

Further investigations of hyperpolarized ^{129}Xe rat head spectra

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Introduction A recent paper has confirmed the existence of five dissolved phase peaks in hyperpolarized ^{129}Xe rat head spectra [1]. The work also presented strong evidence that the dominant peak (peak A in [1]) originates from brain tissue while two other peaks (B and C) originate from xenon in nonbrain tissue and blood, respectively. The origins of the remaining two peaks (D and E) were unresolved and it was suggested that the anaesthetic might influence the emergence of these peaks.

The same paper also noted that the chemical shift of the dissolved phase spectrum (relative to the gas phase peak) varied from publication to publication. In fact, the chemical shift of the dominant peak has been reported in the literature to lie within the range 194-199 ppm, indicating that there may be an unknown source of systematic error.

The work presented here examines the effect that different anaesthetics have on the shape of rat head spectra and suggests that variation in the chemical shifts of the spectral peaks may be due to perturbations in the resonance frequency of the gas reference peak.

Methods A male Sprague-Dawley (360g) rat was anaesthetised with halothane and a tube inserted into the trachea so that hyperpolarized ^{129}Xe could be delivered almost directly into the lungs of the animal from outside the magnet. After preparation the rat was set in a 4.7 T Varian imaging spectrometer and anaesthesia was maintained with 0.5-1% halothane for three hours while spectra were acquired. Thereafter, anaesthesia was switched to α -chloralose (20-40 mg/kg/h, i.v.) and the halothane was allowed to leave the rat's system naturally before more spectra were acquired. ^{129}Xe spectra were obtained with a custom-made 3 cm dual-tuned surface coil. Proton scout images and shimming were performed before the experiment. A single hard-pulse sequence was used with a bandwidth of 30 kHz and RF-pulse centred at around 150 ppm from the gas peak. Spectra were acquired at a TR of 1 s during 40 seconds of xenon inhalation and the results were averaged.

Human spectra were acquired from healthy volunteers (32-57 years) lying in a 1.5 T clinical MRI (Signa, GE medical systems Inc., USA). An inhalation mask fitted with a two-way valve for switching between polarized 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. The volunteers manually turned the two-way valve to inhale about 500 cc of polarized gas from a Tedlar bag attached to the mask and then held 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. Sixty spectra were obtained over a period of one minute beginning from the time the bag was connected to the mask.

For all experiments gas production was as described in [1].

Results & Discussion Figure 1 compares the normalised rat head spectra acquired under halothane (Fig. 1a) and α -chloralose (Fig. 1b) anaesthesia. Following the same peak designations as in [1], peaks D and E are clearly evident for both drugs. The appearance of both peaks indicates that the number of peaks in the dissolved phase spectrum is unaffected by the anaesthesia.

Figure 2 shows gas phase peaks taken from the spectra of two human volunteers. The solid line corresponds to the first spectrum acquired as breath holding commenced and the broken line corresponds to the first spectrum acquired immediately after the subject exhaled. The latter peak has a clear shift of 2-4 ppm from the former peak while the dissolved phase peaks (not shown) have suffered no shift. This is significant because if the broken line were chosen as the gas peak reference then the chemical shift of the dissolved phase peaks would obviously have a different shift to that obtained if the solid line were chosen as the reference point. Whether a similar shift in the gas peak occurs during the acquisition of rat head spectra is under investigation. Possible reasons for the shift in the gas peak include a change in the field experienced by the exhaled gas or the fast-exchange of xenon atoms between air and water vapour.

Reference [1] Nakamura et al, MRM 2005 (in press).

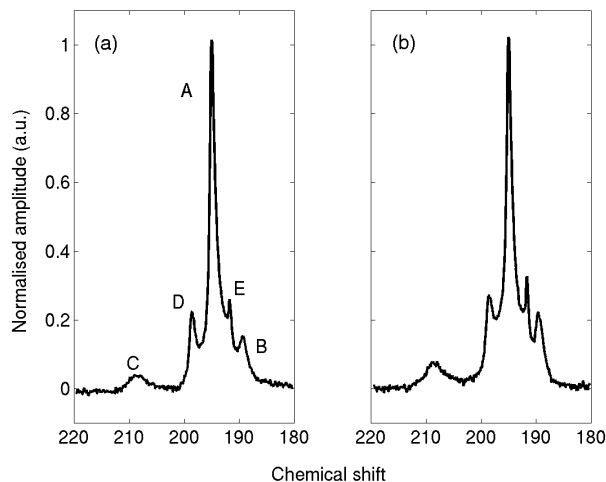


Figure 1: Averaged rat head spectra acquired under (a) halothane and (b) α -chloralose anaesthesia. The peaks are labelled with the same letters as used in [1].

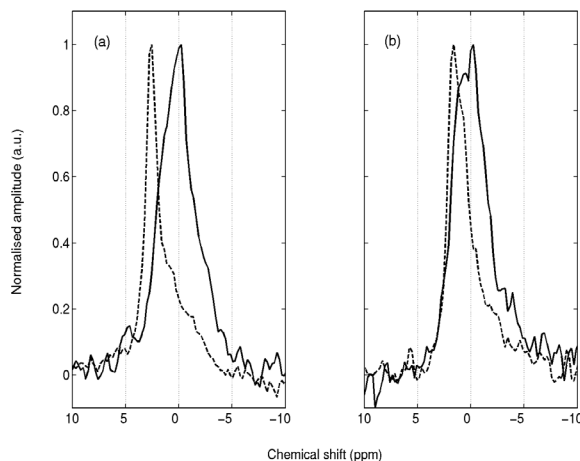


Figure 2: Gas phase peaks from two human volunteers. The solid lines were acquired as the subject began to hold their breath and the broken lines after the subject has exhaled.