EPT - Measurement of Brain Conductivity for Non-oncologic Applications

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Introduction: Imaging electric conductivity of tissue with Electric properties tomography (EPT) has been introduced first in 2009 [1]. Since then it has been used in several studies characterizing brain tumors, especially gliomas. Tha et al. [2] have shown that EPT is able to distinguish between WHO grade IV gliomas and grade I-III. In this study we tested EPT on different neuroradiologic diagnoses to get an idea which other central nervous system disease might benefit using conductivity as additional diagnostic parameter.

Methods: 8 patients, each with a different central nervous system disease, have been examined (Table 1) at 1.5 T respectively 3 T (Philips Achieva) performing T1w images pre and post contrast (TR/TE:1.5T=650/15 ms; 3T=319/2.3 ms), T2w images (TR/TE:1.5T=4376/100 ms; 3T=5312/80 ms), diffusion weighted images (TR/TE: 1.5T=2995/84 ms; 3T=4096/71 ms; b=0/1000) and 3D SSFP (TR/TE=3.0/1.5 ms) for reconstruction of EPT maps [3]. Conventional sequences and EPT maps have than been analyzed by two independent neuroradiologists for focal changes in EPT maps and if these changes correlate with findings in conventional sequences. Regions of interest localized in pathologic areas as well as in contralateral healthy white matter (WM) and healthy striatal structures have been defined and transferred to all sequences and maps. Conductivity values, ADC values and signal intensities have been compared.

Patient	Diagnosis
1	Glioblastoma multiforme
2	Astrocytoma II
3	CNS Lymphoma
4	cerebellar metastases
5	cerebral metastases, malignant melanoma
6	microangiopathy
7	subacute stroke
8	multiple sclerosis

Table 1

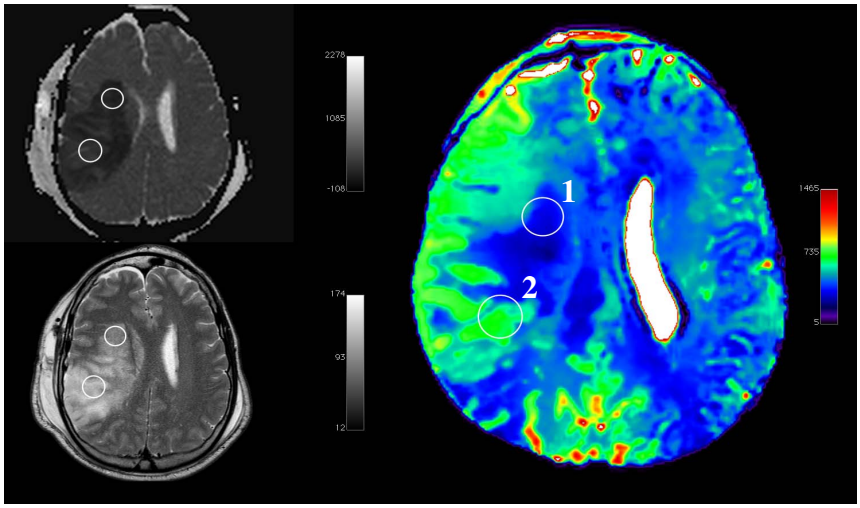

Figure 1: ADC map (upper left), T2w image (lower left) and EPT map (right) of subacute MCA-infarct with following ADC values and conductivities for contralateral healthy white matte (WM) and infarction (I-1 and I-2): ADC-WM/I-1/I-2=437/215/346x10-6 mm²/s; EPT-WM/I-1/I-2=404/457/641 mS/m

Results: As shown in earlier studies Glioblastoma and Astrocytoma showed higher conductivities compared to healthy WM (Δ~400/200 mS/m). CNS-Lymphoma showed slightly higher conductivities compared to healthy WM (Δ~250 mS/m). Metastases show higher as well as even or lower values compared to healthy WM (Δ~0-900 mS/m).. The large medial cerebral artery (MCA)- infarct showed characteristic decrease of ADC-values due to cytotoxic edema attended by increased conductivities. But the more the ADC decreased, the less conductivity increased (Fig. 1). Some microangiopathic lesions are detectable on EPT maps showing higher conductivities compared to healthy WM (up to Δ~700 mS/m), while some microangiopathic lesions do not show changes at all.

Demyelinating lesions in multiple sclerosis showed a small rim of elevated conductivities compared to the lesion itself and healthy WM (Δ ~250 mS/m) (Fig. 2). There was no difference between acute inflammational lesions showing contrast enhancement and older gliotic lesions.

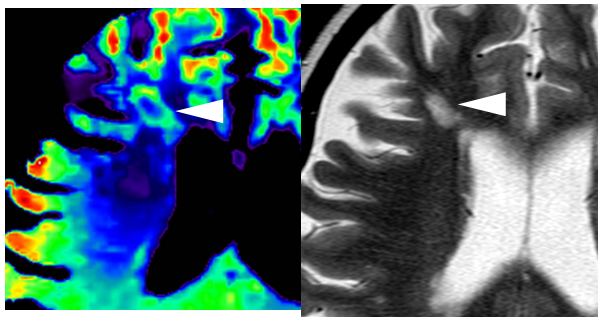

Figure 2:T2w image and EPT-map of multiple sclerosis lesion, hyperintense in T2w and rim of elevated conductivity in EPT map

Discussion: This study shows, that EPT does not only has potential in tumor diagnosis concerning tumor grading, it is also able to detect changes in brain tissue due to other frequent neuroradiological diagnoses. EPT maps show changes correlating with findings in conventional MR sequences for microangiopathy and acute infarction. For acute stroke, a (presumably non-linear) relation between conductivity and ADC has been observed. EPT maps also show findings that are not shown on conventional sequences like in multiple sclerosis, showing a perifocal rim of increased electric conductivity without showing rim like changes in other sequences.

Conclusion: Further EPT studies should not only focus on brain tumors, but also on acute stroke and its follow up and multiple sclerosis considering factors of influence like histopathological subtypes as well as possible effects on conductivity due to therapy.

References: [1] Katscher U et al., IEEE Trans Med Imaging. 2009;28:1365 [2] Tha KK et al., ISMRM 2014; 22:1885 [3] Voigt T et al., MRM 2011; 66:456