Whole Body Sodium MRI at 0.5 Tesla

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Experiments on sodium (^{23}Na) MRI, including the construction of MRI of the whole human body (WB) from head to toe, are described. The studies were performed on a clinical 0.5T scanner Bruker Tomikon S50 which was designed primarily for recording ^{1}H signals (21.1 MHz). ^{23}Na MRI provides diagnostic information, since sodium is actively involved in cellular processes [1]. It is believed that progress in ^{23}Na MRI is possible only with the use of strong magnetic fields – from 3T and above. However, for open-type magnets and compact magnetic systems under development, it is still difficult to achieve fields greater than 1T [2]. Therefore, it is of interest to identify possibilities of ^{23}Na MRI for weak fields – less than 1T.

The gyromagnetic ratio for ^{23}Na is 3.8 times less than for a proton, and the sodium content in living tissues is about $2\cdot10^3$ times less than that of hydrogen. This imposes high demands on the sensitivity of the ^{23}Na MRI equipment. To increase the signal-to-noise ratio (SNR), the sampling rate (BW) defining the receiver bandwidth was set as small as possible ~10^3 Hz [3]. This, in turn, determined the use of a large echo time (TE) in the scanning pulse sequence. The research strategy assumed a minimal modification of the scanner. Therefore, only simple transceiver probehead was made — 20-cm square-shaped frame coil (4 turns) tuned to the Larmor frequency of ^{23}Na (5.6 MHz). Scanning was performed using the gradient echo method with TR/TE=44.7/12 ms, FA=46° (5 ms rectangular pulse), BW=2.87 kHz, echo position was 0.25. In-plane resolution was 6.6×6.6 mm^2, data matrix was N×N, where N=80. There was no slice selection. To increase the SNR about 4 times, for data of the K space, exponential apodization was applied: $K_A(i,j)=K(i,j)\cdot\exp(-(|i-i_0|-|j-j_0|)/kN)$, where $i,j=1\div N$ – coordinates of the K-space, i_0,j_0 – echo position. For our case, $i_0=20$, $j_0=40$, $k=0.1$. Custom written software was used. As a result, images were obtained, in which human organs are represented with the SNR up to 30. The sensitivity zone of the coil is about 20 cm. Therefore, to assemble the WB ^{23}Na MRI, 9 separate body segments in prone and supine positions were scanned. The scan time of one body segment was 30 min. Fig. 1 shows the sum of the WB ^{23}Na MR images (40×170 cm^2) obtained in prone and supine positions for a healthy volunteer – a 28-year-old male.

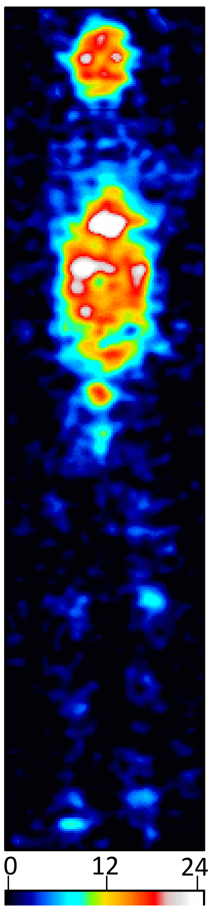

Fig.1. The sum of the WB ^{23}Na MR images obtained in prone and supine positions.

The distribution of contrast for different organs and tissues, in general, corresponds to that obtained at 3T [4]. There are significant reserves to increase sensitivity and reduce scan time – the replacement of the frame coil by the volume coil. Then it is possible to increase the informativeness of the study by performing a slice selective scan, as well as applying pulse sequences with a short TE.

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