Original Investigations

Noncontrast-Enhanced Magnetic Resonance Versus Computed Tomography Angiography in Preoperative Evaluation of Potential Living Renal Donors

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Abbreviations

CT computed tomography; **CTA** computed tomography angiography; **MR** magnetic resonance; **MRI** magnetic resonance imaging; **NCMRA** noncontrast-enhanced magnetic resonance angiography; **CEMRA** contrast-enhanced magnetic resonance angiography; **W** weighted; **TSE** turbo spin echo; **B-SSFP** balanced steady-state free procession; **MPR** multiplanar reconstructions; **MIP** maximum intensity projection; **Ax** axial; **Cor** coronal; **Sag** saggital

Rationale and Objectives: Living renal donors undergo an extensive examination program. These examinations should be as safe, gentle, and patient friendly as possible. To compare computed tomography angiography (CTA) and an extensive magnetic resonance imaging (MRI) protocol without contrast agents to observations from nephrectomy in living renal donors and to evaluate whether noncontrast-enhanced MRI can replace CTA for vessel assessment in living renal donors.

Material and Methods: CTA and MRI results were compared to observations from nephrectomy, which served as the reference standard. Fifty-one potential kidney donors underwent imaging, and 31 donated a kidney. Comparisons in sensitivity, specificity, and accuracy were made with respect to the number of arteries, early branching, and the number of veins. Agreement was assessed using Cohen's kappa. The exact McNemar's test was used to test for statistically significant differences.

Results: In the assessment of more than one renal artery, the sensitivity and specificity of MRI and CTA were high and in perfect agreement compared to observations from surgery. The results for both MRI and CTA were as follows: (sensitivity 100%/specificity100%/accuracy 100%/Kappa = 1/P = 1). When comparing the ability to test for early branching we found, MRI: (sensitivity 33%/specificity 100%/accuracy 87%/Kappa = 0.45/P = 1) and CTA: (sensitivity 50%/specificity 100%/accuracy 90%/Kappa = 0.62/P = 1). When used to depict supernumerary veins, we found MRI: (sensitivity60%/specifivity100%/accuracy 93%/Kappa = 0.72/P = 1), whereas CTA showed: (sensitivity 40%/specificity 96%/accuracy 87% Kappa = 0.43/P = 1).

Conclusions: In conclusion, an optimized MRI protocol that includes noncontrast-enhanced magnetic resonance angiography can be substituted for CTA for preoperative assessment of the renal vessels before living donor nephrectomy.

Key Words: Noncontrast-enhanced magnetic resonance imaging; noncontrast-enhanced magnetic resonance angiography; computed tomography angiography; living renal donation; living kidney donation; living donor nephrectomy.

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Renal transplantation is considered the treatment of choice for end-stage renal disease. Because of a lack of organs, an increasing number of kidney transplantations are performed with kidneys from living donors, which results in longer graft survival (1). The laparoscopic approach has become popular for nephrectomy because it has a lower complication rate, less postoperative pain, and shorter hospital stay than open donor nephrectomy (2). The potential donors are healthy and often younger people who undergo a program of examinations purely to exclude disease and to clarify the renal vascular anatomy for nephrectomy planning. Because of a high frequency of anatomic variations, some guidelines recommend

assessing potential donors with imaging, including renal angiography (3–6). The importance of detailed description of the anatomy and pathology before living renal donation has been emphasized (7). Obviously, the screening program for living kidney donors should be as noninvasive and gentle as possible. Arterial imaging is important because the presence of multiple arteries may increase the operation time, and accessory lower pole arteries are associated with a higher rate of recipient ureter complications (8). Older studies have compared angiography to surgery, but few recent studies have been performed (9–11). Past studies have reported that contrast-enhanced magnetic resonance angiography (CEMRA) can replace digital subtraction angiography (DSA) but has suboptimal accuracy in detecting small accessory arteries (9–11). Only a few studies have compared computed tomography angiography (CTA) and CEMRA in living kidney donors. Although in some cases CEMRA was shown to be preferable, in most cases CEMRA was inferior to CTA in detecting small accessory arteries (12–15). CEMRA has been compared with results from living donor nephrectomy, and it was shown to be a reliable imaging technique for the assessment of the renal vasculature with performance comparable to that of CTA (16). With surgery serving as the reference standard, CEMRA has identical accuracy to CTA in characterizing renal vascular anatomy (17). Two previous studies compared a noncontrast-enhanced magnetic resonance imaging (MRI) protocol that included noncontrast-enhanced MR angiography (NCMRA) to CEMRA (with results from surgery used as the reference standard) and found that MRI without contrast agents can reliably depict renal vascular anatomy and serve as an alternative to CEMRA in the screening of living kidney donors (18,19).

Thus, there is inconsistency in the literature as to whether noncontrast-enhanced MRI has sufficient quality for preoperative assessment of potential renal donors. Recent improvements in MRI and NCMRA sequences that enable better and faster imaging have led us to hypothesize that an MRI protocol that includes NCMRA and other sequences to highlight anatomy and pathology might now be a valuable alternative to CTA and allow subjects to avoid the risks associated with radiation exposure and contrast injections (20–26).

Therefore, in the present study, we compared CTA and an extensive MRI protocol without contrast agents to observations from laparoscopic nephrectomy in living renal donors.

MATERIAL AND METHODS

This study was conducted in accordance with the Declaration of Helsinki. The project was approved by the Central Denmark Region Committee on Health Research Ethics (M-20100123). Informed written and oral consent was obtained from all participants. Approval for data sampling and storage was granted by the Danish Data Protection Agency.

Participants

Sixty potential kidney donors were consecutively included in the prospective study. Ultimately, nine of these individuals dropped out of the study, six due to claustrophobia, one due to several comorbidities, one because the entire examination program was canceled, and one who did not want to be a donor. Fifty-one patients underwent scanning from March 2011 to June 2014 and 31 of them donated a kidney from March 2011 to September 2014. Before nephrectomy, all 51 potential donors underwent CT scanning, including CTA and CT urography, and an extensive MRI protocol including T1 weighted (W) turbo spin echo (TSE), T2W TSE, balanced steady-state free procession (B-SSFP), NCMRA, and MR urography. The vast majority of the CTA and MRI examinations were performed within a timeframe of 3 days because all preoperative examinations of the potential donors were performed as "fast-track" within this timeframe.

Computed Tomography

CTA was performed on one of the following systems: Brilliance 64 (Philips Medical Systems; Cleveland, OH; 20 subjects), Toshiba Aquilion ONE (Japan; 16 subjects), or Somatom Sensation 64 (Siemens Erlangen; 15 subjects). The examinations were performed using clinical standardized protocols. Low-dose unenhanced CT extending from the kidneys to the bladder was performed to detect stones and vessel calcifications. This scan was followed by CTA combined with an excretory phase used for the interpretation of the vascular anatomy as well as the anatomy of the kidneys and urinary collecting system. A split-bolus injection of 30 mL and 100 mL (70 kg body weight) ioversol (Optiray, 300 mgI/mL) was administered at an injection rate of 4 mL/s and was used with a 10-minute interval between the first and second injection, resulting in one scan that included both the arterial and excretory phase. This method was used to simplify the CT protocol and reduce the radiation dose. The scan was performed at 100–120 kV with a variable tube current using automated dose modulation. A slice thickness of 1–2 mm was used depending on the scanner system. The gantry rotation time was 0.5–0.75 seconds, and the pitch was 0.6–1.2. The mean patient radiation dose measured by dose length product was 410 mGYcm (range of 239–1284 mGYcm and a mean of 410 mGYcm). The images were analyzed using the Extended Brilliance Workspace (Philips Medical Systems, Best, The Netherlands) with the possibility of using multiplanar reconstruction (MPR), maximum intensity projection (MIP), and three-dimensional (3D) volume rendering.

Magnetic Resonance Imaging

MRI was performed with a Philips 1.5-T Achieva system with release 3.2.1 software and a 33 mT/m gradient system. A 16-channel torso XL coil was used (Philips). In January 2014, the scanner was upgraded to Achieva dStream and the integrated posterior coil in combination with an anterior coil was used on the last 11 participants in the study.

To evaluate the value of MRI in the examination of potential renal donors, an extensive imaging protocol was