# T2-weighted Fourier velocity encoding: *in vivo* vascular MR oximetry

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**Introduction** MR oximetry based on conventional quantitative T2 measurement [1] is a technique for measuring vascular oxygen saturation noninvasively. However, partial volume effects can limit T2 accuracy or impose increased spatial resolution, requiring long scan times at reduced SNR [2]. The addition of Fourier velocity encoding [3], in a technique called Magnetic resonance Oximetry with Velocity Encoding (MOVE) [4], overcomes these limitations by separating moving blood from static tissue based on velocity. In this study, the MOVE technique was applied in vivo.

**Methods** Conventional MR oximetry consists of a T2 preparation stage, followed by a fast imaging sequence. MOVE augments the conventional technique with flow-encoding and employs a spiral trajectory for fast imaging. Cardiac gating was used for both acquisitions to focus on diastole and minimize signal variation across the cardiac cycle from pulsatile flow. Data were acquired at a range of T2 preparation refocusing times (TE) to measure T2 decay [2]. An experiment was performed on a 1.5-T Signa MR System (GE, USA) on a healthy 27 year old male. The subject was positioned head first and supine. The scan plane was prescribed in an axial plane inferior to the carotid bifurcation. Scans were performed with the conventional technique with TE = 3, 49, 96, 189 ms, TR = 2 cardiac cycles = ~2000 ms, trigger delay = 400 ms, slice thickness = 6 mm, FoV = 160 mm, number of spiral arms = 19, spatial resolution = 0.8 mm, number of averages = 1, scan time = 154 s, n = 8 repetitions, with a 4 channel neurovascular array coil (MRI Devices, UK), and with MOVE using the same parameters except number of spiral arms = 1, spatial resolution = 6.5 mm, number of averages = 4, scan time = 200 s, n = 3 repetitions, number of velocity encodings = 6, velocity resolution= 17.4 cm/s, with the body coil. Zero padding, to achieve comparable interpolated spatial resolution, and phase error correction were applied during MOVE data reconstruction. Phase contrast MR was used to determine the velocity of each vessel. MOVE velocity parameters were selected to separate the dominant diastolic velocity in the right internal jugular vein (RIJV) from static tissue, but the data also allowed for analysis of the left internal jugular vein (LIJV) and the right and left common carotid arteries (RCCA, LCCA).

**Results & Discussion** Figure 1 illustrates the separation of blood vessels from static tissue in representative conventional and MOVE images. Reconstructed conventional MR oximetry images consisted of a collection of 2D images at different TEs. MOVE added velocity encoding to this data to yield images across a range of velocity planes (v = -52.2, -34.8, -17.4, 0, +17.4, +34.8 cm/s). MOVE data were analyzed by quantifying the T2 decay of blood in the dominant velocity plane of the vessel of interest [4].

Table 1 summarizes experimental results, showing measured T2s were higher for the oxygenated blood in the CCAs than in the IJVs, as expected. While left and right IJV and CCA T2s by MOVE are in agreement to within a standard deviation, the conventional measure of T2 was higher in the RCCA than in the LCCA, possibly due to partial volume effects. All standard deviations were within 5% of the mean, equivalent to normal physiologic variation in %O2 [5], with the exception of the MOVE measure of the LIJV which was 6%. Heart rate changes during scanning may contribute to additional variation in T2 from MOVE as a change in the velocity of blood may result in signal shifting across velocity planes.

**Table 1** – Mean and standard deviation of repeat measurements by conventional MR oximetry and MOVE.

| T2 | Conventional | MOVE |
|---|---|---|
| RIJV | 123 ± 4 ms | 116 ± 3 ms |
| LIJV | 125 ± 5 ms | 125 ± 8 ms |
| RCCA | 229 ± 10 ms | 210 ± 10 ms |
| LCCA | 208 ± 10 ms | 207 ± 7 ms |

**Conclusions** By adding velocity encoding to the conventional MR oximetry technique, MOVE was able to scan at low spatial resolution while maintaining T2 accuracy, permitting potential reductions in scan time. Consequently, MOVE may be able to measure blood oxygen saturation in narrow vessels in less time than conventional oximetry and has a lower sensitivity to vessel motion.

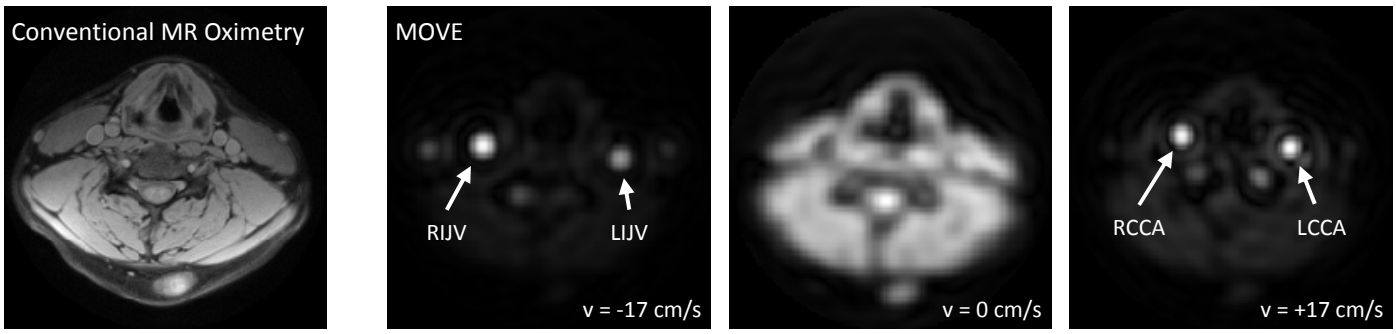


**Figure 1** – Conventional oximetry image (TE = 3 ms) and corresponding MOVE images for selected velocity planes showing separation of static tissue, IJVs, and CCAs based on velocity. Non-zero velocity planes are independently scaled.

**References**

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