Research Paper

Comparative Study on the Effect of Docetaxel and Abiraterone in the Treatment of Metastatic Castration Resistant Prostate Cancer

LIMING MA* AND SHAOPENG CHEN[1]

Department of Clinical Medicine, Affiliated Hospital of Nantong University, [1]Nantong University, Nantong, Jiangsu 226000, China

The study explored to evaluate and compare the effect of docetaxel and abiraterone in the treatment of metastatic castration resistant prostate cancer. 40 metastatic castration-resistant prostate cancer patients were retrospectively analysed and were divided into 2 groups, A and B each of 20 individuals (n=20). Group A was treated with docetaxel+prednisone tablets, and group B was treated with abiraterone+prednisone tablets. After the treatment, the treatment effects, progression-free survival, 1 y survival rate, tumor marker index levels, residual urine volume, maximum flow rate of urine, testosterone, and prostate-specific levels before and after treatment were compared between the two groups. Prostate specific antigen and androgen receptor splice variant-7 levels were compared to evaluate the safety of the two groups. The total effective rate in group B was 85 %, which was significantly higher than that in group A ($p<0.05$). The progression-free survival in group B was 13.2 mo, while in group A it was 10.2 mo ($p<0.05$). There was no significant difference in 1 y survival rate between the two groups ($p>0.05$). The levels of tumor markers in group B were lower than those in group A ($p<0.05$). The reduction of residual urine volume in group B was higher than that in group A ($p<0.05$), and maximum flow rate was greater in group A than in group B ($p<0.05$). The levels of testosterone, prostate specific antigen and androgen receptor splice variant-7 were lower in group B than those in group A ($p<0.05$). The adverse reaction rate of group B was 15 % lower than that of group A (35 %) ($p<0.05$). Abiraterone has a good clinical effect, can effectively improve the clinical symptoms of patients, with high drug safety, and is worthy of promotion.

Key words: Docetaxel, abiraterone, prednisone, drug safety

Metastatic Castration-Resistant Prostate Cancer (mCRPC) is an advanced form of prostate cancer that is characterized by the resistance to castration therapy and androgen receptor antagonists. The development of mCRPC has a great impact on the survival rate and quality of life of patients. Drug therapy plays a very important role in the management of mCRPC. Drug therapy can effectively control tumor growth. Prostate cancer often depends on the presence of androgens for growth, but castrated prostate cancer is less dependent on androgens. Drug therapy can interfere with the growth and proliferation of tumor cells through different mechanisms to control tumor development. In addition, drug treatment also has great significance in prolonging the growth period and improving quality of life. Castrate-resistant prostate cancer is generally considered advanced prostate cancer and carries a poor prognosis. Drug treatment can prolong patient survival and reduce disease progression and metastasis. In addition, prostate cancer and its treatment are often accompanied by a series of adverse reactions, such as sexual dysfunction, osteoporosis, etc. Medication can help reduce side effects like these and improve a patient's quality of life. Therefore, exploring the effective drug regimens is a major topic of mCRPC research. Currently, the treatment options for mCRPC are mainly drug therapy and other adjuvant treatments. In terms of medication, docetaxel and abiraterone are commonly used clinically. As a microtubule inhibitor, docetaxel inhibits cell division and proliferation by inhibiting the dynamic reorganization of microtubules. It has been widely used in a variety of solid tumors. Abiraterone belongs to an androgen

***Address for correspondence**
E-mail: mlm15996670177@163.com

receptor antagonist, and its basic pharmacological mechanism is to prevent the growth and metastasis of prostate cancer by inhibiting the binding and signal transduction of androgen.

Docetaxel is the 1st line drug choice in clinical practice, and its drug effect has been well established. Studies have shown that docetaxel can prolong the overall survival and progression survival of patients, and it has a certain clinical response rate[1]. However, some studies have pointed out that some side effects of docetaxel should not be ignored, mainly including bone marrow suppression, gastrointestinal reactions and neurotoxicity[2]. Abiraterone, another common drug which is used for the treatment of mCRPC, has also received widespread attention. Compared with docetaxel, abiraterone has better oral bioavailability and lower incidence of adverse reactions, especially in terms of bone pain and fatigue. The results of a prospective clinical study showed that abiraterone can improve the overall survival rate and progression survival period of patients, and has a certain clinical response rate[3]. This study aims to retrospectively analyze the efficacy of docetaxel and abiraterone in the treatment of mCRPC and evaluate their safety.

MATERIALS AND METHODS

General data:

The data of this study has been obtained from 40 mCRPC individuals admitted to Jianhu County People's Hospital of Jiangsu Province from January 2019 to January 2022. The study was approved by the Ethics Committee (Approval number: 00362). According to the medication status, 20 individuals who were treated with docetaxel+prednisone tablets were classified as group A, while 20 patients who were treated with abiraterone+prednisone tablets were classified as group B. The general data of the two groups was compared, and there was no significant difference (p>0.05) (Table 1).

Inclusion criteria:

Patients who have been diagnosed with prostate cancer by pathological examination; patients who underwent castration therapy; patients whose testosterone level is <1.7 nmol/l, and having the appearance of metastatic lesions; increase of Prostate Specific Antigen (PSA) value for every 2 w for 3 d consecutively; increased value >2 ng/ml and patients with no anti-androgen treatment in the past 6 mo were included in the study.

Exclusion criteria:

Similarly the patients who received radiotherapy and chemotherapy in the past 6 mo; patients with severe organ dysfunction, chronic liver and kidney diseases or having abnormal transaminases levels; individuals with incomplete data and patients with mental disorders were excluded from the study.

Medication method:

Group A were given docetaxel+prednisone tablets. Docetaxel injection is produced by Shandong Jiurui Pharmaceutical Co., Ltd., approved by the National Pharmaceutical Standard H20064301 whose specification is 0.5 ml:20 mg. The prednisone acetate tablet is produced from Zhejiang Xianju Pharmaceutical Co., Ltd. approved by, the national drug standard H33021207, and the specification is 5 mg×100 tablets. Before receiving docetaxel injection, dexamethasone tablets should be taken orally for 3 d consecutively. On the 1st d, docetaxel was injected intravenously at a dosage of 75 mg/m^2. At the same time, prednisone acetate tablets were taken orally for 21 d twice a day. The patients were recommended to take a total of 3 courses of this treatment.

TABLE 1: COMPARISON OF GENERAL INFORMATION OF PATIENTS IN TWO GROUPS ($\bar{x}$±s)

Normal information	A (n=20)	B (n=20)	t/χ^2	p
Age (y)	52.43±4.27	52.52±4.36	0.031	0.986
PSA (ng/ml)	142.09±2.81	142.59±2.84	0.018	0.956
Number of bone metastasis			0.524	0.726
1-3	6	7		
4-10	6	5		
>10	8	8		
Transferase			0.535	0.718
Bone metastasis	8	7		
Lymphatic metastasis	6	6		
Visceral metastasis	6	7		

Similarly, group B were advice to take abiraterone+prednisone tablets. Abiraterone acetate tablets are produced by Chengdu Shengdi Pharmaceutical Co., Ltd., with the approval number H20193205, and the specification is 0.25 g×120 tablets. Oral once a day, 4 tablets each time, 21 d as a course of treatment. The dosage of prednisone acetate tablets is the same as that of group A. A total of 3 courses of treatment was advised.

Research indicators:

Treatment efficiency: It was explained using different grades namely, markedly effective, effective and ineffective. It was considered to be markedly effective if all target lesions disappeared. If the sum of the long diameters of all target lesions decreased by >30 %, it was considered to be effective. Similarly if the sum of long diameters of all target lesions increased or decreased by <30 %, then it was said to be ineffective.

Total effective rate=marked rate+effective rate

Progression-Free Survival (PFS): The time between patients receiving treatment in Jianhu County People's Hospital and disease progression or death by any cause was recorded.

1 y survival rate: All treated patients were followed up and recorded their 1 y survival rate.

Detection of tumor markers and testosterone, PSA, Androgen Receptor splice Variant 7 (AR-V7) levels: 12 ml of fasting venous blood was taken from the patient in the morning, and was tested to measure the levels of tumor markers Carcinoembryonic Antigen (CEA), Total Prostate-Specific Antigen (TPSA), free PSA, serum testosterone, PSA and AR-V7 level value.

Post-Void Residual (PVR) urine and Maximum Flow Rate (MFR) detection: After 5-10 min of urination, the catheter was used to discharge the residual urine, and PVR was measured through the measuring device. MFR was calculated by recording the time of urine flow and the maximum flow rate of urine flow by patient placed the uroflowmeter on the urine flow path during urination.

Statistical analysis:

The data and the information included in this study were analyzed by statistical software Statistical Package of Social Sciences (SPSS) version, 22.0. T test or Chi-square (χ^2) test was performed and $p<0.05$ was considered statistically significant

RESULTS AND DISCUSSION

Drug efficacy has been studied. After medication, the total effective rate of group A was 65 %, which was much lower than that of group B whose total effective rate was 85 %. There was a significant difference between the two groups ($p<0.05$) (Table 2).

Disease development was evaluated. After receiving drug treatment, the median PFS of group A was 10.2 mo, and that of group B was 13.2 mo. There was a significant difference between the two groups ($p<0.05$). Similarly, 1 y survival rate of group A was 95 %, and that of group B was 100 % where there was no significant difference between the two groups ($p>0.05$) (Table 3).

Tumor marker levels were observed. Before treatment, there was no significant difference in the values of tumor markers between the two groups. After treatment, the values of tumor markers in group B were lower ($p<0.05$) (Table 4).

Serum testosterone, PSA, AR-V7 levels were observed. Before treatment, there was no significant difference in serum testosterone, PSA, and AR-V7 levels between the two groups ($p>0.05$). But, after treatment the values of each level in group B were lower ($p<0.05$) (Table 5).

Comparison of PVR and MFR were evaluated. Before medication, there was no significant difference in PVR and MFR between the two groups ($p>0.05$). After medication, patients in group B had lower PVR and higher MFR ($p<0.05$) (Table 6).

Adverse drug reactions were also compared. After medication, there were 7 patients who had adverse reactions in group A and 3 patients in group B, and there was a significant difference between the two groups ($p<0.05$) (Table 7).

Primarily, studies have shown that most patients with prostate cancer will develop mCRP after undergoing castration therapy[4]. The reasons mainly include weakened hormone dependence, gene variation and abnormal signaling pathways. Prostate cancer is often highly dependent on androgen, and castration therapy is to inhibit tumor growth by reducing the level of testosterone in the patient's body. However, some prostate cancer cells may gradually lose their dependence

on testosterone, resulting in diminished hormone dependence. And these cells rely on other pathways to survive and grow, which leads to disease progression. There are also mutations in growth genes during the growth and spread of cancer cells, which may lead to a series of biological processes such as cell growth regulation and cell death. After castration therapy, some prostate cancer cells may develop genetic mutations that allow them to escape their dependence on testosterone, leading to tumor progression. It is generally believed that the development of mCRP is associated with abnormal activation of multiple signaling pathways. For example, activation of the Phosphoinositide 3 Kinase/protein Kinase B/mammalian Target of Rapamycin (PI3K/AKT/mTOR) signaling pathway often occurs in mCRPC. These abnormal signaling pathways can often bypass the effect of testosterone, thereby promoting the proliferation and survival of tumor cells.

TABLE 2: COMPARISON OF DRUG EFFICACY ($\bar{x}\pm s$, NUMBER OF PATIENTS)

Group	n	Markedly effective	Effective	Ineffective	Total effective rate
A	20	3	10	7	65 %
B	20	6	11	3	85 %
χ^2					1.427
p					0.001

TABLE 3: COMPARISON OF PFS AND 1 y SURVIVAL RATE BETWEEN THE TWO GROUPS AFTER TREATMENT ($\bar{x}\pm s$)

Group	n	PFS	1 y survival rate
A	20	10.2±1.73	95 %
B	20	13.2±1.82	100 %
t		1.826	0.045
p		0.001	0.798

TABLE 4: COMPARISON OF TUMOR MARKER LEVELS ($\bar{x}\pm s$)

Group	n	CEA (U/ml)		TPSA (ng/ml)		FPSA (ng/ml)	
		Before medication	After medication	Before medication	After medication	Before medication	After medication
A	20	17.09±2.76	9.68±1.77	54.28±5.28	19.92±2.36	11.02±1.15	4.36±0.99
B	20	17.14±2.77	6.25±1.17	54.32±5.29	13.58±1.98	11.01±1.14	3.14±0.98
t		0.001	2.726	0.001	2.582	0.001	2.516
p		0.813	0.001	0.856	0.001	0.806	0.001

TABLE 5: COMPARISON OF SERUM TESTOSTERONE, PSA AND AR-V7 LEVELS ($\bar{x}\pm s$)

Group	n	Testosterone (ng/ml)		PSA (ng/ml)		AR-V7	
		Before medication	After medication	Before medication	After medication	Before medication	After medication
A	20	1.19±0.21	0.83±0.11	59.63±5.68	21.35±2.38	2.56±0.78	1.54±0.63
B	20	1.19±0.2	0.64±0.09	59.72±5.69	10.86±1.58	2.54±0.77	1.12±0.48
t		<0.001	2.126	<0.001	4.782	0.001	2.226
p		0.882	0.001	0.836	0.000	0.853	0.001

TABLE 6: PVR AND MFR OF PATIENTS IN TWO GROUPS (x̄±s)

Group	n	PVR (ml)		MFR (ml/s)	
		Before medication	After medication	Before medication	After medication
A	20	36.54±3.72	26.28±2.82	9.26±1.12	12.38±1.35
B	20	36.85±3.76	18.63±1.96	9.28±1.12	15.46±1.38
t		0.001	2.486	0.001	2.018
p		0.911	0.001	0.895	0.001

TABLE 7: COMPARISON OF ADVERSE DRUG REACTIONS BETWEEN THE TWO GROUPS (x̄±s)

Group (n=20)	Hypokalemia	Elevated alanine aminotransferase	Peripheral edema	Hypertension	Liver damage	Neutropenia	Others	Total incidence
A	0	1	0	0	2	2	2	35 %
B	0	0	0		1	1	1	15 %
t								6.854
p								0.000

Treatment methods for mCRP mainly include hormone therapy, 2nd line hormonal therapy, targeted therapy, radiotherapy, and chemotherapy. Hormone therapy is considered the 1st regimen for the treatment of mCRP. It mainly relies on inhibiting the synthesis of testosterone to achieve the purpose of controlling tumor growth. Commonly used hormone therapy drugs include Luteinizing Hormone Releasing Hormone (LHRH) drugs, antiandrogen drugs, and Cytochrome P450 17A1 (CYP17A1) inhibitors. Abiraterone in this study is a CYP17A1 inhibitor. The curative effect of hormonal drugs varies with individual patients, and some patients have better curative effect and can obtain a longer survival period. But over time, the drug loses its efficacy due to the development of drug resistance in patients. In practice, when first-line hormonal drugs lose their efficacy, second-line hormonal drugs are often used for treatment. Commonly used second-line hormone drugs include cyclosporine, antiandrogen drugs, etc. Just like the 1st line hormonal drugs, the 2nd line drugs also have same drawbacks. Targeted therapy drugs have been extensively studied in the treatment of mCRPC in recent years. Its representative drugs include anti-androgen receptor drugs and Poly Adenosine diphosphate-Ribose Polymerase (PARP) inhibitors. The effect of targeted therapy is often related to the target and individual differences. At present, there are few clinical cases of targeted therapy for mCRPC. Some patients with mCRPC have achieved better results after radiotherapy. Cancer progression can be slowed by radiation therapy at the site of the disease. Chemotherapy, as a systemic treatment, can kill cancer cells through chemical drugs to achieve the effect of treating diseases. Common chemotherapy drugs include docetaxel and paclitaxel. However, chemotherapy is often accompanied by more side effects, mainly including nausea, vomiting, and hair loss.

In clinical practice, physicians often recommend the docetaxel regimen. However, mCRPC patients are mostly middle-aged and elderly people, and it is often difficult to bear the adverse reactions during chemotherapy. In recent years, researchers have found that the continuous stimulation of androgen receptors in cancer cells by androgens may be the main reason for the progression of prostate cancer[5]. After the patient undergoes castration treatment, there will be no testicular production of androgen, but cancer cells and adrenal glands can still secrete androgen thereby leading to proliferation and growth of cancer cells. Therefore, the key to treating mCRPC is to inhibit androgen production. Studies have pointed out that CYP17A1, as the basic product of catalyzing androgen production, seems to be the most important pathway for androgen production[6]. In view of this, it is very important to compare the traditional chemotherapy drug docetaxel with the CYP17A1 representative drug abiraterone.

The pharmacological mechanism of docetaxel in the treatment of mCRPC was studied. Docetaxel, as a broad-spectrum chemotherapy drug, is often used in the treatment of mCRPC. Docetaxel is a taxane drug, which interferes with cell mitosis by inhibiting microtubule polymerization, so as to inhibit the proliferation and spread of tumor cells. In general, the pharmacological mechanism of docetaxel can be summarized as the effect on microtubules and cell cycle, inhibition of tumor angiogenesis and growth, and immune regulation. Docetaxel can bind and stabilize microtubules, thereby inhibiting the dynamic instability of microtubules, preventing the polymerization and depolymerization of microtubules, arresting cell mitosis in the G2/M phase, and finally hindering the proliferation of cancer cells with split. The core of the action of docetaxel is to rely on the binding of Beta (β) tubulin in the cell, causing the instability of microtubules, making the cells unable to continue mitosis. Docetaxel can also inhibit tumor angiogenesis. It relies on reducing the migration of vascular endothelial cells, blocking the expression of angiogenesis-related genes, thereby reducing the production of angiogenic factors, so as to reduce tumor angiogenesis. It is this mechanism that causes docetaxel to block the blood supply to the tumor, depriving the tumor of nutrients and oxygen. At the same time, docetaxel also has a certain immune regulation function. Studies have shown that docetaxel can enhance the anti-tumor immune response. It relies on increasing the activity of tumor-specific T cells and promoting the activation and proliferation of T cells, thereby enhancing the lethality of cytotoxic T lymphocytes and improving the body's ability to fight tumors and immune response[7].

The results of many clinical trials have shown that compared with standard treatment, docetaxel can prolong the overall survival and PFS in patients with mCRPC[8]. The efficacy of docetaxel may be related to its drug metabolism. Studies have found that the metabolism of docetaxel is likely to be related to individual differences[9]. It has been clinically shown that in some groups of people, the metabolism of docetaxel is relatively strong, and the drug can be cleared faster in the patient's body[10]. Studies have also confirmed that docetaxel can change the expression of cytokines and growth factors in the tumor microenvironment, and can prevent tumor angiogenesis and tumor cell migration and invasion, so as to inhibit tumor growth and metastasis[11]. In addition, docetaxel may also rely on the regulation of tumor stem cells to inhibit tumor recurrence and drug resistance[12]. Studies have found that docetaxel can inhibit the proliferation and self-renewal ability of tumor stem cells, thereby reducing the number of tumor stem cells and reducing the chance of tumor recurrence and drug resistance[13].

Further, the pharmacological mechanism of abiraterone in the treatment of mCRPC was also studied. Abiraterone which is an oral androgen synthesis inhibitor is widely used in patients with mCRPC. It works by inhibiting the key enzyme CYP17A1 in the synthesis pathway of testosterone, which prevents the production of endogenous androgen in tumor cells, thereby inhibiting the growth and spread of tumors. Abiraterone can rely on inhibiting the activity of CYP17A1 enzyme to cut off the 17 Alpha (α) hydroxylation and 17,20-cleavage reaction in the testosterone synthesis pathway, resulting in cutting off the synthesis of testosterone and androdione. As two kinds of androgens are necessary for the proliferation and survival of prostate cancer cells, once they cannot be synthesized, the level of endogenous androgens in tumor cells will be significantly reduced to inhibit the growth of tumors. Abiraterone can also affect the function of androgen receptors. Studies have confirmed that abiraterone can reduce the nuclear translocation of the androgen receptor and the binding of Deoxyribonucleic Acid (DNA), thereby reducing the transcriptional activity of androgen[14]. Studies have also shown that abiraterone can increase the degradation of androgen receptor and inhibit the phosphorylation of androgen receptor[15]. Under these pharmacological mechanisms, abiraterone can inhibit the transcription and proliferation signalling pathways mediated by the androgen receptor, so that the growth and spread of cancer cells can be inhibited. Similarly, abiraterone also has the effect of affecting the tumor microenvironment to inhibit tumor growth and metastasis. Studies have shown that abiraterone can reduce the normal expression of cell proliferation markers in tumor tissue, thereby inhibiting the growth of angiogenic factors and preventing the normal formation of tumor blood vessels[16].

A number of clinical studies have confirmed that

abiraterone has a significant medicinal effect on mCRPC[17]. For example, studies showed that abiraterone combined with conventional hormone therapy can effectively prolong the PFS and overall survival of patients in compared with placebo. Moreover, abiraterone is a safe and well tolerated drug. The occurrence rate of common side effects such as high blood pressure, nausea and edema is low. Studies have also shown that compared with young patients, elderly patients have similar characteristics of tolerance to abiraterone, and there will not be too many differences in treatment effects[18]. Overall, abiraterone is relatively safe treatment and can play a role in many aspects such as maintaining the androgen synthesis pathway, mediating the androgen receptor, and affecting the tumor microenvironment.

The 1 y survival rate of mCRPC patients with two different combinations of drugs in this study was 95 % in the docetaxel group and 100 % in the abiraterone group. This shows that the two groups of drugs have a good effect on the 1 y survival rate of patients. Prednisone tablets appeared in both groups of drugs. In terms of medication guidance, abiraterone can only be used in combination with prednisone or prednisolone to treat mCRPC, not alone. Docetaxel injection is used in the chemotherapy of mCRPC, and it is often used in combination with carboplatin, paclitaxel, and prednisone. According to the analysis of this study, mCRPC patients are mostly middle-aged and elderly people, and the side effects of docetaxel are unbearable for the group, so most of the people tend to choose abiraterone. However, the actual clinical results show that abiraterone is superior to the docetaxel drug group in many aspects, such as the curative effect, the improvement of the patient's tumor marker level, improvement of the patient's serum testosterone, PSA, AR-V7, PVR, and MFR levels. This shows that the efficacy of abiraterone is better than that of docetaxel.

This study also has certain limitations. One is that the study analyzed abiraterone as the 1st hormone therapy drug for the treatment of mCRPC, which will cause certain drug resistance in patients. But this study did not confirm the conclusion that may be related to the length of follow-up in this study. In addition, the sample size of this study is small, so the conclusions drawn may be somewhat biased. In general, abiraterone, as a drug mechanism for androgen synthesis inhibitors, has a relatively high safety, and the curative effect of the drug observed at a 1 y cycle is better.

Conflict of interests:

The authors declared no conflict of interest.

REFERENCES

1. Yanagisawa T, Hata K, Narita S, Hatakeyama S, Mori K, Yata Y, *et al.* Docetaxel *vs.* abiraterone for metastatic hormone-sensitive prostate cancer with focus on efficacy of sequential therapy. Prostate 2023;83(6):563-71.
2. Lehtonen M, Sormunen J, Luukkaala T, Marttila T, McDermott R, Joensuu T, *et al.* 2-weekly *vs.* 3-weekly docetaxel for metastatic castration-resistant prostate cancer: Complete quality of life results from the randomised, phase-III PROSTY trial. Acta Oncol 2022;61(8):963-71.
3. Lee CL, Chang YH, Liu CY, Hsieh ML, Huang LK, Chu YC, *et al.* Changes in prostate-specific antigen kinetics during androgen-deprivation therapy as a predictor of response to abiraterone in chemonaive patients with metastatic castration-resistant prostate cancer. Investig Clin Urol 2022;63(5):546-53.
4. Nagata Y, Matsukawa T, Tomisaki I, Fujimoto N. Prostate-specific antigen kinetics during androgen-deprivation therapy predict response to enzalutamide in metastatic castration-resistant prostate cancer. Anticancer Res 2023;43(1):429-36.
5. Huang J, Liu W, Lin BY, Li JC, Lu J, Li BY. Scaffold protein MAPK8IP2 expression is a robust prognostic factor in prostate cancer associated with AR signaling activity. Asian J Androl 2022;25(2):198-207.
6. Bordeau BM, Ciulla DA, Callahan BP. Hedgehog proteins consume steroidal CYP17A1 antagonists: Potential therapeutic significance in advanced prostate cancer. ChemMedChem 2016;11(18):1983-6.
7. Wu D, Xiong L. Efficacy analysis of trastuzumab, carboplatin and docetaxel in HER-2-positive breast cancer patients. Oncol Lett 2020;19(3):2539-46.
8. Matsuda T, Takeuchi H, Sakurai T, Mayanagi S, Booka E, Fujita T, *et al.* Pilot study of WT1 peptide-pulsed dendritic cell vaccination with docetaxel in esophageal cancer. Oncol Lett 2018;16(1):1348-56.
9. Crabb SJ, Griffiths G, Dunkley D, Downs N, Ellis M, Radford M, *et al.* Overall survival update for patients with metastatic castration-resistant prostate cancer treated with capivasertib and docetaxel in the phase 2 ProCAID clinical trial. Eur Urol 2022;82(5):512-5.
10. Kamisawa K, Kosaka T, Nakamura K, Yasumizu Y, Hongo H, Takeda T, *et al.* Influence of response to prior docetaxel on sensitivity to cabazitaxel in prostate cancer patients with PTEN alterations. Cancer Sci 2022;113(9):3161-8.
11. Yanagisawa T, Kimura T, Hata K, Narita S, Hatakeyama S, Enei Y, *et al.* Does castration status affect docetaxel-related adverse events?: Identification of risk factors for docetaxel-related adverse events in metastatic prostate cancer. Prostate 2022;82(14):1322-30.
12. Neuberger M, Goly N, Skladny J, Milczynski V, Wessels F, Nitschke K, *et al.* Systemic inflammatory biomarkers as predictive and prognostic factors in men with metastatic castration-refractory prostate cancer treated with docetaxel therapy: A comprehensive analysis in a German real-world cohort. J Cancer Res Clin Oncol 2022;149(7):3371-81.

13. Kreis K, Horenkamp-Sonntag D, Schneider U, Zeidler J, Glaeske G, Weissbach L. Safety and survival of docetaxel and cabazitaxel in metastatic castration-resistant prostate cancer. BJU Int 2021;129(4):470-9.
14. Gu T, Li J, Chen T, Zhu Q, Ding J. Circulating tumor cell quantification during abiraterone plus prednisone therapy may estimate survival in metastatic castration-resistant prostate cancer patients. Int Urol Nephrol 2023;55(4):883-92.
15. Kucukarda A, Gokyer A, Gokmen I, Ozcan E, Hacıoglu MB, Erdogan B, *et al.* Prognostic nutritional index is an independent prognostic factor for treatment response, survival and drug choice in metastatic castration-resistant prostate cancer treated with abiraterone acetate or enzalutamide. Actas Urol Esp 2022;46(5):301-9.
16. Qin S, Gao H, Kim W, Zhang H, Gu Y, Kalari KR, *et al.* Biomarkers for predicting abiraterone treatment outcome and selecting alternative therapies in castration-resistant prostate cancer. Clin Pharmacol Ther 2022;111(6):1296-306.
17. Ohlmann CH, Jaschke M, Jaehnig P, Krege S, Gschwend J, Rexer H, *et al.* LHRH sparing therapy in patients with chemotherapy-naïve, mCRPC treated with abiraterone acetate plus prednisone: Results of the randomized phase II SPARE trial. Prostate Cancer Prostatic Dis 2022;25(4):778-84.
18. Trieu J, Chang M, Rojas V, Varada N, Cao Y, Anderson M, *et al.* Lower fracture rates in patients treated with radium-223, abiraterone or enzalutamide, when given concurrently with bone health agents: A real-world analysis. Clin Genitourin Cancer 2022;20(5):399-403.

This article was originally published in a special issue, "Recent Progression in Pharmacological and Health Sciences" Indian J Pharm Sci 2024:86(2) Spl Issue "70-77"