AbstractID: 4016 Title: Proton Beam Radiotherapy - The State of the Art

The number of proton therapy centers has doubled every 10 years since the beginning of proton therapy in 1954. Today there are 22 proton centers in clinical operation worldwide. In the past 5 years proton and heavy charged particle therapy have received a particular boost in Japan and in Europe, but also in the USA, where there will soon be 5 clinical proton therapy centers. The increased interest in and application of proton therapy motivates this continuing education course. We assume that the audience has a basic understanding of the principles of proton radiotherapy but we will refresh memories by giving a brief review of the principles. The main purpose of the course is to give an update of relatively recent developments in proton beam radiotherapy.

The first part of the presentation will deal with the rationale of proton therapy. We will give a brief summary of the physical characteristics of proton-tissue interactions leading to the typical Bragg peak. We will review recent clinical studies describing the application of protons to new treatment sites, and compare protons with other treatment modalities. The radio-biological effectiveness (RBE) of proton therapy will be addressed next. In-vivo and in-vitro experiments to determine the RBE will be summarized. The proton RBE will also be compared to the RBE of carbon ions.

Next, we will discuss technological aspects proton therapy, starting with beam shaping devices in the “nozzle”. We will review passive double scattering approaches such as the ones integrated in the NPTC and Loma Linda facilities. We will also review active pencil beam scanning techniques. The use of rotating gantries will be contrasted with fixed beamlines. We will then talk about cyclotrons vs. synchrotrons for proton acceleration.

The clinical workflow will be presented for the Northeast Proton Therapy Center (NPTC) in Boston as an example. In this context, we will specifically address important questions of patient setup and immobilization. Recent studies on economical aspects and cost per treatment will be discussed as well.

That protons beams stop in matter is their unique advantage (compared to conventional radiotherapy), but this also poses a challenge for proton treatment planning because the stopping position is somewhat uncertain. If possible, beam angles are selected that avoid stopping protons proximal to critical structures. In other cases “patch fields” are used. How protons are affected by organ motion and how the effects can be reduced will also be discussed. Finally, the potential of intensity-modulated proton therapy in making treatment plans more conformal and more robust will be presented.

Educational objectives

1. To be able to put the physical and clinical potential of proton therapy and its cost into perspective, especially in comparison with photon IMRT.
2. To name the main technical components of a proton therapy system and the design alternatives.
3. To name the characteristics and at least 2 main advantages of intensity-modulated proton therapy (IMPT)