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The effects of respiratory cycle and body position on quantitative pulmonary perfusion by Magnetic Resonance Imaging

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Introduction

Many pulmonary diseases affect pulmonary vasculature whether primarily or secondarily. In patients with advanced primary pulmonary hypertension pulmonary perfusion is marked reduced. Therefore quantitative pulmonary perfusion may be clinically useful in diagnosing pulmonary vascular abnormalities.

Purpose

We investigated 2D dynamic contrast-enhanced magnetic resonance imaging (MRI) using a saturation recovery SSFP sequence to quantitatively analyze pulmonary perfusion in normal volunteers.

Methods

Eight healthy volunteers (ages 30 to 69 years, 6 males) were prospectively enrolled. Using a saturation recovery SSFP technique, first pass perfusion images were acquired on a 1.5 T scanner. A voxel size of $4 \times 2.6 \times 15$ mm^3 was achieved in 3 parallel coronal slices in anterior, mid and posterior lung fields. After injection of gadopentetate (0.01 mmol/kg) dynamic images were acquired with a breath hold during inspiration and expiration in supine and prone positions. The contours of left and right lung parenchyma were drawn manually. The dynamic signal intensity in the pulmonary artery and in the lung parenchyma was measured over time and transferred to a proprietary model-independent deconvolution program. Absolute perfusion was then calculated using pulmonary artery dynamic contrast signal as input and that in the lung parenchyma as the distribution of tracer residence. Pulmonary perfusion was the average of the left and right lung perfusion in anterior, mid and posterior lung fields.

Results

Absolute mean pulmonary perfusion was 248 ± 109 ml/100 ml/min in the right and 255 ± 100 ml/100 ml/min in the left lung (p = NS) during expiration in supine position. There was a graded increase in pulmonary perfusion from anterior to posterior regions ($p < 0.001$) (Table 1). The perfusion gradient direction reversed in the prone position with the highest perfusion in anterior lung and the lowest in posterior lung ($p < 0.001$). Absolute lung perfusion per unit volume of lung tissue varied significantly during the respiratory cycle with nearly two-fold higher perfusion in expiration than that in inspiration, a finding likely due to the decrease in vessel density from airway expansion during inspiration.

Conclusion

First pass pulmonary perfusion MRI using a 2D saturation recovery SSFP technique can quantitatively assess regional lung perfusion. Lung perfusion is gravity dependent with the highest perfusion in posterior lung in supine position. The perfusion gradient is reversed in prone position. Between inspiration and expiration there is a nearly two-fold difference in perfusion per unit volume of lung tissue.

Table 1: Differences in quantitative pulmonary perfusion (mean ± SD) in the anterior, mid and posterior slices in supine and prone positions during inspiration and expiration

Location	Inspiration (ml/100 ml/min)		Expiration (ml/100 ml/min)	
	Supine	Prone	Supine	Prone
Anterior	68.6 ± 51.2	104.4 ± 30.1	191.9 ± 63.0	252.3 ± 91.2
Mid	109.2 ± 52.2	90.0 ± 34.1	242.5 ± 79.4	241.9 ± 111.1
Posterior	153.3 ± 53.3	62.2 ± 35.1	319.5 ± 123.5	177.9 ± 82.8
P value (ANOVA)	< 0.001	< 0.001	< 0.001	< 0.001