
A multicentre QA study on 4DCT and IMRT/VMAT techniques for lung stereotactic treatments using the 008A CIRS 4D phantom

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Résumé

Introduction: To determine stereotactic treatment accuracy in the institutions participating in the Phase II EORTC Lungtech trial, we have performed end-to-end tests investigating both 4D computed tomography (4D-CT) and IMRT/VMAT techniques under static and dynamic conditions.

Methods: All centres audited (12 out of the foreseen 22 centres) performed 3D-CTs and 4D-CTs on the same CIRS008A phantom. The phantom was successively scanned using two film inserts, one with a 15mm diameter target (15mmd) and the other carrying a 25mm diameter target (25mmd). Three motions were tested: 20bpm/15mm amplitude (A), 10bpm/15mmA, and 15bpm/25mmA. We thus developed a test procedure to evaluate the impact of motion on the target volume and motion as determined using the available binned CT data. These results were evaluated and compared to the true volume and the known motion amplitude. Regarding the credentialing of radiotherapy delivery, three treatment plans were made by institutions based on the two targets static 3D-CTs and using the 4D-CT data set of the 15mmd animated by the 20bpm/15A signal. Prior to phantom measurements, a beam output check was performed in water under reference conditions for the institution chosen energy. The plans were then measured twice using EBT3 films (12,5cmx5 cm) and a 0.04cc ionization chamber (Scanditronix/Wellhoffer Inc.). The films analysis was done in RIT113 version 6.3. Gamma analyses were performed using film dose as reference, a normalisation at the centre of the sphere, a low dose threshold at 20% of Dmax and 3% dose /3mm deviation as agreement criteria. **Results:** On average volume deviations (here expressed in % of the true volume) were respectively for the 15mmd and the three motions tested: +10%(+/- 7%), +1% (+/-17%), +12%(+/-12%) and for the 25mmd: +6%(+/-7%), +4%(+/-7%)*. [i]Volume deviations were found higher at the end of inspiration than at the end of expiration 8% (+/-26%) insp and 1% (+/-3%) exp. The range of motion was underestimated in all cases with on average -0.15cm (+/- 0.07cm), the slow breathing pattern (10bbpm) presented the largest mean error -0.2cm(+/- 0.2cm) compared to the breathing pattern 20bpm/15A, -0.09cm(+/- 0,08cm). Regarding the dosimetric evaluation, the output dose mean deviation was 0.57% (+/- 1.42%) across institutions, agreement between chamber doses and point-planned doses were respectively for the 15mmd and the 25mmd static 98.9%(+/-1.3%), and 99.9%(+/- 2.8%). Agreement with planned dose (centre of the PTV taken as reference point) for the 15mmd in motion was 98.6% (+/- 0.86%). The film gamma mean pass rates were 70% for 15mmd static, 59% for 15mmd dynamic and 74% for 25mmd static.

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Conclusion: QA of 4D-CT and stereotactic treatments on a moving target has been performed. Film dosimetry in 4D conditions can be challenging and not many data are available to compare our results too. The mean pass rates found in this study are lower for dynamic than for static measurements. As not many similar studies have been performed yet, we cannot define an acceptability threshold yet. These preliminary results are a starting point for discussion, with more dataset analysed we hope to correlate 4DCT and dosimetric data and to propose relevant evaluation criteria.

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15bpm/25mmA not tested on the 25mmd insert.

Mots-Clés: QA, SBRT, 4D dosimetry, EORTC