Renal Failure
EVIDENCE TABLE

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
1. Davidson AJ, Hartman DS. *Radiology of the kidney and urinary tract.* 2nd ed. Philadelphia, Pa: WB Saunders Co; 1994.	Review/Other-Dx	N/A	Book chapter.	N/A	4
2. Stene JK. Renal failure in the trauma patient. *Crit Care Clin* 1990; 6(1):111-119.	Review/Other-Dx	N/A	Review renal failure in trauma patient.	No results stated.	4
3. Molitoris BA, Levin A, Warnock DG, et al. Improving outcomes of acute kidney injury: report of an initiative. *Nat Clin Pract Nephrol* 2007; 3(8):439-442.	Review/Other-Dx	N/A	To describe the formation of a multidisciplinary collaborative network focused on AKI.	Acute Kidney Injury Network has proposed uniform standards for diagnosing and classifying AKI. These proposed standards will need to be validated in future studies.	4
4. Rose BD. *Pathophysiology of renal disease.* 2nd ed. New York: McGraw-Hill; 1987.	Review/Other-Dx	N/A	Book chapter.	N/A	4
5. Becker JA. Evaluation of renal function. *Radiology* 1991; 179(2):337-338.	Review/Other-Dx	N/A	A review on the evaluation of renal function. Article discussed renal function studies, creatinine, and GFR.	No results stated.	4
6. National Kidney Foundation: Frequently Asked Questions About GFR Estimates. Available at: http://www.kidney.org/professionals/kls/pdf/12-10-4004_KBB_FAQs_AboutGFR-1.pdf. Accessed 10 October 2012.	Review/Other-Dx	N/A	An article on frequently asked questions about GFR estimates.	No results stated.	4
7. Cockcroft DW, Gault MH. Prediction of creatinine clearance from serum creatinine. *Nephron* 1976; 16(1):31-41.	Observational-Dx	505 patients in Group 1; 236 patients in Group II	To compare the ability of creatinine clearance to predict creatinine clearance with that of previously reported methods.	Derivation included the relationship found between age and 24-hour creatinine excretion/kg in 249 patients aged 18-92. Values for creatinine clearance were predicted by this formula and 4 other methods and the results compared with the means of two 24-hour creatinine clearances measured in 236 patients. The above formula gave a correlation coefficient between predicted and mean measured creatinine clearances of 0.83; on average, the difference predicted and mean measured values was no greater than that between paired clearances. Factors for age and body weight must be included for reasonable prediction.	3

Renal Failure
EVIDENCE TABLE

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
8. Levey AS, Coresh J, Greene T, et al. Using standardized serum creatinine values in the modification of diet in renal disease study equation for estimating glomerular filtration rate. *Ann Intern Med* 2006; 145(4):247-254.	Observational-Dx	1,628 patients	To describe the performance of the revised 4-variable Modification of Diet in Renal Disease (MDRD) Study equation and compare it with the performance of the 6-variable MDRD Study and Cockcroft-Gault equations.	Mean measured GFR was 39.8 mL/min per 1.73 m2 (SD, 21.2). Accuracy and precision of the revised 4-variable equation were similar to those of the original 6-variable equation and better than in the Cockcroft-Gault equation, even when the latter was corrected for bias, with 90%, 91%, 60%, and 83% of estimates within 30% of measured GFR, respectively. Differences between measured and estimated GFR were greater for all equations when the estimated GFR was 60 mL/min per 1.73 m2 or greater.	3
9. National Kidney Foundation: Acute Kidney Injury: What Every Clinician Should Know. Available at: http://www.kidney.org/news/newsroom/newsitem.cfm?id=43&&cid=20. Accessed 10 October 2012.	Review/Other-Dx	N/A	An article on a new set of consensus recommendations for the terminology, diagnostic criteria, and staging of AKI.	Diagnostic criteria for AKI: An abrupt (within 48 hours) reduction in kidney function currently defined as an absolute increase in serum creatinine of >0.3 mg/dl (>25 micromole/L), a percentage increase of 50% or a reduction in urine output (documented oliguria of <0.5 ml/kg/hour for >6 hours).	4
10. Kellen M, Aronson S, Roizen MF, Barnard J, Thisted RA. Predictive and diagnostic tests of renal failure: a review. *Anesth Analg* 1994; 78(1):134-142.	Review/Other-Dx	N/A	To review and evaluate the commonly used methods for predicting and diagnosing ARF in the setting of trauma, surgery, and critical care; to examine how well these methods can differentiate between ATN and Prerenal azotemia; and explore some other potentially useful methods for the diagnosis of perioperative ARF in the future.	Serial determination of creatinine clearance is currently the most sensitive test for predicting the onset of perioperative renal dysfunction; however, the test is not practical for measuring renal function under operating room conditions.	4
11. Adcox MJ, Collins B, Zager RA. The differential diagnosis of acute renal failure. *Contemp Issues Nephrol* 1992; 25:73-117.	Review/Other-Dx	N/A	Review diagnosis and management of ARF.	No results stated.	4
12. Emamian SA, Nielsen MB, Pedersen JF, Ytte L. Kidney dimensions at sonography: correlation with age, sex, and habitus in 665 adult volunteers. *AJR* 1993; 160(1):83-86.	Observational-Dx	665 patients	To investigate the normal sonographic measurements of the kidney in adult volunteers.	Median renal lengths were 11.2 cm on the left side and 10.9 cm on the right side. Median renal volumes were 146 cm3 in the left kidney and 134 cm3 in the right kidney. Renal size decreased with age, almost entirely because of parenchymal reduction. Renal volume correlated best with total body area. Renal length correlated best with body height. Measurements of renal length obtained with the subjects supine were not significantly different from those obtained with the subjects prone.	4

Renal Failure
EVIDENCE TABLE

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
13. Beland MD, Walle NL, Machan JT, Cronan JJ. Renal cortical thickness measured at ultrasound: is it better than renal length as an indicator of renal function in chronic kidney disease? *AJR* 2010; 195(2):W146-149.	Observational-Dx	25 patients	To determine whether there is a relationship between renal cortical thickness or length measured on US and the degree of renal impairment in chronic kidney disease.	Mean cortical thickness was 5.9 mm (range, 3.2-11.0 mm). Mean length was 10 cm (7.2-12.4 cm). Mean minimum serum creatinine was 2.1 mg/dL (1.1-6.1 mg/dL). Mean estimated GFR using Cockcroft-Gault was 34.8 mL/min (10.6-99.4 mL/min) and 36 mL/min (8-66 mL/min) using MDRD. There was a statistically significant relationship between estimated GFR and cortical thickness using both Cockcroft-Gault ($P<0.0001$) and MDRD ($P=0.005$). There was a statistically significant relationship between Cockcroft-Gault and length ($P=0.003$) but not between MDRD and length ($P=0.08$).	2
14. Stuck KJ, White GM, Granke DS, Ellis JH, Weissfeld JL. Urinary obstruction in azotemic patients: detection by sonography. *AJR* 1987; 149(6):1191-1193.	Review/Other-Dx	189 patients	To evaluate how often sonography detected obstruction as the cause of the worsening renal function.	In 189 patients, 17 (9%) had hydronephrosis: 11 unilateral (one with a solitary kidney) and 6 bilateral. Obstructive causes were subsequently established in the solitary kidney and in 4 patients with bilateral dilatation. These 5 patients (2.6%) with clinically significant hydronephrosis were shown subsequently to have a clinical history that strongly suggested the presence of urinary tract obstruction. In patients without a clinical history that suggests obstruction (such as calculi, bladder outlet obstruction, or pelvic mass); the likelihood of finding bilateral hydronephrosis by sonography is small.	4
15. Gottlieb RH, Weinberg EP, Rubens DJ, Monk RD, Grossman EB. Renal sonography: can it be used more selectively in the setting of an elevated serum creatinine level? *Am J Kidney Dis* 1997; 29(3):362-367.	Observational-Dx	60 patients	Retrospective study to evaluate outcomes from the use of US in patients with elevated serum creatinine level and to determine relevant clinical parameters in these patients to better triage them for US.	US was effective in guiding management in patients with a suggestive history for obstruction but not in patients with no suggestive history and other more likely causes for renal failure.	4

Renal Failure
EVIDENCE TABLE

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
16. Ritchie WW, Vick CW, Glocheski SK, Cook DE. Evaluation of azotemic patients: diagnostic yield of initial US examination. *Radiology* 1988; 167(1):245-247.	Review/Other-Dx	394 azotemic patients	To determine whether renal US is necessary in all patients with azotemia.	The patients included 119 patients considered clinically to be at high risk for postrenal urinary obstruction and 275 patients considered to be at low risk. In the high-risk population, 35 patients were found to have hydronephrosis (29%). In the low-risk population, 3 patients were found to have hydronephrosis (1%). In two of these patient's surgical intervention resulted in reversal of the azotemia.	4
17. Licurse A, Kim MC, Dziura J, et al. Renal ultrasonography in the evaluation of acute kidney injury: developing a risk stratification framework. *Arch Intern Med* 2010; 170(21):1900-1907.	Observational-Dx	Derivation sample of 200 patients; validation sample of 797 patients	To create a stratification system that would help clinicians ascertain the risk of renal obstruction among those with AKI.	In a derivation sample of 200 patients, 7 factors were found to be associated with hydronephrosis: history of hydronephrosis; recurrent urinary tract infections; diagnosis consistent with obstruction; nonblack race; and absence of the following: exposure to nephrotoxic medications, congestive heart failure, or prerenal AKI. Among 797 patients in the validation sample (mean age, 65.6 years), 10.6% had hydronephrosis and 3.3% had hydronephrosis requiring an intervention. Of 223 patients in the low-risk group, 7 (3.1%) had hydronephrosis and 1 (0.4%) had hydronephrosis requiring an intervention (223 patients needed to be screened to find 1 case of hydronephrosis requiring an intervention). In this group, there were 0 incidental findings on renal US unknown to the clinical team. In the higher-risk group, 15.7% had hydronephrosis and 4.7% had hydronephrosis requiring an intervention.	3
18. Keyserling HF, Fielding JR, Mittelstaedt CA. Renal sonography in the intensive care unit: when is it necessary? *J Ultrasound Med* 2002; 21(5):517-520.	Review/Other-Dx	105 examination 104 patients	To evaluate the efficacy of renal US performed in intensive care units on patients with the diagnosis of acute or acute-on-chronic renal failure.	Only 1 study had positive results for hydronephrosis, which was graded as mild. Incidental findings not immediately affecting patient care and including ascites and simple renal cysts were identified in 91 patients. The estimated total cost of the examinations was $13,350.75.	4

Renal Failure
EVIDENCE TABLE

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
19. Platt JF, Rubin JM, Ellis JH. Acute renal failure: possible role of duplex Doppler US in distinction between acute prerenal failure and acute tubular necrosis. *Radiology* 1991; 179(2):419-423.	Observational-Dx	91 patients	To characterize alterations in the Doppler waveform associated with different types of ARF and to evaluate whether duplex Doppler analysis can play a role in differentiating the two most common forms of ARF, prerenal failure and ATN.	An elevated RI (≥.75) occurred in 91% of patients with ATN vs only 20% of patients with prerenal azotemia. Patients with severe liver disease (hepatorenal syndrome) are a subset of those with prerenal ARF that accounted for most of the elevated RI in this group. Study demonstrates that intrarenal Doppler US allows detection of changes associated with ARF far more often than standard US. More important, Doppler US may be helpful in distinguishing ATN from prerenal azotemia.	3
20. Platt JF. Duplex Doppler evaluation of native kidney dysfunction: obstructive and nonobstructive disease. *AJR* 1992; 158(5):1035-1042.	Review/Other-Dx	N/A	Review recent advances in intrarenal duplex Doppler US of the native kidney and the pathophysiologic basis for these applications.	Intrarenal duplex Doppler US can provide physiologic information reflecting the status of renal vascular resistance. Recent biopsy series, although correlating certain pathologic findings with RI, also indicate that renal Doppler US is not sensitive or specific enough to replace renal biopsy.	4
21. Spital A, Valvo JR, Segal AJ. Nondilated obstructive uropathy. *Urology* 1988; 31(6):478-482.	Review/Other-Dx	4 patients	Case report on patients presented with severe renal failure secondary to urinary tract obstruction.	US and/or CT revealed only minimal dilatation in one patient and no dilatation in the other three. Two patients had prostate cancer, one had bladder cancer, and one had retroperitoneal fibrosis. In all cases, relief of obstruction led to a dramatic improvement in renal function. These cases, and others in the literature, illustrate that in certain settings severe urinary tract obstruction may be present in the absence of dilatation and hence may be missed by noninvasive imaging techniques.	4

Renal Failure
EVIDENCE TABLE

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
22. Burge HJ, Middleton WD, McClennan BL, Hildebolt CF. Ureteral jets in healthy subjects and in patients with unilateral ureteral calculi: comparison with color Doppler US. *Radiology* 1991; 180(2):437-442.	Observational-Dx	29 patients	To determine the color Doppler US characteristics of ureteral jets in patients with ureteral calculi.	In patients with ureteral calculi, three patterns of ureteral jets were seen: no detectable urine flow from the symptomatic side (12 patients), low-level continuous flow from the symptomatic side (4 patients), and periodic ureteral jets on the symptomatic side that were not significantly different from ureteral jets of healthy subjects (10 patients). Of the 12 patients with high-grade obstruction on urograms, 11 had ureteral jets significantly different from those of healthy subjects (either no detectable ureteral jets or continuous low-level jets on the symptomatic side). Only 3/11 with low-grade obstruction or nonobstructing stones had ureteral jets that were different from those of healthy subjects. Analysis of ureteral jets with color Doppler can enable detection and qualitative determination of the degree of ureteral obstruction in many patients with unilateral ureteral calculi.	4
23. Platt JF, Ellis JH, Rubin JM. Renal transplant pyelocaliectasis: role of duplex Doppler US in evaluation. *Radiology* 1991; 179(2):425-428.	Observational-Dx	35 patients	To prospectively evaluate the role of duplex Doppler US in distinguishing the obstructed from the nonobstructed dilated collecting system in the transplanted kidney.	13 kidneys were obstructed (mean RI, .81 ± .06), while 22 had nonobstructive dilatation (mean RI, .66 ± .07). The RI difference was statistically significant (P≤.01). Of 21 kidneys with a normal RI, only two had obstruction. In both of these, the obstruction was associated with a significant peritransplant collection of fluid due to a ureteral leak. In the seven obstructed transplanted kidneys with follow-up, the mean RI was .82 ± .06 before nephrostomy and .67 ± .05 after nephrostomy. Obstruction was a common cause of an elevated RI (≥.75). Other causes of transplant dysfunction can be associated with an elevated RI and nonobstructed dilatation. A normal RI should strongly argue against obstruction unless a ureteral leak is also present.	3

Renal Failure
EVIDENCE TABLE

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
24. Mehta RL, Pascual MT, Soroko S, et al. Spectrum of acute renal failure in the intensive care unit: the PICARD experience. *Kidney Int* 2004; 66(4):1613-1621.	Observational-Dx	618 patients	To describe the methods of patient selection and data acquisition, and the spectrum of collected clinical and process variables in addition to reporting on major study outcomes, focusing on differences by clinical site, dialysis requirement, and etiology of acute renal failure.	The mean age was 59.5 years, 41% were women, and 20% were of minority race or ethnicity. There was extensive comorbidity; 30% had chronic kidney disease, 37% had coronary artery disease, 29% had diabetes mellitus, and 21% had chronic liver disease. Acute renal failure was accompanied by extrarenal organ system failure in most patients, even those who did not require dialysis. 398 (64%) patients required dialysis. The in-hospital mortality rate was 37%, and the rate of mortality or nonrecovery of renal function was 50%. The median hospital length of stay was 25 days (26 days, excluding patients who died).	3
25. Tello R, Thomson KR, Witte D, Becker GJ, Tress BM. Standard dose Gd-DTPA dynamic MR of renal arteries. *J Magn Reson Imaging* 1998; 8(2):421-426.	Observational-Dx	20 patients underwent 22 dynamic MR studies	To determine the ability of dynamic Gd-DTPA administration to demonstrate RAS and renal stent patency compared to conventional angiography as the gold standard.	All 51 renal arteries (13 stenosed, 38 normal) were detected with dynamic MRI. Severity of RAS was classified correctly with an accuracy of 98% (95% CI: 85-100), yielding 98% specificity and 100% sensitivity. All 9 renal stents were visualized with 100% accurate patency documentation. Fast spoiled gradient echo MRI with bolus Gd-DTPA administration can provide adequate time and spatial resolution to demonstrate RAS.	2
26. Dagher PC, Herget-Rosenthal S, Ruehm SG, et al. Newly developed techniques to study and diagnose acute renal failure. *J Am Soc Nephrol* 2003; 14(8):2188-2198.	Review/Other-Dx	N/A	Four techniques that will facilitate the study and diagnosis of ARF are described and illustrated.	State-of-the-art MRI presently allows for enhanced resolution of regional renal blood flow and functional evaluations in patients. Techniques are now being developed and utilized that will allow for the rapid diagnosis of human ARF.	4
27. Kabler RL, Cerny JC. Pre-transplant urologic investigation and treatment of end stage renal disease. *J Urol* 1983; 129(3):475-478.	Review/Other-Dx	112 patients	To evaluate patients with end stage renal disease. Clinical evaluations included cystoscopy, cystometry, voiding cystography, bilateral retrograde pyelograms, history and physical examination, and appropriate serum and urinary studies.	28 (25%) of 112 patients had significant abnormalities of the urinary tracts. Of the 28 patients 17 had lower tract abnormalities, such as detrusor hyporeflexia, obstructing prostatic hyperplasia and urethral stricture, and 11 had upper tract disease, 9 of whom required a pre-transplant surgical procedure.	4

Renal Failure
EVIDENCE TABLE

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
28. Liano F, Pascual J. Epidemiology of acute renal failure: a prospective, multicenter, community-based study. Madrid Acute Renal Failure Study Group. *Kidney Int* 1996; 50(3):811-818.	Review/Other-Dx	748 cases of ARF	To assess all ARF episodes encountered in the 13 tertiary-care hospitals in Madrid, Spain (covering 4.2 million people of over 14 years of age).	ARF was considered when a sudden rise in serum creatinine concentration to more than 177 mumol/liter was found in patients with normal renal function, or when the sudden rise (50% or more) was observed in patients with previous mild-to-moderate chronic renal failure (serum creatinine concentration <264 mumol/liter). Of the 748 cases of ARF studied, 665 episodes presented in inhabitants from the Madrid area. This gives an overall incidence of ARF of 209 cases per million population (p.m.p.; 95% CI, 195 to 223). The incidence of ATN was 88 cases p.m.p. (95% CI, 79 to 97), prerenal ARF 46 p.m.p (95% CI, 40 to 52), acute-onset chronic ARF 29 p.m.p. (95% CI, 24 to 34), and obstructive ARF 23 p.m.p. (95% CI, 19 to 27). The mean age was 63 +/- 17 years. The most frequent causes of ARF were ATN (45%), prerenal (21%), acute-onset chronic renal failure (12.7%) and obstructive ARF (10%). Renal function was normal at admission in 48% of patients who later developed ARF. Mortality (45%) was much higher than that of the other patients admitted (5.4%, P<0.001). This real outcome correlated extremely well with the expected outcome calculated throughout the severity index of ARF 0.433 +/- 0.246 (mean +/- SD). In 187 cases, mortality was attributed to underlying disease, thus corrected mortality due to ARF was 26.7%. Dialysis was required in 36% of patients, and was associated with a significantly higher severity index of ARF (0.57 +/- 0.23 vs 0.35 +/- 0.19, P<0.001) and mortality (65.9 vs 33.2%, P<0.001). Mortality in patients hemodialyzed with biocompatible synthetic membranes (n = 50) was similar to that observed with cellulosic ones (n = 84; 66% vs 59.5%, NS). Mortality was higher in patients with coma, assisted respiration, hypotension, jaundice (all P<0.001) and oliguria (P<0.02).	4

Renal Failure
EVIDENCE TABLE

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29. Tublin ME, Bude RO, Platt JF. Review. The resistive index in renal Doppler sonography: where do we stand? *AJR* 2003; 180(4):885-892.	Review/Other-Dx	N/A	To discuss the technical requirements of intrarenal Doppler US, proposed applications and controversies, recent research exploring the factors that influence the Doppler arterial waveform, and prospects for the future of renal Doppler US.	No results stated.	4
30. Fresco GF, DiGiorgio F, Curti GL. Simultaneous estimation of glomerular filtration rate and renal plasma flow. *J Nucl Med* 1995; 36(9):1701-1706.	Observational-Dx	17 healthy volunteers and 28 patients	To compare the measurements of both GFR and tubular excretion rates (MAG3) by multi-sample and single-sample methods after a single bolus injection of 3.7 MBq 51Cr-EDTA plus 37 MBq 99mTc-MAG3.	Nadir-error for predicted GFR occurs at 180 min (11.0 ml/min/1.73 m2), while the nadir-error for predicted tubular excretion rates (MAG3) is reached at 90 min (26.4 ml/min/1.73 m2). In the computation of GFR and tubular excretion rates (MAG3) with a single-sample method, it appears that the mean residence time for each tracer represents the optimum plasma sampling time. Results suggest that the single injection of 51Cr-EDTA and 99mTc-MAG3 followed by blood sampling twice permits accurate simultaneous estimation of GFR and tubular excretion rates (MAG3) and, after correction of the latter kinetic parameter, effective renal plasma flow.	3
31. Taylor A, Jr., Manatunga A, Morton K, et al. Multicenter trial validation of a camera-based method to measure Tc-99m mercaptoacetyltriglycine, or Tc-99m MAG3, clearance. *Radiology* 1997; 204(1):47-54.	Observational-Dx	69 patients	To evaluate an improved camera-based method for calculating the clearance of 99mTc-MAG3 in a prospective multicenter trial.	Regression models correlating the plasma-based 99mTc-MAG3 clearance with the percentage uptake in the kidney for each time interval were developed; there was no statistically significant difference among sites in the regression equations. Correction for body surface area statistically significantly ($P<.005$) improved the correlation coefficient for each time interval. For the 1.0-2.5-minute interval, the body surface area-corrected correlation coefficient for the four combined sites was .87, and it improved to .93 when one outlier was omitted from the analysis. An improved camera-based method to calculate the clearance of 99mTc-MAG3 was validated in a multicenter trial.	3

Renal Failure
EVIDENCE TABLE

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
32. Zucchelli P, Zuccala A. The diagnostic dilemma of hypertensive nephrosclerosis: the nephrologist's view. *Am J Kidney Dis* 1993; 21(5 Suppl 2):87-91.	Review/Other-Dx	N/A	Review hypertensive nephrosclerosis.	Nonsevere uncomplicated essential hypertension is constantly associated with renal vascular changes that are qualitatively indistinguishable from those related to aging. Notwithstanding the fairly constant presence of so-called benign hypertensive nephrosclerosis in patients with established hypertension, only a subset of these patients showed progressive renal damage.	4
33. Frankel DG, Narla D. Imaging of children with chronic renal failure. *J Pediatr* 1996; 129(2):s33-38.	Review/Other-Dx	N/A	Review current status of imaging in children with chronic renal failure.	Evaluation of children with chronic renal failure is primarily with renal US and DTPA.	4
34. Confer DJ, Banowsky LH. The urological evaluation and management of renal transplant donors and recipients. *J Urol* 1980; 124:305-310.	Review/Other-Dx	N/A	Review of procedures evaluating the bladder of the host prior to renal transplantation.	Use of voiding cystourethrography is recommended.	4
35. The National Kidney Foundation Kidney Disease Outcomes Quality Initiative. National Kidney Foundation. Available at: http://www.kidney.org/professionals/KDOQI/guidelines_commentaries.cfm. Accessed July 5, 2013.	Review/Other-Dx	N/A	To provide evidence-based clinical practice guidelines for all stages of chronic kidney disease.	No results stated in abstract.	4
36. Taylor AJ, Cohen EP, Erickson SJ, Olson DL, Foley WD. Renal imaging in long-term dialysis patients: a comparison of CT and sonography. *AJR* 1989; 153(4):765-767.	Observational-Dx	41 patients (79 kidneys)	To prospectively compare CT and US, using state-of-the-art equipment and techniques, in patients at risk for acquired cystic kidney disease.	Acquired cystic kidney disease (5 or more cysts per kidney) was identified in 59% of kidneys with CT and in 18% with US. CT showed a complete renal contour definition in all cases, US did so in only 57%. Three solid renal tumors (2-4 cm in diameter) were identified with both techniques with no false-negative evaluations. Four benign hemorrhagic cysts were identified with combined CT (hyperdense mass) and US (benign cysts). CT provided the best anatomic image quality and was more accurate for detection of acquired cystic kidney disease. CT and US were equivalent for detection of solid tumors. Results suggest that dynamic contrast-enhanced CT scanning with the supplemental use of US is the best imaging regimen for the evaluation of suspected acquired cystic kidney disease and its potential complications.	3

Renal Failure
EVIDENCE TABLE

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37. Takebayashi S, Hidai H, Chiba T, Takagi H, Koike S, Matsubara S. Using helical CT to evaluate renal cell carcinoma in patients undergoing hemodialysis: value of early enhanced images. *AJR* 1999; 172(2):429-433.	Observational-Dx	23 patients	To evaluate early and delayed enhanced HCT for revealing renal cell carcinoma in patients undergoing hemodialysis. Pathology was used as gold standard.	HCT revealed 225 lesions, 24 of which were found to be renal cell carcinomas at pathology. The sensitivity and specificity of early enhanced CT for revealing renal cell carcinoma were 96% and 95%, respectively. In contrast, delayed enhanced CT achieved a sensitivity of 83% and a specificity of 94%. A significant difference in mean attenuation values between carcinomas and renal parenchymas was observed on the images with early enhancement but not on those with delayed enhancement (P<.0001). Early enhanced HCT is superior to delayed enhanced HCT for revealing renal cell carcinoma in end-stage kidneys.	2
38. Scoble JE, Maher ER, Hamilton G, Dick R, Sweny P, Moorhead JF. Atherosclerotic renovascular disease causing renal impairment--a case for treatment. *Clin Nephrol* 1989; 31(3):119-122.	Review/Other-Dx	10 patients	Prospective survey was performed to evaluate whether atherosclerosis renovascular disease causing renal failure can be treated.	Atherosclerotic renal artery disease was the cause of renal failure in 14% of patients over the age of 50 years accepted for renal replacement therapy. 10 patients were found to be suffering from atherosclerotic renovascular disease causing renal failure but in only one was treatment able to reverse renal failure. The major problem with this group of patients is the widespread nature of their disease affecting many other organs. Significant morbidity is associated with their investigation. Although potentially curable, atherosclerotic renovascular disease is a frequent cause of renal failure in patients over the age of 50 years but is also difficult to treat.	4
39. Stansby G, Hamilton G, Scoble J. Atherosclerotic renal artery stenosis. *Br J Hosp Med* 1993; 49(6):388-395, 398.	Review/Other-Dx	N/A	Review clinical features of atherosclerotic RAS and the investigations and management options available.	Atherosclerotic RAS is a relatively common cause of hypertension and renal impairment in the elderly.	4

Renal Failure
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40. 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.	Observational-Dx	58 renal arteries in 29 patients	To prospectively evaluate the value of duplex US scanning in the detection of RAS.	There were 39 renal arteries with 0% to 59% stenosis, 14 with 60% to 99% stenosis, and 5 occlusions by angiography. Renal duplex scanning accurately diagnosed 38/39, 11/14, and 4/5 of these, respectively, giving a sensitivity of 84%, a specificity of 97%, and a PPV of 94% for the detection of a greater than 60% diameter-reducing stenosis. The overall agreement with angiography was 93%. Data show that renal duplex scanning can be used to diagnose RAS in patients with hypertension or renal dysfunction, thus providing a rational basis for the selection of patients for angiography.	2
41. 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.	Observational-Dx	50 kidneys in 26 patients	Prospective, double-blind comparison of color duplex US with angiography was performed for diagnosing RAS.	Angiography demonstrated 10 stenoses and one occlusion in main or accessory renal arteries in 7 patients. 22% of kidneys had accessory renal arteries. Color duplex scanning helped identify 58% of the main arteries and no accessory vessels. None of the stenotic vessels were identified with duplex scanning, but the single occluded vessel was correctly diagnosed. 9/29 vessels identified with duplex scanning were incorrectly diagnosed as stenotic, findings yielding a specificity of 37%. Authors conclude that the published velocity threshold of 100 cm/sec is too low. Duplex scanning with current technology is unlikely to prove satisfactory for screening patients with hypertension for RAS.	3
42. Middleton WD. Doppler US evaluation of renal artery stenosis: past, present, and future. *Radiology* 1992; 184(2):307-308.	Review/Other-Dx	N/A	Review role and value of Doppler US in RAS. Three articles addressing this topic are reviewed.	The three describe a potentially important advance in the detection of RAS with Doppler US. If the results described by Stavros et al, Lafortune et al, and Patriquin et al can be duplicated by others, then analysis of intrarenal arteries with Doppler US may provide a rapid, inexpensive, noninvasive means of detecting RAS that is technically successful in most patients.	4

Renal Failure
EVIDENCE TABLE

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
43. Schwerk WB, Restrepo IK, Stellwaag M, Klose KJ, Schade-Brittinger C. Renal artery stenosis: grading with image-directed Doppler US evaluation of renal resistive index. *Radiology* 1994; 190(3):785-790.	Observational-Dx	72 patients; 142 kidneys	Prospective double-blinded study to determine the role of intrarenal Doppler US in detection of moderate to severe (>50%) RAS.	In 32 patients, angiography showed mild RAS ≤50% in 13, moderate RAS in 10 and severe RAS in 9. Both renal size and mean RI values were decreased significantly (P<.001) only for severe RAS compared with values in 40 control subjects. For delta RI, no significant difference was noted between controls and patients with mild RAS; highly significant differences, however, were noted for both moderate and severe RAS (P<.001). Sensitivity and specificity of a cutoff delta RI of >5% were 82% and 92% for RAS >50% and 100% and 94% for moderate RAS. Color Doppler US and analysis of intrarenal Doppler spectra are recommended as a useful method for noninvasive diagnosis and grading of RAS. In bilateral RAS >50%, however, calculation of delta RI is potentially biased by undergrading of stenosis.	2
44. 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.	Observational-Dx	123 color Doppler (n=70) or duplex US (n=53) exams performed in 56 consecutive patients	Prospectively perform duplex US in segmental renal arteries to determine the relative efficacies of prolonged acceleration time and diminished acceleration index, and loss of early systolic compliance peak/reflectivewave complex in detection of RAS in patients.	Simple pattern-recognition analysis of early systolic compliance peak/reflectivewave complex proved to be the best of the three parameters. Loss of early systolic compliance peak/reflectivewave complex enabled identification of RAS with 95% sensitivity, 97% specificity, a 92% PPV, a 98% NPV, a 96% overall accuracy. On the basis of the high technical success rate, high sensitivity and specificity, and short examination time, waveform analysis for detection of tardus-parvus abnormalities, especially loss of early systolic compliance peak/reflectivewave complex, of the segmental artery is recommended as an alternative to direct examination of the main renal arteries for evaluation of RAS.	2

Renal Failure
EVIDENCE TABLE

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
45. Kliewer MA, Tupler RH, Carroll BA, et al. Renal artery stenosis: analysis of Doppler waveform parameters and tardus-parvus pattern. *Radiology* 1993; 189(3):779-787.	Observational-Dx	118 kidneys in 46 patients with hypertension and 11 potential renal donors with normal blood pressure	Prospective double-blinded study to examine the value of Doppler parameters and waveform contour analysis for diagnosis of RAS in a hypertensive population screened for renovascular hypertension.	Angiograms demonstrated 28 stenotic renal arteries. There was no significant difference between stenotic (>50% diameter narrowing) and nonstenotic renal arteries for any parameters studied. When stenosis was further categorized as moderate (50%-79%) or severe (80%-95%), significant (P<.05) differences for acceleration time and systolic acceleration were found between nonstenotic and severely stenotic arteries. Doppler characterization of the tardus-parvus phenomenon in the distal renal artery is not an adequate screening method for detection of RAS.	2
46. Kliewer MA, Tupler RH, Hertzberg BS, et al. Doppler evaluation of renal artery stenosis: interobserver agreement in the interpretation of waveform morphology. *AJR* 1994; 162(6):1371-1376.	Observational-Dx	47 patients (94 kidneys); 4 independent observers	To quantify interobserver agreement in waveform pattern recognition and to determine if interobservers differences limit the efficacy of qualitative waveform interpretation for the diagnosis of RAS.	Interobserver agreement in the waveform analysis for the 4 interpreters was statistically significant (P<0.001). The receiver-operating-characteristic areas produced by the observers indicated, however, that such waveform classification was not strongly predictive of RAS. Authors conclude that substantial agreement in the interpretation of waveform morphology can be obtained between independent observers, and that such differences that do exist do not preclude the use of the pattern-recognition approach to waveform analysis. Even so, the specific application of this strategy to the waveform contours of early systole was not successful in predicting the presence or severity of RAS.	3
47. Aitchison F, Page A. Diagnostic imaging of renal artery stenosis. *J Hum Hypertens* 1999; 13(9):595-603.	Review/Other-Dx	N/A	Overview of imaging techniques (intravenous urography, B Mode US, Doppler US, renal scintigraphy with angiotensin-converting enzyme inhibitors, intra-venous and intra-arterial catheter angiography, CTA, MRA) for RAS.	Intra-arterial catheter angiography remains the 'gold standard' test. MRA is currently of limited availability in the UK but is the most promising new development because it is a noninvasive test which can be used to obtain both anatomical and functional information.	4
48. Chen CC, Hoffer PB, Vahjen G, et al. Patients at high risk for renal artery stenosis: a simple method of renal scintigraphic analysis with Tc-99m DTPA and captopril. *Radiology* 1990; 176(2):365-370.	Observational-Dx	50 patients	To evaluate a method that uses DTPA and captopril to distinguish hypertensive patients with RAS from those with normal renal arteries.	A Tmax ≥11 minutes after injection or a GFR ratio (larger GFR/smaller GFR) greater than 1.5 enabled detection of RAS with 91% sensitivity, 93% specificity, and 92% accuracy. Renal scintigraphy without captopril had only 43%-68% sensitivity in detecting RAS, depending on the criteria used.	2

Renal Failure
EVIDENCE TABLE

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
49. 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.	Observational-Dx	113 patients	To define efficacy of captopril renography in evaluating RAS in a clinically selected high-risk group of hypertensives.	58 (51%) of 113 patients had RAS.; Captopril renography was 91% sensitive and 87% specific in identifying or excluding RAS. Diagnostic utility was preserved in those patients with renal insufficiency (serum creatinine ≥1.5 mg/dL) (n=46). Scintigraphic abnormalities induced by captopril were strongly associated with cure or improvement in blood pressure control following revascularization or nephrectomy (16/19), while the lack of captopril-induced change was associated with failure of such intervention (17/1) (P=.0001).	3
50. Davidson RA, Wilcox CS. Newer tests for the diagnosis of renovascular disease. *JAMA* 1992; 268(23):3353-3358.	Review/Other-Dx	N/A	To evaluate published reports of diagnostic methods for renovascular hypertension, including Doppler US, MRI, the captopril test, and captopril scanning.	Among the newer diagnostic tests, both MRI and Doppler US hold promise for the anatomic detection of RAS, but clear diagnostic criteria have not been universally accepted. There is more information concerning the captopril test, which has a sufficiently high sensitivity to be useful in the screening of high-risk patients for renovascular hypertension. Scans after captopril administration, which appears to be more specific, may enable the prediction of a blood pressure response to angioplasty or surgery.	4

Renal Failure
EVIDENCE TABLE

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
51. Hirsch AT, Haskal ZJ, Hertzer NR, et al. ACC/AHA 2005 guidelines for the management of patients with peripheral arterial disease (lower extremity, renal, mesenteric, and abdominal aortic): executive summary a collaborative report from the American Association for Vascular Surgery/Society for Vascular Surgery, Society for Cardiovascular Angiography and Interventions, Society for Vascular Medicine and Biology, Society of Interventional Radiology, and the ACC/AHA Task Force on Practice Guidelines (Writing Committee to Develop Guidelines for the Management of Patients With Peripheral Arterial Disease) endorsed by the American Association of Cardiovascular and Pulmonary Rehabilitation; National Heart, Lung, and Blood Institute; Society for Vascular Nursing; TransAtlantic Inter-Society Consensus; and Vascular Disease Foundation. *J Am Coll Cardiol* 2006; 47(6):1239-1312.	Review/Other-Dx	N/A	Practice guidelines to address the diagnosis and management of atherosclerotic, aneurysmal, and thromboembolic peripheral arterial diseases.	N/A	4
52. Debatin JF, Spritzer CE, Grist TM, et al. Imaging of the renal arteries: value of MR angiography. *AJR* 1991; 157(5):981-990.	Observational-Dx	32 patients; 33 MRA studies; 3 blinded observers	Prospective study was performed to evaluate four MRA image sets (axial 2-D phase-contrast, coronal 2-D phase-contrast, coronal 2-D time-of-flight, and combined axial and coronal 2-D phase-contrast) with respect to image quality and the degree of visualization of dominant renal arteries, accessory renal arteries, and renovascular disease. Standard of reference is conventional arteriography.	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). Data suggest that biplanar MRA has considerable potential as a noninvasive screening technique for the evaluation of renovascular disease.	1
53. Kim D, Edelman RR, Kent KC, Porter DH, Skillman JJ. Abdominal aorta and renal artery stenosis: evaluation with MR angiography. *Radiology* 1990; 174(3 Pt 1):727-731.	Observational-Dx	25 patients; 55 renal arteries	Prospective blinded study to assess the accuracy of MRA for evaluating the renal arteries and the aorta by comparison with conventional angiography or intra-arterial DSA.	MRA had a sensitivity of 100% for detecting RAS of 50% or greater and a specificity of 92%. MRA enabled correct grading of the presence of atherosclerotic plaque and stenoses of the abdominal aorta in 22/25 patients (88%).	2

Renal Failure
EVIDENCE TABLE

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
54. Zuccala A, Zucchelli P. Ischemic nephropathy: diagnosis and treatment. *J Nephrol* 1998; 11(6):318-324.	Review/Other-Dx	N/A	Review diagnosis and treatment of ischemic nephropathy.	Duplex US is a noninvasive, nonexpensive diagnostic tool and when an experienced, dedicated technologist is available, it should be suggested as the first-step test. MRA and spiral CTA play an ancillary role in detecting patients with renovascular disease. Captopril-enhanced scintigraphy when positive indicates the activation of intrarenal renin-angiotensin system and may be useful in detecting patients with RAS. Moreover, captopril-enhanced scintigraphy can play an important role in the choice between the revascularization and a wait-and-see approach.	4
55. Myers DI, Poole LJ, Imam K, Scheel PJ, Eustace JA. Renal artery stenosis by three-dimensional magnetic resonance angiography in type 2 diabetics with uncontrolled hypertension and chronic renal insufficiency: prevalence and effect on renal function. *Am J Kidney Dis* 2003; 41(2):351-359.	Observational-Dx	45 patients	To report the prevalence of RAS by 3D-MRA in patients with type 2 diabetes with uncontrolled hypertension and examine the association of subcritical (<65%) RAS on the course of progression of chronic renal insufficiency.	At baseline, RAS-negative (RAS (-); n=27) and RAS-positive (RAS (+); n=18) groups were similar in duration of diabetes and hypertension, hyperlipidemia, blood pressure, diabetic management, and renal function. RAS (+) subjects were older (P=0.04) and more likely to have claudication (P=0.006), smoke (P=0.02), and have heart disease (P=0.06). During a median follow-up of 9.4 months, 3 patients underwent stent placement, 2 patients died, and 12 patients progressed to dialysis therapy.; The RAS (+) group had a more rapid monthly decline in reciprocal serum creatinine x 100 (mean, 1.63 +/- 0.9 vs 0.69 +/- 1.0 [SD]; P=0.04). The relative risk for progression to end-stage renal disease was 2.4 in the RAS (+) vs RAS (-) group. Multivariate analysis showed that this effect was not independent of several established atherosclerotic risk factors. MRA-detected RAS is common (40%) in patients with type 2 diabetes with uncontrolled hypertension and renal insufficiency. Subcritical (<65%) RAS is a significant risk factor for progressive renal failure.	4

Renal Failure
EVIDENCE TABLE

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
56. Bakker J, Beek FJ, Beutler JJ, 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.	Observational-Dx	44 patients suspected of having RAS and 10 potential kidney donors	To determine the accuracy of gadolinium-enhanced breath-hold MRA in the diagnosis of RAS and visualization of accessory renal arteries. Intra-arterial DSA is used as the standard of reference.	4 MR angiograms were not evaluable because of poor image quality. MRA enabled visualization of all but one of the 121 arteries. In 4 small accessory arteries, a stenosis could not be excluded owing to inadequate spatial resolution. MRA enabled the correct diagnosis in 30/31 arteries with a grade 2 (50%-99%) stenosis and in 7/10 occluded arteries. Sensitivity and specificity for correct identification of a grade 2 stenosis were 97% and 92%, respectively. Gadolinium-enhanced MRA is an accurate, minimally invasive method for detecting RAS and is reliable for visualizing accessory renal arteries.	2
57. Christensson A. Renovascular disease and renal insufficiency--diagnosis and treatment. *Scand J Urol Nephrol* 1999; 33(6):400-405.	Review/Other-Dx	N/A	Review diagnosis and treatment of renovascular disease.	Renal arteriography is the gold standard for detection of renovascular disease. One disadvantage is the risk of contrast-agent induced acute renal insufficiency. This problem can be avoided using carbon dioxide angiography. In the near future spiral CT and MRA may be alternatives for identifying patients with renovascular disease.	4
58. Bellin MF, Deray G, Assogba U, et al. Gd-DOTA: evaluation of its renal tolerance in patients with chronic renal failure. *Magn Reson Imaging* 1992; 10(1):115-118.	Experimental-Dx	20 patients	To examine the clinical and biological tolerance of Gd-DOTA in patients with chronic renal failure.	In the DOTA-group, patients received 0.1 mmol/kg of Gd-DOTA. Spin-echo T1-weighted images were obtained before and after injections; a T2-weighted sequence was performed before injection. Clinical data, serum creatinine, and laboratory parameters were estimated before, and 24 and 48 hours after MRI. No adverse reaction was reported after injection of Gd-DOTA. Mean serum creatinine and GFR remained unchanged in both groups. For 5 patients in the control group and 3 patients in the DOTA-group the serum creatinine levels increased more than 10% and less than 25%. No evidence of nephrotoxicity was observed with Gd-DOTA in patients with chronic renal failure.	3

Renal Failure
EVIDENCE TABLE

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
59. Prince MR, Arnoldus C, Frisoli JK. Nephrotoxicity of high-dose gadolinium compared with iodinated contrast. *J Magn Reson Imaging* 1996; 6(1):162-166.	Observational-Tx	64 patients	Records of patients who had received high-dose gadolinium (.2 to .4 mmol/kg) for MRI were reviewed to identify patients who had also received iodinated contrast for radiographic examinations.	In 64 patients, serum creatinine data were available pre- and post- both gadolinium and iodinated contrast. The mean change in serum creatinine after gadolinium in these 64 patients was -.07 mg/dL (-6 mumol/L). By comparison, the mean change in serum creatinine in the same patients after iodinated contrast was .35 mg/dL (+31 mumol/L) from 2.0 +/- 1.4 to 2.3 +/- 1.8 (P = .002). 11/64 patients had iodinated contrast-induced renal failure (.5 mg/dL or greater rise in serum creatinine); none had gadolinium contrast-induced renal failure despite the high gadolinium dose and high prevalence of underlying renal insufficiency. High-dose gadolinium chelates are significantly less nephrotoxic than iodinated contrast.	2
60. Miyazaki M, Lee VS. Nonenhanced MR angiography. *Radiology* 2008; 248(1):20-43.	Review/Other-Dx	N/A	An overview of methods for nonenhanced MRA techniques and new techniques for MRA.	No results stated.	4

Renal Failure
EVIDENCE TABLE

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
61. Aspelin P, Aubry P, Fransson SG, Strasser R, Willenbrock R, Berg KJ. Nephrotoxic effects in high-risk patients undergoing angiography. *N Engl J Med* 2003; 348(6):491-499.	Experimental-Tx	129 patients	Randomized, double-blind, prospective, multicenter study to compare the nephrotoxic effects of an iso-osmolar, dimeric, nonionic contrast medium, iodixanol, with those of a low-osmolar, nonionic, monomeric contrast medium, iohexol.	The creatinine concentration increased significantly less in patients who received iodixanol. From day 0 to day 3, the mean peak increase in creatinine was 0.13 mg/dl in the iodixanol group and 0.55 mg/dl in the iohexol group (P=0.001; the increase with iodixanol minus the increase with iohexol, -0.42 mg/dl [95% CI, -0.73 to -0.22]). 2/64 patients in the iodixanol group (3%) had an increase in the creatinine concentration of 0.5 mg/dl or more, as compared with 17/65 patients in the iohexol group (26%) (P=0.002; OR for such an increase in the iodixanol group, 0.09 [95% CI, 0.02 to 0.41]). No patient receiving iodixanol had an increase of 1.0 mg/dl or more, but 10 patients in the iohexol group (15%) did. The mean change in the creatinine concentration from day 0 to day 7 was 0.07 mg/dl in the iodixanol group and 0.24 mg/dl in the iohexol group (P=0.003; value in the iodixanol group minus the value in the iohexol group, -0.17 mg/dl [95% CI, -0.34 to -0.07]). Nephropathy induced by contrast medium may be less likely to develop in high-risk patients when iodixanol is used rather than a low-osmolar, nonionic contrast medium.	1

Renal Failure
EVIDENCE TABLE

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
62. Jo SH, Youn TJ, Koo BK, et al. Renal toxicity evaluation and comparison between visipaque (iodixanol) and hexabrix (ioxaglate) in patients with renal insufficiency undergoing coronary angiography: the RECOVER study: a randomized controlled trial. *J Am Coll Cardiol* 2006; 48(5):924-930.	Experimental-Tx	300 patients	Prospective randomized study to compare the nephrotoxicity of iodixanol and ioxaglate in patients with renal impairment undergoing coronary angiography.	The incidence of contrast-induced nephropathy was significantly lower with iodixanol (7.9%) than with ioxaglate (17.0%; P=0.021), corresponding to an OR of contrast-induced nephropathy of 0.415 (95% CI, 0.194 to 0.889) for iodixanol.; The incidence of contrast-induced nephropathy was also significantly lower with iodixanol in patients with severe renal impairment (P=0.023) or concomitant diabetes (P=0.041), or in patients given ≥140 ml of contrast media (P=0.038).; Multivariate analysis identified use of ioxaglate (OR 2.65, 95% CI, 1.11 to 6.33, P=0.028), baseline serum creatinine, mg/dl (OR 2.0, 95% CI 1.04 to 3.85, P=0.038), and left ventricular ejection fraction, % (OR 0.97, 95% CI 0.94 to 0.99, P=0.019) as independent risk factors for contrast-induced nephropathy.	1
63. Glockner JF, Vrtiska TJ. Renal MR and CT angiography: current concepts. *Abdom Imaging* 2007; 32(3):407-420.	Review/Other-Dx	N/A	Review techniques for optimizing renal MRA and CTA, assess the advantages and limitations of MRA and CTA, and provide the current indications for renal vascular imaging including RAS screening. New and future developments in these rapidly evolving techniques are also discussed.	No results stated.	4
64. Leiner T, de Haan MW, Nelemans PJ, van Engelshoven JM, Vasbinder GB. Contemporary imaging techniques for the diagnosis of renal artery stenosis. *Eur Radiol* 2005; 15(11):2219-2229.	Review/Other-Dx	N/A	Overview of MRA, CTA, and color-aided duplex US techniques used in the diagnosis of RAS.	MRA and CTA are significantly more accurate for the diagnosis of at least 50% atherosclerotic RAS than US techniques. Presently, the primary strength of US is its suggested ability to predict functional recovery based on preinterventional resistance index measurements.	4
65. van Helvoort-Postulart D, Dirksen CD, Nelemans PJ, et al. Renal artery stenosis: cost-effectiveness of diagnosis and treatment. *Radiology* 2007; 244(2):505-513.	Review/Other-Dx	1 patient	Use a decision analytic model to determine cost-effectiveness of performing diagnostic DSA, CTA, or MRA or proceeding immediately to tentative percutaneous revascularization in patients suspected of having renovascular hypertension.	Immediate tentative percutaneous revascularization is a cost-effective strategy for the diagnosis of RAS.	4

Renal Failure
EVIDENCE TABLE

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
66. 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):674-682; discussion 682.	Observational-Dx	356 patients	Prospective multicenter study to determine the validity of CTA and MRA compared with DSA for detection of RAS.	Moderate interobserver agreement was found, with kappa values ranging from 0.59 to 0.64 for CTA and 0.40 to 0.51 for MRA. The combined sensitivity and specificity were 64% (95% CI, 55% to 73%) and 92% (CI 90% to 95%) for CTA and 62% (CI 54% to 71%) and 84% (CI 81% to 87%) for MRA. DSA remains the diagnostic method of choice.	2
67. Wheatley K, Ives N, Gray R, et al. Revascularization versus medical therapy for renal-artery stenosis. *N Engl J Med* 2009; 361(20):1953-1962.	Experimental-Tx	806 patients	To determine reliably whether revascularization together with medical therapy improves renal function and other outcomes, as compared with medical therapy alone, in patients with atherosclerotic renal-artery stenosis.	During a 5-year period, the rate of progression of renal impairment (as shown by the slope of the reciprocal of the serum creatinine level) was -0.07x10(-3) liters per micromole per year in the revascularization group, as compared with -0.13x10(-3) liters per micromole per year in the medical-therapy group, a difference favoring revascularization of 0.06x10(-3) liters per micromole per year (95% CI, -0.002 to 0.13; P=0.06). Over the same time, the mean serum creatinine level was 1.6 micromol per liter (95% CI, -8.4 to 5.2 [0.02 mg per deciliter; 95% CI, -0.10 to 0.06]) lower in the revascularization group than in the medical-therapy group. There was no significant between-group difference in systolic blood pressure; the decrease in diastolic blood pressure was smaller in the revascularization group than in the medical-therapy group. The two study groups had similar rates of renal events (hazard ratio in the revascularization group, 0.97; 95% CI, 0.67 to 1.40; P=0.88), major cardiovascular events (hazard ratio, 0.94; 95% CI, 0.75 to 1.19; P=0.61), and death (hazard ratio, 0.90; 95% CI, 0.69 to 1.18; P=0.46). Serious complications associated with revascularization occurred in 23 patients, including 2 deaths and 3 amputations of toes or limbs.	1

Renal Failure
EVIDENCE TABLE

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
68. Bax L, Woittiez AJ, Kouwenberg HJ, et al. Stent placement in patients with atherosclerotic renal artery stenosis and impaired renal function: a randomized trial. *Ann Intern Med* 2009; 150(12):840-848, W150-841.	Experimental-Tx	140 patients	To determine the efficacy and safety of stent placement in patients with atherosclerotic RAS and impaired renal function.	Forty-six of 64 patients assigned to stent placement had the procedure. Ten of the 64 patients (16%) in the stent placement group and 16 patients (22%) in the medication group reached the primary end point (hazard ratio, 0.73 [95% CI, 0.33 to 1.61]). Serious complications occurred in the stent group, including 2 procedure-related deaths (3%), 1 late death secondary to an infected hematoma, and 1 patient who required dialysis secondary to cholesterol embolism. The groups did not differ for other secondary end points.	1
69. Scola FH, Cronan JJ, Schepps B. Grade I hydronephrosis: pulsed Doppler US evaluation. *Radiology* 1989; 171(2):519-520.	Review/Other-Dx	100 consecutive patients; 3 reviewers	To determine whether the presence of blood vessels could mimic the appearance of grade I hydronephrosis on US and thus cause false-positive readings.	Vascular structures accounted for the separation of the sinus echoes in 43% of patients. In patients 12 years of age or younger, this frequency rose to 61%. The simple procedure of evaluating the renal sinus echo separation with pulsed Doppler US should decrease the frequency of false-positive diagnoses of hydronephrosis and thus diminish the need for further confirmatory testing.	4

Renal Failure
EVIDENCE TABLE

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
70. Dalla-Palma L, Panzetta G, Pozzi-Mucelli RS, Galli G, Cova M, Meduri S. Dynamic magnetic resonance imaging in the assessment of chronic medical nephropathies with impaired renal function. *Eur Radiol* 2000; 10(2):280-286.	Observational-Dx	33 consecutive patients (21 vascular nephropathy, 12 glomerular nephropathy)	To evaluate the value of dynamic MRI in chronic renal disease with renal insufficiency.	A good correlation between morphological features of the kidneys and serum creatinine values was found. Morphological findings could not distinguish between vascular and glomerular nephropathies. A statistically significant correlation (P<0.01) between cortical peak intensity value, cortical peak intensity value/time to peak intensity, medullary peak intensity value, and serum creatinine and creatinine clearance was found. A significant correlation (P<0.01) was also found between cortical time to peak intensity, medullary peak intensity value/time to peak intensity, time to peak intensity of the excretory system, and creatinine clearance. The cortical time to peak intensity value was significantly higher (P<0.01) in vascular nephropathy than in glomerular nephropathy. Thus in patients with chronic renal failure dynamic MRI shows both morphological and functional changes. Morphological changes are correlated with the degree of renal insufficiency and not with the type of nephropathy; the functional changes seem to differ in vascular from glomerular nephropathies.	3
71. Furukawa A, Murata K, Morita R. [Evaluation of renal function using Gd-DTPA dynamic MR imaging]. *Nihon Igaku Hoshasen Gakkai Zasshi* 1996; 56(5):264-274.	Review/Other-Dx	68 patients (71 exams)	To establish a new method for evaluating renal function using MRI, dynamic Gd-DTPA enhanced MRI at 1.5 T was performed in patients.	In the patients, time parameters were significantly larger than those of normal subjects and cortex and medulla ratios were lower. This study suggested that dynamic Gd-DTPA renal MRI can serve as a new method for the evaluation of renal function.	4

Renal Failure
EVIDENCE TABLE

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
72. Gaspari F, Perico N, Ruggenenti P, et al. Plasma clearance of nonradioactive iohexol as a measure of glomerular filtration rate. *J Am Soc Nephrol* 1995; 6(2):257-263.	Observational-Dx	41 patients	To find a reliable alternative to inulin clearance that would allow one to avoid the use of radioactivity and problems related to the continuous infusion of the marker.	A highly significant correlation between the plasma clearance of iohexol and the renal clearance of inulin over a wide range of GFR values was found. By analyzing the data with a simplified method that uses a one-compartment model corrected with the Bröchner-Mortensen formula, an excellent correlation with the inulin clearance was also observed. When only patients with moderate to severe renal failure were considered, a significant correlation between the two methods was found.	3
73. Knesplova L, Krestin GP. Magnetic resonance in the assessment of renal function. *Eur Radiol* 1998; 8(2):201-211.	Review/Other-Dx	N/A	Overview on functional MRI of the kidneys with its possibilities and limitations.	The clinical application of functional MRI allows a better understanding of some pathologic conditions such as urinary tract obstruction, renal insufficiency, effects of extracorporeal shock wave lithotripsy, different states of hydration, effects of drugs, vascular disorders, and effects of transplantation.	4
74. Laissy JP, Benderbous S, Idee JM, Chillon S, Beaufils H, Schouman-Claeys E. MR assessment of iodinated contrast-medium-induced nephropathy in rats using ultrasmall particles of iron oxide. *J Magn Reson Imaging* 1997; 7(1):164-170.	Review/Other-Dx	23 rats	To determine the diagnostic value of ultrasmall particles of iron oxide-enhanced MRI at different concentrations to evaluate experimental nephropathy.	Highest sensitivity and specificity to diagnose kidney involvement were obtained with T2-weighted MRI (75% and 91%, respectively) when 60 mumol/kg of ultrasmall particles of iron oxide were used (P<.01). Ultrasmall particles of iron oxide should be useful for in vivo evaluation of the severity of experimentally induced iodinated contrast media renal impairment in animals.	4
75. Sterner G, Frennby B, Hultberg B, Almen T. Iohexol clearance for GFR-determination in renal failure--single or multiple plasma sampling? *Nephrol Dial Transplant* 1996; 11(3):521-525.	Observational-Tx	65 patients	To examine the agreement between single and multiple sample plasma clearance of iohexol in renal failure.	A single plasma specimen collected at 4 hours for GFR above 50 ml/min, at 7 hours for GFR between 20 and 50 ml/min, and at 24 hours for GFR below 20 ml/min gave values in good agreement with those based on a four sample slope clearance. No sign of nephrotoxicity was noted after administration of the contrast agent.; Single sample plasma clearance after single injection of iohexol gives a good estimate of GFR in renal failure and is advantageous in clinical practice.	2

Renal Failure
EVIDENCE TABLE

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
76. Chandna SM, Farrington K. Residual renal function: considerations on its importance and preservation in dialysis patients. *Semin Dial* 2004; 17(3):196-201.	Review/Other-Dx	N/A	Review role of RRF in dialysis patients.	RRF does not necessarily decline rapidly with the initiation of hemodialysis. Peritoneal dialysis may be better than hemodialysis in preserving RRF, although this difference may not persist if biocompatible membranes, bicarbonate buffer, and ultrapure water are used.	4
77. Dittrich E, Puttinger H, Schillinger M, et al. Effect of radio contrast media on residual renal function in peritoneal dialysis patients--a prospective study. *Nephrol Dial Transplant* 2006; 21(5):1334-1339.	Observational-Dx	10 patients; 8 controls	Prospective comparison of two groups to determine effect of radio contrast media on RRF in peritoneal dialysis patients.	No significant difference between the two groups in age, gender, diabetes, duration of dialysis and renal clearance at baseline. Administration of iopromide did not lead to a persistent decline of RRF in continuous ambulatory peritoneal dialysis patients.	3
78. Sterner G, Frennby B, Mansson S, Ohlsson A, Prutz KG, Almen T. Assessing residual renal function and efficiency of hemodialysis--an application for urographic contrast media. *Nephron* 2000; 85(4):324-333.	Observational-Tx	13 patients; (8 anuric); 9 patients; (2 anuric)	Measured clearances of two urographic iodine contrast media with different molecular masses (iohexol 821 u and iodixanol 1, 550 u) to assess RRF and efficiency of hemodialysis.	A single injection of contrast media at the end of dialysis followed by a single blood sample at the start of the next dialysis gives total body clearance.	2
79. Moranne O, Willoteaux S, Pagniez D, Dequiedt P, Boulanger E. Effect of iodinated contrast agents on residual renal function in PD patients. *Nephrol Dial Transplant* 2006; 21(4):1040-1045.	Observational-Tx	36 peritoneal dialysis patients; 36 controls	Prospective study to evaluate the evolution of RRF 2 weeks after iodinated contrast medium administration in a group of stable peritoneal dialysis patients, and compare it with that in a non-treated control group of stable peritoneal dialysis subjects.	Compared with baseline values, RRF, daily urine volume and peritoneal creatinine clearance were not found to be significantly different 2 weeks after iodinated contrast medium administration (7.0+/-4.3 vs 7.2+/-4.3 ml/min/1.73 m(2), P=0.12; 1324+/-696 vs 1360+/-755 ml/day, P=0.5; and 41.1+/-9 vs 40.6+/-9 l/week/1.73 m(2), P=0.6, respectively). Following iodinated contrast medium administration, variations in RRF and daily urine volume were found to be comparable with those of the control group (0.1+/-0.5 vs 0.1+/-0.5 ml/min/1.73 m(2), P=0.9; 36+/-440 vs 40+/-493 ml/day, P=0.8, respectively). In this study, 2 weeks following iodinated contrast medium administration, no accelerated decline in RRF was determined in stable peritoneal dialysis patients with adequate pre-hydration, i.e. subjects treated under optimal circumstances compared with the control group.	1

Renal Failure
EVIDENCE TABLE

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
80. Weisbord SD, Bernardini J, Mor MK, et al. The effect of coronary angiography on residual renal function in patients on peritoneal dialysis. *Clin Cardiol* 2006; 29(11):494-497.	Observational-Dx	29 patients	Retrospective study to determine the effect of coronary angiography on RRF in patients on peritoneal dialysis.	29 patients with a mean preprocedure RRF of 4.4+/-3.2 ml/min/1.73m(2) were evaluated. Of these patients, 23 (79%) had postangiography RRF assessments (mean clearance 3.4+/-3.0 ml/min/1.73m(2)). One of the remaining 6 patients became permanently anuric following angiography, one was lost to follow-up, and there was no postprocedure RRF assessment in 4 others. The rate of decline in RRF in the cases was similar to the composite rate (0.07 ml/min/1.73m(2)/month vs 0.09 ml/min/1.73m(2)/month, P=0.53). Risk for permanent anuria in patients on peritoneal dialysis undergoing coronary angiography is quite small. Patients who do not develop anuria following coronary angiography have the same gradual rate of loss of RRF as other patients on peritoneal dialysis.	4
81. Whittier WL, Korbet SM. Renal biopsy: update. *Curr Opin Nephrol Hypertens* 2004; 13(6):661-665.	Review/Other-Dx	N/A	To review renal biopsy as an invaluable tool in the diagnosis, prognosis, and management of patients with kidney disease.	Without contraindications, the percutaneous renal biopsy remains the standard method of acquiring renal tissue. At least 24 hour of observation is recommended after the percutaneous native kidney biopsy for the development of potential complications. When a contraindication to the procedure exists, other methods of renal biopsy by experienced physicians may be attempted.	4
82. Korbet SM. Percutaneous renal biopsy. *Semin Nephrol* 2002; 22(3):254-267.	Review/Other-Dx	N/A	To review percutaneous renal biopsy in the diagnosis of glomerular, vascular, and tubulointerstitial diseases of the kidney.	No results stated in abstract.	4
83. Vassiliades VG, Bernardino ME. Percutaneous renal and adrenal biopsies. *Cardiovasc Intervent Radiol* 1991; 14(1):50-54.	Review/Other-Dx	N/A	To review both the indications and methods for imaging-guided percutaneous biopsy of the kidney and adrenal gland.	No results stated in abstract.	4

Renal Failure
EVIDENCE TABLE

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
84. Tondel C, Vikse BE, Bostad L, Svarstad E. Safety and complications of percutaneous kidney biopsies in 715 children and 8573 adults in norway 1988-2010. *Clin J Am Soc Nephrol* 2012; 7(10):1591-1597.	Review/Other-Dx	9,288 biopsies; 715 from children, 8,573 from adults	To evaluate safety and relevant complications of renal biopsies in pediatric and adult patients in a large national registry study.	Gross hematuria appeared after biopsy in 1.9% of the patients; 0.9% of patients needed blood transfusion, and 0.2% of patients needed surgical intervention/catheterization. The frequencies were 1.9%, 0.9%, and 0.2% in adults and 1.7%, 0.1% and 0.1% in children, respectively; 97.9% of the biopsies were without complications. In unadjusted analyses, risk factors for major complications were age >60 years, estimated GFR <60 ml/min per 1.73 m(2), systolic hypertension, acute renal failure, and smaller clinical center size (<30 biopsies/year). Adjusted analyses (adjusted for age and/or estimated GFR) showed higher OR only for smaller clinical center (OR=1.60 [1.02-2.50]) and low estimated GFR (estimated GFR=30-59 ml/min per 1.73 m(2) [OR=4.90 (1.60-14.00)] and estimated GFR<30 ml/min per 1.73 m(2) [OR 15.50 (5.60-43.00)]).	4

Renal Failure
EVIDENCE TABLE

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
85. Whittier WL, Korbet SM. Timing of complications in percutaneous renal biopsy. *J Am Soc Nephrol* 2004; 15(1):142-147.	Observational-Dx	750 patients	To examine the timing and severity of complications in patients who underwent percutaneous renal biopsy of native kidneys in an academic nephrology program.	All patients were observed for 23 to 24 hours after biopsy for the presence, severity, and timing of complications. Biopsy-related complications occurred in 98 (13%) patients; minor complications occurred in 50 (6.6%) patients, and major complications occurred in 48 (6.4%) patients. One (0.1%) patient died as a result of the biopsy. Multivariate analysis using logistic regression found only serum creatinine at baseline predictive of a complication. Patients with a serum creatinine ≥5.0 mg/dl were 2.3 times as likely to have a complication (OR, 2.3; 95% CI, 1.3 to 4.1; P<0.005). Complications were identified in 38 (42%) patients by ≤4 hours, in 61 (67%) patients by ≤8 hours, in 77 (85%) patients by ≤12 hours, and in 81 (89%) patients at ≤24 hours. The percutaneous renal biopsy remains a safe procedure, but the risk of complication is higher in patients with advanced renal insufficiency. After biopsy, an observation time of up to 24 hours remains optimal as an observation period of ≤8 hours risks missing ≥3% of complications.	3

Evidence Table Key

Study Quality Category Definitions

- *Category 1* The study is well-designed and accounts for common biases.
- *Category 2* The study is moderately well-designed and accounts for most common biases.
- *Category 3* There are important study design limitations.
- *Category 4* The study is not useful as primary evidence. The article may not be a clinical study or the study design is invalid, or conclusions are based on expert consensus. For example:
  a) the study does not meet the criteria for or is not a hypothesis-based clinical study (e.g., a book chapter or case report or case series description);
  b) the study may synthesize and draw conclusions about several studies such as a literature review article or book chapter but is not primary evidence;
  c) the study is an expert opinion or consensus document.

Dx = Diagnostic

Tx = Treatment

Abbreviations Key

AKI = Acute kidney injury

ARF = Acute renal failure

ATN = Acute tubular necrosis

CI = Confidence interval

CT = Computed tomography

CTA = Computed tomography angiography

DSA = Digital-subtraction angiography

Gd-DTPA = Gadolinium-diethylenetriamine pentaacetic acid

GFR = Glomerular filtration rate

HCT = Helical computed tomography

MAG3 = Mercaptoacetyltriglycine

MRA = Magnetic resonance angiography

MRI = Magnetic resonance imaging

NPV = Negative predictive value

OR = Odds ratio

PPV = Positive predictive value

RAS = Renal artery stenosis

RI = Resistive index

RRF = Residual renal function

SD = Standard deviation

US = Ultrasound