin D. To unlock this potential, the future calls for robust research, public awareness campaigns, dietary improvements, and vigilant medical guidance. Collaborative efforts are poised to pave the way toward a future where vitamin D stands as a sentinel in prostate cancer prevention, ushering in hope and improved health for men worldwide.

Key Words: Cell; Cholecalciferol; Prevention; Prostate cancer; Vitamin D

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Core Tip: This editorial highlights the evolving role of vitamin D in prostate cancer prevention, going beyond its traditional association with bone health. Emerging evidence suggests a link between vitamin D deficiency and increased prostate cancer risk, especially in regions with limited sunlight exposure. Mechanistically, vitamin D regulates cellular processes, inhibiting cancer cell growth and enhancing immune surveillance. To unlock its full potential, personalized prevention strategies are crucial. Robust research, public awareness, dietary improvements, and vigilant medical guidance are essential components. Collaborative efforts aim to position vitamin D as a sentinel in prostate cancer prevention, offering hope and improved health for men globally.

Citation: Cassell A, Konneh S. Unlocking the potential-vitamin D in prostate cancer prevention. *World J Clin Oncol* 2024; 15(2): 169-174

URL: <https://www.wjgnet.com/2218-4333/full/v15/i2/169.htm>

DOI: <https://dx.doi.org/10.5306/wjco.v15.i2.169>

INTRODUCTION

Prostate cancer, a prevalent urological malignancy, poses a significant health burden globally, particularly in developed nations. In 2020, it accounted for a substantial share of cancer cases and deaths among males, contributing to 14.1% and 6.8%, respectively[1]. The sheer magnitude of the impact is evident in the staggering number of 1414259 new cases and 375304 deaths attributed to prostate cancer in the year 2020 alone.

The Age-Standardized Rate of incidence globally was at 30.7 per 100000 persons, unveiling a notable 13-fold variation across different regions[1]. This variability underscores the complex interplay of factors influencing the incidence of prostate cancer, from genetic predispositions to environmental influences.

Prostate cancer, a formidable adversary in the realm of men's health, demands our unwavering attention. In the quest for effective prevention, an unlikely hero has emerged-vitamin D. This unassuming nutrient, long associated with bone health, is now revealing its hidden potential as a guardian against prostate cancer.

Vitamin is performing the magic trick and the scientific community is hoping that this nutrient can assume a more robust role in the prevention of prostate cancer.

In this editorial, we embark on a journey to explore the evolving landscape of vitamin D in prostate cancer prevention, unveiling its promise and the work yet to be done (Figure 1).

THE VITAMIN D REVOLUTION

Vitamin D, commonly dubbed the "sunshine vitamin," has long held its place in the annals of nutritional science. It regulates calcium and phosphorus metabolism, crucial for skeletal health. However, its influence extends far beyond bones, penetrating the intricate realms of the immune system, cell signaling, and cancer prevention.

Vitamin D compounds constitute integral elements of the vitamin D hormone system, and their synthesis in the body is a complex process initiated in the skin under ultraviolet light influence. Unlike traditional vitamins, vitamin D is intricately linked to a series of steps, commencing with the conversion of a cholesterol precursor molecule (7-dehydrocholesterol) into cholecalciferol (vitamin D₃). This synthesis continues with successive hydroxylations in the liver and kidney, ultimately producing the most active hormone form, 1,25-dihydroxycholecalciferol or calcitriol.

The metabolic journey of vitamin D involves crucial enzymatic processes, primarily facilitated by cytochrome P450 (CYP) enzymes CYP11, CYP27B1, and CYP24A1[2]. Liver and kidneys serve as major organs for metabolism and excretion, but notably, various tissues, including tumor cells and microenvironment cells, also partake in the metabolism of these hormones. This intricate interplay highlights the multifaceted nature of vitamin D metabolism, extending its impact beyond traditional metabolic organs.

A MECHANISTIC MARVEL

Vitamin D's potential in prostate cancer prevention is grounded in its ability to regulate fundamental cellular processes. It influences cell proliferation, apoptosis (programmed cell death), and angiogenesis (the formation of new blood vessels). These actions collectively thwart the unchecked growth and spread of malignant cells.

Furthermore, vitamin D plays a pivotal role in immune modulation, potentially enhancing the body's ability to identify and combat cancerous cells. These mechanisms are complex, reinforcing the need for rigorous scientific exploration.

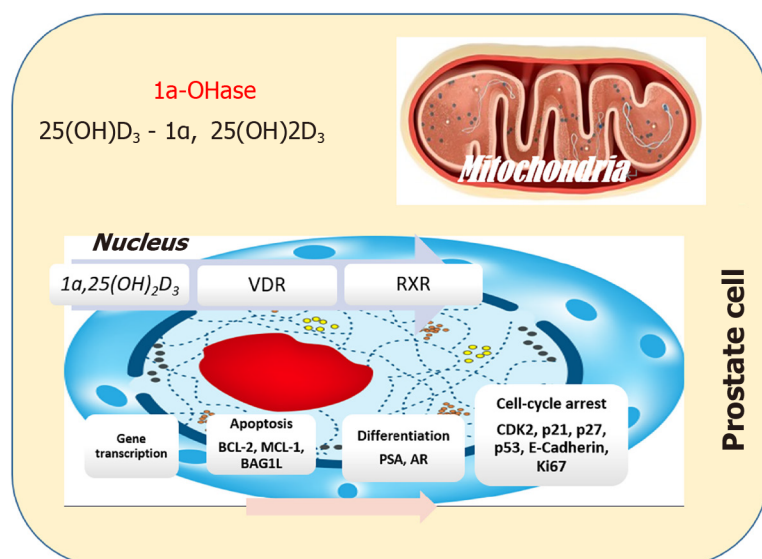


Figure 1 Illustrates the mechanism of vitamin D₃ activity in prostate cells. Both 25-hydroxyvitamin D₃ [25(OH)D₃] and 1α,25-dihydroxyvitamin D₃ [1α,25(OH)₂D₃] enter the cells. Within the mitochondria, 25(OH)D₃ is transformed into 1α,25(OH)₂D₃ by an enzyme called 25(OH)D-1α-hydroxylase (1α-OHase). When 1α,25(OH)₂D₃ binds to the vitamin D receptor (VDR), the VDR forms a complex with the retinoid X receptor. This complex then attaches to specific vitamin D-response elements in the promoter region of genes responsive to vitamin D₃, leading to the activation of gene transcription. VDR: vitamin D receptor; RXR: retinoid X receptor.

DECODING VITAMIN D'S IMPACT: UNVEILING THE MECHANISM IN PROSTATE CANCER CELLS

The inhibitory influence of vitamin D on prostate cell proliferation operates through the vitamin D Receptor (VDR), a member of the steroid/nuclear receptor superfamily. Within target cells, VDR forms a high-affinity bond with 1α,25(OH)₂D and subsequently engages with the retinoid X receptor [3]. This collaborative partnership forms a heterodimeric complex equipped with distinctive zinc-finger motifs. These motifs strategically attach to a specific DNA-sequence motif known as a vitamin D-response element residing in the promoter region of vitamin D-regulated genes [3]. The orchestrated interplay within this complex regulates the pace of RNA polymerase II-mediated transcription for these genes, finely tuning the cellular processes impacted by vitamin D in prostate cancer cells.

NAVIGATING THE COMPLEX TERRAIN: UNRAVELING 1α,25(OH)₂D'S ANTIPROLIFERATIVE ACTIONS

The intricacies of how 1α,25(OH)₂D transmits signals to impede proliferation in prostate cells remain a puzzle with evolving facets. Recent investigations hint at the likelihood that 1α,25(OH)₂D might engage diverse pathways, exerting its inhibitory effects on cell proliferation in a cell-type-dependent manner [4]. For instance, androgen-sensitive prostate-cancer cells like LNCaP exhibit a notable accumulation in the G0-G1 phase of the cell cycle upon 1α,25(OH)₂D₃ treatment. In contrast, the same treatment induces growth inhibition in ALVA-31 and PC-3 cells without eliciting a comparable cell cycle phase accumulation. This nuanced understanding underscores the multifaceted nature of 1α,25(OH)₂D's impact on cell proliferation across distinct prostate cell types [4].

UNLOCKING THE DOOR TO PROSTATE CELL FATE: 1α,25(OH)₂D'S APOPTOTIC INDUCTION (CHEN TC)

In certain experimental scenarios, 1α,25(OH)₂D emerges as a catalyst for apoptosis in LNCaP cells, shedding light on potential therapeutic avenues. Employing the TUNEL assay in tandem with flow cytometric analysis, Blutt *et al* [5] demonstrated DNA fragmentation indicative of apoptosis upon exposing LNCaP cells to 1α,25(OH)₂D₃ [5]. This apoptotic cascade is intricately linked to the downregulation of antiapoptotic proteins, including Bcl2 and BclXL. Interestingly, overexpression of the Bcl2-encoding gene proved effective in preventing this process. Moreover, 1α,25(OH)₂D₃ orchestrates the downregulation of additional antiapoptotic players (Mcl-1, BAG1L, XIAP, cIAP1, and cIAP2) in LNCaP cells, while leaving proapoptotic Bax and Bak levels unaltered [6]. This nuanced orchestration suggests a promising avenue for targeted interventions in modulating apoptotic responses in prostate cells.

EPIDEMIOLOGICAL ENIGMA

Epidemiological studies have long tantalized us with hints of a connection between vitamin D and prostate cancer. Regions with limited sunlight exposure, leading to decreased vitamin D synthesis, often correlate with higher prostate cancer incidence. Similarly, individuals with lower vitamin D levels in their blood have been found to be at an elevated risk. These observations, while intriguing, begged the question: Could vitamin D truly be a sentinel against prostate cancer?

Compelling evidence linking vitamin D to prostate cancer unfolds in studies focused on African-American men. These individuals often exhibit low levels of 25(OH)D₃, attributed primarily to the impact of skin pigmentation limiting vitamin D synthesis. Intriguingly, this demographic faces a notably higher risk of prostate cancer and mortality compared to their Caucasian counterparts. While this correlation has been repeatedly observed, the underlying mechanisms remain elusive [2].

Access to medical care disparities among African-American men emerges as a significant contributing factor to their unfavorable cancer outcomes. If diminished serum levels of 25(OH)D₃ indeed contribute to heightened cancer risks, exploring potential associations between different cancer risks or outcomes and vitamin D-metabolizing genes, and even vitamin D-binding protein, becomes a logical avenue for investigation. Unraveling these intricacies could provide valuable insights into the complex interplay between vitamin D and prostate cancer in specific demographic contexts.

A nationwide, randomized, placebo-controlled trial involving men aged 50 or older in the United States [7]. The primary endpoints were invasive cancer and major cardiovascular events, with secondary endpoints including site-specific cancers and additional cardiovascular events. The results showed that vitamin D supplementation did not lower the risk of invasive cancer or cardiovascular events compared to the placebo. However, the rate of death from cancer was significantly lower with vitamin D than with placebo after 2 years of follow-up).

Novel data have revealed an intriguing relationship between 25(OH)D concentration and cancer [8]. The findings indicated a moderate inverse association with total cancer incidence and a more pronounced inverse association with cancer mortality. Interestingly, it suggests that vitamin D might play a more robust role in supporting survival and improving outcomes rather than solely decreasing cancer incidence.

One noteworthy United States study revealed a negative correlation between serum 1,25 vitamin D₃ and prostate cancer, particularly in men above the median age of 57 years [9]. A Finnish study, spanning 13 years and involving approximately 19000 men, discovered that lower serum 25(OH)D₃ concentrations were associated with a heightened risk of earlier and more aggressive onset of prostate cancer [10].

Furthermore, more recent reports with follow-up periods of 18 years and a median time of 44 months [11] suggested that individuals with circulating 25(OH)D₃ and 1,25(OH)₂D₃, or 25(OH)D₃ alone, at median or higher-than-medium levels exhibited a reduced risk of prostate cancer progression.

Data has shown that engaging in active surveillance coupled with a daily vitamin D₃ supplementation of 4000 IU demonstrated a notable reduction in the number of positive cores during repeat biopsy for over half of individuals diagnosed with low-risk prostate cancer [12]. This promising regimen not only addresses the specific needs of patients with low-risk prostate cancer but also holds the potential to minimize the likelihood of overtreatment for those who, based on repeat biopsy results, exhibit positive responses and maintain stability or improvement in their condition.

Despite these findings, it is crucial to acknowledge the inconsistent nature of the existing research, emphasizing the need for further exploration and comprehensive studies to establish a clearer understanding of the relationship between vitamin D levels and prostate cancer risk reduction.

PERSONALIZED PREVENTION

The road to harnessing the full potential of vitamin D in prostate cancer prevention is paved with complexity. Individual variations in genetics, diet, sunlight exposure, and geographical location contribute to one's vitamin D status. A one-size-fits-all approach falls short in this nuanced arena. Personalized strategies that consider these factors are paramount.

A VISION FOR THE FUTURE

To unlock the potential of vitamin D in prostate cancer prevention, we must set a course guided by science, public health, and individual empowerment:

Research excellence

Continued research into the intricate interplay between vitamin D and prostate cancer is essential. Mechanistic insights and clinical trials will pave the way for evidence-based recommendations.

Public awareness

Raising awareness about the importance of maintaining optimal vitamin D levels and prostate health is paramount. Public health campaigns can be instrumental in educating individuals and dispelling myths.

Nutrition and sun exposure

Encouraging a balanced diet rich in vitamin D and safe sun exposure practices can empower individuals to take control of their health.

Medical guidance

Healthcare providers must be vigilant in assessing and addressing vitamin D deficiency, particularly in individuals at risk. Routine prostate cancer screenings can catch the disease in its early stages.

CONCLUSION

The evolving narrative of vitamin D in prostate cancer prevention beckons us to explore the untapped potential of a humble nutrient. As we embark on this journey, we must heed the call for rigorous research, individual empowerment, and public health enlightenment. Though, vitamin may not uprightly reduce the risk of prostate cancer, it has been shown to be effective in preventing disease progression.

Together, with collaborative efforts from the scientific community, healthcare providers, policymakers, and the public, we can hope for a future where prostate cancer's grip on men's lives is loosened, and where the promise of vitamin D is fully realized. In this vision, we find renewed determination to embrace the dawn of vitamin D as a sentinel in prostate cancer prevention, ushering in a new era of hope and health.

ACKNOWLEDGEMENTS

Special thanks to the department of surgery of the John F Kennedy Medical Center.

FOOTNOTES

Author contributions: Cassell A and Konneh S have equally contributed to the drafting and design of this manuscript; All authors have read and approve the manuscript.

Conflict-of-interest statement: All the authors report no relevant conflicts of interest for this article.

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S-Editor: Li L

L-Editor: A

P-Editor: Yu HG

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