Journal of Cancer and Tumor International

Volume 13, Issue 3-4, Page 85-106, 2023; Article no.JCTI.114517
ISSN: 2454-7360

Role of Nanotrace Element in Prostate Cancer an Update

Nancy Jenifer, S.E. [a*], Evelyn Rainy, J.W [a] and Janaki Velmurugan [a]

[a] Bharath Institute of Higher Education and Research, India.

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/JCTI/2023/v13i3-4246

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/114517

Review Article

Received: 25/10/2023
Accepted: 29/12/2023
Published: 31/12/2023

ABSTRACT

Recently, nanomedicine has had a great impact on drug discovery and made the way for the drug delivery system for therapeutic utility. There are many nanoscale products increasing in the research field and in the medical sector. Nanoparticle modified drugs are being developed and brought into the market for the treatment of cancer. The nanoparticle drug carrier can improve the stability of the drug by decreasing the cancerous cell and involving the drug at disease site. Essential trace elements are mostly important for the physiological and biochemical aspects in the human system. Nowadays nanotrace elements are used for the treatment of prostate cancer. In this review the venture and exploration of application of nanomedicine and the use of nanoparticles with essential trace elements will give a wide range of benefits for the treatment for prostate cancer.

Keywords: Prostate cancer; nanotrace elements; cancer; nanomedicine; diagnosis; chemotherapy.

**Corresponding author: Email: nancyjeni87@gmail.com;*

1. INTRODUCTION

Prostate cancer is one of the most common types of cancer among all types of cancer but it affects particularly in male population. Prostate cancer is the second major diagnosed cancer, ,it takes the sixth place in the cause of cancer death among all men in the world .The expected growth of prostate cancer will be almost 2.3 million new cases and causes of death will be 740 000 deaths by 2040 because of increasing population [1]. The estimation by GLOBOCAN data shows 1,276,000 cases of prostate cancer worldwide in 2018, which is same as an incidence rate of 29.3/100,000 men, and consist of 7.1% prostate cancer cases when compare to all other cancer diagnoses [2]. In previous study report the substantial international variations in long term prostate cancer incidence and mortality rates. These variation indicate the regional difference among the population and variation in genetic susceptibility in which African decent has higher risk than Asian population [3]. During the estimation for prostate cancer cases by the American Cancer Society's found about 191,930 new cases for prostate cancer in the United States for 2020 and also found 33,330 deaths rate for prostate cancer. In Australia/New Zealand (104.2/100,000), contain highest rate of prostate cancer [4]. In India the incidence rates of this cancer are constantly and rapidly increasing and the cancer projection data shows that the number of cases will double by 2020.Incidence rate of prostate cancer is 26,120 and 28,079 during the period of 2010 and 2015 [5].

There is lots of research going on for the therapeutic and diagnosis process of Prostate cancer. Recently LIMK2 inhibits or decreases the development of diseases and also changes the cancer phenotype .At the same PTM of PTEN act as a prognostic and diagnostic biomarkers for the Castration Resistant Prostate Cancer in in vivo and in cell [6]. Here p14ARF is a tumor suppressor inhibits the apoptosis in prostate cancer cell and prevent the androgen receptor activity [7]. The Blockage of FGF/MAPK shows effects of decreasing the prostate cancer along with the Androgen receptor Null phenotype [8].Human prostate cancer shows an increased de novo synthesis of fatty acid .A new metabolic metabolic function of c-Myc (Myc) has been proposed to regulate the fatty acid synthesis [9]. Here Mark Buckup fond that plectin is a regulator for prostate cancer, when compare to benign prostate tissues the metastatic human prostate cancer contain high level of plectin [10]. Here in this review current diagnostic method and tools for prostate cancer detection and trace elements are used cancer treatment and role nanotrace element in the treatment strategy for prostate cancer have been received.

1.1 Prostate Cancer Current Diagnosis

Traditionally the prostate cancer is detected by using digital rectal examination, prostate-specific antigen (PSA) blood test, Transrectal ultrasound (TRUS) guided biopsy, But recently lots of biomarker has been identified for the diagnostic process in prostate cancer.

Glycans: Glycans exhibit as a disease biomarker for prostate cancer .An alteration of glycans has been shown in the prostate cancer along with the changes in PSA glycosylation, increased sialylation and core fucosylation, increased O-GlcNacylation, the emergence of cryptic and branched N-glyans, and changes to galectins and proteoglycans [11].

Serum biomarker: 4Kscore® Test it's a serum based biomarker test detect the high grade risk in prostate cancer performed by biopsy [12]. The PCA 3 a serum based biomarker which over expressed in prostate cancer patients if level is 10 it shows the prostate cancer is positive. 4Kscore® Test is a powerful tool to perform the detection of prostate cancer in confirmatory biopsy in surveillance management. PSA is over expressed in prostate cancer patient which will indicate for the therapeutic process of prostate cancer. The rise of PSA Level also seen nonmalignant prostate disease like benign prostatic hyperplasia [13]. PHI (prostate health index) is serum based biomarker it is a strongest biomarker. When compare to other biomarker PHI has high specificity and sensitivity which use to avoid unnecessary biopsies [14]. TNF-α, sTNFR1 and IL-8 was measured in the serum sample using ELSIA kit, it gives highly significant detection of prostate cancer in men compare to PSA [15]. miRNA is a non coding RNA as regulator for gene expression at the post transcriptional level. miRNA is one of the biomarker for the detection prostate cancer .miRNA expression was predicted in prostate cancer tissue [16].

Urine biomarker: Galectin-3 an urine based biomarker for prostate cancer patients with biochemical relapse, exhibit significant low level of Galectin-3 in prostate cancer patients [17].

Exosome gene expression assay is an urine based biomarker, it is a noninvasive assay used to identify higher-grade prostate cancer in patients [18]. T2: ERG and PCA3 scores clinical-grade transcription-mediated amplification assays used to predict high-grade PCa on biopsy in urine sample with the development of serum prostate-specific antigen [19]. Sarcosine Metabolic profiling wonder full tool for the analysis of prostate cancer. In one of the diagnostic study PSA level in patient were analyzed in that the urinary sarcosine level was higher when compare to PSA level in patient with prostate cancer in negative control [20]. PCA3 (DD3) gene is a noncoding RNA usually mapped for 9q21–22 chromosome which is highly specific for prostate cancer tissue compare normal prostate tissue. Moreover PCA3 avoid unnessacary biopsies [21].

Tissue biomarker: Secernin-1 and vinculin is tissue based biomarker both will be validated by using 2D-DIGE combined with MS a powerful tool for diagnostic the protein level in prostate cancer [17]. ConfirmMDx test is a tissue based biopsy it is based on the presence and absence of GSTP1, APC or RASSF1 methylation in the biopsy tissue for the diagnosis purpose of prostate cancer [22]. Long non-coding RNAs has 200 nucleotide RNS transcript used for the diagnosis of prostate cancer. It is a tissue based new biomarker which is overexpressed in prostate cancer tissue and cancer cell compare to normal tissue [23]. Oncotype DX is a commercially available test kit detect 17 genes based on genomic prostate test score. Oncotype DX test detect both high grade and high stage at surgical pathology .Oncotype DX can detect the time to biochemical recurrence at univarible analysis [24]. Polaris is a commercially available test used to detect the expression of 31 cell-cycle progression genes. It will predict the death of prostate cancer at multivariate model. In the study after the genetic study 65% treatment recommendation changed and 40% decrease in the treatment burden, But also this study shows impact on treatment targeting [25].

PET/CT Imaging: In recent years prostate-specific membrane antigen (PSMA) with ^{68}Ga-labeled and ^{18}F-labeled PET has been proposed for the detection of prostate cancer .It is clinically approved method for prostate cancer imaging based on the detection sites nodal or distant metastases that are often occult on standard-of-care imaging [21].

Lipid quantification vibrational Raman micro spectroscopy: Lipid quatification used by Raman micro spectroscopy act as a capable biomarker for the diagnosis of prostate cancer. Lipogenic genes such as sterol regulatory element-binding protein-1 (SREBP-1) and its downstream effector fatty acid synthase (FASN), and rate-limiting enzyme acetyl CoA carboxylase (ACACA) were increased with prostate cancer [22].

Tetrapeptide Sensor H2L: H2L is a powerful tool for the diagnostic of prostate cancer. Based on photo-induced electron transfer principle (PET) the Tetrapeptide sensor H2L (Dansyl-Gly-Pro-Trp-Gly-NH2) used to imaging the zinc in prostate cancer cell lines .The zinc concentration level is lower with prostate cancer than normal prostate epithelial cells [23].

Aptasensing of prostate specific antigen (PSA) with nanomaterial: Aptamers has been termed as a tool for the detection of prostate cancer .Nowadays nanotechnology in bio sensing has become an advanced technology in the medical field for the detection of cancer. Nanomaterials improve the signal amplification in the biosensors which will reduce the time for diagnosis. Here Nanomaterial based aptasensors is more accurate and sensitive for identifying the PSA biomarker for prostate cancer diagnosis [24].

Digital Biopsy with fluorescence confocal microscope: Tissue analysis with microscopic by Hematoxylin-eosin (HE) for prostate biopsy is a conventional method for the diagnosis of prostate cancer Whereas Fluorescence Confocal Microscope specifically and reliably used for the diagnosis of prostate cancer in which the real time digital image is used without conventional method. This digitalized real time remote access developed on the basis of artificial intelligence and machine learning [25].

Targeted MRI-TRUS fusion biopsy: Targeted MRI-TRUS fusion biopsy is used to diagnosis the prostate cancer patients in which the magnetic resonance imaging/transrectal ultrasound (MRI/TRUS) fusion-guided biopsy for clinically significant prostate cancers (Cs PCas). It is more accurate and cost-effective than visual registration and in-bore biopsy [26].

Histopathology: Diagnosis of the tissue of adenocarcinoma is important for development of the diagnosis of prostate cancer. Using light

Table 1. Current diagnostic method and tools for the detection of prostate cancer

S.no	Diagnostic method	Diagnostic tool	criteria	Author
1.	Liquid based Biomarker	Glycan	Its an multi-analyze liquid based biomarker test for prostate cancer [11]	Emma Scott.,et al., 2019
2.	Serum based biomarker	4Kscore® Test	4Kscore enhanced the predictive accuracy for clinically diagnosed prostate cancer [12]	Carroll.,et al.,2016
3.	Serum based biomarker	Prostate specific antigen (PSA)	Over expressed in prostate cancer [13]	Auprich M.,et al., 2011
4.	Serum based biomarker	PHI	It will avoid unnecessary biopsies Detect high-grade PCa [14]	Al Saidi SS.,et al., 2017
5.	Serum based biomarker	TNFR1and TNF-α and IL 8	highly significantly predictive in differentiating men with CaP [15]	Chadha KC Et al., 2014
6.	Serum based biomarker	MicroRNAs	Different MicroRNAs are found in prostate cancer vs non cancer [16]	Rajnee Kanwal et al.,2017
7.	Serum Based biomarker	Galectin-3	Analyzing prostate cancer patient [17]	Cordelia Geisler et al.,2017
8.	Urine based biomarker	ExoDX Prostate IntelliScore	Improved identification of high-grade PCa [18]	McKiernan J et al.,2016
9.	Urine based biomarker	TMPRSS2:ERG (T2:ERG)	Predict the risk of PCa and csPCa[19]	Tomlins SA et al.,2016
10.	Urine based biomarker	Sarcosine	It is metabolic profiling tools for the analysis of prostate cancer based on	Lucarelli Get al.,2015
11.	Urine Based biomarker	PCA3 score	Metabolites intermediate [20]Expressed highly in Prostate cancer [21]	Buss makers MJet al.,2019
12.	Urine Based biomarker	Secernin-1 and vinculin	Potential diagnostic biomarker candidate for prostate cancer in tissue [17]	Cordelia Geisler et al.,2015
13.	Tissue based biomarker	ConfirmMDx (MDxHealth, Irvine, CA, USA)	Prostate tissue biopsy based, DNA methylation assay [22]	Paul Yonoveret al.,2019
14.	Tissue based biomarker	Long non-coding RNAs	LncRNAs are overexpressed in tumors tissue and cancer cells [23].	Xu, Y.-H., Denget al.,2019
15.	Tissue based biomarker	Oncotype DX	Detect the recurrence PCa death and adverse pathology	Klein EAet al.,2014
16	Tissue based biomarker	Prolaris	evaluates the expression of 31 cell-cycle progressiongenes[25]	Cooperberg. MR et al.,2013
17	PET/CT imaging	PSMA ligand PET/CT	Detection of sites of recurrence and nodal or distant metastases that are often occult on standard-of-care	Sarah M et al.,2016

			imaging [26].	
18	MicroSpectroscopy	Lipid quantification by Raman micro spectroscopy	Lipogenic genes are upregulated with prostate cancer [27].	Jordan O'Malley et al.,2017
19	PET imaging	Tetrapeptide sensor H2L	Assesment of zinc level by using Tetrapeptide sensor H2L[28]	Yong Anet al., 2020
20	Biosensor	Nanomaterial based aptasensing (PSA)	Aptasenors monitor the PSA biomarker for prostate cancer diagnosis [29].	Fatemeh Farshchiet al.,2020
21	Fluorescence confocal microscopy	Digital Biopsy with Fluorescence Confocal Microscope	Diagnostic ability of FCM for prostate cancer and identify the grading from prostate biopsy.[30]	Rocco Bet al.,2020
22	Magnetic resonance Imaging	Targeted MRI-TRUS fusion biopsy	The MRI-targeted biopsy diagnosis with a Prostate Imaging Reporting and Data System (PI-RADS) score[31]	Benelli, Andreaet al.,2020
23	Histopathology	Tissue based diagnosis	Diagnosis of tissue for prostate cancer by using hematoxylin and eosin stained tissue sections[32]	Humphrey PAet al 2017
24	optical coherence elastography(OCE)	TRUS Biopsy	3D data sets will be recorded by using optical coherence electrography for the prostate cancer occurrence [33].	Chunhui Liet al.,2015
25	PSMA-targeted radio ligands.	Prostate-Specific Membrane Antigen (PSMA)	PSMA in overexpressed in prostate cancer [34]	Haberkorn Uet al.,2016
26	Methylation assay	Methylation Marker	Analysis of GSTP1, APC and RASSF1 genes [35]	Desotelle Jet al.,2013
27	Genomic driven test	The Decipher test	Measures RNA expression level of genes [36]	Karneset al.,2013
28	Protein based biomarker	Promark	Estimate eight protein biomarker [37]	Shipitsin M et al.,2014
29	Molecular Marker	Exosome Marker	Prostate derived exosomes shows higher in prostate cancer patients [38,39]	Duijvesz .D, Filella. Xetal.,2011,2016
30	Tissue based Test	Prostate Core Mitomic Test	Identify the true negative prostate biopsies [40]	Frezza . C.et al.,2014
31	TME associated biomarker	Tumor microenvironment	Stromal AR signaling exhibit mediate prostate cancer metastasis [41]	Ricke. E.Aet al.,2012

microscope tissue sections stained with hematoxylin and eosin for the detection of prostate cancer Histopathogical difference shows the carcinoma of prostate cancer are essential for the recognition prostate cancer in tissue [27].

Optical coherence elastography (OCE): When compare to histopathology ,Optical coherence elastography (OCE) has more specificity and sensitivity which will predict the positive and negative values to calculated for Optical coherence elastography (OCE).3D data set was recorded and imaged by using Optical coherence elastography (OCE) for the detection of prostate cancer in suspected patients [28].

Prostate-specific membrane antigen (PSMA): Prostate-specific membrane antigen (PSMA) used for diagnosis and therapeutic process of prostate cancer .Because the Prostate-specific membrane antigen (PSMA) is overexpressed in prostate cancer and Prostate-specific membrane antigen molecules are established to diagnosis and for the treatment of metastatic castration-resistant prostate cancer. 68Ga-PSMA-11 PET/CT, nowadays spreading fast technique for the detection of recurrent prostate cancer.It will diagnosis patient with tumor lesions of high percentage with recurrent prostate cancer. Comparison between 18F-fluciclovine PET-CT and 68Ga-PSMA-11 PET-CT the diagnosis range was lower than the 68Ga-PSMA-11 PET-CT for patients with early biochemical recurrence after prostatectomy [29].

Methylation Assay: DNA methylation related with Tumorigenesis along with hyper methylation which involves in specific gene promotors generate hypo methylation this cause silencing of tumor suppressor genes. Genes such as FILIP1L isoform 2 a known senescence the pi-class glutathione S-transferase gene (GSTP1) marker are hyper methylated in prostate cancer. Biopsies were analyzed for GSTP1, APC and RASSF1 associated with the ACTB gene by using quantitative methylation-specific PCR. In the epigenetic assay 88% of negative value were predicated. This assay shows that it is useful to decrease unnecessary re-biopsy.

Decipher: Decipher is genomic driven based biomarker for the diagnosis of prostate cancer will evaluate the expression of RNA of 22 different genes .These genes are selected because it exhibit different expression in 192 early metastasis cases of prostate cancer .It is Basically involved in biological pathways, including cell cycle progression, cell proliferation, differentiation, adhesion, immune response regulating signaling pathways. The decipher show high risk in RP for pathologic grade upgrading And 5 year development of metastasis .Based on the decipher score timing of postoperative radiotherapy has been involved. It was also the only independent predictor of clinical metastasis in patients with prostate cancer after surgery [35].

ProMark: ProMark is a protein Based biomarker estimate eight protein biomarker using an automated, quantitative, and multiplex immunofluorescence assay on FFPE tissues .It will detect which cancer aggressiveness in patients based on biopsy Gleason scores of 3 + 3 and 3 + 4.The protein marker panel exhibit score 0 to 1 which will detect adverse pathology in patients .This risk score was defined in 381 patients biopsies with matched prostatectomy [36].

Exosomal biomarkers: Exosomes is a double lipid membrane bound extracellular vesicles consists of proteins, lipids, and nucleic acid. Exsosomes designed as biomarker to diagnosis for prostate cancer. Exosomes are a rich source of molecular markers such as protein, RNA, miRNA for prostate cancer detection .This prostate derived exosomes shows higher in prostate cancer patients with high Gleason score [38-39].

Prostate core mitomic test: Prostate core Mitomic test is the tissue based test with the link of mitochondrial function with regulation by oncogenes and tumor suppressors .It mainly detect the true negative prostate biopsies [40].

Tumor micro-environment (TME) associated biomarkers: Tumorigenesis is involved with the interaction of cancer cells with tumor microenvironment. ECM, fibroblasts and myofibroblasts, mesenchymal stem cells, neuroendocrine cells (NE), adipose cells, immune and inflammatory cells, and the blood and lymphatic vascular networks are essential tumor microenvironment. The extracellular matrix and stromal cells link determine the primary tumor is eradicated or metastasizes. At the same time Stromal AR signaling exhibit mediate prostate cancer metastasis [41].

1.2 Prostate Cancer Current Therapy

Radiation therapy for prostate cancer: Many advance radiation therapy has been emerged for

the treatment of prostate cancer. External-beam radiotherapy (EBRT), and brachytherapy are mostly used radiation therapy for prostate cancer, in high risk diseases both External-beam radiotherapy (EBRT), and brachytherapy will control the disease. Image-Guided Intensity Modulated Radiation Therapy (IG-IMRT) used for rapidly increasing dose response radiation therapy. IG-IMRT treated for men with prostate cancer will decrease the treatment failure rate compare to low dose of radiation therapy [42].Stereotypic radiation therapy is mainly used for the therapy for localized prostate cancer. Ultra-hypo fractionated radiation therapy with high dosage per fraction has been used for the prostate cancer therapy by stereotactic body radiation therapy (SBRT) technique [43]. Radiomics mainly involved in the characteristics at cellular and genetic level imaging. It has the capacity to genetic alteration and imaging in the prostate features for disease therapy [44]. proton beam radiation therapy used for the indication of prostate cancer in which the proton energy with charges particles travel to the tissue till the depth then the radiation dose is distributed to the sharp Bragg peak with accurate point [45].

Hormonal therapy: Androgen deprivation therapy (ADT) is mainly used for the treatment of prostate cancer. It will suppress the hormone in prostate cancer cells to grow, because prostate cancer cells need androgen hormones like as testosterone to grow decrease this hormones will protect the patient from the prostate cancer [46]. Abiraterone and Enzalutamide recently found hormonal therapies for prostate cancer .It have been tested and mainly designed for castration resistant prostatic cancer patients .Some studies are going to use this two drugs for prostate cancer [47]. Using testosterone therapy in men with prostate cancer has been restricted previously .But now there are data will challenge this statement and recent changes has been evaluate for testosterone therapy regarded as visible opinion for prostate cancer from testosterone deficiency [48].

Immunotherapy for prostate cancer: Recently Immunotherapy is an essential cancer treatment modality. Sipuleucel-T and Ipilimumab became a new process for immune oncology which was approved by FDA. Immunotherapeutic alone cannot reduce the prostate cancer in patients, but combination of immunotherapy may workout to reduce prostate cancer .Many different ongoing studies exhibit the combination of cancer vaccine with different immunotherapeutic agents hormonal therapy (enzalutamide), radiation therapy (radium 223), DNA-damaging agents (olaparib), or chemotherapy (docetaxel) can increase the immune response without any significant toxicity [49].

Chemotherapy: Chemotherapy process has been elevated in recent year for the treatment of pro

state cancer. In earlier years chemotherapy treatment will become highly palliative rather than curative and tolerable response in patients.

Docetaxel: Docetaxel was the first chemotherapy agent which shows improvement in the treatment of metastatic castration-resistant prostate cancer. But the combination with docetaxel drug has failed to show the improvement and survival rate in prostate cancer patients. However there are varying chemotherapy agent have been used for the treatment of prostate cancer [50]. The upfront docetaxel increase the survival rate for metastatic hormone naïve prostate cancer patients with long term androgen deprivation therapy and mainly the metastatic burden for M1 patients was arranged for the long term outcomes [51].

Cyclophosphamide: Cyclophosphamide is a chemotherapy medication, it is an alkylating agent which disrupt the cell division and cross linking the DNA strand, stop the DNA synthesis and growth of cancerous cell. It usually works by suppressing the immune system in the body. Before it was used to deliver suboptimal responses in urologic tumors [52]. Later it is used in angiogenesis inhibition through metronomic cycling [53]. A study was conducted to quantify the immunologic effects in GM-CSF-secreting allogeneic cellular vaccine with the cyclophosphamide for prostate cancer survival studies, it shows complex immune response along with androgen deprivation therapy [54].

Cisplatin: It is a platinum-containing compound Decrease the synthesis of DNA and disrupt the DNA strand. Cisplatin was studied based on the weekly schedule for 6 weeks then every 3 weeks maintenance and it became partial and complete remission in 17 patients out of 54 [55]. The effects of cisplatin and docetaxel were studied in biomechanical and morphological characteristics of prostate cancer cells .It shows the more stiffness in cisplatin and docetaxel cells also reduce the motility [56].

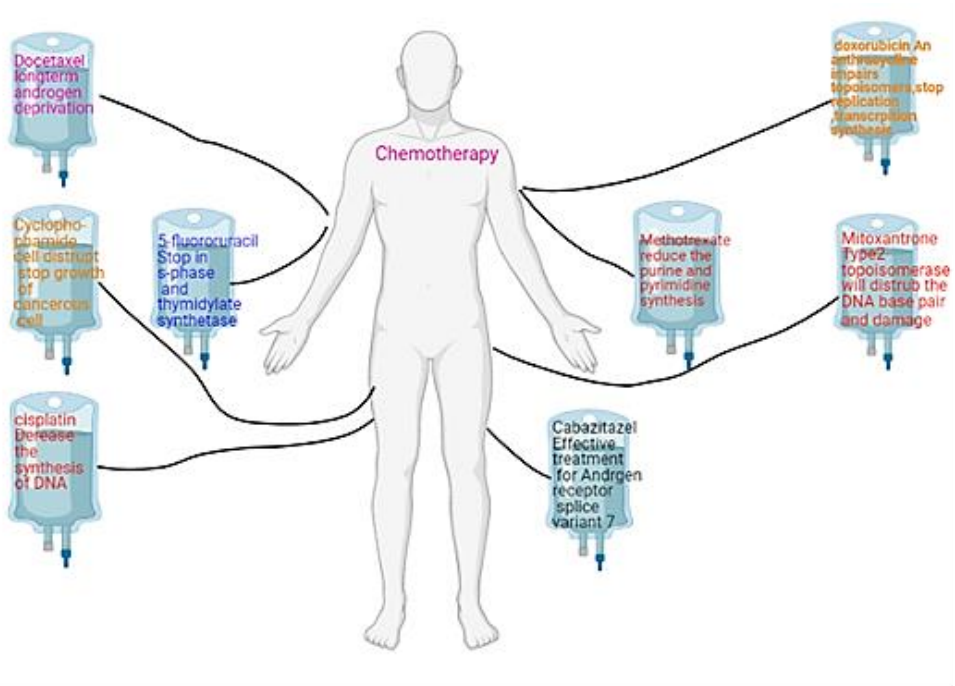

Fig. 1. Chemotherapy for prostate cancer

5-fluorouracil: It is an analog of pyrimidine which stop the DNA synthesis during the S Phase and stop the thymidylate synthetase. In this 124 patient under taken the 5-fluorouracil with varying doses and it exhibit 9% antineoplastic responses [57]. Prostate cancer treatment has been improved after androgen deprivation, abiraterone, and taxane therapy and it became successful. 5-fluorouracil also rapidly improved with continuous infusion in metastatic castrate-resistant prostate cancer [58].

Methotrexate: It is a dihydrofolic acid reductase inhibitor which decrease the purine and pyrimidine acid synthesis by disrupting the DNA synthesis. Methotrexate was taken at varying doses, the PR were occurred in only one out of 63 patients and 20% the disease was stable [59]. Combination of LHRH analog [DLys6]-LHRH and chemotherapy agent Methotrexate reduce the growth of prostate cancer cells in vitro and in vivo based on the concentrations of IC50 value [60].

Doxorubicin: It is an anthracycline inserted in the DNA base pairs which impairs the topoisomerase II function and stop replication and transcription synthesis. The NPCP results exhibit clinical benefit shows the response rate which included the stable disease reaching at 84% [61]. Costunolide with doxorubicin prompt the prostate cancer cells to apoptosis along with activated mitogen-activated protein kinases and with the reactive oxygen species production [62].

Mitoxantrone: It is an anthracenedione drug stop or slow the growth of cancerous cells .It act as inhibitor of Type II topoisomerase will disturb with DNA base pair and damage. Patient those who are not responsible for primary androgen deprivation but, found an improvement in 30% patient with low dose prednisone and mitoxantrone and improvement in symptoms and mainly from bone pain [63]. Based on the pain palliation, cabozantinib versus mitoxantrone-prednisone has been compare in men with metastatic castration-resistant prostate cancer. Cabozantinib did not show better for pain relief than mitoxantrone-prednisone in castration-resistant prostate cancer patients [64].

Cabazitaxel: It is a third generation semisynthetic tubulin-binding taxane drug. It has the capacity to treat against cancer cells like docetaxel .It has an antitumor activity to the models which was resistant effective treatment for Androgen receptor splice variant 7 (AR-V7) in circulating tumor cells in patients with metastatic castration-resistant prostate cancer [65].

2. TRACE ELEMENTS IN CANCER

Trace elements are essential for all living organisms to carry out various metabolic

reactions including the fundamental driving force of oxygen transport, neurotransmission and mitochondrial respiration and oxidative phosphorylation to name a few Excessive amount of trace element or deficiency of trace element may lead to cancer. Recently in the comparative study serum trace element level was analyzed in Korean Breast Cancer Patients by using ICPMS [66]. There are many essential trace elements leads to be anti-cancer effects.

Copper is one of the trace element which include in mechanistic process of our body. High level copper will increase the proliferation of cancer .But a new suggestion has been increased copper became an anticancer effects. Recently copper combined with curcumin elevated the inhibitory effects in the oral cancer cells. This gives a way to mechanistic insight of copper effect in oral cancer cells [67]. Combination of iodinated chlorin p6 with copper (ICp6-Cu) was a chemo toxic agent increased the cytotoxic effects in Human oral carcinoma cells NT8e, 4451 with the increase of reactive oxygen species [68]. Zinc deficiency may lead to various infection in human body system .In many studies shown the connection between zinc and cause of cancer. Zinc exhibit anticancer effect through the antioxidant properties in such a way it also influence the immune system[69]. Higher level of zinc ,copper induce the mortality in lung cancer patients. This studies in patients improve to do cohort studies in patients with other cancer risk [70]. Iron is an essential trace element in human body system higher level iron induce risk of diseases causes carcinogenesis and Ferroptosis. Ferroptosis is denpent on iron became an inducer to cancer therapy .FDA approved ferroptosis as a cancer resistant therapy [71]. Ferroptosis plays an important role in reduce growth of the cancer cells. Different types of drugs like sulfasalazine, lanperisone, sorafenib, fenugreek (trigonelline), acetaminophen, cisplatin, artesunate, combination of siramesine and lapatinib, ferumoxytol, and salinomycin can induce the ferropotosis [72]. Calcium provide an anticancer effects in hormone dependent breast cancer by Src degradation in which the phosphoinositide 3-kinase and protein kinase B were significantly decreased the clonogenic ability of hormone-dependent breast cancer cells [73]. Calcium became an antitumor effect by destabilizing epithelial growth factor receptor which proteolysis Src or α-tubulin and shows some effect in non-small cell lung carcinoma [74]. Ascorbic acid contain antioxidant properties. High Sodium-dependent vitamin C transporter family-2 shows sensitive to AA than low SVCT-2 but it shows hormetic response .Supplement with magnesium ion became an anticancer effect with AA [75]. Comparison between Mgcl2 and cisplatin for anticancer effect in breast cancer in that Mgcl2 shows 59% and 44% apoptosis at 24h .It exhibit Mgcl2 has cytotoxic effect in MCF7 cells [76]. Selenium increase the anticancer activity in MCF7 cells of breast cancer through the transient receptor potential vanilloid 1 (TRPV1) cation channel with or without cisplatin activity [77]. Selenium also shows anticancer effects in cisplatin-induced nasopharyngeal cancer through the activity of caspase 3 [78]. Cobalt became anticancer agent and nontoxic with combination of other anticancer agent through induction of autophagy, cell cycle arrest, and inhibition of cell invasion and P-glycoprotein (P-gp)activity [79]. The cobalt (III) Schiff base complexes such as trans-[Co(salen) (DA)2] (ClO4) (1) and trans-[Co(salophen) (DA)2] (ClO4) (2) (where salen: N,N'-bis (salicylidene) ethylenediamine, salopen: N,N'-bis (salicylidene) -1,2-phenylenediamine, DA: dodecylamine) are accumulated and showed anticancer activity and also as a chemotherapy agent mainly active in lung cancer [80].

2.1 Trace Element in Prostate Cancer

Again Serum trace element Level was analyzed with 30 patients with Prostate cancer 30 control patients by Icpms .It shows significantly increase in serum levels of Co, Cu, Mg and Pb and decrease level of Fe, Mn, and Zn levels [81]. High level of zinc contain in human prostate gland because of zinc-accumulating acinar epithelial of the peripheral zone which may affect the cell metabolism .The decrease of zinc by down regulate the ZIP 1 will stop the cytotoxicity in malignant cells and stop the tumour growth [82]. Zinc ionophore 1-hydroxypyridine-2-thione (ZnHPT) elevate the intracellular concentration of free zinc and increase the antiproliferative activity in phase A549 human lung cancer [83]. In the invitro cell the Combination of copper 8-hydroxyquinoline-2-carboxaldehyde-thiosemicar-bazide complex (CuHQTS) shows an anticancer activity in metastatic prostate cancer it was shown by using fluorescent microscopic imaging [84]. The three dimensional cellular model for prostate cancer exhibit a significant effect after treated with copper 64 .Copper 64 is theranostic agent mainly in PCa ,it is based on the presence of cancer stem cells DU145 shows more resistant than 22RV1, LNCaP

Table 2. List of trace element and cancer types

S.no	Trace Element	Type of Cancer	Author
1	Copper	Anti-cancer effect in Oral cancer Anti-cancer effect Human carcinoma cells	Lee HM .,et al.,(2016)
2	Zinc	Anticancer activity through the antioxidant properties Higher level of zinc in lung cancer patients	Sarbadhikary P .,et al., (2017)
3	Iron	Ferropotosis iron dependent anticancer drug	krajnowska D.,et al.,(2019)
4	Calcium	Calcium mediated Src degradation Calcium in non-small lung cancer	Zabłocka-Słowińska K.,et al.,(2020)
5	Magnesium	Shows anticancer effect with Ascorbic acid Shows cytotoxic effect than cisplatin	Kim IU ., et al .,(2018) Cho S ., et al .,(2019)
6	Selenium	Shows anticancer effects in MCF7 cells with or without cisplatin Exihibit anticancer effect in Cisplatin-induced nasopharyngeal cancer.	Sakallı Çetin E ., et al .,(2017) Zhu K .,et al .,(2016)
7	Cobalt	Show anticancer effect with complexes and collateral sensitive to multidrug resistant cobalt complexes increase anticancer activity in lung cancer	Kim IU ., et al .,(2018) Cho S ., et al .,(2019)

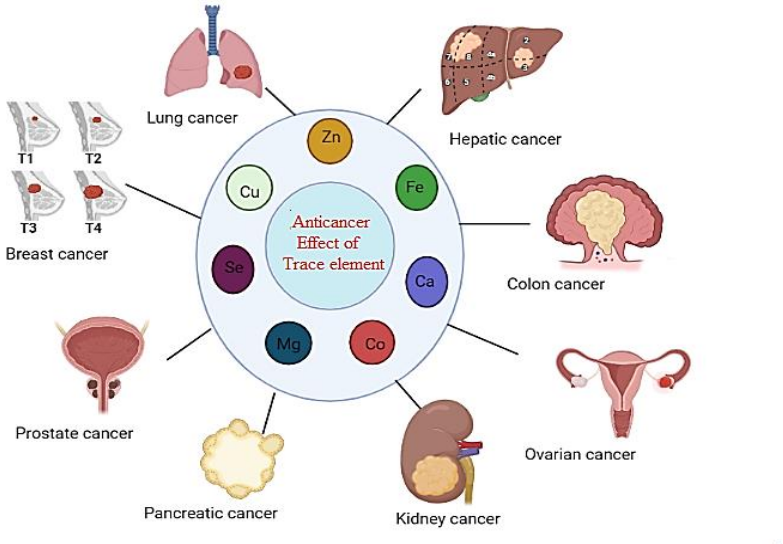

Fig. 2. Trace elements in Cancer

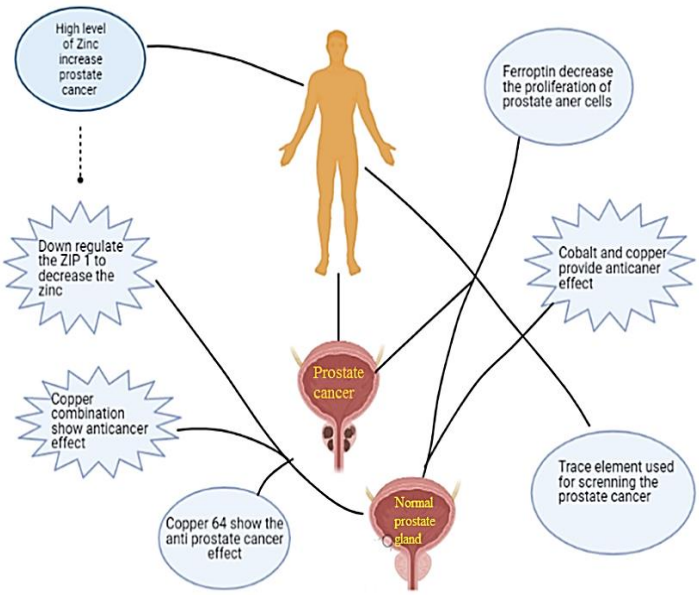

Fig. 3. Trace elements in Prostate Cancer

Cells [85]. Ferropotin decreased the proliferation of prostate cancer cells which is the iron exporter and essential for cellular and systemic iron metabolism .The ferropotin overexpression provide an effects in cells with multiple histological subtypes of prostate cancer [86]. The ferropotin expression was determined by immunohistochemistry and western blotting analysis shows a lower level of ferropotin in prostate cancer cells than the normal prostate RWPE2 cell line [87].

The comparison studies between [64Cu] Cu-NOTA/NODAGA-PEG2-RM26] and [57Co] Co-NOTA/NODAGA-PEG2-RM26 was evaluated to see the expression of Gastrin-releasing peptide receptor (GRPR) by using PET. It shows that Co-NOTA/NODAGA-PEG2-RM26 significant changes in murine PC model than [64Cu] Cu-NOTA/NODAGA-PEG2-RM26] [88]. Trace element not only give anticancer effect but also used for the screening of prostate cancer. EDXRF is an essential data analysis to study the

concentration of trace element in prostate cancer. In recent study trace element concentration was analyzed in hair sample from 22 men from Iran with prostate cancer in which aluminum, silicon, and phosphorus shows statically significant changes in patient with prostate cancer and healthy people [89]. Inversely correlated significance changes in PSA and selenium in men with median age, no smokers, men who is carrying the GPX1 rs1050450 T allele. But overall there is no significant changes in PSA and selenium level supplementation [90].

3. NANOTECHNOLOGY AND CANCER

Nanotechnology the manipulation and manufacture of materials and devices on the scale of small groups of atoms. Recently Nanotechnology has become an innovative field of research is being used for the therapeutic process of diseases. Nanotechnology pays much attention in the 21 centaury for its application in nanomedicine .China and USA are two leading countries for Nanotechnology research they providing preference and funding for research [91]. Cancer is the major concern for USA and china NCI provide funds for more innovative and creative ideas for the solutions for cancer treatment assigned by researchers [92]. Nanomedicine one of the application of nanotechnology particularly in the field of research. Nanomedicine unites with engineering, physics, biology, chemistry, mathematics, and medicine. It make an efforts to improve diagnostics of diseases, imaging, and drug delivery through the use of Nano devices [93].

Nowadays scientist had a great impact on nanotechnology and creating new nanomedicine, Nano biomaterials, nanoparticles etc. There are many approaches has been taken by nanotechnology driven drug in the field of drug delivery system in which administration of drugs to eyes, skin, wound healing, via topical route is the preferred method for drug delivery .But this conventional method for drug deliver is less effective and also intravitreal is another drug delivery method which increase complication like retinal detachment, intravitreal hemorrhage, endophthalmitis, and cataracts. Nanotechnology has the capacity to develop an effective drug delivery via topical route [94].Chronic obstructive pulmonary diseases is a lung diseases .It is associated with airway obstruction, chronic inflammation and oxidative stress .There have been lot more treatment designed for COPD but nanotechnology is an advance field for the current treatment of COPD [95]. Nanoparticles are important to decrease the toxicity and bioactivity to the target for the drug delivery system for therapeutic treatment. There are different nanoparticles in such inorganics nanoparticles of metals Ag, Au, Ce, Fe, Se, Ti and Zn provide a significant contribution in drug delivery system .SeNps is an important Trace element and it has been used as nanoparticle and reduce the toxicity during drug delivery .It reduce oxidative stress and inflammation associated disorder like cancer, neuropathy , diabetes etc [96]. Molybdenum trioxide (MoO_3) Nanoparticles against skin cancer cells (melanoma and non-melanoma) This nanoparticles produce to mitochondrial-mediated apoptosis driven by the apoptotic genes such as BAX and Bcl2 [97]. Iron oxide nanoparticles has been used in many cancer treatment. The liposomal drug delivery and therapy for iron anemia with iron oxide nanoparticles is developed .The injectable iron explore between nanoparticles and innate immune system [98]. Nowadays metal oxide nanoparticles such as zinc oxide nanoparticles has been used in biomedical field and in treatment of disease risk .This zinc oxide nanoparticle plays as anticancer agent [99]. Zinc oxide nanoparticles treated with p53 and LC3 .Zinc oxide nanoparticle shows the upregulation in cells and upregulate the apoptosis and autophagy [100]. Approach of Magnesium oxide nanoparticle has been used for the treatment cancer in which MgO NP combine with Human serum albumin(HSA) . This MgO NP increase cytotoxicity in K562 cell lines but not in peripheral blood mononucleated cells. [101]. The anticancer assay shows that the Cobalt Oxide Nanoparticles with albumin reduce the K562 cell viability and reduce cell membrane damage, activation of caspase-9, -8 and -3, increase of Bax/Bcl-2 mRNA ratio, ROS production, cell cycle arrest, and apoptosis [102]. Cadmium oxide nanoparticles involved in the anticancer effects with UV irradiation in photodynamic therapy [103]. Cadmium oxide nanoparticles also contribute as an anticancer drug in human cancer cell .In the Scanning Electron Microscope (SEM) and also Transmission Electron Microscope (TEM) shows the efficiany of Cadmium oxide nanoparticles as an anticancer drug [104]. Arsenic nanoparticle also used as a therapeutic process and for the treatment of cancer. In china the arsenolite has been used as a traditional medicine for more than 500 years [105]. Also arsenic trioxide nanoparticles used as a drug delivery agent for

solid cancer [106]. Arsenic trioxide with complexes Nano drug used as a therapeutic process in solid cancer therapy [107].

3.1 Nano Trace Elements in Prostate Cancer

At the Same time Nano Trace element play an essential role diagnostic or therapeutic process of cancer. Nowadays Nanotechnology become advanced technique for delivering the drug .There are many approaches has been taken in Nano trace element works for anticancer effects. Trace elements are essential for all living organisms to carry out various metabolic reactions including the fundamental driving force of oxygen transport, neurotransmission and mitochondrial respiration and oxidative phosphorylation to name a few. Here the focus on Nano trace element contribution in prostate cancer. Nowadays Nanotechnology become advanced technique for delivering the drug .There are many approaches has been taken in the nanotechnology field and many Nano trace element works for anticancer effects. ZnO NPs is used for the comparative study of cytotoxicity in PC-3 and RWPE-1 cells in which ZnO NPs decrease the cell viability in PC-3 but not in RWPE-1 cells. The apoptotic cells increased significantly in PC-3 cells in 10ug/ml concentration for 8h [108]. Combination of phototherapy and chemotherapy along with zinc oxide Nano fluids has become the treatment for cancer. The UVA irradiation and zinc oxide Nano fluids grows the DOX effects in DU145 cells. It suggest the modality is a good therapeutic process for cancer [109].

Cuprous oxide nanoparticles (CONPs) Decrease prostate cancer in vitro and in vivo via decreasing the Wnt pathway signaling and induce apoptosis and Cuprous oxide nanoparticles (CONPs) also reduce the stemness of cancerous cell in vitro [110]. Nano particles are also applied in the detection of cancer in patients .Here manganese oxide–mesoporous silica nanoparticles (Mn–Msn) encapsulated with prostate-specific membrane antigen (PSA) for the detection of prostateCancer [111]. To eliminate side effects induce by chemotherapy for prostate cancer a, new therapeutic process was accumulated . A multifunctional double-receptor-targeting iron oxide nanoparticles has been emerged for drug delivery system. There has two tumor-targeting peptides guided this double-receptor-targeting nanoscale drug delivery system. These peptides aims to target LHRH-R and the uPAR on PCa cells. The accumulation and binding of LHRH-AE105-IONPs in PC-3 cells compared to normal prostate epithelial cells (RC77N/E) was confirmed by Using Magnetic resonance imaging (MRI) [112]. SeNPs of 2 µg Se/ml concentration exhibit reactive oxygen species (ROS) and necroptosis in PC-3 cells. The Real-time qPCR analysis showed increased expression of necroptosis associated tumor necrotic factor (TNF) [113].

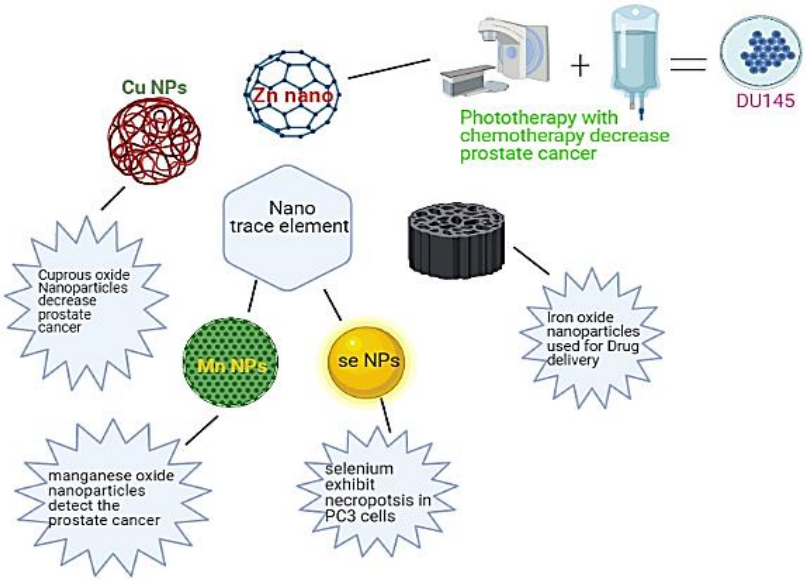

Fig. 4. Nano trace element in prostate cancer

4. DISCUSSION

The involvement of nanotrace elements in prostate cancer is an area of great interest and ongoing investigation. Nano trace elements, due to their unique nanoscale properties, hold promise for a variety of medicinal applications, including cancer detection, imaging, therapy, and prevention. In the context of prostate cancer, nano trace elements may play various crucial roles.Nano trace elements can be created to deliver therapeutic medicines to prostate cancer cells while preserving healthy tissue. This focused administration can reduce side effects while increasing the efficacy of therapies like chemotherapy, radiation therapy, and photodynamic therapy. Nano-based imaging agents can improve the sensitivity and specificity of imaging modalities like MRI, CT, and PET. These drugs can aid in the early detection and correct diagnosis of prostate cancer lesions, allowing for prompt treatment.Nanoparticle-based drug delivery systems can enhance the pharmacokinetics and bioavailability of therapeutic drugs used in prostate cancer treatment. These systems can encapsulate medications, preventing degradation and delivering them to the tumor location in a regulated manner, increasing therapeutic efficacy.Nano-based systems can also help to improve the efficacy of immunotherapy techniques in prostate cancer treatment. Nanoparticles can act as carriers for immunomodulatory drugs or antigens, stimulating the immune system to recognize and destroy cancer cells more efficiently. Nanotrace elements may play a role in prostate cancer prevention. For example, nanoparticles containing antioxidants or other chemopreventive drugs could be tailored to target prostate tissue, potentially lowering the chance of cancer formation. Prostate-specific biomarkers or circulating tumor cells can be found using nano-based biosensors, which enables non-invasive tracking of the course of the disease and the effectiveness of treatment. However, it is crucial to emphasize that, while nano trace elements show significant potential in prostate cancer research, several hurdles remain, including questions about biocompatibility, toxicity, and scalability of nano-based systems. More research is needed to solve these issues and properly adapt nano-based techniques from the lab to clinical settings. Furthermore, as nano-based medicines move closer to clinical deployment, regulatory and ethical concerns must be carefully considered.

5. CONCLUSION

The utilization of nano trace elements represents a promising approach in the comprehensive management of prostate cancer. Continued research efforts aimed at elucidating their mechanisms of action, optimizing their formulations, and evaluating their safety and efficacy in clinical settings are essential for realizing their full potential in combating this prevalent malignancy. Embracing the advancements in nanotechnology holds the promise of revolutionizing prostate cancer care, ultimately leading to improved patient outcomes and quality of life.

CONSENT AND ETHICAL APPROVAL

It is not applicable.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. MaryBeth B. Culp, Isabelle Soerjomataram, Jason A. Efstathiou, Freddie Bray, Ahmedin Jemal. Recent global patterns in prostate cancer incidence and mortality rates, European Urology. 2020;77(1):38-52, ISSN 0302-2838
   Available:https://doi.org/10.1016/j.eururo.2019.08.005
2. Bray F et al. Global cancer statistics: Globocan estimates of incidence and mortality worldwide for 36 cancers in 185 countries. CA. Cancer J. Clin. 2018;68: 394–424.
3. Tonon L, Fromont G, Boyault S et al. Mutational profile of aggressive, localised prostate cancer from African Caribbean men versus European ancestry men. Eur Urol. 2018;75:11–5.
4. Estimation of time trends of incidence of prostate cancer--an Indian scenario. Lalitha K, Suman G, Pruthvish S, Mathew A, Murthy NS Asian Pac J Cancer Prev. 2012;13(12):6245-50.
5. Anon. Time trends in cancer incidence rates 1982–2010. National cancer registry programme. Indian Council of Medical Research, Bangalore, India July; 2013b.
   Available:http://www.ncrpindia.org/ALL_NCRP_REPORTS/TREND_REPORT_1982_2010/ALL_CONTENT/Main.htm)

6. Nikhil K, Kamra M, Raza A, Shah K, Negative cross talk between LIMK2 and PTEN promotes castration resistant prostate cancer pathogenesis in cells and in vivo, Cancer Letters; 2020. Available:https://doi.org/10.1016/j.canlet.2020.09.010
7. Siddiqui S, Libertini SJ, Lucas CA, Lombard AP, Baek HB, Nakagawa RM, Mudryj M. The p14ARF tumor suppressor restrains androgen receptor activity and prevents apoptosis in prostate cancer cells. Cancer Letters; 2020. DOI: 10.1016/j.canlet.2020.03.03
8. Bluemn EG, Coleman IM, Lucas JM et al. Androgen receptor pathway-independent prostate cancer Is sustained through FGF Signaling. Cancer Cell. 2017;32(4):474-489.e6. DOI: 10.1016/j.ccell.2017.09.003
9. Singh KB, Hahm ER, Kim SH et al. A novel metabolic function of MYC in regulation of fatty acid synthesis in prostate cancer. Oncogene; 2020. Available: https://doi.org/10.1038/s41388-020-01553-z
10. Buckup M, Rice MA, Hsu EC et al. Plectin is a regulator of prostate cancer growth and metastasis. Oncogene; 2020. Available: https://doi.org/10.1038/s41388-020-01557-9
11. Scott E, Munkley J. Glycans as biomarkers in prostate cancer. Int J Mol Sci. 2019;20(6):1389. Published 2019 Mar 19. DOI: 10.3390/Ijms20061389
12. Carroll PR, Parsons JK, Andriole G, Bahnson RR, Castle EP, Catalona WJ, Dahl DM, Davis JW, Epstein JI, Etzioni RB, Farrington T, Hemstreet GP 3rd, Kawachi MH, Kim S, Lange PH, Loughlin KR, Lowrance W, Maroni P, Mohler J, Morgan TM, Moses KA, Nadler RB, Poch M, Scales C, Shaneyfelt TM, Smaldone MC, Sonn G, Sprenkle P, Vickers AJ, Wake R, Shead DA, Freedman-Cass DA J Natl Compr Canc Netw. 2016 May;14(5):509-19.
13. Auprich M, Bjartell A, Chun FKH et al. Contemporary role of prostate cancer antigen 3 in the management of prostate cancer. Eur Urol. 2011;60:1045–1054.
14. Al Saidi SS, Al Riyami NB, Al Marhoon MS, et al. Validity of prostate health index and percentage of [-2] pro-prostate-specific antigen as novel biomarkers in the diagnosis of prostate cancer: Omani tertiary hospitals experience. Oman Med J. 2017;32:275–283.
15. Chadha KC, Miller A, Nair BB, Schwartz SA, Trump DL, Underwood W. New serum biomarkers for prostate cancer diagnosis. Clin Cancer Investig J. 2014;3(1):72-79. DOI:10.4103/2278-0513.125802.
16. Rajnee Kanwal, Alexis R. Plaga, Xiaoqi Liu, Girish C. Shukla, Sanjay Gupta,MicroRNAs in prostate cancer: Functional role as biomarkers. Cancer Letters. 2017;407:9-20. ISSN 0304-3835 Available: https://doi.org/10.1016/j.canlet.2017.08.011.
17. Geisler C, Gaisa NT, Pfister D et al. Identification and validation of potential new biomarkers for prostate cancer diagnosis and prognosis using 2D-DIGE and MS. Biomed Res Int. 2015;2015: 454256. DOI:10.1155/2015/454256.
18. McKiernan J, Donovan MJ, O'Neill V et al. A novel urine exosome gene expression assay to predict high - grade prostate cancer at initial biopsy. JAMA Oncol. 2016;2:882–889.
19. Tomlins SA, Day JR, Lonigro RJ et al. Urine TMPRSS2:ERG plus PCA3 for individualized prostate cancer risk assessment. Eur Urol. 2016;70:45–53.
20. Lucarelli G, Rutigliano M, Galleggiante V et al. Metabolomic profiling for the identification of novel diagnostic markers in prostate cancer. Expert Rev. Mol. Diagn. 2015;15(9):1211–224
21. Buss makers MJ, Van Bokhoven A, Verhaegh GW et al. DD3: A new prostate-specific gene, highly overexpressed in prostate cancer.Cancer Res. 1999;59(23): 5975–5979.
22. Paul Yonover, Sandra Steyaert, Justin J. Cohen, Celeste Ruiz, Karolina Grafczynska, Elizabeth Garcia, Jessica DeHart, Michael Brawer, Jack Groskopf, and Wim Van Criekinge, Clinical utility study of confirms mdx for prostate cancer in a community urology practice. Journal of Clinical Oncology 2019;37;7:94-94.
23. Xu YH, Deng JL, Wang G, Zhu YS. Long non-coding RNAs in prostate cancer: Functional roles and clinical implications. Cancer Letters. 2019;464:37–55. DOI:10.1016/j.canlet.2019.08.010
24. Klein EA, Cooperberg MR, Magi-Galluzzi C et al. A 17-gene assay to predict prostate cancer aggressiveness in the context of

Gleason grade heterogeneity, tumor multimodality, and biopsy under sampling. Eur. Urol. 2014;66(3):550–560.

25. Cooperberg MR, Simko JP, Cowan JE et al. Validation of a cell-cycle progression gene panel to improve risk stratification in a contemporary prostatectomy cohort. J. Clin. Oncol. 2013;31(11):1428–1434.
26. Sarah M, Schwarzenboeck, Isabel Rauscher, Christina Bluemel, Wolfgang P, Fendler, Steven P. Rowe, Martin G. Pomper, Ali Asfhar-Oromieh, Ken Herrmann, Matthias Eiber, PSMA Ligands for PET Imaging of Prostate Cancer First published. 2017July 7;58(10):1545-1552.
DOI: 10.2967/jnumed.117.191031 J Nucl Med October 1, 2017
27. Jordan O'Malley, Rahul Kumar, Andrey N. Kuzmin, Artem Pliss, Neelu Yadav, Srimmitha Balachandar, Jianmin Wang, Kristopher Attwood, Paras N. Prasad, Dhyan Chandra,Lipid quantification by Raman microspectroscopy as a potential biomarker in prostate cancer,Cancer Letters. 2017;397:52-60. ISSN 0304-3835.
Available: https://doi.org/10.1016/j.canl
28. Yong An, Wei Chang, Wei Wang, Hao Wu, Ke Pu, Anhu Wu, Ze Qin, Yan Tao, Zhongjin Yue, Peng Wang, Zhiping Wang,A novel tetrapeptide fluorescence sensor for early diagnosis of prostate cancer based on imaging Zn2+ in healthy versus cancerous cells. Journal of Advanced Research. 2020;24:363-370. ISSN 2090-1232.
29. Fatemeh Farshchi, Mohammad Hasanzadeh,Nanomaterial based aptasensing of prostate specific antigen (PSA): Recent progress and challenges in efficient diagnosis of prostate cancer using biomedicine, Biomedicine and Pharmacotherapy. 2020;132:110878. ISSN 0753-3322
Available:https://doi.org/10.1016/j.biopha.2020.110878.
30. Rocco B, Sighinolfi MC, Sandri M, Spandri V, Cimadamore A, Volavsek M, Mazzucchelli R, Lopez-Beltran A, Eissa A, Bertoni L, Azzoni P, Reggiani Bonetti L, Maiorana A, Puliatti S, Micali S, Paterlini M, Iseppi A, Rocco F, Pellacani G, Chester J, Bianchi G, Montironi R. Digital Biopsy with Fluorescence Confocal Microscope for Effective Real-time Diagnosis of Prostate Cancer: A Prospective, Comparative Study. Eur Urol Oncol. 2020 Sep 17:S2588-9311(20)30136-X.
DOI: 10.1016/j.euo.2020.08.009. Epub ahead of print. PMID: 32952095.
31. Benelli A, Vaccaro C, Guzzo S, Nedbal C, Varca V, Gregori A. The role of MRI/TRUS fusion biopsy in the diagnosis of clinically significant prostate cancer. Ther Adv Urol. 2020;12:1756287220916613. Published 2020 May 18.
DOI:10.1177/1756287220916613
32. Humphrey PA. Histopathology of Prostate Cancer. Cold Spring Harb Perspect Med. 2017 Oct 3;7(10):a030411.
DOI: 10.1101/cshperspect.a030411. PMID: 28389514; PMCID: PMC5629988
33. Chunhui Li, Guangying Guan, Yuting Ling, Ying-Ting Hsu, Shaozhen Song, Jeffrey T-J. Huang, Stephen Lang, Ruikang K. Wang, Zhihong Huang, Ghulam Nabi, Detection and characterisation of biopsy tissue using quantitative optical coherence elastography (OCE) in men with suspected prostate cancer, Cancer Letters. 2015;357 (1):121-128.
34. Haberkorn U, Eder M, Kopka K, Babich JW, Eisenhut M. New Strategies in Prostate Cancer: Prostate-Specific Membrane Antigen (PSMA) Ligands for Diagnosis and Therapy. Clin Cancer Res. 2016 Jan 1;22(1):9-15.
DOI: 10.1158/1078-0432.CCR-15-0820 PMID: 26728408
35. Desotelle J, Truong M, Ewald J et al. CPG island hypermethylation frequently silences FILIP1L isoform 2 expression in prostate cancer. J. Urol. 2013;189(1):329–335.
36. Karnes RJ, Bergstralh EJ, Davicioni E, Ghadessi M, Buerki C, Mitra AP, Crisan A, Erho N, Vergara IA, Lam LL et al. Validation of a genomic classifier that predicts metastasis following radicalprostatectomy in an at risk patient population. J. Urol. 2013;190:2047–2053.
37. Shipitsin M, Small C, Choudhury S, Giladi E, Friedlander S, Nardone J, Hussain S, Hurley AD, Ernst C, Huang YE et al. Identification of proteomic biomarkers predicting prostate cancer aggressiveness and lethality despite biopsy-sampling error. Br. J. Cancer. 2014;111:1201–1212.
38. Duijvesz D, Luider T, Bangma CH, Jenster G. Exosomes as biomarker treasure chests for prostate cancer. Eur. Urol. 2011;59:823–831. [CrossRef]
39. Filella X, Foj L. Prostate cancer detection and prognosis: From prostate specific

antigen (PSA) to exosomal biomarkers. Int. J. Mol. Sci. 2016;17:1784.

40. Frezza, C. The role of mitochondria in the oncogenic signal transduction. Int. J. Biochem. Cell Biol. 2014;48:11–17. [CrossRef].
41. Ricke EA, Williams K, Lee YF, Couto S, Wang Y, Hayward SW, Cunha GR, Ricke WA. Androgen hormone action in prostatic carcinogenesis: Stromal androgen receptors mediate prostate cancer progression, malignant transformation and metastasis. Carcinogenesis. 2012;33: 1391–1398.
42. Gay HA, Michalski JM. Radiation Therapy for Prostate Cancer. Mo Med. 2018 Mar-Apr;115(2):146-150. PMID: 30228707; PMCID: PMC6139853.
43. Haque W, Butler EB, Teh BS. Stereotactic body radiation therapy for prostate cancer-a review. Chin Clin Oncol. 2017 Sep; 6(Suppl 2):S10.
DOI: 10.21037/cco.2017.06.05. PMID: 28917248.
44. Michelle Leech, Sarah Osman, Suneil Jain, Laure Marignol,Mini review:Personalization of the radiation therapy management of prostate cancer using MRI-based radiomics, Cancer Letters; 2020.
ISSN n0304 3835.
Available:https://doi.org/10.1016/j.canlet.2020.10.033.(http://www.sciencedirect.com/science/article/pii/S0304383520305656)
45. Gay HA, Michalski JM. Radiation Therapy for Prostate Cancer. Mo Med. 2018 Mar-Apr;115(2):146-150.
PMID: 30228707; PMCID: PMC6139853.
46. Saad F, Fizazi K. Androgen Deprivation Therapy and Secondary Hormone Therapy in the Management of Hormone-sensitive and Castration-resistant Prostate Cancer. Urology. 2015 Nov; 86(5):852-61.
DOI: 10.1016/j.urology.2015.07.034. Epub 2015 Aug 14. PMID: 26282624.
47. Tucci M, Leone G, Buttigliero C, Zichi C, DI Stefano RF, Pignataro D, Vignani F, Scagliotti GV, DI Maio M. Hormonal treatment and quality of life of prostate cancer patients: New evidence. Minerva Urol Nefrol. 2018 Apr;70(2):144-151.
DOI: 10.23736/S0393-2249.17.03066-1. Epub 2017 Dec 14. PMID: 29241313
48. Kaplan AL, Hu JC, Morgentaler A, Mulhall JP, Schulman CC, Montorsi F. Testosterone Therapy in Men With Prostate Cancer. Eur Urol. 2016 May;69 (5):894-903.
DOI: 10.1016/j.eururo.2015.12.005. Epub 2015 Dec 21. PMID: 26719015; PMCID: PMC5000551.
49. Bilusic M, Madan RA, Gulley JL. Immunotherapy of Prostate Cancer: Facts and Hopes. Clin Cancer Res. 2017;23 (22):6764-6770.
DOI:10.1158/1078-0432.CCR-17-0019
50. Nader R, El Amm J, Aragon-Ching JB. Role of chemotherapy in prostate cancer. Asian J Androl. 2018;20 (3):221-229.
DOI:10.4103/aja.aja_40_17
51. Clarke NW, Ali A, Ingleby FC, Hoyle A, Amos CL, Attard G, Brawley CD, Calvert J, Chowdhury S, Cook A, Cross W, Dearnaley DP, Douis H, Gilbert D, Gillessen S, Jones RJ, Langley RE, MacNair A, Malik Z, Mason MD, Matheson D, Millman R, Parker CC, Ritchie AWS, Rush H, Russell JM, Brown J, Beesley S, Birtle A, Capaldi L, Gale J, Gibbs S, Lydon A, Nikapota A, Omlin A, O'Sullivan JM, Parikh O, Protheroe A, Rudman S, Srihari NN, Simms M, Tanguay JS, Tolan S, Wagstaff J, Wallace J, Wylie J, Zarkar A, Sydes MR, Parmar MKB, James ND. Addition of docetaxel to hormonal therapy in low- and high-burden metastatic hormone sensitive prostate cancer: Long-term survival results from the STAMPEDE trial. Ann Oncol. 2019 Dec 1;30(12):1992-2003.
DOI: 10.1093/annonc/mdz396. Erratum in: Ann Oncol. 2020 Mar;31(3):442. PMID: 31560068; PMCID: PMC6938598
52. Non-hormonal cytotoxic agents in the treatment of prostatic adenocarcinoma. Yagoda A Cancer. 1973 Nov;32(5):1131-40.[PubMed] [Ref list].
53. The anti-angiogenic basis of metronomic chemotherapy. Kerbel RS, Kamen BA Nat Rev Cancer. 2004 Jun;4(6):423-36. [PubMed] [Ref list].
54. Treatment of genitourinary tumours with cis-dichlorodiammineplatinum(II):
Experience in 250 patients. Merrin CE Cancer Treat Rep. 1979 Sep-Oct;63(9-10):1579-84.
55. Obradovic AZ, Dallos MC, Zahurak ML, Partin AW, Schaeffer EM, Ross AE, Allaf ME, Nirschl TR, Liu D, Chapman CG, O'Neal T, Cao H, Durham JN, Guner G, Baena-Del Valle JA, Ertunc O, De Marzo AM, Antonarakis ES, Drake CG. T-Cell Infiltration and Adaptive Treg Resistance in Response to Androgen Deprivation With or

Without Vaccination in Localized Prostate Cancer. Clin Cancer Res. 2020 Jul 1;26(13):3182-3192.
DOI: 10.1158/1078-0432.CCR-19-3372. Epub 2020 Mar 15. PMID: 32173650; PMCID: PMC7334055

56. Raudenska M, Kratochvilova M, Vicar T, Gumulec J, Balvan J, Polanska H, Pribyl J, Masarik M. Cisplatin enhances cell stiffness and decreases invasiveness rate in prostate cancer cells by actin accumulation. Sci Rep. 2019 Feb 7;9(1):1660.
DOI: 10.1038/s41598-018-38199-7. PMID: 30733487; PMCID: PMC6367361
57. Manogue C, Ledet E, Guddati AK, Lewis B, Sartor O. Extreme Prostate-Specific Antigen Response to Infusional 5-Flourouracil in Castrate-Resistant Prostate Cancer. Oncologist. 2018 Mar; 23(3):383-385.
DOI: 10.1634/theoncologist.2017-0450. Epub 2017 Dec 19. PMID: 29259071; PMCID: PMC5905692
58. Hormone-refractory metastatic prostatic cancer treated with methotrexate, cyclophosphamide plus adriamycin, cis-platinum plus 5-fluorouracil plus cyclophosphamide. National Prostatic Cancer Project randomized trial Murphy GP, Priore RL, Scardino PT Urology. 1988 Jul;32(1):33-40.
59. A reevaluation of nonhormonal cytotoxic chemotherapy in the treatment of prostatic carcinoma.Eisenberger MA, Simon R, O'Dwyer PJ, Wittes RE, Friedman MA J Clin Oncol. 1985 Jun;3(6):827-41. [PubMed] [Ref list].
60. Zhu S, Wang Q, Jiang J, Luo Y, Sun Z. A conjugate of methotrexate and an analog of luteinizing hormone releasing hormone shows increased efficacy against prostate cancer. Sci Rep. 2016 Sep 22;6:33894.
DOI: 10.1038/srep33894
PMID: 27654169; PMCID: PMC5032167
61. Treatment of metastatic prostatic cancer with low-dose prednisone: evaluation of pain and quality of life as pragmatic indices of response. Tannock I, Gospodarowicz M, Meakin W, Panzarella T, Stewart L, Rider W J Clin Oncol. 1989 May;7(5):590-7. [PubMed] [Ref list]
62. Chen J, Chen B, Zou Z, Li W, Zhang Y, Xie J, Liu C. Costunolide enhances doxorubicin-induced apoptosis in prostate cancer cells via activated mitogen-activated protein kinases and generation of reactive oxygen species. Oncotarget. 2017 Nov 21;8(64):107701-107715.
DOI: 10.18632/oncotarget.22592
63. Phase I and pharmacokinetic study of XRP6258 (RPR 116258A), a novel taxane, administered as a 1-hour infusion every 3 weeks in patients with advanced solid tumors. Mita AC, Denis LJ, Rowinsky EK, Debono JS, Goetz AD, Ochoa L, Forouzesh B, Beeram M, Patnaik A, Molpus K, Semiond D, Besenval M, Tolcher AW Clin Cancer Res. 2009Jan 15;15(2):723-30.[PubMed] [Ref list].
64. Ethan M. Basch, Mark Scholz, Johann S. de Bono, Nicholas Vogelzang, Paul de Souza, Gavin Marx, Ulka Vaishampayan, Saby George, James K. Schwarz, Emmanuel S. Antonarakis, Joseph M. O'Sullivan, Arash Rezazadeh Kalebasty, Kim N. Chi, Robert Dreicer, Thomas E. Hutson, Amylou C. Dueck, Antonia V. Bennett, Erica Dayan, Milan Mangeshkar, Jaymes Holland, Aaron L. Weitzman, Howard I. Scher,Cabozantinib Versus Mitoxantrone-prednisone in Symptomatic Metastatic Castration-resistant Prostate Cancer: A Randomized Phase 3 Trial with a Primary Pain Endpoint,European Urology. 2019;75(6):929-937.
ISSN 0302-2838.
Available:https://doi.org/10.1016/j.eururo.2018.11.033
65. Wendy Onstenk, Anieta M. Sieuwerts, Jaco Kraan, Mai Van, Annemieke J.M. Nieuweboer, Ron H.J. Mathijssen, Paul Hamberg, Hielke J. Meulenbeld, Bram De Laere, Luc Y. Dirix, Robert J. van Soest, Martijn P. Lolkema, John W.M. Martens, Wytske M. van Weerden, Guido W. Jenster, John A. Foekens, Ronald de Wit, Stefan Sleijfer, Efficacy of Cabazitaxel in Castration-resistant Prostate Cancer Is Independent of the Presence of AR-V7 in Circulating Tumor Cells,European Urology. 2015;68(6):939-945.ISSN 0302-2838.
Available:https://doi.org/10.1016/j.eururo.2015.07.007
66. Choi R, Kim MJ, Sohn I, Kim S, Kim I , Ryu JM, Choi HJ, Kim JM, Lee SK, Yu J, Kim SW, Nam SJ, Lee JE, Lee SY. Serum Trace Elements and Their Associations with Breast Cancer Subgroups in Korean Breast Cancer Patients. Nutrients. 2019;11:37.
Available:https://doi.org/10.3390/nu11010037

67. Lee HM, Patel V, Shyur LF, Lee WL. Copper supplementation amplifies the anti-tumor effect of curcumin in oral cancer cells. Phytomedicine. 2016 Nov 15;23(12):1535-1544. DOI: 10.1016/j.phymed.2016.09.005. Epub 2016 Sep 9. PMID: 27765374.
68. Sarbadhikary P, Dube A. Iodinated chlorin p6 copper complex induces anti-proliferative effect in oral cancer cells through elevation of intracellular reactive oxygen species. Chem Biol Interact. 2017 Nov 1;277:137-144. DOI: 10.1016/j.cbi.2017.09.011. Epub 2017 Sep 14. PMID: 28918125
69. Skrajnowska D, Bobrowska-Korczak B. Role of Zinc in Immune System and Anti-Cancer Defense Mechanisms. Nutrients. 2019 Sep 22;11(10):2273. DOI: 10.3390/nu11102273. PMID: 31546724; PMCID: PMC6835436
70. Zabłocka-Słowińska K, Prescha A, Płaczkowska S, Porębska I, Kosacka M, Pawełczyk K. Serum and Whole Blood Cu and Zn Status in Predicting Mortality in Lung Cancer Patients. Nutrients. 2020;13(1):60. Published 2020 Dec 27. DOI:10.3390/nu13010060
71. Hassannia B, Vandenabeele P, Vanden Berghe T. Targeting Ferroptosis to Iron Out Cancer. Cancer Cell. 2019 Jun 10;35(6):830-849. DOI: 10.1016/j.ccell.2019.04.002. Epub 2019 May 16. PMID: 31105042.
72. Su Y, Zhao B, Zhou L, Zhang Z, Shen Y, Lv H, AlQudsy LHH, Shang P. Ferroptosis, a novel pharmacological mechanism of anti-cancer drugs. Cancer Lett. 2020 Jul 28;483:127-136. DOI: 10.1016/j.canlet.2020.02.015. Epub 2020 Feb 14. PMID: 32067993
73. Park SY, Lee JK, Park MH, Jeong KY, Kim HM. Potential Anticancer Effect of Calcium-mediated Src Degradation on Hormone-dependent Breast Cancer. Anticancer Res. 2020 Apr;40(4):1989-1996. DOI: 10.21873/anticanres.14154. PMID: 32234888.
74. Kim IU, Sung IS, Sim JJ, Park M, Jeong KY, Kim HM. Antitumor Effect of Calcium-Mediated Destabilization of Epithelial Growth Factor Receptor on Non-Small Cell Lung Carcinoma. Int J Mol Sci. 2018 Apr 11;19(4):1158. DOI: 10.3390/ijms19041158. PMID: 29641465; PMCID: PMC5979318.
75. Cho S, Chae JS, Shin H et al. Enhanced Anticancer Effect of Adding Magnesium to Vitamin C Therapy: Inhibition of Hormetic Response by SVCT-2 Activation. Transl Oncol. 2020;13(2):401-409. DOI:10.1016/j.tranon.2019.10.017.
76. Mirmalek SA, Jangholi E, Jafari M, Yadollah-Damavandi S, Javidi MA, Parsa Y, Parsa T, Salimi-Tabatabaee SA, Ghasemzadeh Kolagar H, Khazaei Jalil S, Alizadeh-Navaei R. Comparison of in Vitro Cytotoxicity and Apoptogenic Activity of Magnesium Chloride and Cisplatin as Conventional Chemotherapeutic Agents in the MCF-7 Cell Line. Asian Pac J Cancer Prev. 2016;17(S3):131-4. DOI: 10.7314/apjcp.2016.17.s3.131. PMID: 27165250.
77. Sakallı Çetin E, Nazıroğlu M, Çiğ B, Övey İS, Aslan Koşar P. Selenium potentiates the anticancer effect of cisplatin against oxidative stress and calcium ion signaling-induced intracellular toxicity in MCF-7 breast cancer cells: Involvement of the TRPV1 channel. Recept Signal Transduct Res. 2017Feb;37(1):84-93. DOI: 10.3109/10799893.2016.1160931. Epub 2016
78. Zhu K, Jiang L, Chu Y, Zhang YS. Protective effect of selenium against cisplatin-induced nasopharyngeal cancer in male albino rats. Oncol Lett. 2016 Dec;12(6):5068-5074. DOI: 10.3892/ol.2016.5346. Epub 2016 Nov 2. PMID: 28101235; PMCID: PMC5228205.
79. Law BYK, Qu YQ, Mok SWF, Liu H, Zeng W, Han Y, Gordillo-Martinez F, Chan WK, Wong KM, Wong VKW. New perspectives of cobalt tris(bipyridine) system: Anti-cancer effect and its collateral sensitivity towards multidrug-resistant (MDR) cancers. Oncotarget. 2017 Jul 5;8(33):55003-55021.
80. Ambika S, Manojkumar Y, Arunachalam S, Gowdhami B, Meenakshi Sundaram KK, Solomon RV, Venuvanalingam P, Akbarsha MA, Sundararaman M. Biomolecular Interaction, Anti-Cancer and Anti-Angiogenic Properties of Cobalt(III) Schiff Base Complexes. Sci Rep. 2019 Feb 25;9(1):2721.
81. Jagielska, A., Ruszczyńska, A., Wagner B et al. ICP-MS analysis of diet supplementation influence on the elemental content of rat prostate gland. Monatsh Chem. 2019;150:1681–1690

Available: https://doi.org/10.1007/s00706-019-02473-9

82. Costello LC, Franklin RB. A comprehensive review of the role of zinc in normal prostate function and metabolism; and its implications in prostate cancer. Arch Biochem Biophys. 2016 Dec 1;611:100-112.
DOI: 10.1016/j.abb.2016.04.014. Epub 2016 Apr 27. PMID: 27132038; PMCID: PMC5083243
83. Magda D, Lecane P, Wang Z, Hu W, Thiemann P, Ma X, Dranchak PK, Wang X, Lynch V, Wei W, Csokai V, Hacia JG, Sessler JL. Synthesis and anticancer properties of water-soluble zinc ionophores. Cancer Res. 2008 Jul 1;68(13):5318-25.
DOI: 10.1158/0008-5472.CAN-08-0601. PMID: 18593933
84. Xie F, Cai H, Peng F. Anti-prostate cancer activity of 8-hydroxyquinoline-2-carboxaldehyde-thiosemicarbazide copper complexes in vivo by bioluminescence imaging. J Biol Inorg Chem. 2018 Aug;23(6):949-956.
DOI: 10.1007/s00775-018-1596-y. Epub 2018 Jul 13. PMID: 30006867; PMCID: PMC6330258
85. Pinto CIG, Bucar S, Alves V, Fonseca A, Abrunhosa AJ, da Silva CL, Guerreiro JF, Mendes F. Copper-64 Chloride Exhibits Therapeutic Potential in Three-Dimensional Cellular Models of Prostate Cancer. Front Mol Biosci. 2020 Dec 1;7:609172.
DOI: 10.3389/fmolb.2020.609172. PMID: 33335914; PMCID: PMC7736412
86. Deng Z, Manz DH, Torti SV, Torti FM. Effects of Ferroportin-Mediated Iron Depletion in Cells Representative of Different Histological Subtypes of Prostate Cancer. Antioxid Redox Signal. 2019 Mar 10;30(8):1043-1061.
DOI: 10.1089/ars.2017.7023. Epub 2017 Dec 11. PMID: 29061069; PMCID: PMC6354616.
87. Xue D, Zhou CX, Shi YB, Lu H, He XZ. Decreased expression of ferroportin in prostate cancer. Oncol Lett. 2015 Aug;10(2):913-916.
DOI: 10.3892/ol.2015.3363. Epub 2015 Jun 11. PMID: 26622594; PMCID: PMC4509077.
88. Baun C, Mitran B, Rinne SS, Dam JH, Olsen BB, Tolmachev V, Orlova A, Thisgaard H. Preclinical Evaluation of the Copper-64 Labeled GRPR-Antagonist RM26 in Comparison with the Cobalt-55 Labeled Counterpart for PET-Imaging of Prostate Cancer. Molecules. 2020 Dec 18;25(24):5993.
DOI: 10.3390/molecules25245993. PMID: 33352838; PMCID: PMC7766840.
89. Ghanbari Birgani M, Reiazi R, Afkhami Ardekani M, Ghaffari H, Shakeri-Zadeh A, Mofid B. Analysis of trace elements in human hair through X-ray fluorescence spectroscopy for screening of prostate cancer. Med J Islam Repub Iran. 2020 Jul 28;34:86.
DOI: 10.34171/mjiri.34.86. PMID: 33306064; PMCID: PMC7711052.
90. Karunasinghe N, Ng L, Wang A, Vaidyanathan V, Zhu S, Ferguson LR. Selenium Supplementation and Prostate Health in a New Zealand Cohort. Nutrients. 2019 Dec 18;12(1):2.
DOI: 10.3390/nu12010002. PMID: 31861307; PMCID: PMC7019779.
91. Weissleder R. A clearer vision for in vivo imaging. Nat Biotechnol 2001;19:316-7.
92. Koppa Raghu P, Bansal KK, Thakor P et al. Evolution of Nanotechnology in Delivering Drugs to Eyes, Skin and Wounds via Topical Route. Pharmaceuticals (Basel). 2020;13(8):167. Published 2020 Jul 27.
DOI:10.3390/ph13080167.
93. Passi M, Shahid S, Chockalingam S, Sundar IK, Packirisamy G. Conventional and Nanotechnology Based Approaches to Combat Chronic Obstructive Pulmonary Disease: Implications for Chronic Airway Diseases. Int J Nanomedicine. 2020;15:3803-3826. Published. 2020 May 28. DOI:10.2147/IJN.S242516.
94. Gao Y, Jin B, Shen W et al. China and the United States--Global partners, competitors and collaborators in nanotechnology development. Nanomedicine. 2016;12(1):13-19. DOI:10.1016/j.nano.2015.09.007.
95. Hull LC, Farrell D, Grodzinski P. Highlights of recent developments and trends in cancer nanotechnology research—view from NCI Alliance for Nanotechnology in Cancer. Biotechnol Adv. 2014;32:666–78. [PubMed] [Google Scholar]
96. Amit Khurana, Sravani Tekula, Mohd Aslam Saifi, Pooladanda Venkatesh, Chandraiah Godugu, Therapeutic applications of selenium nanoparticles,

Biomedicine Pharmacotherapy. 2019;11: 802-812.ISSN:0753-3322.
Available:https://doi.org/10.1016/j.biopha.2018.12.146.(http://www.sciencedirect.com/science/article/pii/S0753332218362954)

97. Indrakumar J, Korrapati PS. Steering Efficacy of Nano Molybdenum Towards Cancer: Mechanism of Action. Biol Trace Elem Res. 2020;194:121–134.
Available: https://doi.org/10.1007/s12011-019-01742-2
98. Frederik Soetaert, Preethi Korangath, David Serantes, Steven Fiering, Robert Ivkov, Cancer therapy with iron oxide nanoparticles: Agents of thermal and immune therapies, Advanced Drug Delivery Reviews; 2020. ISSN 0169-409X.
Available:https://doi.org/10.1016/j.addr.2020.06.025.(http://www.sciencedirect.com/science/article/pii/S0169409X20300715)
99. Rasmussen JW, Martinez E, Louka P, Wingett DG. Zinc oxide nanoparticles for selective destruction of tumor cells and potential for drug delivery applications. Expert Opin Drug Deliv. 2010;7(9):1063-1077.
DOI:10.1517/17425247.2010.502560.
100. Bai DP, Zhang XF, Zhang GL, Huang YF, Gurunathan S. Zinc oxide nanoparticles induce apoptosis and autophagy in human ovarian cancer cells. Int J Nanomedicine. 2017;12:6521-6535. Published.
2017 Sep 5.
DOI:10.2147/IJN.S140071
101. Behzadi E, Sarsharzadeh R, Nouri M et al. Albumin binding and anticancer effect of magnesium oxide nanoparticles. Int J Nanomedicine. 2018;14:257-270. Published 2018 Dec 27. DOI:10.2147/IJN.S186428.
102. Arsalan N, Hassan Kashi E, Hasan A et al. Exploring the Interaction of Cobalt Oxide Nanoparticles with Albumin, Leukemia Cancer Cells and Pathogenic Bacteria by Multispectroscopic, Docking, Cellular and Antibacterial Approaches. Int J Nanomedicine. 2020;15:4607-4623. Published 2020 Jun 25.
DOI:10.2147/IJN.S257711.
103. Heidari A. Anti-Cancer Effect of UV Irradiation at Presence of Cadmium Oxide (CdO) Nanoparticles on DNA of Cancer Cells: A Photodynamic Therapy Study. Arch Cancer Res. 2016;4:1.
104. Heidari A, Novel and Stable Modifications of Intelligent Cadmium Oxide Nanoparticles as Anti-Cancer Drug in Formation of Nucleic Acids: Biochem Pharmacol (Los Angel). 2016;5:3.
105. Baláž P, Sedlák J. Arsenic in cancer treatment: Challenges for application of realgar nanoparticles (a minireview). Toxins (Basel). 2010;2(6):1568-1581.
DOI:10.3390/toxins2061568
106. Akhtar A, Xiaoyan Wang S, Ghali L, Bell C, Wen X. Recent advances in arsenic trioxide encapsulated nanoparticles as drug delivery agents to solid cancers. J Biomed Res. 2017;31(3):177-188. DOI:10.7555/JBR.31.20160059
107. Weidong Fei, Chaoqun Li, Jiaoyang Tao, Xinjun Cai, Wendong Yao, Yiqing Ye, Yue Zhang, Yao Yao, Qianqian Song, Fanzhu Li, Caihong Zheng,Construction of arsenic-metal complexes loaded nanodrugs for solid tumor therapy: A mini review,International Journal of Pharmaceutics. 2020;583:119385. ISSN 0378-5173.
108. Fu Juan, Zeng, Xianli He, Nongyue. Journal of Nanoscience and Nanotechnology. January 2017;17(1):196-202(7) Publisher: American Scientific Publishers
DOI:
https://doi.org/10.1166/jnn.2017.12444
109. Wang Y, Yang QW, Yang Q, Zhou T, Shi MF, Sun CX, Gao XX, Cheng YQ, Cui XG, Sun YH. Cuprous oxide nanoparticles inhibit prostate cancer by attenuating the stemness of cancer cells via inhibition of the Wnt signaling pathway. Int J Nanomedicine. 2017 Mar 31;12:2569-2579.
DOI: 10.2147/IJN.S130537.
PMID: 28408824;
PMCID: PMC5383080
110. Dou Du, Hui-Jun Fu, Wei-wei Ren, Xiao-Long Li, Le-Hang Guo, PSA targeted dual-modality manganese oxide–mesoporous silica nanoparticles for prostate cancer imaging, Biomedicine and Pharmacotherapy. 2020;121:109614. ISSN 0753-3322,
Available:https://doi.org/10.1016/j.biopha.2019.109614.(http://www.sciencedirect.com/science/article/pii/S0753332219352369).
111. Ahmed MSU, Salam AB, Yates C et al. Double-receptor-targeting multifunctional iron oxide nanoparticles drug delivery system for the treatment and imaging of prostate cancer. Int J Nanomedicine.

2017;12:6973-6984. Published 2017 Sep 19. DOI:10.2147/IJN.S139011.

112. Sonkusre P, Cameotra SS. Biogenic selenium nanoparticles induce ROS-mediated necroptosis in PC-3 cancer cells through TNF activation. J Nanobiotechnology. 2017;15(1):43. Published 2017 Jun 7. DOI:10.1186/s12951-017-0276-3.

113. Amit Khurana, Sravani Tekula, Mohd Aslam Saifi, Pooladanda Venkatesh, Chandraiah Godugu, Therapeutic applications of selenium nanoparticles, Biomedicine Pharmacotherapy. 2019;111:802-812. ISSN 0753-3322. Available:https://doi.org/10.1016/j.biopha.2018.12.146.(http://www.sciencedirect.com/science/article/pii/S0753322218362954)

Peer-review history:
The peer review history for this paper can be accessed here:
https://www.sdiarticle5.com/review-history/114517