Proton Therapy

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Proton therapy is a fast-expanding modality for tumor treatments and the number of new facilities in the world is rapidly increasing.[1,2] In Taiwan, Chang Gung Memorial Hospital (CGMH) has recently commissioned its first proton therapy center and treated six cancer patients by the clinical trial. Regulatory approval of the proton therapy for patient treatments is expected in October 2015. The unique diseases with high prevalence, that is a primary liver tumor and head and neck cancer, will be the dominant types of cancer to be treated at CGMH.

In this special section of Biomedical Journal, four articles are organized to report the research advances of CGMH and Chang Gung University for their preparations of proton therapy in Taiwan. Topics reported include the rationale, biological effectiveness, depth-dose characteristics, and patient dose simulations for proton therapy.

The first review article written by Kao, Shen and Hong is entitled "What are the Potential Benefits of Using Proton Therapy in Taiwanese Cancer Patients?"[3] This article discussed the cost-effectiveness of proton therapy and evaluated the potential case number and clinical benefits of proton therapy in Taiwan. It optimistically concluded that the advancement of proton therapy technique would expand its benefits from diseases such as pediatric cancer, skull base tumor, uveal melanoma to other types of cancers including head and neck cancer, primary liver tumors, lung cancer, left breast cancer, and more.

The second review article written by Tung is entitled "microdosimetric relative biological effectiveness (RBE) of therapeutic proton beams."[4] This article dealt with the comparisons of proton and photon beams in their spatial distributions on the microscopic energy depositions. Compared to photons, the highly localized ionization clusters formed by protons near the Bragg peak induced more non-repairable DNA damages and led to higher RBE values. To evaluate the RBE, three biological models have been reviewed. A simplified model applied the dose-mean lineal energy and the measured RBE data. A more detailed model made use of the full lineal energy spectrum and the biological weighting function. A comprehensive model calculated the yields of DNA damages caused by all primary and secondary particles of the proton beam. For proton beams of 70–250 MeV energies, maximum RBE values at the distal edge of the Bragg peak were theoretically estimated to be 3.0–6.0, depending on the biological endpoint. Although these elevated RBE values existed in a very narrow region, they could be applied in the precision radiotherapy.

The contributed paper authored by Cai *et al*. is entitled "Depth Dose Characteristics of Proton Beams within Therapeutic Energy Range Using the Particle Therapy System Simulation Framework (PTSim) Monte Carlo technique."[5] This paper examined the detailed depth-dose characteristics of therapeutic proton beams using the PTSim Monte Carlo technique. Although the US National Institute of Standards and Technology published tables on proton stopping powers and ranges based on the continuous slowing-down approximation, the published data provided insufficient insight into the characteristic depth-dose properties of clinical proton beams. This paper, however, derived the range-energy relationships for depth-doses at 100%, 90%, 80% and 50% distal dose fall-offs using the third-order polynomial fittings. Parameters to describe the Bragg peak characteristics, including the peak-to-entrance dose ratio, full-width at half-maximum, and width of 80- 20% distal fall-off, were also obtained. This paper serves as a handy reference for the clinical practice of proton therapy.

The other contributed paper authored by Lee

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et al. is entitled "Monte Carlo algorithm (MCNPX) simulation of proton dose distributions in a water phantom."[6] This paper simulated the patient doses of proton therapy using the MCNPX. The algorithm not only was capable of modeling the beamline accurately but also was able to process the complex tissue composition from patient computed tomography images. In the case of proton equilibrium, particle fluence and dose at depths beyond the Bragg peak were found slightly perturbed by the choice of simulated particle types. The doses from secondary particles were observed about three orders of magnitude smaller than the proton dose, but their simulations consumed a significant computing time. In the case of proton disequilibrium, the differences due to various multiple Coulomb scattering models were large. It indicates that careful modeling of the multiple Coulomb scattering is necessary when proton disequilibrium exists, for example, in lung dosimetry.

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