Hemodynamic measurement in pulmonary hypertension: a challenge for automated CT analysis

Q. Maloir[1], L. Libert[2], B. Ernst[1], F. Belmans[2], A. Corsi[2], A. Canivet[3], R.E. Dulgheru[3], P. Lancellotti[3], R. Louis[1], W. Vos[2], J. Guiot[1]

1. Respiratory department, University Hospital of Liège, Belgium; 2. Radiomics.bio – Liège, Belgium; 3. Cardiology department, University Hospital of Liège, Belgium.

RATIONALE

Currently, the diagnosis of pulmonary hypertension (PH) is based on the measurement of pulmonary pressures via right heart catheterization (RHC). There is a growing need for new tools to assist clinicians in the diagnosis and follow-up of PH patients. In this study, we analyzed high-resolution CT (HRCT) scans using artificial intelligence-based vascular quantification, trying to identify new imaging biomarkers.

Aim : To assess the potential of AI-based pulmonary vascular quantification in classification and characterization of pulmonary hypertension

METHODS

We analyzed HRCT of PH patients using AI-based vascular quantification (Radiomics.bio, Belgium). The dataset consisted of a retrospective cohort of adult patients from the University Hospital of Liege. All of them had at least a RHC and a contrast-enhanced chest HRCT within six months. Vascular quantification was performed using a two-step approach: (1) segmentation of the vascular bed with deep learning, and (2) geometrical analysis of the entire pulmonary vasculature. The AI-based segmentations of the pulmonary arteries were manually corrected and validated by a radiologist when needed. Patients were then classified according to the ESC/ERS clinical classification.

PATIENTS CHARACTERISTICS

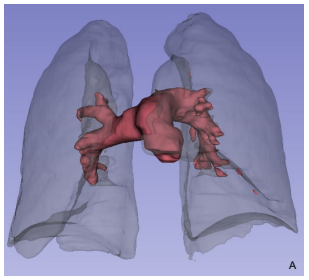
	All patients (n=60)	Group 1 (n=18)	Group 2 (n=17)	Group 3 (n=10)	Group 4 (n=15)
Demography :					
Male/Female	26/34	7/11	8/9	5/5	6/9
Mean age (years)	68	62	74	67	70
Hemodynamics :					
mPAP (mmHg, mean ± SD)	37.5 ± 11.8	43 ± 13.6	32.7 ± 10.7	33.2 ± 7.9	39 ± 9.7
PAWP (mmHg, mean ± SD)	12.3 ± 6.8	7.6 ± 3.2	20.6 ± 4.8	9.3 ± 3.4	10.2 ± 4.9
PVR (WU, mean ± SD)	5.7 ± 3.4	8.2 ± 3.7	2.43 ± 2.1	5.6 ± 2.7	7.9 ± 3.6

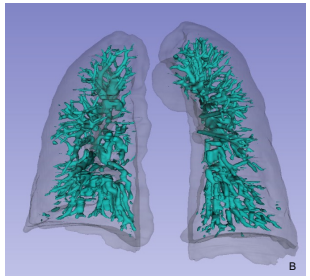
RESULTS

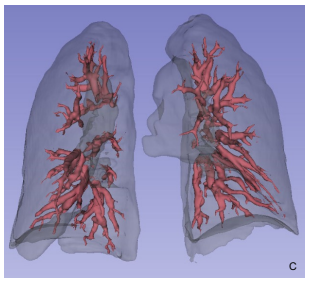
The Mann-Whitney U-test identified a significant difference ($p < 0.05$) in the median and maximal normalized diameters of the main pulmonary artery (MPA) when comparing post-capillary PH (group 2) to pulmonary arterial hypertension (PAH – group 1) and other PH groups. Additionally, the normalized arterial volume for vessels with a radius of less than 4 mm was significantly different between Group 2 PH and the other groups, as were the maximal normalized diameters of the right and left pulmonary arteries (PA).

CONCLUSION

Some new imaging biomarkers demonstrated a statistically significant difference between post-capillary PH and the other groups. Through an AI quantification approach, we identified features specific to Group 2 PH that could assist in better patient classification. These findings suggest that AI-based quantification tools could support the classification and characterization of PH in the near future. However, these results need to be validated in larger cohorts and control population.







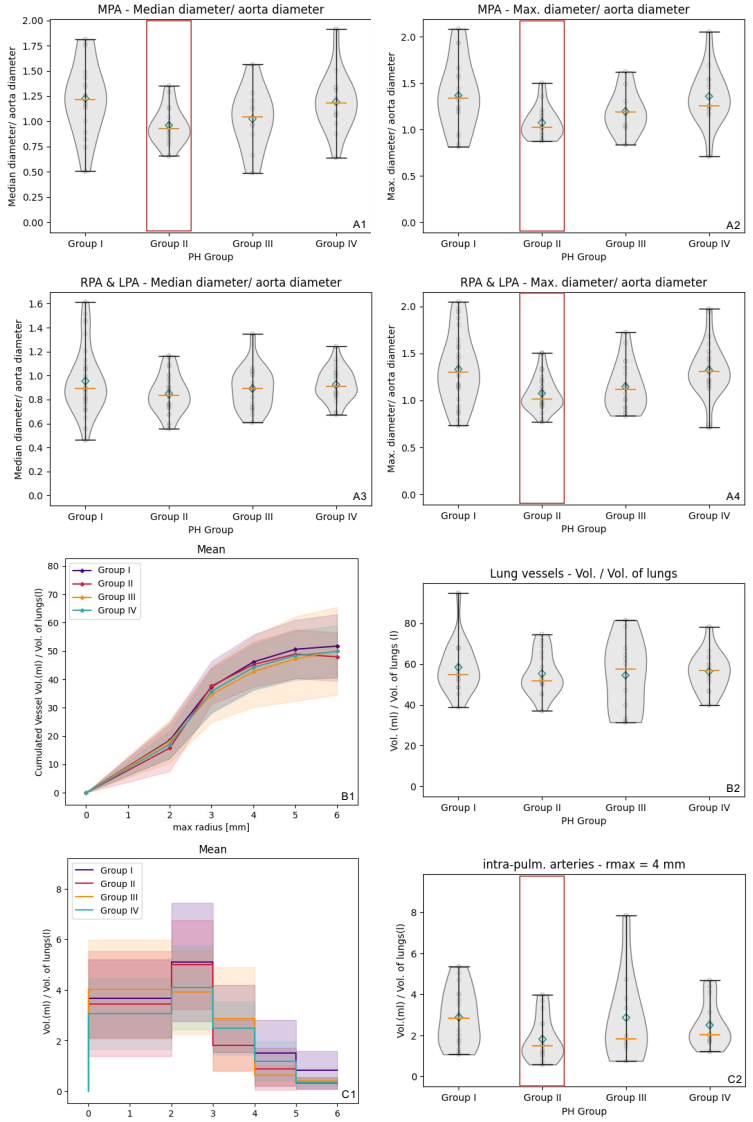


***Fig A**: Visual representation of the main pulmonary artery (MPA) along with the right and left pulmonary arteries (RPA & LPA) (Radiomics.bio, Belgium). Panels A1, A2, A3, and A4 show violin plots of the median MPA, maximum MPA, median RPA & LPA, and maximum RPA & LPA, respectively, normalized by the aortic diameter across PH groups.*
***Fig B**: Visual representation of the full pulmonary vasculature (Radiomics.bio, Belgium). Panel B1 presents a line plot displaying the cumulative pulmonary vessel volume as a function of artery radius (mm) across different PH groups. Panel B2 shows violin plot of the cumulative pulmonary vessel volume normalized by total lung volume across PH groups.*
***Fig C**: Visual representation of the intra-pulmonary arteries (Radiomics.bio, Belgium). Panel C1 displays a bar plot representing the distribution of pulmonary vessel volume as a function of maximal artery radius, normalized by total lung volume across PH groups. Panel C2 shows violin plot of volume of intra-pulmonary arteries with a maximal radius of 4 mm across PH groups. The red boxes highlight the most significant differences observed (p-value < 0.05).*

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