

Quantitative and Qualitative Sodium Imaging of the Prostate at 3T

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Introduction:

Generally, MRI provides detailed information about the anatomic structures of the prostate with a high spatial resolution. Prostatitis and prostate cancer are located in the hyperintense peripheral zone, predominantly, and present as a signal reduction. Both diseases have a high prevalence, especially in elderly patients. Additional sequences such as diffusion-weighted imaging (DWI), spectroscopy and perfusion measurements are necessary to distinguish between benign and malignant lesion. Nevertheless, so far, the specificity is relatively low. A more robust sequence for the differentiation of prostatitis and prostate cancer is desirable.

There are numerous studies about elevated sodium levels in brain tumours. More recently, as part of a study about sodium imaging of breast lesions, a relation between sodium levels and the dignity of breast lesions was observed. Higher sodium levels in cancer compared with benign tumours were detected (1). To our knowledge, there is no study about sodium quantification in the human prostate so far. One study about sodium imaging of the prostate in a murine model at 7 Tesla exists. Quantification of sodium levels of the prostate was feasible due to high sodium levels of the ventral gland (2). The purpose of this study is to evaluate the image quality of sodium MRI of the prostate in a clinical setting in human volunteers at 3 T and to determine if quantification of sodium levels within the gland is feasible. Moreover, possible changes of the sodium levels as a result of prostatitis should be evaluated.

Methods:

All measurements were performed on a 3 T clinical whole-body MR scanner (Magnetom TimTrio 32x102, Siemens Healthcare Sector). For signal reception a dedicated sodium-tuned cardiac coil with 8 coil elements (Rapid Biomedical) was used. It consists of two identical halves with a transmit loop and four receive-only channels each. The coil was tightly fixed around the volunteers and covered a coronar field-of-view of 320 x 320 mm². Beside the torso, standardized 0.6% and 0.9% NaCl-dilutions including 2% agarose were covered in the field-of-view serving as calibration phantoms. Based on the

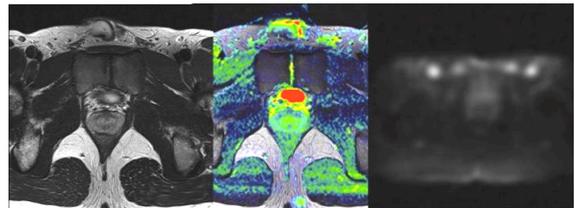


Figure 1: T2 (left), fusion of coloured ADC map and T2 (middle) and sodium axial image (right) of the prostate of a young healthy volunteer. The images indicate that sodium imaging of the prostate is feasible.

comparison of these phantoms, an analog increase of the sodium signal intensities compared to the sodium concentrations was estimated. For adjusting the inhomogeneity of the coil a priori, a homogeneous sodium phantom was measured as reference. According to this reference, all images of the volunteers were corrected. For sodium imaging, a density adapted 3D radial trajectory was used for acquisition (3) with the following parameters: TR = 120 ms, TE = 0.55 ms, flip angle = 85°, readout length per spoke = 20 ms, projections = 8000 resulting in a total scan time of 16 min. The isotropic spatial resolution was 5 mm. After institutional review, board approval and informed consent, 8 healthy volunteers were included. DWI- and T2- images with a H*-body-coil are acquired additionally for correlation of the findings.

Results:

All initial data were successfully acquired. The prostate and its different departments were identifiable in all 8 volunteers. In four patients quantification of the sodium levels within the gland was feasible as shown in table 1 and figure 2. So far, a mean sodium concentration of 63 mmol/l in the central and 70 mmol/l in the peripheral zone was measured.

Subject (n=4)	sodium concentration (mmol/l)	
	central zone	peripheral zone
1	63	73
2	56	66
3	58	59
4	75	84
mean (SD)	63 (+/-8.5)	70 (+/-10.7)

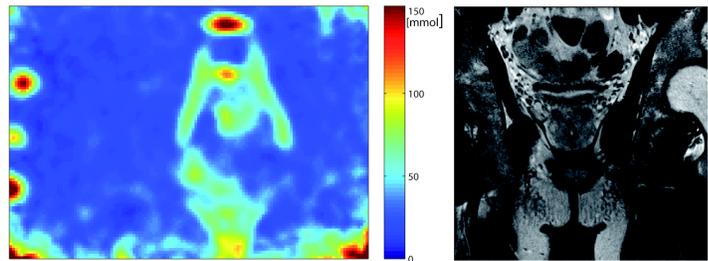


Figure 2: T2 (right) and coloured sodium map coronar (left). Beside the torso, standardized 0.6% and 0.9% NaCl-dilutions including 2% agarose were covered in the field-of-view serving as calibration phantoms. The images show that quantification of the sodium levels within the gland is feasible

Table 1: Sodium concentration (mmol) in the central and peripheral zone of the prostate in four young healthy volunteers.

Discussion:

This study suggests that sodium imaging on a clinical 3T scanner might be an appropriate, noninvasive method for imaging of the human prostate. The current sodium imaging technique is sufficient for the quantification of the sodium concentration within the prostate. Further developments of the coil systems are necessary to increase spatial resolution, to reduce examination time and to enable a more accurate and reliable quantification. Moreover, clinical studies are necessary to evaluate if changes of the sodium levels are apparent in prostate cancer. Sodium imaging of the prostate could be another helpful tool for a reliable differentiation between malignant and benign prostate lesions. We intend to include ten young (< 35 years) and ten older (> 50 years) males in total. A higher prevalence of prostatitis is expected in the group of older volunteers. We hope to gain information about changes of the sodium levels by comparing both groups.

References:

1. Ouwerkerk, R et al. Breast Cancer Research and Treatment 106(2): p. 151-60 (2007)
2. Near, J et al. Magnetic Resonance in Medicine 63(3): p. 822-7 (2010)
3. Nagel AM et al. Magnetic Resonance in Medicine 62: p.1565-73 (2009)