



Advancements in Radiation Therapy Techniques for the Treatment of Cancer

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Description

Radiation therapy, a primary modality in cancer treatment, has transformed over the last century from a crude, high-risk approach to an intricate, finely tuned procedure with remarkable precision. Utilized in nearly half of all cancer treatments, radiation therapy uses ionizing radiation to destroy cancer cells, thereby reducing tumor size and alleviating symptoms. Unlike chemotherapy, which circulates through the entire body, radiation is typically localized to a targeted area, making it suitable for solid tumors and cancer cells in defined locations.

Principles and mechanism of radiation therapy

The fundamental goal of radiation therapy is to damage the DNA within cancer cells to inhibit their ability to reproduce and spread. Using high-energy X-rays, gamma rays, or charged particles, radiation therapy targets DNA within the cell nucleus, causing irreparable breaks in its structure. Cancer cells, with their rapid division rates and less efficient DNA repair mechanisms, are particularly vulnerable to radiation-induced damage compared to healthy cells. Although some healthy cells in the vicinity may be affected, advanced techniques allow for minimizing collateral damage.

Advancements in radiation therapy

Advances in radiation therapy technology over the past few decades have vastly improved its efficacy and safety. These innovations have been instrumental in shifting radiation therapy from a once risky option to a preferred treatment for many types of cancer.

The integration of imaging techniques such as Computed Tomography (CT), Magnetic Resonance Imaging (MRI) and Positron Emission Tomography (PET) scans has transformed treatment planning, allowing radiation oncologists to visualize the tumor and its surrounding anatomy accurately. Improved imaging facilitates more precise targeting of the tumor, which is crucial for protecting healthy tissues.

Advances in genomics and molecular profiling have opened up the possibility of personalized radiation therapy. By understanding the genetic and molecular characteristics of a patient's tumor, clinicians can tailor the radiation dose to optimize efficacy while minimizing toxicity.

SRS and SBRT deliver high doses of radiation with sub-millimeter precision in one or a few sessions. These

methods are particularly effective for small tumors in sensitive areas, such as the brain or lungs, and for patients who may not be candidates for surgery.

Adaptive Radiation Therapy (ART): Adaptive radiation therapy uses real-time imaging to adjust the treatment plan dynamically based on changes in the tumor's position, shape, or size during therapy. ART is beneficial in cases where tumors may shrink, move, or change over the course of treatment, such as in lung or bladder cancers.

Impact on patient quality of life and side effects

Radiation therapy, while often life-saving, is associated with various side effects, depending on the area treated and dose delivered. Acute side effects, which occur during treatment, may include skin irritation, fatigue, and gastrointestinal symptoms, depending on the site. Long-term side effects can also develop, including fibrosis, lymphedema, or secondary cancers, which highlight the importance of continuous research and refinement in techniques.

The impact on patient quality of life can vary. For instance, proton therapy and brachytherapy are associated with fewer side effects compared to traditional external beam radiation therapy, particularly in pediatric patients and those with tumors close to vital organs. Furthermore, advancements in supportive care, such as pain management, skin care, and fatigue management, have been essential in helping patients tolerate and recover from treatment. Enhanced communication and support from radiation oncologists and care teams also play a vital role in addressing patient needs throughout the process.

Conclusion

Radiation therapy continues to be a vital tool in the oncologist's armamentarium, with innovations that have improved its precision, reduced side effects, and expanded its use in treating cancer. From early-stage curative treatments to advanced palliative care, radiation therapy offers versatility across the cancer care continuum. With these advancements, the focus is shifting toward not only eradicating cancer but also preserving the patient's quality of life, offering hope that we are moving closer to more effective, less invasive, and more personalized cancer treatment options. Radiation therapy, once associated with broad effects, is now on the path toward unprecedented specificity, and its ongoing evolution is integral to the broader mission of improving cancer survival and quality of life for millions.