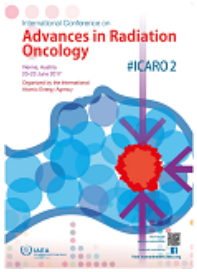

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End-to-end test and TPS QA using heterogeneous anthropomorphic phantom

Thursday, June 22, 2017 10:50 AM (5 minutes)

The procedure of radiotherapy chain testing, from CT imaging to treatment planning and dose delivery, like a part of the quality assurance programme in the N.N. Blokhin Russian Cancer Research Center was implemented and investigated in 2015.
CIRS Pelvis is used to perform such QA procedure in the radiation therapy department the phantom. Phantom CIRS Pelvis has an elliptical shape and an anatomical structure that mimics the pelvic of average person. Phantom has a body made of plastic ("solid water"), bony structure and five cylindrical holes for plugs of various densities (bone, muscle, fat) and ionization chamber cylindrical adaptor. These holes enable verification in the most interesting areas.
The first step of end-to-end test is CT-scanning of the phantom on GE Lightspeed 16. Phantom was scanned in two configurations - an ionization chamber in the middle hole with air space in the bottom, and vice versa. The muscle and adipose tissue inserts were located in upper insert hole in both configurations. The correspondence between HU and electron density was checked based on CT scans. It should be emphasized that the results of HU measurements, obtained by the phantom CIRS, are sufficient only for periodical checks of CT calibration curve test existing curve CT. To enter a new curve in the TPS it is recommended to use a phantom with a large number of inserts made of materials with different densities of wide range.
Particular attention is paid to the verification of treatment planning system Eclipse with different settings and dose calculation algorithms. Beam energy, field sizes, gantry rotation angles, angles of dynamic wedges were varied among test plans based on TECDOC 1583 (IAEA) and Booklet #7 (ESTRO). IMRT plans were created on the basis of the TG-119 (AAPM) recommendations. Several points of prescription and dose measurement have been selected to study the influence of heterogeneities on the accuracy of dose calculation.
The next phase of work with phantom consists of creating test plans with two different dose calculation algorithm (Pencil Beam Convolution (PBC) and Anisotropic Analytical Algorithm (AAA)). Testing covered the following aspects:
- The impact rate of grid size on the accuracy of dose calculation
- Verification of the various types of heterogenity corrections
- Rectangular fields (30x10,cm2)
- Small field sizes (4x4,cm2)
- Oblique incidence, lack of scattering and tangential fields
- Complex field shapes (MLC)
- Dynamic wedges of different angles and directions
- Various SSD
- 4-field box
- IMRT plans

Evaluation of results was carried out in terms of relative dose differences. As we have other model of CIRS Phantom than described in TECDOC 1583 we couldn't take the same criterias for deviation evaluation. But the similar approach was applied - allowable difference between the calculated and measured dose depends on detector position relative to heterogenity regions and on complexity of field configuration. For the fields, passing through the heterogeneous region, as well as containing wedges or MLC allowable difference between the calculated and measured dose is 3%; for beams with simple geometry - 2%.
Results

Both algorithms have shown acceptable results. In the absence of correction for heterogeneity, relative difference reached 9.8% for the PBC and 7.7% for AAA, when the detector was positioned not only behind bone structures but also behind the air cavity. In the case when the camera is located in the center of the phantom, the air cavity didn't have a strong influence on the dose calculation even without correction for heterogeneity. The calculation algorithm PBC usually overestimates dose in areas with a low density, and near the borders with these regions, since it does not account for the lateral scattering of electrons. The existing phantom doesn't contain large areas with a low density (imitating the lungs), so the difference observed after the calculation with two algorithms was not big.
Equivalent TAR method turned out to be more accurate than other inhomogeneity correction factors considering the effects of heterogeneities on scatter, as well as on primary.
As recommended by the AAPM TG-119 several clinical plans were made for IMRT verification. The contours and maximum doses for each volume were taken from this document also. Dose measurement showed appropriate results – discrepancies were not more than 3% for all cases.
*All numeric results are contained in tables

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