ENHANCING MAGNETIC RESONANCE IMAGES USING WATER BAGS

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Fascial planes between tissues are separated by connective tissue, fat, and blood vessels. Magnetic resonance imaging displays surface anatomy and soft tissues. Our team has been successful in demonstrating brachial plexus nerves as a model of magnetic resonance anatomy. Radiologists have devised methods to increase the resolution of images by suppressing noise and increasing the sharpness of the image. We added water bags to a 0.3 tesla permanent magnet suppressing the noise and increasing the signal to image our patients. The images proved to be sharper.

Key words • magnetic resonance imaging • signal to noise ratio • surface anatomy • brachial plexus

Following the first neuroradiology conference in 1964, the University of California at Los Angeles adopted ultrasonography as an imaging modality. The medium of choice for transmission at that time was water. However, due to evaporation and run-off effects, oil or lubricant jelly was substituted and enhanced ultrasound images were thus obtained. Resolution of nuclear medicine studies is improved by subtracting background counts obtained from the thigh from those obtained from the neck for thyroid scans. In 1987, a portion of the left brachial plexus from a recently deceased patient was removed and magnetic resonance (MR) images were obtained by placing a water bag containing a 0.9% saline solution beneath the specimen. Without the water bag, an image could not be obtained. With this observation, it seems logical to apply this technique to enhance the MR images obtained from the chest, abdomen, and soft tissues with a body coil.

We have performed preliminary experiments in six patients with and without saline bags in the gantry and have increased the signal to noise ratio, thereby sharpening the images. Numerical evaluation has verified the success of our experiments. This article reports our findings and suggests improvements on how to enhance imaging, especially when the signal to noise ratio is low.

METHODS AND MATERIALS

A patient's chest and abdomen were imaged with a 0.3 tesla Fonar Beta-3000 permanent magnetic resonance unit with a vertical field. Images were taken on axial (transverse) and coronal planes using a 13.5 × 22 inch elliptical body coil. Six water bags, each containing 500 mL of a 0.9% saline solution, were then placed beneath the patient's chest and abdomen with the longitudinal axis of the bags parallel to the vertebral column of the patient. All images were recorded with an echo time (TE) of 28 msec and repetition time (TR) of 800 msec, with four excitations and 3200 base encoding levels. Slices were 9 mm thick with an interval of 12 mm. Signal to noise measurements were taken with circular regions of interest at the same

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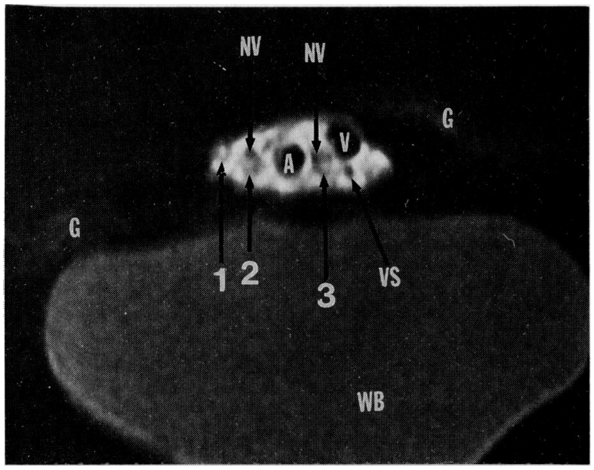
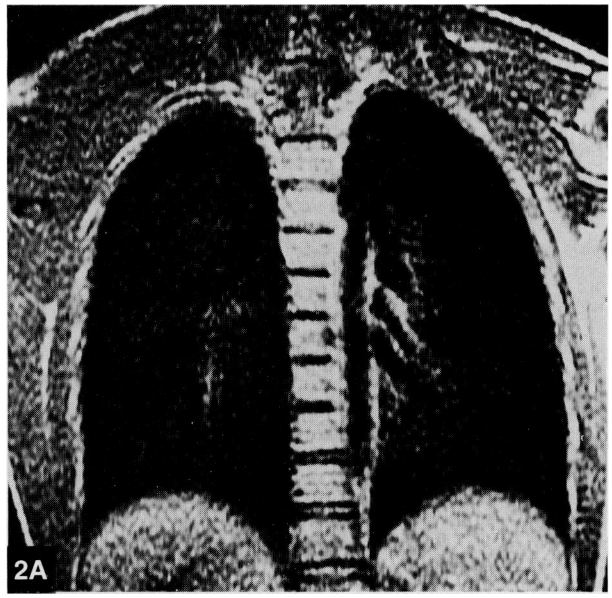
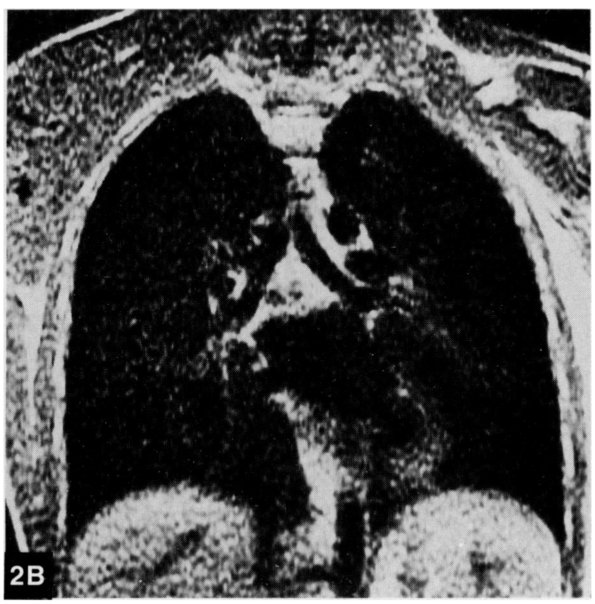
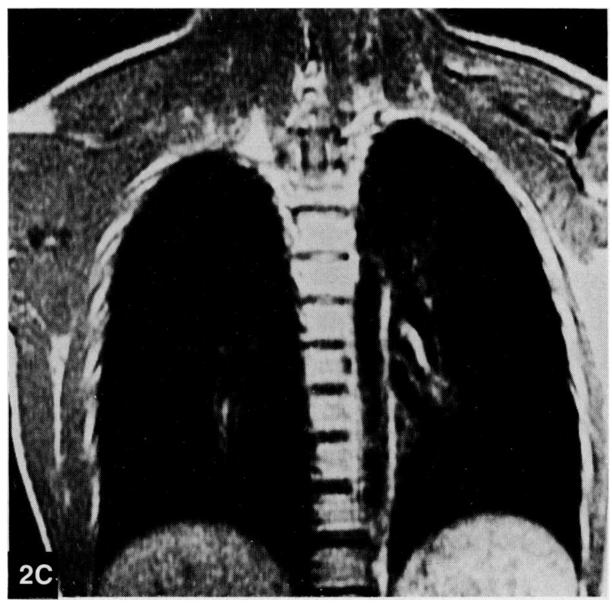


Figure 1. Axial magnetic resonance image of the gross brachial plexus specimen: artery (A), vein (V), and nerves (1, 2, 3). The nerves are identified by their relative intermediate signal. The nutrient arteries (NV) are superior to the brachial plexus nerves. The water-soaked gauze (G) and water bag (WB) enhance the imaging.







anatomical point both with and without the water bags in place.

RESULTS

Figure 1 is the brachial plexus specimen imaged by placing a water bag beneath the small tissue specimen. Imaging of the specimen was not possible until the water bag was placed beneath it.[1] T1-weighted images are coarse in examination of the chest. Until now, we could not correct this coarseness. In Figure 2, selected images are displayed from the coronal images of the chest used to evaluate our theory. Figure 2A and 2B are images obtained without water bags. The images are coarse and not optimal for evaluation. Figures 2C and 2D are coronal images of the chest at approximately the same level as Figures 2A and 2B but with water bags in the gantry. The placement of the water bags beneath the

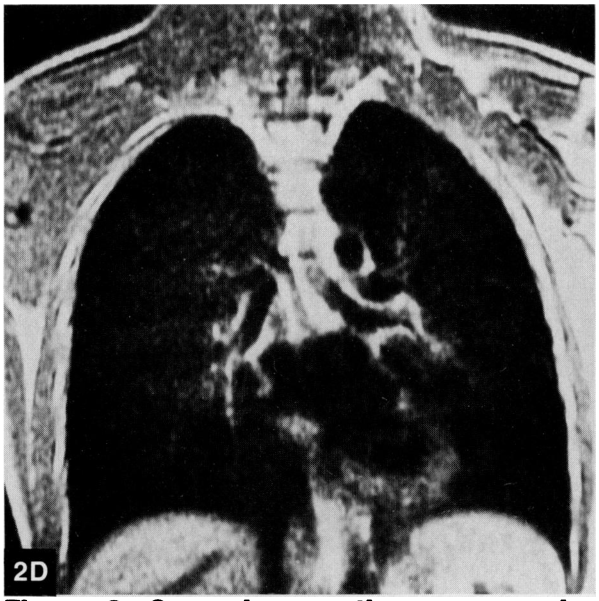


Figure 2. Coronal magnetic resonance images. A. The most posterior of the series without the water bags. Note the coarseness of the muscular structures, liver, spleen, and soft tissues. B. A more anterior cut demonstrating the left atrium. Coarseness of the structure as demonstrated in 2A is unchanged. C. Posterior image corresponding to 2A with the addition of water bags. Note the sharpness of the muscular, soft tissue and osseous structures. D. A more anterior cut corresponding to 2B with the addition of water bags. Note the sharpness of the vasculature in the mediastinum and of the muscular, soft tissue and osseous structures.

patient allowed us to correct the low signal to noise relationship. The experiment was repeated with a newer 0.3 tesla Fonar unit with an optimal high signal to noise ratio. The addition of the water bags did not change the imaging in comparison with the images obtained without the water bags.

DISCUSSION

Small tissues may not have enough protons to provide a sufficiently high signal to obtain optimal MR images. However, placement of water bags beneath such tissues may boost the signal, thus allowing optimal tuning and subsequently better images. When the signal to noise ratio is low, images are coarse. However, placement of water bags beneath the patient boosts the signal and enhances the images. The images are sharper and show greater detail, particularly in the soft tissues, than images obtained without water bags in the gantry. Signal to noise measurements show a twofold improvement. In cases in which sufficient signal and optimal tuning are present, no numerical difference is demonstrated. But even in these cases, decreasing the field of view in order to image small structures, particularly when evaluating pathology, may be desirable. Although the resolution is increased in such cases, the signal to noise ratio is decreased quadratically, ie, as the square of the increase in resolution, and the addition of water bags boosts the signal and provides better tuning, thereby enhancing the images.

The imaging of small tissues which produce diminished proton signals is made possible by the addition of protons into the gantry. Our team suggests that when the signal to noise ratio is low, water bags placed in the gantry may increase the signal to noise ratio and, thus, display sharper MR images of the chest and small extremities. Our work is ongoing, with body MR imaging of adult and pediatric patients and in vitro experiments with pathological specimens being undertaken.

Literature Cited

1. Collins JD, Shaver ML, Batra P, Brown K. Nerves on magnetic resonance imaging. *J Natl Med Assoc.* 1989; 81(2):129-134.