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

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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.
diagnostic accuracy in diagnosis of high risk stenosis but its application had been limited due to dangers of iodized contrast material and ionizing radiation. 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. 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. Three-dimensional MRA using gadolinium had the sensitivity and specificity of 90% to detect stenosis of more than 50% of the renal arteries. 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 6 f 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 T1 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 reformattting 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%.
All sixteen patients who have been undergone 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%). In another meta-analysis study, the sensitivity and specificity of both techniques in detecting the stenosis had been 100% and 90%, respectively. 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%). 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 T1 images can show the functional results. 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 overlap, 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.

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