A Monte Carlo Investigation of Dose Reporting Issue in the Presence of High Hounsfield-Unit Material in Clinical AAA Dose Calculation Algorithm

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PURPOSE

Monte Carlo (MC) simulation directly calculates the dose as dose = (energy deposited) / (physical mass), while AAA uses convolution/superposition based on energy kernels. These kernels are re-scaled using equivalent electron-density path for heterogeneous geometry. This study investigates the difference of dose reported by the AAA algorithm for high density materials compared to those calculated by MC.

METHOD

Spine SBRT patients were used. VMAT plans were generated in Varian's Eclipse. The same plan was converted to a MC model in our commissioned EGS4-based MC system, MCSIM. Region-of-interest (ROI) structures (0.2cm^3 each) were created at different iso-dose-line (IDL), identified as ROI_LD (~ 50%Rx IDL), ROI_HD1 (~126%Rx IDL), and ROI_HD2 (~116%Rx IDL). Dose comparisons between MC and AAA (ver.13.6, Varian) were performed under the following **scenarios**: (**1**) the whole patient body was assigned as water; (**2**) the whole body was assigned as water except ROI_HD1 as medium-density bone (density =1.83 g/cm^3, relative electron density = 1.71); (**3**) the whole body was assigned as water except ROI_HD1 as titanium (Ti) (density =4.51 g/cm^3, relative electron density = 3.72). For MC, a 1mm voxel size was used with ICRU cross-section data and ECUT = 0.7 MeV, PCUT = 0.01 MV, and a 1-σ dose uncertainty <1%. A dose ratio DR=(AAA dose)/(MC dose) was calculated.

CONCLUSIONS

The results show that the reported dose by AAA for high-density media is much higher than MC calculation (e.g., 1.6% higher in medium-density bone and 5.6% in titanium).

RESULTS

→ For scenario 1, DVHs match perfectly with mean DR =100.1% for ROI_LD, 100% for ROI_HD1, and 100% for ROI_HD2.

→ For scenario 2, these DR values are the same for ROI_LD and ROI_HD2, except for ROI_HD1 (DR=101.6%).

→ For scenario 3, these DR values change little for ROI_LD (DR =100.2%) and ROI_HD2 (DR =99.8%), except for ROI_HD1 (DR =105.6%).

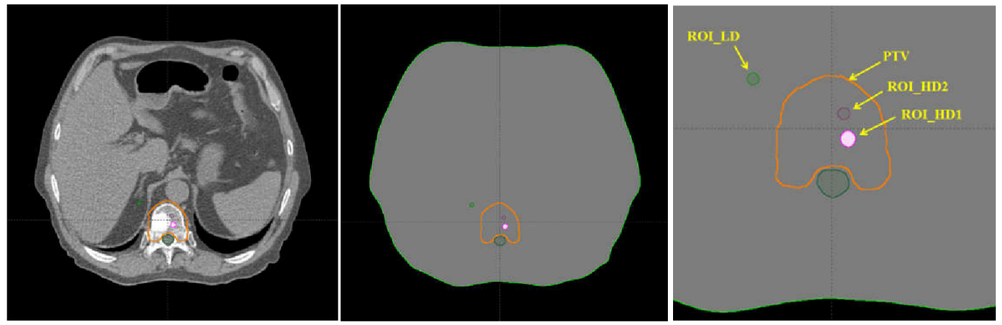

Figure 1. Patient geometry and definition of structures. (left) patient CT; (middle) whole body is assigned as water except ROI_HD1 which was assigned accordingly for different scenarios; (right) definition of structures

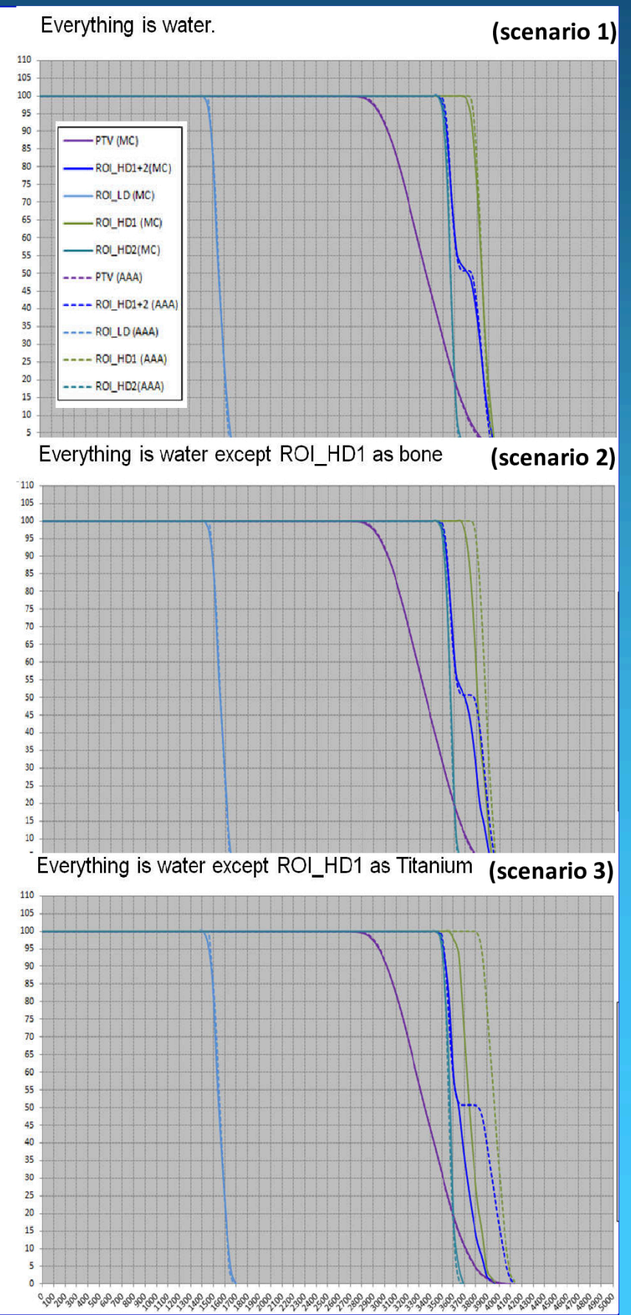

Figure 2. Comparison of DVHs between Monte Carlo (MC) (solid line) vs. AAA (dot line) for different structures under different scenario.