ADNI3 ASL

UCSF

April 2019

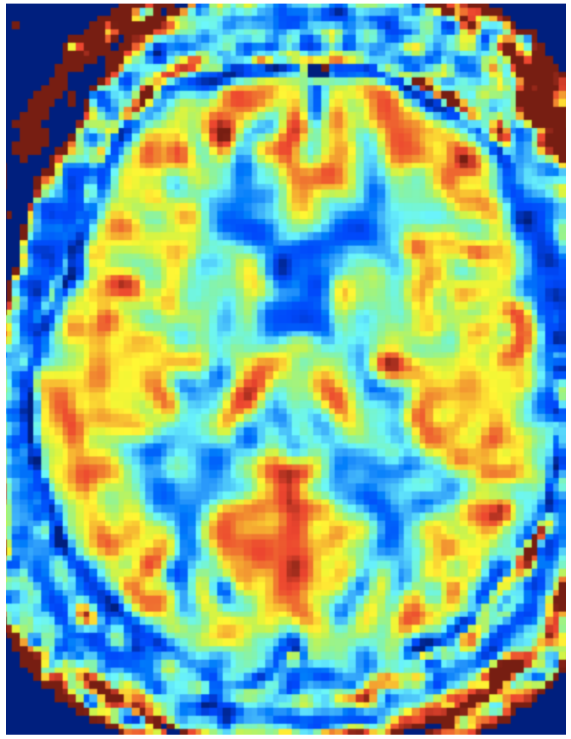
GE ADNI3 ASL flavor

3D PCASL

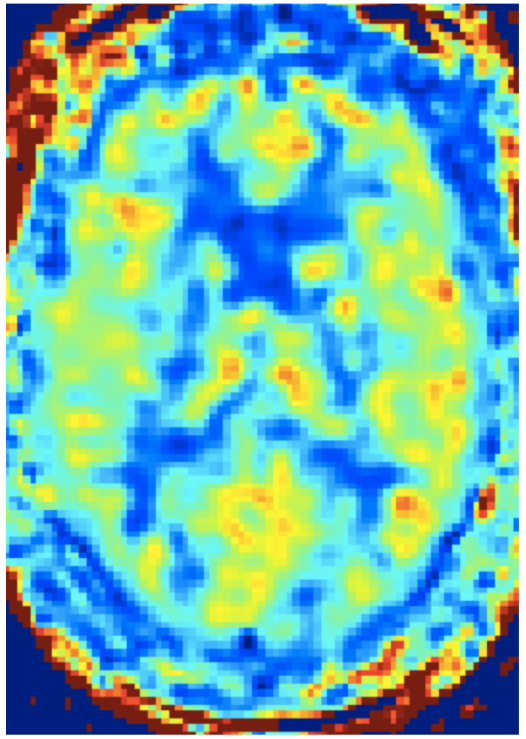
- Labeling time=1.5s
- PLD=2.025s
- Labeling plane offset=8cm
- 3D-PCASL data with
  - TR/TE=4.888s/10.528ms
  - FOV=240x240mm^2
  - matrix size=128x128
  - voxel size=1.875x1.875x4 mm^3
- 40 label-control pairs acquired
- Only vendor estimated CBF map available
- A separate M0 image without any magnetization preparation

CBF quantification in *ml/100g/min*: GE 3D PCASL

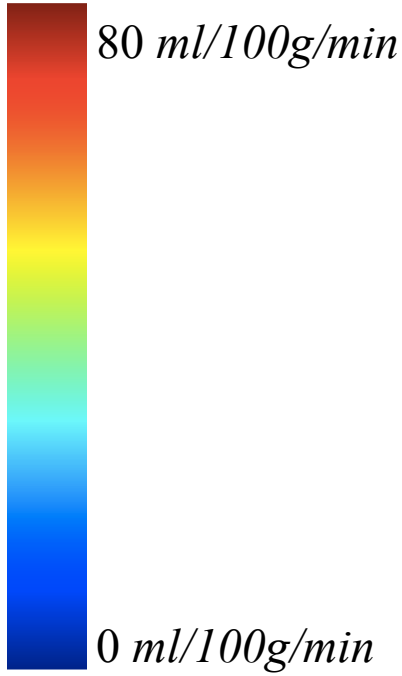
- qCBF = (CBF × 125) / M_0



72y Female, CN



72y Male, MCI



Philips ADNI3 ASL flavors

2D PASL on Philips SW version < 5.3 (scan time 5:10)	**3D PCASL Philips SW v5.3**

• TI/TI_1=2.0s/700ms for accurate bolus definition
• 2D EPI readout with
  • TR/TE=5s/16ms
  • FOV=192x192mm^2
  • matrix size=64x64
  • in plane resolution=3x3mm^2
  • bandwidth=1794 Hz/px
• 40 slices of 4mm-thickness
• 30 label-control pairs (except couple sites)
• No separate M_0 image
	• COMING SOON…

Siemens ADNI3 ASL flavors

2D PASL (scan time 6:02)	3D PASL before ~mid 2017 (scan time 2:45)	3D PASL after mid 2017 (scan time 5:25)

• TI/TI_1=1.9s/700ms for accurate bolus definition
• 2D EPI readout with
  • TR/TE=3.4s/13ms
  • FOV=256x256mm^2
  • matrix size=64x64
  • in plane resolution=4x4mm^2
  • bandwidth=2368 Hz/px
• 24 slices of 4mm-thickness
• 52 label-control pairs
• A separate M_0 image
• Interleaved/ascending
	• TI/TI_1=2.0s/800ms for accurate bolus definition
	• 2D EPI readout with
	  • TR/TE=5s/16ms
	  • FOV=192x192mm^2
	  • matrix size=64x64
	  • in plane resolution=3x3mm^2
	  • bandwidth=2604 Hz/px
	• 40 slices of 4mm-thickness
	• 1 label-control pairs
	• No separate M_0 image
	• DISCOUNTINED!
		• TI/TI_1=2.0s/800ms for accurate bolus definition
		• 2D EPI readout with
		  • TR/TE=4s/20ms
		  • FOV=240x240mm^2
		  • matrix size=64x64
		  • in plane resolution=3.8x3.8mm^2 (interpolated in plane to 1.875mm)
		  • bandwidth=2442 Hz/px
		• 32 slices of 4.5mm-thickness 10 label-control pairs
		• No separate M_0 image

Head-motion correction (Philips and Siemens ASL flavors)

- Estimate a 6-parameter rigid-body transformation for each volume to align it to the first volume of the series
- Regress out the spurious motion component caused by systematic label/control switching from the estimated parameters before applying the transformation to the volumes.

Joint processing with structural MRI

- Coregister the mean control images to the high-resolution T1 images
- Apply the resulting transformations to the corresponding label and control images
- Segment T1 images into GM/WM/CSF tissue probability maps (TPM)
- GM and WM TPMs
  - smoothed by an isotropic Gaussian kernel with FWHM=6mm
  - thresholded at 0.75 to construct binary masks → GM and WM CBF ROIs
  - threshold the sum of smoothed GM and WM TPMs at 0.75 → whole-brain CBF mask
- Spatial normalize T1 images to MNI space
- FreeSurfer v6.0 cortical and subcortical parcellation in native T1 image space

CBF quantification in *ml/100g/min* – 2D/3D PASL

2D PASL:	3D PASL
• $\frac{60x100\lambda\Delta M e^{\omega/T_{1,blood}}}{2\alpha\tau M_0}$ • ΔM control-label difference • Brain/blood partition coefficient λ=λ_{mean}=0.9 ml/g (mean for GM and WM) • Post labeling delay (PLD) ω = TI • $T_{1,blood}$=1650ms (at 3T) • Labeling (tagging) efficiency $\alpha = 0.98$ • Equilibrium magnetization M_0 (= mean control images) smoothed using a 6mm isotropic kernel • Labeling duration τ = TI_1 • Slice time correction	• $\frac{60x100\lambda\Delta M e^{\omega/T_{1,blood}}}{2\alpha\tau M_0}$ • α = 0.85 • No slice time correction

Post correction factors

- To account for incomplete T1 recovery
  - TR is <5 s for M_0/PD
  - only for 2D acquisitions

$$\left(1 - e^{-TR/T_{1,tissue}}\right)$$

- T2*/T2 decay
  - for 2D acquisitions

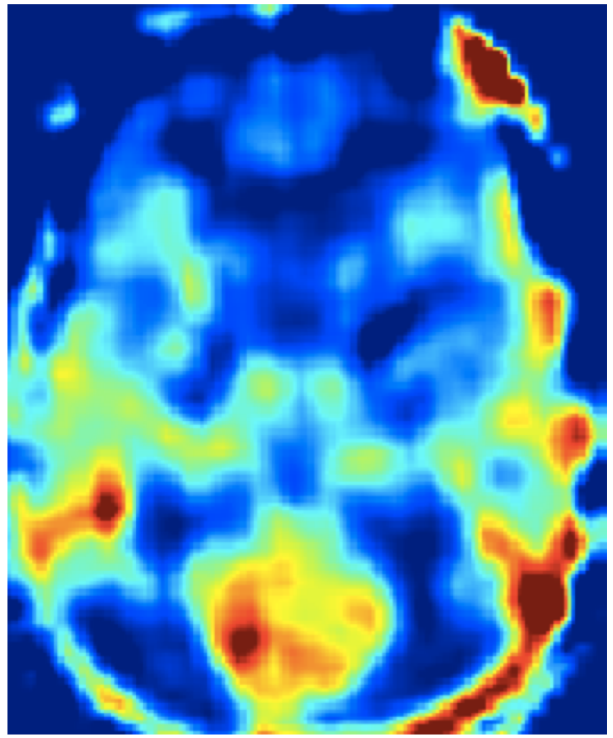
$$\frac{\lambda_{tissue}}{\lambda_{mean}} \times \frac{e^{TE/T^*_{2,blood}}}{e^{TE/T^*_{2,tissue}}}$$

  - for 3D acquisitions

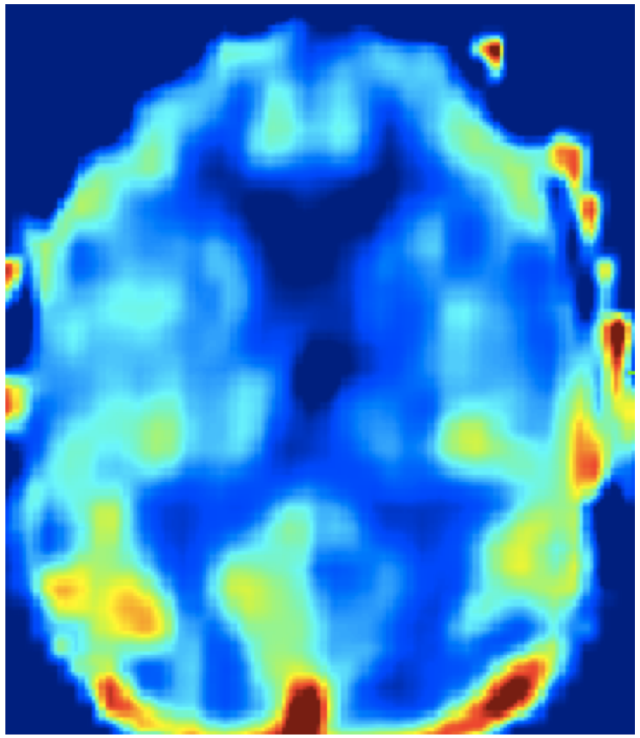
$$\frac{\lambda_{tissue}}{\lambda_{mean}} \times \frac{e^{TE/T_{2,blood}}}{e^{TE/T_{2,tissue}}}$$

	GM	**WM**	**Blood**
$\mathbf{T_1}$	1331ms	832ms	
$\mathbf{T_2}$	80ms	110ms	186ms
$\mathbf{T_2^*}$	44.2ms	44.7ms	43.6ms
$\boldsymbol{\lambda}$	0.98	0.82	

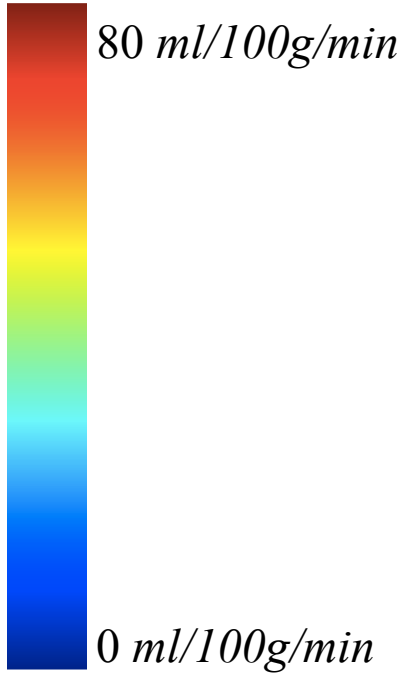
qCBF: 2D PASL



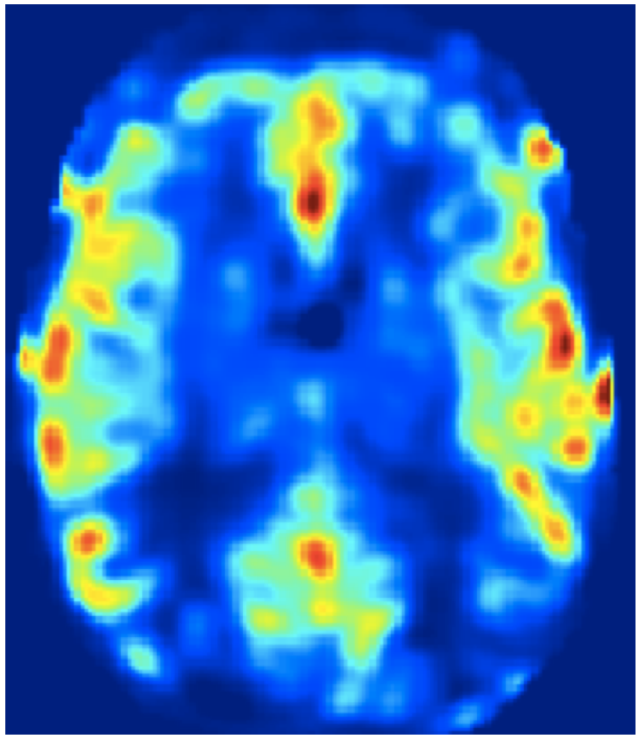
75y Male, CN



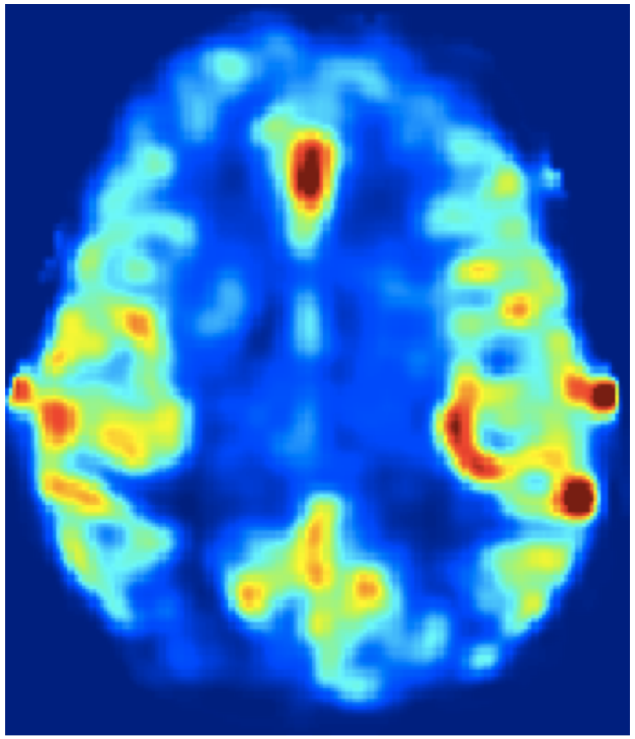
72y Male, MCI



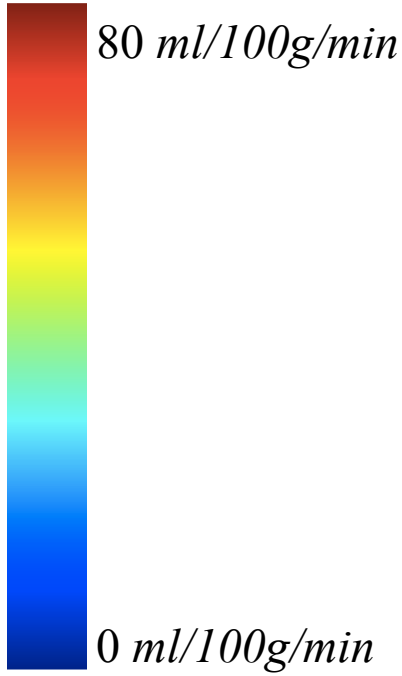
qCBF: 3D PASL



75y Male, CN



72y Male, MCI



Current cohort

		Philips 2D PASL	Siemens 2D PASL	Siemens 3D PASL	GE 3D PCASL
N	CN	82	64	108	93
	MCI	59	37	61	60
	AD	20	4	18	20
Age	CN	74.90 ± 7.65	70.42 ± 7.06	72.92 ± 7.14	72.79 ± 7.21
	MCI	74.15 ± 7.56	74.24 ± 8.98	77.05 ± 8.43	76.19 ± 7.55
	AD	80.80 ± 7.99	69.15 ± 5.86	76.81 ± 9.36	74.71 ± 7.25
F %	CN	54%	72%	58%	55%
	MCI	25%	43%	38%	43%
	AD	65%	75%	61%	20%

Temporal signal-to-noise ratio (tSNR)

	Philips 2D PASL	Siemens 2D PASL	Siemens 3D PASL
CN	7.55 ± 1.74	4.49 ± 1.04	20.24 ± 5.50
MCI	7.32 ± 1.76	5.01 ± 1.35	19.57 ± 7.77
AD	7.86 ± 1.27	3.98 ± 0.95	19.98 ± 6.89
Total	7.52 ± 1.65	4.63 ± 1.16	20.02 ± 6.29

Gray Matter to White Matter Contrast Ratio

	Philips 2D PASL	Siemens 2D PASL	Siemens 3D PASL	GE 3D PCASL
CN	0.82 ± 1.02	1.53 ± 0.45	1.53 ± 0.17	1.20 ± 0.10
MCI	1.25 ± 0.77	1.52 ± 0.37	1.60 ± 0.21	1.16 ± 0.08
AD	1.68 ± 0.46	1.38 ± 0.17	1.67 ± 0.20	1.17 ± 0.05
Total	1.06 ± 0.93	1.52 ± 0.42	1.56 ± 0.19	1.19 ± 0.09

Global CBF

	Philips 2D PASL	Siemens 2D PASL	Siemens 3D PASL	GE 3D PCASL
CN	36.96 ± 7.95	23.46 ± 9.00	24.24 ± 6.14	39.27 ± 8.95
MCI	34.22 ± 5.96	25.10 ± 7.51	22.57 ± 6.40	33.24 ± 8.82
AD	23.18 ± 7.95	21.20 ± 3.64	20.53 ± 7.90	28.48 ± 8.95
Total	29.36 ± 7.65	23.83 ± 8.43	23.62 ± 6.27	36.76 ± 9.71

Sensitivity to differentiate MCI patients from controls (adjusted for age and gender differences)

	Philips 2D PASL	Siemens 2D PASL	Siemens 3D PASL	GE 3D PCASL
PCC	0.12	0.33	0.92	0.46
Precuneus	0.38	0.43	0.56	0.44
Hippocampus	0.22	0.73	1.19	0.92