New method of fat and water signals suppression in MRI diagnostics of brain pathologies

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Introduction

To improve visualization of intracranial pathological formations, it is offered to use MRI methods based on simultaneous water and fat signal suppression [1]. In this case some normal structures on MR images (ventricles of brain, orbital fat tissue, subarachnoid spaces, bone and hypodermic fat) practically are not visualized. As a result tissue contrast becomes significantly simpler and 3D construction of pathological formations (tumors, haematomas, etc.) is facilitated [2]. Due to suppression of powerful background signals from a normal tissues, the sensitivity of receiver increases. The purpose of the work is to study diagnostic efficiency of MRI method based on simultaneous suppression of water and fat signals at the pathology of brain meninges and subarachnoid spaces.

Methods

For simultaneous suppression of signals of water and fat, we used the pulse sequence based on the inversion-recovery effect. In comparison with the frequency selective (chemical shift selective) methods [3], the used sequence gives general decrease in a signal. However it is simpler in realization and does not request exact frequency adjustments. Additionally the method is less sensitive to distortions of magnetic fields. Twice inverting pulse sequence 180^0-T_W-180^0-T_F-(90^0-acquisition) was applied. T_W and T_F delays were adjusted so that start of reading 90^0 pulse took place at the moment when longitudinal magnetizations of water and fat simultaneously passed through zero during recovery process. The calculation with the assumption $T_{1F} << T_{1W}$ shows that it is possible at $T_F = T_{1F}\ln 2$ and $T_W = (T_{1W} + T_{1F})\ln 2$, where T_{1W} and T_{1F} - times of the longitudinal relaxation for water and fat accordingly [4,5,6]. For our field 0.5Tesla these assumptions are quite suitable, because T_{1W} ~ 1-2 c, T_{1F} ~100 ms. As longitudinal magnetizations both of water and fat at the moment of action 90^0 pulse are equal to zero, their transverse magnetizations after action of this pulse are equal to zero as well. In the case the receiver does not register the signals. Only the tissues with T_1 relaxation times different from T_{1W} and T_{1F} can contribute to the signal. The dependence of signal value on T_1, is shown on the Figure 1. According to the picture there is a general decreasing of the signal in 1.6 times. If hardware opportunities provide the high signal/noise ratio, the signal attenuation does not create problems. As we use comparably low-field MRI scanner TOMIKON S50 (BRUKER), the quantity of signal accumulation has been increased from 2 up to 3. Hermite radiofrequency 3.6 ms pulses with power up to 2 kVA were used. Delays had the values T_W=1300 ms, T_F=80 ms. Acquisition was realized by the multislice multiecho (MSME) method (20-24 slices had the thickness 4-6 mm, RARE-factor was equal to 8-12). Scanning time was about 5 minutes for 1 mm on pixel resolution.

Results

14 patients with brain meninges and subarachnoid spaces pathologies, and brain lesions at the vicinity of cerebrospinal fluid were investigated. 4 patients with brain injuries had 2 investigations**.** T1- and T2-weighted images have been obtained. For comparison the well known fat- (STIR) and water-suppression methods (FLAIR) have been used additionally to the simultaneous fat/water-suppression method. For 9 patients with blood close to the brain meninges our method with simultaneous fat and water signals suppression gave improved contrast of the pathological changes as compared with other MRI methods resulting in a much more reliable diagnosis. A typical MRI data for the same FOV is shown in Figure 2 for the patient K. (40 years old) who underwent a resection of subdural haematoma. Comparing the obtained images, one can notice, that the last method most distinctly reveals changes near brain meninges. The reason of it is the signal from the cerebrospinal fluid is the brightest on the T2-weighted and STIR-T2WI images. From the other side, small-information signals of bone and hypodermic fat prevail on the T1-weighted and FLAIR-images. Only at simultaneous fat and water signals suppression, the signal from a changed brain meninges (due to shortening of longitudinal relaxation time) becomes the brightest on the MR image.

Discussion

We put in the forefront the concept of maximal rectification of MRI tissue contrast picture to visualize better and realize 3D-construction of pathological forms presented by weak signals hidden ordinarily under intensive background of water and fat signals. The method of simultaneous fat and water signal suppression is most adaptive for solution of the task. The method is simple to implement and can be modified to improve an image quality and to decrease scanning time. For example one can use the pulses with more optimal shape and flip angle. Probably it will become more fruitful the use not only double inversion method but the combination of the inversion recovery one with chemical shift suppression technique. The method is rather useful for investigation of changes in meninges, subarachnoid spaces and other zones where pathological changes can be invisible because of recovering pathological tissue with fat and free liquid ones.

References

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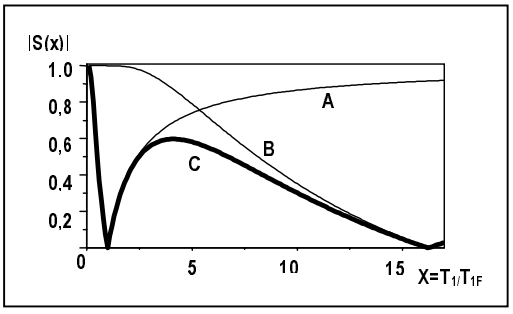

Figure 1. MR signal dependence on T_1 for various methods: A- STIR, B- FLAIR, C-double inversion-recovery. The last curve is described by formula: **$S(x)=1-2(1-\exp(-(\ln 2/x)(1/k+1))\exp(-\ln 2/x)$**, where **$k=T_{1F}/T_{1W}=0.06$**

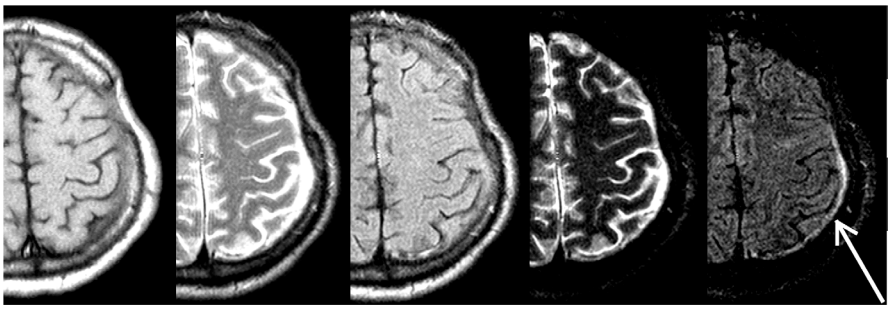

Figure 2. MRI data for the same FOV for the patient after surgery of subdural haematoma. From left to right: T1WI, T2WI, FLAIR, STIR-T2WI, double inversion recovery. Pathological changes are indicated by arrow.