Basic Strategies for Body MRI: Pulse Sequence

Jeffrey C. Weinreb, M.D.- Yale School of Medicine

jeffrey.weinreb@yale.edu

The abdomen and pelvis present an ensemble of problems for MR imaging.

1. There is a problem of **contrast**; there are an almost infinite variety of disease processes that can occur in the abdomen/pelvis, and no one sequence is ideal for all.
2. There is the problem of **signal-to-noise and coverage**; evaluation of the abdomen/pelvis often requires a large field-of-view
3. There are problems with **complex motion** arising from the heart, the vascular structures, breathing, and peristalsis.

There are now solutions for all of these problems, and MRI is assuming more of the clinical burden that has heretofore been the domain of CT.

Since there is no single sequence that is ideal for all types of pathology (either anticipated or not anticipated), multiple sequences are required. However, it is important to use the minimum number of sequences that will provide the maximum amount of information. There should be a rational reason for every sequence obtained, and the MRI examination should be tailored to the specific clinical situation (including specific clinical questions and patient's body habitus and ability to cooperate).

T1-Weighted Sequences

Spoiled gradient-echo (GRE) techniques permit the entire abdomen to be scanned in a single comfortable breath-hold. This, in turn, opens up the possibility of doing dynamic contrast-enhanced scans, and by adjusting the TE, scans can be obtained with water and lipid in-phase (IP) and opposed-phase (OP). Currently, both IP and OP images through the entire abdomen or pelvis can be obtained in one breath-hold sequence. A comparison of IP and OP phase images allows one to diagnose focal and diffuse fatty infiltration of the liver, to characterize incidental lesions in the adrenal glands, and to detect the presence of fat in ovarian dermoids and other tumors that may not be apparent with other techniques.

Fat-saturation improves lesion-organ contrast on T1-weighted images. In early implementations, fat saturation resulted in a decrease in the number of slices obtainable per TR, and heterogeneous fat suppression through the abdomen occasionally introduced problems in interpretation. Improved local shimming and fat saturation pulses placed outside of the imaging loop (i.e. "quick fat-sat") and **Dixon techniques**

permit the entire abdomen/pelvis to be scanned with uniform fat suppression in a single breath-hold

T2-Weighted Sequences

Fast SE sequences (a.k.a. FSE or TurboSE) provide inferior liver/lesion contrast compared with conventional SE due to magnetization transfer and other effects. Longer echo trains may aggravate this problem, However, whatever contrast is sacrificed by using FSE sequences is more than compensated for by an overall improvement in image quality and a substantial savings in time. Contrast is improved and motion artifacts are reduced with the addition of fat suppression, which can be accomplished using **STIR.**

By judicious selection of imaging parameters, and by rearranging the order and manner in which the lines of K-space are acquired, FSE T2-weighted images can be obtained in the time frame of a breath-hold. Variations include a **single shot** version (eg. HASTE, SSFSE). In general, the lesion-liver contrast on these images is compromised and there may be perceptible blurring. These are most useful for (1) T2-weighted images in patients who are not able to suspend respiration, (2) T2-weighted imaged images in an orthogonal plane to supplement the routine sequences, and (3) imaging fluid (so called "hydrograms") for MRCP's, MR urograms, etc. Hydrograms may also be obtained with a **balanced steady state free precession (SSFP)** sequence (eg. FIESTA, true FISP)

3D versions of T2-weighted sequences are available. Thus far, they have been used most commonly in the pelvis.

Because **EPI (echo-planar imaging)** is so fast and can provide images with excellent T2-contrast, it might be able to replace slower T2W sequences for some indications, and when used to implement **DWI (diffusion-weighted imaging)**, it may contribute some additional diagnostic capabilities, such as lesion detection and characterization. In the body problems with susceptibility and chemical shift, even at 3T, have been mitigated with technical advances

Intravenous Contrast Agents

Gadolinium-chelate agents improve the confidence level for lesion detection and characterization in the abdomen and should be used in most instances. The arterial phase is an important component of a dynamic contrast enhanced hepatic scan. Multiphase phase imaging is also useful for evaluation of the pancreas, kidney, and sometimes the uterus. However, for some abdominal applications, such as determination of the presence of lipid in a known adrenal mass, and for many gynecologic applications, they may not be as useful.

3D-fat suppressed breath-hold T1-weighted spoiled gradient echo sequences, such as VIBE and LAVA, are commonly used for contrast-enhanced l MRI studies. There are newer acquisition and reconstruction techniques that are starting to become available that use some **combination of compressed sensing, parallel imaging, and radial sampling**. These obviate the need for timing the bolus injection and even the

need for breath holding for abdominal MRI exams. As these types of techniques are refined and become commercially available, it will likely change the equation about who gets MRI and who gets CT.

REFERENCES

Chandarana MD, Feng Li, Block TK, Rosenkrantz A, Lim RP, Babb JS, Sodickson DK, Optazo R. Invest Radiol 2013;48:10-16

Earls JP, Rofsky NM, DeCorato DR, Krinsky GA, Weinreb JC. Hepatic arterial-phase dynamic gadolinium-enhanced MR imaging: optimization with a test examination and a power injector. Radiology 1997;202:268-273

Keogan MT, Edelman RR. Technologic advances in abdominal MR imaging. Radiology 2001;220:310-320

Reeder SB, McKenzie CA, Pindea AR, Huanzhou Y, Shimakawa A, Brau AJ, Jargreaves BA, Gold G, Brttain JH. Water-fat speeration with IDEAL gradient-echo imaging. J Magn Reson Imaging 2007;25:644-652

Rofsky N, Weinreb JC, Ambrosino M, Safir J, Krinsky G. Comparison between in-phase and opposed-phase T1-weighted breath-hold FLASH sequences for hepatic imaging. J Comput Assist Tomogr 1996; 20(2):230-235.

Rofsky NM, Lee VS, Laub G, Thomassen D, Pollack MA, Krinsky GA, Weinreb JC. Abdominal MR imaging with a volumetric interpolated breath-hold examination. Radiology 1999;212:876-884

Schmid-Tannwald C, Oto A, Reiser MF, Zech C. Diffusion-weighted MRI in the abdomen: current value in clinical routine. J Magn Reson Imaging 2013;37:35-47