Duplex scanning has a limited role in the evaluation of patients with renal failure

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Objective: **Although common indications for renal duplex scanning (RDS) include hypertension (HT) and renal failure (RF), the role of RDS in the evaluation of patients with RF is not known. The goal of this study was to define ultrasound findings with predictive or discriminatory value in patients with RF and to identify patients undergoing a renal artery intervention as a result of RDS findings.**

Methods: **We conducted a retrospective review of 214 consecutive patients referred to an Intersocietal Accreditation Commission-accredited vascular laboratory for an initial RDS from January 1, 2010, to June 30, 2010. RDS included direct ultrasound evaluation of the main renal vessels and renal parenchyma. Significant renal artery stenosis of ≥60% diameter reduction was indicated by a renal/aortic velocity ratio ≥3.5 and abnormally increased parenchymal resistance by an end-diastolic ratio ≤0.3.**

Results: **We separated the patients into two groups by indication for RDS: Group I (HT alone, n = 102) and group II (RF alone or with HT, n = 112). When group I was compared with group II, there were significant differences in gender (50% vs 67% male; $P = .013$), age (50.9 ± 18.5 vs 60.0 ± 14.8 years; $P < .001$), mean arterial pressure (103.1 ± 18.8 vs 85.7 ± 17.0 mm Hg; $P < .001$), and creatinine (0.95 ± 0.35 vs 2.25 ± 1.07 mg/dL; $P < .001$). In group I patients, 86 (84.3%) had normal parenchymal resistance, whereas in group II patients, 68 (60.7%) had abnormally increased parenchymal resistance unilaterally or bilaterally ($P < .001$). Unilateral or bilateral renal artery stenosis was identified in six group I patients and in three group II patients ($P = .315$). Evaluation of group II patients revealed a diagnosis of decompensated congestive heart failure (CHF) and the presence of unilateral or bilateral increased parenchymal resistance in 27 of 68 (39.7%) vs nine of 44 (20.4%) with CHF and normal parenchymal resistance. One renal artery angioplasty was performed in a patient with unilateral renal artery stenosis and fibromuscular dysplasia.**

Conclusions: **Renal artery stenosis is extremely uncommon in patients undergoing RDS for RF, indicating that ischemic nephropathy is rarely a cause of RF in these patients. Abnormally increased renal parenchymal resistance is frequently found in patients being evaluated for RF and is associated with increasing creatinine and age. A diagnosis of CHF is also more common in patients with increased parenchymal resistance. Although patients who undergo RDS for RF rarely require renal artery interventions, ultrasound indices of parenchymal resistance may serve as a marker for renal disease and cardiovascular morbidity. Further studies are required to determine the prognostic significance of these ultrasound findings in the setting of RF. (J Vasc Surg 2014;60:1593-8.)**

Since the first descriptions of renal duplex scanning (RDS) in the 1980s, this noninvasive diagnostic method has been used for the evaluation of renal artery pathology caused by atherosclerosis, fibromuscular dysplasia, arteritis, and dissection.[1,2] This approach is frequently used in patients with hypertension (HT) to identify renovascular disease as an etiology. Although patients referred to the vascular laboratory may also have impaired renal function, the role of RDS in the setting of renal failure (RF) is much less clear.

Modern duplex ultrasound imaging can provide information on blood flow throughout the abdominal aorta, bilateral main renal arteries, hilar and parenchymal arteries, and renal veins. Ultrasound evaluation of the kidneys allows assessment of renal size, the morphology of the cortex and medulla, and the presence of cysts, solid masses, and other abnormalities such as hydronephrosis and calculi. The renal resistive index (RRI) and end-diastolic ratio (EDR) are ultrasound parameters that provide an assessment of renovascular resistance within the parenchyma of the kidney.[1] Although flow patterns in normal kidneys are consistent with low parenchymal resistance, abnormally increased resistance has been associated with progressive renal parenchymal disease and clinical failure of renal artery interventions.[3,4] Increased parenchymal resistance has also been shown to correlate with age, coronary heart disease, increased blood pressure, estimated glomerular filtration rate, and diabetic nephropathy.[5,6]

The diagnostic value of renovascular and parenchymal ultrasound parameters in patients with RF has not been established. Measurement of RRI has been investigated in the critically ill as a bedside modality for evaluation of

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volume status, response to fluid challenge, and differentiation between acute, transient, and persistent RF.[7-10] Patients with decompensated congestive heart failure (CHF) have also been evaluated with RDS, and attempts to correlate CHF class with RRI have been undertaken.[11] In patients with chronic kidney disease (CKD), several attempts have been made to correlate underlying histopathologic diagnosis, prognosis, and response to therapy with RRI.[12,13] In the outpatient setting, this parameter has been used to evaluate diabetic patients without frank albuminuria and to guide timing of renal biopsy.[14,15] RDS has been used to identify occult renal dysfunction in patients with chronic obstructive pulmonary disease, as an attempt to identify preclinical target organ damage in patients with HT without renal disease, and to look for correlations between RRI and blood pressure fluctuations.[16-18]

Our goal in conducting this study was to define ultrasound findings with predictive or discriminatory value in patients with RF, identify patients undergoing a renal artery intervention as a result of the RDS findings, clarify the role of RDS in RF, and guide the use of vascular laboratory resources.

METHODS

The University of Washington Institutional Review Board (Human Subjects Division) approved the study protocol. Individual patient consent was not required due to the retrospective study design.

Patients. This was a retrospective review of consecutive patients referred to the Intersocietal Accreditation Commission-accredited vascular laboratory at the University of Washington Medical Center for an initial RDS from January 1, 2010, through June 30, 2010. Patients undergoing RDS during the specified time period were identified through the vascular laboratory clinical database. Of 269 RDS reports that were initially reviewed, we excluded 6 patients with a solitary kidney and 4 patients with renal artery occlusion to obtain a more representative sample of the general population, and also excluded 3 neonates, 19 scans performed for indications other than HT or RF, 20 follow-up scans, and 3 scans that lacked a complete report. This produced a study cohort of 214 patients, which are included in this analysis.

Standard demographic data were collected along with the RDS results. All data were collected from the electronic medical record at the University of Washington Medical Center, and RDS results were recorded from the vascular laboratory reports. The original interpretations for these reports were performed by two physicians, and ~95% of the reports were interpreted by a single physician. Both interpreting physicians hold the Registered Physician in Vascular Interpretation credential from the American Registry for Diagnostic Medical Sonography. All RDS were performed and interpreted according to the protocol and criteria described below.

Indications for RDS were classified as HT alone, RF alone, and combined HT and RF according to information provided by the referring provider and were verified by records review using the Kidney Disease Outcomes Quality Initiative revised classification[19] and RIFLE (risk, injury, failure, loss, end-stage renal disease) criteria.[20] Information on medical comorbidities and renal interventions was also recorded. Age was available for all 214 patients, systolic blood pressure (SBP) and mean arterial pressure (MAP) were available for 171 patients, kidney lengths were available for 204 patients, and creatinine values were available for 176 patients. Serum creatinine and blood pressure values were obtained on the same date as the RDS or as close to that date as possible.

RDS. The protocol for RDS included direct ultrasound evaluation of the main renal arteries, renal veins, and renal parenchyma, as previously described.[2] All scans were performed by seven registered vascular technologists using iU22 (Philips Healthcare, Andover, Mass) and Logiq 9 (GE Healthcare, Waukesha, Wisc) ultrasound systems and 2.5-MHz to 3.0-MHz phased-array or curved linear transducers. Patients were asked to fast for at least 8 hours before the examination to minimize bowel gas.

The abdominal aorta is scanned first, and a peak systolic velocity (PSV) is obtained at the level of the superior mesenteric artery (SMA) origin for calculation of the renal-to-aortic velocity ratio (RAR). Once the renal artery origins are identified just distal to the level of the SMA with B-mode and color-flow imaging, the renal arteries are evaluated throughout their length with pulsed Doppler spectral waveforms, and the maximum PSV is noted. Transabdominal and flank approaches may both be required for a complete examination of the renal arteries. Whenever possible, an angle of 60° is maintained between the Doppler beam and the arterial wall; however, a smaller angle can be used when this is not possible.

Arterial flow in the renal parenchyma is assessed with a small (1.5-mm to 2.0-mm) pulsed Doppler sample volume at a 0° angle. Color-flow or power Doppler imaging facilitates visualization of the interlobar and the arcuate arteries, and Doppler spectral waveforms are obtained from the upper and lower poles of each kidney. Three separate longitudinal pole-to-pole measurements are obtained, and the average of these is reported as the length measurement for that kidney. We used the sum of both kidney lengths as a single parameter of kidney size for each patient. Although this approach did not account for variations in kidney lengths within an individual patient, it provided an indicator of total renal mass that could be used in the analysis.

The classification of renal artery disease by duplex scanning is based on spectral waveforms from the renal artery and adjacent abdominal aorta. Four categories are defined based on the highest PSV in the renal artery and the RAR: normal, <60% diameter reduction, ≥60% diameter reduction, and occlusion.[1,21] The threshold for a significant renal artery stenosis was a RAR ≥3.5, which corresponds with 60% diameter reduction. A <60% diameter reduction was indicated by a renal artery PSV >180 cm/s and a RAR <3.5. Renal parenchymal resistance was assessed