Noncontrast Magnetic Resonance Angiography Using Inflow Sensitive Inversion Recovery Technique for Vascular Evaluation in Pre–liver Transplantation Recipients

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ABSTRACT

Objective. Vascular anatomy is essential in pretransplantation survey. The purpose of this study is to investigate the feasibility and diagnostic performance of inflow sensitive inversion recovery (IFIR) magnetic resonance angiography (MRA) to evaluate the recipient's hepatic vasculature before liver transplantation.

Materials and Methods. Thirty-one pre–liver transplantation patients underwent both IFIR and conventional contrast-enhanced MRA using a 1.5T MR scanner from December 2012 to December 2014. The contrast-to-noise ratios (CNRs) between liver parenchyma and hepatic vasculature were calculated. The image sets of IFIR and contrast-enhanced MRA were assessed for subjective image quality and depiction of hepatic vasculature on vessel-to-vessel basis by two independent radiologists.

Results. The quantitative results of CNR for hepatic arteries on IFIR were significantly lower than contrast-enhanced MRA, whereas CNR for portal veins and inferior vena cava on IFIR were significantly higher than contrast-enhanced MRA. For subjective assessment of image quality, the overall agreement of scores of IFIR and contrast-enhanced MRA was substantial (kappa values ranged from 0.650 to 0.767). There was no significant difference in the image quality for portal veins between IFIR and contrast-enhanced MRA. The quality scores of IFIR were significantly lower than contrast-enhanced MRA for hepatic arteries. For inferior vena cava evaluation, the scores of IFIR were significantly higher than contrast-enhanced MRA.

Conclusion. IFIR MRA is a reproducible and noninvasive tool to assess the hepatic vasculature that can provide adequate to good image quality. In pre–liver transplantation patients, IFIR MRA becomes even more useful if contrast medium is a contraindication due to impaired renal and liver functions.

HEPATIC vascularity of the recipient must be evaluated before liver transplantation [1,2]. Among the image modalities, computed tomography and digital subtracted angiography have the disadvantage of radiation exposure and adverse reaction related to contrast medium, whereas sonography is operator-dependent. Pre–liver transplantation, the recipient may need to undergo magnetic resonance angiography (MRA) to evaluate the hepatic vasculature.

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Complications of nephrogenic systemic fibrosis related to gadolinium contrast medium on examinee with poor renal function had been reported recently [3,4]. Poor compliance of breath-hold is also the limitation of contrast-enhanced (CE) MRA. In this regard, a noninvasive, objective, contrast medium–free method becomes valuable and necessary for a preoperative survey of living-donor liver transplantation (LDLT).

The inflow sensitive inversion recovery (IFIR) technique in MRA is a reproducible study without need for breath-holding and usage of contrast medium. Recent literature has reported successful results in evaluating renal and lower extremities arteries on patients with renal impairment [5–10]. There are only a few publications that apply the effectivity of IFIR for liver vasculature imaging [11–14]. The aim of this study is to investigate the feasibility and diagnostic performance of IFIR MRA to evaluate the recipient's hepatic vasculature before liver transplantation.

MATERIALS AND METHODS

Subjects

From December 2012 to December 2014, 31 liver transplant recipients (8 women and 23 men) with ages ranging from 27 years to 70 years were enrolled in this study. This study was approved by the Institutional Ethics Committee and informed written consent was obtained from all patients.

Imaging Technique

IFIR noncontrast MRA. 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 450; GE Healthcare, Milwaukee, Wis, United States) equipped with a 12-channel Body Array Coils (GE Healthcare; 1.5T Signa HDxt MR System, United States). This sequence used a spatially selective inversion pulse covering the heart, descending aorta, hepatic veins, and portal veins to suppress the other inflows and static tissue signals, and acquired data using a three-dimensional (3-D) 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 TR = 3.7 ms; TE = 1.9 ms; flip angle = 55°, where BSP TI could be selected in a range of 1000 ms to 1800 ms (BSP TI time for artery = 1400 ms, for portal vein and inferior vena cava [IVC] = 1400 ms and 1800 ms, respectively) [15]; matrix 192 × 320; field of view 36 cm × 36 cm; slice thickness 2.0 mm; slice number 58; readout bandwidth 125.00 kHz, and NEX0.69. Parallel imaging was used with acceleration factor phase 2. The acquisition time was approximately 3 minutes and 45 seconds for a patient with respiratory rate of 16 rpm.

CE MRA. The imaging area was centered in the liver hilum covering the whole liver region. The scanning parameters of 3-D CE MRA were TR = 3.7 ms, TE = 1.2 ms, flip angle = 30°, inversion time = 14 ms, matrix 288 × 192, field of view 36 × 36 cm, slice thickness 3 mm, and readout bandwidth 244.00 kHz.

Image Post-processing and Analysis. The signal-to-noise ratio (SNR) and contrast-to-noise ratios (CNR) between liver parenchyma and hepatic vasculature (hepatic arteries, portal veins, IVC) were calculated in both IFIR MRA and CE MRA according to the following formula:

SNR of liver parenchyma = region of interest of liver parenchyma/background SD

SNR of hepatic vasculature = region of interest of vessels/background SD

CNR = SNR of liver parenchyma/hepatic vasculature

The image sets of IFIR MRA and CE MRA were then assessed by two independent radiologists on PACS (GE Healthcare, Barrington, Ill, United States). Each image was evaluated using a 5-point scale according to sharpness and contrast of the evaluated vessels (1 = nonvisualization of the examined vessel, 2 = vessel is visible but with markedly blurred borders, 3 = adequate image quality with moderately blurred borders, 4 = good image quality with mildly blurred borders, and 5 = excellent image quality with sharply defined borders).

Statistical Analysis

The results were compared on SPSS software Package 18 (SPSS Inc, Chicago, Illinois, United States). Interobserver agreement was assessed using Cohen's kappa correlation coefficient categorized as poor (<0.20), fair (0.20 to 0.39), moderate (0.40 to 0.59), substantial (0.60 to 0.79), and excellent (>0.80). Comparison of CNR and image quality between IFIR MRA and CE MRA was performed and results were analyzed using paired Student t test. A P value $< .05$ was considered statistically significant.

RESULTS

The quantitative results of CNR for hepatic arteries on IFIR MRA were significantly lower than CE MRA (5.55 vs. 8.71, $P < .05$). The quantitative results of CNR for portal veins and IVC on IFIR MRA were significantly higher than CE MRA (7.52 vs. 3.28 and 6.81 vs. 1.12, respectively) (Table 1).

For subjective assessment of image quality, the overall agreement of scores of IFIR MRA and CE MRA was substantial (kappa values range = 0.650 to 0.767). The interobserver agreement of images quality score on IFIR MRA of hepatic arteries, portal veins, and IVC were 0.679, 0.767, and 0.667, respectively. The interobserver agreement of images quality score on CE MRA of hepatic arteries, portal veins and IVC were 0.650, 0.706, and 0.761, respectively (Table 2).

Successful ratings (imaging score ≥ 3) of IFIR MRA for evaluation of hepatic arteries (Fig 1A), portal veins (Fig 1B), and IVC were 86%, 92%, and 97%, respectively, whereas successful ratings of CE MRA were 95%, 97%, and 92%, respectively. There was no significant difference in the image quality for portal veins between IFIR MRA and CE

Table 1. CNR Using IFIR Non-CE MRA and CE MRA

	CNR Average (IFIR non-CE)	CNR Average (CE)	Significance (*P* Value)	Kappa Value (IFIR)	Kappa Value (CE)
HA	5.5473	8.7070	<.005	0.679	0.650
PV	7.5219	3.2800	<.005	0.767	0.706
IVC	6.8138	1.1176	<.005	0.667	0.761

Abbreviations: CNR, contrast-to-noise ration; IFIR, inflow sensitive inversion recovery; CE, contrast enhanced; MRA, magnetic resonance angiography; HA, hepatic artery; PV, pulmonary vein; IVC, inferior vena cava.