DRESS Strategy for Improving Cardiac P-31 MRS at 3T: Coil & OVS

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Introduction

Recent development of elaborate MRS techniques have been shown to enhance the sensitivity and localization in the cardiac P-31 MRS [1,2]. On the other hand, depth resolved surface coil spectroscopy (DRESS) [3] can be easily applied and shows excellent sensitivity by its simplicity with only single slice selection gradient. It still has been effectively used for cardiac P-31 applications where higher signal-to-noise ratio is necessary. The DRESS, however, tends to be contaminated from adjacent tissues. This is because the lateral extent of the sensitive volume is defined by the transverse magnetic field produced by the surface coil. In this study, we pursued a strategy to minimize the contamination from outside tissue especially for cardiac application. First, a laterally elongated P-31 coil was designed and built which minimized contamination from the liver and chest muscle. Second, tailored outer volume suppression (OVS) pulse was devised and added to the DRESS sequence.

Methods

Coil: A quadrature surface coil pair was designed in an oblong shape in order to maximize SNR and reduce contamination from areas outside the ROI (A-P direction). The conductors were constructed from 0.64cm wide copper foil tape (3M, Minneapolis, MN). The total width of the coil is 10.5 cm wide in the x-direction and 6.5 cm wide in the z-direction. Each individual element is 6cm wide and the distance required to cancel the mutual inductance and attain isolation is 0.4cm. A $\lambda/8$ quadrature combiner was designed and verified for power splitting and signal combination. In order to view the placement of the MNS coil during proton imaging Beekley MR-spots (Bristol, CT) were placed in three distinct areas (Figure1).

Outer volume suppression: Two sets of saturation pulses, one for proton and one for P-31, were generated by Shinnar-Le Roux algorithm [4] with maximum phase using General Electric Signa Advantage^{TM} EPIC Tool. Since the slice to be saturated will not be refocused, the saturation pulse does not have to have a linear phase. In order to saturate the target region completely, maximum B_1 amplitude and P-31 bandwidth of passband and stopband were carefully controlled by Bloch simulation. Dephasing in the saturated region was enhanced by a dephasing gradient following the saturation pulse.

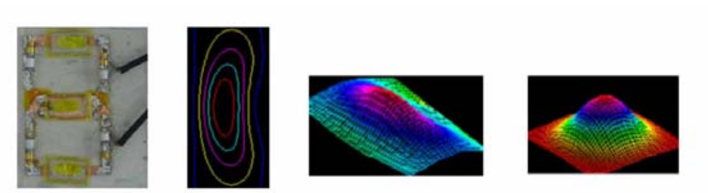
MRI/MRS: The OVS pulse was tested in both proton MRI and P-31 MRS at 3T whole body imager (GE SIGNA, Milwaukee, WI). The localization of the DRESS was tested for two-compartment phantom filled with 30 mM phosphoric acid (H_3PO_4) and 240 mM methylene diphosphonic acid (MDPA). Healthy volunteers were scanned (supine, head first) with the coil placed over the heart along left-right direction. Scout imaging made by FIESTA was followed by B_o shimming by PRESS. An oblique DRESS slice of 15mm was chosen at anterior left ventricle (3 R-R TR, 128 avg, 5kHz). The same scan was repeated with and without OVS pulse for single slice DRESS and DRESS/CSI. Both 1-D CSI with 32 slice (AP) and 2-D CSI with 16(RL) x 24(AP) grid were carried out.

Results and Discussion

Simulated trasnverse magnetic field using Biot-Savart law is illustrated in Figure 1. The field demonstrates efficient B1 profile on the DRESS slice. In two compartment phantom the signal in the OVS band was well suppressed as seen in Figure 2. For MRI, the proton signal in the OVS region was suppressed by more than 90%. For P-31 MRS, the contamination from the adjacent compartment representing outside tissue was dropped by 30 to 75% with oblong shape coil as compared with circular coil depending on the relative position of the DRESS slice. An additional three fold decrease of contamination was observed when OVS pulse was added. The signal gain using the quadrature-driven surface coil was 15 to 25% at 5 cm-deep slice. The spectra from human heart by 1-D CSI was shown in Figure 3. The suppression effects from the optimal combination of coil/OVS may be exploited in routine clinical application, whereas our past experience has shown about 25% of the women's ischemic heart studies using DRESS [5] were contaminated by the skeletal muscle, liver or both.

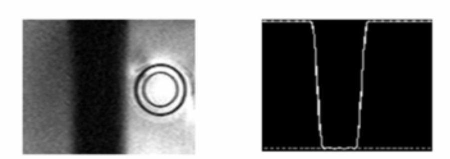
References

1. von Kienlin M, et al. JMRI 13:521-527 (2001)
2. Kozerke S, et al. Mag Reson Med 48:380-384 (2002)
3. Bottomley PA, et al. J Magn Reson 59:338-352 (1984).
4. Pauly J, et al. IEEE Trans 10:53 (1991)
5. Johnson BD, et al. Circulation 109:2993-2999 (2004)



(a) (b) (c) (d)

Figure 1. Cardiac transceiver P-31 oblong coil (a). B1 field profile on the DRESS slice by oblong shape transceiver surface coil when driven in quadrature mode (b,c). B1 field by circular surface coil (d).



(a) (b)

Figure 2. OVS pulse profile was tested in the imaging sequence. OVS band in the two compartment phantom (a). Corresponding drop of simulated magnetization (b)

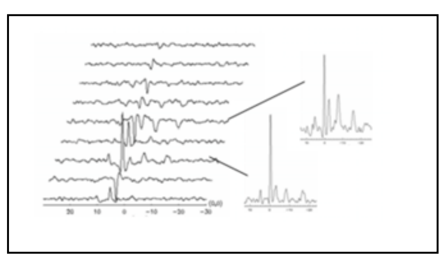


Figure 3. Example of P-31 cardiac spectra from 1D CSI. CSI grid from anterior to posterior on the axial DRESS slice. OVS pulse also applied left and right side.