MD-PhD Symposium: Recent update on MD-PhD collaboration

SY29-1

QSM: technical considerations

Yoonho Nam

Department of Radiology, Seoul St.Mary's Hospital, Seoul, Korea

Quantitative susceptibility mapping (QSM) is a technique that estimates the magnetic susceptibility distribution from phase data of gradient-echo imaging. This technique has developed very rapidly over the past decade and its clinical value is being extensively explored. Although clinical interest in QSM is growing, online reconstruction provided by MR vendors is not yet available. Therefore, it is necessary to collect unfiltered phase images from MR scanner for clinical research using QSM. Recently, open-source QSM processing tools have been provided by several research groups, making it relatively easy to access. However, there are some parts that a researcher should review and control at each step of the QSM processing (multiple coil data combination, region of interest masking, phase unwrapping, background phase removal, susceptibility calculation). In this presentation, technical considerations of QSM research will be reviewed at each step of the data collection, processing and analysis.

Keywords : QSM, Susceptibility, Phase, GRE

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SY29-2

QSM: clinical applications

Jinhee Jang

Radiology, Seoul St. Mary's Hospital, College of Medicine, The Catholic University of Korea, Seoul, Korea

Many radiologists are familiar with magnetic susceptibility effects and artifacts. While some MR techniques were tried to mitigate artifacts from susceptibility, other MR applications are utilized the susceptibility of imaging target and contrast media. One of the successful applications is susceptibility-weighted images, which combines magnitude and phase information. However, direct usage of phase information is uncommon in practice. Because raw (or filtered) phase images gives non-local information of susceptibility, clinicians are not familiar with those dazzling images. Additionally, quantitative measures for a specific properties is desirable for reproducible and objective evaluation of acquired images. Quantitative susceptibility mapping (QSM) might resolves those big huddles for direct clinical application of phase images. However, as a medical doctor, application of QSM to research and clinical works are difficult. For example, lack of standard or commercial processing solution, and delicacy of processing pipeline are not easy problems for radiologists by their own. In this talk, difficulties happened during researches and clinical applications of QSM will be covered. Also clinical potential and current applications of QSM will be presented.

Keywords : Quantitative susceptibility mapping, Clinical application

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Dynamic contrast-enhanced Liver MRI- clinical perspectives

Young Kon Kim

radiology, samsung medical center , seoul, Korea

The use of various scanning techniques in MRI such as parallel imaging, view sharing, non-Cartesian k-space acquisition, and compressed sensing, provides consistently high image quality and good conspicuity of disease with a decrease of imaging times. View sharing techniques go by multiple acronyms dependent on manufacturer, such as TRICKS (GE), Time-Resolved Imaging of Contrast KineticS), TWIST(Siemens, Time-resolved angiography With Stochastic Trajectories), and 4D-Trak(Philips, 4D Time-Resolved Angiography using Keyhole). These technologies have made possible high frame rate time resolved imaging, though data are drawn from relatively wide temporal windows. These techniques have been used primarily for MR angiography, however can also be combined with 3-dimensional liver GRE sequences, allowing to implement 4D time-resolved imaging with high quality and at almost no loss in soft tissue contrast and spatial resolution. These technologies are beneficial to assess pathologies such as hypervascular liver tumors that require high frame rates to detect and characterize.

Many of the non-Cartesian acquisition schema can be combined with other MR imaging techniques for increasing imaging speed, including parallel imaging and compressed sensing, to achieve a combination of both high spatial resolution and high temporal resolution. This approach can be applied to situations in which breath-holding is difficult but timing of scans is also critical, such as in hepatic imaging using gadoxetic acid that can cause transient dyspnea. Non-Cartesian k-space sampling facilitates the use of compressed sensing due to the inherent presence of incoherent aliasing artifacts even for uniform undersampling.

Compressed sensing is a recently emerged powerful tool to accelerate data acquisition in dynamic MRI by exploiting sparsity, incoherence, and nonlinear reconstruction.This enables dynamic imaging studies using continuous data acquisition and retrospective reconstruction of image series with arbitrary temporal resolution by grouping different numbers of consecutive radial lines into temporal frames

With advanced postprocessing, many of the non-Cartesian acquisitions, if originally acquired using appropriate sequence modifications, can be parsed into multiple shorter temporal blocks. The recently developed GRASP (Golden angle Radial Sparse Parallel acquisition) technique synergistically combines compressed sensing, parallel imaging, and golden-angle radial sampling, with continuous acquisition in free breathing. The sequence GRASP can be acquired using the similar parameters as radial VIBE and then be reconstructed at a higher effective temporal resolution relative to standard breath hold acquisitions, despite this sequence’s relatively longer scan time. Similarly, pseudogolden angle is employed with radial sampling in Philips platform. These techniques employ respiratory motion sorting instead of explicit motion correction. The continuously acquired k-space data are sorted into different contrast-enhancement phases at multiple respiratory states using the self-navigation properties of radial imaging. Thus, the number or timing of dynamic phases can be arbitrarily determined from continuously acquired data, which could minimize inappropriate timing for arterial enhancement of small hypervascular hepatic tumor and enhance the detection of capsular rim enhancement of HCC.

Keywords : Liver, Dynamic imaging, MRI, Fast imaging technique

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SY29-4

Dynamic contrast-enhanced liver MRI: technical overview

Yoon-Chul Kim

Clinical Research Institute, Samsung Medical Center, Sungkyunkwan Univ School of Medicine, Seoul, Korea

Dynamic contrast enhanced liver MRI is clinically used to detect and characterize hepatic lesions. It includes the acquisition of 3D volumetric images in pre-contrast, arterial phase, portal venous phase, and hepatobiliary phase. In both portal venous and hepatobiliary phases, the signals become relatively stationary over time in the liver, and multiphase dynamic imaging is not necessary. A static 3D imaging is performed in a single breath-hold to image the liver without any respiratory motion artifacts. Fast 3D imaging with sub-Nyquist sampling and parallel imaging is used to accelerate scan time. Compressed sensing has the potential to further reduce scan time while maintaining image quality.

Arterial phase involves rapid enhancement of contrast agent in the liver. High spatio-temporal resolution imaging is desirable to capture the hemodynamics of lesion enhancement, but trade-offs of spatial coverage, spatial resolution, and temporal resolution need to be compromised due to MR hardware limitations. Arterial phase images can be obtained either during subject’s breath-hold or during free breathing. Breath-hold arterial phase imaging is acquired in a single phase or multiple phases. Multiphase imaging can reduce temporal window and possibly allows one to select a phase free of motion artifact.

Free-breathing techniques acquire data continuously over arterial phase. Golden-angle radial acquisition is a promising technique as it is flexible in retrospectively selecting temporal resolution and the center of temporal window. Image reconstruction is posed as an optimization problem where data consistency term is related to parallel imaging and regularization term promotes sparsity in spatial and temporal domains. Temporal regularization is particularly effective in reducing streak artifact stemming from highly undersampled radial data. Fat suppression is important for improvement of lesion conspicuity. Respiratory motion can be reduced if one can properly bin the raw data into respiratory phases and model the constrained reconstruction with an addition of respiration dimension. We demonstrate our preliminary results on the use of free-breathing dual-echo 3D golden-angle radial sequence.

Keywords : MRI, Liver, Dynamic contrast enhanced imaging, Compressed sensing