Diagnostic Performance of a Non–Contrast-Enhanced Magnetic Resonance Imaging Protocol for Potential Living Related Kidney Donors

Robert Goetti, MD, Stephan Baumueller, MD, Hatem Alkadhi, MD, MPH, Pierre-Alain Clavien, MD, Marc Schiesser, MD, Thomas Pfammatter, MD, Roger Hunziker, MD, Gilbert Puippe, MD

Rationale and Objectives: The objective of the study was to evaluate the performance of a non–contrast-enhanced magnetic resonance (MR) imaging protocol for preoperative screening of living related kidney donors.

Materials and Methods: Forty consecutive subjects (mean age 52.2 ± 11.3 years, range 29–73 years) underwent MR imaging with T2-weighted sequences (coronal and axial plane), with a non–contrast-enhanced respiratory-gated three-dimensional steady state free precession MR angiography (NCE-MRA) sequence and with contrast-enhanced magnetic resonance MR angiography (CE-MRA) sequences in the arterial and venous phases. Two blinded readers independently assessed arterial and venous anatomy and potential kidney lesions. Results of non–contrast-enhanced images were compared to CE-MRA and in a subgroup of 21 subjects to surgery as standard of reference.

Results: Regarding arterial anatomy, NCE-MRA yielded sensitivity, specificity, and accuracy of 100%, 89%, and 91% compared to CE-MRA. Three kidneys were found to have more accessory renal arteries at NCE-MRA than at CE-MRA. In the subgroup of 21 subjects, 1 surgically proven accessory artery was depicted with NCE-MRA but not with CE-MRA. Accuracy of T2-weighted images regarding accessory veins or variant venous course was 99%, with one missed circumaortic vein on T2-weighted images. Two simple cysts were missed on T2-weighted and NCE-MRA but not on CE-MRA images.

Conclusion: A non–contrast-enhanced MR imaging protocol including NCE-MRA and T2-weighted images allows for the accurate screening of living related kidney donors and may serve as an alternative to CE-MRA.

Key Words: Magnetic resonance imaging; angiography; organ donors; contrast media.

Renal transplantation is considered the therapy of choice for end-stage renal failure. Living related kidney donation offers a possibility to overcome the constant shortage of renal allografts. Compared with cadaveric grafts, grafts from living donors are associated with better long-term results, including longer graft survival (1).

Harvesting of donor kidneys via a laparoscopic approach has become the procedure of choice with the advantages of a lower overall complication rate, less postoperative pain, shorter hospital stay, and faster return to work compared to open donor nephrectomy (2). Before nephrectomy, the current guidelines recommend the assessment for potential donors including a complete clinical history, physical examination, laboratory testing, urine analysis, and imaging with a mandatory renal angiogram (3). In particular, laparoscopic harvesting procedures require accurate preoperative imaging, which should provide detailed information on the vascular road map and rule out the presence of focal or diffuse renal lesions and urinary tract dilatation.

Digital subtraction angiography is considered the gold standard for the evaluation of renal artery anatomy (4), but due to its invasiveness and limitations in detecting parenchymal lesions and variant renal veins, it is increasingly abandoned as a primary imaging modality (4). Computed tomography angiography (CTA) has proved to be a reliable and accurate modality for the assessment of potential kidney donors (5,6), but both digital subtraction angiography and CTA hold the disadvantages of ionizing radiation and the need for

Acad Radiol 2013; 20:393–400

From the Institute of Diagnostic and Interventional Radiology, (R.G., S.B., H.A., T.P., R.H., G.P.); and Division of Visceral and Transplant Surgery, University Hospital Zurich, Raemistrasse 100, 8091 Zurich, Switzerland (P.-A.C., M.S.). Received February 18, 2012; accepted December 4, 2012. **Address correspondence to:** R.G. e-mail: robertpaul.goetti@usz.ch

http://dx.doi.org/10.1016/j.acra.2012.12.001

iodinated contrast agents. Contrast-enhanced magnetic resonance (MR) angiography (CE-MRA) was shown to be similarly suitable for potential kidney donor evaluation compared to CTA (5) and thus is preferred in patients without contraindications to MR imaging. Nevertheless, administration of gadolinium-based contrast agents is associated with a small but non-negligible risk for adverse reactions (eg, anaphylactic reactions). Furthermore, routine use of gadolinium-based contrast agents increases the cost of each examination. Thus, recent attempts in MR imaging technology aim at non–contrast-enhanced protocols for imaging of the renal arteries by using steady state free precession (SSFP) sequences to avoid the use of gadolinium-based contrast agents (7–10).

The purpose of this study was to prospectively evaluate the performance of a non–contrast-enhanced MR imaging protocol for preoperative screening of potential living related kidney donors.

MATERIALS AND METHODS

This prospective study was approved by the local ethical committee and our institutional review board. Written informed consent was obtained from each subject.

Study Subjects

From January 2010 to May 2011, a total of 40 consecutive subjects (15 men and 25 women, mean age 52.2 ± 11.3 years, range 29–73 years) under consideration for living related kidney donation were referred for MR imaging of the kidneys and renal vasculature. None of these 40 subjects met the study exclusion criteria, which were denial of written informed consent, pregnancy, or general exclusion criteria for MR imaging (eg, cardiac pacemakers, implantable neuromodulation devices, cochlear implants, or intracranial metallic foreign bodies). Demographics of the study population including risk factors for vascular diseases are listed in Table 1.

Absolute contraindications to kidney donation based on imaging findings were the presence of a renal mass suspicious for malignancy and anomalies such as cross-fused ectopia or horseshoe kidney, which do not allow for harvesting one kidney. Of the 40 subjects, a subgroup of 21 subjects (6 men and 15 women, mean age 49 ± 11 years, range 29–63 years) who fulfilled all criteria for living related kidney donation and laparoscopic donor nephrectomy was approved by our institutional transplant board. Only one patient was excluded from donation based on imaging findings of a renal mass subsequently proven to be renal cell cancer.

MR Imaging

MR imaging was performed on a 1.5-T MR system (Signa HD Echo Speed; GE Healthcare, Milwaukee, WI) in all 40 subjects. Subjects were imaged in the supine position with arms raised above the head. An 8- or 12-channel body-array coil was positioned anteriorly and posteriorly over the abdomen. For respiratory gating at non–contrast-enhanced MR angiography (NCE-MRA), respiratory triggering bellows were applied. Before entering the scanning room a 20–22 gauge canula was placed in a cubital vein in all subjects. Table 2 provides a detailed overview of the scan protocol.

TABLE 1. Demographics of Potential Living Related Kidney Donors

	Study Population (*N* = 40)
Age (y)*	52.2 ± 11.3 (29–73)
Sex	
Men	15
Women	25
BMI (kg/m^2)*	25.3 ± 3.0 (19.8–33.9)
Creatinine clearance (mL/min)†	102 ± 22 (62–145)
Obesity‡	3
Smoking§	5
Hypertension¶	11
Elevated serum cholesterol**	7
Diabetes mellitus	2
Positive family history	1

*Data are mean ± standard deviation (range).

†Calculated creatinine clearance from 24-hour urine collection. Data are represented as mean ± standard deviation and (range).

‡Obesity is defined as body mass index (BMI) ≥30 kg/m^2.

§Positive when actual or any smoking in the past years ≥10 pack-years.

¶Positive when history of hypertension or actual systolic blood pressure ≥140 mm Hg.

**Elevated serum cholesterol is defined as serum cholesterol ≥5 mmol/L.

MR imaging started with two T2-weighted fast spin echo sequences in the axial and coronal planes covering the entire abdomen. Coronal T2-weighted images were also used to localize both kidneys and to plan the subsequent sequences.

Then, NCE-MRA was performed using a respiratory-gated magnetization prepared three-dimensional (3D) steady state free precession sequence (Inhance; GE Healthcare) with inversion recovery and fat saturation. For this, a 3D volume slab with a superoinferior axis coverage of 11 cm was placed over both kidneys. Image acquisition was accelerated by a parallel-imaging factor of 2. Preparation pulses were repetitively applied to suppress background tissue and inflowing venous blood. Subjects were instructed to breathe regularly and at normal amplitude during data acquisition.

Before CE-MRA, a test bolus scan was acquired. The test bolus consisted of 2 mL gadobutrol (Gd-BT-DO3A, Gadovist; Bayer Schering Pharma AG, Leverkusen, Germany) administered at a flow rate of 1.5 mL/sec followed by a 30-mL saline flush at a flow rate of 1.5 mL/sec. The test bolus scan was carried out by repetitive acquisition of the same sagittally orientated image plane, which contained a large segment of the thoracoabdominal aorta. By placing a region-of-interest in the suprarenal aorta, the time interval between the start of injection and maximum enhancement within the region-of-interest (time-to-peak) was measured. The time-to-peak