Virtual Endoscopy in Renal Artery Stenosis: An Innovative Approach for Diagnosis and Follow-Up

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ABSTRACT

Purpose: We investigated the utility of virtual endoscopy (VE) as a diagnostic and follow-up tool in patients with renal artery stenosis, especially as a means of defining vascular patency.

Patients and Methods: We performed VE in 24 patients with ostial atherosclerotic renal artery stenosis and correlated the results with those of conventional angiography. The patients were treated successfully by placement of metal stents and conventional catheter angiography and VE for patency assessment 6 and 12 months after stent insertion.

Results: In all patients, the stenotic segment was identified, and VE findings were concordant with those of angiography. The average degree of stenosis was estimated to be 70% ± 20% when angiography was used and 62% ± 15% when VE was used. After metal stent insertion, the 12-month patency rate was 83.3% (20 patients). Angiography and VE findings remained concordant during the follow-up period, but VE provided more information beyond the stenotic segment, allowing examination of the arterial lumen both cephalad and caudal to the point of obstruction.

Conclusion: Virtual endoscopy provided a more dynamic, direct, minimally invasive approach that was equal to or better than angiography for both the verification of the vascular stenosis and the evaluation of the arterial lumen.

INTRODUCTION

RENAL ARTERY STENOSIS is a common pathological entity and is an established cause of hypertension and renal insufficiency. Atherosclerosis is the main cause in 90% of cases and usually involves the ostium and proximal third of the main renal artery and the perirenal aorta.1,2

Detection of renal artery stenosis has routinely been performed with angiographic studies. Recently, however, the introduction of CT angiography and MR angiography has permitted a more accurate and dynamic evaluation of renal artery stenosis.3–6

Virtual endoscopy (VE) represents a noninvasive technique allowing amplification of the image in three-dimensional (3D) space, simulating the view of fiberoptic endoscopy systems. In this respect, VE takes advantage of information obtained in axial CT slices and further depicts the 3D relations of pathological regions. The study can provide views of the stenotic segment, as well of as the arterial lumen beyond the stenosis. It has also been shown that VE provides intraluminal as well as extraluminal information about a given tubular structure in all possible directions. Thus, VE enables the exploration of vascular structures that are unapproachable with conventional procedures, irrespective of the size of the lumen.7–11

In the present study, we applied VE as a diagnostic or follow-up study or both in patients with renal artery stenosis, especially to define vascular patency. Thus, the aim of the pres-
ent study was to evaluate the diagnostic accuracy of VE in the detection and follow-up of renal artery stenosis.

**PATIENTS AND METHODS**

We performed VE in 24 patients (mean age 67 years) having ostial atherosclerotic renal artery stenosis and correlated the results with those of conventional angiography. Ostial lesions were defined as stenoses of $>$50% of the diameter of the renal artery.

The patients were treated by placement of metal stents, and conventional catheter angiography and VE were applied for assessment of patency 6 and 12 months after stent insertion. We used the Palmaz balloon-expandable endoprosthesis (Johnson & Johnson Interventional Systems, Warren, NJ). The Palmaz device is a stainless-steel mesh mounted on a percutaneous transluminal coronary angioplasty balloon catheter. The stents were 1 to 2 cm long and when fully expanded reached a diameter of 5 to 6 mm. The detailed methodology of stent insertion has been well described. The applied protocol was approved by the hospital ethics committee, and informed consent was obtained from all patients. All patients tolerated angiography and VE without experiencing any adverse reactions.

Data acquisition was performed in a Somatom Plus 4 Power CT scanner (Siemens, Erlangen, Germany) at deep inspiration. Scanning was performed at 140 kV and 171 mAs, with 2-mm slice collimation and a 2-mm/sec table feed. Acquisition was performed after administration of 140 mL of non-ionic contrast medium (Iomeron, Bracco) at 3.5 mL/sec with a 20- to 25-second delay. Images were reconstructed with a soft reconstruction kernel at 1 mm.

The acquired data were transferred to our DICOM server through an asynchronous transfer mode-based local area network. The medical physicist responsible for image processing selected the studies from the DICOM server on request. Image

**FIG. 1.** Angiography showing ostial stenosis of right renal artery.

**FIG. 2.** Virtual endoscopy. (A) View of stenosed renal ostium from aortic lumen. (B) Retrograde view of stenosis, observing from arterial lumen toward aorta. Interrupted line depicts patent arterial lumen and continuous line the site of stenosis.
After stent insertion, the observed 12-month patency rate was 83.3% (20 patients). Angiography and VE findings remained concordant during the follow-up period. Virtual endoscopy depicted with great accuracy, not only the endoluminal view of the stented artery, providing a sound assessment of patency, but also the exact position of the metal stent with respect to the aortic wall and renal artery lumen.

The time required for the creation and analysis of VE was 10 to 15 minutes.

**DISCUSSION**

Renal artery stenosis is a common cause of secondary hypertension, with a prevalence of approximately 1% in the general hypertensive population. Approximately two thirds of the cases are of an atherosclerotic nature, with the lesion usually located at the origin of the renal artery and involving the ostium or the proximal portion of the vessel or both.1,2

Treatment of these stenoses with percutaneous transluminal angioplasty (PTA) is rarely successful, the rates of immediate failure or late restenosis ranging from 9% to 76% and 25% to 45%, respectively. A plausible alternative treatment that can restore renal blood flow is the use of vascular endoluminal stents.2,12–14 Our experience has shown that metal stents provide a mechanical scaffold and prevent elastic recoil while maintaining vessel patency.15

Detection of renal artery stenosis has been widely performed with angiography studies. The introduction of CT and MR angiography has gradually expanded the diagnostic accuracy of detecting vascular pathology.3–6

The rapid image acquisition of synchronous spiral CT scanners and the evolution of computer systems and software have recently generated virtual-reality images from intraluminal nav-
igation through any hollow viscus. Virtual endoscopy has previously been applied to many organs such as the trachea, the colon, and the bladder.

Virtual endoscopy is a novel diagnostic technique that amplifies the image perception in the 3D space, taking advantage of the information inherent in axial CT slices and providing precise spatial depictions of regions of interest and surrounding structures. In addition, it can easily bypass a stenosis, allowing examination of the arterial lumen beyond the narrowed segment. The precise location, size, and shape of an arterial stenosis can be depicted accurately with VE from any orientation, both intraluminally and extraluminally. The endoluminal view is particularly useful in the assessment of the degree of stenosis and clarifies the need for interventional angioplasty or stenting.

In this study, VE, when compared with conventional angiography, allowed accurate, objective assessment of the degree and exact morphology of the stenosis and provided a more dynamic, direct approach for the evaluation of the arterial lumen, as well as in the verification of a vascular stricture both cephalad and caudal to the point of obstruction. In addition, VE provided clear endoluminal views of the stented arterial segments, allowing safe and minimally invasive follow-up.

**CONCLUSION**

On the basis of the results of the present study, we suggest the use of VE as a valuable diagnostic technique for meticulous preoperative planning of endoscopic manipulations, as well as a noninvasive follow-up tool. The future and expected refinement of computer software and spiral CT scanners may further upgrade the significance of VE as a standard diagnostic and follow-up examination.

**REFERENCES**


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