

Treatment Effect of Balloon Pulmonary Angioplasty in CTEPH, Quantified by Automatic Comparative Imaging in CTPA

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ABSTRACT

Purpose: Balloon pulmonary angioplasty (BPA) in patients with inoperable chronic thromboembolic pulmonary hypertension (CTEPH) can have variable outcomes. To gain more insight into this variation, we aimed to visualize and quantify changes in lung perfusion using CT pulmonary angiography (CTPA). We validated these measurements of perfusional changes against hemodynamic changes measured during right-heart catheterization.

Materials and Methods: We studied 14 consecutive CTEPH patients (12 female; age: 65±17), who underwent CTPA and right-heart catheterization, before and after BPA. Post-treatment images were registered to pre-treatment CT scans (using the Elastix toolbox) to obtain corresponding locations. Pulmonary vascular trees and their centerlines were detected using a graph-cuts method and distance transform. Areas distal from vessels were defined for measuring perfusional changes in the parenchyma. Subsequently, the density changes within the vascular and parenchymal areas were calculated and corrected for inspiration level differences, and displayed in color-coded overlays. For quantification, the median and inter-quartile range (IQR) of the density changes were calculated in the vascular and parenchymal areas (Δ VD and Δ PD, respectively). The recorded changes in hemodynamic parameters included changes in systolic, diastolic and mean pulmonary artery pressure (Δ sPAP, Δ dPAP and Δ mPAP, respectively) and in vascular resistance (Δ PVR). The Spearman's correlation coefficients between perfusional changes and hemodynamic changes were tested.

Results: PAP and PVR were significantly improved after BPA. Comparative imaging maps showed distinct patterns in perfusional changes between patients. Within vessels, the IQR of Δ VD correlated with Δ sPAP ($R=-0.58$, $p=0.03$), Δ dPAP ($R=-0.71$, $p=0.005$), Δ mPAP ($R=-0.71$, $p=0.005$) and Δ PVR ($R=-0.77$, $p=0.001$, see

Figure). In the parenchyma, the median of Δ PD correlated with Δ dPAP ($R=-0.71$, $p=0.005$) and Δ mPAP ($R=-0.68$, $p=0.008$).

Conclusion: Comparative imaging in CTEPH patients offers insight into differences in BPA treatment effect. Quantification of these perfusional changes provides non-invasive measures that reflect hemodynamic changes.

Clinical relevance

CTPA studies before and after balloon pulmonary angioplasty in CTEPH can demonstrate density changes in the vascular and parenchymal areas and is recommended to monitor treatment effects.

