Clinical impact of adjunctive donor microvascular reconstruction on renal transplantation

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Introduction: *Microvascular reconstruction was incorporated into our donor organ harvesting algorithm for kidneys with anatomic anomalies or injury of the vasculature. The impact of adjunctive microsurgery was appraised in terms of organ availability and graft quality procedures.*

Methods: *Out of a total of 441 renal transplant procedures performed by one surgeon (JLC) between 1984 and 1997, 104 allografts (83 cadaveric, 21 living related) required ex-vivo microvascular reconstruction. Micro-reconstruction using 2.5-10 X magnification was employed to create a single artery and vein for subsequent in-situ anastomosis. Side-to-side or end-to-side anastomosis was performed, depending on the vascular arrangement. Multiple vessels and those injured during harvesting were reconstructed with a combination of the above techniques.*

Results: *Eleven kidneys had two or more arterial anastomoses; 12 had combination (arterial and venous) anastomoses while 74 required a single micro-reconstruction. In addition, seven kidneys with severely traumatized vessels were salvaged. Average bench surgery times were 30 and 50 minutes for single and multiple reconstructions respectively. Mean warm ischemic time was 29 minutes. Three kidneys were lost due to vascular thrombosis (two venous, one arterial) where in-situ technical difficulties were encountered in all three cases. With mean follow-up of 30 months, 23 kidneys had been lost due to chronic rejection with the remainder functioning.*

Conclusion: *Extensive microvascular reconstruction salvaged 30 suboptimal or previously deemed unusable grafts (30/439 = 7%) and facilitated the vascular anastomosis in another 74 cases (17%). The warm ischemic time and the possibility of in-situ technical errors with small-caliber vessels were minimized. This report affirms the contention that microvascular reconstruction should be available as an adjunctive technique for renal transplantation, to maximize the quantity and quality of donor kidneys.*

Key Words: microvascular reconstruction, renal transplantation

Remembrance

Dr. Ernest Ramsey and I came from very different backgrounds and we became "academic" urologists via different routes. Dr. Ramsey's non-medical interests were quite different from mine. However we had a special "urologic kinship" in that we shared an interest in three fringe areas of Urology: 1) renal transplantation; 2) administration of chemotherapy for germ cell tumors; and 3) loin pain hematuria syndrome. For years, Dr. Ramsey was, amongst his numerous roles, the heart and soul of the renal transplant and the uro-oncology programmes at the University of Manitoba. This article is dedicated from one renal transplant urologist and uro-oncologist to another. I miss the special kinship and the opportunity to consult with Ernie on these urologically esoteric areas.

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Introduction

Renal transplantation is the preferred therapy for patients suffering from end stage renal disease. However, the number of available organs has not kept up with the demand. It has been noted that up to 44% of donors have multiple renal vessels, with up to 12% being bilateral.[1] The presence of multiple vessels increases the technical complexity of the vascular anastomoses during renal transplantation or it may preclude the use of the donor organ altogether. While the Carrel patch is the preferred method of anastomosing multiple renal arteries, it should not be employed in case of a live donor and is technically not feasible if the multiple renal arteries have remote aortic origins. To avoid subjecting the kidney to prolonged warm ischemia with multiple in situ anastomoses, ex vivo microvascular reconstruction of the donor renal vessels had been proposed.[2,3] The main objective is to create single arterial and venous ostium in a >bench= setting, to facilitate the subsequent in situ anastomoses. The same technique is also used to salvage kidneys with damaged vessels, which would otherwise have been discarded. Our technique and early results have previously been described.[4,5] Herein, we report the expanded experience of such microvascular reconstruction in 104 cases with follow up of graft status to affirm its role in renal transplantation.

Patients and methods

From 1984 to 1997, out of 441 renal transplants performed by one surgeon, 104 adjunctive microvascular reconstruction was carried out on 83 cadaveric kidneys (harvested en bloc) and 21 live donor kidneys. Mean age for the allograft recipients (64 male, 40 female) was 46.7 years (range 25-70). Bench dissection and microvascular reconstruction was performed in a basin of iced saline. A Zeiss operative microscope or optical loupes was used to provide 2.5-10 X magnification, and 8-, 9-, 10- 'O' monofilament, nonabsorbable sutures were used, with the goal of creating a single artery and vein for subsequent in situ anastomosis.

Multiple vessels, comparable caliber

Double arteries with similar lumen caliber were anastomosed side-to-side to create a conjoint ostium using 8- >O= running suture.

Multiple vessels, disparate caliber

The polar or accessory artery was anastomosed end-to-side to the larger caliber main artery. An arteriotomy was made by excising a patch from the main artery. The smaller artery was spatulated and a 25-gauge intravenous cannula was used as an intra-luminal stent when completing the anastomosis using 8- to 10- >O= sutures, depending on the vessel diameter.

Veins

Major veins which were large and of comparable caliber were anastomosed side-to-side. Smaller accessory veins were tied off. For renal veins which were too short, part of the inferior vena cava was incorporated into the renal vein to gain length as previously described.[7]

Multiple arteries and veins

Kidneys with three or more vessels were reconstructed using a combination of the afore-mentioned technique, aiming at creating a single ostium for subsequent anastomosis to the recipient vessels. Injured vessels without loss of length were anastomosed end-to-end after appropriate debridement. At the completion of the microvascular reconstruction the main vessels were cannulated and flushed with Collin's solution to check for water-tightness at the anastomoses. Renal transplantation was then carried out in the standard manner with end-to-side anastomosis to the external iliac vessels. In the first four years of the study period all patients underwent post-operative radionuclide renal scan on postoperative day 1. More recently, Doppler flow studies were performed on post-operative day 1 to assess graft perfusion.

Results

Eleven kidneys had two or more arterial anastomoses; 12 had combination anastomoses while 74 required a single microvascular reconstruction Table 1, Figure 1. Included in this group was one living-related donor kidney which, at the time of donor nephrectomy, reviewed a 1.3 cm diameter aneurysm at the junction between the lower pole branch and the main renal artery Figure 2. The pre-operative renal arteriogram had failed to detect this finding. Excision of the aneurysm and microvascular repair was performed ex vivo prior to transplantation Figure 2. Seven kidneys with severely traumatized vessels were salvaged Table 2, Figure 3. Average bench surgery time was 30 minutes for single and 50 minutes for multiple reconstruction respectively. The average warm ischemic time was 29 minutes.

Three kidneys were lost due to vascular thrombosis (two venous, one arterial) with all three transplant procedures having encountered in situ technical

TABLE 1. **Methods of microvascular reconstruction employed**

Anatomy	Anastomosis	Number
Single anastomosis (74)*		
Polar or accessory artery	End to side	41
Duplicate arteries	Side to side	18
Short renal veins	Caval extension	12
Duplicate veins	Side to side	3
Multiple arterial anastomoses (11)		
3 arteries (2 main/1 polar)	End to side + side to side	6
Renal artery aneurysm +/- accessory artery	Excision of aneurysm + end to side	3
5 arteries	Smaller vessels sacrificed, end to side for polar	1
Situs inversus, 2 art. either pole, short vein	Art: anastomosed separately; vein caval extension	1
Multiple artery & venous anastomoses (12)		
2 renal arteries, short vein	Art: end to side; vein caval extension	6
2 renal arteries, two short veins	Side to side	3
3 renal arteries, 2 veins	Art: Carrel patch/end to side; vein: side to side	2
3 renal arteries, short vein	Art: Carrel patch; vein: caval extension	1

Art = artery
* includes one kidney with renal artery anerysm repaired microsurgically

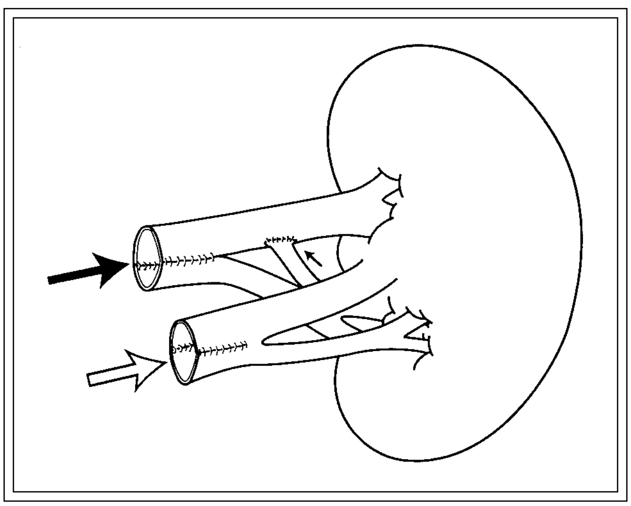

Figure 1a. Kidney with three arteries (two equal-caliber larger and a smaller mid-zone vessel) and two equal-calibre veins. The two larger arteries were anastomosed side-to-side (solid large arrow) and the smaller artery was anastomosed end-to- side to the upper pole larger artery (small solid arrow). The two veins were anastomosed side-to-side (open arrow).

difficulties (severe atherosclerosis and peri-vascular fibrosis). There were two perioperative deaths, due respectively to myocardial infarction and sepsis. The later patient had combined small bowel and renal transplantation. He developed post-operative sepsis in spite of initial graft function.

Figure 1b. Graft after micro-vascular reconstruction with a single arterial and single venous ostium.

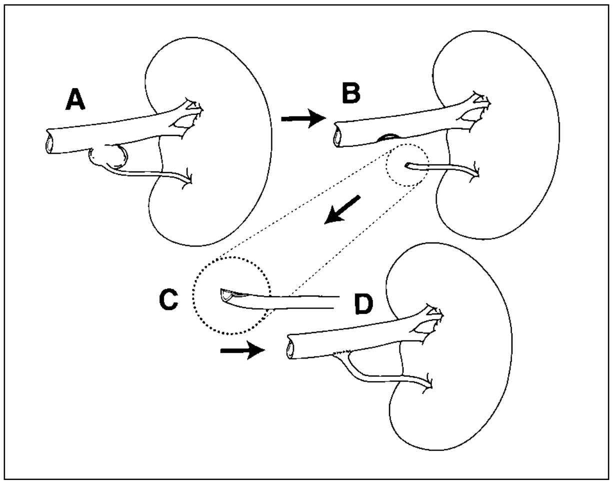

Figure 2a. Schematic drawing of renal artery aneurysm at junction of lower pole branch and main renal artery (A). The aneurysm was excised (B) and the lower pole artery spatulated (C) and anastomosed end-to-side to the main artery (D).

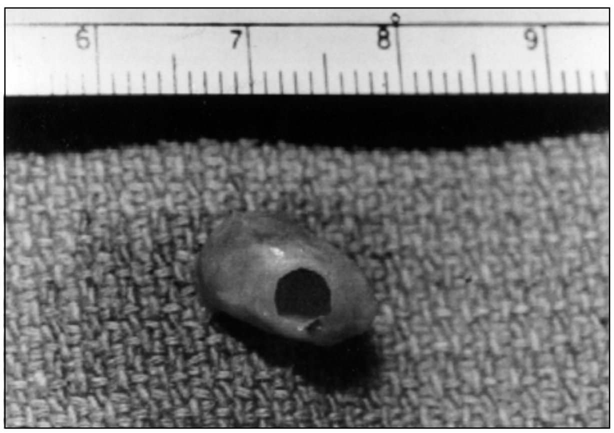

Figure 2b. Excised aneurysm with a 1.3 cm diameter.

Radionuclide renal scan, and more recently Doppler studies, showed good perfusion with no segmental defects in 101 grafts. Four patients with functioning renal grafts subsequently died respectively from urosepsis (at 53 months), myocardial infarction (at 26 months), metastatic lung carcinoma (at 15 months) and intra-abdominal sepsis (at 1.5 months). With mean follow up of 30 months, 23 kidneys were lost due to chronic rejection with the remainder functioning.

Discussion

A significant number of kidneys have multiple

Figure 2c. Completed microvascular reconstruction.

vessels.[1] Due to the universal shortage of cadaveric donor organs, most centres would transplant such kidneys using a variety of techniques to handle the vascular variations. More liberal employment of live donors is the other obvious solution to the organ shortage.

Novick et al[2] popularized the technique of ex-vivo microvascular reconstruction for multiple vessels. They emphasized extracorporeal microvascular reconstruction to preserve and revascularize all the small accessory vessels when a Carrel patch was deemed impossible. In the case of double vessels with similar caliber, the creation of a single ostium for anastomosis allows for more hemodynamically favorable flow than through two separate smaller vessels. In the case of two vessels with disparate calibers an end-to-side anastomosis of the smaller vessel to the main vessel obviates the need of in situ anastomosis of a small vessel either to a small recipient vessel or to a main donor vessel with a major discrepancy in vessel wall thickness and diameter. An end-to-side anastomosis between two vessels with disparate caliber was the most commonly employed

TABLE 2. **Reconstruction for traumatized donor renal vessels**

Anatomy	**Anastomosis**	**Number**
Damaged	Combination of all techniques	5
3 arteries, multiple veins, lacerated artery	Art: end/side, side/side & repaired; Vein; caval extension + side/side, smaller veins ligated	1
Duplicated veins with perforations	Veins repaired & incorporated into cava as single ostium	1

Art = artery

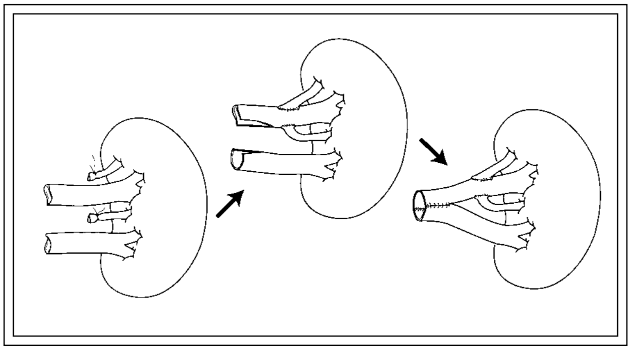

Figure 3. Cadaveric kidney with four arteries harvested with two smaller arteries inadvertently traumatized and ligated by the harvesting surgical team. The two stumps were "freshened" and anastomosed end-to-side to the upper pole artery and the two larger arteries were anastomosed side-to-side. The end result was the salvage of a traumatized kidney with four arteries.

technique in this series. There are authors, however, who advocate in situ separate vascular anastomoses.[7] Although technically feasible, this approach suffers from less than optimal exposure and accessibility. Warm ischemic time is longer than the bench techniques. Alternatively, the recipient's hypogastric vessel and its branches could be used either in situ or harvested as an autograft.[8] However, variations in the anatomic structure of the hypogastric artery or significant atherosclerotic disease frequently precludes its use in this manner. Other recent reports support the use of the ex vivo bench surgery technique as the method of choice in different transplant settings.[8-11]

Microvascular bench reconstruction has increased the number of live donors by rendering individuals with complex renal vascular arrangement (including renal artery aneurysms, as illustrated in one case herein) suitable for kidney donation. Miura et al[8] reported 15 cases of microreconstruction out of 56 cases of living related kidney transplant, while Kawase[10] reported 46 cases in a series of 407. Both authors reported satisfactory results. A significant number of these potential donors would otherwise be refused in favor of cadaver donors because of the complicated vasculatures in the donor. Fourteen kidneys from live donors in our series benefited from microvascular reconstruction. The time required for the ex vivo surgery depends on the number of vessels involved and the complexity of the reconstruction. With cadaveric allografts, the ex vivo reconstruction can be performed prior to the recipient's anesthesia induction and thus, does not impact on the warm ischemic time.

Over the years, a substantial number of donor kidneys have been rejected due to vascular injury at the time of organ harvesting. Kalicinski et al[9] advocated a policy of transplanting all viable grafts, even those with complicated vascular anomalies and/or injuries, which had been rejected by other transplant centres. Primary vascular complications leading to graft loss was noted in 6% in their series, although recipient factors likely contributed to that. Otherwise, the graft function and survival were similar to those without vascular anomalies. Our current series shows that the majority of these grafts can be salvaged by micro-reconstruction. We therefore recommend performing extensive repairs on injured but otherwise viable grafts whenever necessary. In the rare event that a kidney needs to be auto-transplanted due to underlying diseases, microvascular reconstruction again plays an important role when multiple vessels are involved.[5,12] Vegeto et al reviewed the outcome of 551 renal grafts, reporting a slightly higher incidence of reoperation and urological complication amongst those recipients who required ex vivo arterial micro-reconstruction for either damaged or multiple vessels, although the functional and actuarial graft survival was not adversely affected.[13] The high reoperation rate contrasts that from other reports.[4,8,11]

The ex vivo bench approach allows for optimal exposure and illumination, a bloodless surgical field and facilitates meticulous microvascular reconstruction under optimal magnification. The microvascular suture line can also be checked for water-tightness ex vivo prior to transplantation.

Conclusion

This expanded series affirms the notion that microvascular reconstruction can be performed safely and expeditiously in conjunction with renal transplantation. The use of various anastomosis techniques allows for its application in donor kidneys with different vascular arrangements, facilitating the subsequent in situ anastomosis. The most significant clinical impact is the expansion of the donor pool, both live and cadaveric, which has helped to alleviate the donor shortage for renal transplantation. □

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