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Reverse Spatulated Hybrid Technique of Arterial Anastomosis in Kidney Transplant

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Abstract

Introduction: Kidney transplant is the treatment of choice for end-stage renal disease. Vascular anastomosis remains a critical determinant of success, influencing graft perfusion, patency, and long-term function. Several techniques have been developed to minimize ischemia time and reduce vascular complications, particularly in arterial anastomoses. The reverse spatulated hybrid technique (RSHT) combines reverse spatulation of the donor renal artery with an oblique arteriotomy of the recipient internal iliac artery. To create a wide anastomosis and ensure that all sutures are taken under vision, thereby reducing the chances of TRAS to almost negligible levels. This study describes the RSHT and evaluates its clinical outcomes in renal transplantation. **Objective:** To evaluate the outcomes of the RSHT in kidney transplantation, focusing on vascular complications, ischemia times, and early graft function, including delayed graft function. **Methods:** In this single-center observational study, 101 kidney transplants were performed between October 2024 and February 2025. Eighty-six recipients with a single renal artery undergoing end-to-end anastomosis to the internal iliac artery using RSHT were included; 15 cases with multiple renal arteries, end-to-side anastomosis to the external iliac artery, cadaveric donors, or combined liver-kidney transplantation were excluded. The main point in RSHT is visualizing the lie of both RA and IIA and precisely spatulating both vessels in the reverse direction. Lie, and spatulation is a visual assessment made beforehand and is the key learning step in RSHT. The first suture is taken at the 6 o'clock position on both vessels, and the determination of this point and precise suturing is another key step. With both these maneuvers, we are able to create the widest possible anastomosis between RA and IIA and also maintain the final lie of the graft without kinking the anastomosis. Outcomes were assessed by Doppler ultrasonography and serum creatinine at predefined time points, and by clinical follow-up. **Results:** Eighty-six recipients were an-

alyzed (mean age 36 years ± 13.2 years; range 9 - 66), of whom 64 (74.4%) were male, and 22 (25.6%) were female. Most donor nephrectomies were laparoscopic (82; 95.3%), with 4 (4.7%) open procedures; the graft renal artery was anastomosed to the right internal iliac artery in 84 cases (97.6%) and to the left in 2 (2.4%). Mean warm and cold ischemia times were 3.2 minutes (range 1 - 8) and 75.2 minutes (range 49 - 116), respectively; mean arterial and venous anastomosis times were 15.5 minutes (range 9 - 32) and 12.4 minutes (range 7 - 26). No vascular complications were observed in the early postoperative period: there were no cases of arterial or venous thrombosis or arterial stenosis on Doppler ultrasonography at days 1, 4, and 30. Mean serum creatinine values were 2.87 mg/dL on day 1, 1.3 mg/dL on day 3, and 1.2 mg/dL on days 30 and 90, and no delayed graft function occurred in this cohort. Two patients died from medical (non-surgical) complications. **Conclusion:** The RSHT provides a favorable anastomotic geometry that may reduce flow turbulence and optimize vascular hemodynamics in renal transplantation. Although technically more complex and associated with a longer learning curve than conventional end-to-end anastomosis, the technique in this series was associated with acceptable ischemia and anastomosis times, absence of early vascular complications, and excellent early graft function without delayed graft function. The main limitations are the short mean follow-up and single-center design; larger multicenter studies with longer follow-up are needed to confirm the long-term patency and clinical impact of RSHT in kidney transplantation.

Keywords

Kidney Transplantation, Vascular Anastomosis, Reverse Spatulation, Renal Allograft, Ischemia Time, Anastomotic Patency, Delayed Graft Function

1. Introduction

Kidney transplant is the treatment of choice for end-stage renal disease [1]. One of the critical aspects of a successful kidney transplant is vascular anastomosis, ensuring optimal perfusion of the graft while minimizing complications such as thrombosis, stenosis, or anastomotic leaks. Transplant surgeons use different techniques for arterial and venous anastomoses in the recipients. In 1902, Carrel described a 3-point anastomosis technique for allograft arterial anastomosis [2]. Since then, others have described variants using 2-point anastomosis, 1-knot techniques, 4-quadrant techniques, corner-saving techniques, nonsuture techniques, and other methods for vascular anastomoses in kidney transplant [3]-[7]. Most of these techniques were designed to reduce anastomotic and ischemic time while providing good patency, especially in the case of arterial anastomoses. The Reverse Spatulated Hybrid Technique (RSHT) is a vascular anastomosis approach developed at our center for living-donor kidney transplantation. It combines reverse spatulation to optimize luminal geometry with a hybrid suturing strategy designed to facilitate a controlled, wide anastomosis while maintaining a favorable

graft lie. This study describes the RSHT and evaluates its clinical outcomes in renal transplantation.

2. Materials and Methods

A single-center observational retrospective study involving a dedicated transplant team. During the study period (October 2024 to February 2025), a total of 101 renal transplants were performed.

This is the standard technique followed by the team for an end-to-end anastomosis with the internal iliac artery since 2010, with over 3000 transplants done. This technique is not followed for end-to-side anastomosis.

2.1. Surgical Technique

Our transplant team consisted of two main surgeons, one working on donor nephrectomy and one on the recipient transplant procedure. The role was also reversed. Living donor nephrectomies were performed laparoscopically via the transperitoneal route and retroperitoneally for open. All the graft kidneys were placed retroperitoneally in the right iliac fossa. The kidney transplant procedure was performed by two surgeons, and both were experienced in the use of the reverse spatulated hybrid technique.

The reverse spatulated hybrid technique is a modification of the standard vascular anastomosis technique. Hybrid suturing in this context means that sutures can be either continuous or intermittent (interrupted). In our reverse spatulated hybrid technique (RSHT), a 3-point fixation is first created between the renal artery (RA) and the internal iliac artery (IIA); the posterior layer of the anastomosis is then sutured with a continuous stitch, and the anterior layer is completed with interrupted sutures. This configuration creates a wide anastomosis with all sutures placed under direct vision, and in our experience has been associated with an almost negligible incidence of transplant renal artery stenosis (1 case in more than 3000 transplants to date).

Skin preparation and side marking were performed on the morning of the surgery. After the patient was placed on the operating table, povidone iodine was used with a sponge for the first wash, and regular povidone iodine was used twice for the final preparation. The incision started 2 cm above the pubic symphysis and passes laterally and cranially along the edge of the rectus sheath, two finger breadths medial to the anterior superior iliac spine (**Figure 1**).

The confluence of the oblique abdominal muscles just lateral to the rectus sheath (the spigelian fascia) is divided to expose the peritoneum beneath [2]. After exposure of the transversalis fascia and peritoneum, the transversalis fascia is divided, and the peritoneum is reflected upward and medially to expose the psoas muscle and the iliac vessels. A self-retaining retractor is inserted, such as a Bookwalter, which has the advantage of providing good exposure while allowing the assistant to have both hands free to assist with the anastomosis. Lymphatics were ligated to expose the iliac vessels.

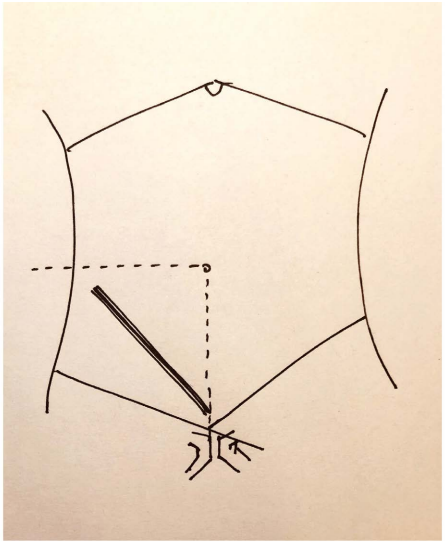
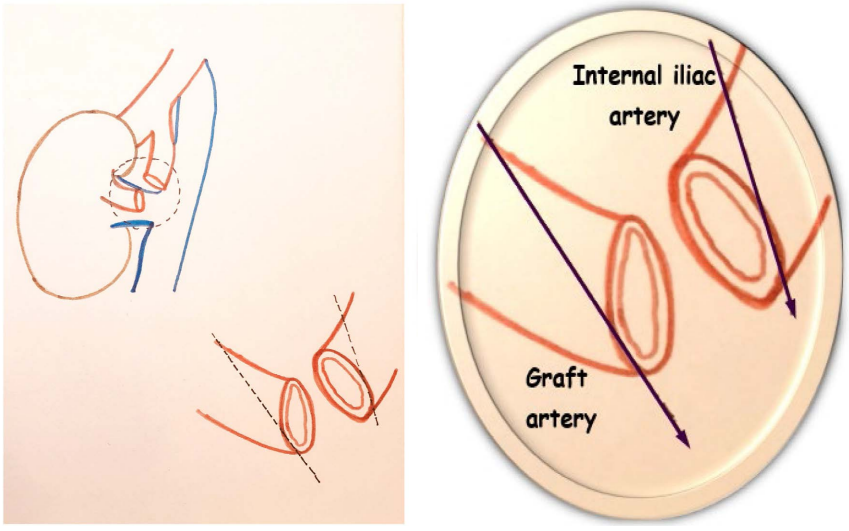


Figure 1. Skin incision and retroperitoneal approach for right iliac fossa kidney transplantation.

The internal iliac artery and external iliac vein were used as the first choice in vascular anastomoses. To prevent twisting or rotation, vessel clamps were used after confirming the exact length and position of the anastomotic site. The Bulldog clamp was preferred for the internal iliac artery. The internal iliac artery was divided and flushed with heparinized saline. For end-to-end anastomosis, an oblique incision on the recipient vessel and a reverse extension on the donor vessel (Figure 2(a) and Figure 2(b)).



(a) (b)

Figure 2. (a) Schematic representation of the graft kidney positioned in the right iliac fossa, showing the relationship between the renal artery and the internal iliac artery before arterial anastomosis; (b) Diagram illustrating the oblique arteriotomy on the internal iliac artery and the corresponding reverse spatulation of the graft renal artery used in the reverse spatulated hybrid technique.

The internal iliac artery is anastomosed end-to-end to the renal artery with 6-0 monofilament vascular suture in running fashion for the posterior layer and interrupted fashion for the anterior layer. Two-thirds of the artery diameter was measured with continuous sutures and one-third with interrupted sutures. The posterior layer started by placing sutures at 6 o'clock, and running suture performed till 10 o'clock with the short thread, stopped and locked by a new 6-0 Prolene. The needle was passed from inside to outside in the renal artery and from outside to inside in the host artery to prevent intimal separation. Posterior arterial anastomosis completed using the long thread till 2 o'clock, stopped and locked by using a piece of 6-0 Prolene (Figure 3, Figure 4(a) and Figure 4(b)).

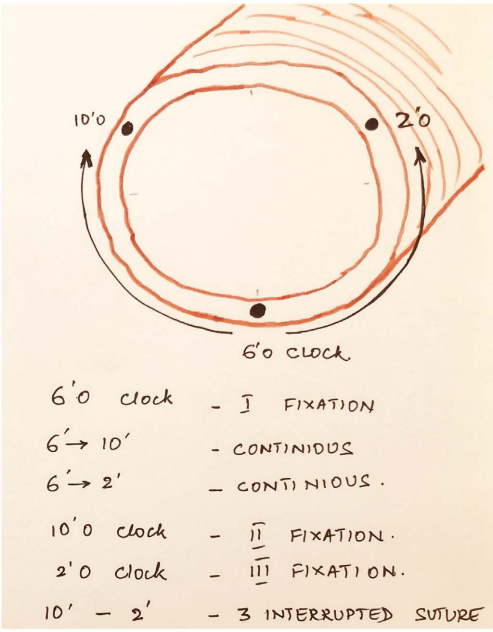


Figure 3. Schematic diagram of the reverse spatulated hybrid arterial anastomosis showing the three-point fixation and suture sequence from the 6 o'clock position, with continuous posterior suturing and anterior interrupted stitches between the 10 and 2 o'clock points.

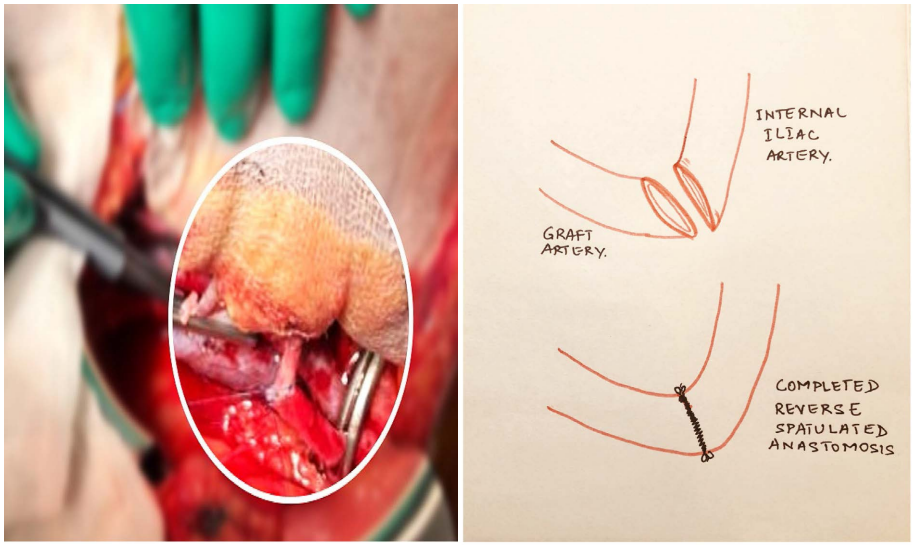
Then, the anterior layer anastomosis was started from both corners and completed by 3 - 4 interrupted sutures using 6-0 Prolene. The advantage of this technique is that the whole procedure is done while the kidney is in its final position in the iliac fossa. Both posterior and anterior walls of the arterial anastomoses are done without handling the kidney.

The graft vein was anastomosed end-to-side to the recipient's right external iliac vein using 6-0 Prolene in a continuous running fashion in posterior and anterior layers with fixation at 12 o'clock and 6 o'clock positions to prevent purse string effect. Ureterovesical anastomosis performed using a modified Lich-Gregoir technique in the anterior wall of the bladder over a 6/16 Fr DJ stent.

2.2. Data and Follow-Up

Intraoperative data, including the warm and cold ischemic times and arterial and

venous anastomotic times, are recorded. Follow-up consists of color Doppler ultrasonographic examination of the anastomosis site on postoperative days 1 and 30, and measuring blood pressure and serum creatinine level daily until postoperative day 10; then, at 1, 3, 6, and 12 months after transplant, and then every 6 months if there is any clinical problem.



(a) (b)

Figure 4. (a) Intraoperative view of the renal graft in the right iliac fossa showing the completed reverse spatulated hybrid arterial anastomosis between the graft renal artery and the internal iliac artery; (b) Schematic view of the completed reverse spatulated hybrid arterial anastomosis between the graft renal artery and the internal iliac artery, illustrating the final wide, linear anastomotic lumen.

3. Results

A total of 86 kidney transplant recipients were included in the final analysis, based on predefined inclusion criteria.

Mean age of recipients was 36 ± 13.2 (9 - 66 years). 64 patients were male (74.42%), and 22 were female (25.58%).

82 (95.35%) of the donor nephrectomies were done laparoscopically and 4 (4.65%) by open surgery.

Mean kidney warm and cold ischemia time was 3.2 (1 - 8 minutes) and 75.2 (49 - 116 minutes).

Mean arterial and venous anastomotic time was 15.51 (9 - 32 minutes) and 12.38 (7 - 26 minutes).

All the graft renal arteries were anastomosed to the internal iliac artery, of which 84 (97.6%) were to the right and 2 (2.4%) to the left. All vein anastomosis was done to the external iliac vein.

No vascular complications were reported in the early postoperative period. Measuring the velocity of blood flow at the anastomotic sites by color Doppler ultrasonography on days 1, 4, and 30 after the transplant showed no evidence of

arterial/ venous thrombosis or stenosis in any of the patients. During a mean follow-up of 2.5 (2 - 3 months), the mean serum creatinine level on the 1, 3, 30 and 60 - 90 days after the operation was 2.87 (0.5 - 9.2 mg/dL), 1.3 (0.5 - 3.8 mg/dL), 1.2 (0.5 - 4.4 mg/dL), 1.2 (0.5 - 4.6 mg/dL), respectively.

No delayed graft function was noted (defined as a persistence of a serum creatinine level of >4 mg/dL beyond the third day after transplant and necessity of at least one dialysis session within the 7 days post-transplant).

There were two mortalities; one case was attributed to septic shock secondary to left-sided cavitary pneumonia on POD-35, and the second case was due to cardiovascular failure on POD-136. Both had a functioning graft with maintained blood flows, proven by USG graft doppler done during their admission.

We did not encounter any vascular complications like renal artery/ vein thrombosis or stenosis. However, no contrast imaging was permissible because of the new kidney in place. The USG Doppler, as a noninvasive tool for documenting graft blood flow, is preferable.

4. Discussion

The introduction of the Carrel patch technique for end-to-end anastomosis of allograft arteries in 1902 marked a significant advancement in transplant surgery [2].

Many transplant surgeons presented their own technique for vascular anastomosis and made efforts to reduce ischemia time and risk of transplant artery stenosis, both of which can lead to allograft dysfunction [8]. Allograft arterial stenosis should be suspected in any recipient who presents with new onset or severe hypertension refractory to medical therapy, unexplained graft dysfunction, and a new audible bruit over the graft.

There are several techniques to do this anastomosis, and each one has its own merits and demerits. The type of anastomosis chosen by the surgeon depends on the mentor, the training received at their institution, and personal preference.

Since the RSHT used at our center is technically complex and associated with a longer learning curve than a conventional end-to-end anastomosis. This complexity is mainly related to two specific steps: the main point in RSHT is visualizing the lie of both the renal artery (RA) and the internal iliac artery (IIA), and precisely spatulating both vessels in reverse direction; lie and spatulation are visual assessments made beforehand and are the key learning steps in RSHT. The first suture is taken at the 6 o'clock position on both vessels, and the determination of this point and precise suturing is another key step. With both these maneuvers, we are able to create the widest possible anastomosis between RA and IIA and also to maintain the final lie of the graft without kinking the anastomosis. The skill is transferred by repeated exposure of the residents, fellows, and post-graduate students to the same technique being done by the same surgeon over and over again.

In the iliac fossa, the kidney is at a right angle to the iliac artery. As the graft kidney falls in the iliac fossa as its final resting place, the RSHT normalizes the kink formed

with the arteries by reducing the angle and thus maintain a smooth linear direction with the anatomical direction of the internal iliac which is medio-obliquely. This approach minimizes turbulence, enhances endothelial alignment, and lowers the risk of vascular kinking, stenosis, or thrombosis, leading to improved graft perfusion and function. In our series, mean arterial anastomosis time was 15.5 minutes, which is within the range reported for conventional end-to-end anastomosis techniques in open and minimally invasive kidney transplantation, where arterial anastomosis times of roughly 12 - 20 minutes are commonly described.

From our observation, it has been shown that this alternative vascular anastomotic technique is safe, with a satisfactory outcome of kidney transplant compared to the conventional technique for a kidney transplant. We had no cases of vascular complications in the early postoperative period in our patients. We did not encounter any case of renal artery or venous thrombosis, or any allograft arterial stenosis. In the era of minimally invasive techniques, for kidney transplantation, including robotic-assisted kidney transplantation, the main challenge is to perform a quality vascular anastomosis in a restricted workspace. The same technique was performed by the same team in a minimally invasive approach. Our center has performed more than 3000 kidney transplants since 2010, and in this broader experience, the reverse spatulated hybrid technique has been associated with an extremely low incidence of clinically significant TRAS, supporting its patency and safety profile.

Zomorrodi *et al.* compared techniques 02 techniques. In 1 group, they used a 2-corner continuous suture technique, and in the other, they used a combined suture technique (two-thirds of the artery diameter with continuous suture and one-third with interrupted sutures). And they determined that factors like gentle tissue handling and adequate vessel diameter are more critical in preventing transplant artery stenosis than the suturing technique itself [9].

The majority of authors presented techniques' variation according to the way of suturing (number of knots, corner saving), while others used clips and staplers. In 1996, Mital *et al.* performed arterial and venous anastomoses in kidney recipients using four stay sutures and vascular clips, completing each anastomosis in 8 minutes, and concluded that it is a safe, easy, and rapid method of renal vascular anastomosis. Jones further improved this by introducing a sutureless method with clips, reducing the ischemic period by 51% in comparison with the conventional running suture technique [10]. Ye *et al.* performed an end-to-end arterial anastomosis with titanium ring pin staplers in 36 kidney recipients [6].

Haberal *et al.* performed arterial anastomosis of transplanted kidneys in 183 recipients using a corner-saving approach. One patient had a renal arterial stenosis. The conclusion was that this approach lowers the incidence of vascular complications and is a simple and safe way to perform arterial anastomosis [4].

In 386 kidney patients, Simforoosh *et al.* reported the outcomes of vascular anastomosis using the 1-suture, 1-knot approach. No vascular complications were reported in the early postoperative period. The technique was safe, time-saving, and especially valuable in obese patients and recipients with deep iliac fossa [7].

In the minimally invasive era, and particularly in robot-assisted kidney transplantation (RAKT), the main technical challenge remains achieving a high-quality vascular anastomosis within a constrained workspace while limiting warm ischaemia. Large contemporary European experiences and comparative series suggest that RAKT can be performed safely with favourable graft outcomes in selected recipients, underscoring the need for standardised, reproducible anastomotic strategies that combine efficiency with precision [11] [12]. In addition, complex vascular anatomy is increasingly addressed in robotic programmes; ERUS data and subsequent comparative work indicate that RAKT using grafts with multiple vessels is feasible and often incorporates extracorporeal vascular reconstruction prior to implantation [13] [14].

The main limitation of the present study is its single-centre, retrospective observational design without a control group and with short follow-up. While a randomised trial would theoretically provide the highest level of evidence, such trials comparing surgical anastomotic techniques are unlikely to be feasible in routine transplantation; therefore, evidence will most realistically accumulate through comparative cohort studies and multicentre registries. Longer follow-up with standardised imaging surveillance is required to assess late events such as transplant renal artery stenosis, anastomotic aneurysm/pseudoaneurysm, and progressive intimal hyperplasia.

5. Conclusion

The RSHT offers optimal anastomotic geometry, reducing turbulence and optimizing vascular flow dynamics in renal transplantation. This technique, although complicated, will have a longer learning curve, but we feel this technique minimizes vascular complications and demonstrates excellent patency rates. This study is limited by its short duration and single-center design. Further multicentric studies with longer follow-up periods are warranted to more accurately evaluate the clinical relevance and long-term outcomes of the RSHT in renal transplantation.

Consent

This retrospective analysis used routinely collected clinical data that were anonymised prior to analysis. The work was conducted in accordance with institutional policies and the Declaration of Helsinki. Written informed consent was obtained for the publication of identifiable intraoperative images, where applicable.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

References

[1] Jofré, R., López-Gómez, J.M., Moreno, F., Sanz-Guajardo, D. and Valderrabano, F. (1998) Changes in Quality of Life after Renal Transplantation. *American Journal of Kidney Diseases*, **32**, 93-100. https://doi.org/10.1053/ajkd.1998.v32.pm9669429

[2] Barry, J.M. and Morris, P.J. (2008) Surgical Techniques of Renal Transplantation. In: Morris, P.J. and Knechtle, S.J., Eds., *Kidney Transplantation*: *Principles and Practice*, 6th Edition, Saunders Elsevier, 161-190.

[3] Lee, H. (1979) Surgical Techniques of Renal Transplantation. In: Morris, P.J., Ed., *Kidney Transplantation*, 2nd Edition, Academic Press/Grune & Stratton, 145-170.

[4] Haberal, M., Karakayali, H., Bilgin, N., Moray, G., Arslan, G. and Büyükpamukçu, N. (1996) Four Quadrant Running Suture Arterial Anastomosis Technique in Renal Transplantation: A Preliminary Report. *Transplantation Proceedings*, **28**, 2334-2335.

[5] Haberal, M., Moray, G., Sevmis, S., Karakayali, F., Aydogan, C., Karakayali, H., *et al.* (2008) Corner-Saving Renal Artery Anastomosis for Renal Transplantation. *Transplantation Proceedings*, **40**, 145-147. https://doi.org/10.1016/j.transproceed.2007.11.071

[6] Ye, G., Mo, H., Wang, Z., Yi, S., Wang, X. and Zhang, Y. (2006) Arterial Anastomosis without Sutures Using Ring Pin Stapler for Clinical Renal Transplantation: Comparison with Suture Anastomosis. *Journal of Urology*, **175**, 636-640. https://doi.org/10.1016/s0022-5347(05)00143-6

[7] Simforoosh, N., Gharaati, M.R., Moslemi, M.K. and Feizzadeh, B. (2010) One Suture, One Knot Technique in Renal Vascular Transplant. *Experimental and Clinical Transplantation*, **8**, 224-227.

[8] Khauli, R.B. (1994) Surgical Aspects of Renal Transplantation: New Approaches. *Urologic Clinics of North America*, **21**, 321-341. https://doi.org/10.1016/s0094-0143(21)00949-6

[9] Zomorrodi, A., Bohluli, A. and Tarzamany, M.K. (2008) Evaluation of Blood Flow in Allograft Renal Arteries Anastomosed with Two Different Techniques. *Saudi Journal of Kidney Diseases and Transplantation*, **19**, 26-31.

[10] Mital, D., Foster, P.F., Jensik, S.C., del Rio, J.V., Sankary, H.N., McChesney, L.P., *et al.* (1996) Renal Transplantation without Sutures Using the Vascular Clipping System for Renal Artery and Vein Anastomosis: A New Technique. *Transplantation*, **62**, 1171-1173. https://doi.org/10.1097/00007890-199610270-00024

[11] Breda, A., Territo, A., Gausa, L., Tuğcu, V., Alcaraz, A., Musquera, M., *et al.* (2018) Robot-Assisted Kidney Transplantation: The European Experience. *European Urology*, **73**, 273-281. https://doi.org/10.1016/j.eururo.2017.08.028

[12] Tuğcu, V., Şener, N.C., Şahin, S., Yavuzsan, A.H., Akbay, F.G. and Apaydın, S. (2017) Robot-Assisted Kidney Transplantation: Comparison of the First 40 Cases of Open vs Robot-Assisted Transplantations by a Single Surgeon. *BJU International*, **121**, 275-280. https://doi.org/10.1111/bju.14014

[13] Siena, G., Campi, R., Decaestecker, K., Tuğcu, V., Sahin, S., Alcaraz, A., *et al.* (2018) Robot-Assisted Kidney Transplantation with Regional Hypothermia Using Grafts with Multiple Vessels after Extracorporeal Vascular Reconstruction: Results from the European Association of Urology Robotic Urology Section Working Group. *European Urology Focus*, **4**, 175-184. https://doi.org/10.1016/j.euf.2018.07.022

[14] Nataraj, S.A., Zafar, F.A., Ghosh, P. and Ahlawat, R. (2020) Feasibility and Functional Outcome of Robotic Assisted Kidney Transplantation Using Grafts with Multiple Vessels: Comparison to Propensity Matched Contemporary Open Kidney Transplants Cohort. *Frontiers in Surgery*, **7**, Article No. 51. https://doi.org/10.3389/fsurg.2020.00051