# Hyperpolarized 13C MRI Cineangiography of Pulmonary Perfusion

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**Introduction:** Accurate and repeatable measures of pulmonary perfusion play an important role in the study of many pulmonary pathophysiologic conditions. Unfortunately, radiation exposure precludes the use of many nuclear medicine and computed tomographic techniques in longitudinal studies. Additionally, current MRI measures of pulmonary perfusion are difficult to implement. Water-soluble HP $^{13}C$ contrast agents display many properties that make them attractive candidates for the study of pulmonary perfusion [1]. We show evidence of this in a porcine study of pulmonary perfusion using the HP contrast agent 2-hydroxyethyl acrylate.

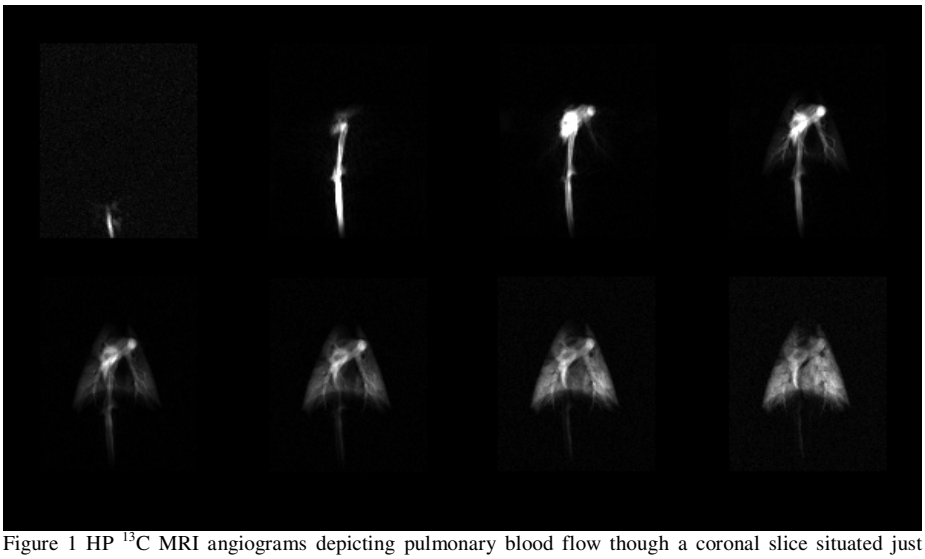

Figure 1 HP $^{13}C$ MRI angiograms depicting pulmonary blood flow though a coronal slice situated just posterior to the heart. Images depicted were taken at one-second intervals. 5 ml of HP 2-hydroxyethyl acrylate, 300 mM solution, was injected into the femoral vein at a rate of 1 ml per second. The inferior vena cava, pulmonary arteries, inferior pulmonary arteries, and perfused lung parenchyma are clear depicted in the images; whereas, air filled structures and tissues not supplied by the pulmonary artery appear devoid of signal. We note that initial images display high signal to noise values and the signal to noise values drop as time progresses since polarization is lost due to the imaging process.

**Method:** Yorkshire pigs were induced, intubated, paralyzed, and maintained on isoflurane anesthesia. Vital signs were monitored during the procedure. The pigs were placed in a birdcage coil tuned to the $^{13}C$ frequency and positioned in a 1.5-T whole-body imager (Sonata, Siemens). The lungs were localized in space using a series of proton images. HP MRI angiography was then performed using 5 ml of 300 mM solution of HP 2-hydroxyethyl acrylate injected at a rate of 1 ml per second. Images were obtained at one-second intervals. The hyperpolarized $^{13}C$ solution was prepared via the parahydrogen induced polarization technique using a prototype polarizer (GE Healthcare, Malmö, Sweden) and a net polarization of 11% was acheived. MRI imaging began five seconds after initiating the HP 2-hydroxyethyl acrylate injection using a tFISP pulse sequence with the following imaging parameters: TR/TE, 4.6/2.3 msec: FOV: 32x32 cm; matrix size 128x128, slice thickness was 2.5 cm.

**Results and Discussion:** In figure 1 we show time lapsed series of $^{13}C$ MRI images depicting the transit of a bolus of HP $^{13}C$ contrast agent though the lungs. These images were obtained in one-second intervals and clearly depict the natural course of the HP contrast agent as is passes through the inferior vena cava, pulmonary artery, and lung parenchyma. In figure 2 we show relative signal intensities measured in the inferior vena cava, pulmonary artery, and lung parenchyma. We note that the signal intensity in the inferior vena cava show a sharp rise to its maximal intensity followed by a rapid decay back to base line as the HP contrast agent is washed out to the vena cava and signal is lost due to imaging. The pulmonary artery shows displays a similar behavior, but with greater scatter due to cardiac mixing. Wash in and wash out of the contrast agent is slowest in the lung parenchyma as expected. This preliminary data suggests that the kinetic data can be fit to a mass balance model, such as the Kety-Schmidt model, modified to account for the HP contrast agent's $T_1$ relaxation and RF- induce polarization to obtain regional perfusion information. The water soluble HP $^{13}C$ contrast agent technique is particularly well suited for this technique due to the high signal to noise ratios and low back ground signal contamination form denovo $^{13}C$ containing molecules in the body.

**Conclusion:** Water soluble HP $^{13}C$ contrast agents such as 2-hydroxyethyl acrylate can be used to study pulmonary perfusion, Both high temporal and spatial resolutions are obtained, suggesting that these agents and its derivatives will lend new insight into pulmonary diseases.

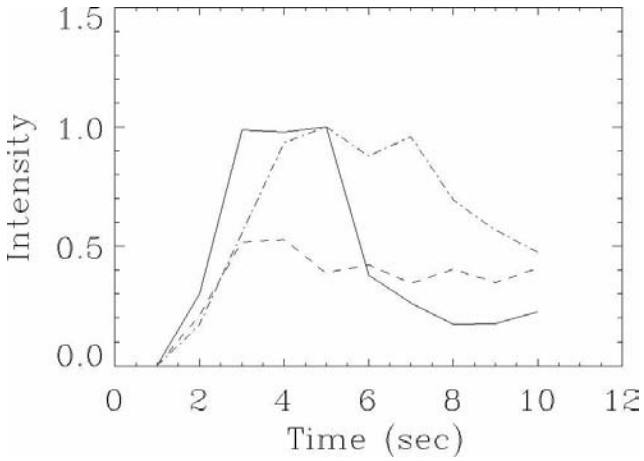


Figure 2: Relative signal intensities measured in the inferior vena cava, solid line, pulmonary artery, dash-dot line, and lung parenchyma, dashed line. Note that the vena cava and, to some extent, the pulmonary artery signals are not entirely separated from the parenchyma signal due to the thickness of the slice.

**References:**

[1] Svensson J, Månsson S, Johansson E, Petersson JS, Olsson LE, Magn. Res. Med. 50(2): 256 – 262 (2003)