Interventional Management of Renal Transplant Arteriovenous Fistula

Jeanne M. LaBerge, M.D.¹

ABSTRACT

Percutaneous needle biopsy has become an indispensable tool for the evaluation and management of patients with renal allograft dysfunction. But this invasive procedure is not without risk. Vascular injury in the form of arteriovenous fistula, pseudoaneurysm, or arteriocalyceal fistula may result in symptoms that require percutaneous endovascular intervention. In this article, the occurrence, detection, and treatment of biopsy-related renal transplant injury are described.

KEYWORDS: Kidney transplantation, percutaneous biopsy complication, arteriovenous fistula, therapy

Objectives: Upon completion of this article, the reader should be able to (1) summarize the important imaging findings of allograft arteriovenous fistula, (2) list indications for embolization, and (3) describe techniques and complications of percutaneous transcatheter embolization.

Accreditation: Tufts University School of Medicine (TUSM) is accredited by the Accreditation Council for Continuing Medical Education to provide continuing medical education for physicians.

Credit: TUSM designates this educational activity for a maximum of 1 Category 1 credit toward the AMA Physicians Recognition Award. Each physician should claim only those credits that he/she actually spent in the activity.

Transplantation is the treatment of choice for patients with end-stage kidney disease. Improvements in surgical techniques and medical management have markedly extended the survival of both renal allografts and patients. Current graft survival rates at 1 and 5 years are 77–82% and 57–64%, respectively. Life expectancy for the recipient of a cadaver kidney is 7–10 years, and it is 15–20 years for the recipient of a living-related kidney.¹

Despite these advances, postoperative renal dysfunction continues to plague allograft recipients. In particular, acute or chronic rejection may occur in 30–40% of patients.² At present, the diagnostic evaluation of allograft dysfunction includes evaluation of blood chemistries and radiologic imaging. Although a variety of noninvasive tests are being investigated as a means

of definitively determining the cause of renal dysfunction, core needle biopsy remains the “gold standard” for management of patients. The technique of ultrasound-guided needle biopsy is described in detail in another article in this issue of *Seminars in Interventional Radiology*. In this article, I elaborate on the complications of needle biopsy and the treatment options for patients who suffer from this complication.

NEEDLE BIOPSY TECHNIQUE AND COMPLICATIONS

Technique

The technique of core biopsy is described in detail elsewhere in this issue. In brief, percutaneous renal

Transplant Interventions; Editor in Chief, Peter R. Mueller, M.D.; Guest Editor, Ravi Murthy, M.D. *Seminars in Interventional Radiology*, volume 21, number 4, 2004. Address for correspondence and reprint requests: Jeanne M. LaBerge, M.D., Department of Radiology, Division of Interventional Radiology, University of California, San Francisco, 505 Parnassus Avenue, M-361, Box 0628, San Francisco, CA 94143.

¹Department of Radiology, Division of Interventional Radiology, University of California, San Francisco. Copyright © 2004 by Thieme Medical Publishers, Inc., 333 Seventh Avenue, New York, NY 10001, USA. Tel: +1(212) 584-4662. 0739-9529,p;2004,21,04,239,246,ftx,en;sir00263x.

allograft biopsy is performed using a 16- or 18-gauge core biopsy needle. The needle is advanced into the lateral cortex of the allograft under ultrasound guidance. A central puncture is avoided to prevent inadvertent puncture of large arterial branches. On average, three needle passes are required to obtain an adequate tissue sample.³

Several technical points can be emphasized with regard to vascular biopsy-related complications. The incidence of injury appears to be related to several technical factors: the size of the needle, the location of the puncture, and the number of needle passes used to obtain sufficient tissue for evaluation. In addition, factors involved in selection of patients seem to affect complication rates, with more problems occurring in patients with prolonged bleeding times, low platelet counts, and hypertension or renal allograft nephrosclerosis.^{4,5}

Complications

Biopsy-induced arterial injury may result in arteriovenous fistula (AVF), pseudoaneurysm (Figs. 1 and 2), arteriolecalyceal fistula (Fig. 3) and rarely arterial thrombosis. Historically, the reported incidence of AVF following biopsy is 5–10%.⁶ However, immediate bleeding complications requiring treatment are seen in only a small percentage of patients. In a recent review of 2124 patients, Furness and colleagues⁷ reported only 3 patients with bleeding requiring intervention and 3 with bleeding requiring transfusion for a major bleeding complication rate of 0.3%.

It has been reported that 70% of all AVFs resolve within 1–2 years and 30% persist or become symptomatic.⁵ The incidence of persistent AVF is clearly dependent on selection of patients and the likelihood of graft survival due to underlying disease. In a study of 100 biopsies, Merkus and colleagues⁸ found 10 patients who developed AVFs that were detected using Doppler ultrasonography within 2 weeks after biopsy (10% incidence). However, during follow-up only one AVF persisted (10% persistence in all patients with AVF). Of note, four of the allografts were lost to rejection and two patients died of sepsis, leaving only four living patients with functioning allografts. Of these four patients with allografts, AVF resolved in three and persisted in one (25% persistence in long-term survivors).

Symptoms and Risk Factors

Persistent AVFs may lead to symptoms including hematuria, renal failure, and hypertension. Heavy bleeding can produce urinary clot that results in renal dysfunction caused by obstruction. In extreme cases, patients can develop high-output cardiac failure and allograft loss. Findings on physical examination

include an abdominal bruit or a palpable thrill over the allograft.⁴

Symptomatic AVFs appear to be more common in coagulopathic or hypertensive patients or in those with renal medullary disease or nephrocalcinosis. Overall, bleeding is the most common symptom from AVF, and this is more common in patients with hypertension.⁹

DETECTION OF BIOPSY-INDUCED VASCULAR INJURY

Ultrasonography

Ultrasonography is the imaging modality of choice for monitoring renal allografts. This technique provides a convenient, noninvasive, and sensitive means of evaluating both the renal parenchyma and the renal vasculature. It is used to detect early postoperative complications and also for surveillance imaging to detect such late complications as hydronephrosis or transplant arterial stenosis.^{1,10–12}

Ultrasonography is a very sensitive means of detecting postbiopsy vascular complications. Characteristic findings include Doppler identification of a focal pool of color representing venous and arterial components, increased systolic and diastolic flow on spectral analysis, and detection of turbulent venous flow and a large draining vein.^{10–12} Three-dimensional ultrasonography may be helpful for precisely identifying the location of the fistula.¹³ Occasionally AVF is missed on ultrasound evaluation. If AVF is not detected on sonography but is suspected clinically, further imaging with magnetic resonance angiography¹⁴ or conventional catheter angiography is warranted.

Angiography

Arteriovenous communications are readily apparent on angiography. The characteristic finding is the presence of an early draining vein emanating from the fistula that is frequently associated with a pseudoaneurysm. The exact location of the fistula requires filming with frame rates of 3–4 frames per second.

A disadvantage of angiography is the requirement for iodinated contrast material and the resultant risk of contrast-induced renal failure. Some authors have suggested the use of alternative contrast agents that lower the risk such as carbon dioxide or gadolinium.¹⁵ The precise advantages of these agents in reducing the incidence of contrast-induced renal dysfunction have not been quantified.

Another disadvantage of transcatheter arteriography is the potential for arterial injury to the femoral or iliac arteries on the side of the transplant. However, with modern techniques, the rate of injury from nonselective diagnostic angiography should be small (<1%).

Figure 1 Biopsy-induced renal transplant arteriovenous fistula (AVF) treated by ipsilateral catheterization and coil embolization. (A) The right iliac fossa transplant renal artery is catheterized and selective injection reveals an upper pole AVF (arrow) evidenced by early opacification of the segmental renal vein. (B) Selective catheterization of the feeding artery is performed with a microcatheter. (C) Microcoils are deposited at the mouth of the fistula. (D) Postembolization selective renal transplant arteriogram shows only a minimal area of infarction with good perfusion of the allograft.

TREATMENT OF BIOPSY-INDUCED VASCULAR INJURY

Conservative Management – Observation

The proper management of AVF is controversial. Many believe that small, asymptomatic AVFs can be

managed conservatively and followed with serial sonograms (i.e., watchful waiting). Advocates of this approach cite historical data showing that 70% of AVFs regress and believe that ultrasonography is an accurate means of surveillance to monitor the size of these lesions.

Figure 2 Biopsy-induced renal transplant arteriovenous fistula (AVF) treated by contralateral catheterization and coil embolization. (A) Catheterization of the right external iliac artery was performed from a contralateral femoral approach. Diagnostic arteriography reveals a small lower pole AVF. (B) Selective renal transplant arteriogram shows the precise anatomy of the injury to a peripheral lower pole vessel. (C) Superselective catheterization of the AVF with a 3-F microcatheter was followed by deployment of several microcoils. Postdeployment angiogram shows occlusion of the AVF. (D) Repeated renal allograft artery injection confirms occlusion of the fistula and excellent perfusion of the remainder of the kidney.

Patients with large AVFs and symptomatic patients with gross hematuria or marked hypertension are referred for treatment. The treatment of choice is selective transcatheter embolization.

Surgical Treatment

Surgical options are limited to partial or total nephrectomy. Thus, surgery is not an attractive option for the management of symptomatic vascular injury and is consequently the treatment of last resort.

Nonoperative Interventions

Over the past decade, endovascular management of AVF has emerged as the treatment of choice for symptomatic patients. Seven case series^{9,16-21} and several case reports^{4,5,22,23} have documented the technique and have provided some preliminary results.

Endovascular techniques for the management of vascular disease have progressed dramatically during the past decade. Key advances include development of small steerable 3-F catheters (termed microcatheters) that can be advanced into small feeding vessels in an

Figure 3 Biopsy-induced renal transplant pseudoaneurysm and arteriocalyceal fistula treated by ipsilateral catheterization and coil embolization. (A) Ipsilateral catheterization and common iliac arteriogram reveals a pseudoaneurysm of the lower pole of the renal allograft. Note filling of the collecting system indicative of an arteriocalyceal fistula. (B) The pseudoaneurysm was catheterized with a microcatheter and the feeding artery was embolized with microcoils. (C) A small defect is visible on the postembolization arteriogram (arrow).

atraumatic fashion and can be used to deliver small microcoils composed of fibered 0.018-inch wires to selectively occlude vessels in a precise and definitive manner. Selective embolization with microcoils delivered through a microcatheter is now the standard endovascular approach to the management of symptomatic

allograft AVF. When this approach is not feasible, other techniques may be used as described in the following.

TIMING OF EMBOLIZATION

Experts do not agree on the proper timing of embolization. Some experts urge caution because the procedure

is technically difficult and exposes the patient to the significant risks of contrast-induced renal failure and catheter-induced vascular injury. At the University of California, San Francisco (UCSF), the complications from AVF have been small and clinicians have been fairly aggressive in requesting embolization in patients with relatively minor symptoms such as hematuria. On the other hand, when complication rates are high, clinicians may request treatment only in patients with major complications such as uncontrollable hypertension, gross hematuria, or a large and growing pseudoaneurysm.^{18,20}

TECHNIQUE

An initial diagnostic arteriogram is performed to identify the precise location of the fistula and to plan therapy. Arteriography can be performed from an ipsilateral (Fig. 1) or contralateral approach (Fig. 2). In general, we have found that subsequent intervention is more easily performed from an ipsilateral approach. Transplant surgeons often anastomose the allograft renal artery to the proximal external iliac artery. With this surgical anatomy, the distance to the transplant renal artery is shorter and selective catheterization of the allograft artery is usually easier from an ipsilateral approach. When the allograft renal artery is anastomosed to the internal iliac artery, catheterization may be facilitated by a contralateral approach.

Contrast-induced renal failure can be minimized through the judicious use of alternative agents such as carbon dioxide or gadolinium. Infarction can be minimized by superselective catheterization with microcoils and the liberal use of antispasmodic agents such as nitroglycerin.

Occlusion of the AVF or pseudoaneurysm has been successfully accomplished with a variety of embolic agents. Stainless steel coils, Gelfoam pledgets, bucrylate glue, and polyvinyl alcohol particles have all been used. Of these, microcoils delivered through a microcatheter appear to be the safest agent for occluding the offending vascular abnormality while preserving the maximum amount of normal parenchyma in the arterial distribution of the AVF (Figs. 1 to 3). When the arteriovenous

connection is large, the fistula can be temporarily occluded by inserting an occlusion balloon catheter in the venous outflow vein to prevent inadvertent embolization of coils through the fistula into the systemic venous system.²³

PUBLISHED RESULTS

The published results of selective embolization for the treatment of postbiopsy AVF are summarized in Table 1. Hematuria was the prevailing indication for intervention and coils were the predominant embolization agent, although numerous agents were used. Technical success (defined as ability to occlude the arteriovenous communication) was achieved in 75–100% of cases. Hematuria was relieved after embolization in most cases but renal failure (and/or hypertension) persisted or worsened in some patients so that overall clinical success has varied from 25% to 100%. Persistent or worsening renal failure following embolization may be due to intrinsic disease in the allograft or may be caused by contrast-induced dysfunction or postembolization infarction.

The disparity in published results concerning clinical success following embolization explains the differing opinions about the overall value of the procedure. The authors of three of the seven studies listed in Table 1 (43%) concluded that embolization should be used with caution. Dorffner et al emphasized that technical success does not necessarily translate into clinical success, particularly when the indication is renal failure or hypertension. Moreover, they cautioned that endovascular intervention may result in a complication that requires emergent surgery. In their series, two patients required nephrectomy because of acute renal artery occlusion or acute anastomotic hemorrhage. Kitajima et al²⁰ strongly recommended against early intervention in asymptomatic patients. Finally, Lawen et al⁹ concluded that AVF occurring in patients more than a year after transplantation was an ominous sign and that even successful embolization was unlikely to result in allograft salvage.

On the other hand, four of seven authors concluded that embolization was effective and generally useful as a treatment for AVF. DeSouza et al¹⁶ found

Table 1 Published Series of Embolization for Biopsy-Induced Arteriovenous Fistula

Author	Predominant Indication	Technical Success	No. of Patients	
			Embolized	Clinical Success
Lawen, 1990	Renal dysfunction	100% (4/4)	4	25% (1/4)
deSouza, 1991	Bleeding	71% (5/7)	5	100% (5/5)
Shimura, 1998	Renal dysfunction	100% (5/5)	5	60% (3/5)
Dorffner, 1998	Bleeding and renal dysfunction	71% (5/7)	7	57% (4/7)
Perini, 1998	Bleeding and renal dysfunction and asymptomatic	95% (20/21)	21	88% (15/17)
Kitajima, 2000	Asymptomatic	100% (11/11)	11	NS (1/11 improved)
Maleux, 2003	Bleeding	100% (13/13)	13	100% (13/13)

NS, not stated.

that embolization was an effective means of treating bleeding and could be accomplished with minimal tissue loss and without development of renal failure in any patients. Shimmura et al¹⁷ concluded that embolization was an effective treatment even when the indication was renal failure, although their clinical results are not much better than those reported by Dorffner. Finally, both Perini and Maleux^{19,21} and their colleagues showed that embolization can be performed safely using microcatheter techniques.

In the end, local practice should be guided by past institutional results. The results of embolization for allograft biopsy-related injury at UCSF as reported by Perini et al¹⁹ are shown in greater detail in Table 2. Over a 10-year period, we performed transcatheter embolization for biopsy-induced arterial injury in 21 patients. This represented 1% of all patients who underwent biopsy during that period. The predominant indication was bleeding (10 of 21 [48%]), although seven patients (33%) presented with hypertension or renal dysfunction and 4 (19%) were asymptomatic. AVFs were successfully occluded in 20 of 21 patients (95%) without any procedural complications (0%). All patients referred for bleeding had resolution of symptoms but two patients referred for renal dysfunction did not improve, resulting in an overall clinical success of 88%. An attempt was made to analyze postembolization renal function to determine whether the procedure contributed to worsening renal function. Using a temporal analysis of renal function, we concluded that angiography and embolization contributed to worsening of renal function in 10%.

CONCLUSIONS

Renal allograft biopsy is an essential tool for the follow-up evaluation of transplant recipients, but it may result in ultrasonographically visible AVF in up to 10% of patients. Conservative management in conjunction with ultrasound surveillance is recommended for most patients. Persistent or symptomatic AVF can be expected in 1–2% of patients, and these injuries can be effectively treated by transcatheter embolization. The

decision to perform embolization and the timing of embolization depend on the degree and type of symptoms that the patients display as well as the institutional experience with transcatheter embolization.

REFERENCES

1. Baxter GM. Imaging in renal transplantation. *Ultrasound Q* 2003;19:123–138
2. Chandraker A. Diagnostic techniques in the work-up of renal allograft dysfunction—an update. *Curr Opin Nephrol Hypertens* 1999;8:723–728
3. Chan R, Common AA, Marcuzzi D. Ultrasound-guided renal biopsy: experience using an automated core biopsy system. *Can Assoc Radiol J* 2000;51:107–113
4. Omoloja AA, Racadio JM, McEnery PT. Post-biopsy renal arteriovenous fistula. *Pediatr Transplant* 2002;6:82–85
5. Martinez T, Palomares M, Bravo JA, et al. Biopsy-induced arteriovenous fistula and venous aneurysm in a renal transplant. *Nephrol Dial Transplant* 1998;13:2937–2939
6. Naraghi RM, Jordan ML. Surgical complications. In: Shapiro R, Simmons RL, Starzl TE, eds. *Renal Transplantation*. Stamford, CT: Appleton & Lange; 1997:269–298
7. Furness PN, Philpott CM, Chorbadian MT, et al. Protocol biopsy of the stable renal transplant: a multicenter study of methods and complication rates. *Transplantation* 2003;76:969–973
8. Merkus JW, Zeebregts CJ, Hoitsma AJ, van Asten WN, Koene RA, Skotnicki SH. High incidence of arteriovenous fistula after biopsy of kidney allografts. *Br J Surg* 1993;80:310–312
9. Lawen JG, van Buren CT, Lewis RM, Kahan BD. Arteriovenous fistulas after renal allograft biopsy: a serious complication in patients beyond one year. *Clin Transplantation* 1990;4:357–369
10. Middleton WD, Kellman GM, Melson GL, Madrazo BL. Postbiopsy renal transplant arteriovenous fistulas: color Doppler US characteristics. *Radiology* 1989;171:253–257
11. Claudon M, Lefevre F, Hestin D, Martin-Bertaux A, Hubert J, Kessler M. Power Doppler imaging: evaluation of vascular complications after renal transplantation. *AJR Am J Roentgenol* 1999;173:41–46
12. Brandenburg VM, Frank RD, Riehl J. Color-coded duplex sonography study of arteriovenous fistulae and pseudoaneurysms complicating percutaneous renal allograft biopsy. *Clin Nephrol* 2002;58:398–404
13. Mohaupt MG, Perrig M, Vogt B. 3D Ultrasound imaging—a useful non-invasive tool to detect AV fistulas in transplanted kidneys. *Nephrol Dial Transplant* 1999;14:940–943
14. Bagga H, Bis KG. Contrast-enhanced MR angiography in the assessment of arteriovenous fistula after renal transplant biopsy. *AJR Am J Roentgenol* 1999;172:1509–1511
15. Spinosa DJ, Pao DG, Matsumoto AH, Hagspiel KD, Angle JF, Hooper TN. Carbon dioxide and gadodiamide as the contrast agents for diagnosis and embolization of a post-biopsy arteriovenous fistula in a renal allograft. *Clin Radiol* 2000;55:801–803
16. deSouza NM, Reidy JF, Koffman CG. Arteriovenous fistulas complicating biopsy of renal allografts: treatment with superselective embolization. *AJR Am J Roentgenol* 1991;156:507–510

Table 2 Expanded Results at the University of California, San Francisco

Indications	Bleeding (48%) Hypertension or renal dysfunction (33%) Asymptomatic (19%)
Technique	Microcatheter and microcoils
Results	Technical success (95%), one failure Clinical success (88%—two patients with renal dysfunction did not improve) Procedure-induced worsening of renal function (10%)

17. Shimmura H, Ishikawa N, Tanabe K, et al. Angiographic embolization in patients with renal allograft arteriovenous fistula. *Transplant Proc* 1998;30:2990–2992
18. Dorffner R, Thurnher S, Prokesch R, et al. Embolization of iatrogenic vascular injuries of renal transplants: immediate and follow-up results. *Cardiovasc Intervent Radiol* 1998;21:129–134
19. Perini S, Gordon RL, LaBerge JM, et al. Transcatheter embolization of biopsy-related vascular injury in the transplant kidney: immediate and long-term outcome. *J Vasc Interv Radiol* 1998;9:1011–1019
20. Kitajima K, Fuchinoue S, Koyama I, et al. Embolization for arteriovenous fistula after graft biopsy in renal transplant recipients: is it essential for all cases? *Transplant Proc* 2000;32:1911
21. Maleux G, Messiaen T, Stockx L, Vanrenterghem Y, Wilms G. Transcatheter embolization of biopsy-related vascular injuries in renal allografts. Long-term technical, clinical and biochemical results. *Acta Radiol* 2003;44:13–17
22. Bilge I, Rozanes I, Acunas B, et al. Endovascular treatment of arteriovenous fistulas complicating percutaneous renal biopsy in three paediatric cases. *Nephrol Dial Transplant* 1999;14:2726–2730
23. Nakatani T, Uchida J, Han YS, et al. Renal allograft arteriovenous fistula and large pseudoaneurysm. *Clin Transplant* 2003;17:9–12