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Vitamin D supplementation and photodynamic therapy

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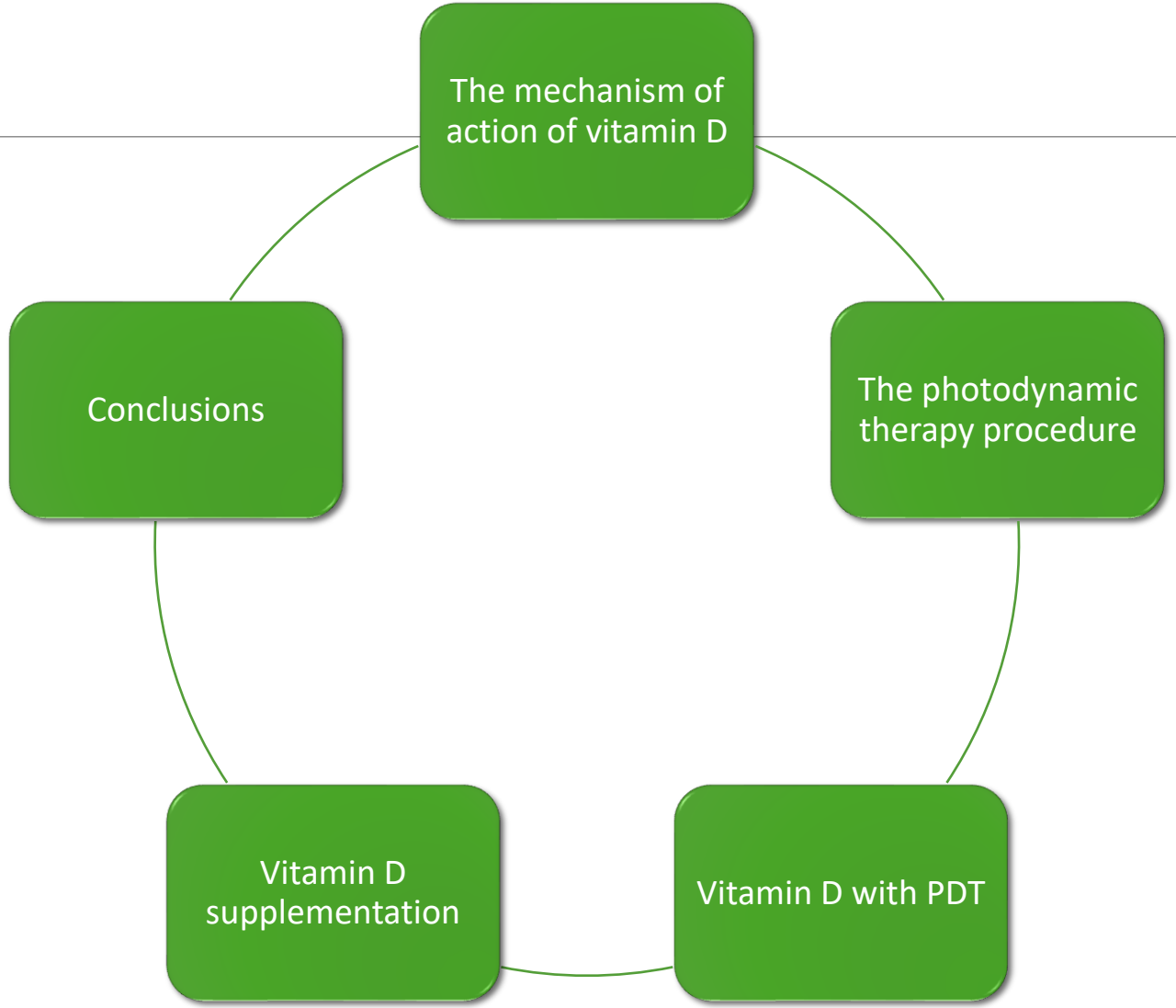

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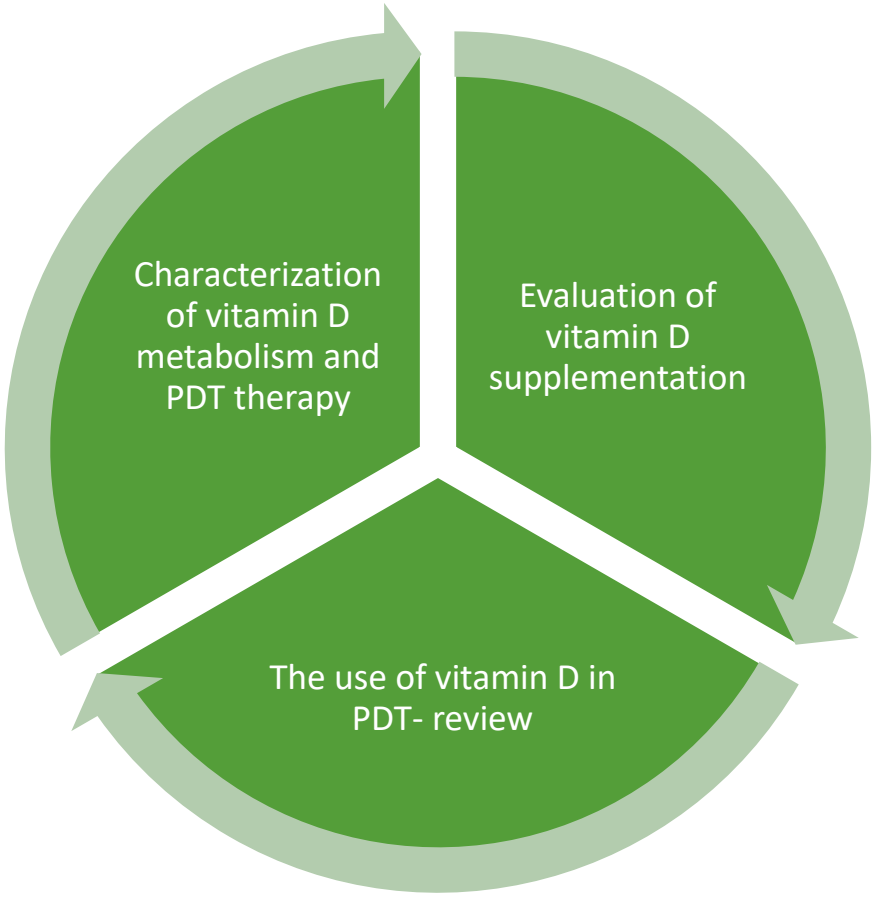
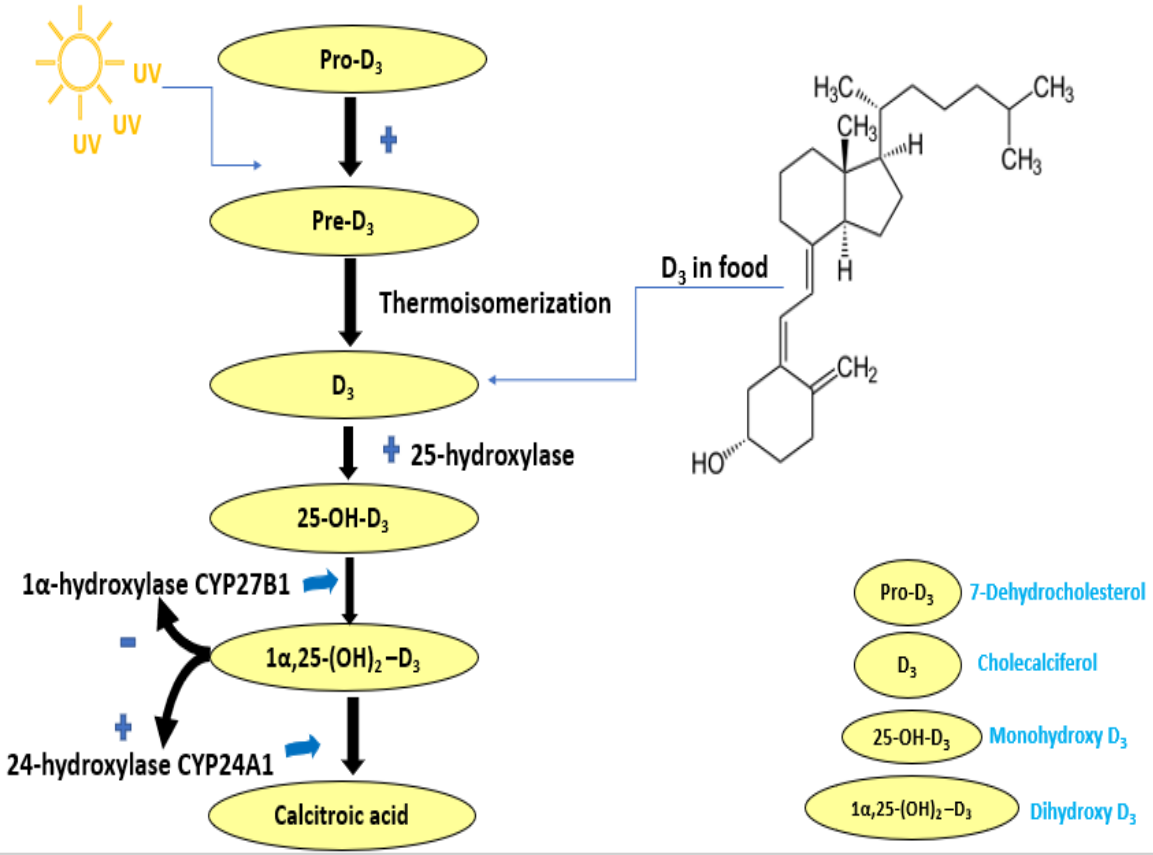

Characterization of vitamin D metabolism and PDT therapy
Evaluation of vitamin D supplementation
The use of vitamin D in PDT- review

The mechanism of action of vitamin D and metabolic pathway for the synthesis of vitamin D3

- Vitamin D is a fat-soluble vitamin that has a significant impact on human functioning and health.
- Vitamin D represents a group of compounds including cholecalciferol (vitamin D_3) and ergocalciferol (vitamin D_2).
- Vitamin D is synthesized in human skin from 7-dehydrocholesterol on contact with ultraviolet light (UVB) and vitamin D_3 activation occurs in two steps.
- First, there is production of 25-hydroxyvitamin D_3 [25 (OH) D_3] and 1α-hydroxylation by cytochrome CYP27B1, followed by the production of active 1α, 25-dihydroxyvitamin D_3 [1.25 $(OH)_2D_3$].



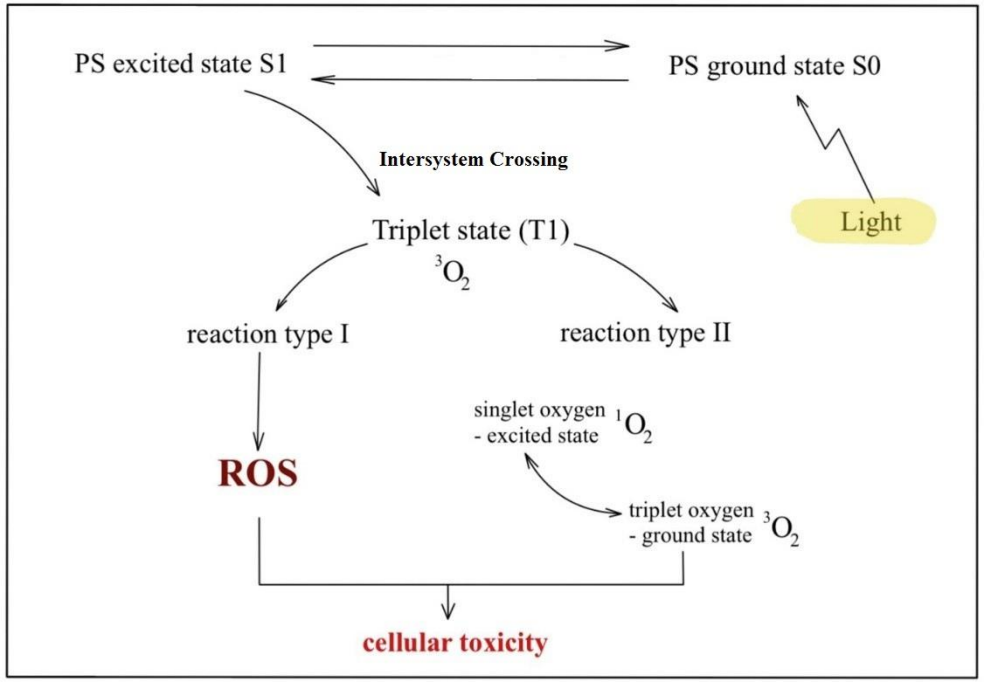
The photodynamic therapy procedure

As a result of the absorption of light (photons) by the ground state photosensitizer (PS), one electron is transferred to a higher-energy orbital, and the photosensitizer reaches the excited singlet state.

After the intersystem crossing, the triplet state PS can react in two ways: reacting with biomolecules or oxygen itself via electron transfer to form reactive oxygen species (ROS).

Both types of reactions result in cellular cytotoxicity that destroys neoplastic cells. Singlet oxygen is capable of oxidizing biological molecules and macromolecules and is considered to be the main cytotoxic factor associated with PDT.

The photosensitizer can also take part in the reactions that cause cellular damage through the formation of radicals. It is speculated that both processes eventually lead to programmed cell death or apoptosis.



Mechanism of action of PDT

Vitamin D with PDT

- Pre-treatment with vitamin D promotes cell differentiation and leads to the selective accumulation of target porphyrins (mainly protoporphyrin IX) within the diseased tissue;
- Vitamin D induces the synthesis of the photosensitizer used and stimulates the proliferation and differentiation of neoplastic cells.
- Treatment of lesions with vitamin D leads to an increased activity of the haem synthesis pathway. Which leads to an increased production of free radicals, and thus to a faster initiation of the apoptosis process.
- Vitamin D is a so-called biological PDT enhancer. It enhances photodynamic cell death through alternative pathways (e.g. necrosis).

Vitamin D supplementation

Poland	China	Brazil
In Poland, 15.1% of adults aged 46 ± 14.1 years from northern Poland had serum 25 (OH) D concentration ≥30 ng / ml among 180 women and 124 men enrolled in the study.	In China, a study of 10,696 children and adolescents aged 6 to 18 years showed that 30% of them were deficient in vitamin D (<30 nmol / L) and 80% had insufficient levels of 25 (OH) D (<50) nmol / l).	In Brazil, 75% of elderly patients were deficient in vitamin D, and low 25 (OH) D levels strongly correlate with the risk of heart failure.
The mean concentration of 25-hydroxyvitamin D in the tested sample was 21.1 ± 9.3 ng / ml	The adjusted mean 25 (OH) D was 39.3 nmol / L for all participants, 40.7 nmol / L for boys, and 37.9 nmol / L for girls	Clinical data were collected from the elderly from August 2015 to February 2016
Reference [12]	Reference [13]	Reference [14]

In order to improve the health condition of adult and childhood patients, it is recommended to include vitamin D supplementation in the daily diet. This is important in the context of the applied and practiced PDT therapy and thus supports the functioning of the entire body.

CONCLUSIONS

1. Treatment of neoplastic and non-neoplastic lesions with the PDT method, despite its advantages, is not widely practiced.

2. In order to improve the quality of PDT research, combination therapies have been sought for several decades that will improve the PDT method by increasing its effectiveness.

   An example of such combination therapy is the use of vitamin D on lesions or diseased cells.

3. PDT in combination with vitamin D provides a more effective and selective therapeutic response. Therefore, this model of proposed therapy should be explored further in future clinical trials.

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REFERENCES

1.Nair, R.; Maseeh, A. Vitamin D: The “sunshine” vitamin. *J Pharmacol Pharmacother*. 2012, *3*, 118–126.
2.Bischoff-Ferrari, H.A. Optimal serum 25-hydroxyvitamin D levels for multiple health outcomes. *Adv Exp Med Biol*. 2008, *624*, 55–71.
3.Chesdachai, S.; Tangpricha, V. Treatment of vitamin D deficiency in cystic fibrosis. *J Steroid Biochem Mol Biol*. 2016, *164*, 36-39.
4.Malloy, P.J.; Pike, J.W.; Feldman, D. The vitamin D receptor and the syndrome of hereditary 1,25-dihydroxyvitamin D-resistant rickets. *Endocr Rev*. 1999, *20*, 156-188.
5.Gorham, E.D.; Garland, C.F.; Garland, F.C.; Grant, W.B.; Mohr, S.B.; Lipkin, M.; et al. Optimal vitamin D status for colorectal cancer prevention: a quantitative meta analysis. *Am J Prev Med*, 2007, *32*, 210-216.
6.John, E.M.; Schwartz, G.G.; Koo, J.; Van Den Berg, D.; Ingles, S.A. Sun exposure, vitamin D receptor gene polymorphisms, and risk of advanced prostate cancer. *Cancer Res*. 2005, *65*, 5470-5479.
7.Holick, M.F. Vitamin D: a millennium perspective. *J Cell Biochem*. 2003, *88*, 296-307.
8.Prosser, E.; Jones, G. Enzymes involved in the activation and inactivation of vitamin D. *Trends Biochem Sci*. 2004, *29*, 664-673.
9.Anand, S.; Rollakanti, K.R.; Horst, R.L.; Hasan, T.; Maytin, E.V. Combination of oral vitamin D3 with photodynamic therapy enhances tumor cell death in a murine model of cutaneous squamous cell carcinoma. *Photochem Photobiol*. 2014, *90*, 1126-1135.
10.Liu, Z.; Xie, F.; Xie, J.; Chen, J.; Li, Y.; Lin, Q.; Luo, F.; Yan, J. New- generation photosensitizer- anchored gold nanorods for a single near-infrared light-triggered targeted photodynamic- photothermal therapy. *Drug Deliv*. 2021, *28*, 1769-1884.
11.Bacellar, I.O.; Tsubone, T.M.; Pavani, C.; Baptista, M.S. Photodynamic efficiency: from molecular photochemistry to cell death. *Int J Mol Sci*. 2015, *16*, 20523-20559.
12.Kmie´c, P.; Sworczak, K. Vitamin D deficiency in early autumn among predominantly non-elderly, urban adults in Northern Poland (54◦ N). *Postepy Hig Med Dosw*. 2015, *69*, 918–924.
13.Li, H.; Huang, T.; Xiao, P.; Zhao, X.; Liu, J.; Cheng, H.; et al. China Child and Adolescent Cardiovascular Health (CCACH) Collaboration Group. Widespread vitamin D deficiency and its sex-specific association with adiposity in Chinese children and adolescents. *Nutrition*, 2020, *71*, 110646.
14.Porto, C.M.; Silva, V.L.; da Luz, J.S.B.; Filho, B.M.; da Silveira, V.M. Association between vitamin D deficiency and heart failure risk in the elderly. *ESC Heart Fail*. 2018, *5*, 63–74.

THANK YOU FOR YOUR ATTENTION!