BRONCHIAL PERFUSION IN THE LUNGS OBSERVED BY DYNAMIC CONTRAST-ENHANCED MRI

N. Saouti[1], A. Vonk Noordegraaf[1], M. Ingrisch[2], and J. T. Marcus[1]
[1]VU University Medical Center, Amsterdam, Netherlands, [2]Ludwig-Maximilian University, Munich, Germany

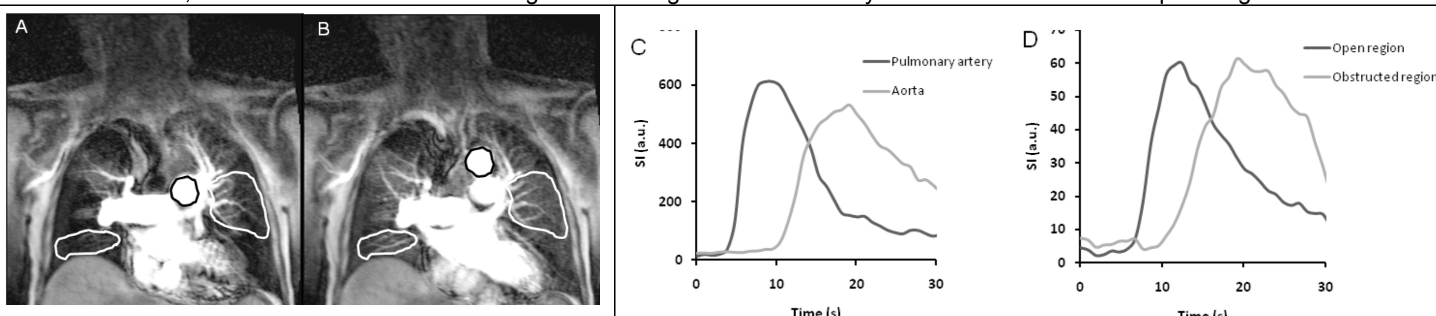
Introduction After obstruction of a pulmonary artery, the bronchial (systemic) arteries can proliferate. In chronic thromboembolic pulmonary hypertension (CTEPH), bronchial blood flow can increase from 1-3% to as much as 30% of the cardiac output. The bronchial flow is supplied by the bronchial arteries branching from the aorta. The trajectory of an intravenously-injected contrast bolus is longer for the bronchial flow, than for the pulmonary artery flow. Because of this longer pathway, there is a time delay in bolus arrival time in the lungs for the bronchial flow, as compared to the pulmonary artery flow. In this study we explore the possibility to visualise the perfusion of the lungs by the pulmonary and bronchial system separately, based on the fact that a contrast bolus injected intravenously will arrive later in the bronchial than in the pulmonary system.

Methods *Patients* In the first part of the study we included 7 patients with pulmonary artery (PA) atresia of the whole left or right pulmonary artery to explore whether it is possible to visualise the signal of the bronchial perfusion and whether this signal can be separated in time from the pulmonary perfusion. In the second part we explored the possibility to visualize regions of bronchial perfusion in patients with partial occlusion of the pulmonary vascular bed. For this purpose we included 6 patients with CTEPH.

MRI Patients were imaged with a Siemens 1.5T Sonata system (Siemens Medical Solutions, Erlangen, Germany). Using a 3-D gradient-echo sequence with parallel imaging, eight consecutive slices (each 15 mm thick) were obtained in the coronal plane each 1.08 seconds during a 30-seconds end-inspiratory breath hold. As soon as dynamic MR image acquisition was started, a Gadolineum-based contrast agent (Magnevist^R; Schering, Berlin, Germany) was injected (0.2 ml/kg body weight) via an antecubital vein at a rate of 5 ml/s, followed by a 20-ml saline flush at the same rate.

Data analysis Signal intensity (SI) time curves were generated by measuring the signal-intensity of the contrast bolus in a region of interest (ROI). To assess the onset-time of pulmonary perfusion a ROI was defined in the main PA, and to assess the onset-time of bronchial perfusion a ROI was defined in the ascending aorta. In the PA atresia patients, ROI's were drawn which covered the entire left and right lung. In the CTEPH patients two independent observers explored all 8 slices and searched where a lung region with 'obstructed' PA could be seen with the most obvious late perfusion signal. A ROI (with area between 4 and 10 cm^2) was placed in a region with 'obstructed' PA, and another ROI in a region with non-obstructed (= 'open' from now on) PA of about equal size in the contralateral lung. The onset-times of the SI-curves of the lung parenchyma were compared with the onset-times of main PA and aorta to assess whether the perfusion was from pulmonary or bronchial arterial origin.

Results *Pulmonary artery atresia* In the PA atresia patients, there is normal perfusion in the open lung in the pulmonary phase. In the obstructed lung, however, there is no perfusion in the pulmonary phase. Only after bolus passage through the left ventricle, thus in the bronchial phase, perfusion starts in the obstructed lung. This bronchial origin of perfusion is proven by the 1s time delay between bolus onset in the aorta, and onset in the obstructed lung. The average onset-time delay between obstructed and open lung was 5.5 ± 1.1 s.



A: Pulmonary phase in a CTEPH patient, showing obstructions. An obstructed ROI in the right lower lobe, and an open ROI in the left middle lobe are delineated. B: Bronchial phase, where the ROI in the right lower lobe shows bronchial perfusion which was not present in the pulmonary phase. The segmental arteries in the 'open' ROI in the left middle lobe, that showed peak perfusion in the pulmonary phase, now show SI decrease in the bronchial phase. SI in the capillaries is high.

C: SI-curves of main Pulmonary Artery and Aorta.
D: SI-curves of open region in the left middle lobe and obstructed region in the right lower lobe, as displayed in panels A and B. Note, images in A and B are exactly at the same anatomical position.

CTEPH In the CTEPH patients there are heterogeneously distributed lung regions with obstructed pulmonary arteries (see fig A). In some of these regions there is no perfusion in the pulmonary phase in contrast to the open lung region with perfusion in the pulmonary phase (Fig A, perfusion image at left). Only in the bronchial phase of the contrast bolus passage, perfusion starts also in the obstructed lung region (Fig B, perfusion image at right). The average onset-time delay between obstructed and open lung regions was 5.3 ± 1.9 s. The onset-time in obstructed regions was also consistently later (on average 0.5 s) than the onset-time in the aorta.

Conclusion The present study demonstrates that bronchial perfusion in an obstructed lung or lung region can be visualized by DCE-MRI, by using the onset-timing of the perfusion signal. This is in line with earlier studies that showed anatomically the presence of increased bronchial circulation in CTEPH [1;2]. A challenge for the future is to provide an absolute quantitative measure of perfusion [3;4;5] in the obstructed regions.

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