Introduction

Magnetization transfer ratio (MTR) has been reported (1,2) to increase during brain activation. Why the MTR changes is still not known, and is the major goal of this abstract. We studied relaxation and magnetization transfer of brain tissue during a controlled experiment of spreading depression (SD). SD is a phenomenon in which the neuronal tissue undergoes a near total depolarization, accompanied by a massive depression and rapid redistribution of ions (3,4). In the experimental setting, SD can be triggered by an application of high-intensity mechanical, chemical or electrical stimulation to the cortical surface. Once triggered, neuronal depolarization propagates outward from the site of initiation and in effect entire depolarization of the hemisphere can be achieved (5). Recovery occurs within approximately 20 minutes after induced depression. SD, therefore, is an effective experimental method to probe physical processes of neuronal depolarization.

Methods

Male Wistar rats weighing between 350g to 400g (Charles River laboratory, Montreal, PQ) were used. Dexamethazone was administered by an intra-muscular injection 2 to 4 hours prior to the experiment to minimize tissue swelling (specifically the cortex). Following the surgical anesthesia (Sodium Pentobarbital; 50mg/kg), an incision (~3cm) was made along the midline and the skull was exposed by pulling back the muscle and the skin using a surgical clamp. One incision (~3cm) was made along the midline and the skull was exposed by pulling back the muscle and the skin using a surgical clamp. One

Results

Figure 1 presents longitudinal (T1) and transverse (T2) relaxation times and MTR as a function of time. Time t=0 indicates KCl delivery. The errors bars represent averages for three measured rats. Instant increase of both, T1 and T2 relaxation times is followed by a slow return to normal, after approximately twenty minutes. MTR decreases after KCl delivery.

Discussion

All measured MR parameters change during experimentally induced depolarization. T1 relaxation time increases by approximately 10% with depolarization. Change in the transverse relaxation time is substantially larger (~100%). Magnetization transfer results show MTR decrease (~10%). No change in the MT exchange rate, R, indicates that the MT process between water and macromolecular protons is not affected by neuronal depolarization. MTR is a phenomenological measurement that has been shown to depend on the amount of magnetization transfer and also on the direct saturation of free water by the rf pulse (8). Figure 2 shows MT curves and direct effect for normal and depolarized brain as calculated using fitted parameters of two-pool model analysis. The direct effect curve in the case of SD is shifted towards smaller offset frequencies, Δ, which is mainly caused by the increase in T2 relaxation. Consequently, MTR (as indicated by arrows in Fig.2) decreases. However, MT effect as defined as a maximum difference between direct effect and MT curve remains unchanged, although, the offset frequency Δ, at which the maximum MT effect occurs decreases. Therefore, changes in MTR due to depolarization are only caused by changes in T2 and to a lesser extent T1 relaxation. The mechanisms of this change in T1 and T2 are not known and require further studies.

Figure 2. MT curves (solid lines) and direct effect (dashed) for normal and depolarized brain.

References

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