Multislice CTA for Renal Artery Stenting

How CTA can be a useful modality for diagnosing and managing renal artery stenosis for stent placement.

BY MICHAEL WHOLEY, MD, MBA; JAMES WU, BA; WILLIAM C.L. WU, MD, FACC; AND IAN NOWAK, CRT

The advent of multislice computed tomographic angiography (CTA) with 64-slice scanners and greater has enabled screening of more of the patient population most at risk for renovascular hypertension. It is possible to screen for renal artery stenosis (RAS) alone or more commonly as part of the screen for coronary or abdominal aorta and runoffs. CTA has been found to have good sensitivity and specificity in detecting RAS. Even with the older 16-slice scanner, high sensitivity and specificity were achieved (90%–98%) with negative predictive values of > 95%.[1] Thus, a normal CTA virtually rules out RAS.[1]

We have a dilemma in screening for RAS. No diagnostic test has been sufficiently accurate, inexpensive, noninvasive, reproducible, and adequately validated in practice settings to be accepted universally as a screening procedure.[2] Ideally, the first step in diagnosis is to identify a group of patients with a prevalence of RAS that is high enough to justify screening.[2] The second step is to select a test with a high sensitivity, and the third step is to perform arteriography in patients who have positive test results.[2] We can then identify the groups of patients with a prevalence of RAS. The majority of our patients have been diagnosed with coronary artery or peripheral vascular disease and therefore have at least a 30% chance of having other atherosclerotic disease such as RAS.[3] Other factors such as new onset hypertension and risk factors such as diabetes, smoking, and age (> 70) contribute to the population of patients who need to be screened.

We looked at our early experience in using CTA as a tool to screen for RAS for possible renal artery intervention with renal stenting and included the surveillance of stent patency. This study is limited in terms of its numbers of patients to make solid conclusions but raises points to consider in the diagnosis and management of hypertension.

METHODS

During the past 10 months, we reviewed our arterial-related CTA scans. In 2008, we performed more than 1,400 CTA scans with the Philips 64-slice CTA scanner (Philips Medical Systems, Bothell, WA). Of these studies, there were three groups that related to renal imaging. The first group had dedicated renal CTA scans; these were patients with malignant hypertension, on at least two medications, and with high degrees of suspicion of RAS. The second group consisted of combined studies of CTA of the coronary, abdomen, or peripheral runoffs in addition to the renal CTA. Many of these patients had hypertension. The third group was a small set of patients who have had previous renal stent placement and were evaluated for restenosis.

Technique with the 64-slice Philips CTA scans consisted of CTA of the targeted area after the administration of 75 to 125 mL of intravenous contrast (iopamidol) was obtained. Subsequently, the data were sent to a separate Phillips workstation, and three-dimensional reconstruction using curved multiplanar reformation (MPR) with maximal intensity projection (MIP) and color three-dimensional imaging was performed. Secondary manipulation was performed with the AQNet workstation (TeraRecon, Inc., San Mateo, CA).

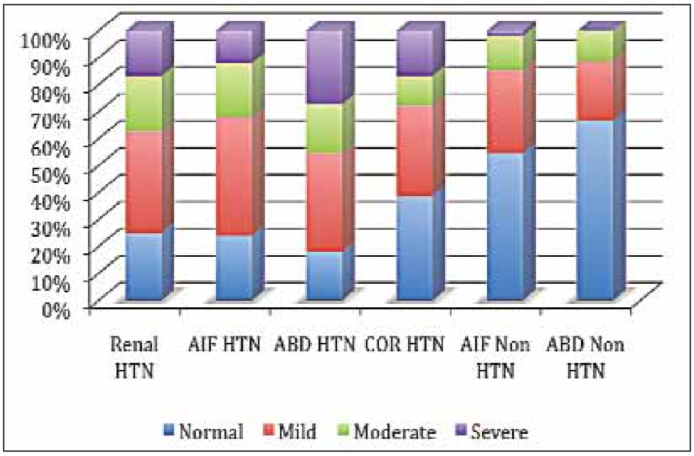

Figure 1. Review of degree of proximal RAS in the study population based on presence of hypertension. Abbreviations: Renal HTN, hypertensive patients with dedicated renal CTA (n = 48); AIF HTN, patients with peripheral vascular disease of lower extremities with hypertension (n = 50); ABD HTN, patients with suspected or diagnosed abdominal aortic aneurysm with hypertension (n = 11); COR HTN, hypertensive coronary CTA patients with renal scans included (n = 18); AIF Non-HTN, patients with peripheral vascular disease of lower extremities without hypertension (n = 55); ABD Non-HTN, patients with suspected or diagnosed abdominal aortic aneurysm without hypertension (n = 9).

Figure 2. CTA revealed high-grade calcified plaque with a soft tissue component involving left renal artery ostium and distal calcified atherosclerosis of segmental and intralobular branches. Arrows denote plaque location proximally and distally.

The degree of RAS was determined by evaluating the degree of narrowing at the targeted vessel compared to a normal segment diameter. Heavy calcified plaque required decreasing the gain and contrast as much as possible. Degrees of stenosis included normal (< 20%), mild (20%–39%), moderate (40%–59%), and severe (> 60%). Statistical probabilities were performed using the logic and computational details of the chi-square and Fisher's exact tests.[4] Distal renal artery atherosclerotic disease, also classified as intrarenal branch stenosis or "pruning," was reviewed in each case.

Exclusion criteria included renal insufficiency. Patients with renal insufficiency defined by glomerular filtration rates < 60 mL/min were first cleared with referring physicians and nephrologists before imaging.

RESULTS

There were a total of 191 patients comprising the three groups who were scanned from January to October 2008. The patients' ages ranged from 18 to 92 years, with the average age of 68. There were 91 women and 100 men.

Of the 191 patients scanned, there were no serious adverse events except for the elevation of one patient's creatinine level 2 weeks after the study from 1.4 to 1.9. Three patients had allergic reactions to the contrast and were treated with medication. Ten patients were found to have mild to moderate renal insufficiency with creatinine levels ranging from 1.7 to 2.6, and these patients were referred for nephrology consults before CTA studies.

The first group included 48 patients with dedicated renal CTA scans. Twelve patients (25%) were normal, 18 mild (38%), 10 moderate (21%), and eight severe (17%) (Figure 1). Ultrasound was performed beforehand in six patients (13%) in whom CTA findings correlated in four (67%) of the findings. Atherosclerotic calcified plaque in the distal renal branches was found in nine patients (19%) (Figure 2). Three patients were found to have fibromuscular dysplasia (FMD).

The second group was composed of three subsets of patients who had the renal arteries scanned in addition to coronary arteries, the abdomen, or lower extremities. There were 105 patients with peripheral vascular disease who underwent CTA of the abdomen and lower extremities. Of these 105 patients, 50 were found to have hypertension; the degree of RAS was found to be normal in 12 patients (24%), mild in 22 (44%), moderate in 10 (20%), and severe in six (12%). Similarly, in the remaining 55 patients without hypertension, 30 had normal renal arteries (54%), 17 had mild (31%), seven had moderate (13%), and one had severe (1%). For the moderate and severe lesions, the *P* value was .07.

There were 21 patients with dedicated abdominal CTA, primarily for aneurysm workup. Of these 21 patients, 11 had hypertension. The renal arteries were normal in two (18%)

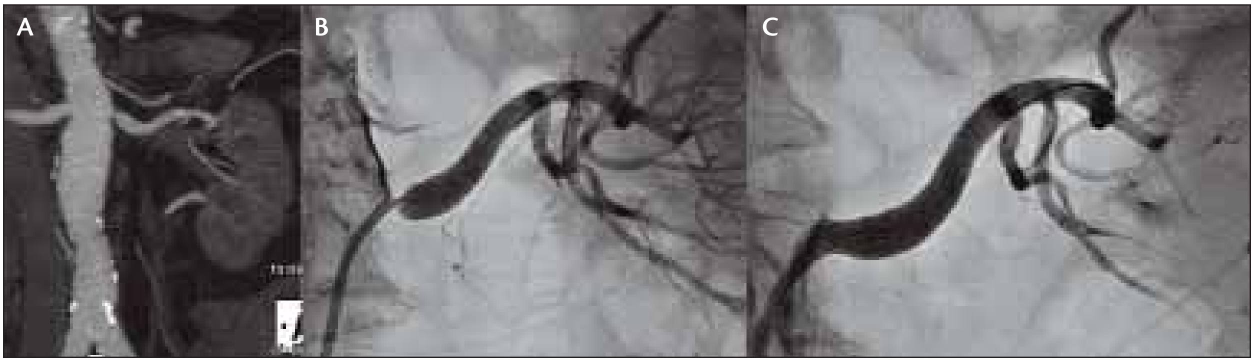

Figure 3. The patient is a 72-year-old man with hypertension, congestive heart failure, and coronary artery disease. CTA revealed high-grade stenoses bilaterally. On the left, a soft tissue plaque causing a severe stenosis was noted (A). Renal angiogram confirmed the renal stenosis (B). Based on measurements from the CTA, a 6- X 15-mm balloon-mounted stent was deployed in the renal artery (C).

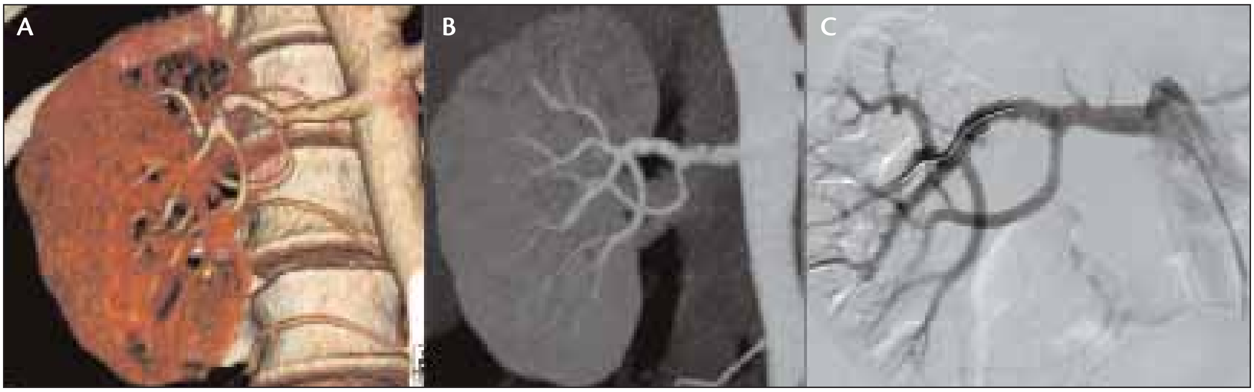

Figure 4. A 48-year-old woman with malignant hypertension diagnosed with FMD shown in three-dimensional CTA (A) and MPR (B) that was treated with angioplasty alone (C).

of these patients, whereas in the remaining patients, four (36%) had mild RAS, two (18%) had moderate stenosis, and three (27%) had severe RAS. In patients who had hypertension, seven (70%) had normal renal anatomy whereas two (20%) had mild, and one (10%) had moderate renal artery narrowing. There were 18 patients with combined coronary and renal scans, all of whom had hypertension; of these coronary hypertension patents, the degree of stenosis was seven normal (39%), six mild (33%), two moderate (11%), and three severe (17%).

From these three groups, 21 patients were diagnosed with severe RAS disease by CTA (> 60%). Two patients were referred back to other groups, and the remaining 19 patients underwent digital subtraction angiography. Angiography confirmed stenosis > 60% in 18 of the 19 patients; one was found to have moderate stenosis (not severe) due to concentric calcified plaque. These 18 patients underwent stent and/or angioplasty (for FMD) (Figures 3 and 4).

CTA was beneficial in all 18 of these patients in intervention planning. The following information was obtained before stent placement or angioplasty:

- Aortic pathology: Severe aortic disease was seen in several patients, which altered the approach to treating the lesion. Because of the prevalence of atheromatous plaque identified along the aortic wall, especially in patients with abdominal aortic aneurysms, a limited “no-touch” technique was used in most renal stent cases.
- Angle of the renal artery: Steep angles of the targeted vessel were noted in four patients, altering the choice of guide catheter used in each case.
- Position of the renal artery relative to the aorta: The renal artery originated off the aorta in a steep posterior position from the aorta in three cases, necessitating a steep oblique position of the image intensifier during stent positioning.
- Vessel diameter: The diameters of the normal renal artery distal to the lesions ranged from 4.2 to 7.5 mm (mean, 5.2 mm).
- Lesion length: Lesion lengths were recorded from 0.8 to 22 mm, with the most common length being 12 mm.

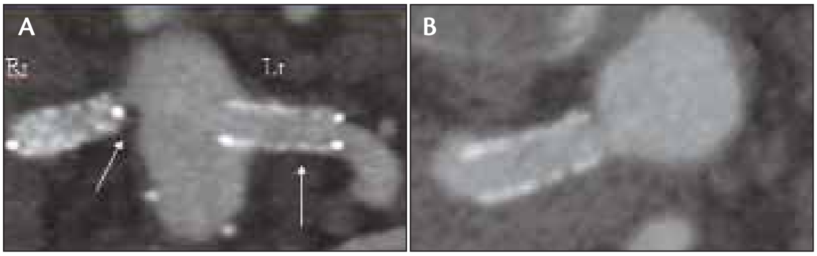

Figure 5. Follow-up CTA of renal stents revealing the right stent to be off of the ostium by approximately 1 mm, possibly setting up hyperplasia (A). The left is widely patent. The axial image confirms the placement of the right renal stent to be just off the ostium with the aorta (B). Although this patient does not have it, placement just past the ostium is crucial in patients with abdominal aortic aneurysms, for the mural thrombus of the aortic wall can shift and cover the stent.

- Plaque composition: Plaque mixture of calcium, soft tissue, and noncalcified plaque was seen in 11 of the patients. Complete calcified lesions were noted in four patients, and complete soft plaque was seen in three patients. In patients with heavily calcified and concentric lesions, predilatation with a 2.5- or 3-mm angioplasty balloon catheter was used to allow easier stent passage. FMD was noted in one patient, altering treatment to angioplasty alone.

The third group of the study was a small subset of 10 patients who had received renal stents 2 to 48 months before. Most were referred for the coronary arteries or lower extremities in conjunction with the renal arteries and were included in the two groups listed earlier. Of the 10 patients, eight were found to have mild restenosis and, two had severe restenosis. The patients with severe disease received a second stent; one of these patients had a second stent that fractured within two months of placement, requiring an additional stent to be placed (Figure 5).

Finally, the incidence of detecting renal and adrenal masses on soft tissue readings of the abdomen was significant. Renal cell carcinoma was found on two of the scans. Four patients had suspicious adrenal masses, which were followed up (Figure 6).

DISCUSSION

Multislice CTA has proven to be beneficial for the treatment of coronary artery disease, and attention has recently grown in its role in diagnosing and managing peripheral vascular disease in areas such as the carotid arteries, lower extremities, and especially renal artery disease.

Because of its high sensitivity to detect RAS on the one hand, and because a normal renal CTA virtually excludes the presence of a significant renal artery stenosis on the other hand, renal CTA plays a useful role in the management of patients with suspected renovascular hypertension.[5] Of the 127 patients with hypertension, 83 (65%) patients were found normal or with mild disease and proved useful in directing these patients for medical management and continued surveillance. Of the remaining 44 patients, 24 (19%) had moderate stenosis and 20 (16%) had severe RAS, allowing for either medical management or angioplasty and/or stent placement. As would be expected, the normotensive group of 64 patients had a greater percentage of normal and mild cases (55 patients, 86%). The remaining nine normotensive patients (14%) had either moderate or severe narrowing.

Comparing the moderate and severe stenoses between the hypertensive and normotensive groups, 44 of the 127 hypertensive (34%) to the nine of 64 in the normotensive group, the *P* value was .001.

An area that we are currently exploring further has been the issue of distal renal artery disease. The presence of distal atherosclerotic disease was shown by the presence of calcified plaque in the branch points of the segmental and interlobar levels. The distal atherosclerotic changes were seen on CTA and later confirmed on angiograms of those who underwent renal artery stenting (Figure 7). This may be a reflection of patients with chronic ischemic changes, which result in long-term damage at the tubular level including thickening at the intrarenal arterial medial level.[6]

It is beyond the scope of this article to definitively answer the question whether stenting the renal ostium is effective in treating hypertension given the significant extent of disease distally. In the later phases of renal vascular hypertension, restoration of renal blood flow may not result in a normalization of the blood pressure, presumably because of secondary irreversible vascular or renal parenchymal disease. With disease extending from divisional to segmental to at least intralobular levels, it is no wonder renal stenting only

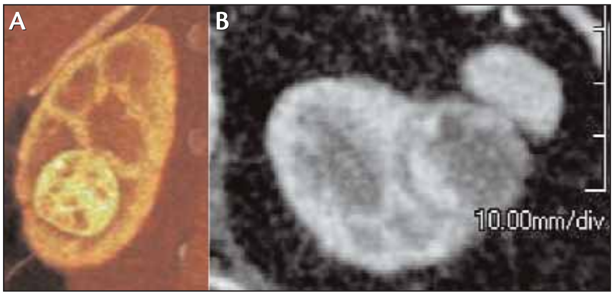

Figure 6. Two different patients with RAS who were found to have renal cell carcinoma (A) and renal cell carcinoma and adrenal mass (B) as shown on three-dimensional and MPR views, respectively. These patients were referred for urology consults.

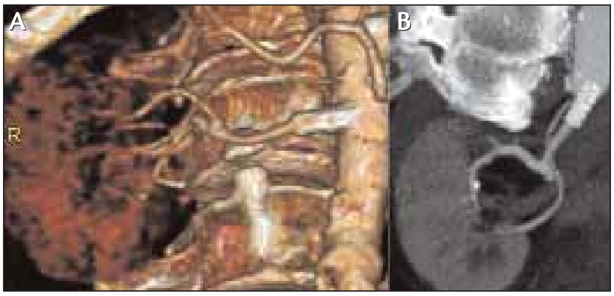

Figure 7. Four-year follow-up of renal stent, which was patent but shows the presence of distal atherosclerotic disease: three-dimensional image (A); MPR image (B). Clinically, the patient's hypertension remains stable, but the patient still requires 3 medications.

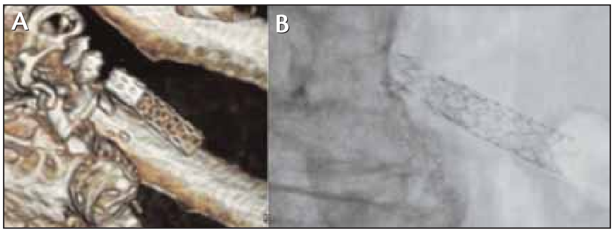

Figure 8. Three-dimensional CT noncontrast showing a patient who received a second renal stent in which the second (more proximal) stent now has a near-complete fracture (A). The patient became more hypertensive, and a follow-up angiogram showed hyperplasia and the fracture was evident on fluoroscopy (B). The patient later underwent an additional stent placement and has done well.

has a marginal cure rate of renal artery hypertension and dysfunction.

Renal CTA provides an understanding of the entire vascular disease process far beyond an invasive angiogram because it is volumetric and can show vascular anatomy from any orientation (including true cranial-caudal projection that is technically impossible with catheter angiography) in addition to the origin of the renal artery and its takeoff angle.[7] Furthermore, CTA demonstrates vascular anatomy far beyond the contrast column, showing both calcified and soft plaque, thrombus, and eccentric plaque. Finally, sizing of vascular stenoses and occlusions permits the interventionist to plan treatment and select appropriately sized balloons and stents.[7] These benefits result in reductions in procedure time, contrast use, radiation exposure, and equipment selection. However, the role of CTA is somewhat limited in the ability to give an exact degree of stenosis especially with concentric calcified plaque.

Finally, CTA has been valuable in assessing renal stent patients to assess patency.[8] Of the 10 patients studied, two had severe restenosis, and both were treated with second stents; one patient had a stent fracture. Doppler ultrasound findings corresponded with all CTA studies. For the stent fracture patient, given the respiratory motion of the kidneys combined with the fixed calcified plaque at the ostium, there is little surprise of the occurrence of metal fatigue with stents that may be too long relative to the dynamic nature of the renal artery (Figure 8).

CONCLUSION

This article provides a preliminary study in the use of CTA multislice scanners in screening for renal artery disease. This study has shown the excellent ability of CTA in detecting RAS and the key tool that CTA has been in planning renal stent procedures. Heavily calcified plaques continue to make accurate stenosis determination difficult, however. The distal disease brings up more questions in terms of the effectiveness of proximal renal stenting, which will require further study. ■

Michael Wholey, MD, MBA, practices interventional radiology and performs peripheral and coronary CTA at Central Cardiovascular Institute of San Antonio in Texas. He has disclosed that he holds no financial interest in any product or manufacturer mentioned herein. Dr. Wholey may be reached at (210) 271-3203; mwholey@hotmail.com.

James Wu, BA, is currently completing his senior year at Washington University in St Louis, Missouri. He has disclosed that he holds no financial interest in any product or manufacturer mentioned herein. Mr. Wu may be reached at (210)-289-9158; jywu13@gmail.com.

William C.L. Wu, MD, FACC, practices peripheral and interventional cardiology at Central Cardiovascular Institute of San Antonio in Texas. Dr. Wu also read coronary and peripheral CTA studies for this article. He has disclosed that he holds no financial interest in any product or manufacturer mentioned herein. Dr. Wu may be reached at (210) 271-3204; williamclwu@cci-sa.com.

Ian Nowak, CRT, is in charge of imaging at the San Antonio Imaging Center in Texas. He has disclosed that he holds no financial interest in any product or manufacturer mentioned herein. Mr. Nowak may be reached at (210) 733-1315; inowak@cci-sa.com

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