Intravoxel incoherent motion analysis of abdominal organs: computation of base values in a large cohort of B57Bl/10 mice

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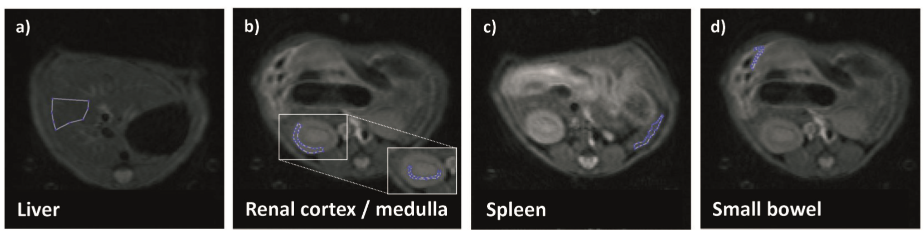
Purpose: Intravoxel Incoherent Motion Magnetic Resonance Imaging (IVIM-MRI) is increasingly applied for characterization of organ lesions and tumor response monitoring [1,2]. In modern translational research, small animal disease models are implemented to obtain a deeper understanding of the underlying pathophysiology and to allow for treatment testing [3,4]. Base values of IVIM parameters in mice are a prerequisite for detection of pathological alterations. The aim of this study was to determine tissue specific IVIM base parameters in a commonly applied laboratory mouse strain (C57Bl/10). Hence, mean and standard deviation of pseudodiffusivity (D_p), tissue diffusivity (D_t) and the perfusion fraction (f_p) of abdominal organs were computed in a large study cohort of C57Bl/10 mice (n=50).

Material and methods: The study was approved by the veterinary Ethics committee. Isoflurane anesthetized mice were measured in a 4.7T small animal MR imager using a linear polarized whole body mouse coil. Data sets for IVIM analysis were acquired with a diffusion-weighted spin-echo echo-planar imaging sequence (set of b-values 0, 13, 24, 55, 107, 260, 514, 767, 1020 s/mm^2) applying respiratory triggering. IVIM analysis of abdominal organs (liver, kidney cortex and medulla, spleen and small bowel) was performed with a custom written MatLab script from signal intensity curves of regions of interest (ROI) (n≥3) manually drawn in identical regions of the investigated organs. Initially, the tissue diffusivity D_t was calculated from the last 5 b-values by linear fitting to the log values. The perfusion fraction f_p was obtained from the intersection of the curve of the last 5 b-values with the y-axis. Finally, the pseudodiffusivity D_p was calculated based on following equation by non-linear fitting:

$$\frac{S_b}{S_0} = \left(1 - f_p\right) * exp^{(-bD_t)} + f_p * exp^{(-bD_p)}$$

If the signal-to-noise ratio of the $b = 1020$ s/mm^2 image was below 5, the last section was excluded from the linear fit yielding D_t.

Results:



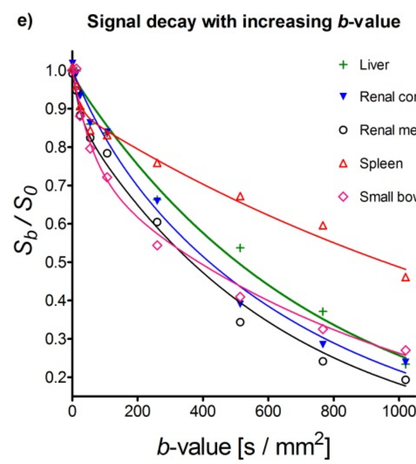


Fig.1: Typical ROIs drawn on the b=0 s/mm^2 images of **a)** liver, **b)** renal cortex and medulla, **c)** spleen and **d)** small bowel and **e)** extrapolated S_b / S_0-values as obtained for each b-value together with the bi-exponential fit applied for computation of pseudodiffusivity (D_p), diffusivity (D_t) and the perfusion fraction (f_p).

Tab.1: Specific tissue diffusion parameters retrieved by IVIM-MRI: pseudodiffusivity (D_p), diffusivity (D_t) and the perfusion fraction (f_p).

Value	Liver	Renal cortex	Renal medulla	Spleen	Small bowel
D_t [mm^2/s]	1.15 ± 0.17	1.45 ± 0.21	1.60 ± 0.20	0.64 ± 0.20	1.09 ± 0.22
D_p [mm^2/s]	39.63 ± 18.54	24.77 ± 18.54	35.00 ± 22.82	45.06 ± 23.97	15.84 ± 8.37
f_p	15.42 ± 6.76	11.76 ± 5.85	16.15 ± 5.89	10.75 ± 5.83	18.85 ± 8.68

Conclusion: We obtained relatively stable results for D_t, whereas D_p and f_p showed considerably higher variability, which may be attributed to residual body motion and physiological tissue variability. The reported values may serve as base parameters for future translational research using IVIM for tissue characterization.

References:

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