AI-driven quality insurance for delineation in radiotherapy breast clinical trials

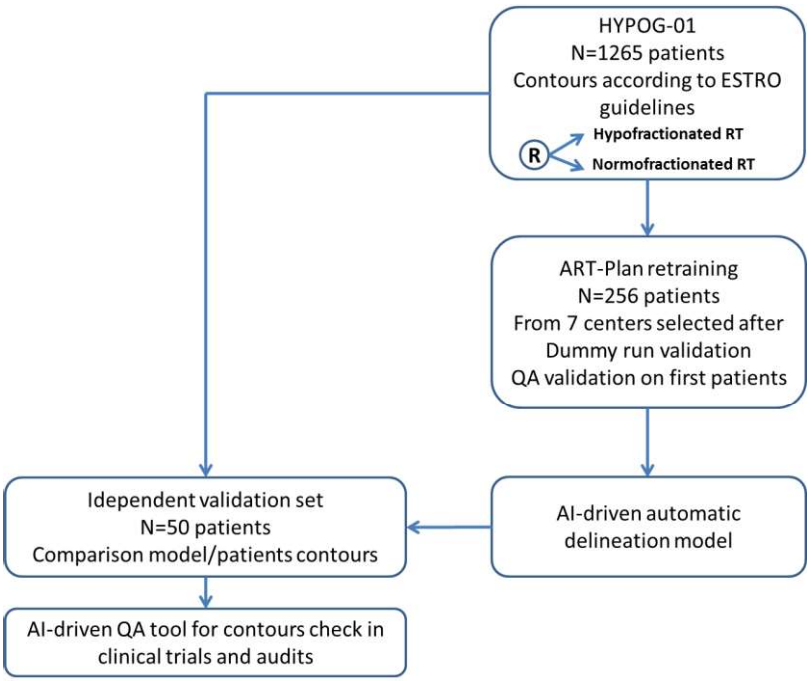
Authors : S. Rivera, A. Lombard, D. Pasquier, S. Wong , E. Limkin, G. Auzac, J. Blanchecotte, M.E. Chand-Fouché, A. Lamrani-Ghaouti, N. Bonnet, N. Paragios, C. Martineau-Huynh, E. Ullmann, A. Ruffier, E. Deutsch

ABSTRACT

Purpose/Objective: Clinical trials in radiotherapy inherit strong uncertainties on their outcomes due to significant inter/intra-user variability with respect to delineation. The lack of systematic review– in particular for academic trials – and the absence of gold standard for the delineation could have a tremendous impact on trial's outcome. In this work we use artificial intelligence towards the development of a systematic, scalable and bias-free tool for quality control assessment of the delineation step.

Material/Methods: ART-Plan is a CE-marked solution for automatic delineation of 65+ ROI in radiotherapy harnessing anatomically preserving deep learning ensemble networks. In this study, ART-Plan was retrained using 256 patients from 7 investigating centers of the HYPOG-01 phase III randomized trial. HYPOG-01 data inclusion was done using a strict verification protocol. Delineations on random initial samples were assessed and evaluated according to the ESTRO breast contouring guidelines. These delineations were used to amend the ART-Plan pre-trained ensemble network towards the development of the quality insurance delineation tool. The derived solution was compared with human delineations on an independent set of 50 patients from HYPOG-01.

Flow chart:



Results: Median Dice Similarity (MDS) and Mean contour distance (MCD) between clinical & deep learning contours were assessed. Organs with a training MDS (MDS_RT) ≥ 0.65 and MCD_RT ≤ 2mm were included to the quality control protocol (coronary artery & brachial plexus were excluded). The spinal cord was included despite low MDS_RT due to variability of practices (z-axis start/end point). Acceptance criteria were set for testing as follows: MDS ≥ 0.8 * MDS_TR & MCD ≤ 1.2*MCD_TR. Quantitative/qualitative results on the testing set are appended:

	MDS	MCD (mm)	Average Volume difference (cc)
Lungs	0.97 ±0.02	0.51 ±0.26	+20
Liver	0.95 ±0.01	0.77 ±0.46	0
Heart	0.91 ±0.03	1.35 ±0.52	+60
Humeral heads	0.90 ±0.05	0.68 ±0.38	+1
CTV Breast/Chest wall	0.89 ±0.06	1.48 ±0.60	+40
Esophagus	0.79 ±0.05	0.72 ±0.42	-1
Spinal cord	0.76 ±0.09	1.98 ±2.00	+19
Thyroid	0.75 ±0.09	0.78 ±0.37	0
CTVn Level 3	0.74 ±0.10	1.00 ±1.16	0
CTVn Level 1	0.72 ±0.10	2.10 ±1.16	0
Larynx	0.72 ±0.20	1.46 ±1.37	+1
CTVn Level 4	0.70 ±0.10	1.39 ±0.57	+1
CTVn Interpectoral	0.66 ±0.10	1.24 ±0.82	-1
CTVn Level 2	0.66 ±0.15	1.49 ±1.03	-2

Conclusion: An anatomically preserving ensemble neural network retrained on high quality contours coming from a multi-center clinical trial could lead to the development of a clinical acceptable control delineation tool. Prospective evaluation in the 30 HYPOG-01 investigating centers is ongoing. Large scale development in breast radiotherapy trials and daily routine audits could lead to treatment standardization and systematization of contours quality assessment in trials involving radiotherapy ensuring a higher reliability of the results, while saving medical expert time.