Neovascularization in vertebral artery atheroma- dynamic contrast enhanced MR Imaging based comparative study in patients with symptomatic and asymptomatic carotid artery disease.

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Introduction

- Stroke remains one of the leading causes of cardiovascular-related mortality and long term disability.
- Ischemic stroke constitutes two-thirds of total strokes, with vertebrobasilar territory ischemia secondary to vertebral artery (VA) atherosclerosis, as a predominant cause of 20% of such events.
- Dynamic contrast-enhanced magnetic resonance (DCE-MR) imaging enables the assessment of plaque neovascularisation.
- The aim of this study was to explore systemic nature of atherosclerosis by assessing difference in severity of neovascularisation as quantified by DCE-MR imaging of vertebral arteries (VA) between patients with symptomatic and asymptomatic carotid artery disease.

Study method

- 10 consecutive patients with asymptomatic vertebral artery stenosis and concomitant symptomatic carotid artery disease (group 1); and 10 consecutive patients with asymptomatic vertebral artery stenosis and concomitant asymptomatic carotid artery disease (group 2), underwent DCE-MR imaging of their cervical segment of vertebral arteries.
- A high-spatial and temporal resolution dynamic three-dimensional contrast-enhanced technique was used to acquire data from 40 VA's. A previously validated pharmacokinetic modelling approach was used for DCE-MR analysis. K^{trans} was calculated in the adventitia and plaque as a measure of neovessel permeability, by two experienced image analysts.
- Following sequences were used[1]:

Sequences	3D TOF	Pre/post-contrast BB T1w 3D FSE	3D DCE/MRA
TE /TR(ms)	2.2/5.9	16.9/540	1.5/3.9
Flip angle(◦)	20	Variable	20
FOV(mm x mm x mm)	140 x 140 x 64	140 x 140 x 76	140 x 140 x 62
Acquired pixel size (mm x mm x mm)	0.5 x 0.5 x 2.0	0.6 x 0.6 x 1.4	0.6 x 0.6 x 1.4
Reconstruction pixel size(mm x mm x mm)	0.5 x 0.5 x 2.0	0.3 x 0.3 x 0.7	0.3 x 0.3 x 0.7
NEX	2	2	1
Receiver bandwidth(±kHz)	31.25	62.5	62.5
Acquisition time	1 min 35 s	2 x 6 min 26 s	6 min 23 s

TOF time of flight, *BB* black blood using delays alternating with nutation for tailored excitation (DANTE) preparation, *FSE* fast spin echo, *DCE* dynamic contrast-enhanced, *MRA* MR angiography, *TE* echo time, *TR* repetition time, *FOV* field of view, *NEX* number of excitations

- Vessel wall and lumen boundaries were mainly based on pre-contrast T_1w images. The subtracted CE-MRA image at the fifth phase with highest contrast of the VA, were used for analysis. Luminal stenosis was measured for each plaque using European Carotid Surgery Trial (ECST) criteria (Figure III).
- K^{trans} was calculated in the adventitia and plaque as a measure of neovessel permeability, by two experienced image analysts.

Results

- 3D DCE MR Imaging is a feasible technique to assess neovascularization in vertebral territory.
- DCE-MR image analysis of vertebral arteries was successfully performed in all 20 patients. The two groups were comparable for patient demographics and co-morbidities. Mean luminal stenosis was comparable for both groups (54.4% vs 52.27%, p= 0.32).
- Patients with completely asymptomatic vertebral artery disease and symptomatic carotid artery disease (Group 1) had more neovessel formation in vertebral territory compared to the completely asymptomatic cohort as demonstrated by high adventitia K^{trans} in contrast to the plaque K^{trans}.
- Completely asymptomatic individuals (Group 2) demonstrated low adventitia K^{trans} and plaque K^{trans} which indicates decreased neovascularization in this patient cohort.
- Group 1 had higher adventitial K^{trans} and plaque K^{trans} (0.08 ± 0.01min^{-1}, 0.07± 0.01min^{-1} compared to Group 2 (0.06± 0.01 min^{-1}, 0.06± 0.01min^{-1}), (p =0.004 and 0.03) respectively. Good correlation was present among the two image analysts (intra-class correlation coefficient=0.78) (Fig II).

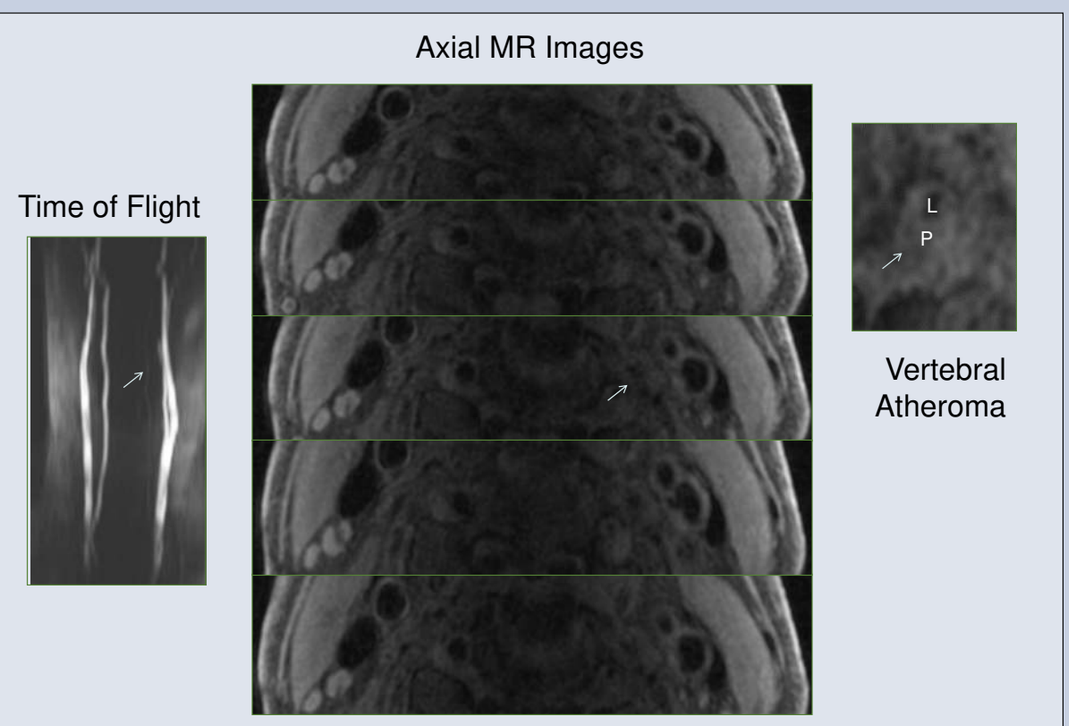

Figure I: Axial images on T1 w DANTE CUBE. Stenosis of left vertebral artery can be visualized. The TOF shows almost no blood flow through the L vertebral indicating the stenosis on L side as compared to the R side. The magnified view shows the lumen (L) and plaque (P).

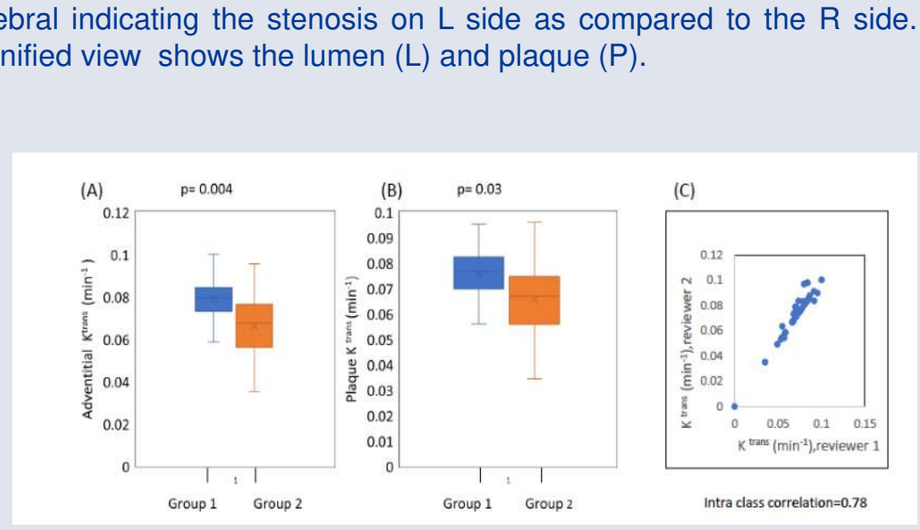

Figure II: Comparison of pharmacokinetics parameters in patients with asymptomatic vertebral artery disease and concomitant symptomatic carotid artery disease (group 1) and asymptomatic carotid artery disease (group 2) showing the difference in adventitial and plaque K^{trans} and their intraclass correlation. (A) adventitial K^{trans} p=0.004, (B) plaque K^{trans} p=0.03, (C) intra class correlation ICC = 0.78.

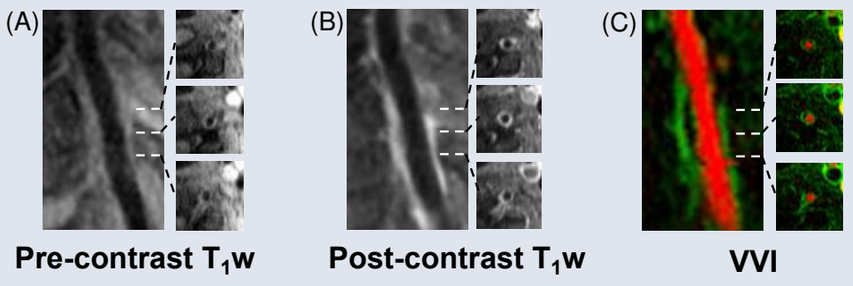

Figure III: Shows the oblique and axial reformat of pre and post contrast T_1w and Vasa Vasorum images(VVI).
(A) Pre contrast T_1 weighted image showing left vertebral artery stenosis and (B) shows post contrast (gadolinium) T_1w enhancement. (C) shows the K^{trans} (green channel) in VVI ranges from 0 to 1min-1, *Vp* (red channel) ranges from 0-100%.

Conclusions

Vertebral artery atheroma of patients with symptomatic carotid artery disease had increased neovessel permeability compared to the patients with asymptomatic carotid artery disease. These findings are consistent with the hypothesis that atherosclerosis is a systemic inflammatory disease. The vertebral artery atherosclerosis is likely to have increased severity of neovascularisation if another arterial territory is symptomatic in the same patient cohort.

References [1] Yuan, et al, MAGMA 2017

Conflict of Interest: None

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