Transcript of the Science Chatter Hamburg Podcast Episode 3:

Elaf Musa talks to Michael Bueker about Proton Therapy

[spacy-music], 'Science Chatter, Hamburg'

Michael:

Welcome everybody to this new episode of the Science Chatter Hamburg Podcast. We're here with Elaf, and she will be talking to us about Proton therapy. Elaf, thank you very much for speaking with us. Maybe you would like to give us an introduction to the topic.

Elaf:

According to the World Health Organization, cancer is considered to be the major cause of death worldwide, with an estimated number of deaths that equals 9.6 million in 2018. Cancer starts when gene changes take place within a cell or a group of normal cells. One or a few of these cells begin to grow and divide in an uncontrolled way. This may cause a growth called a tumor. these Tumors sometimes spread to other parts of the body to form a secondary tumor.

Depending on its type and how advanced it is, cancer can be treated with different techniques or a combination of them such as: Chemotherapy, Surgery, and Radiotherapy. The need of reducing the dose to the normal tissue while maintaining specific doses to the target was solved by taking advantage of dose deposition characteristics offered by specific types of particles. One of them is the proton.

Michael:

So, in this podcast we will focus on one of these advanced radiotherapy techniques, and this is the Proton therapy. It has some advantages over conventional therapies. Can you tell us why this is?

Elaf:

Protons have advantages over conventional radiotherapy (like X-rays) due to their superior depth dose characteristics. They travel in a straight trajectory toward their target emitting a relatively low energy, and give off most of their energy at a defined depth toward the end of their range of travel, called the Bragg peak. Then it stops, with no dose deposited beyond their range of travel.

This is the main advantage of proton radiation therapy, compared with conventional photon radiation therapy, which deposit their radiation doses close to their entrance into the body and make it impossible to avoid the exit dose downstream from the target and hence to save the normal cells.

The deposited dose of protons is about 30% of the Bragg peak maximum dose. Thereafter, the deposited dose falls to practically zero, yielding a nearly nonexistent exit dose. The integral dose with proton therapy is approximately 60% lower than any photon-beam technique.

Michael:

So, the proton therapy has the advantage that healthy tissue is saved from the impacts of radiation, and the radiation is deposited mostly in the diseased tissue of the tumor. Tell us what kind of requirements there are for using protons in therapy.

Elaf:

The protons must fulfill two essential requirements. The energy has to be high enough to reach the tumor volume inside the patient's body, and the intensity must be suitable to deliver the required radiation dose within a reasonable treatment time. Protons exist in cosmic rays with very high energy, and in radioactive decay, the intensity is too low. Hence, the natural sources of protons are rare and unsuitable. Only accelerators can produce protons of sufficient energy and intensity for treatment.

Michael:

So how are protons produced, if they are to be used in therapy?

Elaf:

They are produced by stripping hydrogen atoms of their electrons. These free protons are then accelerated by electric fields to the desired energy. Accelerators produce and shape an electric field to accelerate protons inside them. A dedicated medical accelerator should fulfill some requirements, too. The maximum beam energy out of the accelerator must be sufficient to penetrate the inhomogeneous tissue in order to reach the tumor. This requires energies of different ranges depending on the tumor place inside the patient. These energies are approximately 50 to 300 MeV.

The proton beamline passes through several components that are used to facilitate the patient's treatment. These can be divided into a number of systems, including: the particle accelerator; beam transport system; beam delivery system; patient positioning system; and patient alignment system.

The nozzle shapes the proton beam into a clinically useful three-dimensional (3D) dose distribution. In general, two methods of spreading the beam laterally are applied: passive scattering, in which high atomic number (Z) materials scatter the proton beam to the desired dimension; and magnetic beam scanning, in which magnetic fields sweep the proton beam over a desired area.

Michael:

Thank you for this technical overview. Maybe you could describe to us some of the early and current therapeutic uses of proton beam therapy.

Elaf:

The idea of using protons in medical treatment was first suggested in 1946 by physicist Robert Wilson. The first attempts to use proton therapy to treat patients began in the 1950s in nuclear physics research facilities, but applications were limited to few areas of the body. The first patients treated with proton beam therapy were breast cancer patients treated with a single burst of proton beam therapy. Some of the earliest application of proton beam therapy included pediatric treatments.

In the 1980s, advances in imaging technology, including CT, MRI and PET scans, helped researchers to better diagnose and 'see' tumors, making proton therapy, which requires identifying the precise location of a tumor, a more practical treatment option.

At Loma Linda University Medical Center in the United States, the first hospital-based proton treatment happened in 1990. Following that, a massive number of proton therapy centers were opened worldwide. According to Particle Therapy Co-Operative Group (PTCOG) data, 57 proton accelerators used for the treatment of diseases operate in the world, including facilities in scientific research institutes. Most of them work in the USA (19), Japan (12) and Germany (6). Another 37 centers are under construction.

As more proton therapy centers are being built and more patients are being treated with proton beam therapy, it is important to consider the cost implications of proton beam therapy. Proton beam is more expensive to be delivered than photons, but the cost savings associated with less irradiation of normal tissues compared with photons has to be considered also.

Michael:

Thank you very much, Elaf, for this overview of the advantages of proton beam therapy and the necessary infrastructure and its cost. Thank you also to all the listeners of this Science Chatter Hamburg Podcast episode. Elaf, we wish you all the best for your research, thank you very much for speaking to us!

Elaf:

Thank you.

[space-y closing music]

Disclaimer: This is the transcript of Episode 3 of the Science Chatter Hamburg Podcast, produced by Michael Büker and Theresa Schredelseker. It is a project of the PIER Education Platform. PIER is the strategic partnership between DESY and Universitaet Hamburg. The conversation between Michael Bueker and Elaf Musa was recorded on September 24, 2021, on the Science City Hamburg Bahrenfeld campus.