Non-enhanced Hybrid Arterial Spin Labeling MRA for assessment of the cervical carotid and vertebral arteries in patients with suspected/ known cerebral ischemia: preliminary clinical experience

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Target Audience:
Radiologists and other clinicians, basic scientists and MRI technologists interested in stroke and cerebrovascular imaging.

Purpose:
Extracranial internal carotid artery (ICA) and vertebral artery (VA) disease accounts for up to 15-20% of ischemic strokes[1], with imaging vital for management planning[2]. MRA is commonly used for imaging the supra-aortic arteries, with contrast-enhanced MRA (CE-MRA) demonstrating high accuracy[3]. A reliable contrast-free technique is desirable when renal function is impaired or unknown, or intravenous access is difficult. Recently, a **No**n-enhanced **H**ybrid **A**rterial **S**pin **L**abeling MRA (NoHASL MRA) technique has been described that combines pseudocontinuous and pulsed arterial spin labeling to improve extracranial arterial conspicuity and coverage[4]. The technique uses undersampling, a 3D radial trajectory, and a balanced steady state free precession readout to shorten acquisition time, lessen motion sensitivity and increase arterial contrast. Here, we evaluated the performance of NoHASL MRA in a clinical population against CE-MRA as a reference standard.

Methods:
15 patients (10M, 5F, mean 65y, range 21-89y) referred for suspected or known anterior or posterior circulation cerebral ischemia underwent prototype NoHASL MRA and CE-MRA acquisitions on a 1.5T clinical scanner (MAGNETOM Avanto, Siemens AG, Erlangen, Germany) with a 2-channel neck coil, 8-channel head coil and posterior spine elements. NoHASL parameters were: TR/TE 2500/1.84 ms, echo spacing 3.7ms, FA 90°, true voxel size 1.0x1.0x1.0mm^3, FOV 256 mm, acquisition time 4:05 minutes, radial views 7680, pseudocontinuous labeling duration 1690ms, post label delay 200ms. CE-MRA parameters were: TR/TE 2.82/1.2 ms, FA 25°, true voxel size 0.9x0.8x0.9mm^3, FOV 410 mm, 6/8 slice and phase partial Fourier, 120 partitions, acquisition time 0:24 min, acceleration factor 3 (GRAPPA), gadoterate meglumine (Dotarem, Aspen Pharmacare), 0.2ml/kg, injection rate 2ml/s, 40ml saline flush. Anonymized CE-MRA and NoHASL images were interpreted by two experienced neuroradiologists on a PACS workstation with multiplanar reconstruction capabilities (Impax, Agfa). 14 segments were assessed (bilateral common carotid artery (CCA) origin, mid to distal CCA, ICA bulb, mid and distal extracranial ICA, vertebral artery (VA) origin, mid and distal extracranial VA). Diagnostic confidence was scored on a 5-point Likert scale (1=worst, 3=sufficient for diagnosis, 5=best). Internal carotid artery (ICA) bulb diameter measurements and stenosis were calculated according to NASCET methodology. VA stenosis was qualitatively assessed on a 2 point scale (0-49%, non-significant, and 50-100%, hemodynamically significant stenosis). Diagnostic confidence was compared between NoHASL and CE-MRA using the Mann-Whitney test, with dichotomous data non-diagnostic (Likert 1-2) and diagnostic (3-5) also assessed with Pearson chi-square test. ICA narrowest diameter and NASCET measurements were correlated using Spearman correlation. Sensitivity and specificity of NoHASL MRA against CE-MRA was assessed for hemodynamically significant VA stenosis.

Results:
All patients successfully completed both NoHASL and CE-MRA. At CE MRA, mild (<50%) ICA stenosis was present in 7 patients involving 8 vessel segments, with no moderate or severe stenosis by NASCET criteria. There were 9 hemodynamically significant vertebral artery stenoses at CE-MRA, with the majority (n=6) at the VA origin. Diagnostic confidence was significantly greater for all segments at CE-MRA, but mean diagnostic confidence score remained diagnostic for NoHASL (CE-MRA 3.9±0.87 vs. NoHASL 3.3±1.07, $p < 0.0001$). When comparing dichotomized diagnostic confidence scores, there was no significant difference between diagnostic and non-diagnostic scores for 4 of 7 arterial segments: mid to distal CCA, bulb, mid to distal ICA, mid VA. Other segments demonstrated a significantly higher proportion of diagnostic scores with CE-MRA. For ICA stenosis, NoHASL MRA findings were similar to CE MRA, with no significant (≥50%) stenosis identified. There was moderate correlation between CE-MRA and NoHASL absolute ICA bulb diameter measurements (Spearman rho = 0.6945 $p<0.0001$), and moderate but not significant correlation for NASCET stenosis measurement ($p=0.19$). Vertebral stenosis sensitivity and specificity for hemodynamically significant stenosis was 58.8% and 87.3% respectively.

Discussion/Conclusion:
In our initial clinical experience, NoHASL shows promise as a relatively rapid, large coverage non-contrast sequence for assessment of extracranial carotid disease that is robust to motion due to radial readout. Equivalent diagnostic confidence to CE MRA was demonstrated in all ICA segments, with moderate correlation of ICA absolute diameter measurements with CE MRA. Relatively low sensitivity for detection of significant vertebral artery stenosis and low diagnostic confidence for the vertebral origin was noted, with decreased arterial conspicuity at this location inherent to the technique, due to the pulsed inversion label. Study limitations include small sample size and lack of hemodynamically significant ICA stenosis in the study cohort. Further experience in a larger clinical population is warranted.

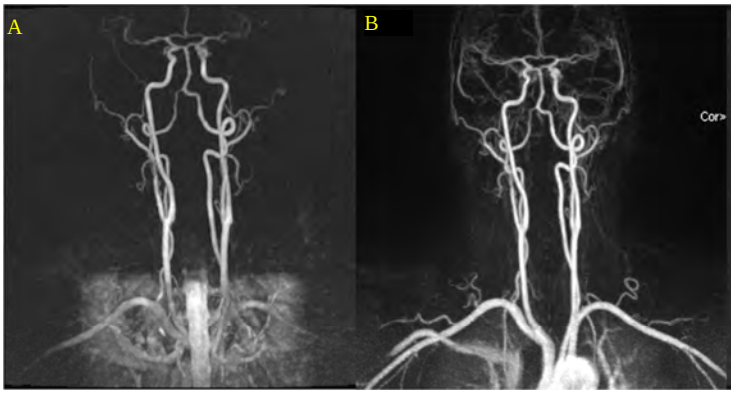

Fig 1. 49 year old female presenting with paresthesia. (A) NoHASL and (B) CE-MRA subtraction maximum intensity projections (MIPs) demonstrate comparable visualization of the extracranial ICA, with no disease identified.

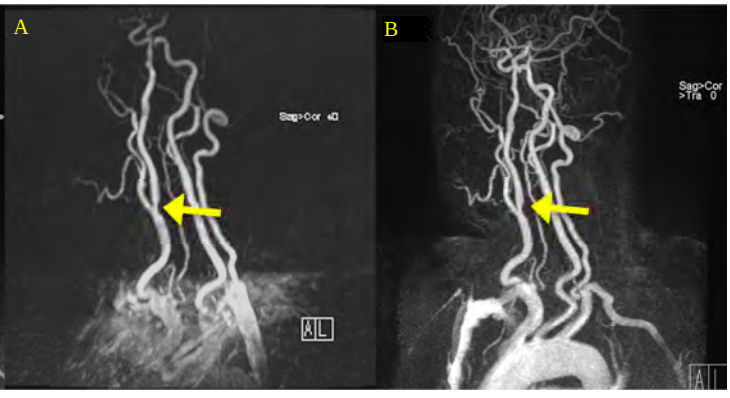

Fig 2. 89 year old male with dysphasia. Oblique (A) NoHASL and (B) CE-MRA subtraction MIPs demonstrate <50% stenosis at the right ICA bulb

References:
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3. Chappell FM et al. *Radiology* 2009; **251**(2): 493-502.
4. Koktzoglou I et al. *Journal of magnetic resonance imaging : JMRI* 2014.