The effect of fat saturation on arterial spin labeling

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Introduction

Arterial spin labeling is a method for measuring cerebral blood flow that has advantages because it is noninvasive and repeatable compared to traditional methods, such as PET and contrast-enhanced MR. However, the downside is that this is a signal-to-noise sensitive method. With the emergence of multi-channel receive-only coils, better signal can be obtained for ASL studies because of improved SNR and the inversion used as the tag is no longer limited by the extent of transmit/receive coils [1]. However, recently our group noticed a difference in the signal-to-noise ratio of images acquired with and without fat saturation. In this study, we compare both static and temporal SNR between fat-saturated, non-fat-saturated and water-excited PASL.

Methods

Imaging protocol: Images were obtained in eleven healthy volunteers on a 3T MR scanner (Magnetom Trio, Siemens, Erlangen, Germany). All of the volunteers were scanned with an eight-channel receive-only head coil. Two of the volunteers were also scanned with a transmit/receive birdcage head coil during the same visit. The PICORE tagging scheme with Q2TIPS [2] was used, with a 10cm tag located 1cm below the lowest slice of interest. A C-shape FOCI pulse of 10.24ms duration was used for adiabatic inversion. Other ASL parameters were: $TI_1/TI_{1s}/TI_2$=700/1200/1400ms. Five slices (5 mm thickness, 2.5 mm apart) were acquired in ascending order using gradient echo EPI. Other pertinent imaging parameters were: TE/TR=19ms/2s, 64x64, 220mm^2 FOV. For the fat-saturation experiment, a frequency-selective fat saturation pulse (FA=110°, 5.12ms Gaussian pulse) was applied immediately before each excitation pulse of the EPI acquisition. This pulse was turned off for the non-fat-saturated experiment. Eight of the volunteers were also scanned with a water-excitation ASL sequence where a 121 spatial-spectral binomial pulse was used as the excitation pulse of the EPI acquisition. A total of 50 control-tag pairs were acquired in approximately 4min. Difference images were calculated by subtracting each tag image from the average of the control images before and after it in the image series [3]. The difference images were then averaged to yield the perfusion-weighted image.

Statistical analysis: Static SNR was calculated from the perfusion-weighted images. Mean signal intensity was calculated from five four-pixel regions-of-interest (ROI) located in cortical gray matter regions throughout the slices. Noise was defined as the standard deviation of an ROI placed outside the brain. Temporal SNR was calculated from the difference image time series. Paired t-test was used to compare static and temporal SNR between the three groups.

Results

Figure 1 shows ASL perfusion-weighted images from a representative volunteer. The fat-saturated images are clearly lower in signal than the non-fat-saturated and water-excited images. Paired t-test comparison between the three groups supports this observation ($p<<0.01$). On average, the static SNR of the non-fat-saturated images was 52% higher than that of the fat saturated images, and the SNR of the water-excited images was 64% higher. The temporal SNRs (tSNR) of the three groups follow the same trend, where the non-fat-saturated and water-excited tSNRs were 66% and 80% higher than the fat-saturated tSNR. The same trend was observed in the white matter SNR comparisons between the three groups. Static and temporal SNR comparisons between fat-saturated and non-fat-saturated images acquired using the transmit/receive head coil were not statistically significant.

Discussion

The frequency-selective fat saturation pulse has a broad bandwidth that extends towards the water frequency, thereby decreasing the water signal. This phenomenon was not observed with a transmit/receive coil because of the limited extent of the RF field, which makes it less likely to affect water signal in blood before it enters the imaging slices. However, simply removing fat saturation could still induce errors due to incomplete subtraction of the fat artifact. Therefore, spectral-spatial selective pulses are a particularly attractive solution as they eliminate the fat artifact without compromising the water signal.

Conclusion

In order to make ASL a useful imaging tool, one needs to improve the SNR. This is typically accomplished by going to higher magnetic fields. We have demonstrated the adverse effect of fat saturation on the ASL signal when using a receive-only coil. This study also presents water excitation as a good alternative to fat saturation. With the alterations to the imaging sequence described, it is possible to gain a significant factor in SNR. Such a substantial improvement in the ASL data can provide more accurate CBF measures as well as more accurate activation maps based on flow.

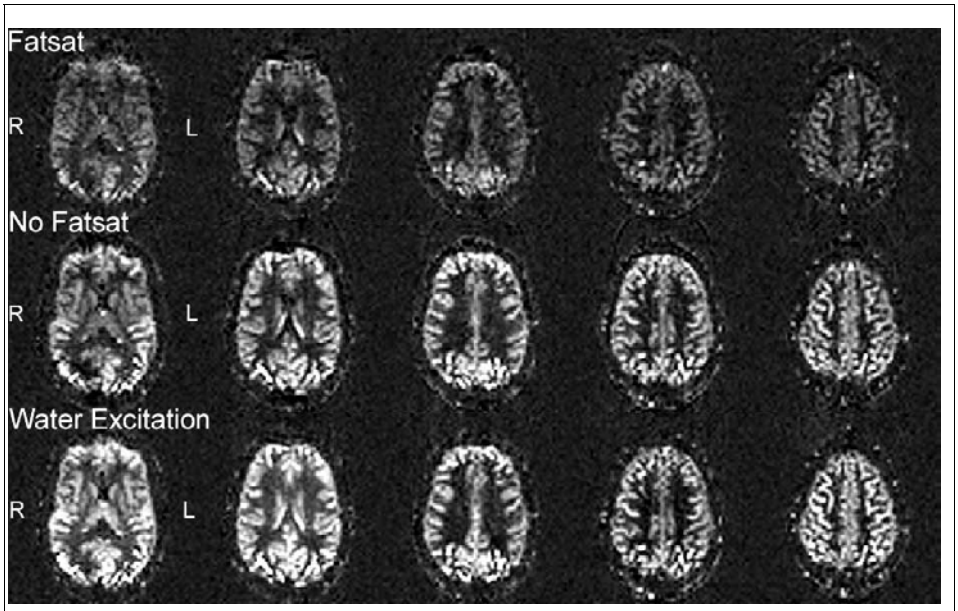

Fig. 1 Images from a single volunteer. Top row: ASL acquired with fat saturation. Middle row: ASL without fat saturation. Bottom row: ASL with water-excitation.

References

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