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Case Report

Transplant Renal Artery Stenosis Following *Ex vivo* Renal Artery Endarterectomy: Report on Two Cases

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Abstract

Introduction: Transplant renal artery stenosis (TRAS) is the most common vascular complication following kidney transplantation. Deceased donor kidneys exhibiting severe atherosclerosis involving the renal artery, if untreated, represent one cause of TRAS.

Methods: We report herein two cases of TRAS that occurred following back bench ex vivo eversion endarterectomy (EE) prior to deceased donor kidney transplantation (DDKT).

Results: Both patients presented in the first year following DDKT with worsening hypertension and one patient experienced acute kidney injury. Duplex ultrasonography was suspicious for markedly elevated renal artery velocities in the proximal to mid-renal artery segment with evidence for distal turbulence. Subsequent arteriography through an ipsilateral femoral approach confirmed severe TRAS that was successfully treated with balloon angioplasty and stenting. Both patients experienced improvements in blood pressure control, and one patient had resolution of acute kidney injury.

Conclusion: Ex vivo EE may be performed successfully as a rescue procedure to prevent nonuse of donor kidneys with severe intrinsic atherosclerosis. However, these patients may still be at risk for developing TRAS, possibly from a localized dissection occurring secondary to an intimal flap.

Keywords: Deceased Donor; Eversion Endarterectomy; Renal Atherosclerosis; Transplant Renal Artery Stenosis

Abbreviations: BMI: Body mass index; DDKT: Deceased donor kidney transplant; EE: Eversion endarterectomy; GFR: Glomerular filtration rate; KDPI: Kidney donor profile index; TRAS: Transplant renal artery stenosis.

INTRODUCTION

In the past 3 years, the number of annual kidney transplants performed in the United States has remained relatively static at approximately 27,500, including just over 21,000 deceased donor kidney transplants (DDKTs) [1]. During this same period, the number of deceased kidney donors has stabilized at roughly 15,500 per annum. However, the number of younger donors has decreased whereas donors 50-64 years and 65+ years of age have increased by 4% and 91%, respectively [1]. In addition, the number of donors with a Kidney Donor Profile Index (KDPI) >85% has increased by 75% and currently represents 18.7% of deceased kidney donors despite KDPI drift [2,3]. As of February 2026, the United Network for Organ Sharing national waiting list had >94,000 candidates awaiting kidney transplantation, a number that has not changed significantly in the new millennium. Unfortunately, in the past twenty years, the number of kidneys recovered with the intent to transplant and subsequently not utilized has more than tripled. In 2025, 8,227 kidneys were not utilized, representing a nonutilization rate of 27.1% [1]. For high KDPI donor kidneys (KDPI >85%), the nonutilization rate approaches 70%.

The continuing disparity between kidney supply and demand in combination with the high kidney nonutilization rate are two of the major current challenges in organ transplantation. With an increasing number of older or medically complex donors, anatomic considerations have become an important cause of kidney nonuse [4-7]. Kidneys from donors that exhibit severe aortic atherosclerosis with hard ulcerative occlusive plaque extending into the renal artery may represent a contraindication to organ acceptance at many centers. There are a few reports describing successful eversion endarterectomy (EE) as a back bench salvage procedure to permit successful kidney transplantation in this setting [8-10]. Transplant renal artery stenosis (TRAS) is the most common vascular complication following kidney transplantation, with a reported incidence ranging from 1% to 23% [11-14]. To our knowledge, there are few if any reports of TRAS occurring after ex vivo renal artery EE. Herein we report two case studies of patients developing TRAS following bench preparation EE that may be related to the salvage procedure.

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METHODS

Study Design and Definitions

We conducted a retrospective chart review of all adult DDKTs performed at our center from 10/1/2001 to 3/1/2025. During this 23.5-year study period, a total of 61 cases of EE prior to DDKT were identified. Standardized donor and recipient selection and management algorithms were followed during the period of study and have been previously reported [10-18]. Delayed graft function was defined as the need for dialysis (for any reason) in the first week post-DDKT. KDPI was determined based on the UNET calculation at the time of the kidney offer [2-19].

Kidney preservation and preparation

Whenever possible, donor kidneys were placed on machine preservation to minimize preservation injury, maintain functional

reserve, and provide another means of assessment [16,17]. EE was performed by subintimal dissection of the Carrel aortic patch surrounding the renal artery followed by complete eversion and removal of the cast as previously reported [10,20]. The EE procedure preserved the length of the renal artery and the accompanying Carrel aortic patch to simplify the arterial implantation. Indications for EE were stenotic plaque involving the ostium with extension into the renal artery such that resecting the area of involvement would result in an extremely short artery that would be difficult to implant. Patients received localized heparin intra-operatively and aspirin 81 mg daily post-operatively. Duplex ultrasonography was performed on post-operative day #1 and whenever clinically indicated for monitoring purposes.

Immunosuppression and Post-Transplant Management

Both recipients received depleting antibody induction with subcutaneous alemtuzumab 30 mg as a single intra-operative dose [18]. Maintenance immunosuppression consisted of tacrolimus, mycophenolic acid (360 mg twice daily in recipients 60 years and older), and tapering doses of steroids to 5 mg/d by one-month post-transplant. Target 12-hour tacrolimus trough levels were 6-9 ng/ml in the first 3 months and then 4-6 ng/ml thereafter in the absence of rejection. Both patients received surgical site prophylaxis with a first-generation cephalosporin for 24 hours, anti-fungal prophylaxis with fluconazole for 1 month, and anti-Pneumocystis prophylaxis with sulfamethoxazole-trimethoprim for at least 12 months. Antiviral prophylaxis consisted of oral valganciclovir for 3-6 months, depending on donor and recipient cytomegalovirus serologic status. Specifics regarding drug dosing and duration have been published previously [10,18]. Post-transplant renal allograft function was evaluated by measuring serum creatinine levels as well as estimating the glomerular filtration rate (GFR) using the abbreviated Modification of Diet in Renal Disease formula.

CASE STUDY #1

The donor was a white male in his late 40s, KDPI score 62%, with a history of hypertension who progressed to brain death following a stroke. The donor had a body mass index (BMI) of 40.6 kg/m^2 and terminal serum creatinine level was 1.29 mg/dl. During organ recovery, the kidneys flushed well and appeared normal, biopsies exhibited mild glomerulosclerosis (9%) with mild interstitial inflammation and moderate vascular changes. The kidney was imported from a non-neighboring state as an out-of-sequence allocation (open offer) and was placed on hypothermic machine perfusion (pump flow 83 ml/min with a resistance of 0.33 mm Hg/ml/min).

The recipient is a Hispanic male in his late 70s with end stage renal disease secondary to type 2 diabetes and hypertension. The recipient had been placed on our waiting list 3 months previously and had just started hemodialysis one week prior to DDKT. During back bench ex vivo preparation of the kidney, we identified the presence of a moderate amount of hard atheromatous plaque extending well beyond the renal ostium. EE was performed and no leaks or vessel wall disruption were noted. The subsequent DDKT of a left kidney into the right iliac fossa through an extraperitoneal approach was performed without incident with a total cold ischemia time of 28 hours.

The patient experienced slow graft function but did not require any hemodialysis support and made an uneventful recovery. Early post-transplant duplex ultrasonography (post-operative day one) was unremarkable. He was discharged on post-operative day #5 with marginal kidney function and at one month post-transplant, the serum creatinine level was 3.4 to 4.0 mg/dl with an estimated GFR of 14-18 ml/min/1.73m^2. At 2 months post-transplant, nadir serum creatinine level was 2.33 mg/dl with an estimated GFR of 28 ml/min/1.73m^2. At 3 months post-transplant, he presented to the clinic with acute kidney injury (serum creatinine level 4.58 mg/dl, estimated GFR 13 ml/min/1.73m^2), elevated blood pressure (171/57 mm Hg), and weight loss.

Transplant renal duplex ultrasonography was suggestive of a hemodynamically significant stenosis at the level of mid-renal artery with a renal artery velocity of 329 cm/sec and associated post-stenotic turbulence. He received intravenous fluid hydration and subsequently underwent arteriography performed by the Interventional Radiology service through a retrograde ipsilateral transfemoral approach that demonstrated an 80% stenosis at the junction of the proximal to mid-renal artery (Figure 1). Balloon angioplasty with a 4 mm and then 6 mm balloon was performed followed by successful deployment of a Palmaz blue stent (6 x 18 mm) across the stenotic area. Incomplete stent expansion was further managed by angioplasty of the stent using a 5 mm Sterling balloon. Completion angiogram revealed significantly improved antegrade flow (Figure 2). He tolerated the procedure well and was discharged on dual anti-platelet therapy the following day.

Post-procedure serum creatinine level declined to 2.53 mg/dl with an estimated GFR of 26 ml/min/1.73m^2. He improved clinically with normalization of blood pressure levels. He was subsequently placed on Belatacept to spare tacrolimus and thereby reduce the risk for calcineurin inhibitor- related nephrotoxicity but renal function remains sub-optimal at 5 months post-transplant.

CASE STUDY #2

The donor was a 56 year old white male with a history of hypertension who developed an irreversible brain injury secondary to anoxic encephalopathy. The donor did not progress to brain death and organ recovery was performed as donation after circulatory death following withdrawal of life support. The donor had a BMI of 37.6 kg/m^2 with a KDPI score of 71%. Peak serum creatinine was 1.16 mg/dL and terminal creatinine level was 0.77 mg/dL. Renal biopsy at the time of procurement showed 0% glomerulosclerosis, no interstitial fibrosis or tubular atrophy, and no vascular changes. Warm ischemia time was 29 minutes. The kidney was imported from a neighboring state as an out-of-sequence allocation (open offer) and was placed on hypothermic machine

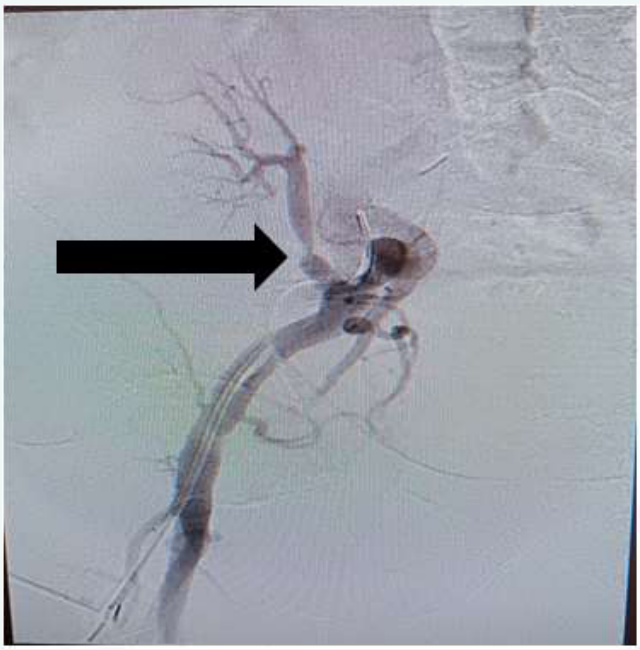

Figure 1: Transfemoral ipsilateral retrograde arteriography demonstrating up to 80% stenosis of mid-renal artery

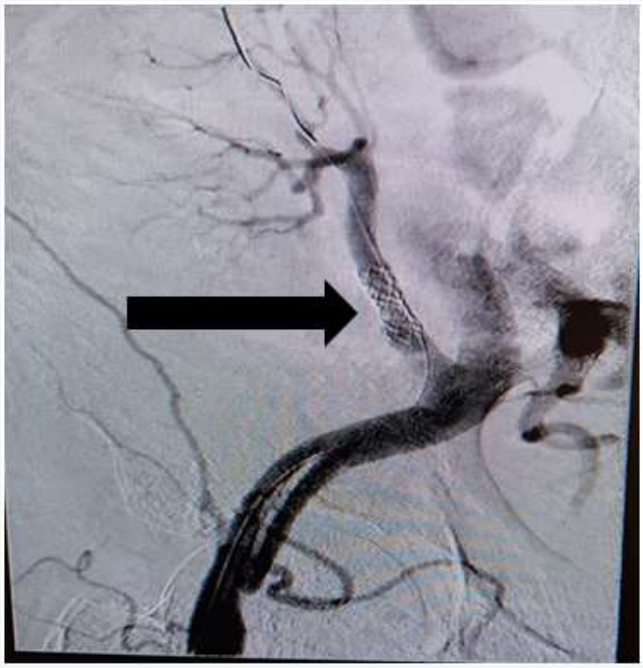

Figure 2: Successful placement of stent across stenotic area following balloon angioplasty with significantly improved antegrade flow.

perfusion with a total cold ischemia time of 23 hours.

The recipient is a 65-year-old African-American female with a BMI of 34.1 kg/m^2 who developed end stage renal disease secondary to hypertension and type 2 diabetes mellitus. She was receiving hemodialysis for 14 months prior to DDKT and underwent transplantation of a right kidney into the right iliac fossa. During back-bench preparation of the renal allograft, moderate hard aortic plaque was noted extending well beyond the orifice of the renal artery. For this reason, EE of the renal artery was performed prior to implantation. Intraoperatively, the kidney reperfused well and post-operative duplex ultrasonography was normal. The recipient initially experienced delayed graft function and required a single hemodialysis treatment on post-operative day #2 for hyperkalemia. The patient otherwise recovered well and was discharged home on postoperative day #3.

Over the next 9 months post-transplant, the serum creatinine level plateaued at 1.4 mg/dL with an estimated GFR of 40 ml/min/1.73m^2. During this time, she was also noted to have progressively worsening hypertension despite the addition of three antihypertensive medications, which raised suspicion for possible TRAS. Body weight was stable without peripheral edema. She underwent duplex ultrasonography of the renal allograft that demonstrated a hemodynamically significant stenosis of the mid-renal artery with a peak systolic velocity of 664 cm/s and associated post-stenotic turbulence.

She subsequently underwent arteriography performed by the Interventional Radiology service through a retrograde ipsilateral transfemoral approach that demonstrated dissection of the mid-renal artery with a corresponding high-grade 90% stenosis (Figure 3). Following heparinization, balloon angioplasty of the renal transplant artery with a 5 mm Sterling balloon was performed followed by deployment of a 6 mm x 18 mm Palmaz blue stent. The distal end of the stent was dilated to 5 mm and the proximal end flared to 6 mm with the Sterling balloon. Completion angiogram revealed a small residual dissection flap but overall excellent luminal gain (Figure 4). She tolerated the procedure well

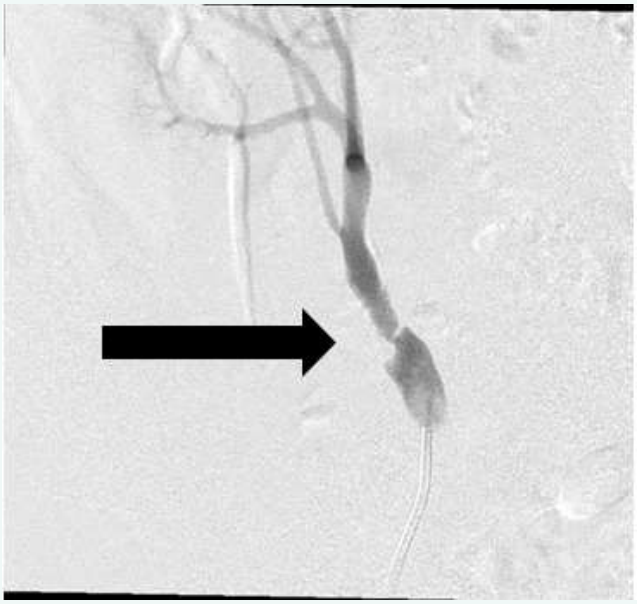

Figure 3: Second case – transfemoral ipsilateral retrograde arteriography demonstrating a high-grade stenosis (greater than 90%) from a dissection of the mid-renal artery

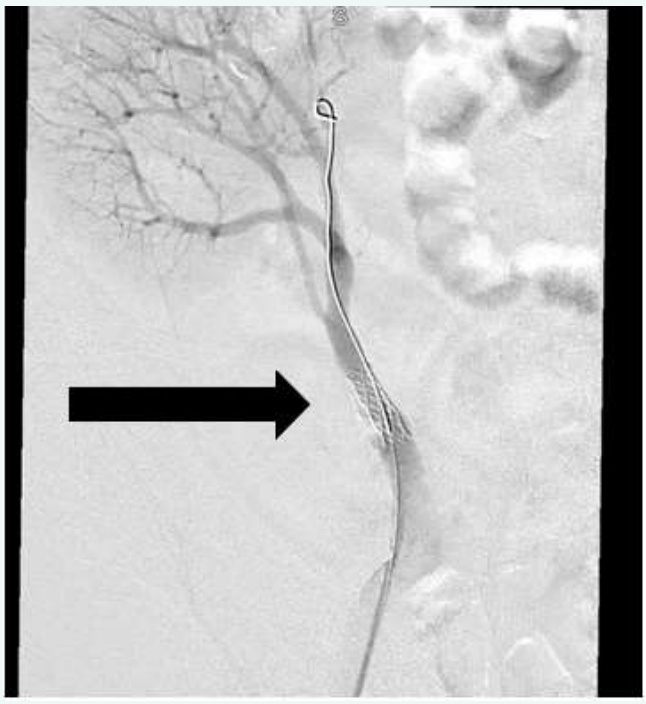

Figure 4: Successful stenting of the mid-renal artery with excellent luminal gain and near complete resolution of the stenosis following balloon angioplasty

and was discharged on dual anti-platelet therapy on the following day. At her clinic visit one week post-stenting, hypertension had improved and the serum creatinine level was 1.3 mg/dL with an estimated GFR of 46 ml/min/1.73m^2.

DISCUSSION

The persistent disparity between organ supply and demand challenges the transplant community to maximize and optimize the use of organs from all living and deceased donors. In the new millennium, the recovery of kidneys from older or medically complex donors has become increasingly accepted as a method to augment the organ supply [1-21]. Unfortunately, because of concerns raised regarding inadequate renal functional capacity and the projected limited life span of these kidneys, the kidney nonutilization rate has steadily increased and proportionately outpaced the rate of increase in kidneys recovered with the intent to transplant [1-7]. Changes in allocation policies and wider geographic sharing have likewise contributed to difficulties in timely placement of medically complex or "better than dialysis" kidneys [21-23].

In addition to limited renal functional capacity, lower projected lifespan, kidney biopsy findings, and poor pump parameters, another risk factor for kidney nonutilization with older donors is abnormal kidney anatomy, including the presence of intrinsic severe renal artery atherosclerosis. In 2018, we reported our initial experience with EE as a method of graft salvage in 17 patients undergoing DDKT [10]. All cases were technically successful and resulted in kidney transplantation. Most of these kidneys were imported from other donor service areas, suggesting that multiple centers had refused these kidneys prior to acceptance at our center and probably would have been discarded in the absence of our rescue utilization. Many transplant programs regard severe donor aortic and renal artery atherosclerosis as a surrogate marker for intra-renal atherosclerosis and intrinsic renal parenchymal disease. Consequently, in this setting, centers are reluctant to consider these kidneys for transplantation. The majority of these kidneys were from expanded criteria donors with a high KDPI score (mean 81±14%), suggesting a burden of atherosclerosis related to advanced age, longstanding hypertension, or diabetes that may have influenced kidney allocation and placement. We have further expanded this experience to include dual EE in dual kidney transplants [20].

With the widespread availability of duplex ultrasonographic imaging following DDKT, TRAS has become an increasingly recognized complication with a reported incidence of 1% to 23% [11-14]. This wide range has been attributed to variations in definition, reporting, and imaging protocols. TRAS usually presents with difficult to control post-transplant hypertension, edema, and/or allograft dysfunction (acute kidney injury). Less commonly, TRAS may present with flash pulmonary edema or even graft loss [11-14]. In some cases, the presence of a bruit over the allograft may be detected on physical examination. In the absence of diffuse disease, TRAS represents a technical complication that can often be managed successfully by timely diagnosis and appropriate intervention. Treatment of TRAS is based on the location and severity of the stenosis as determined by noninvasive imaging, clinical presentation, and angiographic findings [11-14]. In cases of moderate to severe stenosis coupled with the presence of suggestive signs and symptoms, endovascular therapeutic interventions have revolutionized the approach to TRAS.

Although the most common site of stenosis is in the proximal renal artery (either at the arterial anastomosis or renal ostia), early mid-renal artery (post-anastomotic) stenoses may occur secondary to kinking, extrinsic compression, or intimal damage. In our two cases, both patients presented with worsening hypertension that occurred in the first few months post-DDKT in the absence of acute rejection, which implied a nonimmunological etiology. The diagnosis was suggested by duplex ultrasonography, confirmed by arteriography, and treated successfully by percutaneous transluminal balloon angioplasty and stenting. In both cases, there was no angiographic evidence for kinking or extrinsic compression of the mid-renal artery, which further supports an intraluminal cause for the tight stenoses. Other potential risk factors for TRAS such as prolonged cold ischemia time, delayed graft function, progressive atherosclerosis, diabetes, acute or chronic rejection, or cytomegalovirus infection probably did not play a role in these two cases [11-14]. Given that the location of the stenoses in both cases corresponded to the presumed distal edge of the EE, we suspect that an unrecognized intimal flap following EE contributed to the development of this vascular complication.

In our overall experience with treating TRAS, we believe that transluminal balloon angioplasty and stenting rather than angioplasty alone is associated with improved durability. In addition, we prefer to wait at least one-month post-transplant to permit anastomotic healing prior to recommending any endovascular interventions. It is interesting to note that in both cases, the kidneys were imported from other states and the respective local organ procurement organizations granted us "open offers" so that we could proceed with out-of-sequence allocation and select appropriate recipients [16-25].

In summary, the critical shortage of donor kidneys compounded by the increasing rate of kidney nonutilization defines two of the major challenges in organ transplantation today. EE appears to be a safe and under-utilized salvage procedure in highly selected cases that may prevent nonutilization of donor kidneys with significant macrovascular disease. The presence of severe atherosclerosis with partially occlusive plaque extending into the renal artery should not be considered an absolute contraindication to DDKT. However, even in this setting, TRAS may occur, which can be managed by conventional angiographic techniques without risk of rupturing the endarterectomized renal artery.

CONFLICT OF INTERESTS/DISCLOSURE

The authors do not have any conflicts of interest to disclose pursuant to this study. This study was approved by the Atrium Health Wake Forest Baptist Institutional Review Board under the auspices of the Cortex Study, Protocol Number 00084139.

AUTHOR CONTRIBUTIONS

Concept/design: RK, AC, GO, RJS

Data analysis/interpretation/collection: RK, AC, RJS

Drafting article: RK, AC, RJS

Critical revision and approval of article: RK, AC, GO, CW, EM, ACF, RJS

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