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Types of Radiation Therapy Used in Oncology

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Introduction

Radiation therapy, a cornerstone in modern oncology, plays a pivotal role in the treatment of various cancers. It involves the use of high-energy radiation to target and destroy cancer cells, while sparing surrounding healthy tissue as much as possible. Over the years, advancements in technology and a deeper understanding of cancer biology have led to the development of different types of radiation therapy. These therapies are tailored to the specific characteristics of the tumor and its location within the body, as well as the overall health of the patient. While radiation therapy is often used as a primary treatment, it can also serve as an adjunct to surgery or chemotherapy, offering significant benefits in improving treatment outcomes.

External Beam Radiation Therapy (EBRT) is perhaps the most widely recognized form of radiation treatment. In EBRT, radiation is delivered from outside the body using a machine called a Linear Accelerator (LINAC). The patient is positioned on a treatment table, and the machine directs high-energy X-rays or other forms of radiation precisely at the tumor. This type of radiation therapy is typically used for tumors that are accessible from the outside, and it can be delivered to nearly any part of the body. One of the primary advantages of external beam radiation is that it can target deep-seated tumors with high precision, thereby minimizing damage to surrounding healthy tissue. The use of advanced imaging technologies, such as CT scans, MRI, and PET scans, has significantly improved the accuracy of radiation delivery in EBRT, ensuring that the radiation is concentrated on the tumor and not on nearby organs or healthy cells.

Description

Intensity-Modulated Radiation Therapy (IMRT) is a more sophisticated form of external beam radiation that uses computer-controlled linear accelerators to deliver precise radiation doses to a tumor. IMRT allows the radiation oncologist to modulate the intensity of the radiation beams, adjusting them to conform more precisely to the shape of the tumor. This enables higher doses of radiation to be delivered to the tumor while minimizing exposure to the surrounding healthy tissue. IMRT is particularly useful for tumors located near critical structures, such as the brain, head and neck, and prostate, where sparing healthy tissue is crucial for preserving function and reducing side effects. Advancement in EBRT is Stereotactic Body Radiation Therapy (SBRT), also known as Stereotactic Ablative Radiotherapy (SABR). SBRT involves delivering very high doses of radiation to small, well-defined tumors in fewer treatment sessions compared to conventional radiation therapy. The precision of SBRT is achieved by using multiple beams of radiation from various angles, allowing the radiation to converge on the tumor from different directions. This technique is commonly used for tumors in the lungs, liver, spine, and other organs that are not easily accessible for surgery. SBRT is often recommended for patients who are not candidates for surgery or for those with tumors that are difficult to remove surgically.

A related technique is Stereotactic Radiosurgery (SRS), which, despite its name, is a form of radiation therapy rather than surgery. SRS is typically used to treat tumors in the brain, including metastases or benign tumors. It involves delivering a single, highly focused dose of radiation to a tumor, using specialized equipment like the Gamma Knife or Cyber Knife. The precision of SRS allows for the delivery of a very high dose of radiation to the tumor in one or a few treatment sessions, with minimal risk to surrounding brain tissue. SRS is particularly effective for treating tumors that are small and located in regions of the brain where traditional surgery would be too risky. Internal radiation therapy, or brachytherapy, involves placing a radioactive source directly inside or very close to the tumor. This method is often used for cancers of the prostate, cervix, uterus, breast, and eye. Brachytherapy can deliver high doses of radiation to a specific area while reducing the radiation exposure to surrounding healthy tissues [1].

There are two main types of brachytherapy: Low-Dose-Rate (LDR) and High-Dose-Rate (HDR). In LDR brachytherapy, radioactive seeds are implanted in or near the tumor, and the radiation is delivered gradually over time. In HDR brachytherapy, a high dose of radiation is delivered in a short period, typically over a few minutes, and the radioactive source is removed after each treatment session. Brachytherapy is often used in conjunction with external beam radiation to treat certain types of cancer, providing a more targeted and effective approach. Systemic radiation therapy, also known as targeted radionuclide therapy, involves the administration of radioactive substances that travel throughout the body to target cancer cells. These substances can be delivered through the bloodstream or directly injected into a body cavity. The radioactive particles attach to cancer cells, delivering a lethal dose of radiation. This type of therapy is most commonly used in the treatment of thyroid cancer, neuroendocrine tumors, and certain types of lymphoma. One of the major advantages of systemic radiation therapy is its ability to treat cancer cells that have spread to distant areas of the body, offering a systemic approach to cancer treatment [2,3].

One of the most well-known forms of systemic radiation therapy is the use of radioactive Iodine (I-131) for the treatment of thyroid cancer. After thyroid cancer is diagnosed, patients may be treated with radioactive iodine to target any remaining thyroid tissue or cancer cells that may have spread. The iodine is selectively absorbed by thyroid cells, and the radiation it emits helps to destroy cancerous cells. This approach is particularly effective for well-differentiated thyroid cancers, and it can be used both after surgery and as part of the initial treatment regimen.

Another example of systemic radiation therapy is the use of radiolabeled monoclonal antibodies. These are antibodies that are attached to radioactive isotopes and are designed to target specific cancer cells. For example, in the treatment of certain types of lymphoma, radiolabeled antibodies can bind to proteins on the surface of the cancer cells, delivering radiation directly to the tumor while minimizing the impact on healthy tissue. This approach is still in the experimental stages for several types of cancers but shows promise in providing highly targeted treatment options. Proton therapy is a relatively newer type of radiation therapy that uses protons, charged particles, instead of X-rays or other types of radiation. Proton therapy offers a key advantage in that protons deposit their energy directly at the tumor site, delivering a high dose of radiation to the cancer cells while sparing healthy tissues that are located beyond the tumor. This makes proton therapy particularly useful in treating tumors near critical structures, such as the spinal cord, brain, and eye, where

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minimizing damage to healthy tissues is essential. Proton therapy requires specialized equipment, including a proton accelerator, and is therefore available at only a limited number of treatment centers [4,5].

Conclusion

Radiation therapy is not without its risks and side effects. While modern techniques have significantly improved the precision of radiation delivery, some side effects are still common. These include fatigue, skin irritation, nausea, and hair loss, which typically occur in the area being treated. More serious side effects, such as damage to surrounding healthy tissue or organs, can also occur, particularly when the tumor is located near sensitive structures. Advances in radiation techniques, such as IMRT, SBRT, and proton therapy, have helped reduce the risk of side effects by allowing for more precise targeting of the tumor. In conclusion, radiation therapy is a highly effective and versatile treatment for cancer, offering multiple options to target and destroy tumors while minimizing damage to surrounding healthy tissue. External beam radiation therapy, brachytherapy, systemic radiation therapy, and proton therapy each have their own unique advantages, making them suitable for different types of cancer and patient needs. As technology continues to advance and our understanding of cancer biology deepens, the future of radiation therapy holds even more promise for improving cancer treatment and enhancing patient outcomes.

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