Klinikum rechts der Isar
Technische Universität München

1108

Effective oxygen diffusivity mapping with multiparametric quantitative BOLD and pCASL: Comparison between healthy young and elderly subjects

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Live Parallel Q&A Session

Thursday Parallel 4
Probing Physiology with fMRI
Thursday, 13 August 2020
14:20 - 15:05 UTC

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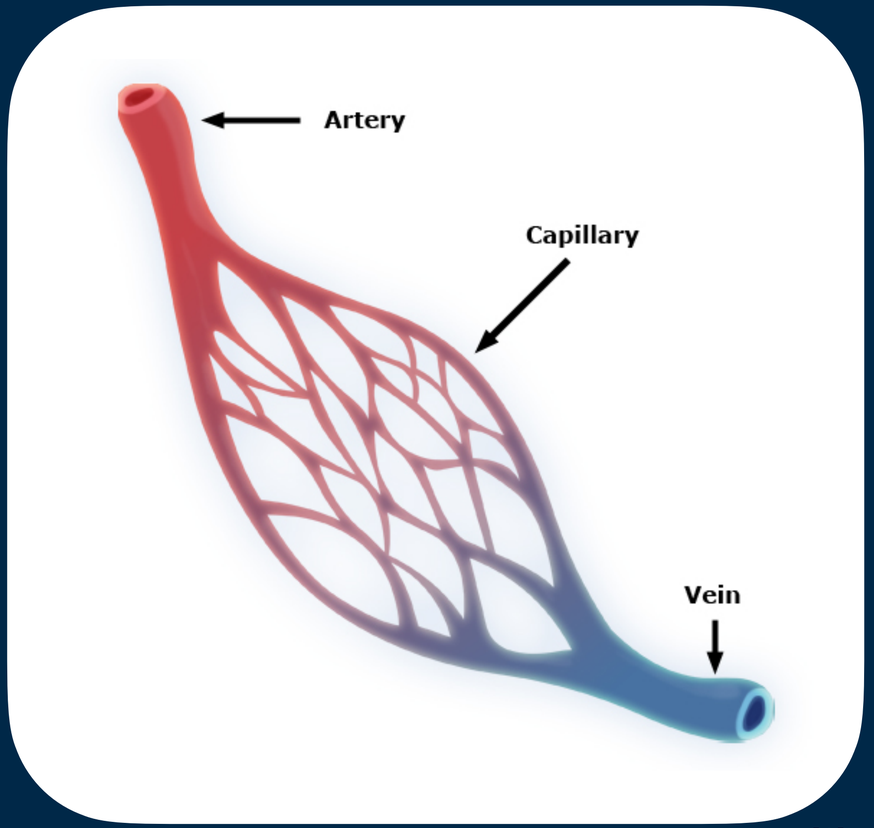
Declaration of Financial Interests or Relationships

Speaker Name: Jan Kufer

I have no financial interests or relationships to disclose with regard to the subject matter of this presentation.

Background and Motivation

- Variable effective oxygen diffusivity (EOD) regulates capillary O_2 transport[2]
- Capillary transit time heterogeneity (CTH) potential underlying mechanism[3]
- Investigate normal aging effects of EOD and CTH
- Novel easily applicable MR approach with mqBOLD and pCASL



[1]

[1]CERT. „Capillary system“ (http://www.citizencorps.gov/cert/IS317/medops/medops/ic_04_02_0091.htm) [2]Hyder et al. (1998) Journal of Applied Physiology **85(**2): 554-564
[3]Rasmussen et al. (2015) J Cereb Blood Flow Metab **35**(3): 432-442

Methods: Participants

MRI

Philips 3T Ingenia | R 5.1.8 | Custom Patches | C-DAS | 32 channel head coil | 16 channel head-neck coil

PET

Elderly healthy subjects (EHS)

- 30 healthy subjects
- 14 male / 16 female
- mean age 70.3 ± 7.3 years

EOD ⟷ CTH

Young healthy subjects (YHS)

- 16 healthy subjects
- 8 male / 8 female
- mean age 29.5 ± 5.9 years

EOD ⟷

Young healthy subjects (YHS)

- 13 male healthy subjects from another study[4]
- mean age 26.1 ± 3.8 years

[4]Hyder et al. (2016) J Cereb Blood Flow Metab **36**(5): 903-916

Methods: MR Imaging protocol

MP-RAGE	DSC	T_2* GRE	T_2 GraSE	pCASL
1x1x1 mm³, TE=4 ms, TR=9 ms, TI=1000 ms, α=8°, 5:59 min	*GE-EPI, 2x2x3.5 mm³, TE=30 ms, TR=1.5 s, α=60°, 80 dyn, 2:01 min, 15 ml* Gd-DOTA bolus-injection, 4ml/s * 7.5 ml in YHS*	*2x2x3 mm³, 30 slices, 12 echoes, TE_1=ΔTE=5 ms, TR=1950 ms, α=30°, 6:08 min*	*2D GraSE, 2x2x3 mm³, 30 slices, 8 echoes, TE_1 = ΔTE=16 ms, TR=8596 ms, 2:23 min * 3D-T_2 was used in YHS*	*segm. 3D GraSE, 2.7x2.8x6 mm³, TE=7.4ms, TR=4403ms, 16 slices, label 1800 ms, delay 2000 ms, 3 dyn, PDw, 5:43 min * * 2D pCASL was used where 3D pCASL was not available*

T_2* → $R_2' = \frac{1}{T_2*} - \frac{1}{T_2}$ ← T_2

CTH [6] → rCBV → $rOEF \propto \frac{R_2'}{rCBV}$ ← CBF

rOEF normalization

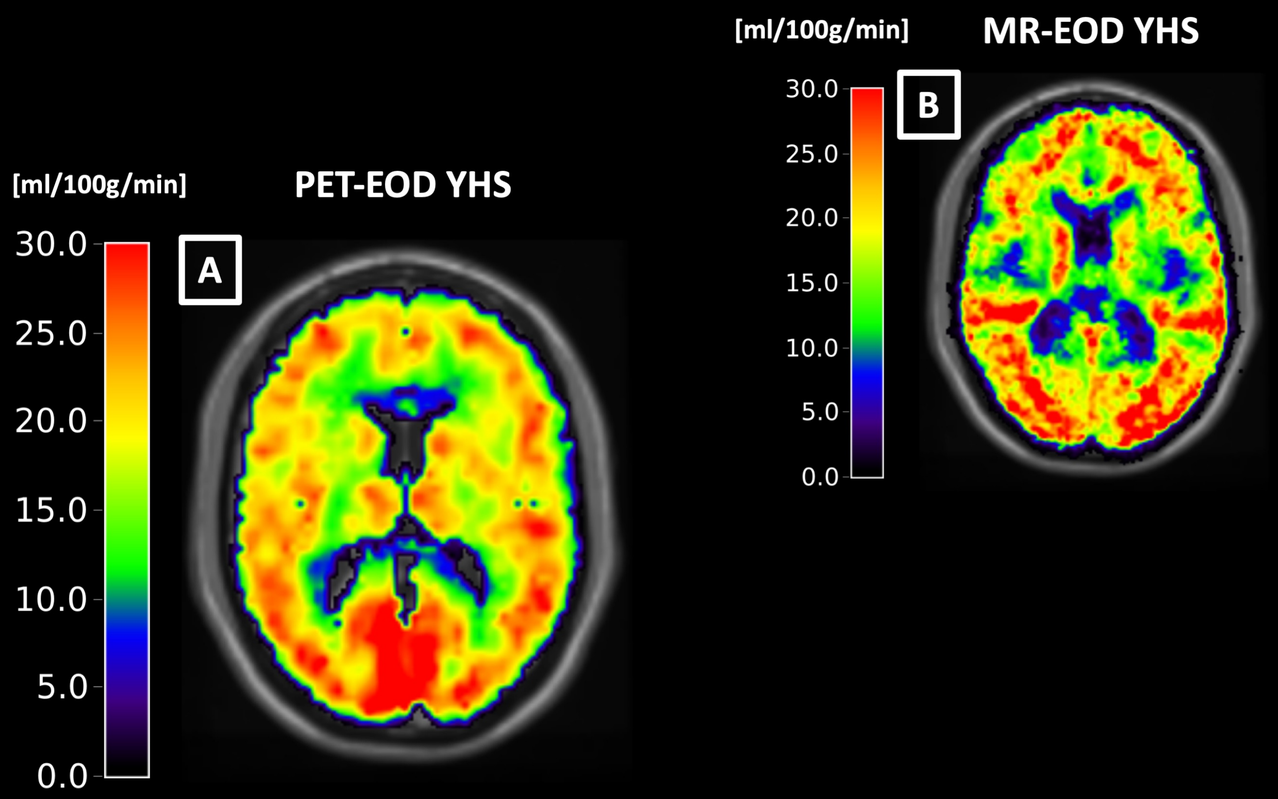
$EOD = CBF \times \ln\left(\frac{1}{1-OEF}\right)$

PET-EOD modelled from $[^{15}O_2]$-water and oxygen PET for CBF and $CMRO_2$

modified from [5]

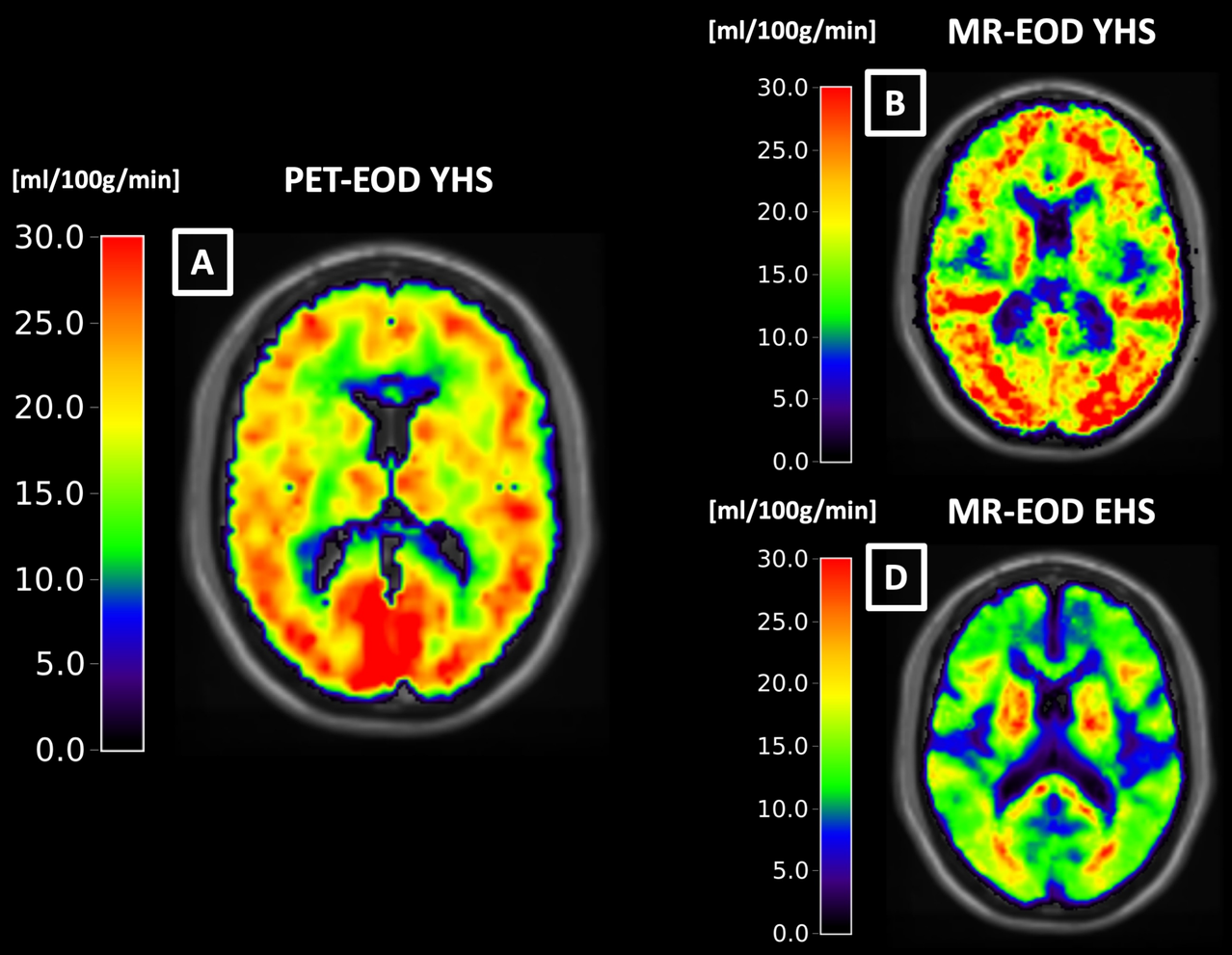
[5]Mark Dow. „3D representation of Brodmann areas“ (http://lcni.uoregon.edu/~dow/Space_software/renderings.html) [6]Mouridsen et al. (2014) J Cereb Blood Flow Metab **34(**9): 1511- 1521

Results: Representative slices of mean parameter maps



Images depicted by Vinci software, Max-Planck-Institute for Neurological Research, Cologne, Germany

Results: Representative slices of mean parameter maps



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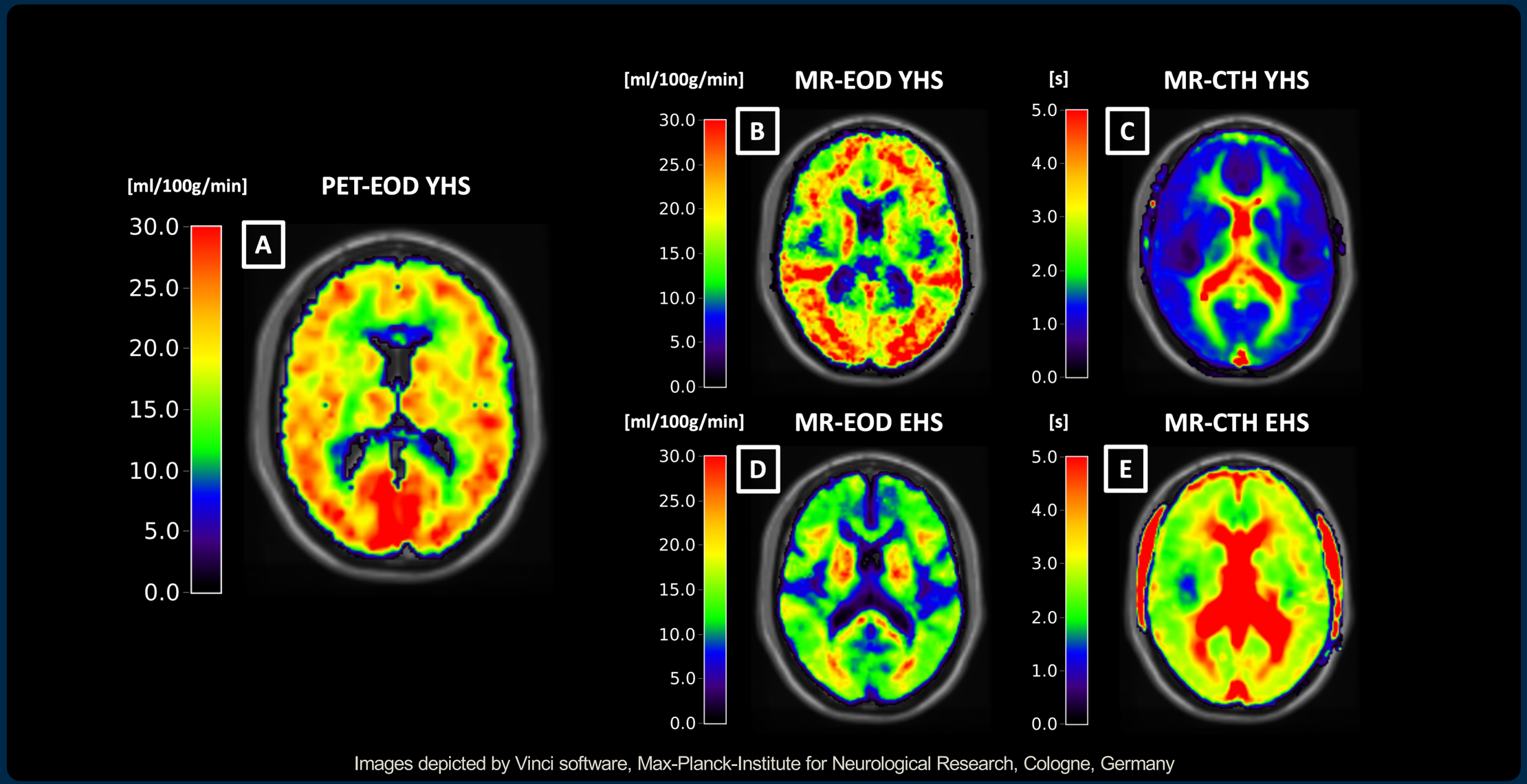
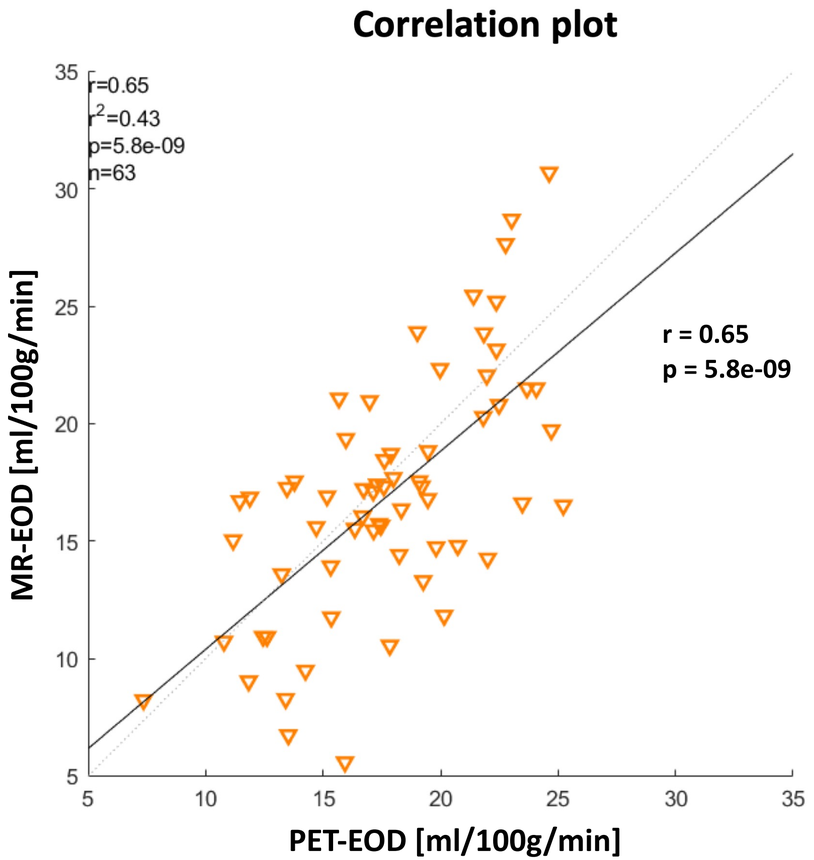
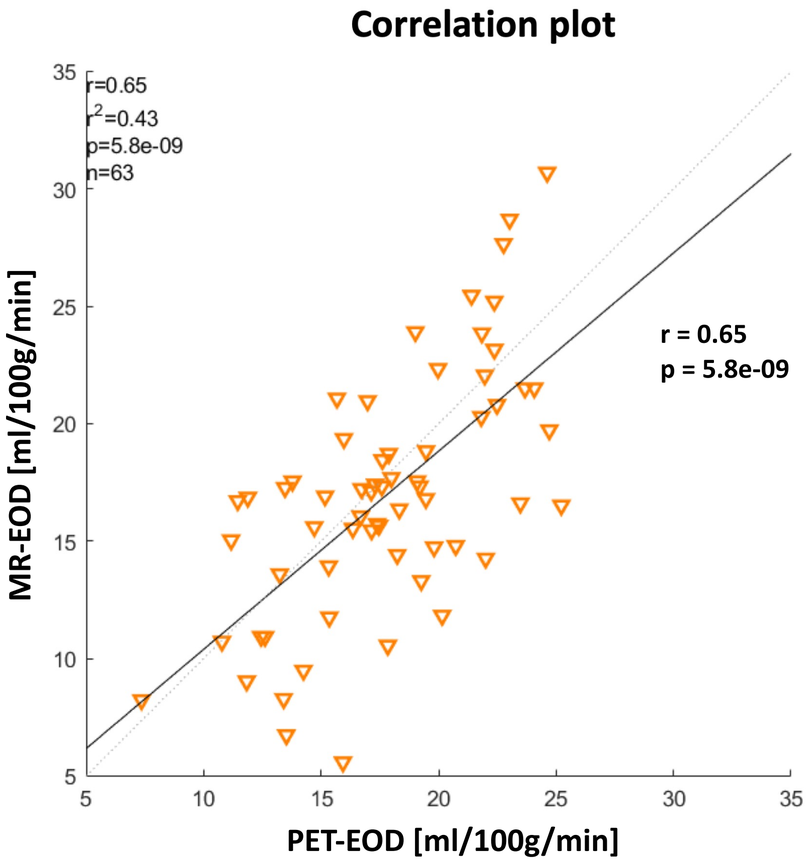


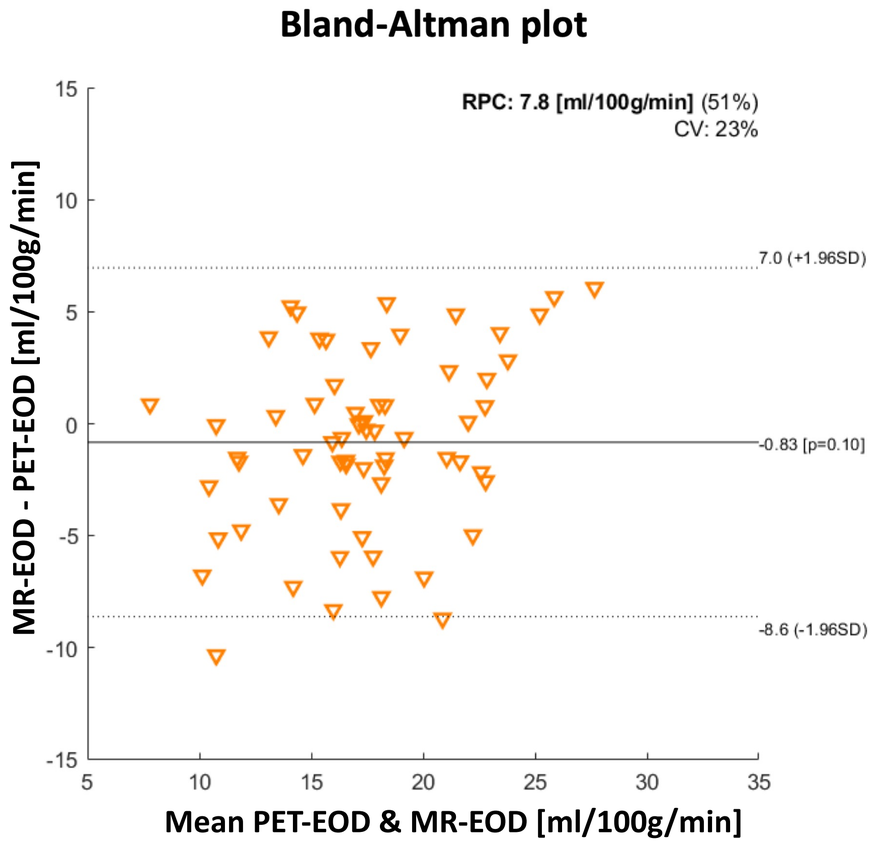
Results: Regional Agreement of PET & MR EOD in YHS



Plot created using: Ran Klein (2020). Bland-Altman and Correlation Plot (https://www.mathworks.com/matlabcentral/fileexchange/45049-bland-altman-and-correlation-plot), MATLAB Central File Exchange.

Results: Regional Agreement of PET & MR EOD in YHS





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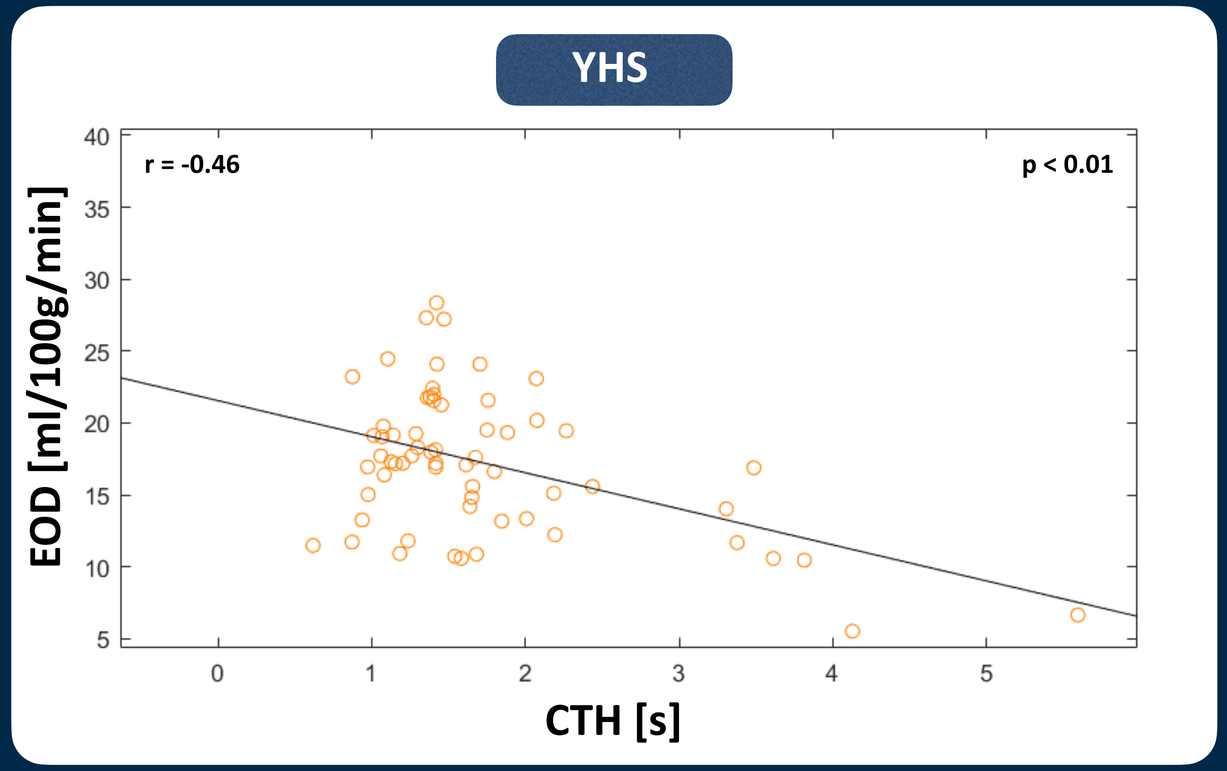
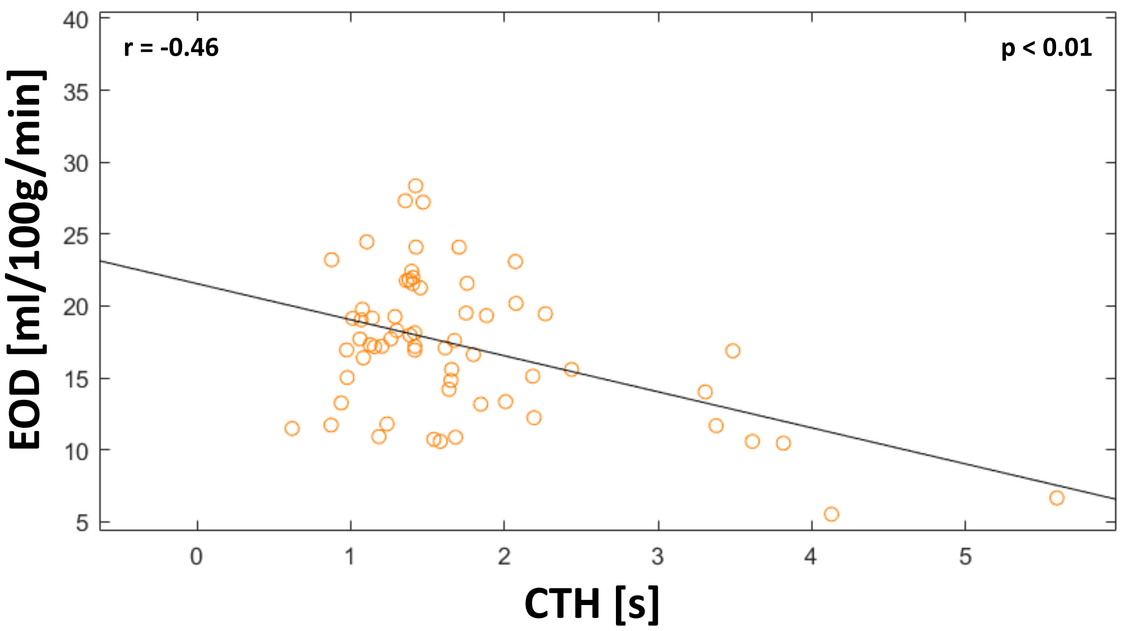
Results: Correlation of EOD and CTH in YHS and EHS



- Negative correlation of EOD and CTH (r = -0.46)
- CTH varies more strongly across brain regions

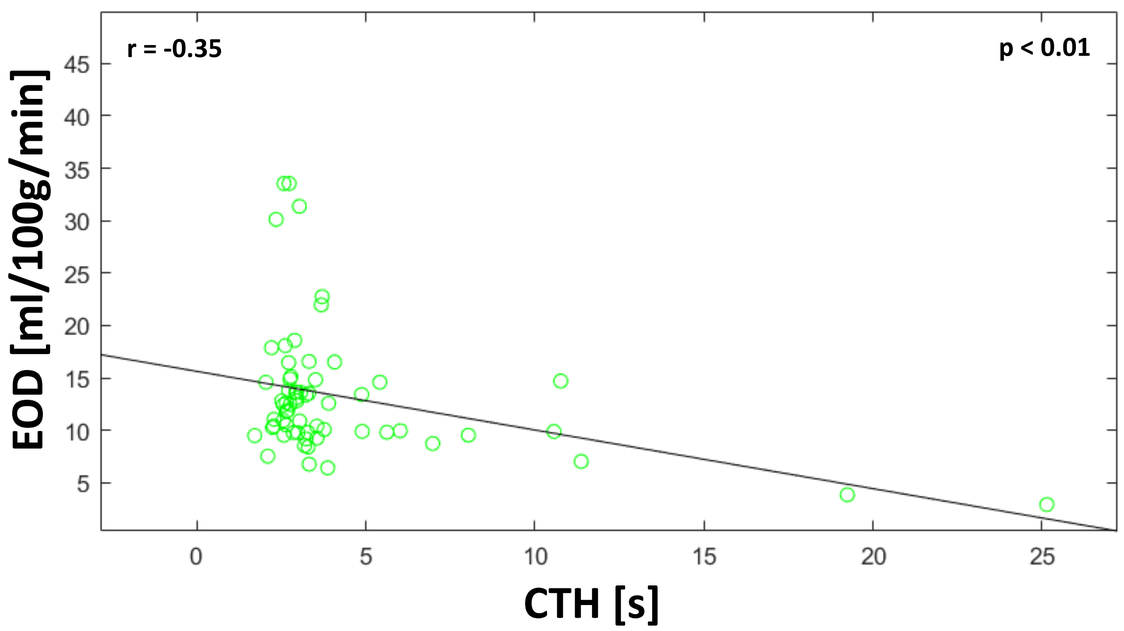
Results: Correlation of EOD and CTH in YHS and EHS

YHS



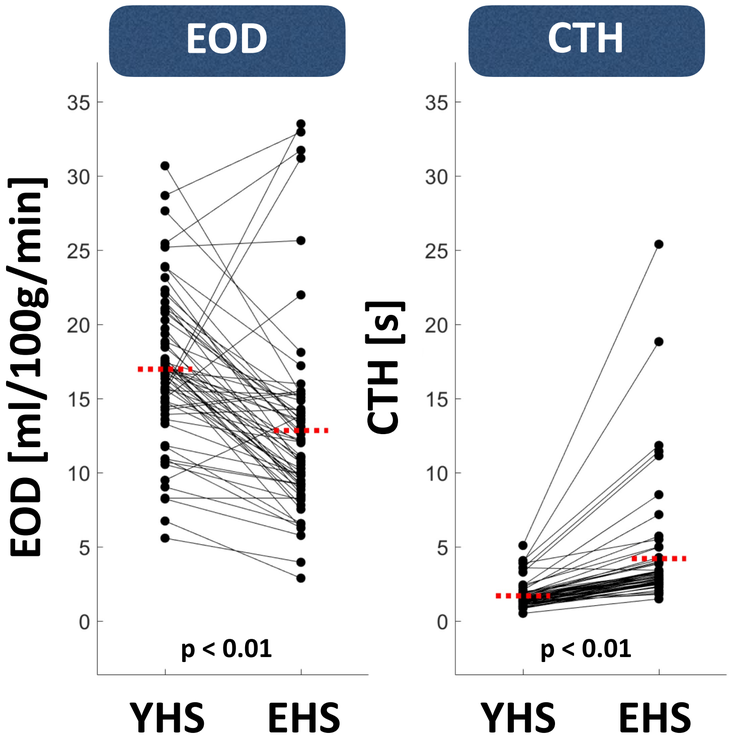
- Negative correlation of EOD and CTH (r = -0.46)
- CTH varies more strongly across brain regions

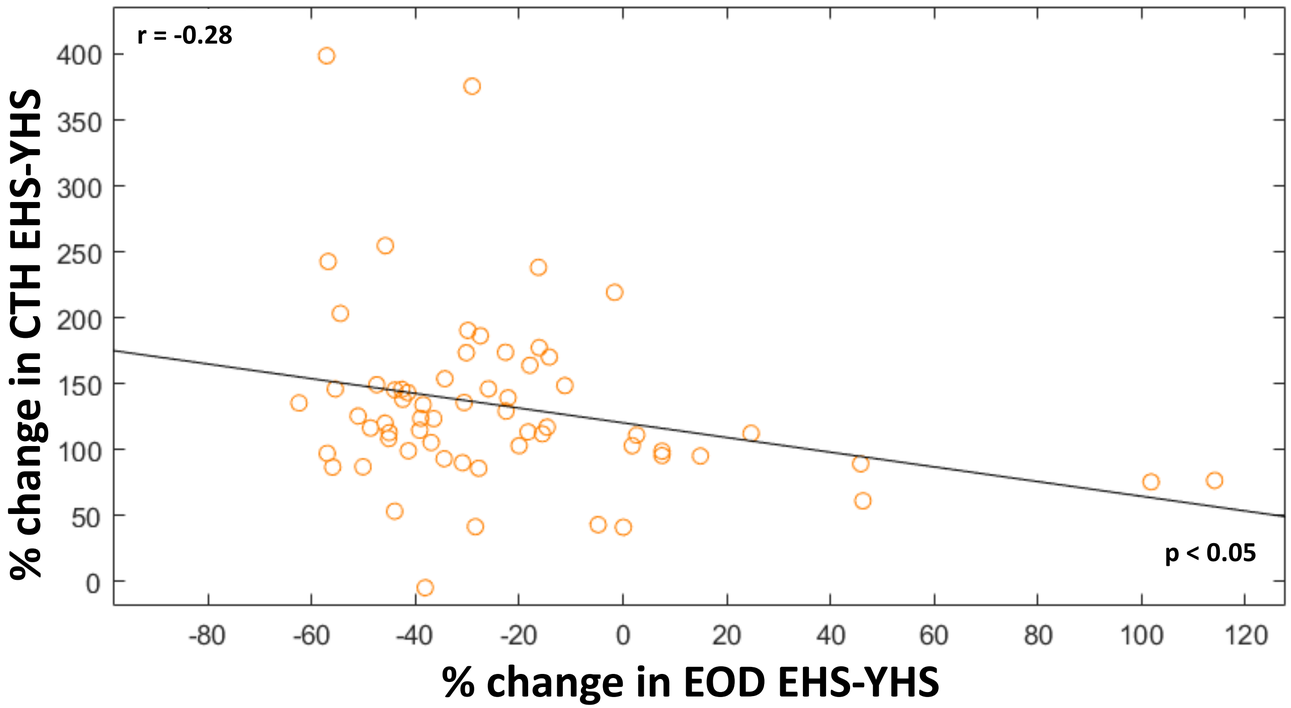
EHS



- Slightly lower inverse correlation of EOD and CTH
- Spread of parameter values increased, especially in CTH

Results: Coupled change of EOD and CTH in aging





EOD averaged across brain areas decreased in aging with concomitant CTH increase (red dashed lines)

% age-related change of EOD and CTH inversely coupled across brain areas

Discussion: Agreement of regional EOD by MR and PET

- Good agreement of regional MR-EOD averages and PET reference
- Correlation within range reported for PET vs. ASL alone[7]
- Zero average difference of PET- and MR-EOD indicates no systematic offset
- No dependence on absolute value of EOD

[7]Fan et al. (2016) J Cereb Blood Flow Metab **36**(5): 842-861

Discussion: EOD & CTH change concomitantly in aging

- Negative EOD/CTH correlation suggests flow patterns regulate EOD
- Increased CTH in EHS - has been observed in aged mice before[8]
- Coupled change of EOD and CTH: 23% EOD decrease with 33% CTH increase
- Additional mechanisms likely acting on EOD e.g. changing capillary density in aging[8]

[8]Moeini et al. (2018) Sci Rep **8**(1): 8219

Conclusion

- Successfully validated EOD quantification with mqBOLD and pCASL
- Decrease of EOD accompanied by CTH increases in healthy aging
- Heterogeneity of capillary flow likely a physiological mechanism regulating EOD

Thank you very much for watching this presentation!

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Live Q&A Session:

Thursday Parallel 4
Probing Physiology with fMRI
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