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Magnetic Resonance Angiographic Inflow-Sensitive Inversion Recovery Technique for Vascular Evaluation Before Liver Transplantation

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ABSTRACT

Background. The recipient's hepatic vascular anatomy is essential in living-donor liver transplantation (LDLT). Magnetic resonance angiographic inflow-sensitive inversion recovery (IFIR-MRA) is a new noncontrast technology for vascular evaluation, particularly for those patients with renal function impairment. The purpose of this study was to improve the image quality with different blood suppression inversion time (BSP TI) settings.

Methods. From October 2012 to March 2013, 21 recipient candidates underwent IFIR-MRA with the use of the GE 1.5T-Discovery 450 for LDLT preoperation evaluation with different BSP TI settings. Subjective visualized image quality and depiction of hepatic arteries, portal veins, and inferior vena cava (IVC) were all evaluated on a vessel-to-vessel basis. A paired *t* test analysis was used to assess the difference in grading scales between the different BSP TI settings in IFIR-MRA.

Results. The 21 recipients (4 female, 17 male) had a mean age of 53.43 ± 11.07 years. A significant difference ($P < .001$) existed in the arterial depiction scores between BSP TI 1,000 ms (3.10 ± 0.70) and BSP TI 1,400 ms (3.57 ± 0.7). There were no significant differences of quality scores in artery (3.71 ± 0.56 vs 3.48 ± 0.60), portal vein (3.57 ± 0.60 vs 3.48 ± 0.51), and IVC (2.71 ± 1.19 vs 2.76 ± 1.09), and no significant differences of depiction scores in portal vein (2.29 ± 0.46 vs 2.48 ± 0.51) and IVC (1.57 ± 0.68 vs 1.62 ± 0.15).

Conclusions. The images with BSP TI 1,400 ms were the most optimal for IFIR noncontrast MRA imaging in LDLT. This new technology can replace traditional contrast-enhanced MRA, especially for patients with renal function impairment.

HEPATIC VASCULAR anatomy is crucial information for living-donor liver transplantation (LDLT) preoperative survey [1]. Conventional gadolinium contrast-enhancement magnetic resonance angiography (MRA) is used in LDLT for preoperative survey [2]. There are several limitations to obtaining hepatic vascularity through MRA with gadolinium contrast enhancement, such as intolerance to hold breath and renal function impairment [3]. The complication of nephrogenic systemic fibrosis with the use of gadolinium has been emphasized in recent reports. Other examinations for acquiring information on hepatic vascularity also have limitations. Digital subtraction angiography is the criterion standard for hepatic vascularity, but the radiation, contrast medium, and complications associated with catheterization should be considered. Enhanced computerized tomographic imaging is rapid and precise but limited by radiation, contrast medium–related allergic shock, and poor renal function. Sonography is radiation and contrast medium free but highly dependent on the operator for success.

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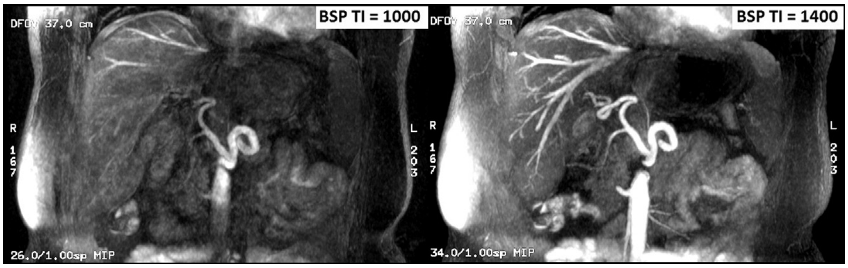

Fig 1. Comparison of blood suppression inversion time (BSP TI) of 1,000 ms (left) versus 1,400 ms (right) of the same patient. The precise hepatic arterial anatomy was obtained under the setting of BSP TI 1,400 owing to superior depiction.

Noncontrast flow-based MRA techniques, including time-of-flight and phase-contrast imaging, have been performed, but images of different vascular anatomy of the liver can not be achieved well owing to the superimposition of the vascular structure inside the liver [2]. Therefore, a new noninvasive, objective, contrast medium–free method is needed for preoperative survey for LDLT.

The new technique of 3-dimensional (3D) noncontrast MRA acquired by inflow-sensitive inversion recovery (IFIR) is used for the whole hepatic vascularity to evaluate the possibility of obtaining crucial information and avoid using the exogenous gadolinium-content contrast agent [4]. The IFIR technique in MRA is known for being free of contrast medium, free of breath-holding, and repeatable. It is used in abdominal vascularity surveys, especially in renal arteries. Its diagnostic ability has been proven in detecting renal artery stenosis [5].

The most common underlying disease of candidates for LDLT is liver cirrhosis, which may alter the velocities of the hepatic vasculature. A proper setting of the blood suppression inversion time (BSP TI) to be well matched to the vascular velocity of the hepatic artery, portal vein, and inferior vena cava (IVC) is the key parameter to obtaining good imaging quality. This study focused on improving imaging quality of the whole hepatic vasculature under different BSP TI settings to facilitate the LDLT preoperative survey.

MATERIALS AND METHODS

From October 2012 to March 2013, 21 recipient candidates underwent IFIR-MRA for LDLT preoperative evaluation with different BSP TI settings at Kaohsiung Chang Gung Memorial Hospital. This study was approved by the Ethics Committee of Chang Gung Memorial Hospital (IRB 102-0591B), and all patients were informed and consented.

All examinations were conducted with subjects in supine position by GE's IFIR pulse sequence led by a normal respiratory trigger on a 1.5-T whole-body scanner (Discovery MR450 1.5T) fitted with 12-channel Body Array Coils (1.5T Signa HDxt MR System). This sequence uses a spatially selective inversion pulse covering the heart, descending aorta, hepatic vein, and portal veins to suppress the other inflows and static tissue signals, and acquires data with the use of a 3D balanced steady-state free precession acquisition with chemical fat suppression. The imaging area was centered in the liver hilum covering the whole liver region. The typical scanning parameters were repetition time 3.7 ms, echo time 1.9 ms, flip angle 55°, BSP TI 1,000–1,400 ms for arteries and 1,400–1,800 ms for portal veins and IVC, matrix 192 × 320, field of view 36 cm × 36 cm, slice thickness 2.0 mm, slice number 58, readout bandwidth 125.00 kHz, and number of excitations 0.69. Parallel imaging was used with acceleration factor phase 2. The acquisition time was 3 min 45 s for a patient with respiratory rate of 16/min.

Subjective visualized image quality and depiction of hepatic arteries, portal veins, and IVC were all evaluated on a vessel-to-vessel basis. The image quality score was divided into 5 levels according to the vascular imaging contrast with the background imaging: 0 point for no signal or completely unreadable; 1 point for very dark but readable; 2 points for gray imaging but not easily differentiated from the background; 3 points for a moderately bright and clear image; 4 points for bright vascular imaging. The depiction score was ranked by evaluating the image signal extension of the hepatic vascular anatomy according to its anatomical segments. There were 4 levels for hepatic arterial imaging: 1 point for demonstration of celiac trunk only; 2 points for demonstration of celiac and common hepatic arteries; 3 points for the addition of the proper hepatic artery; 4 points for showing all intrahepatic arteries. There were 3 levels for portal venous imaging: 1 point for the demonstration of main portal venous trunk; 2 points for the addition of the main portal venous radicles; and 3 points for the whole intrahepatic portal venous branches. Finally, there were 2 levels for hepatic venous imaging: 1 point for the demonstration of the IVC; 2 points for additional intrahepatic venous branches. A paired t test analysis was used to assess the difference in grading scores between different BSP TI settings in IFIR-MRA. All statistical analyses were performed with the use of SPSS software, version 17.0 (SPSS, Chicago, Illinois).

RESULTS

Twenty-one patients underwent complete imaging evaluation for hepatic vascular anatomy before LDLT; 17 were male and 4 were female; overall mean age was 53.43 ± 11.07 years.

For hepatic arterial imaging, the quality score for BSP TI 1,000 ms was 3.71 ± 0.56 and for BSP TI = 1,400 ms was 3.48 ± 0.60. There was no significant difference in quality scores between BSP TI 1,000 ms and BSP TI 1,400 ms ($P = .056$). But considering the images, the score for BSP TI 1,000 ms was 3.10 ± 0.70 and for BSP TI 1,400 ms was 3.57 ± 0.7. A significant difference was found in the arterial depiction scores between BSP TI 1,000 ms and BSP TI 1,400 ms ($P < .001$; Fig 1).

For portal venous imaging, the quality score for BSP TI 1,400 ms was 3.57 ± 0.60 and for BSP TI 1,800 ms was 3.48 ± 0.51. There was no significant difference in quality scores