Proton therapy – An evolving technology

Antonio Cassio Assis Pellizzon

Department of Radiation Oncology, AC Camargo Cancer Center, Sao Paulo, Brazil

Keywords: radiation therapy; protons; re-irradiation; treatment cost; quality of life; cancer


*Correspondence to: Antonio Cassio Assis Pellizzon, Department of Radiation Oncology AC Camargo Cancer Center, 209, Prof Antonio Prudente St, Sao Paulo, 01590-200, Brazil; acapellizzon@accamargo.org.br

Received: 2nd August 2017; Published Online: 8th August 2017

In the last 25 years, more effective chemotherapy and better surgical and radiotherapy techniques have contributed, at least in part, to the improvement in the control of most cancers, and also increasing the number of patients referred for a second course of radiation[1].

Proton therapy (PT) is able to give superior dose distribution and conformation to the target when compared to radiotherapy using photon and or electron beams, while also reducing the dose delivered to non-target tissues. This characteristic of dose distribution can reduce radiation-induced toxicity, especially in children and areas surrounded by critical organs and tissues[2]. Proton beam also deposits energy more intensively through its path when compared to photon beam, having the characteristic of low body-entry dose and depending mainly on its energy to reach the maximum given dose at a determinate depth and then stops—a dosimetric characteristic called Bragg peak[3]. All cited characteristics above allow for a homogeneous dose distribution given through a single beam, in contrast to several fields arrangement needed to deliver a similar dose distribution when using photon beams.

Cyclotrons and synchrotrons are both types of particle accelerators that use powerful magnetic fields to speed up protons. The cyclotron uses constantly applied magnetic and electric fields to move the protons in spiral, while the synchrotron increases the strength of the magnetic field to match the change in particle energy[4].

The protons can be delivered through fixed-beam or isocentric rotating gantry. The final price tag for all construction, furnishings and equipment for a four-room facility in the United States has been roughly estimated to run between US$120 million and US$300 million[5]. Typically, the accelerator unit and the four gantries cost about US$60 million to US$100 million[6]. Another important source of expenses also comes from shielding, which means that a construction of a four-room center can use up to 12,000 m² of concrete[7].

Some developers are bringing PT to a lower cost to reach more health providers. The new technology does it by shrinking the size of the cyclotrons and synchrotrons, hence cutting out multiple rooms to only one and also reducing the necessary area to build the facility[8].

What must be emphasized is that the initial investment and operating costs of PT are still high, but in a near future these costs may drop even more with ongoing technical innovations. It is projected that the number of treatment rooms available to patients will more than duplicate from 2015 to 2019. It is estimated that in 2014, around 14,500 patients were treated worldwide with PT and by 2030, it is expected that a number between 300,000 and 600,000 new patients will be referred to PT[9].

The evolving technology also created a new method of PT, called pencil beam. This method uses a narrow single-proton beam with a diameter at the isocenter as small as 5 mm, allowing a shaper distribution. The main pencil beam’s characteristic is to use multiples pulses of small proton beam that hits defined planned spots within the target tissue. It starts in the deepest layer and deposits dose layer
by layer, until the whole target volume is covered. Pedroni et al. estimated that a typical tumor can have from 1,000 to 2,000 spots that can be distributed in up to 24 layers for a single pencil beam treatment\cite{10}. Of course, the number of spots is related to the size of the spot. A recent study to assess the impact of three different spots sizes was recently published, indicating that PT with larger spots (>8 mm at isocenter) does not offer a dosimetric or clinical advantage over smaller spots, recommending the use of apertures to treat complex and/or small lesions\cite{11}.

Another advantage of pencil beam is that it is not necessary to construct beam-shaping devices, which also reduces the final treatment costs, making PT even more attractive and affordable, besides allowing a shaper dose distribution, avoiding excessive dose given to surrounding critical tissues or organs. Studies to predict and to estimate the potential increase in therapeutic ratio and reduction in acute side effects, late side effects and secondary neoplasm resulting from the improvement in dose distribution associated with PT have already been published\cite{12-17}. More innovations in PT delivery, as with the development of rotational PT, are underway\cite{18}.

The American Society of Radiation Oncology (ASTRO) recently published a policy model for PT coverage, which details the cancer diagnoses that should be covered by private insurers and also Medicare. ASTRO emphasizes different groups of lesions for which PT should be the first or one of the preferential treatment option, based on medical requirements and published clinical data\cite{19}.

In conclusion, the use of proton beams in some instances, in addition to providing a possibility of increasing the therapeutic ratio in some critical anatomical areas and re-irradiation of previously treated and/or irradiated areas, can add functional preservation, improving the quality of life in cancer survivors.

Conflict of interest

The author declares no potential conflict of interest with respect to the research, authorship, and/or publication of this article.

References


