4D-Cone Beam CT implementation for clinical use: validation using an anthropomorphic thorax phantom

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Résumé

Introduction: The 3D-Cone Beam CT (CBCT), is a blurred image and so is the reference verification image for lung tumors treated with the ITV strategy. SymmetryTM (Elekta), or respiration correlated 4D-CBCT, was recently installed in our center. This software allows a temporal reconstruction (3D+t) resulting in ten 3D-CBCT. The objectives of our study were: 1/ to estimate uncertainties due to the reconstruction of the 4D-CBCT, 2/ to compare calculated corrections of tumor positioning depending on the reference image used, i.e average CT scan or Mid-Ventilation (Mid-V) CT scan.

Materials and Methods: A 4D-CT acquisition of the anthropomorphic thorax phantom (Dynamic Thorax PhantomTM, CIRS) was performed using the Big BoreTM (Philips). The target was moving according to a cos4 breathing pattern (Lujan et al, 1999) and with a 24mm peak-to-peak amplitude in the SI direction. Ten 3D-CT scans and the average CT scan were then reconstructed and exported to the MonacoSimTM workstation. The tumor insert (GTV) was delineated on each phase of the 4D-CT scan and the ITV was generated from the 10 GTV on the average CT scan. The Mid-V CT scan was determined from the breathing pattern. Two isocenters of treatment plan were defined according to the treatment strategy: one at the center of the ITV (ITV strategy) and the other at the tumor center of the Mid-V CT scan (Mid-V strategy). The two reference planning CT scans were exported to SymmetryTM. For each strategy, a 4D-CBCT projection dataset was acquired. ITV or GTV positioning corrections were automatically calculated using the tumor motion mask and applied in order to center the tumor according to the reference CT scan. 1/ The accuracy of the 4D-CBCT reconstruction was verified through the amplitude comparison between the 4D-CT and the 4D-CBCT. 2) For each treatment plan, the global mean correction based on the ten 3D-CBCT registration was compared to either the distance between the MidP and the treatment isocenter (ITV strategy) or the positioning correction of phase corresponding to the MidV (MidV strategy).

Results: The relative difference between the tumor motion amplitude found between the 4D-CT and 4D-CBCT was 8.30%. For the amplitude used, we found a 3mm shift from the registration of the average CT scan (ITV strategy) and the average correction of the tumor motion mask. The correction associated with the MidV phase was the same as the one given by SymmetryTM for the MidV strategy.

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Conclusion: Our preliminary results showed that the accuracy of the moving tumor amplitude estimated by 4D-CBCT was satisfying. The MidV strategy is more appropriate for the use of the SymmetryTM. Our future works are to investigate the accuracy and the image quality of the average CBCT reconstructed from the 4D-CBCT.

Mots-Clés: 4D CBCT, anthropomorphic dynamic phantom, ITV and Mid V strategy