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An Overview of Proton Therapy

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Editorial

Proton therapy, often known as proton radiation, is a sort of particle therapy that involves irradiating diseased tissue with a beam of protons, most commonly to treat cancer. Proton treatment has a significant benefit over other methods of external beam irradiation in that the dose of protons is deposited over a small depth range, resulting in less entry, exit, or dispersed radiation exposure to healthy adjacent tissues. When deciding whether to treat a tumour with photon or proton therapy, doctors may choose proton therapy if delivering a higher radiation dosage to targeted tissues while dramatically reducing radiation to surrounding organs at risk is important. According to the American Society for Radiation Oncology's Model Policy for Proton Beam Treatment, proton therapy is considered appropriate when normal tissue sparing "cannot be properly achieved with photon-based radiation" and is beneficial to the patient. Proton therapy, like photon radiation treatment, is frequently used in conjunction with surgery and/or chemotherapy to treat cancer more successfully [1].

Ionizing radiation is used in proton treatment, which is a kind of external beam radiotherapy. Medical professionals utilise a particle accelerator to direct a beam of protons at a tumour in proton therapy. These charged particles damage cells' DNA, eventually killing them and eradicating the tumour by preventing their reproduction. Because of their fast rate of division and low ability to repair DNA damage, cancerous cells are particularly sensitive to DNA attacks. Proton radiation may be particularly sensitive to tumours with certain DNA repair abnormalities.

Proton therapy allows doctors to provide a highly conformal beam of radiation, which means the radiation conforms to the shape and depth of the tumour while preserving much of the surrounding, healthy tissue. When compared to the most advanced types of photon therapy, such as Intensity-modulated Radiotherapy (IMRT) and Volumetric Modulated Arc Therapy (VMAT), proton therapy can deliver similar or higher radiation doses to the tumour while delivering a 50 percent to 60 percent lower total body radiation dose.

Protons can focus energy delivery to adapt to the contour of the tumour, delivering only low-dose radiation to the surrounding tissue. As a result, there are less negative effects for the patient. A fixed range of penetration exists for all protons of a given energy; very few protons penetrate beyond that distance. Furthermore, only the last few millimetres of the particle's range enhance the dose supplied to tissue; this maximum is known as the spread out Bragg peak, or SOBP (see visual).

To treat malignancies at greater depths, the proton accelerator must produce a higher-energy beam, usually measured in electron volts (eV) (electron volts). Proton treatment accelerators typically produce protons with energy ranging from 70 to 250 MeV. Adjusting proton energy during treatment increases the amount of cell damage caused by the proton beam within the tumour. Tissue that is closer to the body's surface than the tumour receives less radiation, resulting in less damage. The dosage becomes infinitely little when protons reach deeper tissues in the body [1,2].

Equipment

Isochronous cyclotrons are used in the majority of proton treatment systems. Cyclotrons are thought to be simple to run, dependable, and small, especially when superconducting magnets are used. Synchrotrons can also be employed, having the added benefit of being easier to produce at different energies. As size and cost constraints are overcome, linear accelerators for photon radiation therapy are becoming commercially viable. Modern proton systems include high-resolution imaging for daily tumour contour assessment, treatment planning software that depicts 3D dose distributions, and a variety of system configurations, such as several treatment rooms connected to a single accelerator. The number of hospitals delivering proton treatment continues to rise, partially as a result of technological developments and partly as a result of the growing amount of proton clinical data [2].

Types

Pencil beam scanning, the newest kind of proton therapy, administers treatment by sweeping a proton beam laterally over the target, delivering the appropriate dose while closely adhering to the geometry of the targeted tumour. Oncologists employed a scattering mechanism to focus a wide beam at the tumour before using pencil beam scanning.

Passive scattering beam delivery: To provide the therapy, the earliest commercially available proton delivery systems used a scattering method, often known as passive scattering. The proton beam is stretched out by scattering devices, and the beam is then modified by inserting things like collimators and compensators in the path of the protons in scattering proton treatment. Passive scattering distributes a uniform dose throughout the target volume. As a result, passive scattering gives you less control over dosage distributions near the target. Many scattering therapy systems have been updated throughout time to include pencil beam scanning. Because scattering therapy was the first type of proton therapy available, scattering technology was used to collect the majority of clinical data on proton therapy, notably long-term data as of 2020 [3].

Pencil beam scanning: Pencil beam scanning is a newer and more flexible proton therapy delivery method that uses a beam that sweeps laterally over the target, delivering the needed dose while precisely adhering to the shape of the targeted tumour. This conformal delivery is performed by magnetic scanning of tiny protons beamlets to shape the dose without the use of apertures or compensators. As the dose is sprayed layer by layer, several beams are given from different directions, and magnets in the treatment nozzle steer the proton beam to conform to the target volume layer. This method of scanning allows for more flexibility and control, allowing the proton dose to fit to the contour of the tumour more precisely [4].

Side effects and risk

Proton therapy is a type of external beam radiotherapy that has the same risks and side effects as other radiation treatments. Because proton therapy takes full advantage of the Bragg peak, the dose outside of the treatment region for deep-tissue cancers can be much lower than X-ray therapy. Proton therapy has been used for over 40 years and is a well-established treatment option. Understanding of the interaction of radiations with tumour and normal tissue is still incomplete, as is all medical knowledge [5].

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Conflict of Interest

None.

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