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dkfz. GERMAN CANCER RESEARCH CENTER IN THE HELMHOLTZ ASSOCIATION

The Complex Signal in MRI

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Complex Spinecho – Signal

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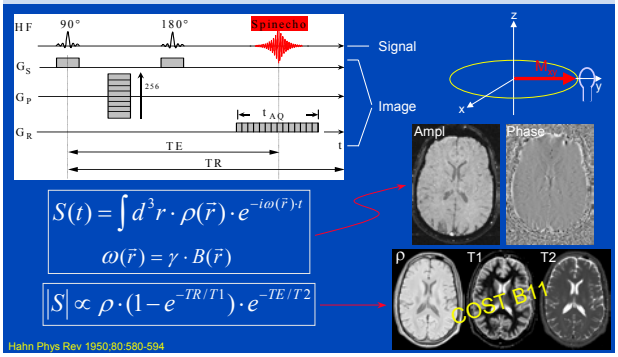

$$S(t) = \int d^3r \cdot \rho(\vec{r}) \cdot e^{-i\omega(\vec{r})\cdot t}$$

$$\omega(\vec{r}) = \gamma \cdot B(\vec{r})$$

$$|S| \propto \rho \cdot (1 - e^{-TR/T1}) \cdot e^{-TE/T2}$$

Hahn Phys Rev 1950;80:580-594

Oxygenation: BOLD Contrast

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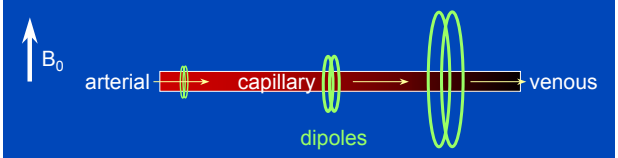
- BOLD: Blood Oxygen Level Dependent Contrast



magnetic properties of hemoglobin:
oxygenated - diamagnetic
deoxygenated - paramagnetic

$$\frac{1}{T_2^*} \sim \Delta B_{loc}$$

Ogawa et al. Proc Natl Acad Sci 1987,9868-9872

Oxygenation: Functional MRI

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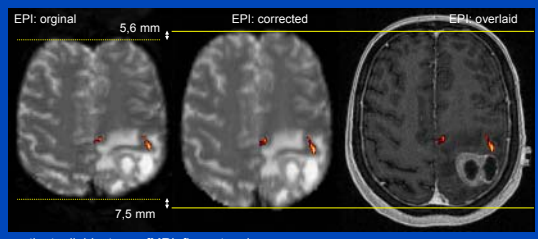
- Definition of Functional Structures at Risk



patient: glioblastoma, fMRI: finger tapping

Schad et al. Eur Radiol 1996,6(1):38-45

Oxygenation: BOLD & Carbogen

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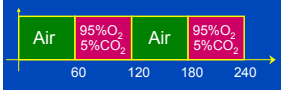
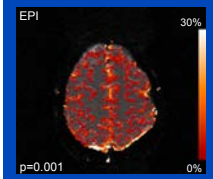
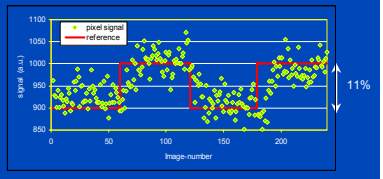
- FLOOD: Flow and Oxygenation Dependent Contrast



EPI-images [3 sec]

- air- / carbogen breathing
- CO_2 acts as vasodilator





Howe et al. MRI 1999,17:1307-1318

Oxygenation: Brain Tumors

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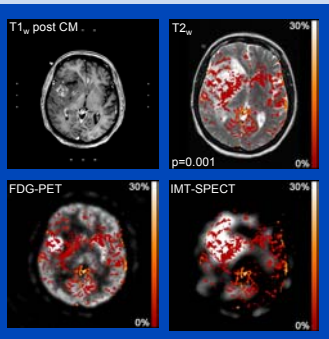

patient: astrozytoma III

FLOOD open questions:

- correlation to tumor angiogenesis ?
- consequence for dose calculation ?

Bongers et al. MAGMA 2002;15(1):297

Oxygenation: OEF Quantification

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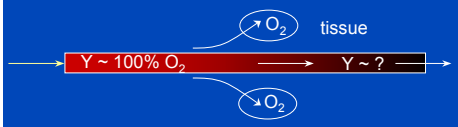
- Determination of Oxygen Extraction Fraction (OEF, in %)



How much of the delivered O_2 is used by the tissue ?

$$OEF = \frac{R_2'}{\lambda} \cdot \frac{3}{4}\left(\pi\gamma B_0 \cdot Hct \cdot \Delta\chi_{OxDeox}\right)^{-1}$$

Two „unknowns" to determine : R_2' and λ

R_2' : relaxation rate
λ : relative blood volume [%]
Hct : hematocrit value
$\Delta\chi_{OxDeox}$: susceptibility difference

Yablonskiy et al. MRM 1994;32:749-763

Oxygenation: OEF Measuring Technique

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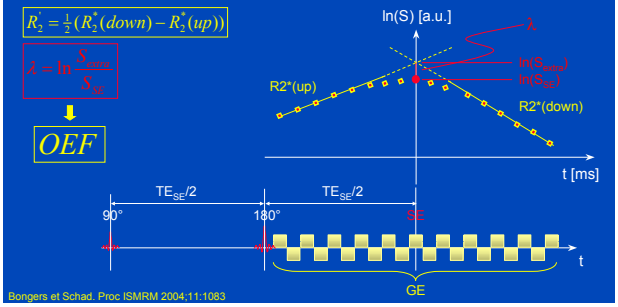
- Combined Gradientecho / Spinecho Sequence

$$R_2' = \frac{1}{2}\left(R_2^*(down) - R_2^*(up)\right)$$

$$\lambda = \ln\frac{S_{ZERO}}{S_{SE}}$$

$$OEF$$



Bongers et Schad. Proc ISMRM 2004;11:1083

Oxygenation: OEF Parameter Maps

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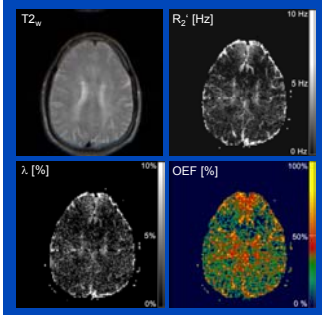

Gradientecho / Spinecho Technique
at 1.5 Tesla

TR = 1000 ms, FOV = 220 mm
25 gradient echoes, TE_{GE} = 4 ms
TE_{SE} = 118 ms, BW = 500 Hz/pixel
T_{acq} = 18 min

	mean	std. dev.
$R2'$	2.3 Hz	2.2 Hz
λ	3.4 %	2.9 %
OEF_{Brain}	43 %	23 %
OEF_{GM}	50-55 %	15 %

Bongers Dissertation 2004, Heidelberg

Thanks to ...

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Falko Lohberger	RPT-Lung	Jurek Maßner	HF-Pulses

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