New Contrast Material to Enhance MRI of Liver

Prof. Samir M. Badawi, Eng. Ehab H. Barakat, Prof. Mohamed Fokiren

Automatic control department, Menoufia University, Egypt

Abstract

Magnetic resonance imaging (MRI) image enhancements have been carried out using different contrast agents. In this paper, the influence of orally administrated accurately pre-specified magnetized-water (MW) on received signal of human liver MRI was investigated. Two experiments been carried out. The first (Invitro) performed using MW phantom. The latter a volunteer (40 years old, 80kg male) drank 750ml of MW. Twin groups of MRI images were performed over the same circumstantial conditions and MRI protocols; before and after oral administration of MW. The focused study on MRI showed a difference in image intensities after drinking the MW compared to normal MRI images. Further quantitative measurements applied using MATLAP genetic algorithm on images of MW phantoms lead to the result; patient preparation by drinking magnetized water affect signal intensity of MRI liver images.

Keywords: component; image contrast; MRI; magnetized water; enhancement

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Introduction

MAGNETIC resonance imaging (MRI) is useful and increasingly popular method for imaging the liver [1]. The efficacy of liver MR has been proven using magnet strengths from 0.5 to 1.5 Tesla (T). High field strength units generally produce images with the greatest liver-to lesion contrast and have shorter image acquisition time. Low field strength (0.2 to 0.4T) MR units are the majority in Egypt as well as other developing countries due to its respectively low price. According to World Health Organization (WHO) surveillance report, Egypt has a very high prevalence of HCV and a high morbidity and mortality from chronic liver disease, cirrhosis, and hepatocellular carcinoma. Approximately 20% of Egyptian blood donors are anti-HCV positive. Egypt has higher rates of HCV than neighboring countries as well as other countries in the world with comparable socioeconomic conditions and hygienic standards.

It is easy to imagine the high interest in development of new natural and safe contrast agents (CA) able to *enhance images in low field strength* MRI unit by increasing (locally) the *nuclear relaxation rates*. Most MRI contrast agents are paramagnetic chemicals that increase parameters called the T1 and T2 relaxation rates of water, as observed in tissue and solution; T1 or T2 relaxation enhancements produce image brightening or darkening, respectively [2]. Additional classes of contrast agent's work by a chemical exchange-based mechanism called chemical exchange saturation transfer (CEST) [3. The Toxicity of contrast agents should be considered, where Nephrotoxicity (toxicity to the kidneys) is a major consideration for clinicians when requesting tests which use an iodine-based contrast media. Patients whose renal function is impaired (usually with a creatinine >120 micro mol/liter) should only have contrast media if absolutely necessary. In these circumstances, a special form of contrast media, which is 'kinder' to the kidneys, can be given to prevent contrast-induced nephropathy [10]. Nephrogenic systemic fibrosis (NSF) with MRI contrast agent can appear through the administration of gadolinium for MR contrast enhancement. Although rare and only in renal compromised patients, it produces serious side-effects that may involve fibrosis of skin, joints, eyes, and internal organs.

Because of this toxicity, using magnetized water or injecting magnetic saline will be healthier than normal contrast agents in MRI.

The ordinary water (tap water) molecules consist of one oxygen and two hydrogen bonded as an isolated triangle with its upper angle is 105º, as shown in Fig. 1. Generally, when water is subjected to a magnetic field *(magnetized water)*, the water molecules will arrange in one direction as shown in Fig.2. This mode of arrangement is caused by relaxation bonds, then the bond angle decreases to less than 105º [16], leading to a decrease in the consolidation degree between water molecules, and increase in size of molecules. For these reasons, the viscosity of magnetic water is less than viscosity of normal water. This change in water molecules composite causes a change in permeability pressure, surface tension, pH and electric conduction.

Material and Methods

Magnetic water phantom Imaging

Two water phantoms used. Each one is constructed of biodegradable latex rubber balloons and filed with 450 ml. one is field with normal tap water to be used as a reference, where the other is field with magnetic water. Both phantoms are scanned using small body coil of 0.2 Tesla MR (IRIS MATE, Hitachi, Japan). The magnetic water phantom scanned after 4 hours of magnetization Fig. 3.

The resulted images for magnetized and non- magnetized water phantoms are quantitatively processed by MATLAP Genetic Algorithms (GAs) after calculating (signal/noise) S/N ratio. We applied the following signal equation for a repeated spin-echo sequence as a function of the repetition time (TR), and the echo time (TE) where it defined as the time between the 90o pulse and the maximum amplitude in the echo.

$$S = k (1 - e^{-TR/T1}) e^{-TE/T2} \qquad (1)$$

This equation is only valid when TR >> TE. In our experiment we used TR= 2700,TE=120, and k = $8560*10^{7}$.

MRI live imaging

Liver imaging experiment executed on a volunteer (40 years old, 80 kg, 173 cm) using a standard abdomen coil of 0.2 T MRI machine (Open Viva, Siemens). The initial MRI examination included axial Fast spin-echo (FSE), T1-weighted [repetition time (TR) 570 ms, echo time (TE) 15 ms], matrix of 512X164.

Two identical image series of MRI abdomen images acquired. The first image series performed at 12.30 PM (before drinking MW), Fig. 4. At 1:00 PM the volunteer start drinking 750 ml of magnetized water, where at 5.30 PM the second series of delayed images acquired, Fig. 5. The volunteer did not report any complaints during or within 48 h after the process of MW.

Results

Phantom imaging analysis

Quantitative analyses performed by using MATLAB Genetic algorithms (GAs) to estimate T1 and T2 for both magnetized and non-magnetized water phantoms based on calculated S/N ratio for both images. Table (1) shows imaging parameters in addition to the indicative S/N ratio, and results of GAs. We used for both magnetized and non- magnetized images the same calculating parameters as: Function tolerance= 1e-100, Generation = 10000.

The results present encouraging changes in T1, where no significant changes occurred in T2.

Liver imaging analysis

Qualitative and quantitative analysis considered to insure the research results. The qualitative analyses done by two expert radiologists jointly where they analyzed matched pre and post-oral administration of magnetized water images. The process carried out based on visual inspection and experience as regular diagnostic and reporting process. One of the expert radiologists experienced minor improvement on the images, where the other radiologist doesn’t report any considerable changes with respect to image enhancement.

Quantitative assessment performed using different software packages (efilm, Image tool V. 3, and medical image processing and visualization MIPV) for image acquire and calculations. For region of interest (ROI) considered on each image with total area of 2.4 cm2 as shown in Fig. 6. Mathematical mean value increased in all ROIs of the images acquired after drinking the magnetized water, with respect to before oral administration of magnetic water

Discussion

In conclusion, this study clearly indicated significant quantitative changes in MRI of magnetized water phantom with respect to tap water. Magnetized water is promising to be administrated orally as a CA to enhance MRI liver images, where further investigations and experiments on patients with pathological liver are needed.

TABLE I. Water phantoms imaging parameters and results of Matlab GAS

Magnetization time	TR	TE	S/N ration	T1	T2
0 Hours	2700	120	**156.3**	672	11
4 Hours	2700	120	**337.5**	1513	12

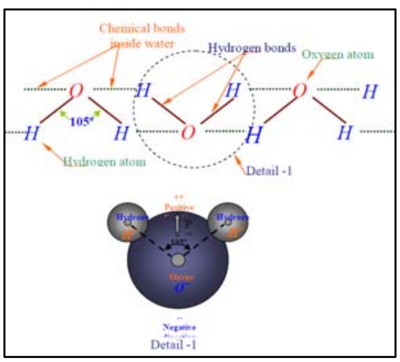

Fig. 1. Water Molecule

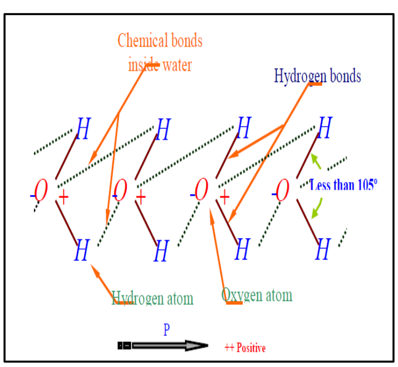

Fig. 2. Directional arrangement of water Molecule under effect of magnetization

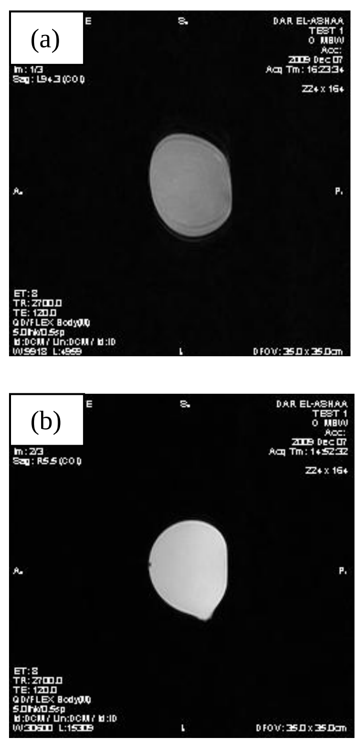

Fig. 3. Images of water phantoms
(a) Non-Magnetized water phantom
(b) Magnetized water phantom

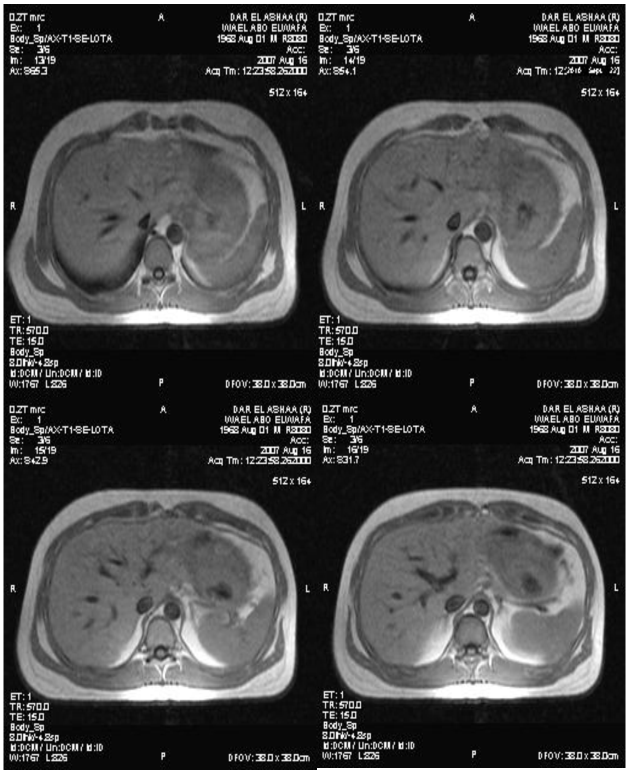

Fig. 4, Liver MRI pre-oral administration of Magnetized water

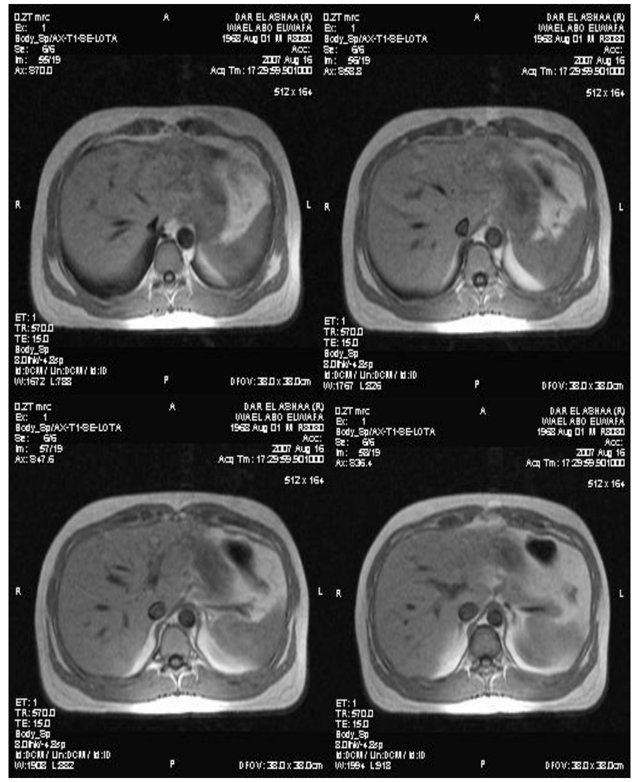

Fig. 5, Liver MRI post-oral administration of Magnetized water.

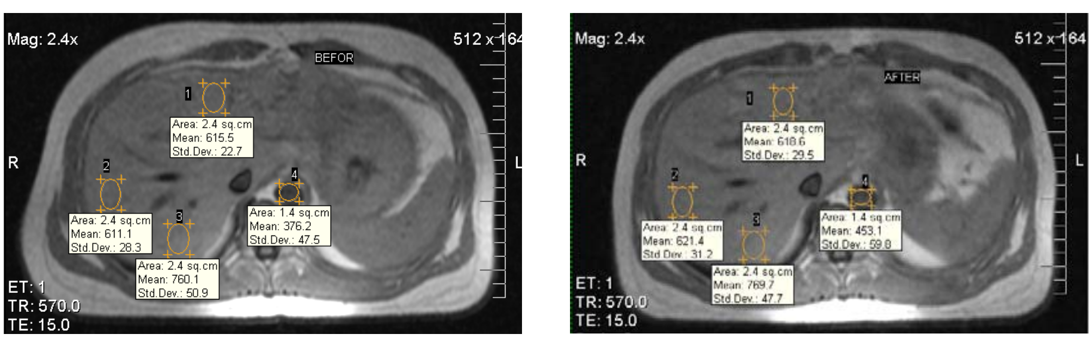

Fig. 6. MRI liver with different ROI to compare mathematical mean in (a) Before oral administration of magnetic water, (b) After oral administration of magnetic water.

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