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Principles and Different Techniques Involved in Radiation Therapy

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Introduction

Radiation Therapy (RT) is now widely regarded as an important component of any good cancer treatment programme, regardless of a country's economic situation. Localized tumors can be cured with RT; it can also give local control with no recurrence in the treated area, as well as symptom relief in cancers that are locally progressed or disseminated. It is usually used in conjunction with surgery, either preoperatively or postoperatively, as well as systemic chemotherapy prior to, during, or after the course of RT. Because radiation affects both normal tissues and tumors, achieving an acceptable therapeutic ratio, which is defined as the probability of tumor control versus the probability of unacceptable toxicity, necessitates the delivery of the radiation dose within very tight tolerances of less than 5% deviation. Specialized equipment, which is maintained and handled by a team of qualified individuals, is required for the regulated generation and exact delivery of radiation. Radiation therapy (RT) is used to treat malignancies of the breast, prostate, cervix, head and neck, lung, and brain, as well as sarcomas. In low and middle income countries, the first four cancers are frequent [1].

High-energy radiation damages cells' genetic material (deoxyribonucleic acid, or DNA), preventing them from dividing and proliferating further. Despite the fact that radiation destroys both normal and cancer cells, the purpose of radiation treatment is to increase the radiation dose to aberrant cancer cells while reducing exposure to normal cells adjacent to cancer cells or in the path of radiation. Normal cells, on the other hand, can usually repair themselves faster and maintain their normal function status than cancer cells. Cancer cells in general are less effective than normal cells at repairing damage caused by radiation treatment, resulting in cancer cell death that is not uniform.

Radiation can be provided with the goal of curing the cancer, or it can be used as a very effective palliative treatment to relieve cancer-related symptoms. Combination methods with other treatment techniques like as surgery, chemotherapy, or immunotherapy are other indications for radiation therapy. Radiation, when used before surgery (neoadjuvant therapy), aims to reduce the tumor. Radiation can be used after surgery to kill microscopic tumor cells that may have been left behind (adjuvant therapy) [2].

Fractionation

The different radiobiological characteristics of cancer and other normal tissues are used to administer fractionated radiation therapy. In general, these regimes augment normal tissues' survival advantage over cancer cells, owing to superior sub lethal damage repair of radiation damage in normal cells against cancer cells. Normal cells reproduce more slowly than cancer cells, giving them more time to repair damage before replicating [3].

3D Conformal Radiotherapy (3DCRT)

2D radiation therapy based on rectangular fields and conventional X-ray imaging has largely been superseded by 3D radiation therapy based on CT imaging, which enables for precise localization of the tumor and key normal organ structures for optimal beam placement and shielding. The goal is to deliver radiation to the gross tumor volume (GTV), with a clinical target volume (CTV) margin for microscopic tumor expansion and a planned target volume margin to account for organ movements and setup variables (PTV).

Intensity Modulated Radiation Therapy (IMRT)

The oncologist can use IMRT to provide irregular-shaped radiation doses that adhere to the tumor while avoiding important organs. Inverse planning software and computer-controlled intensity-modulation of numerous radiation beams during treatment make IMRT possible. IMRT can now be administered by linear accelerators with static or dynamic multi-leaf collimators or tomotherapy equipment in several clinical departments. This has resulted in therapeutic ratio improvements for a variety of tumor types, including head and neck cancers, prostate malignancies, and gynecological cancers [4].

Image-Guided Radiotherapy (IGRT)

The risk of missing tumor due to organ motion and patient setup changes increases as treatment margins become tighter and more conformal. When essential tissues are adjacent to the tumor, even a minor positioning error can result in accidental radiation of normal organs. IGRT enables for the detection and repair of such faults using information obtained from pre-radiotherapy imaging. One example is the use of daily cone-beam CT scans before to each treatment. Because of the enhanced precision, dosage escalation has been possible, allowing for an improvement in the therapeutic ratio for a variety of tumor sites, including head and neck cancers and prostate cancers.

Stereotactic Body Radiation Therapy (SBRT)

SBRT ablates tiny, well-defined primary and oligo metastatic tumors anywhere in the body by carefully delivering extremely high individual doses of radiation during just a few treatment fractions. Any tissue immediately close to the tumor is likely to be destroyed due to the high radiation exposure. Clinically meaningful toxicity is negligible in the high dosage range because the proportion of normal tissue is tiny and non-eloquent. SBRT has proved to be effective in treating early stage non-small cell lung cancer in individuals who are unable to undergo surgery. Prostate, head and neck, hepatic, renal, oligo metastases, spinal, and pancreatic tumors are among the others.

Photons radiation (x-rays and gamma rays) are widely used

Photon beams have a low radiation charge and a far lower mass than electron beams. Photons such as X-rays and gamma rays are commonly employed in radiation treatment to treat a variety of malignancies. X-rays and gamma rays are sparsely ionizing radiations with a low LET (linear energy transfer) that are further made up of massless energy particles known as photons. X-rays are produced by devices that excite electrons (for example, cathode ray tubes and linear accelerators), whereas gamma rays are produced by radioactive decay (e.g.cobalt-60, radium and cesium).

Radiation therapy and cell death

Radiation treatment has a number of techniques for killing cancer cells. Radiation therapy's main purpose is to deprive cancer cells of their ability to multiply and, as a result, destroy them. Cancer cells that have had their DNA damaged beyond repair cease proliferating and eventually die. The process

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of cell death in response to irradiation, on the other hand, is complicated. As a result, determining the impact of radiation-induced cell death and other processes involved might have therapeutic implications for enhancing radiation treatment results [5].

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