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SY02-01

Current states of 3D MRCP: sequence, application, advantage and limitation

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Magnetic resonance cholangiography (MRCP) is an extremely powerful tool to noninvasively navigate the bile duct. Coronal heavily T2-weighted images of several distinct acquisition techniques in addition to T1-weighted dual echo 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 technique acquires thin (1-2 mm) slice of images by spending an extended scan time (4-5 minutes). These high-resolution images then can be 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 of subjects with non-dilated duct. To obtain quality MRCP images, it is important to know strengths and weaknesses of these techniques.

Keywords : Magnetic resonance cholangiopancreatography

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SY02-02

Recent developments in fast 3D MRCP

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The realisation that T2 weighted imaging with a relatively long TE allowed the visualisation of fluids was one of the early breakthroughs that expanded the use of MRI in the clinical field. Arguably the most successful application of this approach was in MRCP, as it could replace the highly invasive ERCP technique for imaging pancreatic and biliary fluids.

The first implementations of this technique were based on gradient echo acquisitions, quickly moving to TSE acquisitions. Later 2D was superseded by 3D acquisitions.

Recently two new techniques that bring a considerable acceleration of MRCP imaging were introduced. On the one hand, we saw that the compressed SENSE acceleration could be used very efficiently thanks to the inherently high sparsity of the MRCP data. This led to a considerable shortening of the acquisition time. On the other hand, the almost forgotten GraSE technique can be applied successfully. Both techniques allow the MRCP data acquisition to be finalised within one breathhold.

Keywords : 3D MRCP, GraSE, Compressed SENSE

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SY02-03

Compressed-sensing accelerated 3D MRCP

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Pioneer studies suggest that CS-3D MRCP could be performed in both navigator-triggered (NT) mode and breath-hold (BH) mode, and both seem to work well. However we wondered whether this is true for imaging delicate pancreatic duct abnormalities. We prospectively compared CS-BH MRCP and CS-NT MRCP in patients with suspected pancreatic diseases, concerning image quality, duct visibility and diagnostic performance in pancreatic duct-related pathologies.

We found that both CS-NT MRCP and CS-BH MRCP works well for imaging bile ducts, but CS-BH MRCP seems to be inferior for imaging pancreatic duct. CS-NT MRCP is good for imaging pancreatic diseases, with time reduction and diagnostic performance increment. CS-BH MRCP needs further refinement for imaging pancreatic diseases.

After a new prototype of modified CS-BH MRCP was developed, we further carried out our trial, with the hypothesis that the modified CS-BH MRCP prototype may provide better image quality, duct visibility and diagnostic performance, compared to the original CS-BH MRCP. The key features of the modified CS-BH-MRCP included smaller field of view (FOV), higher spatial resolution, and application of saturation bands to prevent aliasing along phase-encoding directions in the 3D acquisition.

We found that With modified BH-CS-MRCP, Image quality and diagnostic performance for pancreatic and biliary disorders is equally good or better than NT-CS-MRCP. However, NT-CS-MRCP has its advantage for non-cooperative patients. An individualized plan should be made according to the patient’s condition, to achieve good diagnostic images efficiently.

Keywords : Compressed-sensing, MRCP

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SY02-04

BH T2-weighted 3D MRCP: generalizability and clinical relevance

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Magnetic resonance cholangiopancreaticography (MRCP) is a non-invasive method of evaluating biliary and pancreatic diseases. MRCP is often considered as an initial workup method for obstructive jaundice or for the evaluation of pancreatic diseases, and it has largely replaced invasive retrograde cholangiography, which has a complication risk of up to 5%. MRCP is often obtained as either a breath-hold (BH) two-dimensional (2D) or respiratory-triggered (RT) three-dimensional (3D) image. Despite few respiratory artifacts and susceptibility effects, a 2D MRCP has a critical drawback of obscuring small stones or anatomic variations.

On the other hand, 3D-MRCP has higher SNR than 2D MRCP and is more useful for small structure evaluation. Thus, many authors have advocated the use of 3D MRCP sequences. 3D MRCP acquires contiguous sections, allowing reconstruction of any projection and enabling better spatial resolution with thinner imaging sections. To obtain high resolution isotropic images, 3D MRCP sequences have been performed principally with a respiratory-triggered technique for the last 10 years. However, despite the use of parallel acquisition technique, the acquisition time of respiratory-triggered (RT) 3D MRCP often exceeds 5 min, which has been a clinical burden. Further, longer acquisition time cause motion artifacts and worsen the image quality.

With this background, there have been several attempts to shorten the acquisition time of 3D-MRCP, while keeping high spatial resolution. One of the approaches is 3D-BH-MRCP using compressed sensing (CS) technique, which enables a substantial reduction of the scan time by a high k-space undersampling. Other approaches to 3D-BH-MRCP are 3D MRCP using gradient and spin-echo (GRASE), 3D balanced steady-state free precession (b-SSFP), or fast-recovery fast spin-echo (FPFSE) sequences. Except for recent introduced 3D MRCP using GRASE, those techniques could not be generalized due to poor image quality compared with conventional 3D-RT-MRCP.

GRASE technique is combination of the spin-echo and gradient-echo sequences, where several spin echoes are replaced with gradient-echoes. Fewer refocusing radiofrequency (RF) pulses coming from alteration between the RF refocusing pulse and the gradient within echo train allow improved temporal resolution compared with turbo spine echo (TSE) sequence, which has been used as conventional RT 3D-MRI. Nevertheless, GRASE technique at 1.5T MRI has limitation due to blurring or susceptibility artifacts related with the echo-planar component.

With the recent technological developments in MR including the high SNR of 3 T, a high-fidelity gradient system, and improved field homogeneity of the magnet, a better image quality from the GRASE MRCP could be expected. Two recent studies demonstrated BH-GRASE-3D MRCP at 3T MRI had shorter acquisition time (15-20 sec), better overall image quality, less blurring artifacts, and fewer non-diagnostic examinations compared with conventional RT-3D MRCP. BH-GRASE-3D MRCP can replace conventional RT-3D MRCP, in which the acquisition time is long and often unpredictable in patients with an irregular breathing rhythm, even though3D RT-MRCP can still play an important role for patients who have a limited breath-holding capacity.

Keywords : MRCP, Breath-hold, 3D MRCP, GRASE

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SY02-05

T1-weighted MRCP: technical advances and clinical applications

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Even though 3D-T2W-MRCP has been a well-established non-invasive technique for the evaluation of the bile duct, its relatively long acquisition time, potentiality of motion artifacts related to irregular breathing, and limited signal-to-noise ratios have remain unsolved. In this regard, another approach to evaluating the biliary anatomy may be gadoxetic-acid-enhanced MR imaging which uses the properties of biliary excretion and the strong T1-shortening effect. Yet, conventional breath-hold (BH) 3D-T1W-MRCP with gadoxetic acid has also shown a limitation in relatively lower spatial resolution when evaluating intrahepatic bile ducts compared with navigator-triggered 3D-T2W-MRCP with an isotropic resolution of 1 mm^3, as it is usually performed with a slice thickness of 1.8~3 mm and an in-plane resolution of 1.3 mm~1.5 mm. Thus, in an attempt to improve the limited spatial resolution of conventional T1W-MRCP for biliary anatomy evaluation, navigator-triggered high-resolution (HR) T1-MRCP techniques were developed providing improved image quality compared with T2W-MRCP or BH-T1W-MRCP. Yet, until now, the total scan time of navigator-triggered HR T1W-MRC took as long as 4–6 minutes depending on the respiratory pattern and rate, and possessed a technical failure rate of 3.5% ~5%. Thus, by applying 2D parallel imaging technique with a high acceleration factor and an iterative denoising algorithm, high spatial resolution (1mm^3) could be obtained in one breath hold. Though it needs intravenous contrast (gadoxetic acid) injection, it is expected more accurate depiction of BD anatomy and it could be a good alternatives to 3D-T2W-MRCP.