Influence of Nuclear Interactions in Body Tissues on Tumor Dose in Carbon-Ion Radiotherapy

Taku Inaniwa, Nobuyuki Kanematsu, Hiroshi Tsuji, and Tadashi Kamada
Research Center for Charged Particle Therapy, National Institute of Radiological Sciences

Abstract

Background: In carbon-ion radiotherapy treatment planning, water nonequivalence of body tissues in inelastic nuclear interactions is usually ignored and can cause dose errors. This study aims to assess the influence of the water nonequivalence for typical tumor sites in carbon-ion radiotherapy.

Methods: We used a non-commercial treatment planning system dedicated to clinical research at the National Institute of Radiological Sciences, Japan, co-developed with Elekta AB, Sweden, in which a stoichiometric dose correction algorithm for water nonequivalence in nuclear interactions was implemented. Using ten to twenty cases per each tumor sites of prostate, head and neck, bone and soft tissue, lung, liver, pancreas, and uterus, carbon-ion radiotherapy treatments were planned without the correction. The corresponding dose distributions were calculated with and without the correction to evaluate the effect.

Results: The median effects in target mean dose were +0.2% for prostate, 0.0% for head and neck, -0.3% for bone and soft tissue, -0.1% for lung, -0.1% for liver, -0.4% for pancreas, and -0.3% for uterus. The largest effect was observed in a uterus case of a very fat patient to be -1.6% in target mean dose and -2.5% at maximum. Generally, positive effects were observed for the beams penetrating bone and negative effects were observed for the beams penetrating fat.

Conclusions: The effects of water nonequivalence of body tissues in nuclear interactions on tumor dose would be generally marginal although, in some extreme cases, the effects could be substantial. The correction algorithm consistently worked for a variety of clinical cases and would improve the dose accuracy for carbon-ion beams penetrating fat or bone.