Abdomen MRI Symposium ll: Special focus session_Enhancing throughput of liver MRI and MRCP

SY09-1

Review of Current Abdominal MRI Protocols

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Magnetic resonance imaging (MRI) is an essential imaging modality in detecting and characterizing abdominal pathology. Specifically, dynamic enhanced liver MRI and MR cholangiopancreatography (MRCP) are the two most widely performed MRI examinations in the abdomen. In this talk, major protocols for dynamic enhanced liver MRI and MRCP will be covered. Also, recently highlighted abbreviated MRI protocols for HCC screening and pancreatic cyst follow-up will be briefly summarized.

In dynamic enhanced liver MRI, current protocols generally consisted of in- and opposed-phase gradient echo (GRE) sequences, axial T2-weighted images of variable TE (short or long TE) and acquisition techniques (with- and without fat saturation, breath-hold or respiratory/navigator-triggered, cartesian or non-cartesian k-space sampling), diffusion weighted images (DWI) of various ranges of b-values, and dynamic enhanced sequence. Dynamic enhanced scan use volumetric 3D GRE T1-weighted sequence to capture temporal hemodynamic changes of the lesion at different time points which can be adjusted according to the contrast media, i.e., extracellular agents or hepatocyte-specific agents, used. While a full-sequence of gadoxetic acid-enhanced liver dynamic MRI may require up to 30-40 minutes, HCC-screening abbreviated MRI protocols can remarkably shorten the imaging time.

Regarding MRCP, coronal heavily T2-weighted images of several distinct acquisition techniques in addition to in- and opposed-phase GRE, DWI, and dynamic enhanced scan are the mainstay of the protocol. For 2D MRCP, breath-hold thick-slab single shot RARE and multi-slice HASTE techniques are used in coronal and axial planes. In 3D MRCP, respiratory or navigator-triggered RARE techniques acquire thin (1-2 mm) slice images during an extended time (4-5 minutes) period. Thin-slice 3D MRCP can be readily reconstructed to maximal intensity projection and volume rendering formats through post-processing. More recently, enhanced T1-weighted MRCP using gadoxetic acid has shown advantages in visualizing biliary anatomy. For long-term follow-up of pancreatic cystic lesion, abbreviating dynamic enhancement and DWI can effectively reduce the scan time to less than 10 minutes.

Keywords : Abdomen, Dynamic-enhance liver MRI, MR cholangiopancreatography

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Faster T2WI and MRCP

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Magnetic Resonance Cholangiopancreaticography (MRCP) is a heavily T2w imaging technique to image fluid-filled structures in gall bladder, the bile, and parts of liver. Most of conventional MRCP are acquired with heavily T2-weighted fast spin echo (FSE) pulse sequences. 3D MRCP imaging could offer better image quality than 2D imaging. However, without acceleration techniques, high-resolution 3D FSE is a very time-consuming sequence. In this talk, we present two acceleration techniques, HyperSense (GE's compressed sensing technique) and HyperCube, to acquire the high-resolution 3D FSE in a manageable imaging time and their use in 3D MRCP.

Compressed sensing in MRI utilizes the sparsity of MR images and reconstructs images from under-sampled data without noise penalties compared to traditional parallel imaging techniques. This can be used to reduce data acquisition time or increase resolution over the same scan time. Due to higher sparsity, higher acceleration can be achieved in volumetric 3D imaging and high resolution imaging. To achieve more acceleration, compressed sensing can be combined with parallel imaging techniques, which utilizes multi-channel receive coils.

Hypercube is a 3D FSE imaging method which delivers a small field of view organ specific imaging acquisition that can reduce artifacts originating from outside of the prescribed FOV. By using outer volume suppressions on the either side of phase FOV, it allows reduced FOV in phase encoding direction and zooming into the region of interests.

When used together to a 3D MRCP imaging, HyperSense and HyperCube reduce the scan time and make it possible to acquire high spatial resolution and detect small lesions and visualize thin biliary ducts.

Keywords : T2 weighted imaging, MRCP, Compressed Sensing

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Body DWI: past and future

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Ever since its implementation on clinical scanners diffusion weighted imaging has shown excellent clinical performance. However, it was originally limited to neuro applications. There has always been great interest in applying DWI outside of the brain, but motion was always perceived to be a major issue, as one probes random motion of (typically) water molecules in the micrometre range while the body is moving over centimetres. Further, the presence of fat hampered good quality body DWI, due to the low diffusivity of fat resulting in residual signal at higher b-values even with relatively well suppressed fat. We largely overcame both issues by introducing the DWIBS technique, which can now be implemented on standard clinical systems.

As with most body imaging applications motion, distortion and imaging speed are the main determinants of both image quality and of acceptance in the clinical environment. Further, one would like to use DWI for quantitative imaging.

Imaging speed has been tackled by using various undersampling techniques, including parallel imaging and compressed sensing. We introduced a technique where both are implemented simultaneously and where we optimally exploit the strengths of both approaches. This technique is compressed SENSE. Motion was approached with correction techniques, while distortion can be improved by undersampling and by moving from the classical EPI acquisition to TSE based sequences.

Finally, one would like to use DWI for quantitative imaging. ADC, and some other diffusion related parameters, have the advantage of being B0-field independent. It is however still impossible to correctly predict ADC based on any model. Many parameters have been described that influence the ADC, with cellularity probably being the most cited, but the situation is complex. I will introduce data suggesting that in a well-controlled cell system it is actually the cell perimeter length, a marker of the amount of membrane in a voxel, that seems to determine the ADC.

Keywords : Diffusion weighted imaging Body imaging Oncology

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Contrast-enhanced sequence

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Contrast enhanced dynamic imaging is essential for liver lesion detection and characterization. Volumetric 3D fat suppressed (FS) T1-weighted (T1W) gradient-recalled echo (GRE) sequence is considered as a standard of reference of contrast enhanced MR protocols, which offers the 3-dimensional acquisition of the entire liver during a single breath-hold, enabling dynamic, multiphasic MRI examinations at a high temporal and spatial resolution.

Fat suppression is routinely applied to contrast-enhanced T1-weighted liver MRI to minimize the motion-related artifacts derived from high signal producing fat and to enhance the contrast of nonfatty tissue. Compared to imaging at 1.5 T scanners, imaging at 3T scanners often suffers from incomplete fat suppression and inhomogeneous signal intensity caused by the higher susceptibility to field inhomogeneity. However, a modified Dixon-3D GRE technique (mDixon) provides stronger and homogeneous suppression of fat signals across the entire field of view and a higher spatial resolution, even at 3T, compared with that of conventional 3D GRE techniques.

Significant progress in contrast enhanced sequences has been made over the last decade in improving image quality and temporospatial resolution. In order to increase acquisition speed of 3D T1W imaging, bi-directional or 2D parallel imaging techniques were developed and allowed the use of high acceleration factors for reducing scanning time or improving spatial resolution with maintained signal-to-noise ratio. In addition, non-Cartesian acquisition schemes are robust to motion artifacts, although they require longer reconstruction times and higher computational hardware demands. Several studies showed that free-breathing contrast-enhanced T1W GRE imaging with radial data sampling is able to reduce respiratory artifacts and to deliver good image quality.

Keywords : Contrast enhanced sequence, Advanced MRI, Liver

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Future directions to Enhancing throughput of liver MRI and MRCP

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Recently, Abdominal MRI has been able to obtain high quality images in a short time with high hardware performance and advanced image reconstruction technology. In addition, the mature understanding of the abdomen has been able to control breathing movements and can no longer cause a longer scan time. Abdominal MRI is already a well-established with multiparametric capabilities. Among them, various kinds of MRI contrasts such as T1w, T2w, DWI, Fat quantification and MRCP are mainly used. In order to take these MRI images with a wide field-of-view and a high resolution without affecting respiratory motion, the scan time will be long. The latest MRI imaging technologies are being investigated based on parallel imaging, such as SENSE or GRAPPA, in shorter time without sacrificing any image quality. Compression sensing and simultaneous multiple slice imaging techniques, which are now being used in clinical studies, are expected to shorten the imaging time of abdominal MRI with high imaging efficiency.

Keywords : Abdominal, Magnetic Resonance Imaging, Fast imaging