Pulmonary Parenchymal Blood Flow in Early Chronic Obstructive Pulmonary Disease (COPD): the MESA COPD Study

Katja Hueper[1,2], Jens Vogel-Claussen[1,2], Megha Parikh[3], John HM Austin[3], David A Bluemke[4], James Carr[5], Thomas A Goldstein[6], Antoinette S Gomes[7], Eric A Hoffman[8], Joao AC Lima[1], Wendy Post[1], Martin Prince[3], Kiang Liu[5], Jan Skrok[1], Karol Watson[7], Jie Zheng[9], and Graham Barr[3]

[1]Johns Hopkins University, Baltimore, Maryland, United States, [2]Hannover Medical School, Hannover, Germany, [3]Columbia University Medical Center, New York, New York, United States, [4]Radiology and Imaging Sciences, National Institutes of Health, Bethesda, Maryland, United States, [5]Northwestern University, Chicago, Illinois, United States, [6]Stanford University, Stanford, California, United States, [7]David Geffen UCLA School of Medicine, Los Angeles, California, United States, [8]University of Iowa Carver College of Medicine, Iowa City, Iowa, United States, [9]Washington University School of Medicine, St Louis, Missouri, United States

Introduction: Cor pulmonale and pulmonary vascular changes are known to occur in very severe chronic obstructive pulmonary disease (COPD). We tested the hypothesis that pulmonary vascular flow and volume are reduced in mild-moderate COPD.

Methods: The Multi-Ethnic Study of Atherosclerosis (MESA) COPD Study recruited cases of GOLD-defined mild, moderate and severe COPD and controls from two population-based cohort studies. Participants were age 50-79 years, had smoked 10 or more packyears and were free of clinical cardiovascular disease. Pulmonary perfusion measurements were performed on a 1.5 T scanner (GE Healthcare) using the TRICKS sequence and a contrast bolus of 0.1 mmol/kg Gd-DTPA at a rate of 5 ml/s. Pulmonary blood flow (PBF), pulmonary blood volume (PBV) and mean transit time (MTT) were calculated from signal intensity-time curves on a pixel-by-pixel basis by using deconvolution analysis (Fermi function model), indicator dilution theory and the central volume principle. The arterial input function was derived from a cardiac short axis gradient echo MR sequence (TR 1300 ms, TE 179 ms) in the right-ventricular cavity with 1RR temporal resolution over 40 seconds and a contrast dose of 0.05 mmol/kg to minimize saturation effects of the contrast agent. Mean PBF, PBV and MTT of a central coronal slice were calculated and displayed in quantitative maps using dedicated software. Linear regression models were adjusted for age, sex, race/ethnicity, height, weight, smoking status, pack-years and left ventricular stroke volume.

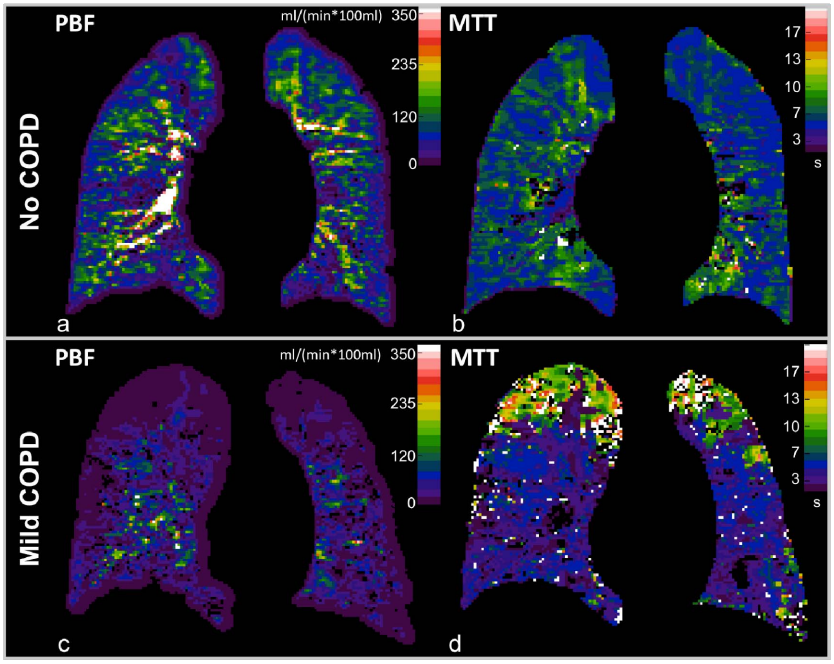

Figure 1: Quantitative maps of PBF (a,c) and MTT (b,d) in a control and a patient with mild COPD. Maps show the homogenous distribution of perfusion. In mild COPD perfusion abnormalities in the lung apex with decrease of PBF and increase of MTT are depicted.

Results: Pulmonary perfusion MRI allowed for quantification of perfusion abnormalities and distribution of perfusion in COPD (Fig 1). Among 48 controls, mean PBF was 85 ml/(min*100ml), mean PBV was 5.3 ml/100ml and mean MTT was 4.0 sec. In comparison in COPD patients (n=52) PBF was reduced in mild (-19 ml/(min*100ml), 95% CI -42, 3; P=0.10), moderate (-25 ml/(min*100ml), 95% CI -10, -6; P=0.009) and severe (-46, 95% CI -81, -11; P=0.01) disease when compared to controls. Similarly PBV was reduced in mild (-1.0 ml/100ml, 95% CI -2.4, 0.4; P=0.18), moderate (-1.1 ml/100ml, 95% CI -2.3, 0.1; P=0.07) and severe (-2.5 ml/100ml, 95% CI -4.7,-0.3; P=0.03) COPD compared to controls. MTT increased significantly with increasing COPD severity. These perfusion changes were similar among current and former smokers and were not appreciably changed by additional adjustment for partial arterial oxygen saturation and hyperinflation.

Discussion: Pulmonary parenchymal perfusion on MRI was reduced in mild to severe COPD. These findings suggest pulmonary vascular dysfunction and/or damage in early COPD, which has implications for cardiac function and potentially for COPD pathogenesis.

Funding: NIH/NHLBI R01-HL093081, R01-HL077612, R01-HL075476, and N01-HC95159-HC95169.

Katja Hueper and Jens Vogel-Claussen are contributed equally as first authors.