

**Renal Transplant Dysfunction  
EVIDENCE TABLE**

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
1. OPTN/SRTR: Transplant Data 1988-2011. Available at: <a href="http://optn.transplant.hrsa.gov/latestData/rptData.asp">http://optn.transplant.hrsa.gov/latestData/rptData.asp</a> . Accessed: 24 October 2012.	Review/Other-Dx	N/A	Transplant data are analyzed and explained by experts in transplantation.	No results stated.	4
2. Dubovsky EV, Russell CD, Erbas B. Radionuclide evaluation of renal transplants. <i>Semin Nucl Med</i> 1995; 25(1):49-59.	Review/Other-Dx	N/A	Review imaging of renal transplants. The article is an update of a more comprehensive previous review ( <i>Semin Nucl Med</i> , 181-198, 1988) and emphasizes the changes that have taken place in this field in recent years.	Changes in renal transplant comprise new criteria for the selection of transplant candidates, newer techniques for the diagnosis of medical and surgical complications after transplantation, the use of new tracers (Tc-99m MAG3), and new antirejection regimens.	4
3. Loubeyre P, Cahen R, Grozel F, et al. Transplant renal artery stenosis. Evaluation of diagnosis with magnetic resonance angiography compared with color duplex sonography and arteriography. <i>Transplantation</i> 1996; 62(4):446-450.	Observational-Dx	12 consecutive patients	To prospectively assess the value of a 3D phase contrast MRA for diagnosing TRAS. Patients first had CDUS, then MRA and, on the following day, IA-DSA.	On MRA images, any signal cutoff or any vascular narrowing of more than 50% of the diameter of the vessel was considered to be a significant stenosis. 8 patients were considered to have TRAS on MRA, but only two stenoses were noted on IA-DSA. The 6 false-positive results of MRA (due to major intravoxel phase dispersion) were observed when elevated peak systolic velocities were noted on Doppler US (mean: 214 cm/sec). These elevated peak systolic velocities were noted in the proximal part of the renal artery when there was a tortuous vessel or a sharp angle between the renal artery and the parent vessel. The authors believe MRA is of limited value for the diagnosis of renal transplant artery stenosis because of a high number of false-positive results.	3
4. Brown ED, Chen MY, Wolfman NT, Ott DJ, Watson NE, Jr. Complications of renal transplantation: evaluation with US and radionuclide imaging. <i>Radiographics</i> 2000; 20(3):607-622.	Review/Other-Dx	N/A	Review the general surgical techniques of renal transplantation as a basis for understanding potential complications. The most common complications are described, and their appearances on US and radionuclide images are illustrated.	Radionuclide imaging is the most useful modality for assessing renal function. Vascular complications of transplantation include occlusion or stenosis of the arterial or venous supply, arteriovenous fistulas, and pseudoaneurysms. Although the standard for evaluating these vascular complications is angiography, US is an excellent noninvasive method for screening. Other transplant complications such as abnormalities of the collecting system and renal parenchyma are well-evaluated with both radionuclide imaging and US.	4

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5. Buckley AR, Cooperberg PL, Reeve CE, Magil AB. The distinction between acute renal transplant rejection and cyclosporine nephrotoxicity: value of duplex sonography. <i>AJR</i> 1987; 149(3):521-525.	Observational-Dx	119 exams in 106 patients with normally functioning renal transplants 65 exams in 34 patients with renal transplant dysfunction	To determine the role of pulsed Doppler flow analysis (duplex US) in differentiating acute rejection from cyclosporine nephrotoxicity.	In the healthy control subject, the diastolic/systolic velocity ratios varied in the different arterial segments, ranging from a mean of 0.23 in the segmental arteries to a mean of 0.32 in the arcuate arteries. 17 patients experienced acute rejection: 8/9 with acute vascular rejection had abnormal Doppler ratios; 8 patients with acute cellular rejection had normal ratios. 9 patients with cyclosporine nephrotoxicity all had normal duplex scans. 7 patients with chronic rejection had normal ratios. One patient with hemolytic-uremic syndrome had an abnormal flow pattern. Findings indicate that duplex US may be useful in differentiating acute vascular rejection from cyclosporine nephrotoxicity in the transplanted kidney.	3
6. Steinberg HV, Nelson RC, Murphy FB, et al. Renal allograft rejection: evaluation by Doppler US and MR imaging. <i>Radiology</i> 1987; 162(2):337-342.	Observational-Dx	38 renal allograft recipients, 43 Doppler US and 42 MRI exams	Prospective study to compare the efficacy of Doppler US and MRI in evaluating renal allografts, with specific attention to transplant rejection.	Doppler US was significantly superior to MRI in identifying allograft rejection, demonstrating a higher sensitivity (95% vs 70%), specificity (95% vs 73%), and accuracy (95% vs 71%). Because of its low cost and accessibility, Doppler US should become the primary modality for renal transplant screening.	2
7. Rifkin MD, Needleman L, Pasto ME, et al. Evaluation of renal transplant rejection by duplex Doppler examination: value of the resistive index. <i>AJR</i> 1987; 148(4):759-762.	Observational-Dx	81 patients 145 exams	To evaluate the ability of the duplex Doppler examination and RI to identify patients with acute rejection.	With a RI >0.90, a 100% PPV was obtained for the diagnosis of acute rejection. A value <0.70 was unlikely to be rejection (NPV, 94%). This approach uses a simple analysis of the waveform. Use of a duplex Doppler examination and the formula described here appears to be an accurate method for the detection of acute rejection and for the differentiation of acute rejection from the various other causes of acute renal failure.	3

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8. Genkins SM, Sanfilippo FP, Carroll BA. Duplex Doppler sonography of renal transplants: lack of sensitivity and specificity in establishing pathologic diagnosis. <i>AJR</i> 1989; 152(3):535-539.	Observational-Dx	77 US exams in 77 renal transplants	Combined retrospective and prospective analysis of duplex Doppler examinations performed over a 2-year period to assess the value of such studies in evaluating renal allograft dysfunction.	When a RI of $\geq 0.9$ was used to indicate acute rejection, US had a sensitivity of only 9% and a specificity of 91% for this diagnosis. In 1/8 cases of cyclosporine, a toxicity and in 3 of 6 examples of acute tubular necrosis, the RI was $>0.9$ . In all 6 instances of chronic rejection, the RI was $<0.84$ . None of 8 patients with evidence of infection had a RI $>0.9$ . The RI range of 12 normally functioning allografts was 0.57-0.69. Correlation between the RI and the severity of arterial and arteriolar changes on biopsy was poor. An increased RI of renal transplant blood flow, as measured by duplex Doppler US, usually signals pathologic changes in an allograft. However, the data indicate that this test is not as sensitive or specific in identifying the cause of transplant dysfunction as has been suggested previously.	2
9. Radermacher J, Mengel M, Ellis S, et al. The renal arterial resistance index and renal allograft survival. <i>N Engl J Med</i> 2003; 349(2):115-124.	Observational-Dx	601 patients	To determine whether a renal arterial resistance index of $<80$ was predictive of long-term allograft survival.	A renal arterial resistance index of 80 or higher measured at least 3 months after transplantation is associated with poor subsequent allograft performance and death.	3
10. McArthur C, Geddes CC, Baxter GM. Early measurement of pulsatility and resistive indexes: correlation with long-term renal transplant function. <i>Radiology</i> 2011; 259(1):278-285.	Observational-Dx	178 consecutive patients	Retrospective study to correlate PI and RI measured at early specific intervals after transplantation with 1-year eGFR and death-censored transplant survival to assess the long-term prognostic value of these Doppler indexes.	Within 1 week after transplantation, there was a significant association between PI and 1-year eGFR when analyzed as tertiles ( $P=.02$ ). Between 1 week and 3 months after transplantation, there was a significant relationship between 1-year eGFR and both PI and RI when comparing the lowest and highest tertiles (47.5 mL/min/1.73 m <sup>2</sup> for PI $<1.26$ vs 32.7 mL/min/1.73 m <sup>2</sup> for PI $>1.49$ [ $P=.01$ ], 42.8 mL/min/1.73 m <sup>2</sup> for RI $<0.69$ vs 32.3 mL/min/1.73 m <sup>2</sup> for RI $>0.74$ [ $P=.03$ ]). Both PI and RI were independent predictors of death-censored transplant survival (HR, 1.68 per unit [ $P<.001$ ] and 260.4 per unit, respectively [ $P=.02$ ]). PI and RI in the early post-transplantation period correlate with long-term transplant function and can potentially be used as prognostic markers to aid risk stratification for future transplant dysfunction.	2

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11. Bruno S, Ferrari S, Remuzzi G, Ruggenti P. Doppler ultrasonography in posttransplant renal artery stenosis: a reliable tool for assessing effectiveness of revascularization? <i>Transplantation</i> 2003; 76(1):147-153.	Observational-Dx	12 renal transplant patients	To compare changes in Doppler US parameters (RI and PSV) with concomitant changes in renal vascular resistances, renal blood velocity, and wall shear stress measured before and 1 month after PTA and stenting in patients with renal artery stenosis.	After revascularization, PSV and RI normalized in all patients. Changes in PSV (-72%; $P<0.001$ vs basal) were positively correlated ( $P<0.0001$ ; $r=0.87$ ) with those in renal blood velocity (-88%; $P<0.01$ vs basal) and with those ( $P<0.0005$ ; $r=0.80$ ) in wall shear stress (-97%; $P<0.005$ ). Changes in RI (+21%; $P<0.005$ ) were negatively correlated ( $P=0.009$ ; $r=0.51$ ) with those in renal vascular resistances (-40%; $P<0.01$ ). Changes in Doppler parameters (RI and PSV) reflected those in renal vascular resistances and renal blood velocity with 100% sensitivity and specificity. Doppler US is a reliable, noninvasive, and easily available tool for identifying subjects who may benefit from kidney graft revascularization and to assess the effectiveness of the procedure.	3
12. Baxter GM, Ireland H, Moss JG, et al. Colour Doppler ultrasound in renal transplant artery stenosis: which Doppler index? <i>Clin Radiol</i> 1995; 50(9):618-622.	Observational-Dx	106 patients	Prospective study comparing CDUS with the 'gold standard' of IA-DXA in the evaluation of renal transplant artery stenosis was performed.	Of 106 patients, 31 had a PSV $>1.5$ ms-1 in the transplant renal artery and were referred for DSA. Of the multiple renal Doppler indices recorded, the PSV in the transplant artery was the best discriminating measurement for the detection of renal artery stenosis. A PSV of $\geq 2.5$ ms-1 in the transplant renal artery had a sensitivity of 100% and a specificity of 95% for the detection of renal artery stenosis ( $>50\%$ diameter reduction). Although a significant difference in PI, RI, Acceleration Index and Acceleration Time was recorded from the intrarenal vessels in the angiographically normal and stenosed groups with Doppler, these measurements were less useful as discriminating diagnostic tests. The PSV in the transplant renal artery is the most sensitive Doppler criterion for renal artery stenosis and is sensitive and specific enough to be used as a screening test. The intrarenal acceleration time and index should not be used in isolation.	3

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13. Krumme B, Grotz W, Kirste G, Schollmeyer P, Rump LC. Determinants of intrarenal Doppler indices in stable renal allografts. <i>J Am Soc Nephrol</i> 1997; 8(5):813-816.	Observational-Dx	110 patients	Analysis of potential determinants of Doppler resistance parameters in patients with stable renal allografts to determine whether Doppler indices may be useful in gaining information about graft integrity.	In multivariate regression analysis, RI and PI correlated significantly with age and arterial pulse pressure of the recipient. There was no correlation with donor age, heart rate, mean arterial blood pressure, and cyclosporine trough levels. Furthermore, parameters of kidney function, such as serum creatinine concentration, creatinine clearance rate, 51Cr-ethylenediaminetetraacetate clearance rate, and proteinuria, showed no significant correlation with the Doppler indices. The data indicate that intrarenal Doppler indices of the grafts are hemodynamic indices, primarily depending on the recipient-related vascular compliance rather than on the function of the graft. Therefore, only intraindividual comparison of the Doppler indices may be useful to detect potential changes of graft resistance during long-term follow-up.	3
14. de Morais RH, Muglia VF, Mamere AE, et al. Duplex Doppler sonography of transplant renal artery stenosis. <i>J Clin Ultrasound</i> 2003; 31(3):135-141.	Observational-Dx	22 patients suspected to have TRAS (10 without and 12 with confirmed significant stenosis) and 19 controls	To evaluate the accuracy of duplex Doppler US in diagnosing TRAS and to determine which parameter is the most reliable for making that diagnosis.	The most accurate parameters to use in diagnosing TRAS were an acceleration time of 0.1 second or higher in the renal and intrarenal arteries, a PSV of >200 cm/sec in the renal artery, and a ratio of PSVs in the renal and external iliac arteries of >1.8. Duplex Doppler US is an excellent method for screening patients suspected to have TRAS and can help select which of those patients should undergo digital subtraction arteriography.	2
15. AbuRahma AF, Srivastava M, Mousa AY, et al. Critical analysis of renal duplex ultrasound parameters in detecting significant renal artery stenosis. <i>J Vasc Surg</i> 2012; 56(4):1052-1059, 1060 e1051; discussion 1059-1060.	Observational-Dx	313 patients (606 renal arteries)	To compare renal duplex US vs angiography and assess various published Doppler criteria to detect significant renal artery stenosis.	The mean PSVs and renal-to-aortic ratios for normal, <60%, and ≥60% stenosis were 173, 236, and 324 cm/s (P<.0001), and 2.2, 2.9, and 4.5, respectively (P<.0001). The PSV cutoff value that provided the best overall accuracy for ≥60% stenosis was 285 cm/s, with a sensitivity, specificity, and overall accuracy of 67%, 90%, and 81%, respectively. The renal-to-aortic ratio cutoff value with the best overall accuracy for ≥60% stenosis was 3.7, with a sensitivity, specificity, and overall accuracy of 69%, 91%, and 82%, respectively.	2

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16. Baxter GM. Imaging in renal transplantation. <i>Ultrasound Q</i> 2003; 19(3):123-138.	Review/Other-Dx	N/A	Review of the use/value of imaging in renal transplants.	Renal transplantation is the best treatment option for chronic renal failure, with marked improvement in social activity, work, and family life. In addition to these obvious improvements, it is an extremely cost-effective procedure when successful. US plays a major role in the imaging of these patients, and US (including color Doppler) is helpful to the transplant physician in detecting graft dysfunction and peritransplant collections, some of which may be drained under US guidance. It is also helpful in the diagnosis of chronic vascular complications including transplant artery stenosis and arteriovenous fistula. It has no specific application in the diagnosis of chronic rejection.	4
17. Baxter GM, Morley P, Dall B. Acute renal vein thrombosis in renal allografts: new Doppler ultrasonic findings. <i>Clin Radiol</i> 1991; 43(2):125-127.	Review/Other-Dx	2 patients	Report of two cases of histologically proven renal vein thrombosis with an 'inverted M' appearance of the diastolic component of the arterial waveform and postulate this as perhaps being more specific for acute renal vein thrombosis.	Both cases of acute renal vein thrombosis showed absence of venous flow at parenchymal and hilar level. The arterial waveform in both cases was remarkably similar with a steep rise and fall of the systolic component. In addition, however, the reverse diastolic component showed an 'inverted M' appearance, a sign previously undescribed in renal vein thrombosis. Real time US alone showed no textural abnormality or increase in renal size appearances that may occur in renal vein thrombosis.	4
18. Lockhart ME, Wells CG, Morgan DE, Fineberg NS, Robbin ML. Reversed diastolic flow in the renal transplant: perioperative implications versus transplants older than 1 month. <i>AJR</i> 2008; 190(3):650-655.	Observational-Dx	59 total patients	To evaluate the causes, waveform morphology, and clinical outcomes of high-resistance reversed diastolic flow in transplanted kidneys.	Acute reversed diastolic flow was associated with higher likelihood of graft survival (P=0.001, Fisher's exact test) compared with reversed diastolic flow discovered in the perioperative or long-term group. In the acute group, hematoma, acute tubular necrosis, renal vein thrombosis, and vascular kink produced reversed diastolic flow. The causes of reversed diastolic flow for the perioperative group were acute tubular necrosis, rejection, and renal vein thrombosis; for the long-term group, reasons for diastolic reversal were rejection, glomerulosclerosis, low cardiac output, and diabetic nephrosclerosis.	3

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19. Furness PN, Philpott CM, Chorbadian MT, et al. Protocol biopsy of the stable renal transplant: a multicenter study of methods and complication rates. <i>Transplantation</i> 2003; 76(6):969-973.	Review/Other-Dx	2,127 biopsy events for major complications and 1,486 events for minor ones	Retrospective audit of a sequential series of protocol biopsies was performed in four major transplant centers to determine risk of biopsy of a stable kidney.	The incidence of clinically significant complications after protocol biopsy of a stable renal transplant is low. Direct benefits to the patients concerned (irrespective of the benefit that may accrue in clinical trials) were not formally assessed but seem likely to outweigh the risk of the procedure. Authors believe that it is ethically justifiable to ask renal transplant recipients to undergo protocol biopsies in clinical trials and routine care.	4
20. Fischer T, Filimonow S, Dieckhofer J, et al. Improved diagnosis of early kidney allograft dysfunction by ultrasound with echo enhancer--a new method for the diagnosis of renal perfusion. <i>Nephrol Dial Transplant</i> 2006; 21(10):2921-2929.	Observational-Dx	45 patients	Prospective study to compare the value of US contrast media with conventional US in the diagnosis of early allograft dysfunction.	19 patients had an uneventful clinical course (control group); PQ was 1.2 +/- 0.4. Seven patients with a large perirenal haematoma, without rejection had an increased PQ (P<0.05) and a prolonged time difference (P<0.05). Based on clinical and histological criteria, the remaining patients were classified as acute tubular necrosis (n=7), non-vascular rejection (n=7) or vascular rejection (n=5). RI determination could not discriminate these groups. Patients with acute tubular necrosis (PQ = 1.6 +/- 0.7) or non-vascular rejection (PQ = 1.1 +/- 0.6) had a lower PQ than patients with vascular rejection (PQ = 2.2 +/- 0.8, P<0.05). The time difference in all three subgroups was longer compared with controls. US contrast media might be superior in the diagnosis of early kidney allograft dysfunction compared with conventional US by means of RI determination. Perirenal haematoma, acute tubular necrosis and vascular rejection are associated with characteristic changes of the time-intensity curve.	3

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21. Schwenger V, Hinkel UP, Nahm AM, Morath C, Zeier M. Real-time contrast-enhanced sonography in renal transplant recipients. <i>Clin Transplant</i> 2006; 20 Suppl 17:51-54.	Review/Other-Dx	N/A	Review role of conventional CDUS in diagnosing kidney allograft dysfunction.	CDUS is still limited in interpreting vascular integrity. In contrast-enhanced US is a feasible technique for quantitative analysis of kidney perfusion and early diagnosis of biopsy proven chronic allograft nephropathy. Contrast-enhanced US does not provide only quantitative information on microvascular perfusion of the renal allografts but also represents improved diagnostic significance compared with CDUS for the detection of chronic allograft nephropathy.	4
22. Helck A, Bamberg F, Sommer WH, et al. Optimized contrast volume for dynamic CT angiography in renal transplant patients using a multiphase CT protocol. <i>Eur J Radiol</i> 2011; 80(3):692-698.	Observational-Dx	36 patients	Prospective, clinically controlled cohort study to examine the feasibility of an optimized multiphase renal-CTA protocol in patients with history of renal transplantation compared with Doppler-US (standard of reference).	Using the best of 12 phases in each patient, optimal attenuation was $353 \pm 111$ HU, $337 \pm 98$ HU and $164 \pm 51$ HU in the iliac arteries, renal arteries, and renal veins, respectively. Mean image quality was $1.1 \pm 0.3$ (n=36) and $2.1 \pm 0.6$ (n=30) for the transplant renal arteries and veins, respectively. Six renal veins were non-diagnostic in multiphase-CTA. In 36 patients, multiphase-CTA showed 13 vascular complications and 10 parenchymal perfusion defects. Doppler US was not assessable in 8 patients. Overall, multiphase-CTA showed 15 cases with pathology (42%) not identifiable with Doppler US. The mean effective radiation dose of the multiphase-CTA protocol was $13.5 \pm 5.2$ mSv. Multiphase-CTA can be sufficiently performed with reduced contrast volume at reasonable radiation dose in renal transplant patients, providing substantially higher diagnostic yield than Doppler US.	3



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23. Rountas C, Vlychou M, Vassiou K, et al. Imaging modalities for renal artery stenosis in suspected renovascular hypertension: prospective intraindividual comparison of color Doppler US, CT angiography, GD-enhanced MR angiography, and digital subtraction angiography. <i>Ren Fail</i> 2007; 29(3):295-302.	Observational-Dx	58 patients	To evaluate the diagnostic accuracy of CDUS, CTA, and Gd-enhanced MRA compared with DSA (gold standard) for the detection of renal artery stenosis in patients with clinically suspected renovascular hypertension.	DSA depicted 132 renal arteries, 16 stenoses, and 4 arteries with fibromuscular dysplasia. CDUS failed to detect 1 main and 14 polar arteries. CTA depicted all main renal arteries and 7/16 polar arteries, but failed to detect stenosis in two accessory vessels. Likewise, MRA did not detect stenotic accessory renal arteries, depicted 9/16 polar renal arteries, but missed two main renal arteries. All methods depicted the four main renal arteries with fibromuscular dysplasia. The overall sensitivity, specificity, and PPV and NPV were 75%, 89.6%, 60% and 94.6%, respectively, for CDUS; 94%, 93%, 71%, and 99%, respectively, for CTA; and 90%, 94.1%, 75%, and 98%, respectively, for Gd-enhanced MRA. CTA and Gd-enhanced MRA have comparable and satisfactory results with respect to the negative predictive accuracy of the suspected renal artery stenosis. The concept of an imaging algorithm including US as screening test when appropriate and CTA or MRA as the second step-procedure is suggested. Therefore, DSA may be reserved for cases with major discrepancies or therapeutic interventions.	1

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24. Paven G, Waugh R, Nicholson J, Gillin A, Hennessy A. Screening tests for renal artery stenosis: a case-series from an Australian tertiary referral centre. <i>Nephrology (Carlton)</i> 2006; 11(1):68-72.	Observational-Dx	75 consecutive patients who had 79 screening investigations (4 patients had 2 screening tests)	To determine physician preferences and diagnostic accuracy of screening tests for renal artery stenosis when applied to clinical practice in a large, Australian tertiary referral centre.	Case series showed that 19 (24%) patients did not have any screening investigations prior to angiography. Duplex US was the most utilized screening test, being used in 20 (33%) of the remaining 60 screening tests. CTA was used in 19 (32%), MRI in 13 (22%) and renal scintigraphy was used in four (7%) screening procedures. MRA was the most accurate screening test with PPV of 92%, followed by duplex US with 88% and CTA was relatively inaccurate, with a PPV of 58% (P=0.036). Clinical suspicion alone was inaccurate with a PPV of 40%, except in previously treated renal artery stenosis (PPV 89%). Duplex US was the most utilized screening investigation. MRA and duplex US had good PPVs, while CTA may not be as reliable as previously reported when applied to a large, non-selective clinical practice.	3
25. Prince MR, Schoenberg SO, Ward JS, Londy FJ, Wakefield TW, Stanley JC. Hemodynamically significant atherosclerotic renal artery stenosis: MR angiographic features. <i>Radiology</i> 1997; 205(1):128-136.	Observational-Dx	47 patients underwent MRA of the renal arteries	To identify MRA features of hemodynamically significant renal artery stenosis.	Poststenotic dilatation of greater than 20% was present in 36 (59%) of 52 hemodynamically significant renal artery stenoses, and severe dephasing was present in 45 (87%) of 52. In patients with unilateral hemodynamically significant stenosis or occlusion, mean ischemic kidney length was reduced to 9.3 cm compared with 10.7 cm for the contralateral normal kidney (P=.009), mean parenchymal thickness was reduced (1.2 vs 1.7 cm; P<.001), and mean parenchymal enhancement was 15% less on the ischemic side (P=.05). Severe dephasing on phase-contrast angiograms was present in 9 (75%) of 12 unilateral hemodynamically significant stenoses but in only one contralateral normal renal artery (P<.001). MRA depicts features of renal artery stenosis that are markers of hemodynamic significance.	2

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26. Broome DR, Girguis MS, Baron PW, Cottrell AC, Kjellin I, Kirk GA. Gadodiamide-associated nephrogenic systemic fibrosis: why radiologists should be concerned. <i>AJR</i> 2007; 188(2):586-592.	Observational-Dx	12 patients	Retrospective chart review was performed on patients diagnosed with NSF to identify any common risk factors and determine whether IV gadodiamide is associated with the development of NSF.	All 12 patients had renal insufficiency, 8 with dialysis-dependent chronic renal insufficiency and 4 with acute hepatorenal syndrome. All 12 patients developed skin fibrosis within 2-11 weeks after gadodiamide administration. The odds ratio for development of NSF after gadodiamide exposure was 22.3. No other common event or exposure could be found. Four patients had abnormal scintigraphic bone scans with skin and muscle uptake and lower-extremity MRI finding of edema in the muscles, intermuscular fascia, and skin. Despite the fact that 10 patients were dialyzed within 2 days of gadodiamide administration, this did not prevent the development of NSF. Development of NSF was strongly associated with gadodiamide administration in the setting of either acute hepatorenal syndrome or dialysis-dependent chronic renal insufficiency.	4
27. Omary RA, Baden JG, Becker BN, Odorico JS, Grist TM. Impact of MR angiography on the diagnosis and management of renal transplant dysfunction. <i>J Vasc Interv Radiol</i> 2000; 11(8):991-996.	Observational-Dx	31 patients	To evaluate the impact of MRA on referring physicians' diagnoses and treatment of patients with renal transplant dysfunction.	Pre-MRA and post-MRA questionnaires were prospectively completed on 31 separate patients. The mean gain in diagnostic certainty percentage from MRA was 33% (95% CI, 19%-51%; P<.001). MRA changed physicians' initial diagnoses in 20 patients (65%; 95% CI, 47%-79%). Immediate clinical management changed in 16 patients (52%; 95% CI, 35%-68%). Invasive procedures were avoided in 12 patients (39%). MRA has considerable impact on referring physicians' diagnoses and treatment of patients with suspected renal allograft dysfunction.	3

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28. Sharafuddin MJ, Stolpen AH, Dixon BS, Andresen KJ, Sun S, Lawton WJ. Value of MR angiography before percutaneous transluminal renal artery angioplasty and stent placement. <i>J Vasc Interv Radiol</i> 2002; 13(9 Pt 1):901-908.	Observational-Dx	39 patients had attempted percutaneous renal angioplasty with or without stent placement; 48 renal arteries treated	To determine the benefit of preprocedural 3D Gd-enhanced MRA before PTR and stent placement in terms of procedural success, iodinated contrast material load, and procedure duration. Two subgroups: patients who had preprocedural Gd-enhanced MRA ("prior MRA group") and those who did not ("no MRA" group).	Preprocedural planning with use of Gd-enhanced MRA significantly reduces the iodinated contrast material requirement during percutaneous renal artery interventions. It can also significantly shorten procedure duration.	3
29. Law YM, Tay KH, Gan YU, Cheah FK, Tan BS. Gadolinium-enhanced magnetic resonance angiography in renal artery stenosis: comparison with digital subtraction angiography. <i>Hong Kong Med J</i> 2008; 14(2):136-141.	Observational-Dx	27 consecutive patients; 39 renal arteries evaluated, 2 blinded reviewers	Retrospective study to evaluate the accuracy of Gd-enhanced MRA in assessing renal artery stenosis compared to catheter DSA (standard of reference).	MRA and DSA were concordant in 89% of the arteries; MRA overestimated the degree of stenosis in 8% and underestimated it in 3% of them. In the evaluation of clinically significant renal artery stenosis ( $\geq 50\%$ ) with MRA, the overall sensitivity, specificity, PPV, and NPV were 97%, 67%, 90%, and 86% respectively. The sensitivity and specificity of MRA in TRAS was 100%. Gd-enhanced MRA is a sensitive non-invasive modality useful in the assessment of clinically significant renal artery stenosis.	2
30. Neimatallah MA, Dong Q, Schoenberg SO, Cho KJ, Prince MR. Magnetic resonance imaging in renal transplantation. <i>J Magn Reson Imaging</i> 1999; 10(3):357-368.	Review/Other-Dx	N/A	Review the role of MRI in renal transplantation, technical aspects of image acquisition, and MR findings of post-transplantation complications.	Imaging modalities that are currently used to evaluate transplanted kidneys are US, CT, scintigraphy, intravenous urography, contrast angiography, and MRI. MRI offers multiple advantages. MRI provides cross sectional and vascular information without the risks of ionizing radiation, iodinated contrast, or arterial catheterization.	4
31. Ismaeel MM, Abdel-Hamid A. Role of high resolution contrast-enhanced magnetic resonance angiography (HR CeMRA) in management of arterial complications of the renal transplant. <i>Eur J Radiol</i> 2011; 79(2):e122-127.	Observational-Dx	30 renal patients	To assess the accuracy of contrast-enhanced MRA in the detection of arterial complications after renal transplantation.	The high resolution contrast-enhanced MRA shows 93.7% sensitivity, 80% specificity, 88.2% PPV, 88.9% NPV and 88.5% accuracy.	2

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32. Helenon O, Attlan E, Legendre C, et al. Gd-DOTA-enhanced MR imaging and color Doppler US of renal allograft necrosis. <i>Radiographics</i> 1992; 12(1):21-33.	Review/Other-Dx	21 patients	To correlate the results of imaging with pathologic and histologic data in order to describe MRI and CDUS characteristics of infarcts in renal transplants.	Gd-DOTA-enhanced MR images showed no contrast material uptake in infarcted areas. CDUS characteristics of infarction included absence of Doppler signal and alteration of the cortical echogenic structure, particularly in cases of ischemic necrosis. CDUS allows measurement of vascular resistance and assessment of intrarenal vasculature and the renal pedicle. Gd-DOTA-enhanced MRI is useful in confirming the diagnosis of infarction and provides an accurate evaluation of the extent of the infarct.	4
33. Hricak H, Terrier F, Demas BE. Renal allografts: evaluation by MR imaging. <i>Radiology</i> 1986; 159(2):435-441.	Observational-Dx	45 patients with 46 allografts	To prospectively evaluate the value of MRI in assessing renal allografts.	No abnormalities on MRIs were observed in allografts compromised by cyclosporin nephrotoxicity. Hydronephrosis of the renal allograft was easily diagnosed with MR. Perirenal abscess (3 cases) and perirenal hematomas (5 cases), because of their higher MR signal intensity on T1-weighted images (TR = 0.5 sec, TE = 28 msec), could be differentiated from clinically insignificant postoperative fluid seromas (7 cases), lymphoceles (11 cases), and urinoma (1 case).	2
34. Rholl KS, Lee JK, Ling D, Sicard GA, Griffith RC, Freeman M. Acute renal rejection versus acute tubular necrosis in a canine model: MR evaluation. <i>Radiology</i> 1986; 160(1):113-117.	Review/Other-Dx	13 dogs	To evaluate the potential of MRI in the differentiation of acute rejection and acute tubular necrosis.	MRI findings correlated with changes in water content in these three groups of kidneys. Kidneys undergoing acute rejection showed a marked increase in water content compared with kidneys in the other two groups. No change in fat content was found in any group.	4

**Renal Transplant Dysfunction  
EVIDENCE TABLE**

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
35. Hricak H, Terrier F, Marotti M, et al. Posttransplant renal rejection: comparison of quantitative scintigraphy, US, and MR imaging. <i>Radiology</i> 1987; 162(3):685-688.	Observational-Dx	46 patients	To compare the value of quantitative scintigraphy, US, and MRI in the diagnosis of acute rejection in transplant recipients. Renal biopsy was used as standard for comparison.	Accuracy in demonstrating rejection was 72% for US and 75% for scintigraphy, indicating no significant difference between the two. MRI was significantly more accurate, reaching a level of 98%. However, accuracy of MR in demonstrating acute tubular necrosis in a larger number of patients is not known, and its accuracy in indicating recurrent glomerulopathy or infectious disease has not been addressed. The definitive role of MR in evaluating post-transplant renal failure is currently not established, but because of its high sensitivity in detecting renal abnormality, MR can be used for cases when results of US or scintigraphy are equivocal or contradict clinical impressions or when biopsy cannot be performed for medical reasons.	2
36. Liu X, Berg N, Sheehan J, et al. Renal transplant: nonenhanced renal MR angiography with magnetization-prepared steady-state free precession. <i>Radiology</i> 2009; 251(2):535-542.	Observational-Dx	15 patients, 2 blinded reviewers	Retrospective study to examine nonenhanced MRA with steady-state free precession with inversion recovery for assessing renal arteries in patients with renal transplants.	Thirteen recipients of renal transplants underwent steady-state free precession MRA before contrast material-enhanced MRA. Three stenoses (two mild, one severe) were identified at steady-state free precession MRA in agreement with findings at contrast-enhanced MRA. There was no significant difference in image quality between the two methods. Results suggest steady-state free precession MRA permits image quality of renal transplant arteries and detection of arterial stenosis comparable with those at contrast-enhanced MRA.	2

**Renal Transplant Dysfunction  
EVIDENCE TABLE**

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
37. Juillard L, Lerman LO, Kruger DG, et al. Blood oxygen level-dependent measurement of acute intra-renal ischemia. <i>Kidney Int</i> 2004; 65(3):944-950.	Review/Other-Dx	8 pigs	To determine if blood oxygen level-dependent can detect the characteristic of renal hypoxia induced by renal artery stenosis.	During the control period, blood oxygen level-dependent signals were not significantly different between the right and the left kidneys. In the occluded kidney, blood oxygen level-dependent signal of the cortex (19.3 +/- 1.9/s) and the medulla (17.3 +/- 2.0/s) increased during occlusion gradually and significantly ( $P<0.0001$ ) to a maximum (at total occlusion) of 33.8 +/- 2.0/s (+79%) and 29.8 +/- 2.3/s (+78%), respectively, and returned to baseline values during recovery. Study shows that the blood oxygen level-dependent technique can noninvasively detect change in intra-renal oxygenation during an acute reduction of renal blood flow. This study provides a strong rationale for developing the blood oxygen level-dependent method for the detection and evaluation of renal hypoxia induced by renal artery stenosis, which may be potentially applicable in humans.	4
38. Schoenberg SO, Rieger J, Weber CH, et al. High-spatial-resolution MR angiography of renal arteries with integrated parallel acquisitions: comparison with digital subtraction angiography and US. <i>Radiology</i> 2005; 235(2):687-698.	Observational-Dx	45 consecutive patients, 2 blinded reviewers	To retrospectively compare 3D Gd-enhanced MRA, performed with an integrated parallel acquisition technique for high isotropic spatial resolution, with selective DSA and intravascular US for accuracy of diameter and area measurements in renal artery stenosis.	Mean percentage of difference in stenosis measurement was reduced from 39.3% +/- 78.4 (standard deviation) with use of in-plane views to 12.6% +/- 9.5 with use of cross-sectional views ( $P<.05$ ). Interobserver agreement for stenosis grading based on perpendicular area of stenosis was significantly better than that for stenosis grading based on in-plane diameter of stenosis (mean percentage of difference, 15.2% +/- 24.2 vs 54.9% +/- 186.9; $P<.001$ ). Measurements of perpendicular area of stenosis on MR angiograms correlated well with those on intravascular US images ( $r(2) = 0.90$ ). Evaluation of cross-sectional images reconstructed from high-spatial-resolution 3D Gd-enhanced MR renal angiographic data increases the accuracy of the technique and decreases interobserver variability.	2

**Renal Transplant Dysfunction  
EVIDENCE TABLE**

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
39. Heaf JG, Iversen J. Uses and limitations of renal scintigraphy in renal transplantation monitoring. <i>Eur J Nucl Med</i> 2000; 27(7):871-879.	Observational-Dx	213 consecutive transplants	To investigate the value of thrice weekly technetium-99m mercaptoacetyl triglycine renography after renal transplantation.	The initial renogram grade was primarily a marker of ischaemic damage, being poorer with cadaver donation, long cold ischaemia (>24 hours), and high donor and recipient age. High primary renogram grade predicted primary graft non-function, long time to graft function, low discharge Cr EDTA clearance and low 1- and 5-year graft survival. Discharge renogram grade predicted late (>6 months) graft loss. Renogram grade was highly correlated ( $P<0.001$ ) with creatinine and creatinine clearance, and changes in renogram grade were correlated with changes in renal function. A change in renogram grade of 0.5 was non-specific, while a change of 1 or more predicted clinical complications in 95% of cases. The NPV was low (58%).	3
40. Dubovsky EV, Russell CD, Bischof-Delaloye A, et al. Report of the Radionuclides in Nephrourology Committee for evaluation of transplanted kidney (review of techniques). <i>Semin Nucl Med</i> 1999; 29(2):175-188.	Review/Other-Dx	N/A	A review of the optimal processes and techniques for the evaluation of kidney transplantation.	The protocol recommended at the Copenhagen meeting includes a flow study, scintigram of the kidneys, prevoid and postvoid bladder image, injection site image (quality control), time/activity curves of the graft and bladder, and quantitative data of perfusion, function, and tracer transit.	4



**Renal Transplant Dysfunction  
EVIDENCE TABLE**

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
41. Audard V, Matignon M, Hemery F, et al. Risk factors and long-term outcome of transplant renal artery stenosis in adult recipients after treatment by percutaneous transluminal angioplasty. <i>Am J Transplant</i> 2006; 6(1):95-99.	Observational-Tx	29 renal allograft recipients, 58 controls	Retrospectively review records of renal allograft recipients treated with PTA in order to determine the predisposing factors for TRAS.	Predisposing factors for TRAS included cytomegalovirus infection (41.4% vs 12.1% P=0.0018) and initial delayed graft function (48.3% vs 15.5% P=0.0018), respectively in the TRAS and the control group. Acute rejection occurred more frequently in patients from the TRAS group (48.3%) compared with the control group (27.6%), although the difference was not significant (P=0.06). In a multivariate analysis, only cytomegalovirus infection (P=0.005) and delayed graft function (P=0.009) appear to be significantly and independently associated with TRAS. The long-term graft survival was significantly higher in the control group, compared with the TRAS group (P=0.03). Study suggests that cytomegalovirus infection and delayed graft function are two reliable risk factors for TRAS. Despite treatment by PTA with primary successful results, TRAS significantly affects long-term graft outcome.	2

**Renal Transplant Dysfunction  
EVIDENCE TABLE**

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
42. Beecroft JR, Rajan DK, Clark TW, Robinette M, Stavropoulos SW. Transplant renal artery stenosis: outcome after percutaneous intervention. <i>J Vasc Interv Radiol</i> 2004; 15(12):1407-1413.	Observational-Tx	21 interventions performed in 18 allografts	Retrospective review to assess the outcome of PTA and stent placement as the primary treatment for TRAS.	The technical success rate of PTA/stent placement was 100% and the clinical success rate was 94% (17/18 allografts). The mean preintervention serum creatinine level among 12 allografts presenting with elevated creatinine levels was 2.8 mg/dL +/- 1.4 (SD), compared with a 1-month postintervention mean of 2.2 mg/dL +/- 0.7 (P=.03). Of 6 allografts that presented with hypertension, significant improvement was seen between the preintervention and 1-month postintervention mean systolic (174 mm Hg vs 135 mm Hg, P=.003) and diastolic (99 mm Hg vs 82 mm Hg, P=.02) pressures. These patients required a mean of 2.3 medications for blood pressure control before intervention, compared with a mean of 1.0 medications at 1 month after intervention (P=.002). Primary patency rates at 3, 6, and 12 months (+/-95% CI) were 94% +/- 6%, 72% +/- 12%, and 72% +/- 12%, respectively. Secondary patency rates at 3, 6, and 12 months (+/-95 CI) were 100%, 85% +/- 10%, and 85% +/- 10%, respectively. Mean follow-up time was 27 months. Of the 8 allografts that underwent stent placement, all 8 remained patent at last follow-up (mean, 18.3 months +/- 9.2). One major complication of a puncture site pseudoaneurysm occurred (5%). Primary treatment of TRAS with PTA with or without stent placement has good intermediate-term patency and is associated with significant early improvement in blood pressure and creatinine level.	2

**Renal Transplant Dysfunction  
EVIDENCE TABLE**

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
43. Geddes CC, McManus SK, Koteeswaran S, Baxter GM. Long-term outcome of transplant renal artery stenosis managed conservatively or by radiological intervention. <i>Clin Transplant</i> 2008; 22(5):572-578.	Observational-Tx	43 patients: 27 had percutaneous intervention (including 10 patients with >1 intervention) and 16 were managed conservatively	Patients diagnosed with TRAS were analyzed to report long-term clinical outcomes.	Patients in the intervention group had lower mean eGFR (36.3 mL/min/1.73 m <sup>2</sup> ) vs 46.3 mL/min/1.73 m <sup>2</sup> ; P=0.07) at baseline. Five transplants in the intervention group failed (including two as a direct result of intervention) and one in the conservative group failed. There was no significant difference in the rate of deterioration in renal function (mean slope of eGFR minus 0.8 mL/min/yr and minus 1.0 mL/min/yr in the intervention and conservative groups, respectively; P=0.79). There was no significant difference in blood pressure or number of anti-hypertensive agents between the groups at any time point. Baseline Doppler US indices showed no significant correlation with slope of eGFR in either group. Data demonstrate that selected patients with TRAS can be managed without intervention and that this approach is associated with good long-term outcome. Selection of appropriate patients for intervention remains difficult and larger randomized studies are required.	2
44. Ghazanfar A, Tavakoli A, Augustine T, Pararajasingam R, Riad H, Chalmers N. Management of transplant renal artery stenosis and its impact on long-term allograft survival: a single-centre experience. <i>Nephrol Dial Transplant</i> 2011; 26(1):336-343.	Observational-Tx	67 patients	Retrospective study to compare management strategies and outcomes of TRAS and its impact on long-term allograft survival.	44, 9 and 14 patients were managed with primary PTAA, surgical intervention and conservative treatment, respectively. Uncontrolled hypertension was the most common presentation noted in 74.62%. Post-anastomotic single stenosis was the commonest occurrence (n=53). Angioplasty had the highest 1- and 5-year graft survival rate of 91% and 86%, respectively. The worst prognosis was noted in patients treated with secondary PTAA after failed surgery or secondary surgery after failed primary PTAA. TRAS is a recognized complication resulting in loss of renal allografts. Early Doppler US is a good primary diagnostic tool. Early intervention is associated with a good long-term graft function.	2

**Renal Transplant Dysfunction  
EVIDENCE TABLE**

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
45. Hagen G, Wadstrom J, Magnusson M, Magnusson A. Outcome after percutaneous transluminal angioplasty of arterial stenosis in renal transplant patients. <i>Acta Radiol</i> 2009; 50(3):270-275.	Observational-Tx	24 patients 28 stenoses treated	To evaluate the technical and clinical success rate of renal transplant patients with stenosis in the transplant renal artery or in the iliac artery after PTA.	The immediate technical success rate after PTA was 93%. The clinical success rate after 1 month was 58%, increasing to 75% after 3 months. The technical success rate is not equivalent to the clinical success rate when treating TRAS with PTA. Furthermore, there is a delay in clinical response, sometimes of 3 months, after a technically successful PTA.	2
46. Henning BF, Kuchlbauer S, Boger CA, et al. Percutaneous transluminal angioplasty as first-line treatment of transplant renal artery stenosis. <i>Clin Nephrol</i> 2009; 71(5):543-549.	Observational-Tx	11 patients with TRAS	To determine whether PTA should be first-line treatment of TRAS.	The immediate success rate for PTA was 92.3% (12/13). The beneficial effect of PTA of TRAS on renal function is long-lasting. Therefore, PTA, usually combined with stent placement, should be first-line treatment in TRAS in all patients. Surgical revascularization is only warranted, if PTA fails.	2
47. Pappas P, Zavos G, Kaza S, et al. Angioplasty and stenting of arterial stenosis affecting renal transplant function. <i>Transplant Proc</i> 2008; 40(5):1391-1396.	Observational-Tx	24 patients	To evaluate the efficacy of percutaneous angioplasty and stenting in cases of artery stenosis of the transplanted kidney or proximal iliac artery stenosis causing transplant dysfunction and/or increase of the arterial blood pressure.	Successful angioplasty and stenting were performed in 22 patients. The method was technically feasible in 100%. The procedure-related morbidity was 0%. During the follow-up period (range: 3 to 104 months), two patients died with normal transplant function, two suffered transplant failure, and the remaining 18 still have normal transplant function and easily controlled hypertension. Percutaneous angioplasty and stenting in cases of arterial stenosis affecting the renal transplant function are safe and effective procedures. Even more, the strong clinical suspicion must lead to angiographic investigation regardless of the results of other imaging approaches.	2

**Renal Transplant Dysfunction  
EVIDENCE TABLE**

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
48. Peregrin JH, Stribrna J, Lacha J, Skibova J. Long-term follow-up of renal transplant patients with renal artery stenosis treated by percutaneous angioplasty. <i>Eur J Radiol</i> 2008; 66(3):512-518.	Observational-Tx	58 PTRAs in 55 adults (three times Re-PTRA)	To evaluate if PTRA in patients with transplanted kidney and TRAS can have long-term effect on hypertension and renal function.	PTRA technical success was 88.4%. In 51 kidney recipients at the end of follow-up, blood pressure improved in 65.2% of patients (mean arterial pressure decreased from 123+/-13.1 to 107+/-12.1 mmHg), but no patient remained normotensive medication free. Graft function improved in 44.8% of patients and was stabilized in 20.7% of them (average creatinine clearance before PTRA: 0.48+/-0.29, after PTRA: 0.78+/-47 ml/s). PTRA complications were observed in 25.5% of procedures, most often with no clinical sequel. Thirty days mortality was 1.8% (one patient). PTRA results in kidney recipients are valuable mainly in preserving graft function.	2
49. Polak WG, Jezior D, Garcarek J, et al. Incidence and outcome of transplant renal artery stenosis: single center experience. <i>Transplant Proc</i> 2006; 38(1):131-132.	Review/Other-Tx	793 kidney allograft recipients	Retrospective study to examine incidence, analyze the treatment options, and ascertain the outcomes of TRAS.	Screening CDUS showed hemodynamic changes in 6 patients with the definitive diagnosis confirmed by angiography in all patients. One patient with an anastomotic stenosis was treated with a surgical operation and 6 patients, PTA, with stenting in three cases. Both surgical as well as PTA treatment were successful in all but one patient, who underwent PTA alone, developed chronic renal insufficiency necessitating hemodialysis and finally lost his allograft. In the other patients all symptoms resolved after treatment and the patients are doing well with functioning allografts. Although TRAS was an uncommon complication, if recognized promptly it could be treated by surgery or PTA with a high success rate.	4
50. Seratnahaei A, Shah A, Bodiwala K, Mukherjee D. Management of transplant renal artery stenosis. <i>Angiology</i> 2011; 62(3):219-224.	Review/Other-Tx	N/A	Review the existing data and analyze management of TRAS as reported in multiple case series including findings from the authors' center.	PTA has now become the initial treatment of choice for TRAS. However, there are conflicting data regarding the efficacy of PTA, with growing evidence showing lack of significant benefit in blood pressure or renal function in patients undergoing PTA vs medical management. However, there have been no randomized control studies that have established the superiority of either method.	4

**Renal Transplant Dysfunction  
EVIDENCE TABLE**

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
51. Valpreda S, Messina M, Rabbia C. Stenting of transplant renal artery stenosis: outcome in a single center study. <i>J Cardiovasc Surg (Torino)</i> 2008; 49(5):565-570.	Observational-Tx	32 interventions in 30 allografts	To retrospectively evaluate the clinical outcome of patients with TRAS or post-PTA recurrent TRAS treated by endoluminal stenting.	The technical success rate of stenting was 100% with a single major complication event (a puncture site pseudoaneurysm). Mean follow-up time was 7.1 years; of the 30 allograft that underwent stent placement, all were patent at the last follow-up, with five restenosis (15.6%) of which only one needed to be retreated endoluminally. A reduction of the mean serum creatinine levels and of the number of blood pressure medications was observed. There was no difference in the survival curve of the grafts without TRAS compared to those with stenting treated TRAS. The treatment of the TRAS with selective or primary stenting is safe with a long-term patency rate. The efficacy of the stenting in this study is suggested by a decrease in mean systolic and diastolic blood pressure, serum creatinine levels and number of blood pressure medications.	3
52. Voiculescu A, Schmitz M, Hollenbeck M, et al. Management of arterial stenosis affecting kidney graft perfusion: a single-centre study in 53 patients. <i>Am J Transplant</i> 2005; 5(7):1731-1738.	Observational-Tx	53 patients	To assess the clinical and duplex US findings and outcome in patients with stenosis of the TRAS or the aorto-iliac segment proximal to the graft (TRAS) treated with dilatation (PTA), stenting and surgery.	52 patients underwent invasive treatment (21 PTA, 10 PTA/stenting and 21 surgery) after which hypertension and creatinine significantly improved. PI increased. Restenosis occurred in 16 (52%) cases of the interventional (PTA 62% and PTA/stenting 30%) and in 3 (14%) of the surgical group (P=0.011). Hypertension and graft dysfunction due to perfusion problems are rare. Clinical findings are nonspecific but duplex US findings are helpful to select patients for angiography. Invasive treatment leads to clinical improvement. Surgery yields better results than PTA, but additional stenting will probably improve the outcome of angioplasty.	2
53. da Silva RG, Lima VC, Amorim JE, Machado PG, Pacheco-Silva A, Medina-Pestana JO. Angioplasty with stent is the preferred therapy for posttransplant renal artery stenosis. <i>Transplant Proc</i> 2002; 34(2):514-515.	Observational-Dx	30 patients	Retrospective study was performed to present authors' experience in the diagnosis and treatment of TRAS.	Both angiography and subsequent PTA were performed in all patients. Patients with prolonged allograft dysfunction and refractory hypertension should be investigated for TRAS, and PTA with expandable endoprostheses is the treatment of choice. PTA was performed in 30 patients; all of them displayed improved renal function quickly.	4

**Renal Transplant Dysfunction  
EVIDENCE TABLE**

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
54. deSouza NM, Reidy JF, Koffman CG. Arteriovenous fistulas complicating biopsy of renal allografts: treatment of bleeding with superselective embolization. <i>AJR</i> 1991; 156(3):507-510.	Review/Other-Dx	7 patients	A report on patients in which superselective transcatheter embolization in renal allograft was used effectively as a means of controlling bleeding while allowing maximal conservation of renal parenchyma.	Bleeding was effectively controlled in all patients. None of the patients showed an increase in serum creatinine level after embolization, and in four, significant improvement was seen. Nuclear medicine studies showed no loss of renal function and a dramatic improvement in one patient. No complications due to the procedure were seen. Study suggests that superselective embolization with coaxial catheter techniques is an effective method of treating bleeding from postbiopsy arteriovenous fistulas in renal transplants with minimal loss of renal parenchyma.	4
55. American College of Radiology. <i>Manual on Contrast Media</i> . Available at: <a href="http://www.acr.org/~link.aspx?_id=29C40D1FE0EC4E5EAB6861BD213793E5&amp;z=z">http://www.acr.org/~link.aspx?_id=29C40D1FE0EC4E5EAB6861BD213793E5&amp;z=z</a> .	Review/Other-Dx	N/A	Guidance document on contrast media to assist radiologists in recognizing and managing risks associated with the use of contrast media.	N/A	4

## 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.

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Dx = Diagnostic

Tx = Treatment

## Abbreviations Key

CDUS = Color Doppler US

CI = Confidence interval

CT = Computed tomography

CTA = Computed tomography angiography

DSA = Digital-subtraction angiography

eGFR = Estimated glomerular filtration rate

Gd = Gadolinium

HR = Hazard ratio

HU = Hounsfield Units

IA-DSA = Intra-arterial digital subtraction angiography

MRA = Magnetic resonance angiography

MRI = Magnetic resonance imaging

NPV = Negative predictive value

NSF = Nephrogenic systemic fibrosis

PI = Pulsatility index

PPV = Positive predictive value

PQ = Perfusion quotient

PSV = Peak systolic velocity

PTA = Percutaneous transluminal angioplasty

PTRA = Percutaneous transluminal renal angioplasty

RI = Resistive index

TRAS = Transplant renal artery stenosis

US = Ultrasound