# Quiet, Dual-Contrast Ultra-Short Echo Time MRA of the Extracranial Carotid Arteries

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**Target Audience:** Physicians and scientists performing magnetic resonance angiography (MRA) of the extracranial carotid arteries.

**Purpose:** Magnetic resonance angiography is an accurate diagnostic modality for evaluating stenotic disease of the extracranial carotid arteries. For patients in whom the administration of gadolinium-based contrast agents is contraindicated, time-of-flight MRA is commonly used. However, image quality is variable and only a limited vascular region is depicted. We describe an alternative approach for non-contrast MRA leveraging a quiet, ultra-short echo time 3D point-wise encoding time reduction with radial acquisition (PETRA) sequence that allows for evaluation of the carotid arteries using both bright- and dark-blood projection images.

**Methods:** Imaging of a severe carotid stenosis in a flow phantom was performed to test the potential of an ultra-short echo time to mitigate signal loss due to turbulence; results were compared to a short-TE (TR/TE = 2.6/1.2s) fast low angle shot (FLASH) sequence used in contrast-enhanced MRA (CEMRA). 5 healthy subjects and 3 patients were imaged using a MAGNETOM Avanto 1.5T MRI system (Siemens AG, Erlangen, Germany) under an IRB-approved protocol. Dual-contrast MRA had ≈1mm$^3$ isotropic spatial resolution. For dual-contrast MRA, two data sets were acquired using a prototype 3D PETRA sequence[1]. For one data set, a 10cm-thick inferior saturation region was applied every 100ms to suppress the arterial signal. PETRA sequence parameters were: TR/TE/flip angle = 4.6ms/0.07ms/5°, 320 matrix, 320mm field of view, 25,000 views, 2min 9sec per data set. For bright-blood MRA (referred to as arterial spin-labeled (ASL) PETRA), the two PETRA data sets were subtracted and maximum intensity projections (MIP) were created. For dark-blood MRA, minimum intensity projections (minIP, 15-25mm thick) were created from the arterial-saturated PETRA data set. Arterial-to-background contrast-to-noise ratio (CNR) was computed.

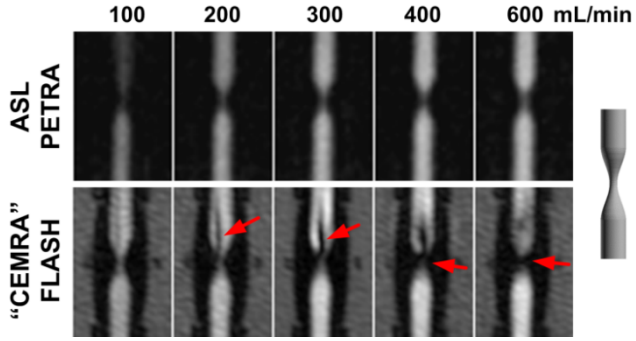


**Fig. 1.** Flow phantom data showing elimination of signal loss due to intravoxel dephasing (arrows) with ASL PETRA. Flow rates and phantom geometry are shown at top and right, respectively.

**Results:** In the flow phantom study, the bright-blood ASL PETRA contrast eliminated signal loss near the severe stenosis caused by turbulence **(Fig. 1)**. Bright-blood ASL PETRA and dark-blood PETRA contrasts provided excellent depiction of the extracranial carotid bifurcations in a volunteer **(Fig. 2)**. Bright-blood ASL PETRA depicted the arteries from the level of the common carotid artery to the circle of Willis. Imaging in patients with stenosis showed excellent correlation between bright-blood ASL PETRA and CEMRA (**Fig. 3**). Because of the ultra-short TE, susceptibility artifacts were absent. On minimum intensity projections of the dark-blood PETRA data, there was no confounding low signal from ligaments, tendons, and fat/water interfaces. However, overestimation of the luminal diameter on the dark-blood minIP images was observed, probably due to the presence of hypointense calcification at the carotid bulb/bifurcation (arrows in Fig. 3)[2]. This artifact was not present in the MIP images of the bright-blood ASL PETRA data set. CNR values for the dark-blood and bright-blood image sets were 10.6±5.6 and 13.8±3.3, respectively.

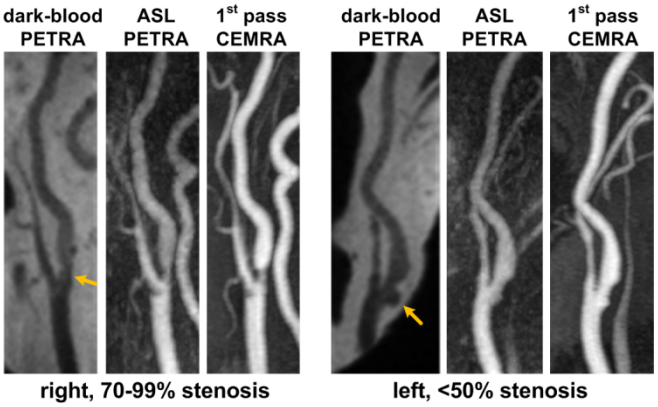


**Fig 3.** Images obtained in a patient with 70-99% stenosis of the right internal carotid artery.

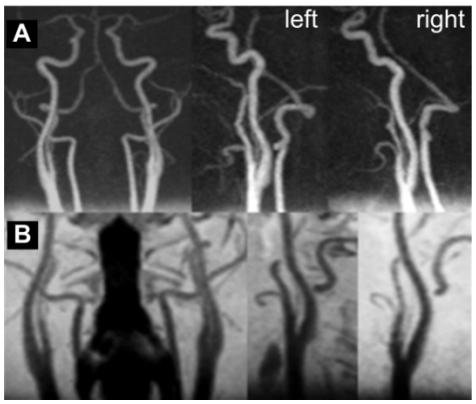


**Fig. 2.** Bright-blood ASL (A) and dark-blood (B) PETRA contrasts showing the carotid arteries.

**Discussion and Conclusion:** Dual-contrast PETRA-based MRA permits evaluation of the extracranial carotid arteries with both bright- and dark-blood contrasts, and demonstrates immunity from intravoxel dephasing and susceptibility artifacts. The use of an ultra-short echo time is essential for creating dark-blood projection images, since it ensures that all tissues except saturated blood (and air) have substantial signal and thus are not apparent with minimum intensity projection processing[2]. Further study is needed to determine potential diagnostic utility and the impact of arterial calcification on the dark-blood minimum intensity projection images.

**References: 1.** Grodzki DM et al. Magn Reson Med. 2012;67:510–518. **2.** Edelman RR et al. Magn Reson Med. 2014; doi: 10.1002/mrm.25320.