Using Multiple Half-Echos to Improve Sampling Efficiency and Fat Supression in Time-Resolved MRA

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SYNOPSIS
We present a T1-weighted application of Vastly undersampled Isotropic PRojection imaging with Multiple Echoes (VIPR-ME) that doubles sampling efficiency and suppresses fat signal. Sampling during the previously idle time of gradient ramps, dephaser, and rephaser allows nearly double the sampled projections per unit time. This significantly increases SNR and CNR in VIPR contrast-enhanced angiography by decreasing the undersampling artifact as well as the stochastic noise signal. Fat suppression decreases the impact of subcutaneous and retroperitoneal fat. The improved performance shows fine vessel detail without the thinly targeted MIPs previously necessary.

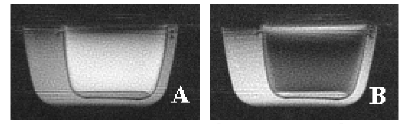

Figure 1 – Conventional VIPR (A) and VIPR-ME (B) scans of a fat(inside)/water phantom show the ability of VIPR-ME to suppress fat signal.

INTRODUCTION
VIPR exams offer high resolution over a large FOV, with excellent arterial/venous separation and ease of prescription, but, up until now, limited CNR and structured noise has required relatively thin MIPs for clinical interpretation.[1] This limitation stems primarily from the large speedup over conventional scans. Additionally, eddy currents cause shifts in the k-space trajectory. Misregistration between the trajectory actually acquired and the trajectory used for regridding causes degradation in image quality. Furthermore, the pulse sequence has been sensitive to fat, which distracts from the vascular signal. We demonstrate an application of a new acquisition scheme called Multiecho VIPR (VIPR-ME), which doubles the sampling efficiency, corrects k-space shifts, and decreases fat sensitivity, allowing the use of thicker MIPs for interpretation.

METHODS
We have improved SNR and CNR by using multiple echoes to acquire four radial lines during each TR, double the number used in our previous implementation. Previous 2D multiecho work has required techniques of varying complexity to combine the echoes.[2,3,4,5] Using a half second of calibration data acquired at the beginning of the exam, we can measure the actual trajectory through k-space for the entire gradient waveform.[6] Sampling can then occur during gradient ramps and the half echoes formed by the dephaser and rephaser. The accurate k-space trajectory measurement allows the complete multiecho dataset to be regridded in one step without further corrections, rather than requiring regridding on a per-echo basis. This enhancement requires only a slight increase in TR, as the only changes in the pulse sequence are that the spoiler and rephaser can no longer be played concurrently and two small rotational blips are necessary.

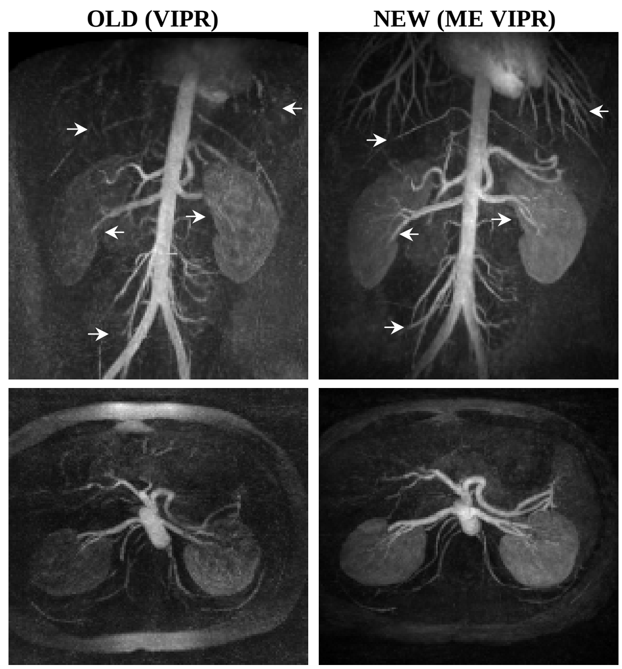

Figure 2 – Comparison of conventional VIPR vs. VIPR-ME in the same subject. Images obtained from 16 cm thick coronal MIP and 8 cm thick axial MIP. Note the markedly improved demonstration of small distal vessels (pulmonary artery branches, intercostal, lumbar, and mesenteric branches). The improved vessel CNR is attributed to increases in vessel signal and decreases in undersampling artifact and fat signal.

RESULTS
Our previous implementation acquired 256 points (1.0 ms) during a 3.8 ms TR, for a sampling efficiency of 27%. VIPR-ME acquires 608 points (2.4 ms) during a 4.4 ms TR, for an efficiency of 55%. In addition to the increase in sampled projections, VIPR-ME has an added benefit in that the center of k-space is sampled multiple times during each TR, leading to reduced fat sensitivity. A four half-echo scan samples the origin three times, with 1.3 ms between passes. As fat dephases 180° every 2.2 ms, the DC fat signal from the first and last half echo sums nearly to zero, as shown by Larson.[4]

We tested the four half-echo sequence with a GE 1.5T EchoSpeed Plus magnet on a fat/water phantom and a human subject. The phantom scans (Figure 1) clearly demonstrate the favorable fat-water imaging characteristics of the VIPR-ME technique, with a 70% reduction in fat signal and a 340% increase in the water/fat signal ratio. An abdominal study was produced of a healthy volunteer with 1.6 mm isotropic resolution across a 40 cm spherical FOV, using a scan time of 40 seconds to match an earlier conventional VIPR scan on the same volunteer. We injected 40 ml of Gadodiamide (Omniscan, Amersham Health, Inc.) at 3 ml/s and selected the arterial time frame from a series of time-resolved images. We measured a 70% increase in SNR and a 240% increase in the vessel/fat signal ratio. Limited coronal (16 cm thick) and axial (8 cm thick) MIPs were used to compare the conventional VIPR and VIPR-ME exam (Figure 2). Notice the improved overall SNR, suppression of signal from subcutaneous fat in the abdominal wall, and improved definition of small vessels

DISCUSSION AND CONCLUSION
VIPR-ME using four half echoes demonstrates great improvements over conventional VIPR. Doubling the acquisition efficiency leads to significant improvements in SNR, which, coupled with the suppression of subcutaneous fat, makes possible clinical interpretation using thick MIPs, sometimes through the entire volume. Gradient correction leads to improved depiction of small distal vessels. Additional signal remains after four half echoes, so potentially six half echoes could be acquired, sampling 928 points in a 5.7 ms TR, for a 65% sampling efficiency. This is expected to yield additional gains in SNR and CNR. Furthermore, with six half echoes, the k-space trajectory would sample the origin four times, yielding two opposite pairs and further improving fat suppression.

REFERENCES
1. KR Pillai, *et al.*, Proc 10th ISMRM, 1783 (‘02)
2. DC Peters, *et al.*, Proc. 9th ISMRM, 1882 (‘01)
3. T Schaeffter, *et al*., Proc 10th ISMRM, 102 (‘02)
4. AC Larson, *et al.*, MRM 46:1059-1066, (‘01)
5. V Rasche, *et al.*, MRM 42:324-334 (‘99)
6. J Duyn, *et al.*, JMR 132:150-153 (‘98)
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Non-Max Suppression Algorithm. Now if you observe the algorithm above, the whole filtering process depends on single threshold value. So selection of threshold value is key for performance of the model.Â These techniques works well for filtering predictions of a single model, What if you have predictions from multiple models? Weighted boxes fusion is a novel method for combining predictions of object detection models. Check out my article to know more about that. . Using multiple half-echoes to improve sampling efficiency and fat suppression in time-resolved MRA. In: Proceedings of the 11th Annual Meeting of International Society of Magnetic Resonance in Medicine, Toronto, Ontario, Canada. July 10â€"16, 2003;24.Â . Time-resolved contrast-enhanced carotid MR angiography using sensitivity encoding (SENSE). AJNR Am J Neuroradiol 2001;22:1615â€"19. Abstract/FREE Full Text. An algorithm is sample efficient if it can get the most out of every sample. Imagine learning trying to learn how to play PONG for the first time. As a human, it would take you within seconds to learn how to play the game based on very few samples. This makes you very "sample efficient". Modern RL algorithms would have to see 100 thousand times more data than you so they are, relatively, sample inefficient.Â Importance sampling is a technique to filter these samples. Its original use was to understand one distribution while only being able to take samples from a different but related distribution. In RL, this often comes up when trying to learn off-policy. Namely, that your samples are produced by some behaviour policy but you want to learn a target policy. The key principles of contrast-enhanced magnetic resonance angiography (CE-MRA) are also explained in detail, especially focusing on timing of the acquisition following contrast agent bolus administration, and current approaches to achieving time resolved MRA.Â Abstract. This is the second of two reviews that is intended to cover the essential aspects of cardiovascular magnetic resonance (CMR) physics in a way that is understandable and relevant to clinicians using CMR in their daily practice. Starting with the basic pulse sequences and contrast mechanisms described in part I, it briefly discusses further approaches to accelerate image acquisition. So basically with time it should improve on its own as more data is used? Do the pool and log size variables like innodb_buffer_pool_size, innodb_buffer_pool_instances, binlog_cache_size and innodb_log_buffer_size have any impact on this efficiency? Copy link. Collaborator.Â @jmrenouard, I already have it at 2Gb for a DB that occupies on disk 1.3Gb. The previous version some time ago recommended to reduce the innodb_log_file_size value (I had it at 512Mb, reduced it to 256Mb), then some months after the change I noticed the new warning (about the Write Log efficiency) with the new version, so I'm not sure what to do, it's a bit confusing :) Copy link.