

Impact of tissue T_1 on perfusion measurement obtained with ASL

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GIN5/Bruker

Wednesday, 12 December 2012

Introduction:

Issue:

Some **pathologies** \Rightarrow change of T_1

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In literature: **equation** of CBF quantification in ASL
with and without T_1 map



So, what is the effect of tissue T_1 on the
quantitative measurement of **CBF** in ASL?

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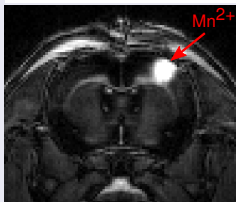
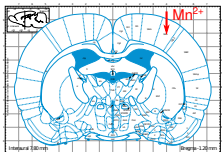
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So, what is the effect of tissue T_1 on the quantitative measurement of **CBF** in ASL?

Materials and methods: Manganese

Injection of manganese

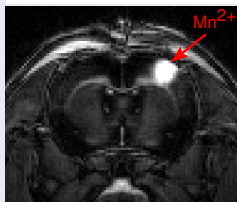
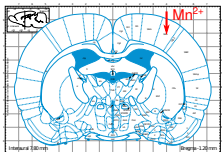


- Intra-cerebral injection: **cortex S1**
- **Isofluorane** anesthesia
- **Stereotactic** frame
- **cannula** diameter $150\mu\text{m}$
- 80nl of 100mM : **non toxic** [Canals et al., 2008]
- Injection **speed**: $8\text{nl}/\text{min}$
- 5 **control** rats & 5 **Mn injected** rats
- Control: Tris-HCl
- Injected: Tris-HCl + Mn^{2+}
- MRI **6hours** after injection
- Images are **positioned** within 1 or 2mm of the injection point



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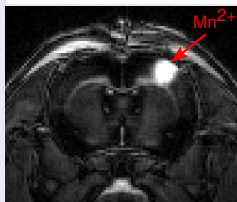
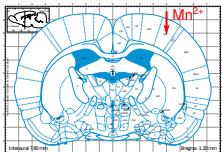


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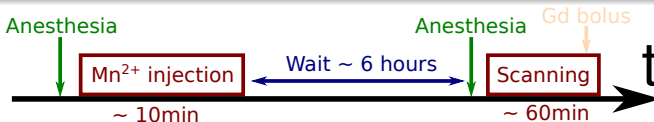


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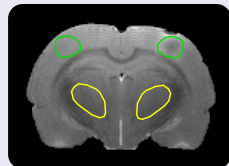
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Materials and methods: MRI sequences

MRI facility

- Bruker horizontal magnet (Avance III)
- $B_0 = 7T$
- Volume transmit & surface receive coil configuration



CASL

- ASL module: CASL
 - Global 2nd order shim
 - labeling time: 4s
 - Post-labeling time 200ms
- Image acquisition: SE-EPI
 - $TR/TE = 5s/17.2ms$
 - $Voxel = 0.234mm \times 0.234mm \times 1mm$

First passage: Gd bolus

Image acquisition: GE-EPI

- $TR/TE = 250ms/15ms$
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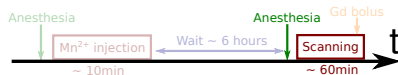
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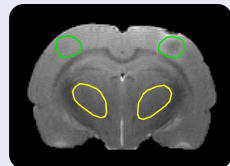
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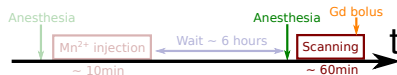
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Materials and methods: Quantification techniques

Two classic methods inspired and commonly found in the [literature](#):

CASL

- Without T_1^{app} map:

$$CBF^{wo} = \frac{\Delta M \lambda \exp(\omega/T_1^b)}{2\alpha M_0 T_1^b} [1 - \exp(-\tau/T_1^b)]^{-1}$$

[Buxton et al., 1998] [Wang et al., 2002] [Wang et al., 2008] ...

- With T_1^{app} map:

$$CBF^w = \frac{\Delta M \lambda}{2\alpha M_0 T_1^{app}}$$

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Parameters

- $\lambda = 0.9 \text{ g/ml}$
- $\alpha = 0.84$
- $\omega = 200 \text{ ms}$
- $T_1^b = 2100 \text{ ms}$
- $\tau = 4 \text{ s}$
- M_0 :
approximated to control image
- T_1^{app} : measured by inversion recovery (18 TI)

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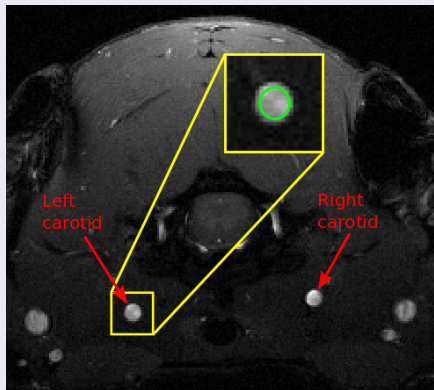
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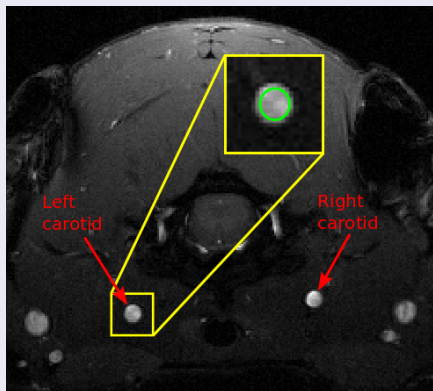
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Inversion efficiency: CASL



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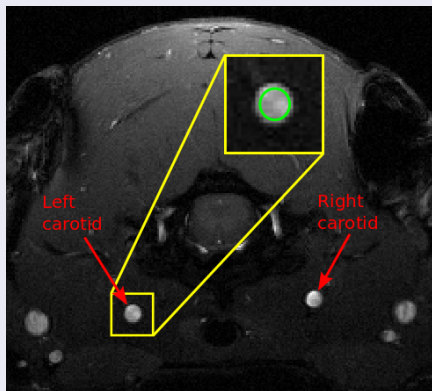
Inversion efficiency: CASL



$$\alpha = \frac{M_a^0 - M_a}{2M_a^0}$$

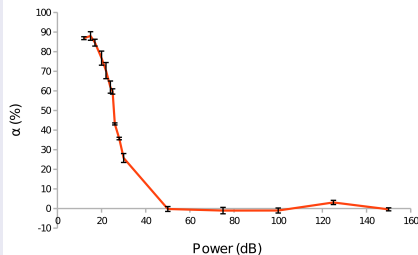
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$$\alpha = \frac{M_a^0 - M_a}{2M_a^0}$$

Inversion efficiency as function of power



Materials and methods: Quantification techniques

Gd bolus: gamma variate function

$$c(t) = K(t - T_0)^\alpha \exp\left(-\frac{t - T_0}{\beta}\right)$$

$$MTT = \beta(\alpha + 1)$$

Adjustable parameters: K , T_0 , α , β [THOMPSON et al., 1964]

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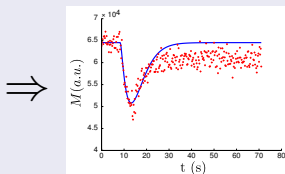
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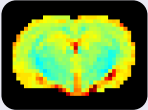
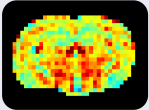
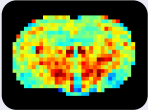
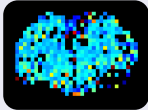
Example



- Intra-venous injection in **caudal vein**
- Injection at 15 ml/min with Harvard **pump**
- **Fitting** pixel by pixel

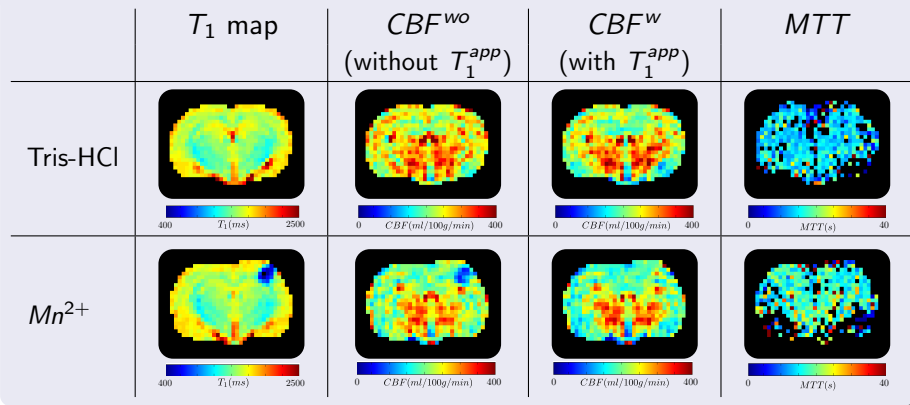
Results: Images

Quantification of CBF:

	T_1 map	CBF^{wo} (without T_1^{app})	CBF^w (with T_1^{app})	MTT
Tris-HCl	 <p>400 T_1(ms) 2500</p>	 <p>0 CBF(ml/100g/min) 400</p>	 <p>0 CBF(ml/100g/min) 400</p>	 <p>0 MTT(s) 40</p>
Mn^{2+}				

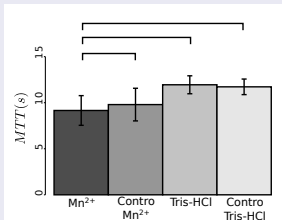
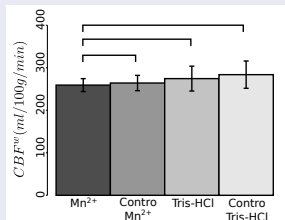
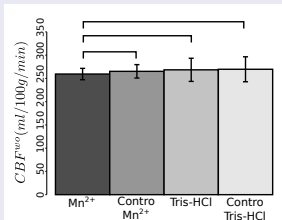
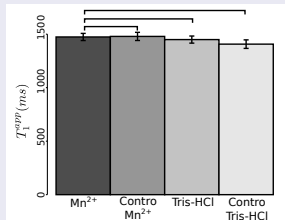
Results: Images

Quantification of CBF:



Results: Value

THALAMUS



- Wilcoxon

rank sum test

*: $p < 0.05$ **: $p < 0.01$

- Error bar

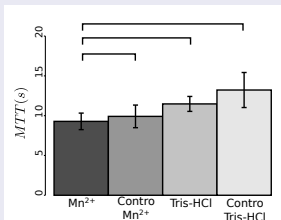
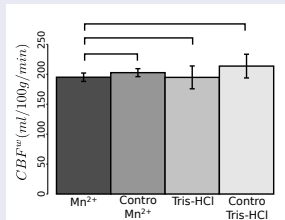
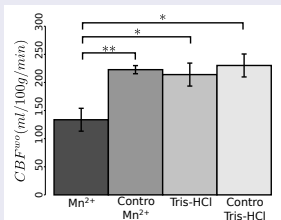
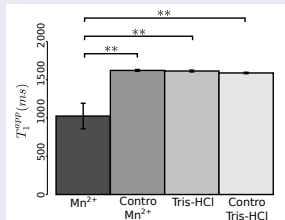


Standard error

of the mean

Results: Value

CORTEX



● Wilcoxon

rank sum test

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Standard error

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Discussion:

Conclusion: Mn^{2+} Injection ~~⇒~~ ↗ or ↘ of CBF because → MTT

HOWEVER

 Mn^{2+} ⇒ ↘ T_1

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 Mn^{2+} IS tool to study impact of T_1

Conclusion: Quantification

Significant effect of T_1 on CBF if ~~T_1 map~~

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Corrected if equation with T_1 map

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