Demonstration of Gravity Dependent Lung Perfusion with Contrast Enhanced Magnetic Resonance Imaging
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Purpose
To demonstrate that MRI is sensitive enough to detect small pulmonary perfusion heterogeneity due to gravity, which make the technique valuable for assessing regional perfusion abnormalities caused by pulmonary disorders.

Introduction
Lung perfusion is unevenly distributed within the lung [1-3]. Typically, regional blood flow is determined by a number of factors, including cardiac output, microvascular pressure, and gravity. In the upright individual, increased pulmonary perfusion is present in lower portions of the lung [4]. In recumbent subjects, an increase in perfusion in the direction of gravity has been demonstrated by positron emission tomography [5]. In addition, blood transit times are faster in gravitationally dependent regions of the lung than in non-dependent regions [6, 7].

In this study, we have designed and conducted experiments to demonstrate the gravity dependent lung perfusion using contrast enhanced MRI. In comparison with other modalities previously used for detection of perfusion heterogeneity, MR has the advantage of a higher temporal/spatial resolution and lack of radiation.

Methods
Six volunteers (1 male, 5 female, mean age = 32 yr) were studied in both supine and prone positions. Three subjects were initially examined in the supine position, while the other three in the prone position. They remained in the position for at least 15 minutes before imaging. All were non-smokers and had no known pulmonary disease.

Data were acquired using a 1.5 Tesla MR imaging system (Magnemot VISION, Siemens AG, Germany). A body coil was used to produce uniform spin excitation within the lung. Lung perfusion was assessed using a spoiled 2D gradient-echo sequence with ultra short TR and TE following intravenous administration of a T1 contrast agent gadopentetate dimeglumine (Magnevist, Berlex Lab, NJ). An ultra short TE was used (0.9 msec) to overcome the signal loss due to the short T2* in the lung. 15 ml of gadopentetate dimeglumine was administered as a 3-second bolus. Sequence parameters were: TR/TE/FA = 3.0msec/0.9 msec/25°, readout bandwidth = 976 Hz/pixel, 10 mm thick slices, 96x128 matrix size, FOV = 25 - 40 cm x 34 - 40 cm, acquisition time 0.29 sec per image. The contrast injection was synchronized to the start of the 2D dynamic gradient-echo sequence. Data for 3 sagittal slices were collected each second for 45 repeated acquisitions. Two sagittal slices were placed in the right lung, one in the left lung.

Results
One example showing differences in signal intensity (SI) between dependent and non-dependent regions of the lung is displayed in Figure 1. In the supine position, the ROI located in the dorsal (dependent) portion of the lung demonstrated both a higher mean peak SI increase (236% vs. 157%, p<0.05) and a faster rise in the slope of enhancement (55%/sec vs. 30%/sec, p<0.05) than the ventral (non-dependent) ROI. In the prone position, similar gravitationally dependent differences were seen. In this case, however, the ventral (dependent) lung had a greater mean peak SI (234% vs. 177%, p<0.05) and slope of enhancement (60%/sec vs. 35%/sec, p<0.05) than the dorsal (non-dependent) lung.

Time series of signal enhancement showing the same results are further illustrated in Figure 2.

Figure 1. MR images showing gravity-dependent perfusion enhancement in supine and prone positions.

Figure 2. Time series of signal changes due to the passage of a bolus of contrast agent.

Conclusion
We have show that contrast enhanced MRI is sufficiently sensitive to demonstrate gravitational dependent differences in lung perfusion. This method may play an important role as a diagnostic or investigation tool for evaluation of perfusion heterogeneity under various pathologic conditions.

References