



## Mark Bitsch Vestergaard

Postdoc, M.Sc., Ph.D.



Born: 28<sup>th</sup> December 1986, Copenhagen, Denmark.



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## Key research interests

Human cerebral metabolism and perfusion during metabolic and hypoxic stress.

Age-related changes of cerebral metabolism.

Alteration of cerebral metabolism from vascular disease.

Development of MR-imaging, MR-spectroscopy and PET techniques for studying cerebral physiology.

Data analysis and statistical modelling.

## Experience

March 2020

June 2017 -

### Postdoc

Department of Clinical Physiology and Nuclear Medicine and PET, Rigshospitalet, Copenhagen, Denmark.

Projects: Human cerebral perfusion, oxygen consumption and energy metabolism during hypoxic exposure. Age-related changes in cerebral energy metabolism. Brain metabolism and diabetes mellitus.

September 2013 - May 2017

### Ph.D. Student

University of Copenhagen and Functional Imaging Unit, Department of Clinical Physiology and Nuclear Medicine and PET, Rigshospitalet, Glostrup, Denmark.

Projects: Human cerebral perfusion, oxygen consumption and energy metabolism during hypoxic exposure.

September 2012 - August 2013

### Research Assistant

Functional Imaging Unit, Department of Clinical Physiology and Nuclear Medicine and PET, Rigshospitalet, Glostrup, Denmark.

Projects: Acquisition of cerebral oxygen metabolism, blood perfusion and cerebrovascular reactivity using non-invasive MRI-techniques.

September 2011 - August 2012

### Research Assistant

Danish Research Centre for Magnetic Resonance, Hvidovre Hospital, Hvidovre, Denmark.

## Education

2013-2017 **Ph.D.** Graduate Programme in Neuroscience, University of Copenhagen.

Thesis: *Energy Metabolism of the Hypoxic Brain in Healthy Humans and Freedivers.*

2005-2011 **Master degree.** Biomedical Engineering, University of Copenhagen and the Technical University of Denmark.

Master thesis: *Motion Tracking During Magnetic Resonance Imaging based on Gradient Induced Signals.*

Bachelor Thesis: *Changes in the electroencephalogram during hypoglycaemia.* In collaboration with Novo Nordisk.

## Key skills

**Magnetic resonance imaging:** Quantitative measurements, cerebral perfusion, cerebral metabolism, arterial spin labelling, phase contrast velocity mapping, susceptibility based imaging, magnetic resonance spectroscopy, fMRI.

**Positron emission tomography:** Perfusion measurements (<sup>15</sup>O-H<sub>2</sub>O PET). Image-derived input function.

**Data analysis:** Matlab, R, FSL, MrVista, Freesurfer, PMOD.

**Brain metabolism:** Perfusion, oxygen consumption, lactate, hypoxia.

## Grants

2013 **Full Ph.D. scholarship**, University of Copenhagen. (~1,500,000 DKK)

2018 **Postdoc scholarship**, Rigshospitalets forskningspuljer. (~1,100,000 DKK)

## Other

Co-supervisor for one Ph.D.-student. Teacher on Ph.D. course in tracer kinetic (University of Copenhagen).

Reviewer for scientific journals: Journal of Neurophysiology, Cephalgia, Journal of Pain and Headache, Obesity.

## Mark B. Vestergaard - Publications (updated March 2020)

1. Bashir A, **Vestergaard MB**, Binderup T, Broholm H, Marner L, Ziebell M, Fugleholm K, Mathiesen T, Kj, Law I.  
Pharmacokinetic analysis of [68Ga]Ga-DOTA-TOC PET in meningiomas for assessment of in vivo somatostatin receptor subtype 2. *European Journal of Nuclear Medicine and Molecular Imaging*. March 2020 [Accepted]
2. Zhang DG, Amin FM, Gou S, **Vestergaard MB**, Hougaard A, Ashina M.  
Plasma glucose levels increase during spontaneous attacks of migraine with and without aura. *Headache*. February 2020. [Epub ahead of print, DOI:10.1111/head.13760]
3. Bashir A, Broholm H, Clasen-Linde E, **Vestergaard MB**, Law I.  
Pearls and pitfalls in interpretation of 68Ga-DOTATOC PET imaging. *European Journal of Nuclear Medicine and Molecular Imaging*. January 2020. [Accepted]
4. Bashir A, Binderup T, **Vestergaard MB**, Broholm H, Marner L, Ziebell M, Fugleholm K, Kjaer A, Law I.  
In vivo imaging of cell proliferation in meningioma using 3'-deoxy-3'-[18F]fluorothymidine PET/MRI. *European Journal of Nuclear Medicine and Molecular Imaging*. January 2020. [Accepted]
5. Younis S, Christensen CE, **Vestergaard MB**, Lindberg U, Tolnai D, Paulson OB, Larsson HBW, Hougaard A, Messoud A.  
Glutamate levels and perfusion in pons during migraine attacks: a 3 tesla MRI study using proton spectroscopy and arterial spin labeling. *Journal of Cerebral Blood Flow and Metabolism*. January 2020. [Accepted]
6. **Vestergaard MB**, Jensen MLF, Arngrim N, Lindberg U, Larsson HBW.  
Higher physiological vulnerability to hypoxic exposure with advancing age in the human brain. *Journal of Cerebral Blood Flow and Metabolism*. January 2020, 40(2);341-353.
7. Hougaard A, Younis S, Iljazi A, Haanes KA, Lindberg U, **Vestergaard MB**, Amin FM, Sugimoto K, Kruse LS, Ayata C, Ashina M.  
Cerebrovascular effects of endothelin-1 investigated using high-resolution magnetic resonance imaging in healthy volunteers. *Journal of Cerebral Blood Flow and Metabolism*. September 2019. [Epub ahead of print, DOI:0271678X19874295]
8. Calvo OP, **Vestergaard MB**, Lindberg U, Hansen AE, Ulrich A, Andersen FL, Johannesen HH, Rostrup E, Law I, Larsson HBW, Henriksen OM.  
Phase contrast mapping MRI measurements of global cerebral blood flow across different perfusion states - a direct comparison with 15O-H2O positron emission tomography using a hybrid PET/MR system. *Journal of Cerebral Blood Flow and Metabolism*. December 2019, 39(12):2368-2378.
9. Calvo OP, Henriksen OM, **Vestergaard MB**, Hansen AE, Andersen FL, Johannesen HH, Ladefoged CN, Rostrup E, Larsson HBW, Lindberg U, Law I.  
Comparison of simultaneous arterial spin labeling MRI and O-H2O PET measurements of regional cerebral blood flow in rest and altered perfusion states. *Journal of Cerebral Blood Flow and Metabolism*. September 2019. [Epub ahead of print, DOI:0271678X19874643]
10. **Vestergaard MB**, Larsson HBW.  
Cerebrovascular reactivity and oxygen consumption during breath-hold and hypoxic challenge in freedivers and healthy controls. *Journal of Cerebral Blood Flow and Metabolism*. May 2019, 39(5):834-848.
11. Arngrim N, Hougaard A, Schytz HW, **Vestergaard MB**, Britze J, Faisal AM, Skovgaard KO, Larsson HBW, Olesen J, Messoud A.  
Effect of hypoxia on BOLD fMRI response and total cerebral blood flow in migraine with aura patients and healthy volunteers. *Journal of Cerebral Blood Flow and Metabolism*. April 2019, 39(4):680-689.

12. Younis S, Hougaard A, Christensen CE, **Vestergaard MB**, Petersen ET, Paulson OB, Larsson HBW, Ashina M.  
Effects of sildenafil and calcitonin gene-related peptide on brainstem glutamate levels: A pharmacological proton magnetic resonance spectroscopy study at 3.0 T. *The Journal of Headache and Pain*. December 2018, 19(44):1:11
13. Henriksen OM, **Vestergaard MB**, Lindberg U, Aachmann-Andersen NJ, Lisbjerg K, Christensen SJ, Rasmussen P, Olsen NV, Forman JL, Larsson HBW, Law I.  
Interindividual and regional relationship between cerebral blood flow and glucose metabolism in the resting brain. *Journal of Applied Physiology*. October 2018, 125(4):1080-1089.
14. Ismaili ARA, **Vestergaard MB**, Hansen AE, Larsson HBW, Johannesen HH, Lawe I, Henriksen OM.  
Components of day-to-day variability of cerebral perfusion measurements - a phase contrast mapping magnetic resonance imaging study in healthy volunteers. *PloS one*. June 2018, 13(6).
15. **Vestergaard MB**, Henriksen OM, Lindberg U, Aachmann-Andersen NJ, Lisbjerg K, Christensen SJ, Olsen NV, Law I, Larsson HBW, Rasmussen P.  
No evidence for direct effects of recombinant human erythropoietin on cerebral blood flow and metabolism in healthy humans. *Journal of Applied Physiology*. April 2018, 124(4):1107:1116.
16. Arnglim N, Schytz HW, Britze J, **Vestergaard MB**, Sander M, Olsen KS, Olesen J, Messoud A.  
Carbon monoxide inhalation induces headache in human headache model. *Cephalgia*. April 2018, 38(4):697-706.
17. Jensen MLF, **Vestergaard MB**, Tønnesen P, Larsson HBW, Jennum PJ.  
Cerebral blood flow, oxygen metabolism and lactate during hypoxia in patients with obstructive sleep apnea. *Sleep*. March 2018, 41(3):zsy001.
18. Arnglim N, Hougaard A, Ahmadi K, **Vestergaard MB**, Schytz HW, Amin FM, Larsson HBW, Olesen J, Hoffmann MB, Ashina M.  
Heterogenous migraine aura symptoms correlate with visual cortex fMRI responses. *Annals of Neurology*. December 2017, 82(6):925-938.
19. Younis S, Hougaard A, **Vestergaard MB**, Larsson HBW, Ashina M.  
Migraine and magnetic resonance spectroscopy: A systematic review. *Current Opinion in Neurology*. 2017 June, 30(3); 246-262.
20. **Vestergaard MB**, Lindberg U, Aachmann-Andersen NJ, Lisbjerg K, Christensen SJ, Rasmussen P, Olsen NV, Law I, Larsson HBW, Henriksen OM.  
Comparison of global cerebral blood flow measured by phase-mapping magnetic resonance imaging and  $^{15}\text{O}\text{-H}_2\text{O}$  positron emission tomography. *Journal of Magnetic Resonance Imaging*. 2017 March, 45(3); 692-699.
21. **Vestergaard MB**, Lindberg U, Aachmann-Andersen NJ, Lisbjerg K, Christensen SJ, Law I, Rasmussen P, Olsen NV, Larsson HBW.  
Acute hypoxia increases the cerebral metabolic rate - a magnetic resonance imaging study. *Journal of Cerebral Blood Flow and Metabolism*. 2016 December, 36(6); 1046-1058.
22. Larsson HBW, **Vestergaard MB**, Lindberg U, Iversen HK, Cramer SP.  
Brain capillary transit time heterogeneity measured by dynamic contrast-enhanced T1-weighted perfusion Magnetic Resonance Imaging. *Journal of Magnetic Resonance Imaging*. 2016 June, 45(6):1809-1820.
23. Arnglim N, Schytz HW, Britze J, Amin FM, **Vestergaard MB**, Hougaard A, Wolfram F, de Koninck PJ, Olsen KS, Secher NH, Larsson HBW, Olesen J, Ashina M.  
Migraine induced by hypoxia: a MRI spectroscopy and angiography study. *Brain*. 2016 March, 139; 723-737.

## Conference Contributions

### Invited talks

1. **Vestergaard MB**. Cerebral perfusion and oxygen consumption during hypoxic exposure in patients with obstructive sleep apnea and freedivers. The International Society for Magnetic Resonance in Medicine 2018 Nordic Chapter Meeting. Oral presentation. Trondheim, Norway. October 2018.
2. **Vestergaard MB**, Larsson HBW. Measurement of total brain oxygen consumption using sagittal phase information. The International Society for Magnetic Resonance in Medicine 2016 Nordic Chapter Meeting. Oral presentation. Uppsala, Sweden. June 2016.
3. **Vestergaard MB**, Gruner JM, Andersen U, Iversen H, Larsson HBW. Ny MR-metode til vurdering af hjernens blodgennemstrømning hos patienter med forsnæget halspulsår. (In Danish). Dansk Selskab for Klinisk fysiologi og Nuklearmedicin 2014 Årsmøde. Oral presentation. Kolding, Denmark. September 2014.

### Peer-reviewed

1. **Vestergaard MB**, Ghanizada H, Lindberg U, Arnglim N, Paulson OB, Ashina M, Larsson HBW. Effects from inhalation of hypoxic air and carbon monoxide exposure on human cerebral perfusion, oxygen consumption and lactate production. International Society for Magnetic Resonance in Medicine 2020 annual meeting. Poster presentation. Paris, France. August 2020. [accepted]
2. Bashir A, **Vestergaard MB**, Binderup T, Broholm H, Marner, Ziebell M, Fugleholm K, Kj, Law I. Pharmacokinetic analysis of  $^{68}\text{Ga}$ -DOTATOC in meningiomas using PET/CT for assessment of somatostatin receptors and correlation with angiogenesis, inflammation and proliferation. 24<sup>th</sup> Annual Scientific Meeting and Education Day of the Society for Neuro-Oncology. Poster presentation. November 2019.
3. Bashir A, **Vestergaard MB**, Marner L, Larsen AV, Ziebell M, Fugleholm K, Law I. Dynamic imaging of meningioma with 3-deoxy-3-[ $^{18}\text{F}$ ]-Fluorothymidine using Positron Emission Tomography: A possible predictor of tumor growth. 24<sup>th</sup> Annual Scientific Meeting and Education Day of the Society for Neuro-Oncology. Poster presentation. November 2019.
4. Zhang DG, Amin FA, Guo S, **Vestergaard MB**, Hougaard A, Ashina M. Plasma glucose levels increase during spontaneous attacks of migraine with and without aura. Congress of the International Headache Society. Poster presentation. Dublin, Ireland. September 2019.
5. Younis S, Hougaard A, Christensen CE, **Vestergaard MB**, Petersen ET, Boer VO, Paulson OB, A Messoud, Marsman A, Larsson HBW. Feasibility of pharmacokinetic mapping using  $^1\text{H}$ -MRS at 3T and 7T. The 13<sup>th</sup> European Headache Federation Congress. Oral presentation. Athens, Greece. May 2019.
6. Bashir A, Broholm H, **Vestergaard MB**, Marner L, Ziebell M, Fugleholm K, Law I. Imaging proliferation in meningioma with dynamic  $^{18}\text{F}$ -FLT PET: Correlation with histopathology and  $\text{k}850$  DNA-methylation. Dansk Patologiselskabs Årsmøde 2019. Poster presentation. Kolding, Denmark. March 2019.
7. Opheim G, Ganz-Benjamin M, Lindberg U, **Vestergaard MB**, Hamrouni N, Simonsen H, Leffers AM, Madsen CG, Larsson HBW, Paulson OB, Pinborg LH. The impact of multimodal 7T MRI in presurgical evaluation of epilepsy patients. The International Society for Magnetic Resonance in Medicine 2018 Nordic Chapter Meeting. Oral presentation. Trondheim, Norway. October 2018.
8. Calvo OP, Lindberg U, **Vestergaard MB**, Rostrup E, Hansen AE, Larsson HBW, Law I, Henriksen OM. Simultaneous measurements of global cerebral blood flow with 2D pseudo-continuous multi-TI arterial spin labeling and  $^{15}\text{O}$  -  $\text{H}_2\text{O}$  PET in a hybrid PET/MR system. International Society for Magnetic Resonance in Medicine 2018 annual meeting. Poster presentation. Paris, France. June 2018.

9. Younis S, Hougaard A, Christensen CE, **Vestergaard MB**, Petersen ET , Paulson OB, Larsson HBW, Ashina M. Effects of sildenafil and calcitonin gene-related peptide on brainstem glutamate levels: A pharmacological proton magnetic resonance spectroscopy study at 3.0 T. 5<sup>th</sup> National Headache Update. Oral presentation. Islamabad, Pakistan. December 2017.
10. Younis S, Hougaard A, Christensen CE, **Vestergaard MB**, Petersen ET , Paulson OB, Larsson HBW, Ashina M. Effects of calcitonin gene-related peptide and sildenafil on glutamate metabolism in brainstem and thalamus: A pharmacological proton magnetic resonance spectroscopy study at 3.0 T. 11<sup>th</sup> European Headache Federation Congress. Oral presentation. Rome, Italy. December 2017.
11. Calvo OP, **Vestergaard MB**, Lindberg U, Rostrup E, Hansen AE, Larsson HBW, Law I, Henriksen OM. Simultaneous measurements of global cerebral blood flow changes with phase contrast mapping and <sup>15</sup>O - H<sub>2</sub>O PET in a hybrid PET/MR system. European Society for Magnetic Resonance in Medicine and Biology 2017 conference. Poster presentation. Barcelona, Spain. September 2017.
12. Arngrim N, Hougaard A, Schytz HW, **Vestergaard MB**, Britze J, Faisal AM. Skovgaard KO, Larsson HBW, Olesen J, Messoud A. Effect of hypoxia on BOLD fMRI response and total cerebral blood flow in migraine with aura patients and healthy volunteers 18<sup>th</sup> Congress of the International Headache Society. Oral presentation. Vancouver, Canada. September 2017.
13. Arngrim N, Schytz HW, Britze J, **Vestergaard MB**, Sander M, Olsen KS, Olesen J, Messoud A. Carbon monoxide inhalation induces headache in human headache model. 18<sup>th</sup> Congress of the International Headache Society. Oral presentation. Vancouver, Canada. September 2017.
14. Henriksen, OM, **Vestergaard MB**, Lindberg U, Aachmann-Andersen NJ, Lisbjerg K, Christensen SJ, Olsen NV, Rasmussen P, Larsson HBW, Law I. Interindividual and regional variations in coupling of cerebral blood flow and metabolism measured by PET and MRI. 28th Symposium on Cerebral Blood Flow, Metabolism and Function and 13<sup>th</sup> Conference on Quantification of Brain Function with PET. Oral presentation. Berlin, Germany. April 2017.
15. Jensen MLF, **Vestergaard MB**, Smith MN, Tnnesen P, Larsson HBW, Jennum PJ. Cerebral blood flow, cerebral metabolism and metabolites during hypoxia in patients with obstructive sleep apnea. 23<sup>rd</sup> Congress of the European Sleep Research Society. Oral presentation. Bologna, Italy. September 2016.
16. **Vestergaard MB**, Lindberg U, Aachmann-Andersen NJ, Lisbjerg K, Christensen SJ, Rasmussen P, Olsen NV, Law I, Larsson HBW, Henriksen OM. Comparison of measurements of total cerebral blood flow by MRI phase-mapping techniques and H<sub>2</sub><sup>15</sup>O Positron Emission Tomography. European Society for Magnetic Resonance in Medicine and Biology 2015 conference. Oral presentation. Edinburgh, United Kingdom. September 2015.
17. **Vestergaard MB**, Schultz J, Turner R, Hanson LG. Motion Tracking from Gradient Induced Signals in Electrode Recordings. European Society for Magnetic Resonance in Medicine and Biology 2011 conference. Oral presentation. Leipzig, Germany. September 2012.