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Different techniques of vessel reconstruction during kidney transplantation

Različite tehnike rekonstrukcije krvnih sudova prilikom presađivanja bubrega

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Abstract

Background/Aim. Multiple renal arteries (MRAs) represent a surgical challenge by the difficulty in performing anastomoses, bleeding and stenosis. MRAs should be preserved and special attention should be paid to accessory polar arteries. All renal arteries (RAs) must be reconstructed and prepared for safe anastomosis. The paper decribed the different techniques of vessel reconstruction during kidney transplantation including important steps within recovery of organs, preparation and implantation. **Methods.** In a 16-year period (1996–2012) of kidney transplantation in the Military Medical Academy, Belgrade, a total of 310 living donors and 44 human cadaver kidney transplantations were performed, of which 28 (8%) kidneys had two or more RAs. **Results.** All the transplanted kidneys had immediate function. We repaired 20 cases of donor kidneys with 2 arteries, 4 cases with three RAs, one case with 4 RAs, one case with 4 RAs and renal vein reconstruction, one case with 3 arteries and additional polytetrafluoroethylene (PTFE) graft reconstruction, one case with transected renal artery and reconstruction with 5 cm long deceased donor external iliac artery. There were no major complications and graft failure. At a minimum of 1-year follow-up, all the patients showed normal renal function. **Conclusion.** Donor kidney transplantation on a contralateral side and "end-to-end" anastomosis of the renal artery to the internal iliac artery (IIA) is our standard procedure with satisfactory results. Renal artery reconstruction and anastomosis with IIA is a safe and highly efficient procedure and kidneys with MRAs are not contraindicated for transplantation. A surgical team should be fully competent to remove cadaveric abdominal organs to avoid accidental injuries of organs vessels.

Key words:
kidney transplantation; surgical procedures, operative; postoperative period; renal artery; renal blood flow, effective; anastomosis, surgical.

Apstrakt

Uvod/Cilj. Multiple bubrežne arterije (MBA) predstavljaju hirurški izazov zbog anastomoza, krvarenja i stenoza. One se moraju sačuvati, rekonstruisati i pripremiti za sigurnu anastomozu. Posebna pažnja usmerena je na polarnu arteriju. U ovom radu prikazali smo različite tehnike koje koristimo za rekonstrukciju krvnih sudova tokom transplantacije bubrega, uključujući važne korake tokom eksplantacije, preparacije i implantacije. **Metode.** Tokom 16 godina (1996–2012.) transplantacije u Vojnomedicinskoj akademiji u Beogradu, uradili smo 310 živih i 44 kadaverične transplantacije bubrega, a kod 28 (8%) bubrega bile su prisutne dve ili više bubrežnih arterija (BA). **Rezultati.** Svi transplantirani bubrezi profunkcionisali su neposredno posle operacije. Nije bilo većih komplikacija ni gubitka grafta. Rekonstruisali smo 20 bubrega sa dve BA, 4 bubrega sa tri BA, 1 bubreg sa četiri BA, jedan sa 4 arterije i rekonstrukcijom vene, 1 bubreg sa 3 arterije i interpozicijom politetrafluoroetilenskog (PTFE) grafta i jedan bubreg sa odsečenom BA i rekonstrukcijom donorskom spoljašnjom ilijačnom arterijom. U minimalnom praćenju od 1 godine, svi transplantirani bolesnici su imali normalnu funkciju bubrega. **Zaključak.** Transplantacija donorskog bubrega na kontralateralnu stranu recipijenta i terminoterminalna anastomoza bubrežne arterije sa unutrašnjom ilijačnom arterijom je naša standardna procedura kojom ostvarujemo zadovoljavajuće rezultate. Rekonstrukcija bubrežnih arterija i anastomoza sa unutrašnjom ilijačnom arterijom predstavlja sigurnu i efikasnu proceduru za koju bubrezi sa više arterija nisu kontraindikovani za transplantaciju. Hirurški tim za kadaveričnu eksplantaciju organa mora biti u potpunosti spreman da bi se izbegle povrede organa i krvnih sudova.

Ključne reči:
transplantacija bubrega; hirurgija, operativne procedure; postoperativni period; a.renalis; krvni sudovi, prolaznost; anastomoza, hirurška.

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Introduction

Grafts with anatomic variants, especially multiple renal arteries (MRAs), are still challenging problems to the surgeons. The use of grafts with MRAs has been considered relatively contraindicated because of the increased incidence of vascular and urologic complications [1]. Injuries of renal arteries (RAs) during recovery of organs make additional problems in organ transplantation. In this retrospective study, we reviewed variation of surgical technique in reconstruction of renal allograft with multiple and injured arteries.

Methods

In the Military Medical Academy (MMA) in Belgrade during a 16-year experience (1996–2012) in kidney transplantation we performed 354 transplantation, 310 living donor and 44 deceased donor kidney transplantations, out of which 28 (8%) had two or more MRAs and some kind of reconstruction. We repaired 20 donor kidneys with 2 arteries, 4 with 3 RAs, one with 4 RAs, one case with 4 RAs and renal vein reconstruction, 1 with 3 arteries and additional polytetrafluoroethylene (PTFE) graft reconstruction, 1 with transected renal artery and reconstruction with a 5 cm long deceased donor external iliac artery. All kidney transplantation were performed to the iliac fosse and almost all anastomoses performed as "end-to-end" to the IIA using two opposite knots suture technique. Donor's renal veins were anastomosed "end-to-side" to the external iliac vein in all cases.

This technique provides good feasibility in case of short transplant renal artery. "End to side" anastomosis of the renal artery and the external iliac artery was performed in 5 cases. In deceased donor recovery of organs, RAs and veins as well as existing patches dissected from perivascular tissue and branches leaving the renal vessels were ligated. MRAs or accessory polar arteries were located and explanted on a single aortal patch, and anastomosed with external iliac artery in "end-to-side" fashion**.** In case of great distance between the arteries the patch was divided in two for sequential anastomosis. In living donor nephrectomy the most common case of multiple arteries, namely polar artery, were conjoined with renal artery and anastomosed like "end-to-end" to the IIA.

In one difficult case we used the PTFE vascular graft N^{o}V (GORE-TEX,WL Gore & Associates, Newark, Delaware, USA) as a 4 cm interposed graft between the kidney allograft with 3 conjoined short RAs and recipient's short IIA during kidney transplantation. Both anastomoses on graft were in "end-to-end" fashion. PTFE grafts in kidney transplantation are short in length and have a high blood flow. In this case, 3 arteries conjoined in one problematic ostium with tendency to stenosis, and PTFE graft secured these tiny anastomoses and held them open.

Additional problems were iatrogenic injuries of kidney vessels during recovery of organs. There were 5 cases of such injuries successfully resolved. One case of complete section of renal artery during deceased donor recovery of organs resolved with interposition of 5 cm length deceased donor external iliac artery. The second case was the injury of 4 kidney arterial branches (2 mm diameter) during living donor nephrectomy repaired with Prolen 8/0 suture. Small bleeding stoped spontaneously with a little help of Surgicell (Johnson & Johnson).

Other injury cases were resolved with multiple Prolen 6/0 suture. Probably, the most difficult case of reconstruction in our series was a case of deceased donor right kidney with injury of all 4 arterial branches and renal vein. Arterial branches conjoined in one, and the right renal vein were reconstructed with interposition of a 3 cm long part of donor's inferior vena cava.

Routine color duplex sonography was performed after renal transplantation and repeatedly during the early postoperative phase for evaluation of the perfusion. In case of any problems or doubt we perform multisliced computed tomography (MSCT) angiography with immediate reoperation if it is needed.

Results

Various techniques of vessel reconstruction during kidney transplantation are presented in Figures 1–6. Operation time was significantly longer in group with MRAs than with single RA. Mean ischemic time in living donor cases with single artery and without injuries was 59 minutes and in cases with arterial reconstruction these time was prolonged to 102 min ($p < 0.05$), but without any clinical signs of decreased kidney function. Except 4 cases with thrombosis of polar branch and 3 cases with minor intraoperative bleeding, surgery of MRAs was without other major complications. There was no difference in postoperative hospital stay and for the rate of surgical complication comparing these two groups ($p < 0.05$). At a minimum of 1-year follow-up, all the patients showed normal renal function, and color Doppler sonography indicated no thrombus formation or obstruction in the main renal artery. There were no differences in a 5-year graft function comparing these 2 groups ($p < 0.05$). Further follow-up was not done because patients scattered in all directions.

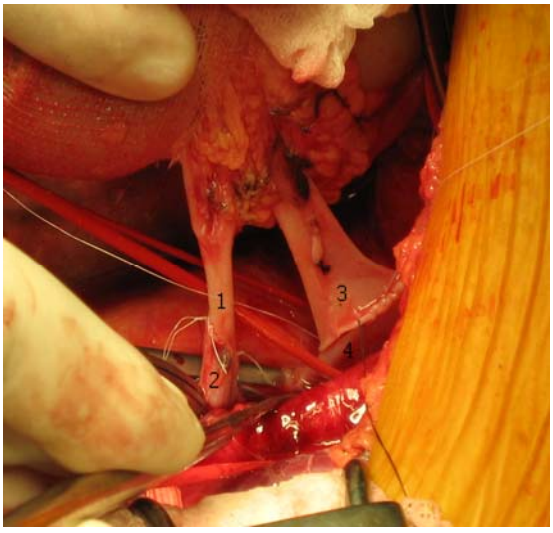

Fig. 1 – "End-to-end" anastomosis of the renal artery and the iliac internal artery. "End-to-side" anastomosis of the renal vein and the iliac external vein (1 – the renal artery, 2 – the iliac internal artery, 3 – the renal vein, 4 – the iliac external vein).

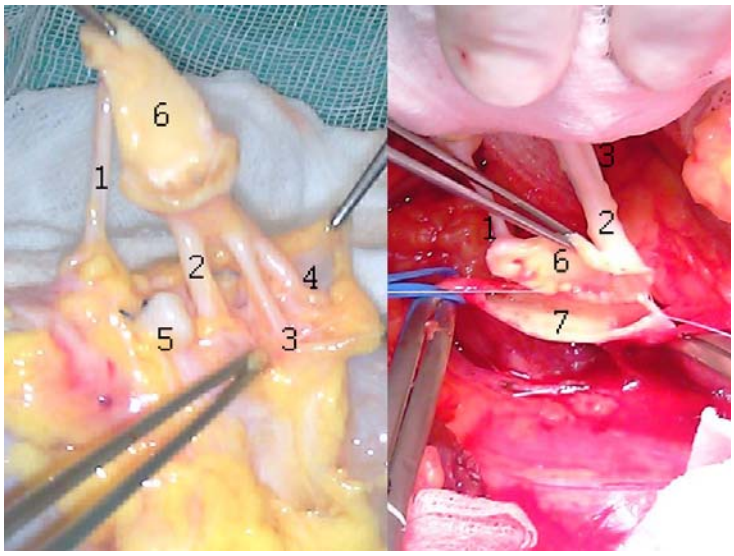

Fig. 2 – Conjoined renal artery and the accessory renal artery, and anastomosis with the IIA (1 – the renal artery, 2 – the accessory renal artery, 3 – the iliac internal artery, 4 – the renal vein, 5 – the iliac external vein, 6 – the iliac external artery, 7 – the gonadal vein).

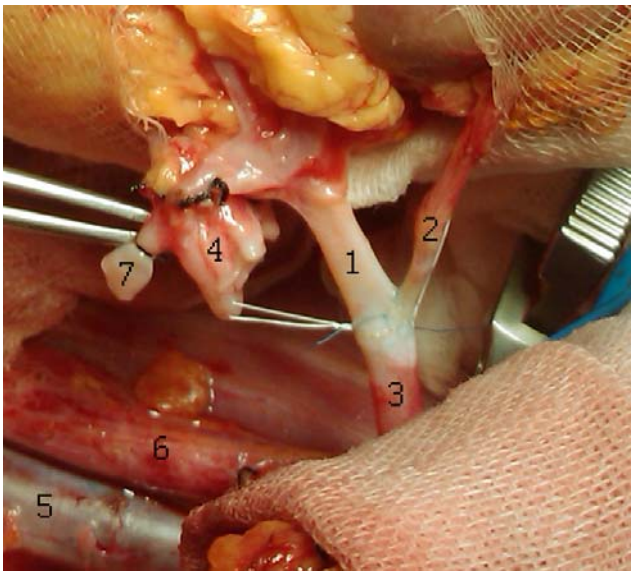

Fig. 3 – "End-to-side" anastomosis of the renal arteries on aortic patch and the external iliac artery (1 – accessory renal artery; 2, 3, 4 – renal artery branches; 5 – the renal vein; 6 – aortic patch; 7 – external iliac artery).

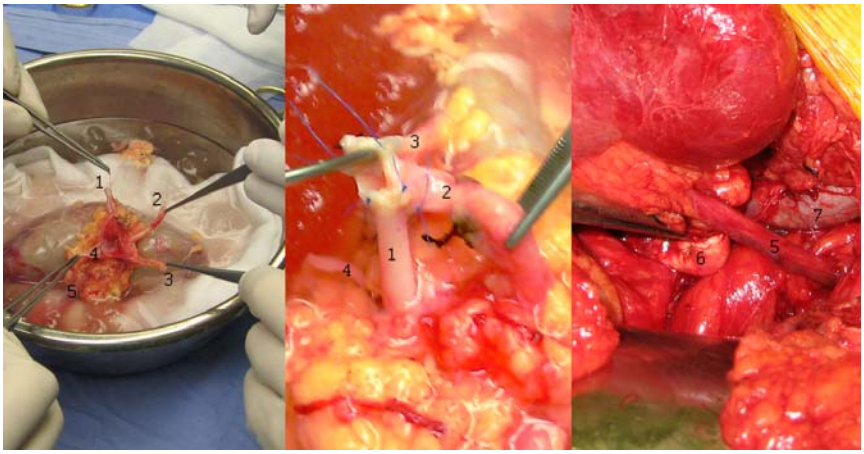

Fig. 4 – Conjoined 3 renal arteries anastomosed with polytetrafluoroethylene (PTFE) graft anastomosed with the iliac internal artery (1 – superior arterial branch, 2 –middle arterial branch, 3 – inferior arterial branch, 4 – the renal vein, 5 – the urether, 6 – PTFE graft, 7 – the iliac external vein).

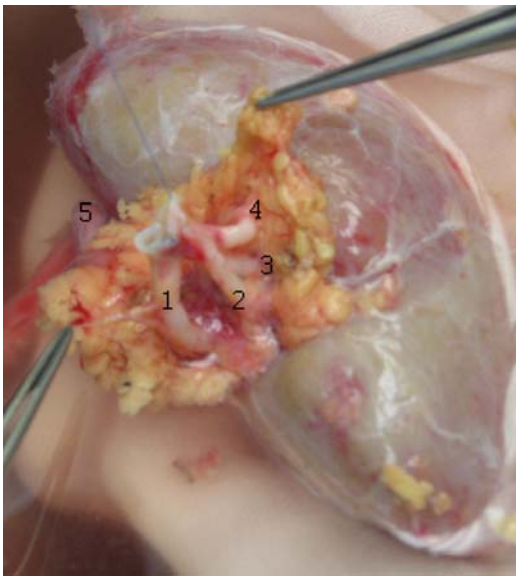

Fig. 5 – Conjoined 4 arterial branches with multiple anastomosis (1, 2, 3, 4 – arterial branches).

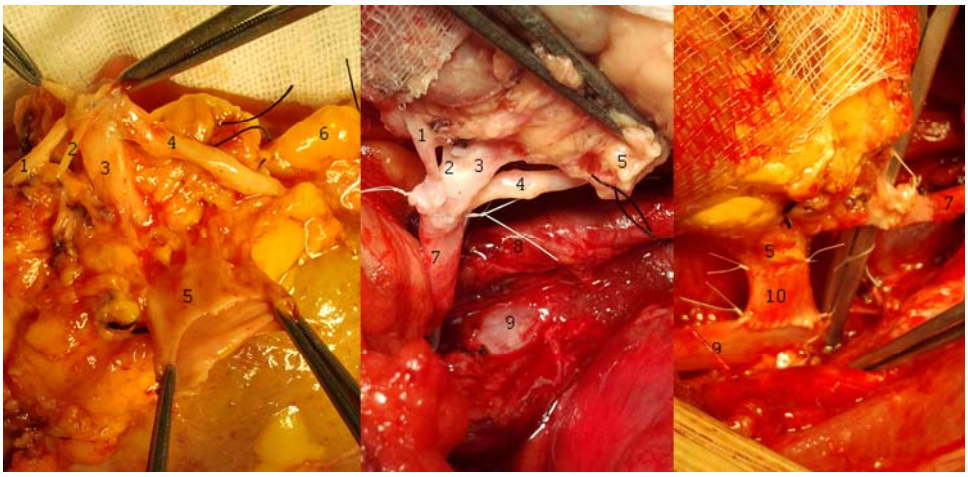

Fig. 6 – (1, 2, 3, 4- arterial branches; 5 – renal vein; 6 – the urether; 7 – the iliac internal artery; 8 – the iliac external artery; 9 – the iliac external vein; 10 – interposition of vena cava inferior conduit).

Discussion

The existence of MRAs has been considered a relative contraindication because of the incidence of vascular and urologic complications [1]. In our patient population of kidney transplantation we analyzed the outcomes of kidneys recipients with MRAs or repaired RAs in comparison to grafts with single arteries, and found no difference between these two groups [2]. Recently, studies have also shown that grafts with MRAs *vs* grafts with single artery present no differences of surgical complications and outcome [3, 4]. Respectable authors suggested some different and alternative techniques of vessels reconstruction [5]. Alternatively, a polar artery should be reconstructed to the renal artery like "end-to-side" anastomosis, but with a high risk of vascular obliteration of both vessels. If anastomosis of small polar arteries seems to be very difficult, it can be perfused and closed with a risk for distal necrosis of the ureter and small area of infarction in lower part of the kidney. In our series almost all renal anastomosis made as "end-to-end" to internal iliac artery (IIA). We found that these anastomoses offer good position for the kidney because of extended length of artery and kidney can be placed in the best position in iliac bed. Also, living donor kidneys a procured without an aortal patch for transplantation and IIA adds length to the RA. The length of the arteries is even more important than the existence of patches. Unfortunately, incongruity of the lumen often appears making anastomosis difficult and complex and the IIA bears the risk of kinking, leading to vascular occlusion [5]. In addition, the IIA does not provide possibilities for sequential anastomosis in case of MRAs as common and external iliac arteries, but conjoined MRA can be efficiently anastomosed as "end-to-end" with IIA. The external iliac artery provides good opportunity upon the existence of accessory renal or polar arteries without a common patch, and used for "end-to-side" anastomosis [5, 6]. The polar artery also can be anastomosed with the epigastric inferior artery [6]. We favor the conjoined arterial anastomosis technique in case of MRAs rather than separate or sequential anastomoses. The distal part of the IIA is ligated. In very rare cases impaired blood flow may have im-

pact on penile vascularity and erectile function in particular after second kidney transplantation to the contralateral side with both IIA ligated [5]. In our series this complication prevention was by preserving branches of IIA and ligature above bifurcation. With that, collateral circulation between branches is allowed. There was no complication as erectile dysfunction in our series (one case of bilateral kidney transplantation on IIA in a young male). Arteriosclerosic plaques were frequently found in donor organs, and mild occurrence had no effect. Along with severe arteriosclerosis the risk of intimal injury and vascular occlusion is augmented. Intimal desquamation within the patch or proximal artery requires shortening of the artery or fixation of the intimal flap to avoid dissection and vascular occlusion. Patches with severe arteriosclerosis and intimal lesions should rather be removed. Gentle dissections of the recipient's vessels with ligature of the lymphatic vessels are performed to avoid lympoceles. Injuries of donor organ vessels must be minimized, especially in deceased donor procurement. In living donor nephrectomy, in our hospital senior surgeons with wide experience in techniques rarely inflict injuries. But, in deceased donor recovery of organs, younger specialists and residents with less experience, frequently make mistakes. An abdominal team should be fully competent to remove kidneys [7]. Recently, our team of vascular surgeons and urologists has tried to avoid accidental injuries of kidneys, especially kidney's vessels. There are disagreements among transplant surgeons which side and which vessels of recipient's pelvis to use in receiving the kidney. Some respectable authors prefer placing the donor kidney in recipient's contralateral side (left kidney on the right side) to ensure the renal pelvis and ureter are anterior if future reoperation is required. In case of doubt, these authors recommended right side, because of wider choice of vessels for reconstruction [8]. Right side as better choice is recommended because right vessels are "more horizontal" and easier to use in anastomoses [9]. We recommend contralateral side in cases of RA and IIA anastomosis. As mentioned above, anterior position of the renal pelvis and the ureter ensure better approach if reoperation is required. Additional reasons are better positioning of the kidney in iliac bed, because of longer arteries "loop" and better mobility of the kidney. In these cases there is no pressure on renal vein by renal artery with probably vein congestion as in cases of "end-to-side" renal artery anastomoses with external iliac artery in contralateral position of kidney. If we plan anastomoses on external iliac artery, it is better to choose ipsilateral kidney (right kidney to right side). In this surgically easier case, there is no compression of the renal artery on the renal vein and the renal pelvis and the ureter are in anterior position, but with a reduced mobility of the kidney. If we could choose the side and the kidney, the best option would be transplantation of the left kidney to the right side, with "end-to-end" anastomosis of RA and IIA. The left renal vein is longer than the right one which makes vein anastomosis much easier. Right iliac vessels are slightly more accessible than left sided. "End-to-end" anastomosis of the kidney and IIA ensure good mobility and the best kidney positioning, with no pressure on the renal vein and excellent vein outflow. Rare incongruity of RA and IIA could be resolved by spatulation of smaller artery and meticulous surgical technique.

Conclusion

Donor organs with multiple renal arteries, missing aortic patches or severe arteriosclerosis challenge the technical skills of each transplant surgeon. Transplantation of donor kidney on contralateral side and "end to end" anastomosis of the renal artery to the internal iliac artery is our standard procedure with satisfactory results. Conjoined multiple renal arteries and anastomosis with interval iliac artery is safe and highly efficient, instead of increasing technical difficulties. A surgical team should be fully competent to remove abdominal organs to avoid accidental injuries of organs vessels.

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