PhD ABSTRACTS

METHODOLOGY TO ASSESS THE CLINICAL AND DOSIMETRIC IMPACTS RESULTING FROM THE CHANGE OF A CALCULATION ALGORITHM IN RADIOTHERAPY

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Introduction: Treatment planning is one of the main steps in radiotherapy. It involves as a final output the calculation of Monitor Units (MUs), which describe the real quantity of ionizing radiation delivered to the patient. As yet, it is unclear when and how to adjust the prescribed dose by the radiation oncologist when changes are introduced in TPS calculations. In this study we proposed a quantitative method to assess changes introduced by a new calculation algorithms in clinical use for radiation therapy. The ultimate goal is to help the clinician to decide when and how to alter his dose prescription.

Method and materials: This original method is based on dosimetric, statistical and global analysis. The dosimetric analysis is based on the comparison of MUs, isodose curves, cumulative and differential dose volume histograms and quality indices such as the conformity index, homogeneity index, PTV conformity index and geometrical index. The goal of the statistical analysis is to provide the radiation oncologists with interpretable results to help them to make a medical decision. Thanks to its operability with small series, the Wilcoxon signed rank test was used to assess the statistical significance of differences. A p-value < 0.05 was considered as statistically significant. The global analysis is based on 2D and 3D gamma index. To compare the dose distribution using the CT-Scan image, two treatment plans were generated: the reference plan (Dr) using the current algorithm and the tested plan (Dt) using the novel algorithm. The DICOM images including the PTV and the OAR for each patient were exported from TPS Eclipse®. The 2D gamma analysis was displayed using a gamma plot and gamma pixel histogram indicating the fraction of pixels with a gamma index equal or below a specific value. A mean value of gamma ≤ 1 indicates agreement between dose distributions. In order to discriminate an over- from an under-estimated dose using 3D gamma, a sign was attributed to absolute values of γ, i.e. $Dt \geq Dr$ had a positive sign and $Dt < Dr$ had a negative sign. The 3D γ maps and the cumulative Gamma Voxels Histograms (GVH) were generated. The GVH show each voxel according to its gamma value and provided a visual representation of the proportion of voxels which respect the conventional tolerance (3mm, 3%). For this study, the gamma criterion was set at 3% for the dose and 3 mm for the distance to agreement. We considered that the dose distribution using the tested algorithm agreed with the dose distribution, calculated with the reference algorithm, if 95% of the pixels or voxels had gamma ≤ 1.

Clinical application: We applied this method for the change of dose calculation algorithms and the change of irradiation techniques (breast cancer) and we also evaluated the impact of the modification of CT-Scan calibration curve on

dose using density correction methods. For clinical comparison, 4 cancer sites were compared including chest cancers, head and neck cancers, brain cancers and prostate cancers.

Results and discussion: The comparison between Clarkson and Pencil Beam Convolution PBC algorithms without density correction showed that the difference for monitor unites was 1.2% for lung and less than 1% for head and neck, brain and prostate (p>0.05). The dosimetric parameters derived from dose volume histograms were higher for organs at risks using Clarkson compared to PBC inviting clinicians to make "safer" prescriptions [1].
The density correction methods such as Batho power low, Batho modified and ETAR produced a lower number of MUs than PBC algorithm by an average of 5% for chest cancer including 6 patients. The Wilcoxon test showed a significant difference between PBC and density correction methods ($p<0.001$). Dosimetric parameters derived from the DVH were higher for the planning target volumes and organs at risks using density correction methods when compared to PBC [2]. The quantitative analysis, of dose distribution based on 2D and 3D gamma, confirms the under dosage observed with density correction methods using MUs comparison, for chest cancer when the density correction was done [3]. This means that the risks related to the modification from the homogeneity plan to the heterogeneity plan were the reduction of delivered dose to the PTV and the increase of the dose to the organs at risk, as shown in **figure 1**. For chest tumors, according to this study, the prescribed dose had to be increased by 5% when moving from PBC algorithm to density correction methods in order to obtain the same clinical results.

Conclusion: Our method enables clinicians and physicists to understand treatment modifications associated with any changes in dose calculation procedure: software or irradiation techniques. According to this study the concept of 3D gamma index and the non-parametric statistical test (Wilcoxon) were validated to evaluate and compare the difference of dose in irradiation therapy.

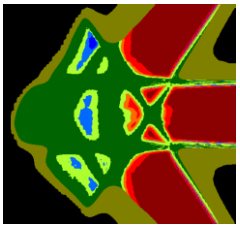
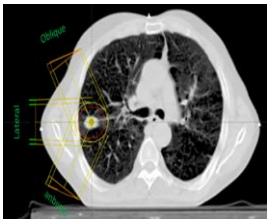
a)  b) 

Figure 1.a. shows a sample of 3D γ maps to compare PBC with modified Batho algorithms. The red and blue colorings indicate that gamma is outside the tolerance criteria showing respectively over- and under-estimated doses for OAR and PTV. Graph 1.b. shows the corresponding treatment planning picture for the parenchyma site.

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Conflict of Interest : None