3 Tesla MRI: Higher the better?

Until recent past, 3 Tesla (measuring unit of magnetic field strength) magnetic resonance imaging (3T MRI) was only used in research applications. However, as MRI technology evolves, 3T MRI studies (as opposed to 1.5T) are increasingly common in the clinical settings both hospitals and out-patients services. This shift in interest of radiology community from 1.5T to 3T validates the notion that very high filed MRI would be superior to 1.5T for clinical imaging. The higher field strength of 3T MRI (1 T=10,000 Gauss) results in an increase in signal-to-noise ratio (SNR), spatial resolution, and speed, all of which may provide substantial benefits. However, radiologists familiar with 3T MRI have cited several limitations to the increased field strength, such as a greater amount of acoustic noise, imaging contrast issues, and safety concerns.

We understand that signal increases proportional to the square of the static magnetic field strength while noise increases linearly. This infers that SNR of a 3T system would be twice as good as at of 1.5T. But we now know that in most tissues the actual improvement is only in the 30-60% range (instead of 100%). This is mainly because due to changes in imaging parameters related to the increase in T1 and in the specific absorption rate (SAR), a measure of energy deposition in the patient's tissues. However, parallel imaging techniques play an important role in maintaining the increased SNR and an acceptable SAR while achieving decreased acquisition time and possibly, improved spatial resolution at 3T body imaging.

The rapid gradient switching is responsible for acoustic noise in MRI and noise level in a 3T MRI is much greater than 1.5T and may exceed 130 dBA which is greater than permissible FDA's limit of 99 dBA. The acoustic noise in new shorter bore MRIs is much louder than older long bore systems. This requires better insulation of both the unit itself and imaging room and also provision of hearing protection to patients like ear plugs or headphones.

Another issue with 3T MRI is SAR which is defined as the amount of radiofrequency energy (Joules) deposited in tissue mass (Kg) and causes local rise in tissue temperature. It is considered that unregulated absorption may lead to tissue injury and this potential is higher with 3T than 1.5T machines. The FDA has set a limit of SAR which results in increase of 1 degree centigrade in any tissue. The most considerable safety apprehension is effect of magnetic field on medical devices and various metallic implants. At this time, it appears that most patients who are eligible for 1.5T imaging will be able to undergo 3T imaging. However, problems presented by 3T systems for metallic implants include translational attraction (projectile effect) and torque. Since data is gathering regarding this aspect of 3T, it is suggested that patients with a surgical implant or device should better be evaluated with a lower-field-strength magnet. Pregnant patients and patients with ascites also may be better evaluated with a 1.5T MR imaging system than with a 3T system because of RF inhomogeneity artifacts, which may lead to non-diagnostic images.

Superior quality images provided by 3T system is the major impetus for enticing the neurology community due to higher lesion detectability attributed to higher spatial resolution and lower noise. Higher SNR ensures a better diffusion weighted imaging (DWI) although with susceptibility artifacts which can limit interpretation of structures in close vicinity to skull base or paranasal sinuses. But these artifacts are tailored by adopting parallel imaging techniques with surface coils and broadband. Similarly higher magnetic field is associated with enhanced chemical shift with improved spectral resolution of metabolites like glutamate and glutamine. 3T imaging also provides superior flow based MR angiography (time of flight MR angiography; TOF MRA) and this is attributed by exploitation of longer T1 of background tissue in higher magnetic field. 3T has undeniably improved the capability of functional MRI (fMRI) with about 40% increases in detection efficiency of blood oxygen level dependent (BOLD) than 1.5T MRI.Body imaging using 3T provides high resolution images with promising results in 3DMR cholangiopancreatography (MRCP), staging of cervical carcinoma, staging of rectal carcinoma and carcinoma of prostate (without endorectal coils).Currently availability of phased arrayed surface coils with higher SNR and spatial resolution have made 3T MRI a preferred choice upon 1.5T machine for musculoskeletal and cardiovascular imaging.

3T MRI has undeniably higher SNR, spatial and temporal resolutions than 1.5T system and in recent years modification in hardware and new image sequences have adequately addressed the safety issues, noise and image contrast linked with higher magnetic field. It seems that with continuous trend of using higher magnetic field for clinical imaging with introduction of newer MRI agents, MRI as standalone or as hybrid modality (PET/MRI or SPECT/MRI) seems to dominate the imaging horizon in this decade.

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