Comparing diagnostic techniques of magnetic resonance angiography (MRA) and Doppler ultrasonography in determining severity of renal artery stenosis

Mohammad Hashemi Jazi[(1)], Mahfar Arasteh[(2)], Hamid ShamsolKetabi[(3)], Aliakbar Tavassoli[(4)], Peyman Nilforoush[(5)], Mojgan Gharipour[(6)]

Abstract

BACKGROUND: Renal artery stenosis is one of the important causes of hypertension and end stage renal failure. Magnetic resonance angiography (MRA) and Doppler ultrasonography are non-invasive and safe diagnostic techniques that have also high sensitivity and specificity. Since the accuracy and reliability of these techniques depend upon technicians and softwares, we decided to evaluate and compare the sensitivity and specificity of these techniques in Isfahan.

METHODS: Our study included all the patients (37 patients) who underwent renal artery angiography during 2 years from May 2003 to May 2005 and up to six months after that had underwent MRA (21 patients) and Doppler sonography (16 patients) in Isfahan. Renal artery angiography was considered as the gold standard.

RESULTS: Sensitivity, specificity, positive and negative predictive values of 100%, 25%, 25%, and 100% were obtained for MRA respectively. Specificity and positive predictive values (PPV) of Doppler sonography were 67%. Its sensitivity and negative predictive values (NPV) were 57%.

CONCLUSION: Although it seems that technician dependency, technical and software problems were the reasons of low specificity of gadolinium-enhanced MRA in our study, further studies with larger sample sizes are recommended.

Keywords: MRA, Doppler Ultrasonography, Renal Artery Stenosis.

ARYA Atherosclerosis 2011; 7(2): 58-62.

Date of submission: 20 May 2011, ***Date of acceptance:*** 31 Jul 2011

Introduction

Renal artery stenosis or its main branches is the cause of 1 to 5% of hypertension cases and its prevalence increases in patients with resistant hypertension to 20%, in coronary artery disease to 20-15% and in peripheral artery diseases to 40-30%.[1] Interventional treatments such as renal artery angioplasty in patients who had high blood pressure due to renal artery stenosis had decreased the need for antihypertensive drugs and even in a few cases had treated the blood pressure and also improved patients with renal failure.[2-3] Color Doppler ultrasonography, CT angiography and MRA (magnetic resonance angiography) have high sensitivity and specificity among the non-invasive techniques to detect renal artery stenosis. The first screening test was the color Doppler ultrasonography which is so affordable and accessible, is possible to be done in all patients and its positive results help the detection of stenosis.[4] Measuring resistance index during Doppler ultrasonography would help determine the prognosis after returning the function in post-surgical period. Despite this advantage, Doppler ultrasonography has some limitations and insoluble problems including technical difficulties in obese patients or those with flatulence, low sensitivity in multiple cases of renal arteries, small arteries and posterior view of the middle and distal vessels, as well as inability of the patients in keeping their breath and also difficulty in appropriate acoustic window.[5] Moreover, this technique requires a skilled and experienced operator. Spiral CT clinically has a high

1- MD, Cardiologist, Department of Cardiology, School of Medicine, Isfahan University of Medical Sciences, Isfahan, Iran.
2- MD, General Practitioner, Delasa Heart Center, Sina Heart Hospital, Isfahan, Iran.
3- MD, Cardiologist, General Cardiologist, Sina Heart Hospital, Isfahan, Iran.
4- MD, Associate Professor of Cardiology, Cardiac Rehabilitation Research Center, Isfahan Cardiovascular Research Institute, Isfahan University of Medical Sciences, Isfahan, Iran.
5- MD, Delasa Heart Center, Sina Heart Hospital, Isfahan, Iran.
6- MSc, Researcher in Clinical Biochemistry, Isfahan Cardiovascular Research Center, Isfahan Cardiovascular Research Institute, Isfahan University of Medical Sciences, Isfahan, Iran.
Correspondence To: Mojgan Gharipour, Email: gharipour@crc.mui.ac.ir

www.mui.ac.ir

diagnostic accuracy in diagnosis of high risk stenosis but its application had been limited due to dangers of iodized contrast material and ionizing radiation.[6] In recent years, three-dimensional MRA has obtained a significant success in renal artery and abdominal aortic angiography using gadolinium contrast and by breath-holding.[7-9] In addition, MRA using gadolinium in patients with some degrees of renal failure is preferred than other diagnostic techniques and thank to it, the possibility of evaluating the sensitive patients to iodized contrast material has been made possible as well as those with difficulty in artery access and patients who are not able to provide this technique due to angiography risks or difficulty of this technique or its expensive costs.[10-14] Three-dimensional MRA using gadolinium had the sensitivity and specificity of 90% to detect stenosis of more than 50% of the renal arteries.[15-18] In this simultaneous technique with renal artery, the diagnosis of abdominal aortic complications, mesenteric and iliac arteries is possible within approximately 30 seconds (with breath-hold). In MRA visualization in three-dimensional cine phase-contrast method (PC), loss or lack of signal in areas of very slow flow or turbulence indicates the hemodynamic importance of stenosis. Renal toxicity of contrast material by use of noninvasive, relatively inexpensive and safe diagnostic methods has made the diagnosis of renal artery stenosis important particularly in patients with renal failure, as well as catheterization complications.

In routine clinical practice of the radiologist, in which MRA is assessed, usually a computer station will be used; therefore, the accurate interpretation of MRA depends upon the software abilities in reconstruction of the images and features by which the radiologist can manipulate the images. Moreover, the results of Doppler ultrasonography would depend upon technician skills in conducting this technique. The present study aimed to evaluate sensitivity and specificity of Doppler ultrasonography of renal arteries and MRA with angiography as the gold standard of Iran for the first time in Isfahan.

Materials and Methods

This was a cross-sectional study on 37 patients carried out from May 2003 to May 2005. In all patients, diagnostics techniques of MRA and/or Doppler ultrasonography had been used to detect renal artery stenosis and up to six month after that, they underwent renal artery angiography surgery in Isfahan Sina Specialized Heart Center. Doppler ultrasonography was done for 16 ones and MRA for the rest (21 patients). Angiography technique was conducted based on standard technique of Seldinger through femoral artery and with Judkins and Pigtail catheters size 6f as selective and non-selective methods. All the angiographic films after reviewing by two cardiologists were under QCA (Quantitative Coronary Angiography) and the stenosis that engaged ≤ 50% diameter of the vessel (< 75% vessel cross-section) were considered as the significant stenosis. Three-dimensional MRA was done by MRI scanner 1.5 tesla and coronal, axial and sagittal sections obtained through T_1 and dual echo sequences. Gadolinium-enhanced injection rate of approximately 60 ml was done with speed of 1-2 cc/s and with breath-hold method. In image reconstruction method, maximum intensity projection (MIP) and reformatting were used. Analysis of the images was done by a radiologist unaware from the results of the angiography. Stenosis was estimated based on the most reduction in the arterial diameter and its comparison with the most natural proximal or distal device and reduction more than 50% of the arterial diameter was considered as the significant stenosis. In this study, the following sonography parameters were used for the stenosis criteria: peak systolic flow velocity (PSV) compared to renal-aortic ratio (RAR), resistance index (RI) into the renal artery, pulse index (PI), flow velocity waveforms and acceleration time (AT). PSV > 180-200 cm/s, RI > 0.8, RAR > 3.5 and AT > 70 were accepted as the significant stenosis criteria.

Results

The patients of the study consisted of 54% females and 46% males. The mean age of the patients was 60 years. Out of 21 patients who underwent MRA, somehow all of them had renal artery stenosis to some extents. Out of them, 20 patients had a significant stenosis at least in one of their renal arteries. Eighteen patients had bilateral renal artery stenosis which in 15 ones, the stenosis was significant at least in one of their arteries. Significant bilateral stenosis was observed in 11 patients. Out of 20 MRA patients who had been reported significant stenosis, only 5 patients had significant stenosis in angiography and in other 15 patients, stenosis was less than 70% (false negative = 15). These five patients who had stenosis less than 50% in MRA, in angiography also had a non-significant stenosis (false negative = 0). Thus, sensitivity of MRA was 100% and specificity of this diagnostic technique in the present study was 25%. Positive predictive value (PPV) in MRA was 25% and negative predictive value (NPV) was 100%.

www.mui.ac.ir

All sixteen patients who have been underwent Doppler sonography had stenosis to some extent. Out of 16, seven patients had a significant stenosis and 9 patients had a lesser degrees of stenosis. Out of 7 patients with significant stenosis in Doppler sonography, 4 patients had a significant stenosis also in angiography (false positive = 3) and out of 9 patients with non-significant stenosis in Doppler sonography, 3 in angiography had severe stenosis (false negative = 3) and 6 had stenosis with lesser degrees. Therefore, in the present study, the sensitivity of Doppler sonography was 57%, its specificity 67%, the PPV 57% and its NPV was 67%.

Discussion

In a meta-analysis, the sensitivity of MRA in detecting stenosis of more than 50% has been 98%, while the sensitivity of Doppler sonography in detecting this stenosis had reported to be 88%. Both techniques were similar in terms of specificity (96% vs. 95%).[19] In another meta-analysis study, the sensitivity and specificity of both techniques in detecting the stenosis had been 100% and 90%, respectively.[20] In the present study, similar to the mentioned studies, the sensitivity of MRA was more than that of Doppler sonography. Then, the sensitivity difference in the present study was higher (100% vs. 57%). In the present study, the specificity of MRA in detecting stenosis of more than 50% was low in comparison with Doppler in other studies.

In many studies, the sensitivity and specificity of MRA have been close to those of angiography (91-97%).[21-28] In the present study also, the sensitivity of this technique obtained 100% which was in accordance with the previous studies. In this study, the sensitivity of MRA obtained 25% which was so low in comparison with other current studies and meta-analysis; in other words, it seems that considering angiography as a gold standard, MRA false-positive was high in detecting stenosis. The most common problems that may occur in using gadolinium are failure to keep the breath, inappropriate interval in injection or insufficient dose. Assessing breath-holding capacity of the patients and also education before and during images are important in obtaining more clear images. Difference in kidneys size, delay in filling (different in concentrations of gadolinium in the renal collecting system) and losing corticomedullary distinction which are obtained from sagittal or mile T_1 images can show the functional results.[29-31] The concurrency of contrast-enhanced with central K-space is of very high importance. This can be solved with test injection of contrast and taking successive images to obtain time-density curve. The other technique is using fluoroscopic images to monitor exact time of arrival of contrast to start images which of course is possible through very high-tech devices which is not available everywhere. Furthermore, there must be an exact synchronization between the person who injects and the technician who takes the images.

Anteroposterior limitation of the image is one of the major problems of this technique when MRA is done in the coronal level. Therefore, it is important to adjust the image size in a way that includes all the desired area. There are many problems in association with image reconstruction. If MIP is thick due to renal vein or the cortex overlapping, it will be possible that stenosis to be reported falsely and if MIP is thick due to outflow from MIP, the false renal vein or the false cortex overlap will be occurred. In order to better investigate artery stenosis, it is recommended that in addition to the results of MIP, the original images also be checked. Analyzing the original images prevents from venous overlapping. Multi-slice reconstruction and MIP also are of high importance. MIP helps in showing long vessel segments in an image. Besides, in some of the studies, it was recommended that PC MRA with reduction of the number of false positive can help increase 3-D MRA specificity using gadolinium enhanced.

Conclusion

Generally, three-dimensional MRA technique with gadolinium was an efficient method clinically and had high diagnostic accuracy but like other visualization techniques with accurate application and no background problems, its specificity can be improved.

Conflict of Interests

Authors have no conflict of interests.

References

1. Olin JW. Atherosclerotic renal artery disease. Cardiol Clin 2002; 20(4): 547-62, vi.
2. Dorros G, Jaff M, Mathiak L, Dorros II, Lowe A, Murphy K, et al. Four-year follow-up of Palmaz-Schatz stent revascularization as treatment for atherosclerotic renal artery stenosis. Circulation 1998; 98(7): 642-7.
3. Harden PN, MacLeod MJ, Rodger RS, Baxter GM, Connell JM, Dominiczak AF, et al. Effect of renal-artery stenting on progression of renovascular renal

www.mui.ac.ir

failure. Lancet 1997; 349(9059): 1133-6.
4. Harrison TR, Kasper DL. Harrison's principles of internal medicine. 16th ed. New York: McGraw-Hill; 2005. p. 1487-98.
5. Turi ZG, Jaff MR. Renal artery stenosis: searching for the algorithms for diagnosis and treatment. J Am Coll Cardiol 2003; 41(8): 1312-5.
6. Holley KE, Hunt JC, Brown AL, Kincaid OW, Sheps SG. Renal artery stenosis. A clinical-pathological study in normotensive and hypertensive patients. Am J Med 1964; 37: 124-32.
7. Prince MR, Narasimham DL, Stanley JC, Chenevert TL, Williams DM, Marx MV, et al. Breath-hold gadolinium-enhanced MR angiography of the abdominal aorta and its major branches. Radiology 1995; 197(3): 785-92.
8. Snidow JJ, Johnson MS, Harris VJ, Margosian PM, Aisen AM, Lalka SG, et al. Three-dimensional gadolinium-enhanced MR angiography for aortoiliac inflow assessment plus renal artery screening in a single breath hold. Radiology 1996; 198(3): 725-32.
9. Leung DA, McKinnon GC, Davis CP, Pfammatter T, Krestin GP, Debatin JF. Breath-hold, contrast-enhanced, three-dimensional MR angiography. Radiology 1996; 200(2): 569-71.
10. Goldstein HA, Kashanian FK, Blumetti RF, Holyoak WL, Hugo FP, Blumenfield DM. Safety assessment of gadopentetate dimeglumine in U.S. clinical trials. Radiology 1990; 174(1): 17-23.
11. Niendorf H, Haustein J, Alhassan A. Safety of gadolinium-DTPA: extended clinical experience. In: Brasch R, Editor. Workshop on contrast-enhanced magnetic resonance. California: Society for Magnetic Resonance in Medicine; 1991. p. 70-9.
12. Haustein J, Niendorf HP, Krestin G, Louton T, Schuhmann-Giampieri G, Clauss W, et al. Renal tolerance of gadolinium-DTPA/dimeglumine in patients with chronic renal failure. Invest Radiol 1992; 27(2): 153-6.
13. Prince MR, Arnoldus C, Frisoli JK. Nephrotoxicity of high-dose gadolinium compared with iodinated contrast. J Magn Reson Imaging 1996; 6(1): 162-6.
14. Rofsky NM, Weinreb JC, Bosniak MA, Libes RB, Birnbaum BA. Renal lesion characterization with gadolinium-enhanced MR imaging: efficacy and safety in patients with renal insufficiency. Radiology 1991; 180(1): 85-9.
15. Prince MR, Narasimham DL, Stanley JC, Wakefield TW, Messina LM, Zelenock GB, et al. Gadolinium-enhanced magnetic resonance angiography of abdominal aortic aneurysms. J Vasc Surg 1995; 21(4): 656-69.
16. Hany TF, Debatin JF, Leung DA, Pfammatter T. Evaluation of the aortoiliac and renal arteries: comparison of breath-hold, contrast-enhanced, three-dimensional MR angiography with conventional catheter angiography. Radiology 1997; 204(2): 357-62.
17. De Cobelli F, Vanzulli A, Sironi S, Mellone R, Angeli E, Venturini M, et al. Renal artery stenosis: evaluation with breath-hold, three-dimensional, dynamic, gadolinium-enhanced versus three-dimensional, phase-contrast MR angiography. Radiology 1997; 205(3): 689-95.
18. Bakker J, Beek FJ, Beutler JJ, Hene RJ, De Kort GA, De Lange EE, et al. Renal artery stenosis and accessory renal arteries: accuracy of detection and visualization with gadolinium-enhanced breath-hold MR angiography. Radiology 1998; 207(2): 497-504.
19. Visser K, Hunink MG. Peripheral arterial disease: gadolinium-enhanced MR angiography versus color-guided duplex US-a meta-analysis. Radiology 2000; 216(1): 67-77.
20. Nelemans PJ, Leiner T, De Vet HC, Van Engelshoven JM. Peripheral arterial disease: meta-analysis of the diagnostic performance of MR angiography. Radiology 2000; 217(1): 105-14.
21. Schoenberg SO, Prince MR, Knopp MV, Allenberg JR. Renal MR angiography. Magn Reson Imaging Clin N Am 1998; 6(2): 351-70.
22. Lee VS, Rofsky NM, Krinsky GA, Stemerman DH, Weinreb JC. Single-dose breath-hold gadolinium-enhanced three-dimensional MR angiography of the renal arteries. Radiology 1999; 211(1): 69-78.
23. Shetty AN, Bis KG, Vrachliotis TG, Kirsch M, Shirkhoda A, Ellwood R. Contrast-enhanced 3D MRA with centric ordering in k space: a preliminary clinical experience in imaging the abdominal aorta and renal and peripheral arterial vasculature. J Magn Reson Imaging 1998; 8(3): 603-15.
24. Thornton MJ, Thornton F, O'Callaghan J, Varghese JC, O'Brien E, Walshe J, et al. Evaluation of dynamic gadolinium-enhanced breath-hold MR angiography in the diagnosis of renal artery stenosis. AJR Am J Roentgenol 1999; 173(5): 1279-83.
25. Rieumont MJ, Kaufman JA, Geller SC, Yucel EK, Cambria RP, Fang LS, et al. Evaluation of renal artery stenosis with dynamic gadolinium-enhanced MR angiography. AJR Am J Roentgenol 1997; 169(1): 39-44.
26. De Cobelli F, Venturini M, Vanzulli A, Sironi S, Salvioni M, Angeli E, et al. Renal arterial stenosis: prospective comparison of color Doppler US and breath-hold, three-dimensional, dynamic, gadolinium-enhanced MR angiography. Radiology 2000; 214(2): 373-80.
27. Dong Q, Schoenberg SO, Carlos RC, Neimatallah M, Cho KJ, Williams DM, et al. Diagnosis of renal vascular disease with MR angiography. Radiographics 1999; 19(6): 1535-54.
28. Steffens JC, Link J, Grassner J, Mueller-Huelsbeck S, Brinkmann G, Reuter M, et al. Contrast-enhanced, K-space-centered, breath-hold MR angiography of the renal arteries and the abdominal aorta. J Magn Reson Imaging 1997; 7(4): 617-22.

www.mui.ac.ir

29. Walsh P, Rofsky NM, Krinsky GA, Weinreb JC. Asymmetric signal intensity of the renal collecting systems as a sign of unilateral renal artery stenosis following administration of gadopentetate dimeglumine. J Comput Assist Tomogr 1996; 20(5): 812-4.
30. Schoenberg SO, Knopp MV, Bock M, Kallinowski F, Just A, Essig M, et al. Renal artery stenosis: grading of hemodynamic changes with cine phase-contrast MR blood flow measurements. Radiology 1997; 203(1): 45-53.
31. Prince MR, Schoenberg SO, Ward JS, Londy FJ, Wakefield TW, Stanley JC. Hemodynamically significant atherosclerotic renal artery stenosis: MR angiographic features. Radiology 1997; 205(1): 128-36.

www.mui.ac.ir