

External Beam Radiotherapy in Prostate Cancer: Technological advances to improve patient care

Dr Cattleya Gaspar – Radiation Oncologist
FC Rad Onc (SA), MMed Rad (Pret), MBChB Cum Laude (Pret)



Dr Gaspar completed her MBChB at the University of Pretoria in 2011. Having served two years of medical internship at the Steve Biko Academic Hospital in Pretoria, Dr Gaspar then completed her community service at the Kalafong Tertiary Hospital in family and emergency medicine. She then returned to the Steve Biko Academic Hospital in 2015 where she worked as a medical officer in Medical Oncology. After eighteen months, Dr Gaspar started her specialisation and was admitted as a Fellow of the College of Radiation Oncologists in 2021. She joined DMO in 2022, where she is now a partner.

Dr Gaspar has completed her Master's Degree at the University of Pretoria, with her research focused on the predisposing factors of chronic radiation proctitis. She enjoys academics and attends both local and international meetings, to continuously broaden her expertise. She is a member of several esteemed organizations such as SASCRO and ICON and is a participant in several multi-disciplinary cancer forums in Pretoria.

Dr Gaspar works at the Groenkloof Radiation Oncology and Mûelmed Radiation Oncology Centres and is part of a team of Oncologists that consult at the DMO locations. Her areas of interest are broad and include breast, gynaecological, genito-urinary, gastro-intestinal as well as Head and Neck Cancers

"Oncology is a remarkable field. With advances in medical sciences and technology, there are continuous opportunities on the horizon to improve patient care and treatment outcomes. For me, Oncology is about empathy, kindness and compassion. The care journey doesn't end when the treatment is completed. The cancer journey is a lifelong one of helping patients through difficult decisions, being there for them through their most difficult of times and guiding them through their follow up care pathways. This, to me, is most rewarding and I find it an honour to work in this field.

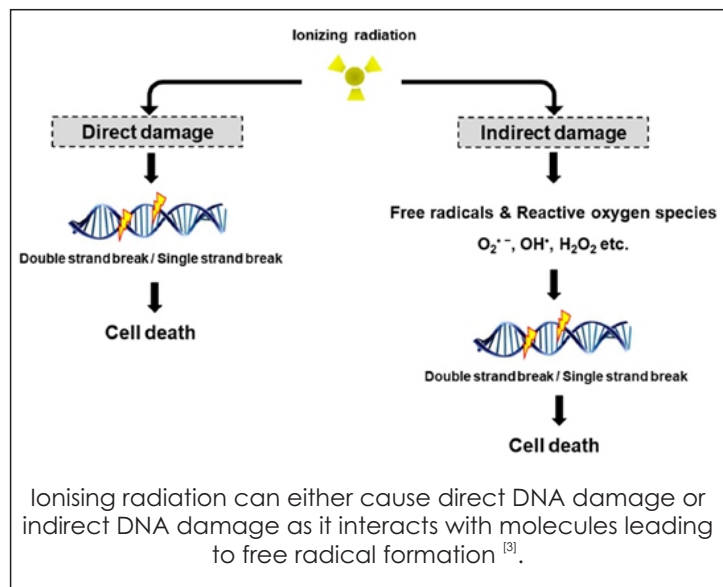
I remain grateful for the mentorship by some of the greatest minds in the field and have dedicated my career to help those impacted by cancer and my wish is to truly make a meaningful difference in the lives of my patients and their loved ones." - Dr Cattleya Gaspar.

Prostate cancer has become the most common cancer among males in South Africa, with a lifetime risk of 1 in 15^[1]. Routine PSA screening allows for early detection and appropriate management. Radiotherapy is one of the most common treatment modalities used in the management of prostate cancer. It can be used in the post operative setting, in locally advanced disease and even in metastatic disease.

External Beam Radiotherapy (EBRT) has significantly evolved over the past few decades. Newer technological advances have not only enhanced the precision of treatments, but have also allowed for a reduction in treatment time and treatment-related side effects.

What is External Beam Radiotherapy (EBRT)?

Radiation occurs when there is a **release of energy** caused by an electromagnetic wave or a moving sub-atomic particle. Radiation can be ionising or non-ionising. Ionising radiation has **high energy** and causes **the ionisation of molecules** whereby a molecule gains a negative or positive charge. When this happens in human tissue, DNA damage is the end result. **Ionising radiation destroys cancer cells** by causing **DNA damage**. DNA damage will prevent the cancer cell from dividing successfully and will subsequently cause cancer cell death ^[2].



Ionising radiation is produced by a machine known as a linear accelerator (LINAC) and is delivered to a focused area, in the form of external beam radiotherapy (EBRT). There are a number of different forms of EBRT namely:

Conventional Radiotherapy:

- Three-dimensional conformal radiation therapy (3D-CRT)
- Intensity-Modulated Radiation Therapy (IMRT)
- Volumetric modulated arc therapy (VMAT)

Specialised Treatments:

- Stereotactic Body Radiation Therapy (SBRT)
- MRI-Guided Radiation Therapy

How has radiotherapy for prostate cancer changed over time?

Radiotherapy Techniques:

In the recent past, radiotherapy was delivered using a 3D-CRT technique, whereby the planned target was localised using a CT-planning scan. A significant additional "margin" was required to account or compensate for localisation uncertainties. The radiotherapy beam arrangements were planned using a classic "six-field" or a "four-field box". Subsequently, a significant amount of normal tissue (aka, the "organs at risk" such as the bladder and rectum) was also included within the treatment volume. In order to limit the doses to the organs at risk, radiotherapy was delivered over 35-40 daily fractions of 2Gy each.

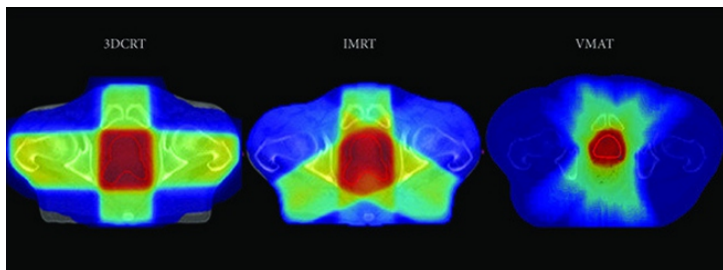
These longer treatment schedules had many logistic and practical limitations for the patients receiving radiotherapy. The treatment related side effect profile was also more of a problem with many patients developing both genitourinary and gastrointestinal related toxicities.

Nowadays, with newer radiotherapy treatment techniques, as well as better image guidance, patients are able to receive higher doses of radiotherapy over a shorter period of time, with fewer treatment-related side effects. Newer, highly conformal radiotherapy treatment techniques include Intensity-Modulated Radiation Therapy (IMRT) and Volumetric modulated arc therapy (VMAT). These techniques deliver radiation with high precision to target tumours while minimizing damage to the surrounding healthy tissue (or "organs at risk")

When combined with image guidance (daily on-treatment cone beam CT or MRI-linac real time RT), tumour localisation is even more accurate, and normal tissue sparing is possible. This allows for higher doses to be delivered in a safer manner.

These techniques, for example, have reduced the occurrence of chronic radiation induced proctitis. A rate of <2 % of grade 3 chronic radiation proctitis at five years has been noted

^[4]



Difference in dose distribution using a 3DCRT, IMRT and VMAT technique respectively.

Changes in fractionation schedules:

Radiobiology is the study of the **effects of radiation** on living organisms. It combines principles of radiation physics and biology to understand how radiation interacts with tumour cells as well as healthy tissues. Due to the radiobiology of prostate cancer cells, it was noted that higher daily treatment doses ($>2\text{Gy}$ per fraction) allowed for an improved “tumour cell kill”. This means that a higher dosage per treatment is more effective than using a lower dose over a longer period of time. This significantly impacts treatment delivery time, as the same amount of radiation (“equivalent dose”) can be delivered over a shorter period of time.

Delivering a dose of $> 2\text{Gy}$ per treatment is known as “hypofractionation”. Current hypofractionated schedules used in practice include ^[5]:

- 3Gy/day in 20 treatments (commonly used)
- 2.7Gy/day in 26 treatments
- 2.5Gy/day in 28 treatments

Therefore, a treatment that would span six to eight weeks can now span over a four-week period.

In some cases, treatments can be delivered over two weeks, using Stereotactic Body Radiation Therapy (SBRT)

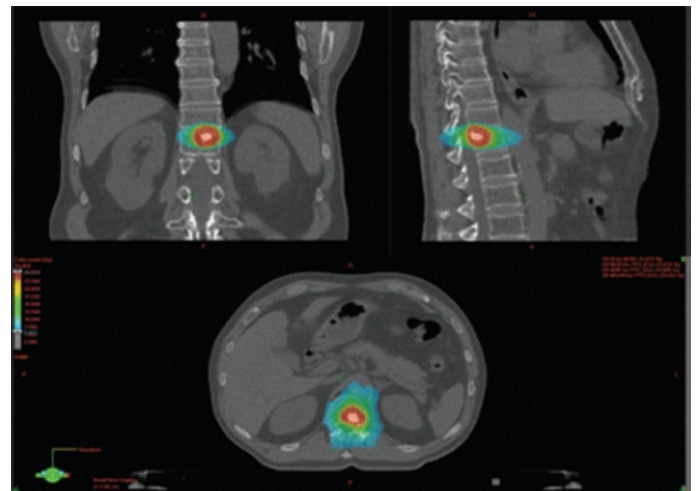
Stereotactic Body Radiation Therapy (SBRT)

Stereotactic body radiation therapy (SBRT) is a specialized type of EBRT that delivers high doses of radiation to small, well-defined tumour volumes. Treatments are delivered over a much shorter period of time and the doses to the surrounding organs at risk are kept to a minimum.

SBRT can be performed in four to five treatments of 6 - 10Gy, typically three times per week.

This form of hypofractionation (known as extreme hypofractionation) is commonly used in metastatic-directed therapy in prostate cancer patients with oligometastatic disease.

The treatment of oligometastatic prostate cancer has become popular over the past few years. Several studies have demonstrated that the addition of SBRT to hormonal deprivation therapies can lead to improved PFS and OS rates ^[6,7].



SBRT treatment plan. A single skeletal metastatic lesion was treated using 5Gy per fraction up to a total dose of 35Gy . A well-defined, small tumour volume is noted. The organs at risk (liver, kidneys, small bowel for example) are safely within tolerance.

In Summary

Radiotherapy is one of the most common treatment modalities used in the management of prostate cancer. External Beam Radiotherapy (EBRT) has significantly evolved over the past few decades. Newer technological advances have not only enhanced the precision of treatments, but have also allowed for a reduction in treatment time and treatment related side effects, making treatment for patients with prostate cancer a lot more manageable.

References:

1. CANSA.org
<https://cansa.org.za/prostate-cancer/#:~:text=The%20lifetime%20risk%20for%20prostate,locally%20and%20showing%20significant%20increases.>
2. CDC.gov
https://www.cdc.gov/nceh/radiation/ionizing_radiation.html
3. Molecular Pathogenesis of Radiation-Induced Cell Toxicity in Stem Cells, Wonhee Hur et al. Int. J. Mol. Sci. 2017, 18(12), 2749
<https://www.mdpi.com/1422-0067/18/12/2749>
4. Widmark A, Gunnlaugsson A, Beckman L, et al. Ultrahypofractionated versus conventionally fractionated radiotherapy for prostate cancer: 5-year outcomes of the HYPO-RT-PC randomised, non-inferiority, phase 3 trial. Lancet 2019;394:385-95
5. Principals of Radiotherapy. NCCN Guidelines Version 2.2025 Prostate Cancer 04/16/25 © 2025 National Comprehensive Cancer Network® (NCCN®)
6. Outcomes of Observation vs Stereotactic Ablative Radiation for Oligometastatic Prostate Cancer: The ORIOLE Phase 2 Randomized Clinical Trial. JAMA Oncol. 2020;6(5):650.
7. Stereotactic Ablative Radiotherapy for the Comprehensive Treatment of Oligometastatic Cancers: Long-Term Results of the SABR-COMET Phase Randomized Trial. J Clin Oncol. 2020;38(25):2830. Epub 2020 Jun 2.