Technical Note

# HASTE MR Imaging: Description of Technique and Preliminary Results in the Abdomen

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**HASTE (HAlf fourier Single-shot Turbo spin-Echo) is a single-section T2-weighted sequence that acquires images in less than 1 second. Images are breathing independent and possess a variety of other features useful for imaging the abdomen. The design of this technique is described. Clinical studies of 38 consecutive patients were performed using this technique. HASTE images were considered good in 28 and fair in 10 patients, including five patients who could not suspend respiration. Definition of liver and bowel was particularly clear.**

**Index terms:** Magnetic resonance (MR), rapid imaging 761.121416 • Magnetic resonance, pulse sequences • Abdomen, MR studies, 70.1214 • Magnetic resonance (MR), technology

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**Abbreviations:** FOV = field of view, FSE = fast spin-echo, GRASE = gradient and spin echo, HASTE = HAlf Fourier Single-shot Turbo spin-Echo, PSIF = reversed FISP (fast imaging with steady state precession).

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ABDOMINAL MR EXAMINATIONS are limited by lengthy study time, frequent problems with artifacts, lack of consistent image quality, and poor definition of bowel. Breath-hold and breathing-independent techniques have been developed to overcome these limitations. We describe the design of a new, breathing-independent T2-weighted sequence termed "HASTE" (HAlf fourier Single-shot Turbo spin-Echo) and present our initial results in the abdomen.

## • MR TECHNIQUE

HASTE images were performed on 1.5-T MR imager (Magnetom VISION, Siemens Medical Systems, Iselin, NJ). The HASTE technique uses a single slice-selective excitation and multiple refocusing RF pulses (1). Each echo is acquired after the application of a different phase-encoding gradient pulse. HASTE images were acquired with the following parameters: TR = infinite, TE = 60 msec, receiver bandwidth = 650 Hz/pixel, echo train length = 104, echo spacing = 4.3 msec, section thickness = 8 mm, gap = 2.4 mm, matrix = 192 × 256 (phase encoding, readout), field of view (FOV) = 350 mm with 3/4 rectangular FOV, half-Fourier reconstruction. Data collection required approximately 500 msec per slice, and a 1-second delay between each slice was used. This enabled 15 slices to be acquired in 22 seconds. The circularly polarized scanner body coil was used as the transmitter coil for all patient studies and as receiver coil for seven patients. A four-element phased-array body surface coil was used as the receiver coil for 31 patients.

## • PATIENTS AND IMAGE ANALYSIS

HASTE MR images were acquired in 38 consecutive patients (19 men, 19 women; age range, 3–80 years; mean, 46.7 years). Five of the patients were unable to suspend respiration. Two investigators evaluated HASTE images in concert and the following determinations were made: image quality (rated as poor, fair, good), breathing-related ghosting artifact, bowel motion susceptibility difference artifact from air in bowel lumen, and chemical shift artifact (all artifacts rated as negligible, moderate, or severe). The following parameters were used to evaluate image quality: resolution, sharpness, clarity, and lack of artifacts.

## • RESULTS

Image quality of transaxial images was rated as good in 28 cases and fair in 10 cases. Coronal images acquired in 31 of the 38 patients were considered good in 29 patients (Fig. 1) and fair in 2 patients. Four of the patients in whom transaxial images were rated as fair were of small transverse diameter (approximately 200–250 mm), and the remaining six patients were imaged in the scanner body coil. These images had low signal-to-noise ratio with evident pixel graininess. Coronal images were obtained for eight of these patients and were considered good in six and fair in two patients, which presumably reflected the fact that interrogated tissue was of larger volume in the coronal plane. Artifacts including ghosting, bowel motion, susceptibility difference, and chemical shift were negligible in all cases (Fig. 1).

## • DISCUSSION

Use of breathing-averaged T2-weighted techniques in abdominal MRI has been problematic because of decreased patient throughout, high study cost, and variable image quality. All of these problems result from lengthy examination times. This has stimulated the development of a variety of breath-hold or breathing-independent T2/T2*-weighted techniques. These include 90°–180°–90° preparation pulse turbo *f*ast *l*ow-*a*ngle *s*hot (FLASH) (2), long TE gradient echo (3), PSIF (4), gradient and spin echo (GRASE) (5), and echo-planar imaging (6,7). All of these approaches, however, have limitations in abdominal imaging that have resulted in a lack of widespread acceptance. These limitations include nontrue T2-weighting (long TE gradient echo, PSIF), sensitivity to susceptibility artifact (long TE gradient echo, echo-planar imaging), decreased signal-to-noise ratio (turbo FLASH), sensitivity to motion (PSIF, echo-planar im-

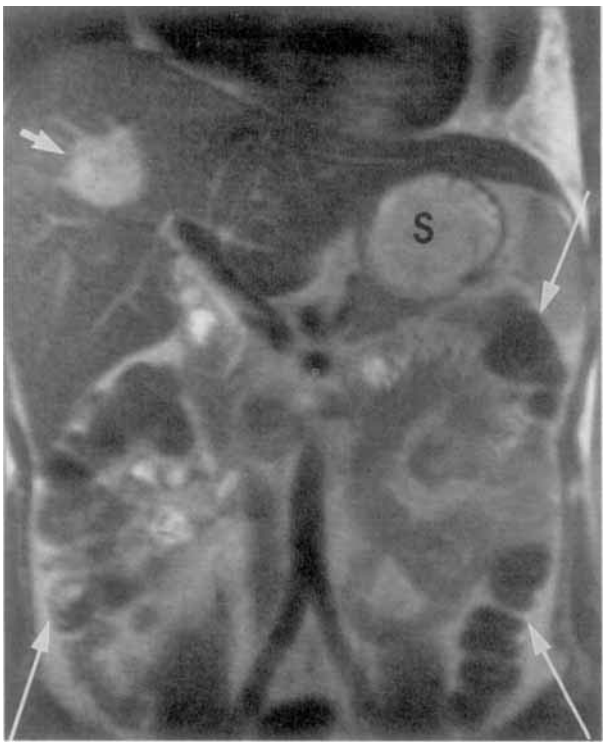


**Figure 1.** Coronal HASTE (TR = infinite, effective TE = 60 msec, section thickness = 8 mm, matrix = 192 × 256, FOV = 350 mm) image acquired in the phased-array body coil in a 28-year-old man with hepatic lymphoma. High signal focus of lymphoma is noted in the liver (small arrow). Note the sharp delineation of stomach (S) and small bowel and the lack of susceptibility artifact related to air-filled colon (long arrows). Image quality is good despite the inability of the patient to suspend respiration.

aging), and severe chemical shift artifacts (echo-planar imaging).

The HASTE technique is similar to the fast spin-echo (FSE) technique (8,9) and to GRASE (5). The difference between them is that FSE uses multiple excitation pulses to acquire the complete raw data set, whereas HASTE uses a single excitation pulse together with half-Fourier acquisition and reconstruction to produce relatively high-resolution images in less than 1 second. GRASE also uses multiple excitation pulses together with gradient echoes, making motion-free imaging more problematic. The results of our study demonstrate that HASTE results in reproducible and good image quality, even in patients who breathe through the data-acquisition period, which occurred in five patients in our study. Lack of artifacts is also an important attribute for an imaging sequence, and we had observed negligible artifacts in all patients in this study. Breathing-related ghosting artifact, bowel motion, chemical shift, and susceptibility artifact were virtually absent in all examinations. The major drawback of the sequence at this time is low signal-to-noise ratio. In the 10 examinations in which HASTE was rated as fair, the patients were either small or the scanner body coil was used and the lower signal-to-noise ratio resulted in pixel graininess. Other problems include limited FOV and slice-thickness capabilities due to the short-duration, high-amplitude gradient pulses required for rapid data collection. Localized RF energy absorption rates are also greater than for standard sequences.

Common T2-weighted sequences in clinical use, such as conventional spin-echo, fat-suppressed spin-echo, and turbo (fast) spin-echo, generally have limited applicability in the investigation of abdominal disease outside the liver or pelvic organs. The explanation for this is poor delineation of bowel and poor separation of normal bowel from other structures, both normal and diseased, in the peritoneal or retroperitoneal spaces. The combination of breathing-related ghosting artifact, bowel motion, and magnetic susceptibility difference artifact from air in bowel are largely responsible for this shortcoming. HASTE overcomes this problem with subsecond temporal resolution, which effectively freezes bowel motion and narrow spacing of the RF refocusing pulses that minimize susceptibility artifact. Clear definition of bowel with the HASTE sequence may represent the most important feature of this sequence and may have an impact for increased use of MRI in abdominal examinations. Although none of the patients in this study had surgical clips, our subsequent clinical experience shows that susceptibility artifacts from surgical clips are diminished with HASTE.

T2-weighted imaging also suffers from intrinsically low signal-to-noise ratio, which is usually alleviated by the use of a narrow receiver bandwidth. A narrow receiver bandwidth results in chemical shift artifacts that may mask disease, which is a particular problem along the liver capsule or bladder wall. HASTE employs a wide receiver bandwidth because of the necessity of short sampling time periods due to the short echo spacing. The wide bandwidth results in negligible (<1 mm) chemical shift artifacts, which were observed in our patient population.

In summary, HASTE is a breathing-independent T2-weighted technique that possesses reproducible image quality and does not suffer from breathing, bowel motion, chemical shift, or susceptibility difference artifacts. Based on the results of our initial experience, we have incorporated HASTE into our everyday abdominal imaging protocols, and our clinical experience with over 400 additional examinations reflects the results of the current study. This technique has the potential to greatly reduce examination times while expanding the role of MR for the investigation of abdominal disease.

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