Experimental assessment of relative stopping power prediction by single energy and dual energy CT

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differences underlines the clinical potential of DECT, which now needs to be confirmed against a ground truth. Further investigations of patients' DECT scans enable comprehensive SPR evaluations to quantify CT-related range uncertainties and to assess clinical safety margins.

OC-0151 Experimental assessment of relative stopping power prediction by single energy and dual energy CT

J.K. Van Abbema[1], M.J. Van Goethem[1,2], A.K. Biegun[1], G.J. Pelgrim[3], M. Vonder[3], M.J.W. Greuter[4], A. Van der Schaaf[2], S. Brandenburg[1], E.R. Van der Graaf[1]
[1]*University of Groningen- Kernfysisch Versneller Instituut - Center for Advanced Radiation Technology, Medical Physics, Groningen, The Netherlands*
[2]*University of Groningen- University Medical Center Groningen, Radiation Oncology, Groningen, The Netherlands*
[3]*University of Groningen- University Medical Center Groningen - Center for Medical Imaging North-East Netherlands CMI-NEN, Radiology, Groningen, The Netherlands*
[4]*University of Groningen- University Medical Center Groningen, Radiology, Groningen, The Netherlands*

Purpose or Objective

To assess the accuracy of the single energy CT (SECT) stoichiometric calibration method and a new proposed dual energy CT (DECT) method for relative proton stopping power (RSP) calculation in proton therapy treatment planning.

Material and Methods

The accuracy of both methods has been assessed based on CT and proton stopping power measurements of 32 materials with known composition and density and of 17 bovine tissues. With CT, the 32 materials have been measured in a 33 cm diameter Gammex 467 tissue characterization phantom and the bovine tissues in a 30 cm diameter water phantom. The CT data has been acquired on a dual source CT system (SOMATOM Force) at 120 kV and 90 kV/150 kV Sn for SECT and DECT, respectively. The data has been reconstructed with a Qr40 strength 5 ADMIRE kernel and a slice thickness of 1 mm. A SECT calibration curve has been established relating CT numbers to RSPs based on average tissues described in literature. Using this calibration curve RSPs have been derived from measured CT numbers at 120 kV. With the DECT method effective atomic numbers and relative electron densities have been determined from CT numbers measured at 90 kV and 150 kV Sn. RSPs have been calculated from the DECT derived electron density and a relation between the effective atomic number Z' and mean excitation energy. Experimental RSPs have been obtained from residual range measurements of 190 MeV protons in water and compared to the predicted RSPs by SECT and DECT. For the proton measurements, all samples have been prepared with a water equivalent thickness of about 2 cm.

Results

The experimental RSPs of the 32 materials have been determined with an uncertainty <0.5%. The relative differences between SECT predicted and experimental RSPs for these 32 materials range from -21.4% (Al_2O_3) to 16.4% (Silicone oil). The DECT predicted RSPs are predominantly within 3.5% of the experimental values (figure 1). For the 17 bovine tissues the differences between SECT and DECT are small except for lung, adipose and bone (figure 2). Compared to the experimental RSPs, the SECT and DECT predicted RSPs of the bovine tissues are within 3.7% and 3.3% respectively, except for the bone samples. For the two bone samples the SECT predicted RSPs deviate 19% and 24% from experimental values while for the DECT predicted RSPs the deviations are 5.4% and 5.2%. Due to partial volume averaging in the two bone samples between air and bone the density of the samples is smaller than expected by the SECT calibration curve which introduces errors in the SECT derived RSPs. The DECT method determines the effective atomic number and relative electron density and on basis of these physical parameters enables a more accurate estimate of the RSP.

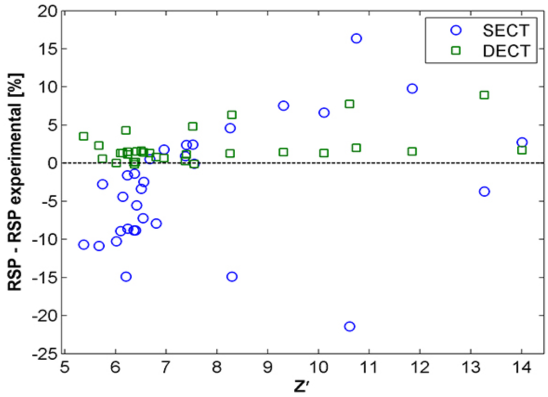

Figure 1. Relative difference of relative stopping powers (RSPs) for the 32 materials determined with SECT and DECT with respect to experimental RSPs as a function of the effective atomic number Z'.

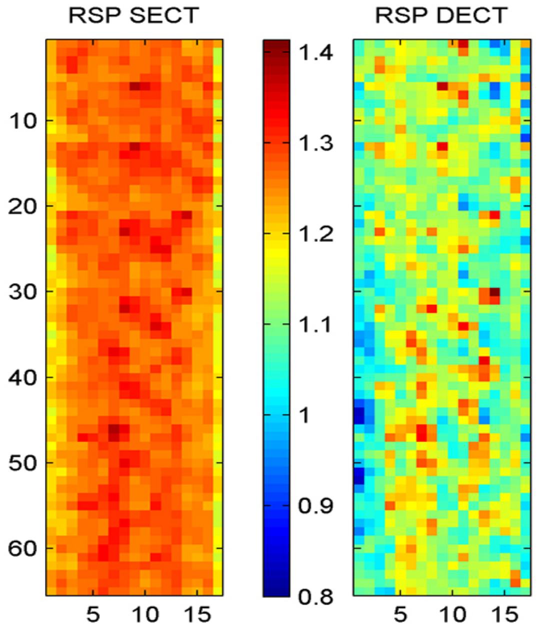

Figure 2. Relative stopping powers (RSPs) for bone determined from SECT and DECT in 3D volumes of interest where the x-axis represents the slice position.

Conclusion

The developed DECT method is more accurate in prediction of relative proton stopping powers than the SECT calibration method for a wide range of materials and tissues and can be of benefit to proton therapy treatment planning.

OC-0152 Innovative solid state microdosimeters for Radiobiological effect evaluation in particle therapy

T.L. Tran[1], L. Chartier[1], D. Bolst[1], D. Prokopovich[2], A. Pogossov[1], M. Lerch[1], S. Guatelli[1], A. Kok[3], M. Povoli[3], A. Summanwar[3], M. Reinhard[2], M. Petesecca[1], V. Perevertaylo[4], A. Rozenfeld[1]
[1]*University of Wollongong, Centre for Medical Radiation Physics, Wollongong, Australia*
[2]*Australian Nuclear Science and Technology Organisation, Engineering Material Institute, Lucas Heights, Australia*
[3]*SINTEF, Microsystems and Nanotechnology, Oslo, Norway*
[4]*SPA-BIT, SPA-BIT, Kiev, Ukraine*