Sapporo Medical Journal
Volume 56, Issue 12, December 2022

Changes In Bladder and Rectum Filling Volume and Their Effects on Dose Distribution in EBRT For Prostate Cancer Patients

Huda I. AL-Mohammed[1], Hoda F. Alkasme1, Joud K. Alteraifi[2], Ftoun F. Alsubaie[1], Hala M. Alotaibi[1], Bushra H. Alzahrani[1], Hanan A. Alharbi[1], Basim A. Alhomida[2]

[1]Department of Radiological Sciences, College of Health and Rehabilitation Science, Princess Nourah Bint Abdulrahman University, Saudi Arabia
[2]College of Medicine, Almaarefa University, Riyadh, Saudi Arabia

Abstract— The dose distribution among prostate cancer cases is changed according to the conditions of the bladder and rectum filling, which are associated with the radiation's toxicity. This study aims to evaluate the changes in bladder and rectum filling volumes and their effects on dose distribution in external beam radiation therapy for prostate cancer patients. The treatment plans of 28 patients were retrospectively reviewed to compare the difference in planned and received dose for planning target volume (PTV), bladder, rectum, and other organs at risk. Data were then analyzed using the SPSS 24 program. Comparison between planned and achieved doses; D98%, D50%, and D2% for planning target volumes; V60, V56, and V52 for bladder and rectum; maximum dose for bowels and femoral heads; and mean dose used for penial bulbs in both full and empty bladders—showed a significant difference in bladder dose, a minimal difference in planning target volume, and no difference in rectum, bowel, femoral head, and penile bulb dose. Changes in bladder filling volume affect dose distribution. The full bladder and empty rectum protocol was safe and effective. recommended the continuous use of the full bladder and empty rectum protocol and identified a new method to keep the volume of the bladder fixed at all radiotherapy treatment sessions.

Keywords: External Beam Radiation Therapy, Prostate Cancer, Bladder, Empty Rectum Protocol, OAR

Introduction

In Saudi Arabia, prostate cancer is one of the most common cancers in men (1). The incident of Prostate cancer in Saudi Arabia is mostly in the Eastern part of the country which having the highest values for age standardized incidence rates (ASIR) (2). Men in the Arab world share a common feature of lack of knowledge and attitudes about prostate cancer testing and screening practices (3).Radiotherapy for patients with prostate cancer, preferably provided with a full urinary bladder and empty rectum. This technique is used to move the small intestine from the radiation region, which will lead to decrease the gastrointestinal toxicity (4). In addition, it keeps the prostate in a consistent position for each radiotherapy session. This technique also reduces the exposure to organ at risk (OAR) and reduce the possibility of side effects[4] such as dysuria and hematuria (5). The radical treatment for prostate cancer needs surgical intervention and/or radiation therapy.

Major categories of radiotherapy (RT) for prostate cancer treatment are: (1) external beam RT (EBRT), and (2) brachytherapy (BT) (6). Radiotherapy uses a high energy mode to kill cancer cells and to shrink the tumors. Based on the previous studies prostate cancer may respond positively to a higher dose per day thus Ultra hypofractionation (UHF) Including the radiation course into just 5-7 fraction of 6-8 Gy each (7). In general, prostate cancer grows slowly[8], although this is considered an advantage, however, since the prostate is a movable organ that will make radiotherapy treatment more challenging to deliver the precise dose. To solve this problem prostate's motion can be detected by fiducial marks implanted inside the prostate or using cone-beam computed tomography (CBCT) (9).

Methodology

study design and place of the study

This study was a retrospective comparative dose metric study approved by institutional review broad (IRB: Princess Nourah bint Abdulrahman University (IRB Number: 22-0045). The study was conducted at the Radiation Oncology Department at King Fahad Medical City, Riyadh, Kingdom of Saudi Arabia. From January-March 2022. 28 Prostate cancer patients from 30-85 years old were treated with external beam radiation therapy. Sampling method was accessible sampling. The collected data were computerized and statistically analyzed using SPSS program (statistical package for social science) version 24. Ages and treatment modalities were reviewed using patients' medical files. The data were collected using the treatment planning system which contains data of patients with prostate cancer. The research is based on a compression between two groups of patients, the first group with a full bladder and empty rectum, the other group with an empty bladder and empty rectum.

Results

Patient Characteristics

Table 3.1: Patient Characteristics

Bladder volume	N	%
Empty	14	50.0
Full	14	50.0
Total	28	100.0

This table shows that the study included 28 prostate cancer 14 patients (50%) treated with full bladder and 14 patients (50%) treated with empty bladder.

Dosimetry

Table 3.2 PTV prostate dosimetry

PTV dose in full bladder					PTV dose in empty bladder					Mann-whitney U	Sig
PTV	D98%	>57 Gy	Full	1	PTV	D98 %	>57 Gy	Empty	4	91.5	0.765
PTV	D50%	60Gy	Full	2	PTV	D50 %	60 Gy	Empty	5	52	0.035
PTV	D2%	<63 Gy	Full	3	PTV	D2%	<63 Gy	Empty	6	66	0.141

This table shows that for PTV98% and PTV2% in empty and full bladder, there was no significant difference while in PTV 50% there was a significant difference between full and empty bladder.

Table 3.3 Bladder Volume

Volume of full bladder					Volume of empty bladder					Mann-whitney U	sig
Bladder	V60	<25%	Full	7	bladder	V60	<25 %	Empty	10	46	0.017
Bladder	V56	<35%	Full	8	bladder	V56	<35 %	Empty	11	45	0.015
Bladder	V52	<50%	Full	9	bladder	V52	<50 %	Empty	12	47.5	0.02

This table shows that in all three volumes of the bladder (v60, v56, and v52), there was a significant difference in dose received compared to tolerance.

Table 3.4 Rectum volume

	e of rectum (in full bladder)				of rectum (In empty rectum)					Mann-whitney U	sig
Rectum	V60	<15%	Full	13	rectum	V60	<15%	Empty	16	88	0.646

Rectum	V56	<25%	Full	14	rectum	V56	<25%	Empty	17	70	0.198
Rectum	V52	<35%	Full	15	rectum	V52	<35%	Empty	18	68.5	0.175

This table shows that in the rectum there was no significant difference between the planned dose and the achieved dose.

Table 3.5 Organs at Risk

OAR (in full bladder)					OAR (in empty bladder)					Mann-whitne y U	sig
Bowel	D ma x	52Gy	Full	19	bowel	D max	52Gy	Empty	23	28	0.123
LT femoral head	D ma x	<45Gy	Full	21	LT femoral head	D max	<45Gy	Empty	25	45	0.612
Penile bulb	mean dose	<42gy	Full	22	penile bulb	mean dose	<42gy	Empty	26	23	0.897

In this table, we can clearly see that there is no significance difference between tolerance and achieved dose in organs at risk (right and left femoral head, bowel and penile blub)

Discussion

The prostate is a mobile organ enclosed by the bladder and rectum. Because of these moveable elements, the usual location of the prostate might change on a daily basis. However, the greatest fluctuation in its location is caused by the filling of the bladder and rectum. When the rectum is filled, the prostate travels anteriorly toward the patient. As a result, changes in these quantities have a significant influence on the prostate's location. (10).

Our findings supported several investigations (11), (12), (13), (14) and (15), following statistical analysis, the bladder dosage differed significantly between full and empty bladders, highlighting the importance of the full bladder protocol to protect the organs surrounding the prostate, reduce acute and chronic adverse effects, and improve patient quality of life after treatment. Although our data indicate that the PTV does not change much when the bladder is full or empty, we cannot minimize the importance of filling the bladder to capacity prior to treatment in order to minimize the risk of radiation exposure to sensitive organs. During data collection, we saw that the full bladder received a lower dose, but statistical analysis revealed a significant difference between the doses given to the full and empty bladders, highlighting the relevance of the full bladder procedure. However, the results reveal that there is no substantial difference between the PTV of a full and empty bladder. We focused on the disparity in dose distribution between the PTV, the bladder, and other organs at risk. During data collection, we observed that the empty bladder got a higher dose; statistical analysis revealed a significant difference in bladder dose between empty and full bladders, highlighting the significance of the full bladder procedure. The data, however, indicates that the difference in PTV between a full and empty bladder is not significant.

Conclusion and Recommendation

The dosage distribution in prostate cancer patients varies depending on the bladder and rectum filling states, which are linked to radiation damage. The purpose of this study is to assess changes in bladder and rectum filling volumes and their implications on dose distribution in prostate cancer patients receiving external beam radiation treatment. The treatment plans of 28 patients were evaluated retrospectively to compare the difference in planned and received dosage for PTV, bladder, rectum, and other organs at risk. The data was then examined with the SPSS 24 application. The comparison of planned and achieved doses; D98%, D50%, and D2% for planning target volumes; V60, V56, and V52 for bladder and rectum; maximum dose for bowels and femoral heads; and mean dose for penial bulbs in both full and empty bladders revealed a significant difference in bladder dose, a minimal difference in planning target volume, and no difference in rectum, bowel, femoral head, and penile bulb dose. Dose distribution is affected by changes in bladder filling capacity. The regimen of full bladder and empty rectum was both safe and effective. The full bladder and empty rectum procedure was suggested indefinitely, and a novel mechanism was developed to keep the capacity of the bladder constant during all radiation treatment sessions.

The retrospective nature of the study and the small number of patients have an influence on the data's limitations. As a result, our statistical power is likewise constrained. The data is further restricted between 2018 and 2022 owing to COVID-19, which limits patient appointments and distributes them over a 2-year period across several institutions.

References

[1] [WedadAlqahtani, Nawaf Almufareh, Dalia Domiaty et al. Epidemiology of cancer in Saudi Arabia thru 2010–2019: a systematic review withconstrained meta-analysis.AIMS Public Health.2020;7(3):679–696.

[2] Latifah Alhawiti. Prostate Cancer in Saudi Arabia. Electronic Interdisciplinary Miscellaneous Journal.2020; 10:3-5.

[3] Mostafa Arafa, Danny Rabah. With increasing trends of prostate cancer in the Saudi Arabia and Arab World: Should we start screening programs. World Journal of Clinical Oncology. 2017; 8(6):447-449.

[4] Nasser N, Fenig E, Klein J et al. Maintaining consistent bladder fillingduring external beam radiotherapy for prostate cancer. Technical Innovations & Patient Support in Radiation Oncology. 2021; 17:1-4.

[5] Mayo Foundation for Medical Education and Research, 2021. External beam radiation for prostate cancer. Retrieved from mayo clinic website: https://www.mayoclinic.org/tests-procedures/external-beam-radiation-for-prostate-cancer/about/pac-20384743

[6] Tarun K Podder et al. Advances in Radiotherapy for Prostate Cancer Treatment. Molecular & Diagnostic Imaging in Prostate Cancer. 2018; 1126: 31-37.

[7] Byun DJ, Gorovets DJ, Jacobs LM et al. Strict bladder filling and rectal emptying during prostate SBRT. Radiation oncology (London, England). 2020; 15 (1):2-4.

[8] Mayo Foundation for Medical Education and Research, 2021. Prostate cancer. Retrieved from mayo clinic website:https://www.mayoclinic.org/diseases-conditions/prostate-cancer/symptoms- causes/syc-20353087.

[9] Ariyaratne H, Chesham H, Alonzi R. Image-guided radiotherapy for prostate cancer in the United Kingdom: a national survey. The British Journal of Radiology.2017;90(1070):20160059.

[10] Casares-Magaz O, Moiseenko V, Hopper A, Pettersson N, Thor M, Knopp R et al. Associations between volume changes and spatial dose metrics for the urinary bladder during local versus pelvic irradiation for prostate cancer. Acta Oncologica. 2017;56(6):884-890.

[11] Chen Z, Yang Z et al. Dosimetric impact of different bladder and rectum filling during prostate cancer radiotherapy. Radiation Oncology. 2016;11(1):1-8.

[12] Fuchs F, Habl G, Devečka M et al. Interfraction variation and dosimetric changes during image-guided radiation therapy in prostate cancer patients. Radiation Oncology Journal. 2019;37(2):127-133.

[13] Gurjar O, Arya R, Goyal H et al. A study on prostate movement and dosimetric variation becausof bladder and rectum volumes changes during image-guided radiotherapy in prostate cancer. Prostate International. 2020;8(2):91-97.

[14] Huang T, Chou K, Yang S et al. Fractionated changes in prostate cancer radiotherapy using cone-beam computed tomography. Medical Dosimetry. 2015;40(3):222-225.

[15] Pearson D, Gill S, Campbell N et al. Dosimetric and volumetric changes in the rectum and bladder in patients receiving CBCT-guided prostate IMRT: analysis based on daily CBCT dose calculation. Journal of Applied Clinical Medical Physics. 2016;17(6):107-117.