

Whole brain arterial transit times in the elderly estimated using arterial spin labeling

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Rationale In order to use arterial spin labeling (ASL) as parameter for vascular or degenerative cerebral pathology, it is essential to define reference values in asymptomatic elderly. Arterial transit time is not only a major confounder in ASL, but is also a physiologic parameter of hemodynamic impairment and may provide valuable diagnostic information that is unavailable with cerebral blood flow (CBF) measurements alone.¹ To quantify transit time, Flow Encoding Arterial Spin Tagging (FEAST) has been proposed as a time-efficient alternative to multiple temporal measurements (multi-TI).² FEAST has demonstrated its ability in young volunteers to capture whole brain CBF and transit time within clinical scanning time.² In addition, it includes not only macro-vascular transit time but also micro-vascular transit time (δ). Therefore, it may also be sensitive to changes due to small vessel disease. The current study aims to evaluate δ estimated by FEAST in a large sample of healthy elderly.

Methods 186 community-dwelling elderly (46% male, aged 77.4 yrs (SD 2.5)) were drawn from the *pre-DIVA-M* study, a study investigating whether intensive vascular care can prevent or delay the onset of dementia.³ FEAST was added to the clinical scanning protocol on a 3.0T Philips Intera. FEAST parameters were: two consecutive GE-EPI pseudo-Continuous ASL scans, one without and one with vascular crushing (Venc, 5 cm/s; b, 0.6 s/mm²). Other parameters include: in-plane resolution, 64x64; 17 slices; FOV 24 cm²; TE/TR, 14/4000ms; background suppression; post-labeling delay (PLD), 1525 ms; NSA, 20 each scan; total scanning duration, 4 minutes. For quantification of CBF, a single compartment model was used with a fixed δ of 1500 ms. δ -maps were computed using the FEAST-equation with the ratio between crushed and uncrushed CBF as input.² We used standard vascular territory maps (*figure 1-d*) to investigate spatial variation between mean anterior (δ -ACA), middle (δ -MCA) and posterior δ (δ -PCA). A linear regression analysis was performed to estimate the influence of age and gender on δ (*table 1*).

Results The average whole brain GM uncrushed and crushed CBF were respectively 39.0 (SD 6.7) and 32.6 (SD 7.6) mL/100g/min. δ -ACA, δ -MCA, δ -PCA and whole brain δ were 1640 ms (SD 65), 1660 ms (SD 77), 1770 ms (SD 111) and 1680 ms (SD 80) respectively. δ -PCA was on average 110 ms (SD 5 ms, $p<0.01$) longer than δ -MCA, which was on average 19 ms (SD 4 ms, $p<0.01$) longer than δ -ACA. Increased δ (1700-1800 ms) were found in the watershed border regions (*figure 1-c*, transversal and coronal slice). Highest δ (1900-2000) were found cranially in the PCA vascular territory (*figure 1-c*, transversal and sagittal slice). Both age ($p=0.02$) and gender ($p<0.01$) were significantly correlated with δ (*table 1*).

Discussion Micro-vascular transit times can be measured in the elderly using FEAST within clinical scanning times. Our data confirm previously described spatial variation of δ .¹ Although substantial variation exists between subjects, δ show a consistent spatial pattern in this elderly population. Furthermore, these data show variation of δ with age and gender. Inter-gender differences seem as large as a difference of 10 years of age. In this population, a PLD of 1525 ms seems to retain sufficient crushed signal to noise ratio as well as a sufficient δ -range. If no δ -maps are available, the linear regression analyses parameters shown in *table 1* may provide an estimate with age and gender as input.

References

¹Chen, *Magn Reson Mater Phy* 2012

²Wang, *Magn Reson Med* 2003

³Richard, *Alzheimer Dis Assoc Disord* 2009

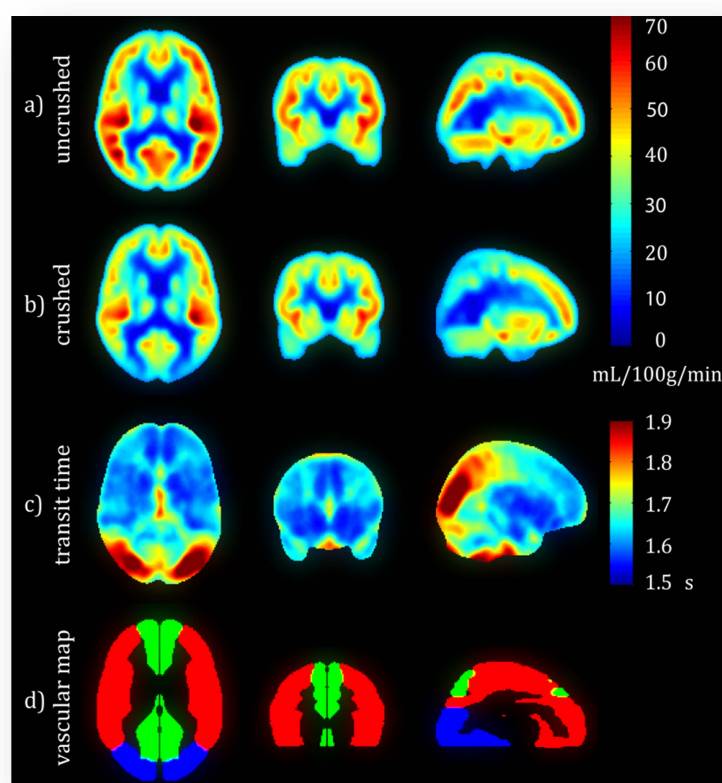


Figure 1 a-d shows transversal, coronal and sagittal slices of a) mean uncrushed and b) mean crushed cerebral blood flow maps (mL/100g/min), c) mean micro-vascular transit time (s) and d) vascular territory maps (green, red and blue representing anterior, middle and posterior vascular territory respectively).

		Intercept	Gender (M)	Age (yrs)
δ -ACA	(ms)	1290	46.0 ($p<0.01$)	5.48 ($p=0.03$)
δ -MCA	(ms)	1340	68.8 ($p<0.01$)	5.50 ($p=0.50$)
δ -PCA	(ms)	1200	90.0 ($p<0.01$)	9.16 ($p=0.02$)
Whole brain δ	(ms)	1280	68.2 ($p<0.01$)	6.72 ($p=0.02$)

Table 1 summarizes regression coefficients for estimation of micro-vascular transit time (δ) with age and gender (n=186). δ -ACA, δ -MCA and δ -PCA refer to the mean δ of the corresponding vascular territory map as shown in *figure 1-d*.