Hyperpolarized ^{129}Xe spectra from human head after modulating cerebral blood flow

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[*Introduction*] After inhalation of hyperpolarized ^{129}Xe, the signal decay during the washout phase is thought to depend on the blood flow and T_1 of the tissue compartment [1,2]. Several studies have already used this idea to estimate cerebral blood flow (CBF) from the washout kinetics in vivo in both animals [3,4] and humans [5]. Nevertheless, the changes in ^{129}Xe spectra due to changes in human CBF have not been previously described. A study during different CBF states would help to confirm the relationship between ^{129}Xe signal and CBF. In this work, ^{129}Xe spectra were acquired from human volunteers while modulating the CBF with CO_2 inhalation.

[*Methods*] Six healthy volunteers (32-57 year old males) lay in a 1.5 T imaging spectrometer (Signa, GE medical systems Inc., USA). An inhalation mask with a 3-way cock for switching between polarized xenon gas and air was secured over their face. Xenon MR measurements were performed with a custom-made singly tuned eight-element birdcage coil. The body coil in the MRI gantry was used to shim and obtain proton scout images at the beginning of each study. Each volunteer inhaled ^{129}Xe gas four times, twice each in the normal and hypercapnic conditions. Hypercapnia was induced by requiring the volunteer to inhale CO_2 gas (500 cc/min of pure CO_2) mixed with room air for one minute prior to xenon inhalation. By following this procedure the CBF is enhanced by around 30%.
The ^{129}Xe inhalation protocol was the same for both conditions. About 500 cc of hyperpolarized gas was drawn from the polarizer into a 1000 cc Tedlar bag, which was then connected to the inhalation mask. The volunteers turned the 3-way cock by themselves and quickly inhaled the Xe gas, thereafter holding their breath for between 15 and 30 seconds. Spectra were acquired using a single hard-pulse acquisition sequence with a bandwidth of 8 kHz and the RF pulse centered at approximately 150 ppm from the gas peak. The flip-angle of the pulse was estimated to be around 30 degrees. The polarisation of the ^{129}Xe gas was estimated for every experiment from 20 cc of gas extracted from the pumping cell immediately prior to the extraction of the inhaled gas.

[*Results*] Figure 1 shows spectra from a healthy human volunteer (32 years old) constructed from the average of 24 acquisitions at a TR of 4 s. Three dissolved-phase peaks were observed at around 197 ppm, 194 ppm and 191 ppm during both the normal (Fig. 1a) and hypercapnic conditions (Fig. 1b). Since the gas polarisation was approximately the same for both experiments, the amplitude of the dominant peak is clearly enhanced by the increase in blood flow during the hypercapnic condition, whereas the smaller peaks are relatively unchanged. The kinetics of the largest peak is shown in Fig. 2, with the hypercapnic data (triangles) having a faster decay time than the normal data (squares).

[*Discussion*] This is the first study to observe ^{129}Xe spectra from human head after modulating CBF. Considering the size of the human brain and normal CBF, the increase in signal intensity of the peak at 197 ppm strongly suggests that it originates from brain tissue. The results also confirm that the signal decay rate is dependent on blood flow.

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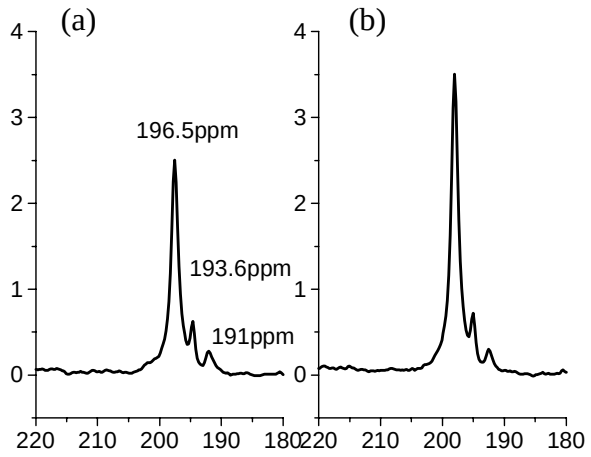

Fig. 1: Typical ^{129}Xe spectra obtained from human head. The amplitude of the peak at around 197 ppm in the normal state (a) is smaller than in the hypercapnic state (b).

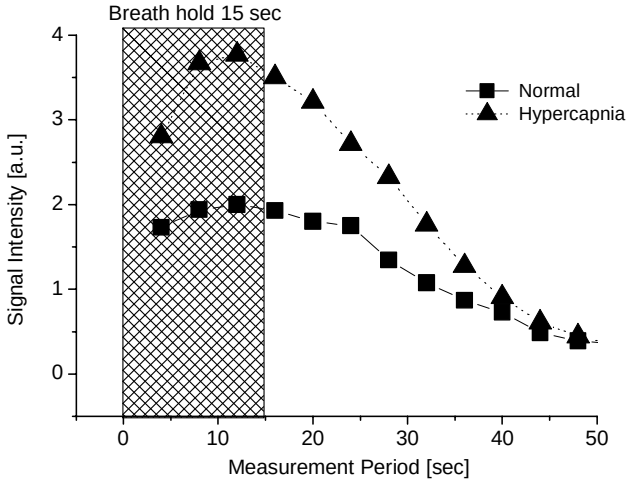

Fig. 2: Typical kinetics of the peak at 197 ppm. The squares and triangles correspond to the normal and hypercapnic conditions, respectively.