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Right adrenal vein: comparison between adaptive statistical iterative reconstruction and model-based iterative reconstruction

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ARTICLE INFORMATION

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AIM: To compare right adrenal vein (RAV) visualisation and contrast enhancement degree on adrenal venous phase images reconstructed using adaptive statistical iterative reconstruction (ASiR) and model-based iterative reconstruction (MBIR) techniques.

MATERIAL AND METHODS: This prospective study was approved by the institutional review board, and written informed consent was waived. Fifty-seven consecutive patients who underwent adrenal venous phase imaging were enrolled. The same raw data were reconstructed using ASiR 40% and MBIR. The expert and beginner independently reviewed computed tomography (CT) images. RAV visualisation rates, background noise, and CT attenuation of the RAV, right adrenal gland, inferior vena cava (IVC), hepatic vein, and bilateral renal veins were compared between the two reconstruction techniques.

RESULTS: RAV visualisation rates were higher with MBIR than with ASiR (95% versus 88%, $p=0.13$ in expert and 93% versus 75%, $p=0.002$ in beginner, respectively). RAV visualisation confidence ratings with MBIR were significantly greater than with ASiR ($p<0.0001$, both in the beginner and the expert). The mean background noise was significantly lower with MBIR than with ASiR ($p<0.0001$). Mean CT attenuation values of the RAV, right adrenal gland, IVC, and hepatic vein were comparable between the two techniques ($p=0.12$–0.91). Mean CT attenuation values of the bilateral renal veins were significantly higher with MBIR than with ASiR ($p=0.0013$ and 0.02).

CONCLUSION: Reconstruction of adrenal venous phase images using MBIR significantly reduces background noise, leading to an improvement in the RAV visualisation compared with ASiR.

Introduction

Adrenal venous sampling (AVS) is currently considered the diagnostic reference standard for primary aldosteronism (PA).[1] AVS has been increasingly used due to the awareness that PA occurs more frequently than previously believed[2]; however, AVS of the right adrenal vein (RAV) remains difficult because the RAV is small and has anatomical variations. Dynamic contrast-enhanced computed tomography (CT) is commonly used for pre-AVS detection of the RAV. A previous study demonstrated that dual adrenal venous phase CT (45- and 55-second delays) visualises the RAV well with rates of 91% and 92%,

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respectively.[3] Nevertheless, it is difficult to find the RAV for the aforementioned reason. Sufficient visualisation of the RAV is very important for pre-AVS.

Recently, benefits of iterative reconstruction techniques, such as adaptive statistical iterative reconstruction (ASiR; GE Healthcare, Milwaukee, WI, USA) or model-based iterative reconstruction (MBIR; Veo, GE Healthcare), have been reported for use in vascular imaging, including CT angiography of the head and neck,[4,5] chest,[6] whole body,[7] and CT venography.[8] Many of these studies concluded that reconstruction using MBIR improves image quality compared with that using ASiR. MBIR is a further development of ASiR and is believed to provide superior image quality compared with ASiR.[5,6,8,9] It was hypothesised that image quality can be markedly improved using MBIR, leading to improvement in RAV visualisation on adrenal venous phase images; however, to the authors' knowledge, no study has evaluated the usefulness of MBIR in the reconstruction of adrenal venous phase images. Thus, this study aimed to compare RAV visualisation and contrast enhancement degree on adrenal venous phase images reconstructed using ASiR and MBIR techniques.

Materials and methods

Patients

This prospective study was approved by the institutional review board, and written informed consent was waived. Sixty consecutive patients with PA scheduled for AVS between January 2014 and September 2016 underwent adrenal venous phase imaging for pre-AVS adrenal vein detection. Three of the 60 patients were excluded due to unstable breath-holding (n=2) and technical failure during contrast material injection (n=1). Therefore, the remaining 57 patients (mean age, 64.8±14.1 years; range, 21–87 years; mean body mass index [BMI], 22.7±4.8; range, 16.6–45.3), 32 men (mean age, 66.8±12.3 years; range, 27–85 years; mean BMI, 21.4±2.9; range, 16.6–27.7) and 25 women (mean age, 62.4±16.1 years; range, 21–87 years; mean BMI, 24.3±6.1; range, 18.1–45.3), comprised the study cohort.

CT protocols and contrast material injection

A 64-detector CT system (Discovery CT750 HD; GE Healthcare) and an automatic tube current modulation program (3D mA Modulation; GE Healthcare) were used for performing CT imaging. The X-ray tube current was modulated using the tube current modulation-incorporated z-axis and angular dimension modulations of tube current that were adjusted for the individual patient's body size. Based on the preset noise index of 10 HU at 5-mm slice collimation, the X-ray tube current was automatically modulated to obtain an acceptable image noise level across various anatomical thicknesses and asymmetries.[10]

Other CT imaging parameters were fixed as follows: 120 kVp tube voltage, 5 mm slice collimation, 0.6 mm/0.6 mm reconstruction thickness/interval, variable tube current, 64 detectors with 0.625-mm section thickness, 40 mm beam collimation, 0.4 (early and late adrenal venous phase) or 0.5 (portal venous and equilibrium phases) seconds rotation time, 0.561:1 pitch, large body scan field-of-view (FOV), and 40 cm display FOV.

In all patients, contrast material (600 mg iodine/kg body weight) containing 300 mg/ml of iohexol was intravenously injected for 30 seconds using a commercially available 110- or 150-ml syringe package and a power injector through a 22-G (injection rate <3.4 ml/sec) or 20-G (injection rate ≥3.4 ml/s) plastic intravenous catheter typically placed in an antecubital vein. The actual volume of contrast material delivered was 2 ml/kg of body weight for 52 patients with weights ranging from 41 to 75 kg and was fixed at 150 ml for five patients with weights ranging from 77 to 119 kg. The early adrenal venous phase images were fixed at 45 seconds after contrast material administration. The other diagnostic CT images were obtained at 55 seconds for the late adrenal venous phase, 65 seconds for the portal venous phase, and 180 seconds for the equilibrium phase after contrast material administration.

Image reconstruction

Raw data were reconstructed using either ASiR 40% or MBIR with 0.625-mm section thickness and 0% overlap. An ASiR 40% reconstructed image was obtained by combining 60% filtered back projection (FBP) and 40% ASiR, as previously described with CT angiography.[7]

Qualitative image analysis

Two radiologists (S.G., with 15 years of post-training experience interpreting abdominal CT images as an expert and S.N., with 1 year of post-training experience as a beginner) independently reviewed CT images. Preset window settings of all CT images were initially fixed with 350 HU width and 40 HU level, but the radiologists were allowed to adjust the window settings at their own discretion during evaluation. The radiologists evaluated transaxial images with a 0.625-mm section thickness using a commercially available Digital Imaging and Communications in Medicine viewer. An enhanced tubular or linear structure arising from the right adrenal gland and eventually entering the inferior vena cava (IVC) either directly or indirectly was identified as the RAV. According to the anatomical characteristics above, the radiologists independently graded the conspicuity of the RAV using a five-point rating scale: 5 for excellent, 4 for good, 3 for moderate, 2 for poor, and 1 for not visible.[3,11] A confidence rating of 3–5 was regarded as a visualised RAV.

Quantitative image analysis

The radiologists also measured the mean CT attenuation values of the RAV, right adrenal grand, IVC, hepatic vein, bilateral renal veins, and background noise on 0.625-mm thick axial images. The mean CT attenuation values of the RAV were measured with a region-of-interest (ROI) in cases