An Analytical Proton Dose Algorithm

Efficient employment of the superior dose localization properties of proton beams requires fast and accurate dose calculation algorithms. (Hong L, et al, Sandinson, et al) This is especially true in the case of proton Intensity Modulated Radiotherapy . (Deasy) We have developed a macroscopic analytical proton transport algorithm. It uses a simplified model of proton transport, derived from the Fokker-Planck equation, which allows an analytical calculation of dose in an inhomogeneous medium for different beam parameters. The algorithm explicitly accounts for multiple Coulomb scattering effects which are responsible for the formation of cold and hot spots downstream of tissue inhomogeneities. Energy loss is modeled by using experimental energy-range tables for specific materials in a continuous-slowing-down approximation, while energy deposition is modeled by using a measured dependence of dose on depth in water (the Bragg curve) and the concept of water equivalent thickness. Nuclear collisions are accounted for by the inclusion of the experimental Bragg curve data in water. Eyges' solution to Fermi's equation is applied in the treatment of the multiple Coulomb scattering. The simplified model of proton transport is suited to study various numerical implementations and approximations in pencil beam dose calculation algorithms. It is also useful as a mathematical tool to examine techniques of proton inverse treatment planning.

REFERENCES

Hong L, et al, Phys. Med. Biol. 41, 1305-1330 (1996)
Sandinson, G A, et al, Med.Phys.24, 841-849 (1997)
Deasy J O, Med. Phys. 25, 476-514 (1998)