Journal of Cardiovascular Magnetic Resonance
BioMed Central

Poster presentation

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Impaired lung perfusion in patients with congestive heart failure by quantitative MRI perfusion

Jie J Cao*, Yi Wang, Jeannette McLaughlin, Elizabeth Haag, Michael Passick, Joshua Cheng, Justine Lachmann and Nathaniel Reichek

Address: St Francis Hospital, Roslyn, NY, USA
* Corresponding author

from 13th Annual SCMR Scientific Sessions
Phoenix, AZ, USA. 21-24 January 2010

Published: 21 January 2010

Journal of Cardiovascular Magnetic Resonance 2010, **12**(Suppl 1):P108 doi:10.1186/1532-429X-12-S1-P108

This abstract is available from: http://jcmr-online.com/content/12/S1/P108

Introduction

Congestive heart failure (CHF) is associated with reduced end-organ perfusion and can lead to organ failure. Clinical assessment of organ perfusion has relied on measures of organ function, an indirect strategy.

Purpose

We sought to assess lung perfusion quantitatively by MRI in patients with CHF and to define factors associated with impaired lung perfusion.

Methods

Study subjects were prospectively enrolled and underwent cardiac MRI at 1.5 T. First-pass perfusion was performed with 0.01 mmol/kg gadopentetate in 3 coronal slices covering anterior, mid and posterior lung fields during inspiration using a saturation recovery SSFP sequence. Mean signal intensity of all pixels in pulmonary parenchyma at each time point was evaluated using a custom model-independent deconvolution program for perfusion quantitation. Pulmonary transit time was measured as the time interval between peak signal intensity in the main pulmonary artery and peak signal intensity in the left atrium. Cardiac function was assessed using SSFP standard short axis cine imaging. Pulmonary flow was measured by through plane phase contrast imaging in the main pulmonary artery.

Results

Of the 25 subjects enrolled 7 were normal controls and 15 were patients with systolic CHF in I-III NYHA functional class who completed lung perfusion imaging in inspiration. Average lung perfusion was reduced in CHF patients, 81 ± 32 ml/100 ml/min vs 118 ± 48 ml/100 ml/min in controls ($p = 0.046$). Similar to normal controls patients with CHF maintained a perfusion gradient in the gravity direction with the highest perfusion in posterior and the lowest in anterior lung field. However, the absolute perfusion was reduced in all lung fields with anterior, mid and posterior perfusion 58 ± 26, 85 ± 38, 106 ± 36 ml/100 ml/min in CHF patients and 73 ± 53, 116 ± 53, 165 ± 45 ml/100 ml/min in controls. Reduced lung perfusion was associated with lower pulmonary flow (indexed by BSA) ($r = -0.771$, $p < 0.001$), longer pulmonary transit time ($r = -0.729$, $p < 0.001$), a marker of total pulmonary resistance, lower LVEF ($r = 0.443$, $p = 0.039$) and lower RVEF ($r = -0.474$, $p = 0.026$). In a multivariate regression analysis including all variables associated with lung perfusion and an interaction term for pulmonary flow and pulmonary transit time since they were significantly correlated, the predictors of lung perfusion were pulmonary flow and flow/transit time interaction, suggesting the importance of both forward flow and total pulmonary resistance.

Conclusion

Lung perfusion is decreased in patients with systolic CHF. The reduced perfusion is associated with both impaired

forward flow and increased pulmonary vascular resistance.