EVALUATION OF RENAL ARTERY STENOSIS WITH GADOLINIUM-ENHANCED MR ANGIOGRAPHY

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ABSTRACT

Purpose: To determine the accuracy of gadolinium-enhanced breath-hold magnetic resonance angiography in the diagnosis of renal artery stenosis.

Material and Methods: Twenty-eight patients underwent gadolinium-enhanced magnetic resonance angiography (MRA) in order to assess renal arteries. Nine of these patients had digital subtraction angiography (DSA) for correlation. Twenty renal arteries of these nine patients were evaluated for presence or absence of renal artery stenosis, as well as location and severity of stenosis. Degree of stenosis was classified as mild (<30% narrowing), moderate (30-50% narrowing) and severe (>50% narrowing).

Results: Using DSA as a gold standard, sensitivity, specificity, positive predictive value, negative predictive value and total accuracy of MRA for detection of renal artery stenosis were 90.0, 80.0, 81.8, 88.9 and 85.0% consecutively.

Conclusion: Gadolinium-enhanced MRA is a good imaging modality with minimal invasion for screening of renal artery stenosis. The most important role of MRA is its high negative predictive value. If MRA shows no evidence of renal artery stenosis, there is no need for angiography. Angiography should be performed in positive MRA cases in order to confirm the presence of stenosis, to correctly define the degree of stenosis and eventually to perform angioplasty in certain cases.

INTRODUCTION

Renal artery stenosis is an important and treatable cause of hypertension and progressive renal insufficiency. At present time, the gold standard for diagnosis of renal artery stenosis is digital subtraction angiography (DSA). Non-invasive imaging modalities of the renal arteries include Doppler sonography, contrast-enhanced Computed Tomographic Angiography (CTA) and gadolinium -enhanced Magnetic Resonance Angiography (MRA).

Gadolinium-enhanced MRA has several advantages over intra-arterial DSA and CTA. Intravenous contrast agents, used in DSA and CTA, are potentially toxic to kidneys and in certain cases are contraindicated if renal impairment is severe. In contrast, gadolinium used in MRA is quite safe and recommended in cases of renal insufficiency. Catheter-induced artheroembolism from DSA is not an uncommon complication [1], which is of no concern in MRA. All these advantages make gadolinium -enhanced MRA a potential screening method for patients whose renal artery stenosis is suspected.

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The purpose of this study was to evaluate diagnostic accuracy of renal artery stenosis by gadolinium-enhanced MRA in our institution, using DSA as a method of reference.

MATERIALS AND METHODS

From January 2000- December 2001, 51 patients were scheduled for MRA of renal arteries at our institution. Of these 51 patients, 28 had the images available for review and were the subjects of our study. Of these 28 patients, 15 were male and 13 were female with an average age of 59 years (range, 10-87 years). Nine of 28 patients had DSA, performed for confirmation and as a gold standard for renal arteries assessment. Other 19 patients did not have DSA and only MRA results were reported.

All renal arteries were analyzed retrospectively. The number of renal arteries, the presence or absence of renal artery stenosis, as well as location and severity of stenosis were assessed. Degree of stenosis was determined by the percentage of lumen narrowing. It was classified as mild (< 30% narrowing), moderate (30-50% narrowing) and severe (> 50% narrowing).

MR Imaging Technique

MR Imaging was performed with a 1.5 teals MR imager (Signa Horizon, GE, USA) using a phased array body coil. Axial spin echo T1W (TR 400-800 msec/TE 8-9 msec) and axial fast spin echo T2W (TR 4000-6000msec/TE 84-91msec) were performed for general evaluation of upper abdomen and kidneys. Location of peri-renal abdominal aorta was localized at sagittal plane using fast gradient -recovery-echo (FGRE) pulse sequence (TR 100 msec/TE min, flip angle 20 degrees) or spin echo T1W (TR 300 msec /TE min). Gadopentetate dimeglumine (Magnevist, Schering, Germany), 0.4 ml/kg or about 20 ml, was injected via the MR-compatible power injector, followed by a saline flush of 10 ml, at a rate of 2-3 ml/sec. MRA was performed using Smart Prep technique with software package provided by GE. Timing of arrival of contrast agent in the peri-renal aorta was depicted automatically by Smart Prep, triggering the first pass of the sequence. Three passes of breath hold, three-dimensional time of flight, fast spoiled gradient-recalled-echo (3D TOF FSPGR) pulse sequence with fat suppression technique were performed in the coronal plane. Images of these 3 passes were reviewed and the best one was selected for reformation at MR workstation. Both source and reformatted images were analyzed. Finally, post contrast axial and coronal FSPGR T1W with fat suppression (TR 100-150msec/TE min, flip angle 60 degrees) of the upper abdomen were performed for general surveillance.

Statistic Analysis

Sensitivity, specificity and predictive values of MRA as a diagnostic test for renal artery stenosis were analyzed, using DSA as the method of reference. These parameters were compared with others published in the literature.

Definition

- Sensitivity = True positive/ True positive + False negative
- Specificity = True negative/ True negative + False positive
- Positive predictive value = True positive / True positive + False positive
- Negative predictive value = True negative / True negative + False negative
- Total accuracy = True positive + True negative / All patients in the study

RESULTS

I) MRA of renal arteries with DSA correlation

In this group, 9 of 28 patients had both MRA and DSA performed.

Number of renal arteries

In 9 patients, 20 renal arteries were identified on MRA. Seven patients had single right and left renal arteries. One patient had single right renal artery and double left renal arteries, and one patient had single left renal artery and double right renal arteries. The number of renal arteries, visualized on MRA, was all corresponded to finding on DSA.

Renal artery stenosis assessment (Table I)

TABLE 1 Comparison of stenosis grading by MRA versus DSA

Grading on DSA	Grading on MRA				Total
	Normal	Mild	Moderate	Severe	
Normal	8	1	-	1	10
Mild	-	1	4	-	5
Moderate	1	-	1	-	
Severe	-	-	-	3	3
Total	9	2	5	4	20

Mild stenosis, < 30% of diameter reduction,
Moderate stenosis, 30-50% of diameter reduction,
Severe stenosis, > 50% of diameter reduction.

Using DSA as a gold standard, 10 renal arteries were normal and 10 renal arteries had stenosis. Of the 10 stenotic arteries, 9 located at main renal artery and 1 at segmental branch of renal artery. Of 10 normal renal arteries, MRA showed 8 true negative and 2 false positive (1 mild, 1 severe stenosis). Renal artery, interpreted as severe stenosis on MRA, was found to be a kinking renal artery on DSA (Fig 1). Of 10 stenotic renal arteries, MRA showed 9 true positive (Fig 2,3) and 1 false negative (Fig 4). Location of stenosis in 9 renal arteries, detected by MRA, was all at the main renal arteries. The only false negative, found on MRA, was secondary to location of stenosis, which was in the segmental branch (Fig 4).

In 10 stenotic renal arteries, detected by DSA, 5 arteries were shown to have the same degree of stenosis by MRA (1 mild, 1 moderate, 3 severe). Four renal arteries showed mild degree of stenosis on DSA, but moderate degree on MRA (Fig 5). One renal artery shown moderate degree of stenosis at segmental branch (Fig 4), but interpreted as normal by MRA (same patient mentioned above, as a false negative).

Regardless of degree of stenosis, sensitivity, specificity, positive predictive value, negative predictive value and total accuracy of MRA for detection of renal artery stenosis were 90.0, 80.0, 81.8, 88.9, 85.0 % consecutively. These parameters were compared with others, which were published in the literature [2-6] (Table 2).

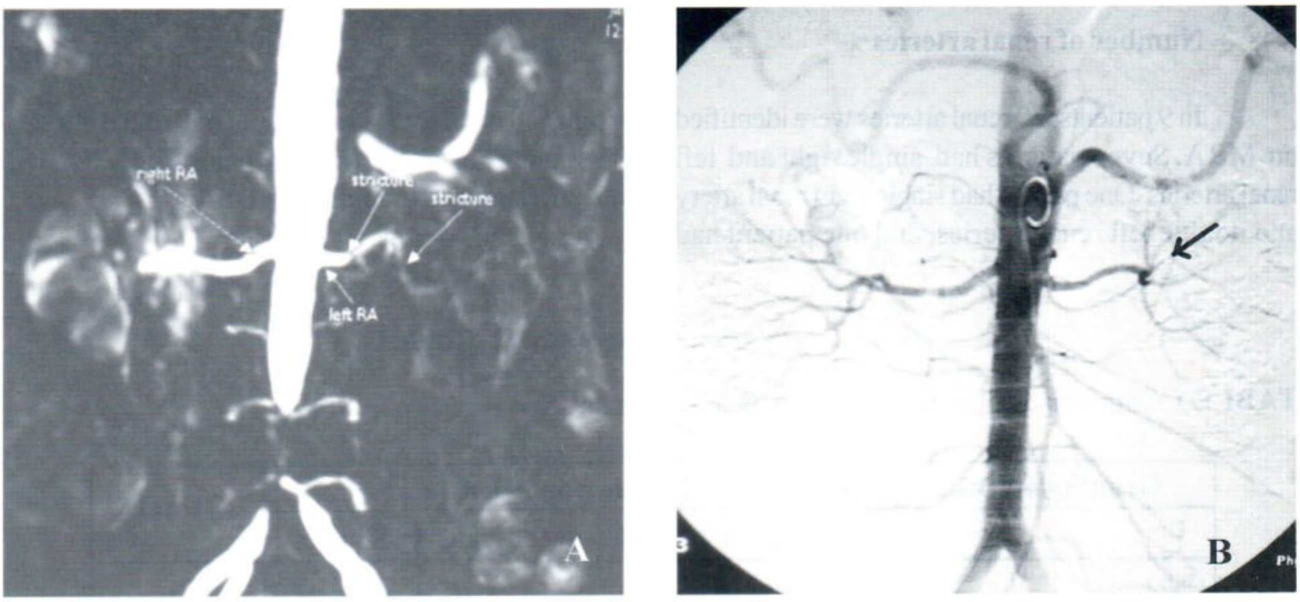

Fig.1 A-66-year-old woman presented with DM and hypertension. (A) MRA shows severe stenosis of proximal and distal parts of left renal artery, but (B) DSA shows kinking distal part of left renal artery without evidence of stenosis (false positive MRA).

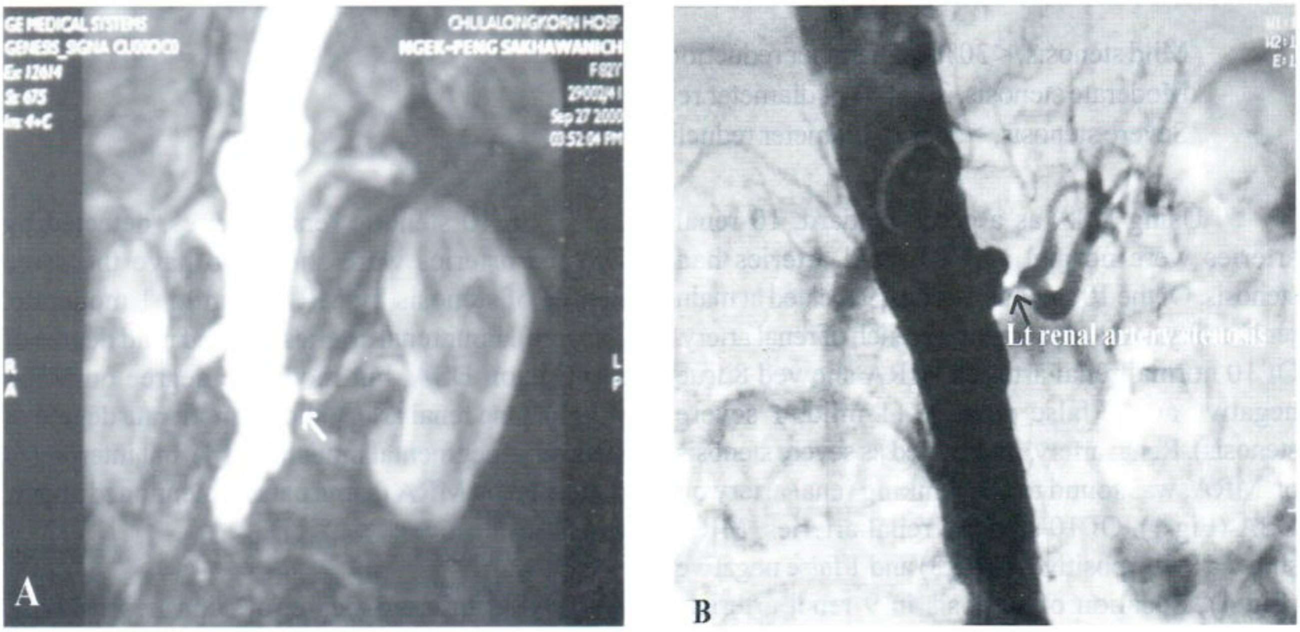

Fig 2 A 82-year-old woman presented with DM, hypertension and chronic renal failure. (A) MRA and (B) DSA show severe stenosis of left renal artery (true positive MRA).

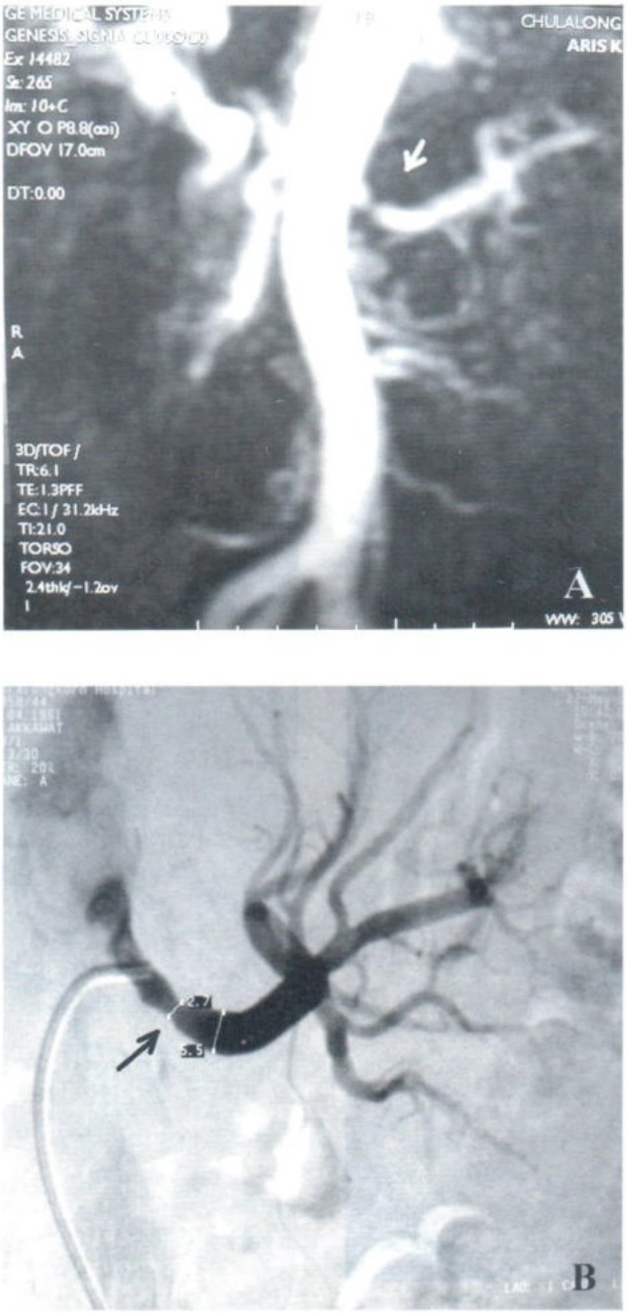

Fig. 3 A 40-year-old woman presented with malignant hypertension. (A) MRA and (B) selective left renal DSA show moderate

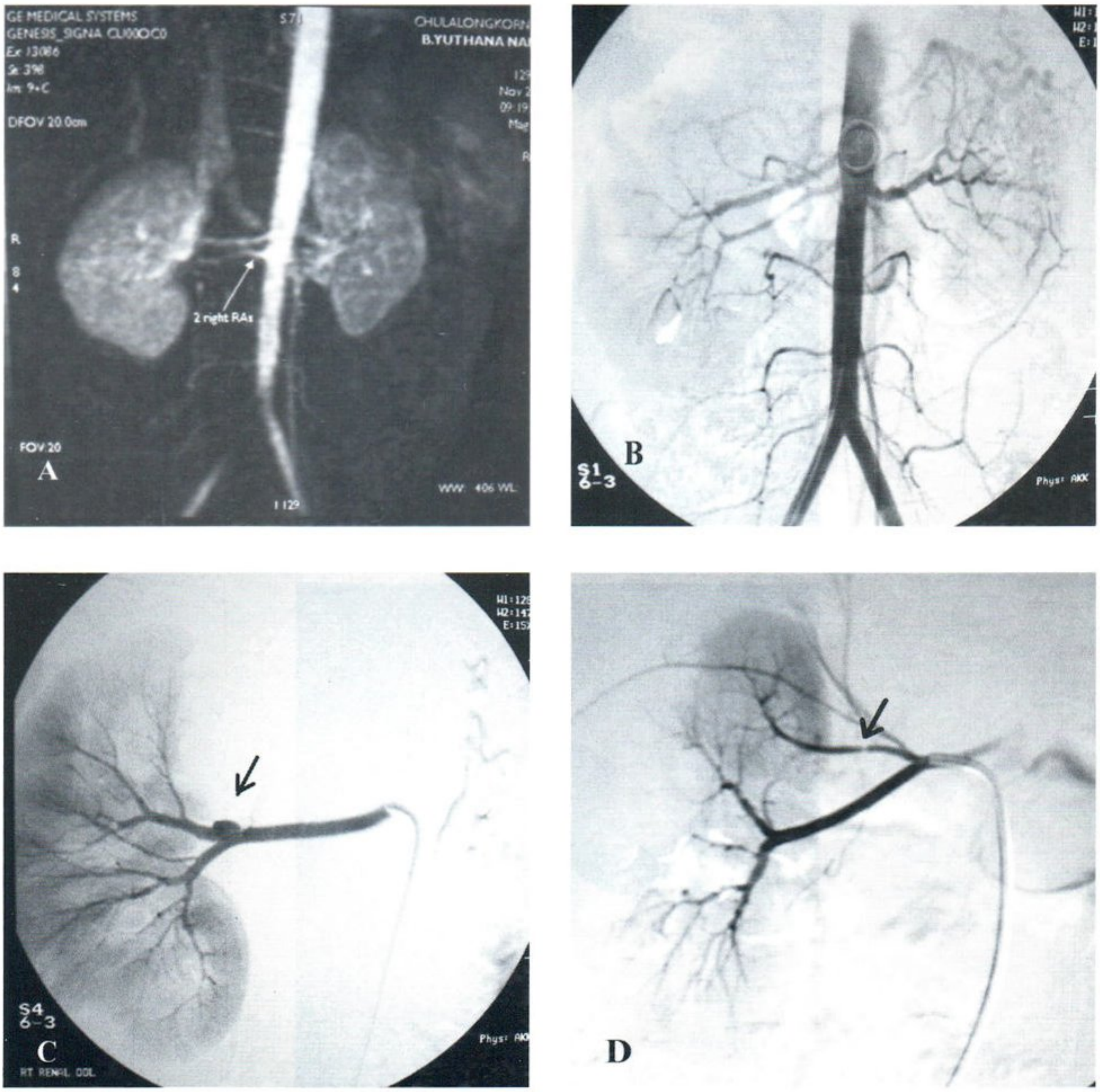

Fig. 4 A 10-year-old boy presented with hypertension. (A) MRA and (B) DSA show single left renal artery and double right renal arteries without evidence of renal artery stenosis. (C) Selective right upper renal angiography shows small aneurysm at just proximal to its bifurcation. (D) Selective right lower renal angiography shows 50% stenosis at segmental portion (false negative MRA).

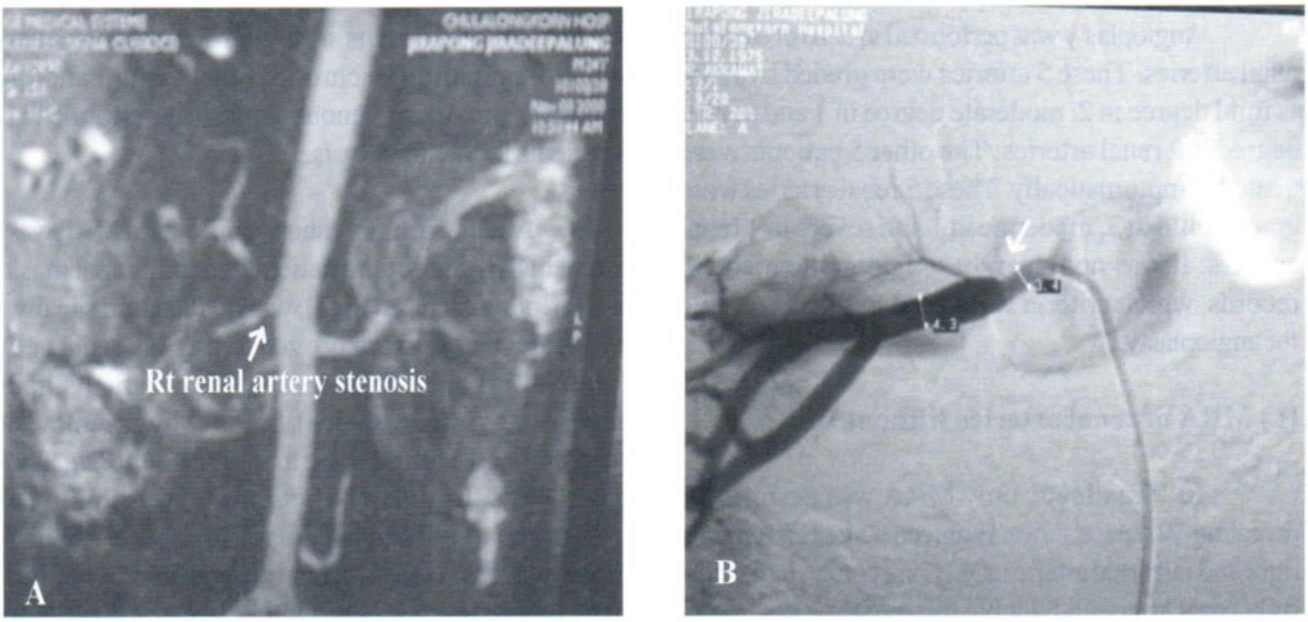

Fig.5 A 26-year-old man presented with hypertension. (A) MRA shows moderate stenosis of right main renal artery. (B) Selective right renal angiography shows mild stenosis of right main renal artery (true positive, but overgrading MRA).

TABLE 2 Comparison of sensitivity, specificity, positive predictive value, negative predictive value and accuracy of this study and others.

	Our study	Bakker et al (1)	De cobelli et al (4)	Korst et al (14)	Thornton et al (22)	Volk et al (24)
Sensitivity	90.0	97.0	94.0	100.0	100.0	92.0
Specificity	80.0	96.0	88.0	85.0	98.0	83.0
Positive predictive value	81.8	91.0	89.0	85.7	-	-
Negative predictive value	88.9	99.0	94.0	100.0	-	-
Accuracy	85.0	-	91.0	-	99.0	85.9

Angioplasty was performed in 5/10 of stenotic renal arteries. These 5 arteries were graded by DSA as mild degree in 2, moderate degree in 1 and severe degree in 2 renal arteries. The other 5 patients were treated symptomatically. These 5 renal arteries were graded mild in 3, moderate in 1 and severe in 1 renal arteries. It was not clear, based upon the medical records, which criteria were used to select patients for angioplasty.

II) MRA of renal arteries without DSA

In 19 patients, only MRA was performed, revealing 39 renal arteries. Eighteen patients had single right and left renal arteries. Only one patient had single right renal artery and double left renal arteries. Of 39 renal arteries, 27 arteries were normal and 12 showed stenosis. These 12 stenotic renal arteries were all located at main renal arteries and were graded as mild in 1, moderate in 4 and severe in 7 renal arteries (Fig 6).

All 19 patients in this group were treated symptomatically for chronic renal failure and/or hypertension. Arteriovenous fistula was performed in 3 patients for hemodialysis.

Additional information, gained form MRI, was found in 8 patients. One patient had right renal mass and left adrenal mass (Fig7), which treated surgically, and these masses were proved to be right renal cell CA and left adrenal adenoma. Two patients had adrenal masses (one of each), but only 1 was removed surgically and found to be a benign adenoma. The other was believed to be benign and was followed up. Three patients had liver masses (one of each) and these masses were all characteristic for benign hemangiomas and were followed up. Three patients had small abdominal aortic aneurysms and were all followed up (Fig 8). One patient showed perinephric hematoma form prior renal biopsy and was also followed up.

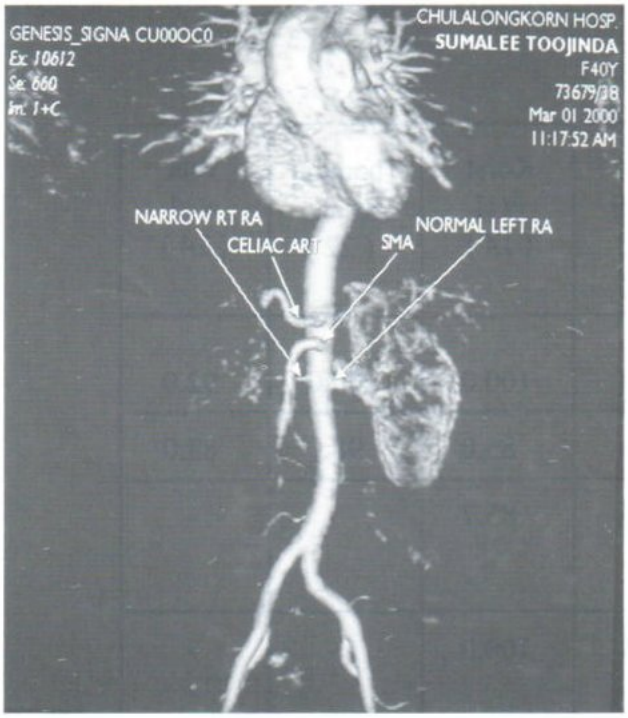

Fig. 6 A 42-year-old woman presented with hyper tension, MRA shows diffuse narrowing of right renal artery with normal left renal artery.

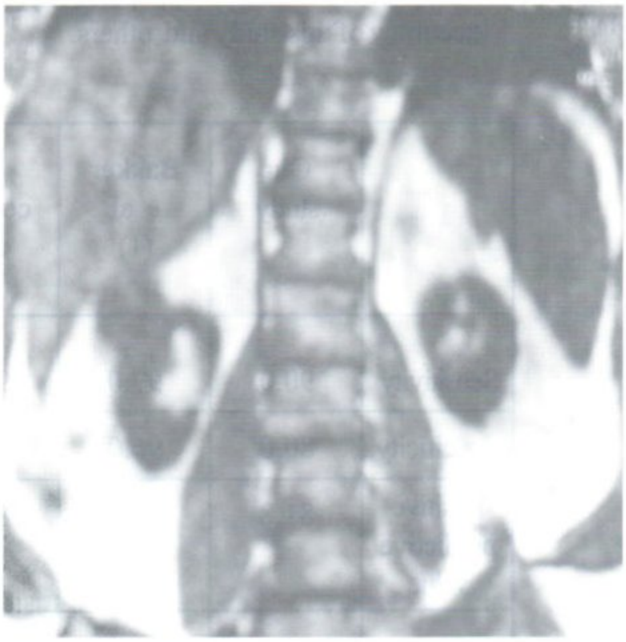

Fig.7 A 61-year-old man presented with acute on top chronic renal failure, MRA shows a 3.3x3.8 cm right renal cell mass, which was proved to be a renal cell carcinoma.

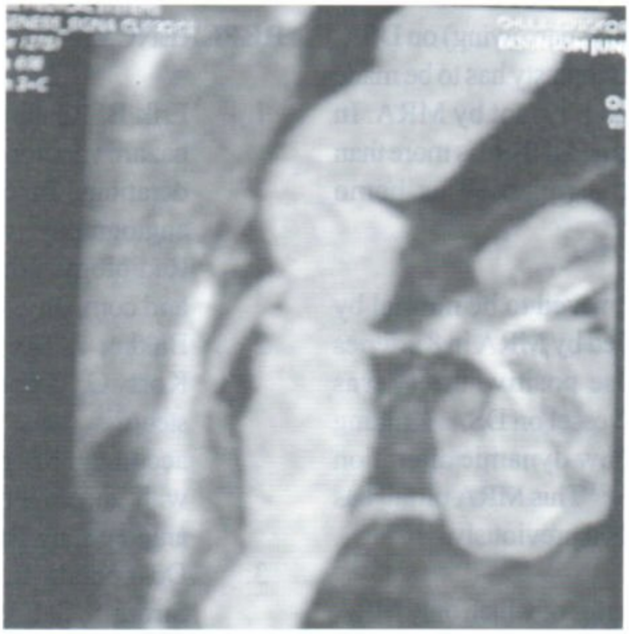

Fig.8 A 65-year-old woman presented with hyper tension and chronic renal failure, MRA shows fusiform aneurysm of abdominal aorta.

DISCUSSION

In our study, a total of 59 MRA of renal arteries were performed, but only 20 arteries had DSA for a standard of correlation. Although the number of MRA of renal arteries with DSA correlation is rather small, it is very useful for preliminary analysis and provides us with important information. The number of renal arteries on both left and right sides, either single or double, were all correctly depicted by MRA in this study. High accuracy of MRA for detection of number of renal arteries has been well publicized [3,713] and is now accepted to replace angiography in preoperative assessment of potential renal transplant donors. [11-12,14]

Sensitivity of MRA for detecting renal artery stenosis in our study was 90% (9/10) which is comparable to other studies (Table 2). [2-10,13,15-20] One false negative case was secondary to the location of stenosis, which was at the segmental branch, not at the main renal artery (Fig 4). At present time, MRA is still not good enough to reveal the abnormality of the medium to small sized vessels, and the abnormality largely depends on angiography. [2,4,6,9,13-14,17-18,20-22] Therefore, a false negative in this artery was actually unavoidable. If this renal artery is excluded, the sensitivity and negative predictive value will rise to 100%. High negative predictive value is very important for MRA as a screening test for renal artery stenosis, so that cases, interpreted as no stenosis, do not need to have angiography. Angiography should be performed only in positive MRA cases.

In terms of luminal narrowing, MRA tends to exaggerate the degree of stenosis. This is secondary to signal loss from slow or reduced flow. [23] In our cases, 4 renal arteries were over interpreted as moderate degree of stenosis (30-50% narrowing), but showed mild degree (< 30% narrowing) on DSA. Therefore, the decision of angioplasty has to be made upon the finding on angiography, not by MRA. In general, angioplasty is performed if there is more than 50% narrowing,[24] which is regarded as hemo dynamically significant.[3,6-8,21]

Ten renal arteries, proved to be normal by DSA, were correctly identified by MRA in 8 arteries (specificity 80%). One false positive artery was secondary to kinking of the vessel on DSA. Kinking or tortuous vessel causes flow dynamic alteration creating signal loss on MRA.[23] This MRA pitfall has been recognized and published previously.[17,22]

Another 39 renal arteries of which only MRA were performed, 12 renal arteries were actually interpreted as stenosis. The reason for not performing DSA was not clear. Based upon the retrospective review on medical records, we predicted that benefits for angioplasty in these cases were small, and supportive treatment was the only choice of therapy in these patients.

One advantage of MRA over angiography is that it could detect other abnormalities, which otherwise are not suspicious clinically. As shown in our cases, right renal cell carcinoma, left adrenal gland tumors, liver tumors and abdominal aortic aneurysm were detected. MRI, routinely performed with MRA, plays an important role for delineation of these abnormalities.

In conclusion, our study concurs with other studies, which indicate that MRA is a good imaging modality for screening of renal artery stenosis. The most important role of MRA is its high negative predictive value. If MRA shows no evidence of renal artery stenosis, there is no need for angiography. Angiography should be performed in positive MRA cases for confirmation, correctly defining the degree of stenosis and eventually performing anigoplasty in certain cases.

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