Non-Contrast-Enhanced MR portography using 3D inversion recovery-in flow iterative spatial saturation pulses (IR-IFIS) steady-state Free Precession (FIESTA)

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Introduction

In order to evaluate portal vein, gadolinium-contrast-enhanced dynamic MR angiography with 3D gradient echo sequence has been one of the most useful and non-invasive methods. However, non-contrast examinations must be chosen when patients refuse or have contraindications to use intravenous contrast agents such as bronchial asthma and renal failure. A new method has been developed to depict a specific blood and separate one-way blood flowing into the slab from undesired blood. It is called inversion recovery - inflow iterative spatial saturation pulse (IR-IFIS). Iterative spatial saturation pulses are used to tag a specific blood and non-selective inversion pulse suppresses background tissues in a non-subtractive fashion. The purpose of our study was to evaluate non-contrast MR portography with 3D IR-IFIS sequence.

Materials and methods

The pulse sequence diagram was shown in Fig.1. Iterative spatial saturation pulses were applied with the interval time of 50 msec for around 2 second. These pulses were placed on liver region to excite veins such as superior and inferior mesenteric vein, splenic vein flowing into portal vein. Non-selective inversion pulse was triggered during respiratory and peripheral gating. After a waiting time, the T2 preparation sequence for contrast enhancement (echo time 48 msec) was followed by the spectral-selective fat-saturation pulse, and the segmented 3D SSFP (FIESTA) sequence. The data was acquired at diastolic phase.

9 normal volunteer studies (male: 4, female: 5, mean age 30 years-old) were performed to optimize the parameters of the IR-IFIS FIESTA. The parameters include the preparation time between 900 to 1400 msec and the width of spatial saturation pulse between 50 to 150 mm (See Fig.2). 11 patients (male: 6, female: 5, mean age 60 years-old), suspected of having hepatobiliary disorders, underwent with the optimized parameters. All studies were performed on 1.5T MRI system (SIGNA TWINSPEED EXCITE HD, GE Healthcare) using 8-channel phased array body coil. The parameters of 3D FIESTA were as follows; coronal images, TR / TE: 3.8 / 1.9 msec, Slice thickness: 3 mm, Number of slices: 56-100, FA: 90 degree, matrix: 256x256, Band width: 125 kHz, FOV: 35 x35 cm, ASSET (reduction factor2), with respiratory triggering, chemical selective fat-saturation, and peripheral gating technique, and total acquisition time: 157-285 sec. All images were evaluated using MPVR technique on a cine display.

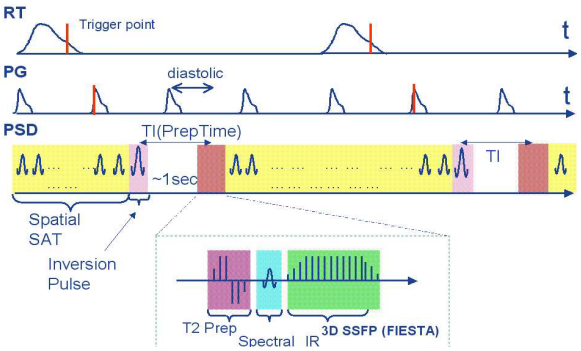

Fig.1. The pulse sequence diagram of IR-IFIS is shown. Iterative spatial saturation pulses are used to tag a specific blood and non-selective inversion pulse suppresses background tissues in a non-subtractive fashion. Both respiratory and peripheral triggering (RT, PT) are performed. TI is inversion time equal to preparation time.

The qualitative assessment of image quality, visualization of vessels and contrast between vessel and liver was conducted using a 5-point scale. The image quality was evaluated by the degradation due to motion artifact and overall image quality independently. The visualization of vessels was focused on main portal trunk, the first, second, third branches of intrahepatic portal system, superior mesenteric vein (SMV), hepatic vein, inferior vena cava, and abdominal aorta respectively. These vessels and the liver region were manually identified and quantified by region-of –interest measurements of the mean signal intensities (SI).

Results

As preparation time is longer to 1400 msec, the signal intensity of all tissues was increased. The visualization of portal vein was improved at 1300-1400 msec. As the spatial saturation was widened up to 100 mm, the signals of portal veins were gradually increased. In contrast, background signal was increased from 100 mm to 150mm. In patients, the qualitative results were as follows; image quality: 4.0 +/- 0.9, artifacts: 4.1 +/- 0.8, main portal trunk: 4.9 +/-0.3, first branch: 4.7 +/- 0.9, second branch: 4.5 +/- 0.9, third branch: 3.5 +/- 1.4, SMV: 4.6 +/- 0.8, hepatic vein: 2.0 +/- 1.6, IVC: 2.8 +/- 1.5, abdominal aorta: 2.7 +/- 1.3, respectively. The quantitative results of the contrast were as follows; main portal trunk/ liver: 2.6 +/- 0.7, first branch/ liver: 2.5 +/- 0.8, second branch/liver: 2.4 +/- 0.8,hepatic vein/ liver: 1.4 +/- 0.8, IVC: 2.6 +/- 2.9, respectively.

Conclusion

Results from volunteer and patient experiments have demonstrated the depiction of portal vein with the IR-IFIS method. The long preparation time was set to improve the visualization of portal vein. However, motion artifact is likely to happen due to extended delay time from trigger to data acquisition and further studies related to avoiding respiratory motion is necessary. The non-contrast-enhanced 3D IR-IFIS FIESTA technique provides separation of portal vein from undesired vessels and longer depiction of portal vein and furthermore an alternative choice to gadolinium-contrast-enhanced dynamic MR angiography.

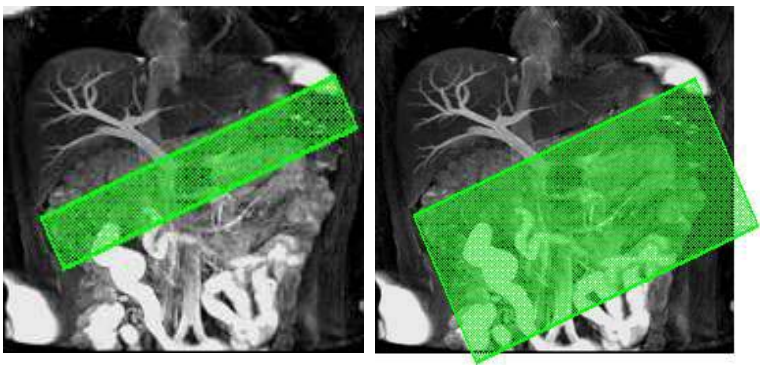

Fig.2. Spatial saturation pulse (Green square) is placed on liver region to excite veins into portal vein. Changing the width of the pulse from 50 (left figure) to 150 mm (right figure).

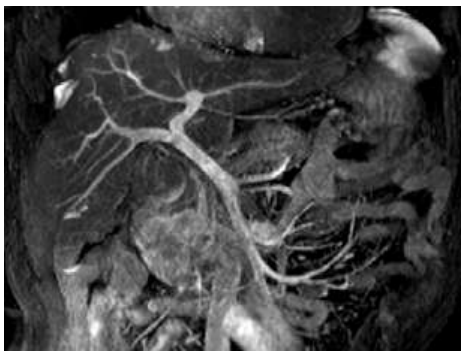

Fig.3. MIP image with 3D IFIS FIESTA in a patient with Liver Cirrhosis shows the branches of portal veins clearly.