Unenhanced renal artery MR Angiography in the diagnosis of renal artery stenosis

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Purpose

Evaluate 3D Inhance Inflow IR non-contrast-enhanced MR angiography in the detection of renal artery stenosis.
Methods and Materials

96 patients: 43 females, 53 males, age range 13-87 years with a mean age of 60 years. Five patients have only one kidney.

All MR images were obtained with a 1,5 T MR imaging system. In the routine renal artery protocol, in addition to conventional MR images (axial and coronal FIESTA with fat suppression images and SS- FSE T2), axial 3D Enhance Inflow IR (IFIR) and axial 3D-PC images were acquired. The following parameters were used in the IFIR sequence: TE=2,2 ms, TR=4,4 ms, flip angle, 90º, TI=200 ms, blood suppression inversion time=1200ms, band width 15 Khz, field of view,40 cm, frequency matrix=256, phase matrix 256, array spatial sensitivity encoding technique (ASSET) was used in the in plane phase encode direction with an acceleration factor of 2, Zip, 512, slice thickness, 1,2 mm, locations per slab 84, acquisition time: 3-5 min depending on the patient’s respiration rate and anatomy.

An 8-channel phased array body coil was used for signal reception.

Free breathing was allowed with respiratory bellows used. The phase's lines were acquired via respiratory triggering.

A slab-selective inversion prepulse with an inversion delay of 1200 ms was applied to suppress the renal vein blood. Spectral fat saturation and a saturation band inferior to the imaging volume were used to suppress the signals from fat and the inferior vena cava, respectively.

The source images, maximum intensity projection images (MIP) reformatted views and volume rendered images (VR) were analysed.

The image quality of the MIP was graded by using three scoring categories: good quality image (high homogeneous signal intensity within the vessel lumen, optimal delineation of the vessel border, evaluation possible with high diagnostic confidence); moderate quality image (moderate enhancement of the vessel lumen, incomplete delineation of the vessel border, evaluation possible with satisfactory diagnostic confidence) and poor quality image (low inhomogeneous signal intensity, incomplete delineation of vessel border, evaluation possible with low diagnostic confidence.

Renal artery stenosis was classified as haemodynamically insignificant renal artery stenosis (< 50 % stenosis) and as haemodynamically significant (> 50 stenosis), a criteria applied in previous studies.
Results

Unenhanced renal artery MRA was successfully acquired in all subjects.

The image quality was categorized as good in 81 % (78 of 96), moderate in 15 % (14 of 96) and poor quality in 4 % (4 of 96) of the patients.

In 68 patients (70%) the unenhanced renal artery MRA was normal. Case 1: 64-year-old man with arterial hypertension. The unenhanced-MRA shows normal bilateral renal arteries (figs. 2, 3 and 4).

In 28 patients (29 %) was pathological: 12 stenoses not relevant and 16 patients with haemodynamically significant stenosis and a patient with a renal artery aneurysm.

A total of 222 renal arteries were identified in the 96 patients. Of 30 renal artery stenoses identified in 27 patients, 19 stenosis in 16 patients were relevant, three patients had bilateral relevant stenosis. 11 stenosis were not relevant in 11 patients. A renal artery aneurysm was found in 1 patient.

In 13 patients a conventional angiography was performed.

- A renal artery aneurysm was found in a patient.

Case 2: 50-year-old man with arterial hypertension. The unenhanced-MRA shows a fusiform aneurysm in the bifurcation of the right renal artery. (figs. 5, 6, 7 and 8). Angiogram shows the same findings seen on the unenhanced-MRA (figs. 9 and 10).

- 9 relevant stenosis. Three patients had bilateral relevant stenosis.

Case 3: 64-year-old man with arterial hypertension, dyslipidemia and hyperuricemia. The unenhanced-MRA shows a nearly occlusion-severe stenosis of the left renal artery and atrophied right kidney and a severe stenosis of the right renal artery (figs. 11, 12 and 13). Angiogram confirms a severe stenosis of the left renal artery (figs. 14 and 15), with faint retrograde filling of distal left renal artery and pathological parenquimograma. The left kidney was embolized with multiple coils (fig. 16). The left renal artery has a severe stenosis (80%). A stent was implanted with good result (fig. 17).
Case 4: 54-year-old man with resistant hypertension and dyslipidemia. The unenhanced-MRA shows severe bilateral renal stenoses (figs. 18 and 19). Angiogram confirms the findings, demonstrated a 95% stenosis of the left renal artery and a 85% stenosis of the right renal artery (figs. 20 and 21). A 6 mm diameter and 17 mm length stent was implanted in the right renal artery and a 6 mm diameter and 12 mm length stent in the left renal artery with good morphological results (fig. 22).

- Two not relevant stenosis were confirmed.

- A patient with a not relevant stenosis in the unenhanced-MRA, the conventional angiography was normal, without stenosis.

In 28 patients (29%) we found anatomic variations, the most frequent variants were the accessory renal arteries.

Case 5: 41-years-old woman with renal insufficiency secondary to vesicoureteral reflux and arterial hypertension. The unenhanced-MRA shows a normal right renal artery and two normal left renal arteries (figs. 23 and 24).

Case 6: 73-year-old man with arterial hypertension, diabetes mellitus type 2 and dyslipidemia. The unenhanced-MRA shows a normal right renal artery and normal three left renal arteries (figs. 27 and 28).

Case 7: 57-years-old with arterial hypertension. The unenhanced-MRA shows two renal arteries on both sides without stenosis (figs. 27 and 28).

As incidental findings we found:

- transitional cell cancer of the left ureter. pT3.

Case 8: 74-year-old man with hypertension and dyslipidemia. He was admitted to the hospital for a TIA. He presents progressive increase in creatinine (figs. 29, 30, 31 and 32).

- Three adrenal nodules suggestives of adenomas.

- A macronodular adrenal hyperplasia.

- A renal cortical hemosiderosis.

Case 9: 61-year-old woman with malfunctioning prosthetic cardiac valve.

The unenhanced-MRA shows normal renal arteries (figs. 33 and 34).
Renal artery stenoses occur in fewer than 5% of adult patients with hypertension. However, this remains the commonest curable cause of hypertension. Therefore, it is important to identify an accurate, non-invasive screening investigation for the detection of renal artery stenosis in hypertensive patients.

Atherosclerotic disease is the most common pathologic condition of renal arteries. This disease is more predominant beginning in the middle age and more common among men. The atherosclerotic disease of the renal arteries is a manifestation of generalized atherosclerosis that also involves coronary, cerebral, and peripheral vessels. In patients with coronary artery disease, the prevalence is 15% and bilateral in 3% of cases. The stenosis typically involves the ostium and proximal renal artery.

Case 10: 68-year-old man with renal insufficiency and hypertension. The unenhanced-MRA shows a severe stenosis of the left renal artery and a not significant stenosis of the right renal artery (fig. 35). Angiogram confirms the findings seen on the unenhanced-MRA (figs. 36 and 37).

Case 11: 54-year-old man with stage 3 of chronic renal insufficiency, diabetes mellitus type 2, hypertension and smoker. The unenhanced-MRA shows a relevant stenosis of the left main renal artery estimated at 80%, with good remaining distal flow (figs. 38 and 39). The conventional angiography confirmed the findings (fig. 40). Received endovascular treatment, a stent was implanted. An excellent morphological result was achieved (fig. 41).

Case 12: 84-year-old woman with hypertension. The unenhanced-MRA shows a relevant stenosis of the right main renal artery estimated at 80% (figs. 42 and 43). Conventional angiography confirms the relevant stenosis at the origin of the right renal artery. A stent was implanted (figs. 44 and 45).

Case 13: 64-year-old man with hypertension. Admitted to our hospital because of acute pulmonary oedema. The unenhanced-MRA shows a tight stenosis at the origin of the right renal artery (figs. 46, 47 and 48). Conventional angiography confirms the relevant stenosis and detects a pathological gradient of 18 mm Hg (fig. 49). A stent is implanted with good morphological result (fig. 50).

Case 14: 71-year-old woman with left nephrectomy for renal cell carcinoma in 2009. He presents hypertension and mild renal impairment. Doppler ultrasound shows increased of velocity in the right renal artery. The unenhanced-MRA shows a relevant stenosis in the the right renal artery (Fig. 51). Angiogram confirms the stenosis in the proximal right renal artery (figs. 52 and 53). Two stents were implanted with good results (fig. 54).
Case 15: 62-year-old woman with diabetes mellitus type 2, hypertension and chronic renal failure. Ultrasound detected renal asymmetry. The unenhanced-MRA shows a not relevant stenosis of the right renal artery (fig. 55). Conventional angiography confirms the findings (figs. 56 and 57).

Case 16: 72-year-old woman with hypertension. Ultrasound shows renal asymmetry with left renal atrophy. The unenhanced-MRA shows two right renal arteries, the inferior is irregular, and small with a stenosis (figs 58 and 59) Angiogram shows no stenosis. Intraarterial blood pressure measurements revealed no gradient between the aorta and renal artery (figs 60 and 61).

Fibromuscular dysplasia is the second most common cause of renal artery stenosis. This is predominantly seen in young or middle-aged women. The lesions typically involve mid or distal main renal artery, in contrast to more proximal involvement in atherosclerosis. Bilateral involvement can be seen in the two-thirds of patients, more common in the setting of familial involvement.

Case 17: 19-year-old woman with hypertension, dizziness, nausea and insomnia.

The unenhanced-MRA shows irregularities of both main renal arteries an appearance suggestive of fibromuscular dysplasia and a long stenosis in medial part of the right renal artery (figs. 62 and 63). Conventional arteriography shows fibromuscular dysplasia involving both renal arteries and a long stenosis in medial part of the right renal artery (figs. 64 and 65) Balloon angioplasty was performed in both renal arteries lesions with good morphological results (fig. 66).

Others aetiologies of renal artery stenosis are:

- Renal artery aneurysm. The prevalence of renal artery aneurysms is 1%. Most renal artery aneurysms are seen in the fourth and fifth decades of life with a female predilection. Although there are many possible causes: atherosclerotic disease, fibromuscular dysplasia, Wegener’s granulomatosis, neurofibromatosis, pregnancy, mycotic aneurysms, iatrogenic and traumatic injury.

Most aneurysms are seen in the main renal artery or at the bifurcation of renal artery where congenital anomalies are most common.

Extraparenchymal aneurysms, such as those at the bifurcation, comprise approximately 85 % of all renal artery aneurysms; the rest are intraparenchymal. Most renal artery
Aneurysms are saccular (80%) and non calcified (82%). Multiple small intrarenal aneurysms are usually associated with polyarteritis nodosa or fungal infections.

Most renal artery aneurysms are asymptomatic; it may be associated with hypertension and generally undergoes atherosclerotic degeneration.

- Vasculitis: Takayasu’s arteritis.

- Spontaneous renal artery dissection.

- Neurofibromatosis.

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Most renal artery aneurysms are asymptomatic; it may be associated with hypertension and generally undergoes atherosclerotic degeneration.

- vasculitis: Takayasu's arteritis.

- spontaneous renal artery dissection.

- neurofibromatosis.
Fig. 1: Acquisition volume (yellow), suppressed background (green), red arrow: artery and blue arrow: vein.

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Fig. 2: Coronal MIP image from unenhanced-MRA shows normal bilateral renal arteries.

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Fig. 3: Coronal MIP image from unenhanced-MRA shows a normal right renal artery.

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**Fig. 4:** Coronal MIP image from unenhanced-MRA shows a normal left renal artery with clear delineation of intraparenchymal vessels.

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**Fig. 5:** Coronal MIP image from unenhanced-MRA shows a renal artery fusiform aneurysm.

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**Fig. 6**: Oblique coronal MIP image from unenhanced-MRA shows right renal artery aneurysm.

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Fig. 7: Video: shows right renal artery aneurysm.

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**Fig. 8:** Source image from axial IFIR: shows aneurysm with high signal.

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**Fig. 9:** Arteriogram confirmed the right renal artery aneurysm.

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**Fig. 10:** Arteriogram shows renal artery aneurysm at the bifurcation of the right renal artery.

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Fig. 11: Coronal MIP image from unenhanced-MRA shows severe bilateral renal artery stenoses.

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**Fig. 12:** Coronal MIP image from unenhanced-MRA shows a severe (80%) right renal artery stenosis.

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Fig. 13: Volume-rendered from unenhanced-MRA demonstrated a severe stenosis close to occlusion and a very small left renal artery.

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Fig. 14: Arteriogram shows the findings seen on the unenhanced-MRA with good correlation.

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Fig. 15: Arteriogram shows a very thin left renal with retarded flow and pathological parenquimograma.

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Fig. 16: Embolization of the left renal artery was performed.

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Fig. 17: Arteriogram after implantation of stent in the right renal artery.

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**Fig. 18:** Coronal MIP image from unenhanced-MRA shows severe bilateral renal artery stenoses.

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**Fig. 19:** Volume-rendered reveals severe bilateral renal artery stenoses.

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**Fig. 20:** Conventional aortogram shows the same findings seen on the unenhanced-MRA.

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**Fig. 21:** Aortogram shows a 85% stenoses of the right renal artery and a 95% stenosis of the left renal artery.

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Fig. 22: Renal arteriogram obtained after placement of two stents in both renal arteries.

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**Fig. 23:** Coronal MIP image from unenhanced-MRA shows a normal right renal artery and two left renal arteries normal.

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**Fig. 24:** Volume-rendered image from the unenhanced-MRA.
**Fig. 25:** Coronal MIP image from unenhanced-MRA shows a right renal artery and three left renal arteries.
Fig. 26: Oblique MIP shows a right renal artery and three renal arteries arising from the aorta.

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**Fig. 27:** Coronal MIP image from unenhanced-MRA shows two renal arteries on both sides.

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Fig. 28: Volume-rendered image shows two renal arteries on both sides.

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**Fig. 29:** Coronal MIP image from unenhanced-MRA shows severe left renal artery stenosis.

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Fig. 30: Coronal SS-FSE-T2 shows pevicalyceal system dilatation of the left kidney.

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**Fig. 31:** Axial SS-FSE-T2 shows left ureter dilatation.

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**Fig. 32:** Contrast-enhanced coronal MDCT shows a transitional cell cancer of the distal left ureter.

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**Fig. 33:** Coronal SS-FSE-T2 shows hipointense renal cortex by iron deposits.

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**Fig. 34:** Coronal MIP image from unenhanced-MRA shows normal renal arteries.

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**Fig. 35:** Coronal MIP image from unenhanced-MRA shows a severe stenosis of the left renal artery.

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Fig. 36: Conventional aortogram shows a right renal artery without stenosis and a severe stenosis of the left renal artery.

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**Fig. 37:** Conventional aortogram shows a severe stenosis of the left renal artery.

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Fig. 38: Coronal MIP image from unenhanced-MRA shows a severe stenosis of the left renal artery.

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Fig. 39: Coronal MIP image from unenhanced-MRA shows a severe stenosis of the left renal artery.

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**Fig. 40**: Conventional aortogram shows the findings seen on the unenhanced-MRA with good correlation.

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**Fig. 41:** Angiogram obtained after implantation of stent.

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**Fig. 42:** Coronal MIP image from unenhanced-MRA shows proximal renal arterial stenosis on the right side.

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**Fig. 43:** Oblique Coronal MIP image shows a 80 % stenosis of the right renal artery.

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Fig. 44: Arteriogram shows the same findings seen on the unenhanced-MRA.

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Fig. 45: Arteriogram after implantation of stent with good results.

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**Fig. 46:** Coronal MIP image from unenhanced-MRA shows a relevant stenosis of the right renal artery.

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**Fig. 47:** Oblique coronal MIP image shows a relevant stenosis of the right renal artery.

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**Fig. 48:** Volume-rendered image from unenhanced-MRA shows the same findings.

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**Fig. 49:** Angiogram shows the same findings seen on the unenhanced-MRA.

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**Fig. 50:** Angiogram obtained after implantation of stent shows wide patency of the right renal artery.

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**Fig. 51:** Coronal MIP image from unenhanced-MRA shows a 90 % stenosis of the right renal artery.

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Fig. 52: Arteriogram confirms the findings in a patient with solitary kidney.

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Fig. 53: Angiogram shows a severe stenosis of the right renal artery.

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Fig. 54: Arteriogram after implantation of two stents.

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**Fig. 55:** Coronal MIP image from unenhanced-MRA shows a no relevant stenosis of the right renal artery.

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Fig. 56: Angiogram shows no stenoses.

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**Fig. 57:** Angiogram shows no stenoses or pathological gradients.

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**Fig. 58:** Coronal MIP image from unenhanced-MRA shows a inferior right renal artery with stenosis.

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Fig. 59: Coronal MIP image shows a inferior right renal artery with stenosis.

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Fig. 60: Angiogram shows no stenoses or pathological gradients.

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Fig. 61: Angiogram shows two right renal arteries without stenoses.

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Fig. 62: Coronal MIP image from unenhanced-MRA shows irregularities of both main renal arteries an appearance suggestive of fibromuscular dysplasia and a long stenosis in medial part of the right renal artery.

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**Fig. 63:** Oblique coronal MIP image shows the same findings.

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Fig. 64: Conventional arteriogram shows the same findings seen on the unenhanced-MRA.

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Fig. 65: Conventional arteriogram shows long stenosis in medial part of the right renal artery.

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**Fig. 66:** Conventional arteriogram obtained after angioplasty with good results.

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Conclusion

Unenhanced-MRA is a good technique for evaluation of renal arteries, specially in the patients with chronic kidney disease with contraindications for contrast-enhanced MRA.
References


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