Renovascular Hypertension
EVIDENCE TABLE

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Strength of Evidence
1. Bookstein JJ, Abrams HL, Buenger RE, et al. Radiologic aspects of renovascular hypertension. 1. Aims and methods of the radiology study group. *JAMA* 1972; 220(9):1218-1224.	12	N/A	Review report by a Radiologic Study Group. Define and evaluate major (kidney length, calyceal appearance time, and concentration of contrast medium) and minor urographic features. Contrast agent, route of administration and complications were included in arteriographic evaluation.	Significant differences were seen between local, central, and re-review interpretation of renal length, appearance time, and concentration of contrast medium and in estimating the degree of arterial stenosis from the arteriogram.	4
2. Bookstein JJ, Abrams HL, Buenger RE, et al. Radiologic aspects of renovascular hypertension. 2. The role of urography in unilateral renovascular disease. *JAMA* 1972; 220(9):1225-1230.	9	771 patients urograms evaluated for all 3 features	Correlate urograms with arteriographic findings and treatment results to determine the role of urography in unilateral renovascular disease and its usefulness in predicting surgical results.	Urogram is a satisfactory method for diagnosing severe renovascular disease. Differentiating patients for surgery or not was not possible with urography.	2
3. Thornbury JR, Stanley JC, Fryback DG. Hypertensive urogram: a nondiscriminatory test for renovascular hypertension. *AJR* 1982; 138(1):43-49.	10	1st group – 197 patients operated for renal artery stenosis 2nd group – 131 patients had hypertensive urography	Retrospective study to assess usefulness of hypertensive urogram in hypertension patients and compare results to a prospective cooperative study that says hypertensive urogram is a satisfactory primary screening test for evaluation of hypertensive patients.	• 1st group: True-positive rate for hypertensive urography for prediction of surgical cure was 60.2%. • 2nd group: Incidence of positive exams in screening was 0.8%. • Reexamination of the cooperative study data reveals that false-negative rate for screening is at least 21.8%, rather than 1.7%. Study does not recommend hypertensive urography.	3
4. Cameron HA, Close CF, Yeo WW, Jackson PR, Ramsay LE. Investigation of selected patients with hypertension by the rapid-sequence intravenous urogram. *Lancet* 1992; 339(8794):658-661.	10	241	Retrospective review of case records to determine the diagnostic yield of the rapid-sequence IVU in hypertensive patients selected for features suggesting renal or renovascular disease.	The IVU was abnormal in 27% of patients. The IVU led to intervention aiming at correcting hypertension in 5% of patients. A normal rapid-sequence IVU excludes renovascular disease with 93% probability but failed to diagnose about 20% of cases.	3
5. Clark RA, Alexander ES. Digital subtraction angiography of the renal arteries. Prospective comparison with conventional arteriography. *Invest Radiol* 1983; 18(1):6-10.	9	40 patients 92 renal arteries	To prospectively compare intravenous digital subtraction angiography (IV-DSA) of the aorta and renal arteries with conventional arteriography in patients with renal arteries.	Sensitivity of IV-DSA was 87.5%, specificity 100% and accuracy 95.3%. Overall, accurate IV-DSA was obtained in 89.1% of arteries and 85% of the patients. IV-DSA is recommended for renal artery stenosis.	2
6. Dunnick NR, Svetkey LP, Cohan RH, et al. Intravenous digital subtraction renal angiography: use in screening for renovascular hypertension. *Radiology* 1989; 171(1):219-222.	9	94	Prospective study to determine the sensitivity and specificity of IV digital subtraction renal angiography (DSRA) as compared to conventional angiography in hypertensive patients.	In 20 patients, a stenosis of a renal artery confirmed. Sensitivity of IV-DSRA was 100%, specificity 93%, PPV 83% and NPV 100%. IV-DSRA is recommended in patients at increased risk for renovascular hypertension.	2
7. Hillman BJ, Ovitt TW, Capp MP, Fisher HD, 3rd, Frost MM, Nudelman S. Renal digital subtraction angiography: 100 cases. *Radiology* 1982; 145(3):643-646.	10	100	To evaluate the utility of IV-DSA in the evaluation of renal vascular disease. Prospective data was used and retrospective chart review was performed.	DSA is safe, quickly performed, and relatively inexpensive and suitable for examining patients with renal-related indications.	3

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8. Illescas FF, Ford K, Braun SD, Dunnick NR. Intraarterial digital subtraction angiography in hypertensive azotemic patients. *AJR* 1984; 143(5):1065-1067.	10	10	Review intraarterial DSA studies in azotemic patients to assess the technical adequacy and the effect of contrast load on renal function.	100% studies were adequate. 2/10 had transient deterioration in the degree of renal insufficiency. Intraarterial DSA is recommended for evaluating azotemic patients.	4
9. Norman D, Ulloa N, Brant-Zawadzki M, Gould RG. Intraarterial digital subtraction imaging cost considerations. *Radiology* 1985; 156(1):33-35.	15	400 angiograms	Retrospective study to estimate cost savings in intraarterial DSA studies as compared to conventional film screen angiography.	Digital angiographic unit resulted in 82% reduction in film costs, 25% reduction in staffing costs, 19% reduction in time of exam, and 30% reduction in the time required per run.	2
10. Wilms GE, Baert AL, Staessen JA, Amery AK. Renal artery stenosis: evaluation with intravenous digital subtraction angiography. *Radiology* 1986; 160(3):713-715.	9	45 patients 92 arteries	To compare IV-DSA with intraarterial DSA and define the ability of IV-DSA to quantify renal artery stenosis.	• 90% of cases had agreement about the degree of stenosis. • IV-DSA grading was correct in 94% of atheromatous lesions and in 56% of the fibromuscular dysplastic lesions. • In high-grade atheromatous lesions, degree of stenosis was slightly overestimated on IV-DSA studies in 22.5%. • In fibromuscular dysplasia, stenosis was underestimated in 33% of the cases.	3
11. Shurrab AE, Mamtora H, O'Donoghue D, Waldek S, Kalra PA. Increasing the diagnostic yield of renal angiography for the diagnosis of atheromatous renovascular disease. *Br J Radiol* 2001; 74(879):213-218.	10	249 patients-screening intravenous (197) or intra arterial (52) DSA	Retrospective review of renal angiograms to identify patients who are at greatest likelihood of developing atherosclerotic renal vascular disease.	More patients with atheromatous renal vascular disease had chronic renal failure, comorbid vascular disease, vascular bruit or US discrepancy in the size of the two kidneys. All these features were present in 19.3% of the patient's vs only 3.0% in non atheromatous renovascular disease patients. (PPV 76.2%, specificity 97%).	2
12. Pickering TG, Sos TA, Vaughan ED, Jr., et al. Predictive value and changes of renin secretion in hypertensive patients with unilateral renovascular disease undergoing successful renal angioplasty. *Am J Med* 1984; 76(3):398-404.	10	46	To determine the predictive value of renal vein renins in the detection of clinically significant renal artery stenosis in hypertensive patients undergoing renal angioplasty.	Renal vein renins had 74% sensitivity, 100% specificity. Predictive value of renal vein renin activity is poor when plasma renin activity is stimulated by long-term administration of captopril.	3
13. Roubidoux MA, Dunnick NR, Klotman PE, et al. Renal vein renins: inability to predict response to revascularization in patients with hypertension. *Radiology* 1991; 178(3):819-822.	10	133	Prospectively examine patients with hypertension to determine the usefulness of captopril-stimulated renal vein renin ratio (CSRVRR) to aid detection of patients with menovasculam hypertension due to renal artery stenosis.	CSRVRR >1.5 in 13/20 hypertension patients (sensitivity 65%), but also >1.5 in 54/113 patients without hypertension (false-positive rate 47.8%). PPV of CSRVRR was 18.6%; NPV 89.3%. CSRVRR has low sensitivity and specificity.	2

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14. Hasbak P, Jensen LT, Ibsen H. Hypertension and renovascular disease: follow-up on 100 renal vein renin samplings. *J Hum Hypertens* 2002; 16(4):275-280.	3a	100	Retrospective study to evaluate the clinical value of renal vein renin sampling as a prognostic tool in the treatment of renovascular hypertension.	About half the patients were treated interventionally by angioplasty (21%) nephrectomy (20%), or vascular surgery (8%).Seven were cured (15%) and 15 (32%) were improved after 6 month follow-up, whereas 3 patients improved (6%) and 12 (26%) improved after 3-4 year follow-up. The only positive finding was that a peripheral renin concentration lower than 8 mlU/l predicted no effect on intervention, which might lead an exclusion of 11% of the patients before entering the diagnostic program.	2
15. Postma CT, van Aalen J, de Boo T, Rosenbusch G, Thien T. Doppler ultrasound scanning in the detection of renal artery stenosis in hypertensive patients. *Br J Radiol* 1992; 65(778):857-860.	9	61	Prospective study to determine the accuracy of Doppler US compared with renal angiography in the diagnosis of renal artery stenosis in hypertensive patients.	Sensitivity of Doppler US was 62.5%, specificity 86.4% and accuracy 73.9%. Doppler US has limited value in the screening of hypertensive patients for renal artery stenosis.	2
16. Berland LL, Koslin DB, Routh WD, Keller FS. Renal artery stenosis: prospective evaluation of diagnosis with color duplex US compared with angiography. Work in progress. *Radiology* 1990; 174(2):421-423.	9	26	Prospective, double-blinded study comparing color duplex US to angiography in the detection of renal artery stenosis.	Color duplex helped identify 58% of the main arteries. 9/29 vessels identified with duplex were incorrectly diagnosed as stenotic, findings yielding a specificity of 37%. Published velocity threshold of 100 cm/sec is too low. It is unlikely for duplex scanning to prove satisfactory in renal artery stenosis.	2
17. Stavros AT, Parker SH, Yakes WF, et al. Segmental stenosis of the renal artery: pattern recognition of tardus and parvus abnormalities with duplex sonography. *Radiology* 1992; 184(2):487-492.	9	56	To prospectively evaluate segmental renal artery branches within the renal sinus with color Doppler imaging and pulsed-Doppler spectral analysis in patients before angiography. Findings were compared with subsequent findings on angiograms to determine their value in detection of hemodynamically significant renal arterial stenosis in 32 kidneys in 26 patients.	Loss of early systolic compliance peak/reflective-wave complex (ESP) helped identify renal artery stenosis with 95% sensitivity, 97% specificity, 92% PPV, 98% NPV, 96% accuracy.	2
18. Taylor DC, Kettler MD, Moneta GL, et al. Duplex ultrasound scanning in the diagnosis of renal artery stenosis: a prospective evaluation. *J Vasc Surg* 1988; 7(2):363-369.	9	29 patients 58 renal arteries	Prospective study to compare duplex Doppler (renal/aortic ratio) to angiography in the detection of renal artery stenosis.	Renal duplex scanning had a sensitivity of 84%, specificity of 97%, PPV of 94% for the detection of >60% diameter-reducing stenosis. Overall agreement with angiography was 93%. Renal duplex scanning is recommended in the diagnoses of renal artery stenosis in patients with hypertension or renal dysfunction.	3

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19. De Cobelli F, Venturini M, Vanzulli A, 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):373-380.	9	45	Prospective comparison of color Doppler US with fast, breath-hold, 3D, gadolinium-enhanced MRA in detecting renal arterial stenosis. DSA was used as standard of reference.	• For all stenoses, MRA had a sensitivity of 94% and accuracy of 91%. US had sensitivity of 71% and specificity of 76%. • For stenoses with at least 50% narrowing, sensitivity for MRA was 100%, specificity 93%, accuracy 95% and NPV 100%. US had sensitivity of 79%, specificity of 93%, and accuracy of 95% and NPV of 90%. • MRA is superior to color Doppler US in accessory renal artery detection.	2
20. Lee HY, Grant EG. Sonography in renovascular hypertension. *J Ultrasound Med* 2002; 21(4):431-441.	13	1,500 exams	To examine role of US in the diagnosis of renal artery stenosis.	Duplex/color Doppler US is important in the diagnosis of renal artery stenosis and occlusion; it has an excellent correlation with contrast-enhanced angiography.	2
21. Lacourciere Y, Levesque J, Onrot JM, et al. Impact of Levovist ultrasonographic contrast agent on the diagnosis and management of hypertensive patients with suspected renal artery stenosis: a Canadian multicentre pilot study. *Can Assoc Radiol J* 2002; 53(4):219-227.	9	78	Multicenter, controlled trial to compare unenhanced US, contrast-enhanced US and captopril-enhanced renal scintigraphy and determine if contrast agent improves ability to assess the renal arteries with duplex Doppler US.	Enhanced US yielded diagnosis in 99% vs 82% for unenhanced US. Diagnosis was possible with both enhanced and unenhanced duplex Doppler US in 64 (82%), and the diagnosis was the same with both methods for 63 (98%) of 64 patients. Enhanced US is preferred over unenhanced US and captopril-enhanced renal scintigraphy.	2
22. Nchimi A, Biquet JF, Brisbois D, et al. Duplex ultrasound as first-line screening test for patients suspected of renal artery stenosis: prospective evaluation in high-risk group. *Eur Radiol* 2003; 13(6):1413-1419	9	91 patients 177 arteries assessed 2 readers	Prospective study to compare duplex US with DSA in assessing renal artery stenosis.	Accuracy, sensitivity and specificity for duplex US were 96%, 91% and 97%, respectively. Kappa for interobserver agreement was 0.95 for duplex US and 0.92 for DSA. Authors believe duplex US is accurate for renal artery stenosis, although it is still unreliable for the detection of accessory arteries.	2

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23. Oliva VL, Soulez G, Lesage D, et al. Detection of renal artery stenosis with Doppler sonography before and after administration of captopril: value of early systolic rise. *AJR* 1998; 170(1):169-175.	9	71 patients 135 kidneys 2 observers	To assess the value of quantitative and qualitative analysis of early systolic rise on Doppler waveform before and after administration of captopril. All cases were compared with conventional or digital subtraction angiography.	• Before captopril the Doppler US had a sensitivity of 81% and specificity of 98% for detection of renal artery stenosis ≥50%; sensitivity and specificity of Doppler US after captopril was 100%. • For renal artery stenosis ≥70%, sensitivity was 94% and specificity was 89% before administration of captopril. • After captopril administration, an acceleration threshold value of 440 cm/sec^2 for early systolic rise was associated with a sensitivity of 100% and a specificity of 94% for the detection of renal artery stenosis ≥50%. • Doppler US of the renal arteries performed before administration of captopril is recommended in the detection of severe stenosis (≥70%).	2
24. Radermacher J, Chavan A, Bleck J, et al. Use of Doppler ultrasonography to predict the outcome of therapy for renal-artery stenosis. *N Engl J Med* 2001; 344(6):410-417.	10	138	Prospectively identify patients whose renal function and blood pressure will improve after the correction of renal artery stenosis to determine whether a high level of resistance to flow in segmental arteries can be used to select patients.	Of 5,950 patients, 138 had renal artery stenosis. They were grouped into those with resistive index >80 and those with resistive index value <80. A resistive index >80 will not improve in renal function, blood pressure or kidney survival following treatment.	2
25. Setaro JF, Chen CC, Hoffer PB, Black HR. Captopril renography in the diagnosis of renal artery stenosis and the prediction of improvement with revascularization. The Yale Vascular Center experience. *Am J Hypertens* 1991; 4(12 Pt 2):698S-705S.	10	113	To determine the ability of captopril renography to diagnose renal artery stenosis and the prediction of improvement with revascularization.	Captopril renography was 91% sensitive and 87% specific in identifying or excluding renal artery stenosis and it accurately predicts the success or failure of therapeutic intervention.	2
26. Postma CT, van Oijen AH, Barentsz JO, et al. The value of tests predicting renovascular hypertension in patients with renal artery stenosis treated by angioplasty. *Arch Intern Med* 1991; 151(8):1531-1535.	9	31	To evaluate and compare renal vein renins, captopril test and renal scintigraphic tests to the blood pressure outcome 12 months after relief of renal artery stenosis by percutaneous transluminal renal angioplasty.	• Captopril test showed a sensitivity of 36% and accuracy of 43%. • Renal captopril technetium Tc-99m-labeled pentetic acid scintigraphy had 60% sensitivity.	3
27. Dondi M, Monetti N, Fanti S, et al. Use of technetium-99m-MAG3 for renal scintigraphy after angiotensin-converting enzyme inhibition. *J Nucl Med* 1991; 32(3):424-428.	10	82	To evaluate role of Tc-99m-MAG3 for renal scintigraphy after angiotensin-converting enzyme inhibition.	Sensitivity and specificity for the detection of renal artery stenosis >50% were 89% and 91%, respectively.Tc-99m-MAG3 is an effective compound for detecting renal artery stenosis ≥50% with captopril renal scintigraphy.	2

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28. Mann SJ, Pickering TG, Sos TA, et al. Captopril renography in the diagnosis of renal artery stenosis: accuracy and limitations. *Am J Med* 1991; 90(1):30-40.	10	55 2 observers	To determine the accuracy of renography with captopril administration ("captopril renography") in diagnosing renal artery stenosis.	Renal artery stenosis was seen in 35/55 patients. Three criteria for diagnosing renal artery stenosis: 1) a percent uptake of DTPA by the affected kidney of <40% of the combined bilateral uptake, 2) a delayed time to peak uptake of DTPA >5 minutes longer in the affected kidney than in the contralateral kidney, 3) a delayed excretion of DTPA, with retention at 15 minutes, as a fraction of peak activity, more than 20% greater than in the contralateral kidney. Presence of one or more of these criteria was diagnostic of renal artery stenosis, with a sensitivity and specificity of 71% and 75%, respectively before captopril administration, and 94% and 95% after captopril administration. Lesser degrees of asymmetry (ie, uptake of 40%-50%) had very poor diagnostic specificity.	2
29. Taylor A. Renovascular hypertension: nuclear medicine techniques. *Q J Nucl Med* 2002; 46(4):268-282.	11	291 patients 10 studies	Review general components of renal scintigraphy and components specific to angiotensin converting enzyme inhibition (ACEI) renography.	Mean PPV of ACEI renography is 92%. ACEI renography is highly accurate in patients with suspected renovascular hypertension who have normal or near normal renal function.	2
30. Bongers V, Bakker J, Beutler JJ, Beek FJ, De Klerk JM. Assessment of renal artery stenosis: comparison of captopril renography and gadolinium-enhanced breath-hold MR angiography. *Clin Radiol* 2000; 55(5):346-353.	9	43	Prospective study comparing captopril renography with gadolinium-enhanced breath-hold MRA in the diagnosis of 50-99% renal artery stenosis.	Captopril renography accurately categorized 22/26 patients who had renal artery stenosis. The sensitivity and specificity were 85% and 71%, respectively. For MRA sensitivity and specificity were 100% and 94%, respectively. The accuracy of captopril renography was lower in patients with renal impairment than in those with normal renal function.	2
31. Huot SJ, Hansson JH, Dey H, Concato J. Utility of captopril renal scans for detecting renal artery stenosis. *Arch Intern Med* 2002; 162(17):1981-1984.	9	86 patients 169 kidneys	Retrospective review to determine value of captopril renal scans in detecting renal artery stenosis. Patients also had renal arteriography.	The prevalence of renal artery stenosis was 43%. Captopril renal scanning had sensitivity of 74%, specificity of 59%, PPV of 58% and NPV of 75%. Captopril renal scanning is not recommended as the initial screening test for the diagnosing renal artery stenosis.	3

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32. Johansson M, Jensen G, Aurell M, et al. Evaluation of duplex ultrasound and captopril renography for detection of renovascular hypertension. *Kidney Int* 2000; 58(2):774-782.	9	98	Prospective study to evaluate duplex US and captopril renography for detection of renal artery stenosis among hypertensive patients. Renal angiography was performed in all patients.	Renal artery stenosis of 50% degree or more - sensitivity and PPV for duplex US were 84% and 76%, whereas for captopril renography it was 68% for both. The specificity and NPV for duplex US were 94% and 96%; the corresponding values for captopril renography were 92% for both. Duplex US is recommended.	2
33. Kramer U, Wiskirchen J, Fenchel MC, et al. Isotropic high-spatial-resolution contrast-enhanced 3.0-T MR angiography in patients suspected of having renal artery stenosis. *Radiology* 2008; 247(1):228-240.	9	29	To prospectively evaluate the accuracy of contrast material–enhanced MRA performed at 3-T for assessment of renal artery stenosis by using parallel acquisition techniques with high acceleration factors compared with DSA.	The sensitivity and specificity of MRA in grading significant (>75%) stenosis were 94% and 96%, respectively. Contrast-enhanced 3-T MRA can be used to exclude renal artery stenosis and can serve as a useful screening method in the diagnostic workup of patients with arterial hypertension.	2
34. McGregor R, Vymazal J, Martinez-Lopez M, et al. A multi-center, comparative, phase 3 study to determine the efficacy of gadofosveset-enhanced magnetic resonance angiography for evaluation of renal artery disease. *Eur J Radiol* 2008; 65(2):316-325.	9	145 patients 3 blinded readers 18 centers	Multicenter, blinded, prospective study to determine the safety and efficacy of the blood-pool contrast agent gadofosveset trisodium in renal artery MRA. Images were compared to non-contrast MRA, using catheter X-ray angiography (XRA) as the standard of reference.	127 with complete efficacy data entered the primary efficacy analysis. Gadofosveset-enhanced MRA led to significant improvement ($P< 0.01$) in sensitivity (+25%, +26%, +42%), specificity (+23%, +25%, +29%), and accuracy (+23%, +28%, +29%) over non-enhanced MRA for all the readers.	1
35. Soulez G, Pasowicz M, Benea G, et al. Renal artery stenosis evaluation: diagnostic performance of gadobenate dimeglumine-enhanced MR angiography--comparison with DSA. *Radiology* 2008; 247(1):273-285.	9	268 patients 3 reviewers	Multicenter, blinded, prospective study to determine the accuracy of contrast material–enhanced MRA with 0.1 mmol/kg of body weight gadobenate dimeglumine for depiction of significant steno-occlusive disease using DSA as standard of reference.	Sensitivity, specificity, and accuracy of contrast-enhanced MRA for detection of 51% or greater stenosis or occlusion were 60.1%-84.1%, 89.4%-94.7%, and 80.4%-86.9%, respectively, at segment level. Similar values were obtained for predictive values and for patient level analyses. Few contrast-enhanced MR angiographic examinations (1.9%-2.8%) were technically inadequate. Interobserver agreement for detection of significant steno-occlusive disease was good (79.9% agreement).	1
36. Tan KT, van Beek EJ, Brown PW, van Delden OM, Tijssen J, Ramsay LE. Magnetic resonance angiography for the diagnosis of renal artery stenosis: a meta-analysis. *Clin Radiol* 2002; 57(7):617-624.	11	998 patients 25 studies	Meta-analysis to compare the accuracy of MRA with and without gadolinium in diagnosing renal artery stenosis, using catheter angiography as reference.	• Non-enhanced MRA had sensitivity of 94% (95% CI: 90%-97%) and specificity of 85% (95% CI: 82%-87%). • Gadolinium-enhanced MRA had sensitivity of 97% (95% CI: 93%-98%) and specificity of 93% (95% CI: 91%-95%). • Gadolinium-enhanced MRA had better specificity and PPV.	1

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37. Volk M, Strotzer M, Lenhart M, et al. Time-resolved contrast-enhanced MR angiography of renal artery stenosis: diagnostic accuracy and interobserver variability. *AJR* 2000; 174(6):1583-1588.	9	40 patients 4 observers evaluated 80 renal arteries, 19 vessels	Prospective study to compare contrast-enhanced MRA with DSA in the detection of renal artery stenosis.	Overall sensitivity for significant stenoses was 92.9%, overall specificity 83.4%, and overall accuracy 85.9%. Interobserver variability of gadolinium-enhanced MRA exceeded that of DSA. Gadolinium-enhanced MRA is recommended for screening suspected renal artery stenosis.	2
38. Debatin JF, Spritzer CE, Grist TM, et al. Imaging of the renal arteries: value of MR angiography. *AJR* 1991; 157(5):981-990.	9	32 patients 33 MRA studies 3 observers	Prospective study to compare the value of MRA with conventional angiography for visualizing the renal arteries and detecting renovascular disease.	• Renal artery visualization and detection of renovascular disease were more complete with coronal phase-contrast (80% sensitivity, 91% specificity) than with time-of-flight (53% sensitivity, 97% specificity) images. • Combined axial and coronal phase-contrast images permitted visualization of the proximal 35 mm of all dominant renal arteries and detection of 13/15 stenoses (87% sensitivity, 97% specificity). • MRA is useful for the evaluation of renovascular disease.	2
39. Fain SB, King BF, Breen JF, Kruger DG, Riederer SJ. High-spatial-resolution contrast-enhanced MR angiography of the renal arteries: a prospective comparison with digital subtraction angiography. *Radiology* 2001; 218(2):481-490.	9	38 patients 2 readers	Prospective study to evaluate a high-spatial-resolution 3D contrast material-enhanced MRA for detecting proximal and distal renal arterial. MR results were compared with DSA.	High-spatial-resolution small-FOV technique provided high sensitivity (97%) and specificity (92%) for the detection of renal arterial stenosis. The portrayal of the segmental renal arteries was adequate for diagnosis in 19 (76%) of 25 patients. In 12% of the patients, impaired depiction of the segmental arteries was linked to motion. Conclusion: The combined high-spatial-resolution small-FOV and large-FOV MR angiographic examination provides improved spatial resolution in the region of the renal arteries while maintaining coverage of the abdominal aorta and iliac arteries.	2

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40. Korst MB, Joosten FB, Postma CT, Jager GJ, Krabbe JK, Barentsz JO. Accuracy of normal-dose contrast-enhanced MR angiography in assessing renal artery stenosis and accessory renal arteries. *AJR* 2000; 174(3):629-634.	9	38	To examine the accuracy of normal-dose contrast-enhanced MRA in the assessment of renal artery stenosis and accessory renal arteries by comparing with DSA.	DSA showed 75 main and 17 accessory renal arteries (n=92). All main renal arteries and 13 accessory renal arteries were identified on MRA. One false-positive finding on MRA identified retrospectively on DSA. Sensitivity and specificity for grading significant stenosis were 100% and 85%, respectively. Contrast-enhanced MRA using +/-0.1 mmol/kg of gadolinium is recommended in the diagnosis of renal artery stenosis and accessory renal arteries.	2
41. Mallouhi A, Schocke M, Judmaier W, et al. 3D MR angiography of renal arteries: comparison of volume rendering and maximum intensity projection algorithms. *Radiology* 2002; 223(2):509-516.	9	27 2 observers	Retrospective , blinded study to compare volume rendering (VR) and maximum intensity projection (MIP) as postprocessing techniques of MRA for detection and quantification of renal artery stenosis. Findings were compared with DSA.	All main renal arteries and accessory renal arteries depicted at DSA were also demonstrated on MIP and VR images. VR performed slightly better than MIP.	2
42. Qanadli SD, Soulez G, Therasse E, et al. Detection of renal artery stenosis: prospective comparison of captopril-enhanced Doppler sonography, captopril-enhanced scintigraphy, and MR angiography. *AJR* 2001; 177(5):1123-1129.	9	41	Prospective study to compare the value of captopril-enhanced Doppler US, captopril-enhanced renal scintigraphy, and gadolinium-enhanced MRA for detecting renal artery stenosis.	For >50% stenosis MRA had 96.6% sensitivity, captopril enhanced Doppler 69%, and Captopril enhanced scintigraphy 41.4%. Captopril enhanced Doppler US in combination with gadolinium–enhanced MRA needs to be evaluated for cost effective analysis.	2
43. Kanal E, Barkovich AJ, Bell C, et al. ACR guidance document for safe MR practices: 2007. *AJR* 2007; 188:1-27.	15	N/A	ACR practice guideline for safe MR practices. Purpose of document is to guide MR facilities in the development of safe MR programs.	N/A	3
44. Broome DR, Girguis MS, Baron PW, Cottrell AC, Kjellin I, Kirk GA. Gadodiamide-associated nephrogenic systemic fibrosis: why radiologists should be concerned. *AJR* 2007; 188(2):586-592.	13	12	Retrospective chart review to identify any common risk factors and determine whether IV gadodiamide is associated with the development of nephrogenic systemic fibrosis (NSF).	All patients had renal insufficiency and all developed skin fibrosis within 2-11 weeks after gadodiamide administration. The odds ratio for development of NSF after gadodiamide exposure was 22.3. Development of NSF was strongly associated with gadodiamide administration in the setting of either acute hepatorenal syndrome or dialysis-dependent chronic renal insufficiency.	3

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45. Sadowski EA, Bennett LK, Chan MR, et al.: Nephrogenic systemic fibrosis: risk factors and incidence estimation. *Radiology* 2007; 243(1): 148-57.	13	13	To retrospectively review data in patients with biopsy-confirmed NSF, assess the associated risk factors, and report the incidence of NSF at the authors' institution.	A combination of factors, including altered kidney function, inflammatory burden, and exposure to gadolinium-based contrast agents may all play a role in development of NSF. Alternative imaging should be considered in patients with these factors. If use of a gadolinium-based agent is clinically indicated, the referring physician and patient should be informed of the potential risk of developing NSF.	2
46. Willmann JK, Wildermuth S, Pfammatter T, et al. Aortoiliac and renal arteries: prospective intraindividual comparison of contrast-enhanced three-dimensional MR angiography and multi-detector row CT angiography. *Radiology* 2003; 226(3):798-811.	9	46 patients 2 readers	Prospective study to compare contrast material-enhanced 3D MRA with MDCTA in the same patients for assessment of the aortoiliac and renal arteries. DSA is the standard of reference.	The patients considered CTA as least uncomfortable procedure and DSA to be the most uncomfortable procedure. The total sensitivity of MRA was 92% to 93% and specificities of 100% and 99%. For MDCT the sensitivities were in the range of 91% and 92% and specificity of 99%.	2
47. Beregi JP, Elkohen M, Deklunder G, Artaud D, Coullet JM, Wattinne L. Helical CT angiography compared with arteriography in the detection of renal artery stenosis. *AJR* 1996; 167(2):495-501.	9	50	Prospective comparison of digital renal arteriography and helical CTA in hypertensive patients suspected to have renal artery stenosis.	For >50% stenosis, helical CTA had sensitivity of 88%, specificity of 98%. For main renal artery disease only, CTA had sensitivity of 100%, specificity of 98%.	2
48. Farres MT, Lammer J, Schima W, et al. Spiral computed tomographic angiography of the renal arteries: a prospective comparison with intravenous and intraarterial digital subtraction angiography. *Cardiovasc Intervent Radiol* 1996; 19(2):101-106.	9	18	Prospective comparison of CTA with IV-DSA and intraarterial DSA in assessing renal artery stenosis.	For >50% stenosis CTA had sensitivity of 96%, specificity of 77%, accuracy of 89%. CTA limited in its ability to visualize branches of renal artery and accessory arteries.	3
49. Berg MH, Manninen HI, Vanninen RL, Vainio PA, Soimakallio S. Assessment of renal artery stenosis with CT angiography: usefulness of multiplanar reformation, quantitative stenosis measurements, and densitometric analysis of renal parenchymal enhancement as adjuncts to MIP film reading. *J Comput Assist Tomogr* 1998; 22(4):533-540.	10	37 patients 78 renal arteries	To evaluate CTA in the assessment of renal artery stenosis.	MIP films showed 100% sensitivity but only 42%-54% specificity. Combined visual interpretation of MIP films with quantitative measurements yielded best diagnostic performance; 92% sensitivity, 80% specificity and 84% overall accuracy.	3

Renovascular Hypertension
EVIDENCE TABLE

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Strength of Evidence
50. Mallouhi A, Rieger M, Czermak B, Freund MC, Waldenberger P, Jaschke WR. Volume-rendered multidetector CT angiography: noninvasive follow-up of patients treated with renal artery stents. *AJR* 2003; 180(1):233-239.	9	16 patients 16 renal artery stents	To evaluate the role of volume-rendered MDCT angiography for estimating the patency of renal artery stents by comparing three volume-rendering techniques with DSA and multiplanar volume reformations.	Eight restenosis were identified on DSA. VR with high to low parameter setting on MDCT achieved the best performance.	3
51. Lufft V, Hoogestraat-Lufft L, Fels LM, et al. Contrast media nephropathy: intravenous CT angiography versus intraarterial digital subtraction angiography in renal artery stenosis: a prospective randomized trial. *Am J Kidney Dis* 2002; 40(2):236-242.	8	80	Prospective study of patients with renal artery stenosis randomized to either CTA or DSA. To determine serum creatinine level and single-shot inulin clearance for evaluation of renal function and urine alpha1 microglobin and beta-N- acetyl-glucosaminidase as markers for tubular toxicity.	• Mean serum creatinine levels increased from 1.78 +/- 1.61 to 1.92 +/-1.73 mg/dL (157 +/- 142 to 170 +/- 153 micromol/L; P=0.00001) in the CTA group and from 1.52 +/- 1.23 to 1.60 +/- 1.28 mg/dL (134 +/- 109 to 141 +/- 113 micromol/L; P=0.01) in the DSA group. • Mean inulin clearance decreased from 63 +/- 28 to 58 +/- 23 mL/min (P=0.01) and 65 +/- 26 to 62 +/- 26 mL/min (P<0.01), median beta-NAG levels increased from 4.6 to 6.0 U/g creatinine (P=not significant) and 2.5 to 8.0 U/g creatinine (P<0.001), and median alpha1-microglobulin levels increased from 13 to 17 microg/g creatinine (P<0.025) and 11 to 21 microg/g creatinine (P=not significant) in the CTA and DSA groups, respectively. • CTA used for the detection of renal artery stenosis is not associated with an increased risk for contrast media nephropathy compared with intraarterial DSA.	1
52. Mounier-Vehier C, Lions C, Devos P, et al. Cortical thickness: an early morphological marker of atherosclerotic renal disease. *Kidney Int* 2002; 61(2):591-598.	10	49	To evaluate morphological abnormalities on post-stenotic and contralateral kidneys with spiral CTA.	The post stenotic kidneys showed significant cortical atrophy. The contralateral kidneys also underwent cortical disease as judged by comparison with control kidneys. A threshold of 800 mm^2 was identified for cortical area and 8 mm for cortical thickness. Cortical measurements are more sensitive than renal lengths.	3
53. Vasbinder GB, Nelemans PJ, Kessels AG, et al. Accuracy of computed tomographic angiography and magnetic resonance angiography for diagnosing renal artery stenosis. *Ann Intern Med* 2004;141(9): 674-82	9	356 patients 2 panels of 3 observers	Prospective, blinded, multicenter study to determine the value of CTA and MRA compared with digital DSA for detection of renal artery stenosis.	The combined sensitivity and specificity were 64% and 92% for CTA and 62% and 84% for MRA. DSA is preferred to the other modalities.	1

Renovascular Hypertension
EVIDENCE TABLE

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Strength of Evidence
54. Vasbinder GB, Nelemans PJ, Kessels AG, Kroon AA, de Leeuw PW, van Engelshoven JM. Diagnostic tests for renal artery stenosis in patients suspected of having renovascular hypertension: a meta-analysis. *Ann Intern Med* 2001; 135(6):401-411.	11	343	Meta-analysis study to compare the value of CTA, MRA, US, captopril renal scintigraphy, and the captopril test for diagnosis of renal artery stenosis in patients suspected of having renovascular hypertension.	343 CTA, 306 MRA, 314 US, and 172 captopril renograms meet inclusion criteria. Receiver-operating characteristic (ROC) curves found that CTA and gadolinium-enhanced, 3D MRA had better performance than other diagnostic tests. Further research is recommended since a limited number of CT and MRA studies were included.	2
55. Eklof H, Ahlstrom H, Magnusson A, et al.: A prospective comparison of duplex ultrasonography, captopril renography, MRA, and CTA in assessing renal artery stenosis. *Acta Radiol* 2006; 47(8): 764-74.	9	58	To prospectively compare the diagnostic accuracy of duplex US, captopril renography, CTA, and 3D gadolinium-enhanced MRA in diagnosing hemodynamically significant renal artery stenosis. Standard of reference was measurement of trans-stenotic pressure gradient.	The prevalence of renal artery stenosis was 77%. US had sensitivity of 73%, specificity of 71%. Captopril had sensitivity of 52%, specificity of 63%. CTA had sensitivity of 94%, specificity of 62%. MRA had sensitivity of 93%, specificity of 91%.US had a lower sensitivity than CTA and MRA ($P<0.001$) but higher than captopril renography ($P=0.013$). MRA and CTA were much better than duplex US and captopril renography.	2
56. American College of Radiology. *Manual on Contrast Media*. Available at: http://www.acr.org/SecondaryMainMenuCategories/quality_safety/contrast_manual.aspx.	15	N/A	Guidance document on contrast media to assist radiologists in recognizing and managing risks associated with the use of contrast media.	N/A	3

Evidence Table Key

Study Type Key

Numbers 1-7 are for studies of therapies while numbers 8-15 are used to describe studies of diagnostics.

1. Randomized Controlled Trial — Treatment
2. Controlled Trial
3. Observation Study
    a. Cohort
    b. Cross-sectional
    c. Case-control
4. Clinical Series
5. Case reviews
6. Anecdotes
7. Reviews
8. Randomized Controlled Trial — Diagnostic
9. Comparative Assessment
10. Clinical Assessment
11. Quantitative Review
12. Qualitative Review
13. Descriptive Study
14. Case Report
15. Other (Described in text)

Strength of Evidence Key

- Category 1 - The conclusions of the study are valid and strongly supported by study design, analysis and results.
- Category 2 - The conclusions of the study are likely valid, but study design does not permit certainty.
- Category 3 - The conclusions of the study may be valid but the evidence supporting the conclusions is inconclusive or equivocal.
- Category 4 - The conclusions of the study may not be valid because the evidence may not be reliable given the study design or analysis.