AI-based cardiac annotation for radiotherapy planning

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Introduction et but de l'étude
Whilst radiotherapy increases cure rates in breast cancer, lung cancer, Hodgkin lymphoma, among others, it may also involve some cardiac exposure, which in turn may increase the risk of different heart diseases. The heart is a complex anatomical organ that involves many different structures making it difficult to contour cardiac sub-structures reproducibly. Contouring, especially for these cases, suffers from inter- and intra-expert variability while being time consuming. Previously, cardiac atlases have been developed to aid in the delineation of cardiac substructures. However, these methods have many shortcomings, including the inability to overcome variations in patient anatomy. In this study, a deep-learning based commercial solution for automatic OAR delineation was trained following international guidelines for heart substructures delineation and tested on an unseen cohort of lung and breast patients to evaluate its clinical acceptability.

Matériel et méthodes
ART-Net, a CE-marked, FDA-cleared anatomically preserving deep-learning ensemble architecture for automatic annotation of OAR was retrained on a thoroughly selected and delineated data set (n=135) coming from 2 renowned radiotherapy centers. This dataset was delineated by professionals who have been trained on the delineation of the heart-substructures and further validated by senior experts before being used for training of the deep-learning architecture. In addition, experts were involved in the building of the model to ensure that rules of continuity of structures and biological constraints were integrated and respected. The resulting model was evaluated using data of 20 breast/lung patients from 2 centers. For each patient, automatic annotation of 16 structures (Ventricles (left and right), atria (left and right), left ventricle anterior, left ventricle inferior, left ventricle lateral, left ventricle septal, left ventricle apical, coronary sinus, left main coronary artery, ascending aorta, pulmonary arteries, vena cava inferior, vena cava superior and the heart) was performed. These annotations were mixed with the manual contours of the same patients and submitted to 2 experts across 2 centers for qualitative evaluation (40 cases in total). Contours were scored as A/acceptable, B/ acceptable after minor corrections, and C/ not acceptable for clinical use. To avoid any bias, experts were blind to whether the contours were produced manually by clinical experts or by the AI model.

Résultats et analyse statistique
Automatic contours were generated in a mean time of 0.5s per scan slice. Out of the 16 structures, 13 were considered clinically acceptable (A+B) in 100% of the cases. For all these 13 structures, AI contours were rated at the same level as manual contours. For 3 structures (coronary sinus, left main artery and vena cava inferior) the performance of the AI contours was slightly below that of the manual contours (within 3.4% difference with the least performing structure being the coronary sinus (84% for AI vs 87% manual).

Conclusion
We show first results for the evaluation of AI-based auto-contouring tool for annotation of the substructures of the heart. The results show very good clinical acceptance, highlighting the high usability of the commercial tool for cardiac cases and its clinical implementation feasibility. The use of this AI tool can facilitate and accelerate future research studies investigating relationships between substructure doses and cardiac outcomes.