Motion-Artifact-Free T2-Weighted 3D Imaging of the Cervical Spine

JP Mugler III

Department of Radiology, University of Virginia School of Medicine, Charlottesville, VA, USA

INTRODUCTION

The quality of T2-weighted cervical-spine images is often compromised by artifacts arising from the pulsatile motion of the cerebrospinal fluid (CSF) surrounding the cord, even when established flow-compensation techniques are used. One potential solution to this problem is fluid-attenuated inversion-recovery (FLAIR) imaging [1,2]. While properly-designed FLAIR techniques can completely suppress the signal from CSF, there remains concern about the ability of FLAIR to depict the full range of clinically-relevant cord lesions [3,4].

We have devised an alternative method for obtaining motion-artifact-free T2-weighted cervical-spine images. This method takes advantage of motion-induced dephasing to selectively suppress the signal from moving CSF, while potentially avoiding the contrast limitations of FLAIR imaging.

MATERIALS AND METHODS

Motion-induced intravoxel dephasing is used in fast-SE-based "black-blood" MR angiography to selectively suppress the signal from flowing blood [5]. Refocusing RF-pulse flip angles less than 180˚ and long echo trains favor increased phase dispersion secondary to motion. It was therefore our hypothesis that a very long SE train, using low-flip-angle refocusing pulses, may permit the signal corresponding to even relatively low CSF velocities to be suppressed.

Using a computer-based theoretical model, a variable-flip-angle refocusing RF-pulse series was calculated that yielded T2-weighted contrast and prescribed, well-behaved signal evolutions for T1 and T2 relaxation times corresponding to those for central-nervous-system tissues at 1.5 T. The RF-pulse series included 160 echoes with an average refocusing flip angle of 60˚. Additional details of this long SE train can be found in reference [6].

The 160-echo variable-flip-angle series was implemented in a 3D single-slab T2-weighted fast-SE-based pulse sequence, adapted from previously-described techniques [7]. Imaging was performed on a 1.5 T whole-body imager (Symphony, Siemens Medical Systems). To verify the basic contrast properties of the pulse sequence, images of the head were acquired in healthy volunteers after obtaining informed consent. Subsequently, images of the cervical spine were acquired in volunteers.

RESULTS

Figure 1 shows an axial 3D image of the brain acquired using the 160-echo pulse sequence. Although the effective TE is 328 ms, the image contrast appears very similar to that for T2-weighted conventional SE imaging. Note the high signal from CSF, typical of T2-weighting imaging.

Figure 2 shows a sagittal image of the cervical spine, also acquired using the 160-echo pulse sequence. By simply orienting the readout axis along the spine, the signal from CSF is uniformly suppressed without generating motion artifacts. Images were also acquired with the readout gradient perpendicular to the spinal cord. In these images the CSF was bright; however, motion artifacts overlaying the cord substantially degraded the image quality.

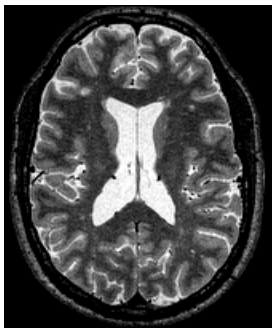

FIG 1: T2-weighted axial 3D-SE image demonstrating the contrast properties of the 160-echo pulse sequence in the brain. Age-related, non-specific white-matter lesions are seen in this 59-year-old volunteer. The phase-encoding direction corresponding to the 160-echo train is left-to-right; no image artifacts secondary to this very long SE-train are apparent. Sequence parameters included TR/effective TE, 2750/328 ms; matrix, 256 x 160 x 216; FOV, 25.6 x 16.0 x 21.6 cm; echo spacing, 4.1 ms; ETL, 160; acquisition time, 10 minutes.

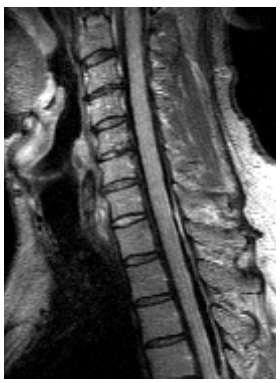

FIG 2: Sagittal T2-weighted 3D-SE image demonstrating CSF suppression in the cervical spine with the 160-echo sequence. Imaging parameters included TR/effective TE, 2750/336 ms; matrix, 256 x 160 x 168; FOV, 25.6 x 19.2 x 25.2 cm; echo spacing, 4.2 ms; ETL, 160; acquisition time, 7.7 minutes.

DISCUSSION

These "dark-CSF" images, such as illustrated in Fig. 2, differ from FLAIR images in an important way. With FLAIR, the CSF is suppressed based on its long T1. Hence, the signals from any other tissues with relatively long T1s will be diminished. This is one potential explanation for the problems in depicting certain multiple sclerosis lesions with FLAIR [3,4]; these lesions may have long T1 components. In contrast, the CSF is suppressed in Fig. 2 solely due to its motion; long T1 lesions in the cord will be unaffected.

CONCLUSION

A single-slab T2-weighted fast-SE-based 3D pulse sequence has been combined with a very long SE train to yield motion-artifact-free, T2-weighted images of the cervical spine. This technique has the advantage over existing methods of providing contrast properties analogous to established T2-weighted methods and robust suppression of CSF-motion-induced artifacts.

REFERENCES

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