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PICTORIAL ESSAY

Interventional radiological management of vascular complications following renal transplantation

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ABSTRACT
In this pictorial essay, we describe the angiographic appearance of the most common vascular complications following renal transplantation, such as arterial stenoses, arteriovenous fistulas, pseudoaneurysms, and thromboses, and illustrate their interventional radiological management.

Key words: • *renal transplantation* • *vascular complications* • *radiology, interventional*

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Vascular complications in renal transplant recipients are important causes of graft dysfunction associated with high morbidity and mortality. Interventional radiology plays a major role in the management of vascular complications in renal transplants, including arterial stenoses, arteriovenous fistulas (AVF), pseudoaneurysms (PA), and thromboses. Although color Doppler ultrasonography and gadolinium-enhanced magnetic resonance angiography (MRA) are useful diagnostic screening methods, conventional angiography not only remains the gold standard procedure for final diagnosis, and also enables endovascular treatment (1). In this article, we describe the angiographic appearance of the most common vascular complications following renal transplantation and illustrate their interventional radiological management.

Arterial stenosis

Transplant renal artery stenosis (TRAS), with an incidence rate ranging from 1% to 23%, is the most frequently reported vascular complication in renal transplantation, and is an important cause of hypertension and/or graft dysfunction (2). Three different locations of transplant stenoses are anastomosis, distal to the anastomosis, and recipient iliac artery (3). Each type have particular predisposing causes, which include operative, hemodynamic, and immunological factors. Although surgical techniques for renal transplantation vary by institution, transplant renal vessels are anastomosed to the recipient external (end-to-side) or to the internal iliac artery (end-to-end) and to the recipient external iliac vein (end-to-side). The vast majority of TRAS occurs within 1 cm of the anastomosis and is directly related to the surgical technique (Fig. 1–3). Distal donor artery stenoses are less common and are thought to be caused by intimal injury or rejection, with the typical angiographic appearance of beaded intrarenal vessels (Fig. 4). Recipient iliac artery stenoses are rare and result from vascular clamp injury or native atherosclerotic disease (Fig. 5). Although the diagnosis of TRAS is clinically suspected in a patient with progressive renal dysfunction and hypertension, asymptomatic, but hemodynamically significant TRAS may be detected with the increased use of noninvasive imaging modalities, such as color Doppler ultrasonography, MRA, and computed tomography angiography. Treatment should be muldisciplinary involving the interventional radiologist, the transplant surgeon, the vascular surgeon, and the nephrologist. Conventional arteriography should be performed to evaluate TRAS and the option of subsequent endovascular therapy. With the shift from traditional surgical revascularization to interventional radiological techniques, percutaneous transluminal angioplasty (PTA) alone is the initial treatment of choice in TRAS. Indications for additional stenting include recurrent and/or ostial stenosis, significant residual stenosis after balloon angioplasty, and flow-limiting dissection. High rates of tech-

Figure 1. a-e. Renal transplantation with end-to-side anastomosis to the right external iliac artery (EIA). Arteriograms show a stenosis *(arrow)* of EIA **(a)** successfully treated by angioplasty **(b)**, and a high-grade anastomotic stenosis of the transplant renal artery **(c)** dilated using a 4-mm balloon **(d)**. Despite the presence of residual stenosis on the post-angioplasty arteriogram **(e)**, the clinical symptoms (uncontrolled hypertension and decreased renal function) ceased after the intervention.

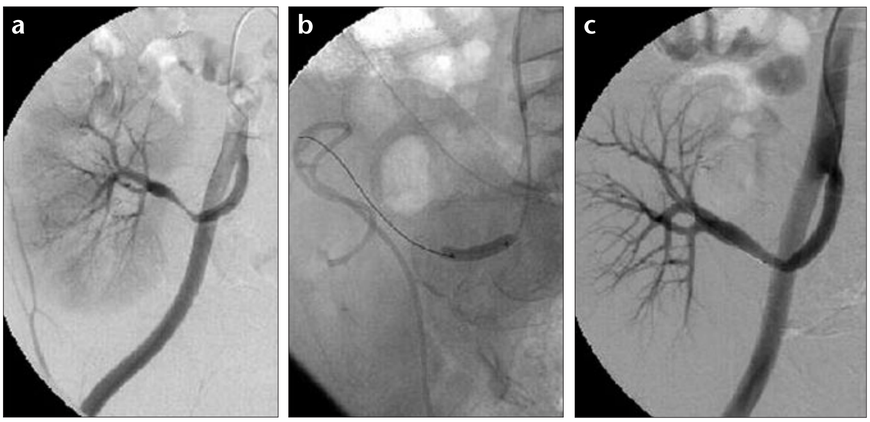

Figure 2. a-c. Renal transplantation with end-to-end anastomosis to the right internal iliac artery. Transplant renal angiogram demonstrates a stenosis within the post-anastomotic segment **(a)**, which was successfully dilated with a balloon **(b)**. Repeat arteriogram after the procedure reveals a widely patent transplant renal artery without residual stenosis **(c)**.

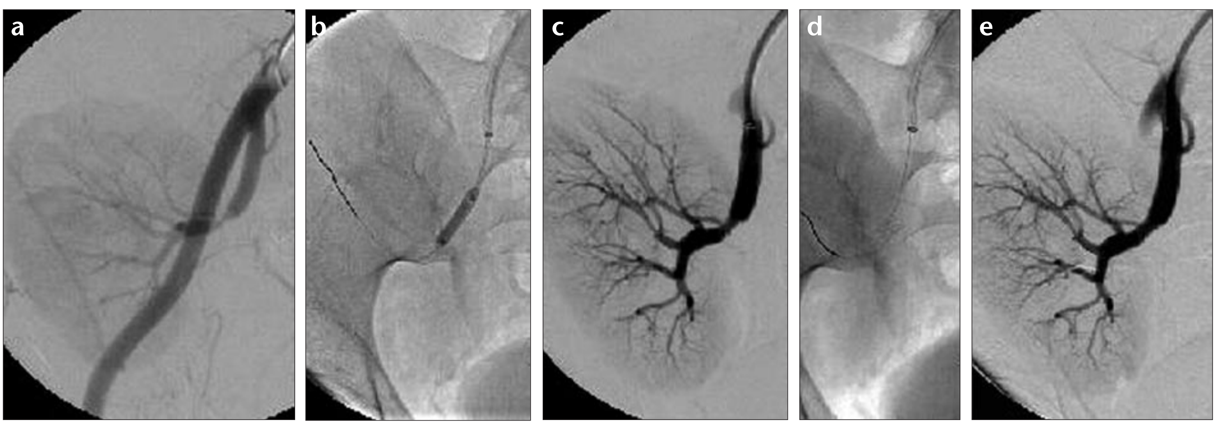

Figure 3. a-e. Angiogram obtained with a right common iliac artery injection reveals an end-to-end (internal iliac to transplant renal artery) anastomotic stenosis **(a)**. First, a balloon dilatation was performed **(b)**. A residual stenosis is seen on the arteriogram after balloon angioplasty **(c)**, and therefore, a stent was subsequently deployed **(d)**. Angiogram after stenting shows resolution of the stenosis **(e)**.

nical and clinical success, and low procedure-related complication rates of PTA/stent placement in the treatment of TRAS have been reported in the literature (2, 4). The clinical success rate, as indicated by improvement in blood pressure control, averages 82% (3). Recurrent stenoses, with reported rates of 10%–33%, can usually be successfully treated by repeat angioplasty or stenting (3).

Arteriovenous fistulas and pseudoaneurysms

Percutaneous biopsy of the transplanted kidney is frequently necessary for differential diagnosis in patients with loss of renal function. Biopsy-related renal vascular complications include AVF resulting from simultaneous laceration of the adjacent artery and vein, and PA due to isolated arterial injury. Occasionally, AVF and PA can occur simultaneously. Most of these

Figure 4. Chronic rejection. The main renal artery is patent, but all intra-renal arteries are irregularly narrowed. Note the parenchymal defects in the kidney.

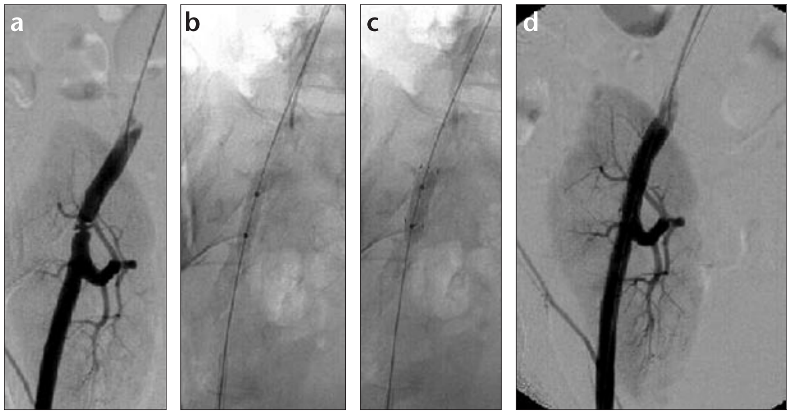

Figure 5. a-d. Iliac artery stenosis due to clamp injury. Angiogram obtained with a right external iliac artery (EIA) injection shows a significant stenosis of EIA proximal to the end-to-side anastomosis **(a)**. Predilation **(b)**, and in-stent postdilation **(c)** were performed. No residual stenosis is seen on the angiogram after the procedure **(d)**.

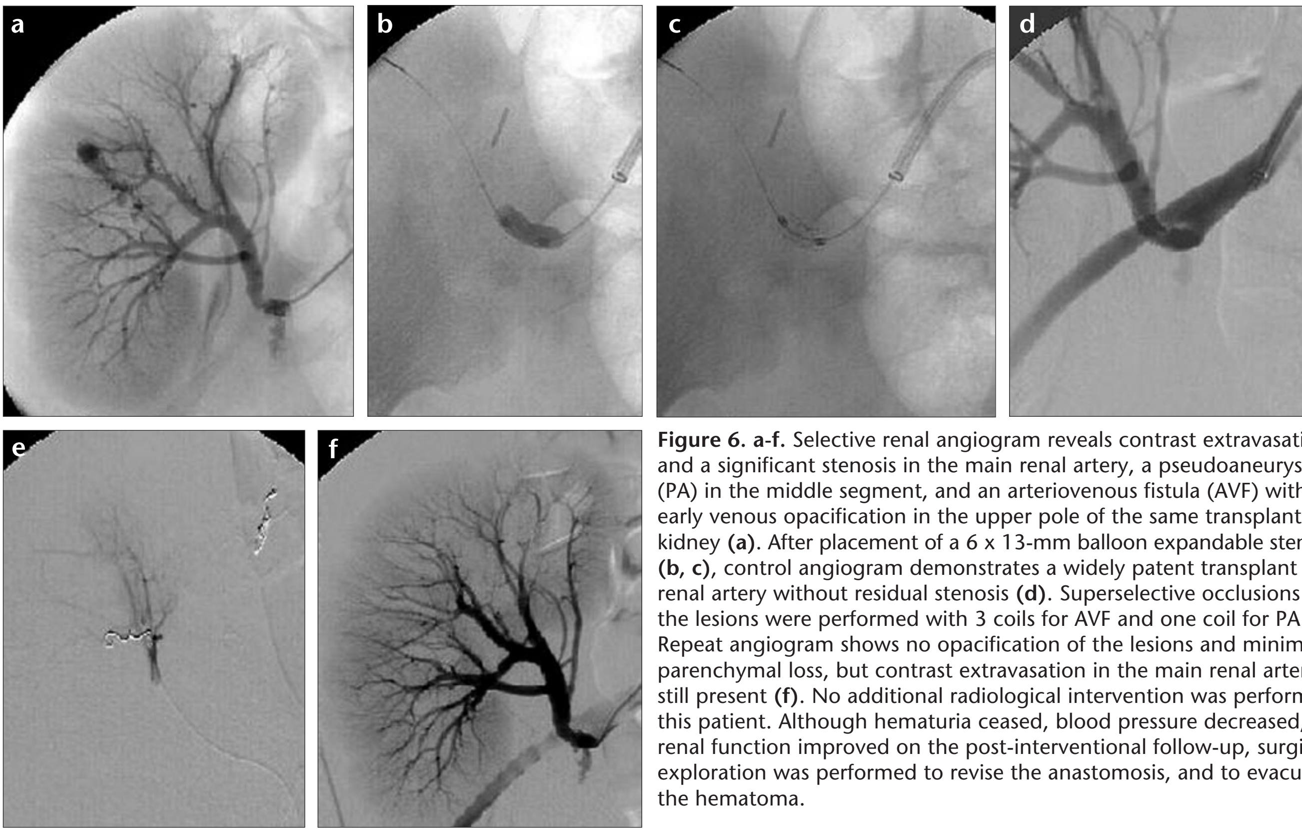

Figure 6. a-f. Selective renal angiogram reveals contrast extravasation and a significant stenosis in the main renal artery, a pseudoaneurysma (PA) in the middle segment, and an arteriovenous fistula (AVF) with early venous opacification in the upper pole of the same transplanted kidney **(a)**. After placement of a 6 x 13-mm balloon expandable stent **(b, c)**, control angiogram demonstrates a widely patent transplant renal artery without residual stenosis **(d)**. Superselective occlusions of the lesions were performed with 3 coils for AVF and one coil for PA **(e)**. Repeat angiogram shows no opacification of the lesions and minimal parenchymal loss, but contrast extravasation in the main renal artery is still present **(f)**. No additional radiological intervention was performed in this patient. Although hematuria ceased, blood pressure decreased, and renal function improved on the post-interventional follow-up, surgical exploration was performed to revise the anastomosis, and to evacuate the hematoma.

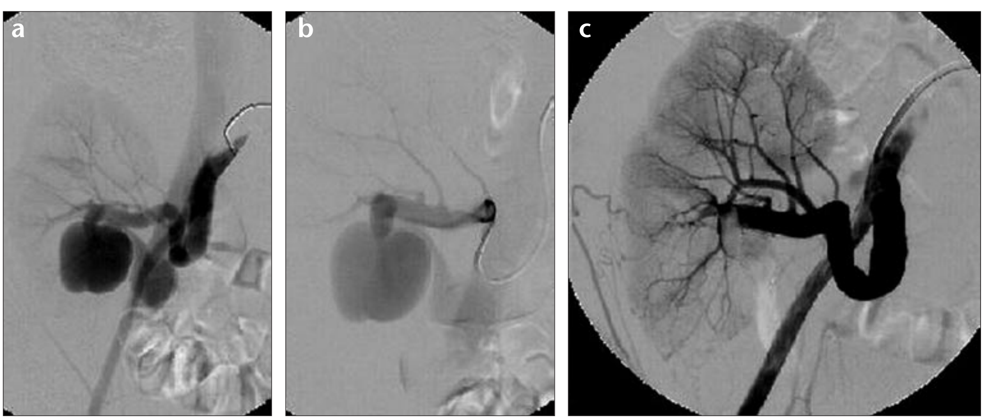

Figure 7. a-c. Transplant renal angiogram demonstrates a huge pseudoaneurysm (PA) with a high-flow arteriovenous fistula (AVF) **(a)**. Note the contrast jet into the PA and early opacification of the renal vein **(b)**. Repeat angiogram after embolization of the fistula, using a detachable balloon, shows complete occlusion of the PA and AVF **(c)**. The patient did well after this procedure.

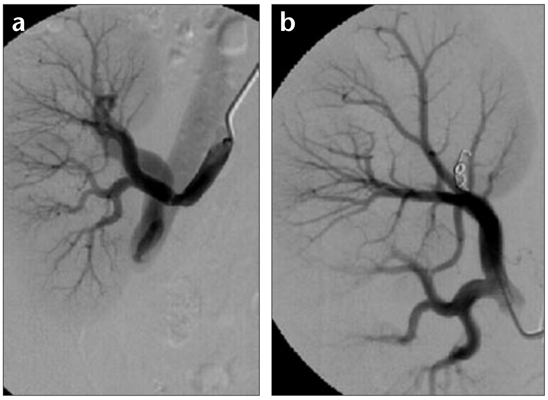

Figure 8. a, b. Selective angiography of the transplant kidney demonstrates early venous opacification indicating the presence of an arteriovenous fistula, and small rounded collections of contrast material representing a concomitant pseudoaneurysm **(a)**. Control angiogram after superselective coil embolization clearly shows the absence of any vascular lesion **(b)**. On the post-procedural follow-up, the patient's hematuria ceased without any loss of renal function.

Figure 9. a-c. Angiographic image obtained during injection of the main renal transplant artery shows pseudoaneurysm and arteriovenous fistula shunting into a large vein **(a)**. Superselective embolization was performed with 3 coils **(b)**. The proximal coil was displaced during retrieval of the micro-catheter, but no early venous opacification was present and minimal parenchymal loss is seen on the follow-up angiogram **(c)**.

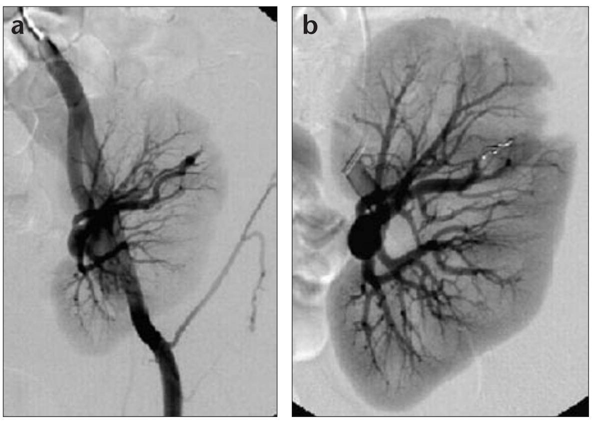

Figure 10. a, b. Arteriovenous fistula and pseudoaneurysm are seen in the upper pole of the transplanted kidney **(a)**. Note the parenchymal defect representing renal infarction after selective coil embolization **(b)**. Despite the parenchymal loss, renal function remained stable, and the patient's hematuria stopped during the post-interventional course.

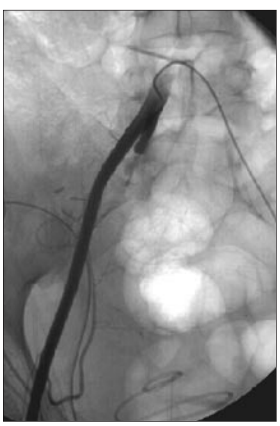

Figure 11. Digital subtraction angiographic image obtained during injection of the common iliac artery demonstrates complete occlusion at the anastomosis site of the transplant renal artery due to thrombosis. No distal perfusion is seen. Thrombolytic therapy was not considered in this patient who had been anuric for more than 24 hours.

vascular lesions are of little clinical importance and resolve spontaneously. The frequency of these complications is estimated to be between 1% and 18% (1, 3). Nonetheless, patients may present with life-threatening bleeding or marked arteriovenous shunting, which may result in renal ischemia, or even cardiac decompensation. Although post-biopsy intrarenal AVF and PA are identified accurately by color Doppler ultrasonography, for definitive diagnosis, renal arteriography should be performed in unresolved cases with persistent or recurrent renal bleeding. Symptomatic lesions need to be treated immediately. Transcatheter embolization is an effective endovascular technique to treat biopsy-related renal allograft vascular injury (Fig. 6–9). Technical radiological success rates after percutaneous embolotherapy is very high and adverse effects like major parenchymal infarction are very rare (5, 6) (Fig. 10). Embolization can be performed superselectively using a micro-catheter and an embolic agent micro-coils in most cases. Coils are equivalent to surgical ligation and occlude medium to small arteries, allowing the protection of vessels at the arteriolar level or the capillary bed. Other embolic agents, such as N-butyl-cyanoacrylate, gelfoam, and detachable balloons, can also be used in addition to coils, or alone, in selected cases.

Graft thrombosis

Arterial, or more commonly venous type of renal graft thrombosis, occurs quickly in the early postoperative period and leads to graft loss (3). Graft thrombosis is characterized by sudden anuria and an almost inevitable irreversible loss of renal function; however, the diagnosis is usually delayed (Fig. 11). In cases of early diagnosis of vascular thrombosis in the late post-transplant period, selective thrombolysis or clot aspiration can be performed as an alternative to surgical thrombectomy. Thrombolytic therapy in transplant renal artery thrombosis is successful up to 24 hours after the arterial occlusion (7).

Conclusions

Since traditional surgical correction gives rise to significant morbidity and mortality, and is expensive, minimally invasive endovascular interventions, such as PTA and transcatheter embolization procedures, following selective angiographic evaluation, should be considered as a first-line treatment choice in vascular complications following renal transplantation.

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