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Robot-assisted Kidney Transplantation
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Corresponding Author:	Sung Shin Asan medical center, University of Ulsan College of Medicine Seoul, Seoul KOREA, REPUBLIC OF
Corresponding Author's Institution:	Asan medical center, University of Ulsan College of Medicine
Corresponding Author E-Mail:	sshin@amc.seoul.kr
Order of Authors:	Seong Jun Lim
	Youngmin Ko
	Dong Hyun Kim
	Joo Hee Jung
	Hyunwook Kwon
	Young Hoon Kim
	Sung Shin
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TITLE:

Robot-assisted Kidney Transplantation

AUTHORS AND AFFILIATIONS:

Seong Jun Lim,[1] Youngmin Ko,[1] Dong Hyun Kim,[1] Joo Hee Jung,[1] Hyunwook Kwon,[1] Young Hoon Kim,[1] Sung Shin[1]

[1]Division of Kidney and Pancreas Transplantation, Department of Surgery, Asan Medical Center, University of Ulsan College of Medicine, Seoul, Republic of Korea

Email addresses of co-authors:

Seong Jun Lim	(dkhe1986@naver.com)
Youngmin Ko	(chun8710@naver.com)
Dong Hyun Kim	(accong81@naver.com)
Joo Hee Jung	(juri7902@amc.seoul.kr)
Hyunwook Kwon	(hwkwon@amc.seoul.kr)
Young Hoon Kim	(kyh-001@hanmail.net)

Corresponding author:

Sung Shin (sshin@amc.seoul.kr)

KEYWORDS:

Robot-assisted, kidney transplantation, living donor, minimally invasive, kidney allograft, vascular anastomosis

SUMMARY:

This paper provides technical details for robot-assisted kidney transplantation from a living donor.

ABSTRACT:

This paper describes robot-assisted kidney transplantation (RAKT) from a living donor. The robot is docked between the parted legs of the patient, placed in the supine Trendelenburg position. Kidney allografts are provided by a living donor. Before vascular anastomosis, the kidney allograft is prepared by inserting a double-J stent in the ureter, and the temperature for the anastomosis is lowered by wrapping it in an ice-packed gauze. A 12 mm or 8 mm port for the robotic camera and three 8 mm ports for robotic arms are placed. A peritoneal pouch is created for the kidney allograft by raising the peritoneal flaps on both sides over the psoas muscle before dissecting the iliac vessels and bladder. A 6 cm Pfannenstiel incision is made to insert the kidney into the peritoneal pouch, lateral to the right iliac vessels.

After clamping the external iliac vein with Bulldogs clamps, a venotomy is performed, and the graft renal vein is anastomosed to the external iliac vein in an end-to-side continuous manner with a 6/0 polytetrafluoroethylene suture. After clamping the graft renal vein, the iliac vein is declamped. This is followed by clamping of the external iliac artery, arteriotomy, arterial

anastomosis with a 6/0 polytetrafluoroethylene suture, clamping of the graft renal artery, and declamping of the external iliac artery. Reperfusion is then carried out, and ureteroneocystostomy is performed using the Lich-Gregoir technique. The peritoneum is closed at a few locations with polymer locking clips, and a closed-suction drain is placed through one of the working ports. After deflating the pneumoperitoneum, all incisions are closed.

INTRODUCTION:

Kidney transplantation contributes to prolonged survival and a better quality of life compared with peritoneal dialysis or hemodialysis[1]. Although the open approach is the standard procedure for kidney transplantation, robotic-assisted techniques have been recently adopted[2-4]. Specifically, robot-assisted kidney transplantation (RAKT) has several advantages over open kidney transplantation: minimal postoperative pain, better cosmesis, fewer wound infections, and shorter hospital stay[5]. Moreover, minimally invasive access and robotic technology enable surgeons to safely perform kidney transplants in morbidly obese patients[6-9]. However, due to its complexity, RAKT requires a learning curve to achieve sufficient reproducibility in the operation time, functional results, and safety[10].

Allografts with multiple vessels usually require vascular reconstruction, which leads to extended cold and warm ischemic times. Despite the technical challenges of RAKT, a European multicenter study reported that RAKT using allografts with multiple vessels is technically feasible and leads to favorable functional results[11]. Although it is more common to place the kidney allograft in the pelvis medially during vascular anastomosis, according to previous reports[4-9], the allograft was placed on the peritoneal pouch lateral to the iliac vessels in this protocol. Although it may be safe to put an allograft medially during anastomosis and flip it to the peritoneal pouch, this technique may not be familiar for inexperienced surgeons. Furthermore, it is more convenient to perform vascular anastomosis with the allograft in the peritoneal pouch and renal vessels in the proper position. This paper describes the step-by-step procedures for RAKT without flipping.

PROTOCOL:

This study got approval from the Institutional Review Board of Asan Medical Center (IRB number: 2021-0101).

1. Pretransplant preparation

1.1. Patient selection

1.1.1. Include patients with end-stage renal disease who require kidney transplantation.

NOTE: RAKT may not be considered if a recipient is younger than eighteen years old.

1.1.2. Exclude those with any kind of untreated malignancy or active infection.

1.1.3. Ensure that the recipient is suitable for surgery with respect to cardiac and pulmonary function and appropriate for a minimally invasive approach.

1.1.4. Do not consider RAKT if a patient has a history of major abdominal surgery or severe intraperitoneal adhesion. In addition, do not consider RAKT and recommend open kidney transplantation if there is severe calcification in the iliac arteries on computerized tomography.

1.2. Patient preparation

1.2.1. Begin the standard presurgical preparation. Administer laxative suppository tablets for bowel preparation. Ensure that the patient does not ingest anything orally from midnight of the day of the operation. Administer prophylactic first-generation cephalosporin just before a skin incision.

1.2.2. Provide the maintenance immunosuppressants (e.g., calcineurin inhibitors, methylprednisolone, mycophenolate mofetil) from two days (conventional cases) or seven days (ABO-incompatible or human leukocyte antigen-incompatible cases) before the transplantation according to the protocol of the respective center.

1.2.3. Prepare the induction immunosuppressants (i.e., anti-thymocyte globulin or basiliximab) that will be administered during the RAKT.

1.3. Equipment

1.3.1. Ensure the availability of a robotic system.

1.3.2. Ensure the availability of standard laparoscopic equipment and robotic instruments (see the **Table of Materials**).

1.3.3. Ensure the availability of 6/0 or 7/0 polytetrafluoroethylene (ePTFE) sutures for artery and vein anastomosis.

1.3.4. Ensure the availability of 6/0 polydioxanone suture and 3/0 polyglactin adsorbable suture for neocystoureterostomy.

1.3.5. Ensure the availability of a double-J stent.

2. Surgical preparation

2.1. Anesthesia

2.1.1. Evaluate the operative risk according to the American Society of Anesthesiologists' classification of Physical Health.

2.1.2. Induce general anesthesia and use rocuronium bromide as a muscle-relaxant.

2.1.3. Insert a central venous line and an arterial line.

2.1.4. Insert a foley catheter and fill the bladder with normal saline. Keep the foley catheter clamped until ureteroneocystostomy is performed.

2.1.5. Perform arterial blood gas analyses at 1 h intervals during the transplantation.

2.1.6. Reverse the anesthesia with sugammadex (2 mg/kg, intravenous) at the end of the surgery.

2.2. Operation field

NOTE: A schematic arrangement map of the operating room is shown in **Figure 1**.

2.2.1. Have the operator perform procedures from the robotic console.

2.2.2. Have the first assistant stand on the left side of the patient.

NOTE: The first assistant will be in charge of performing irrigation and suction, supplying sutures and bulldog clamps, and helping with retraction.

2.2.3. Have the second assistant stand on the right side of the patient's hip to exchange robotic instruments and help the first assistant.

2.2.4. Have a scrub nurse stand on the left side of the patient's left leg.

2.2.5. Place the patient in the left lateral decubitus position with the legs parted and the Trendelenburg position (20°–30°). Dock the robot between the legs.

2.3. Preparation of the kidney allograft (**Figure 2**)

2.3.1. Ensure that cold ischemia is started immediately after recovering the kidney from the living donor. Remove the perinephric fat tissue and perform meticulous ligation of the lymphatics around the hilum of kidney allograft on a back table.

2.3.2. Measure the weight and size of the kidney allograft.

2.3.3. Consider arterial reconstruction if there are multiple renal arteries such as side-to-side anastomosis, end-to-side anastomosis of the polar artery into the main renal artery, and polar artery anastomosis to the inferior epigastric artery.

2.3.4. Consider venous extension with a gonadal vein of the recipient or an iliac vein of the deceased donor.

2.3.5. Insert a 4.8-French, 12 cm double-J stent in the ureter using a guide-wire.

2.3.6. Wrap the kidney allograft in an ice-packed gauze.

3. Positioning of the robotic and gel ports (Figure 3)

3.1. Establish and maintain a pneumoperitoneum at approximately 10 mmHg.

NOTE: Trocar positioning is for right-sided kidney transplantation.

3.2. Introduce the 12 mm or 8 mm robotic camera port just above the umbilicus.

NOTE: The camera port should be placed at about 10–15 cm from the nearest boundary of the target anatomy.

3.3. Place the 8 mm robotic port for Arm II on the right lateral side at ~8–9 cm away from the camera port.

3.4. Place another 8 mm robotic port for Arm III along the line between the umbilicus and anterior superior iliac spine at a distance of approximately 8–9 cm from the umbilicus.

3.5. Place the other 8 mm robotic port for Arm IV at approximately 8–9 cm laterally to the port for Arm III.

NOTE: Ensure a distance of 2 cm between the ports and bony prominences.

3.6. Place the gel port (6 cm Pfannenstiel incision) on the right suprapubic area (the target anatomy). Make two or three ports on the gel port for the first and second assistants.

4. Intraabdominal dissection and insertion of the kidney allograft (Video 1)

4.1. Incise the peritoneum along the right paracolic gutter to make a pouch for the kidney allograft with monopolar curved scissors (Arm II), fenestrated bipolar forceps (Arm III), and robotic forceps (Arm IV) (see the **Table of Materials**).

4.2. Dissect the right external iliac vessels along their entire length. Encircle each vessel with a vessel loop.

4.3. Dissect the bladder for ureteroneocystostomy on the right corner of the bladder and separate it from the peritoneal incision for the kidney allograft.

4.4. After opening a cap of the gel port, insert slushed ice followed by the kidney allograft wrapped in the ice-packed gauze through the 6 cm Pfannenstiel incision.

4.5. Place the allograft on the peritoneal pouch lateral to the iliac vessels on the right side.

5. Vascular anastomosis and reperfusion (Video 1)

5.1. Keep the allograft as cold as possible with either slushed ice or cold normal saline.

5.2. Clamp the right external iliac vein distal and proximal to the anastomosis site with Bulldog clamps, manipulated by Prograsp forceps (Arm IV).

5.3. Make a venotomy with Potts scissors in a linear or oblique fashion, considering the diameter of the renal vein.

5.4. Anastomose the allograft renal vein to the right external iliac vein in an end-to-side continuous manner using a 6/0 ePTFE suture. Make a knot at the caudal end of veins, and suture the posterior wall intraluminally in a continuous manner. Afterwards, suture the anterior wall in a continuous manner.

NOTE: The anastomosis is performed with a large needle driver on Arm II and black diamond microforceps or Maryland forceps on Arm III for right-handed surgeons.

5.5. Flush the lumen with heparinized normal saline (5 IU/mL) just before knotting the anastomosis using a silastic tube through the gel port.

5.6. Clamp the allograft renal vein with a Bulldog clamp.

5.7. Declamp the right external iliac vein.

5.8. Clamp the right external iliac artery distal and proximal to the anastomosis site with Bulldog clamps.

5.9. Make an arteriotomy with Potts scissors. Create a round hole with Potts scissors and without an arterial punch.

5.10. Using the same method as vein anastomosis, anastomose the allograft renal artery to the right external iliac artery in an end-to-side continuous manner using a 6/0 ePTFE suture.

5.11. Flush the lumen with heparinized normal saline just before knotting the anastomosis using a silastic tube through the gel port.

5.12. Clamp the allograft renal artery with a Bulldog clamp.

5.13. Declamp the right external iliac artery.

5.14. Declamp the allograft renal vein and artery if there is no evident bleeding at the anastomosis sites.

5.15. Remove the ice-packed gauze.

5.16. Apply warm normal saline on the allograft with an irrigation tube through the gel port.

6. Ureteroneocystostomy and peritoneal covering (Video 1)

6.1. Perform ureteroneocystostomy according to the Lich-Gregoir technique[11].

6.2. Put the distal end of the double-J stent into the bladder.

6.3. Starting at the posterior corner, perform a continuous suture using a 6/0 polydioxanone suture and make a knot at the anterior corner. Then, perform a continuous suture from the anterior corner to the posterior corner.

6.4. From the anterior corner to the posterior corner, close the detrusor muscle antireflux tunnel in an interrupted manner using a 4/0 polyglactin multifilament absorbable suture.

6.5. Cover the kidney allograft with the incised peritoneum along the right paracolic gutter intermittently using polymer locking clips.

7. Wound closure

7.1. Insert a closed-suction drain through the 8 mm robotic port for Arm II on the right lateral side and put the drain around the kidney allograft.

7.2. Deflate the pneumoperitoneum by opening the gel port.

7.3. Close the gel port and the camera port incisions layer by layer (peritoneum, muscles, subcutaneous layer, and skin). Close the 8 mm robotic port incisions only at the level of the subcutaneous layer and skin.

REPRESENTATIVE RESULTS:

We set up a routine clinical pathway for recipients who have RAKT at this center. Renal Doppler ultrasound is performed one day post-transplant and technetium-99m diethylenetriamine penta-acetic acid renal scan two days post-transplant. For venous thromboembolism prophylaxis, an intermittent pneumatic compression device is applied during the first 24 h after RAKT. Foley catheter is removed on the fourth postoperative day. On the fifth day, a closed-suction drain is removed after confirming no intra-abdominal complication on non-enhanced computerized tomography. A patient is discharged on the sixth postoperative day unless there is a major adverse event.

At this center, RAKT was performed in 21 recipients from August 2020 to April 2021 (**Table 1**). All patients had RAKT under robotic assistance except for one morbidly obese patient. Owing to the difficulty in visualization, the Pfannenstiel incision was extended up to 15 cm in length to complete the vascular anastomosis and ureteroneocystostomy. There was one case of primary non-function due to renal vein thrombosis in another patient. Graftectomy was performed three days after KT. There was no delayed graft function. The mean cold ischemic time, vascular anastomosis time, rewarming time, and operative time were 129.2 min (55–253 min), 54.4 min (38–69 min), 73.8 min (44–119 min), and 334.8 min (238–422 min), respectively. The mean estimated glomerular filtration rate (eGFR) (the Chronic Kidney Disease Epidemiology classification [CKD-EPI]) one month after RAKT was 74.9 (47.0–101.0) mL/min/m^2.

FIGURE AND TABLE LEGENDS:

Figure 1: Schematic cross-sectional diagram of the operating room.

Figure 2: Preparation of the kidney allograft. The allograft is wrapped in an ice-packed gauze, including the insertion of a double-J stent in the ureter.

Figure 3: Positioning of the patient and the robotic and laparoscopic ports.

Table 1: Baseline characteristics and results of 21 consecutive cases of robot-assisted kidney transplantation. Abbreviations: HLA, human leukocyte antigen; DSA, Donor-specific antibody; KT, kidney transplantation; eGFR, estimated glomerular filtration rate; CKD-EPI, Chronic Kidney Disease Epidemiology Collaboration.

Video 1: Step-by-step operative procedures using a robotic system (intraabdominal dissection, insertion of the kidney allograft, vascular anastomosis, reperfusion, ureteroneocystostomy, and peritoneal covering).

DISCUSSION:

Although laparoscopic and robotic-assisted techniques have been widely applied for living donor nephrectomy, kidney transplantations are still mainly performed using conventional open techniques. Recently, however, a minimally invasive approach for kidney transplantation has been increasingly used. Compared with traditional open surgery, minimally invasive kidney transplantation has a lower risk of surgical site infection, incisional hernia, and wound dehiscence, as well as shorter hospitalization[12-16].

In the early learning curve of a laparoscopic approach, longer cold and warm ischemic times and anastomosis time should be considered negative predictive factors for postoperative creatinine level, graft function, and graft survival[12,17]. Nowadays, RAKT has replaced laparoscopic kidney transplantation due to several advantages such as the use of articulated robotic instruments, a three-dimensional magnified view, and favorable operator ergonomy. These advantages enable surgeons to perform more reproducible and sophisticated procedures under conditions of up-to-date facilities with sufficient financial and technical support[18-20].

Like Vignolini et al., we use the Pfannestiel incision, allowing better cosmetic outcomes, easier placement of the allograft directly into the peritoneal pouch, and direct access to the operative field in case of intraoperative urgency[21]. However, we do not usually use a 12 mm laparoscopic port for the assistants. Instead, two or three ports are made on the gel port for the first and second assistants. In addition, the Pfannestiel incision is made on the right lower abdomen rather than on the midline for easier access to the operative field for the assistants or any emergent situation. Like previous reports, regional hypothermia is adopted for allograft cooling before reperfusion[4,22]

Many centers prefer positioning the allograft on the medial side of iliac vessels when performing vascular anastomosis[4,14,23]. Gallioli et al. suggested shortening of the anterior wall of the artery to reduce the kinking after allograft retroperitonealization because they put the allograft on the medial side of iliac vessels[10]. Unlike previous reports, we employed a strategy in which the kidney allograft is positioned on the lateral side of iliac vessels at the time of vascular anastomosis in a manner similar to the conventional open technique to prevent unexpected torsion or kinking of the renal vessels.

Of the 21 cases, we performed RAKT using an allograft with double renal arteries in five patients. Compared with allografts with a single renal artery, there was no significant difference in vascular anastomosis time, rewarming time, and operative time. This is consistent with the report by Siena et al., showing that RAKT using grafts with multiple vessels from living donors is technically feasible and achieves favorable perioperative and short-term functional outcomes[24]. However, we performed RAKT in three obese patients (≥30 kg/m^2 BMI) with favorable results compared to non-overweight recipients in terms of functional outcomes and postoperative complications. Two of them were morbidly obese (≥30 kg/m^2 BMI). We agree with previous reports about RAKT in obese patients in that RAKT in obese recipients is safe compared to non-overweight recipients and yields optimal functional outcomes[7,8,25]. It was also reported that RAKT from deceased donors is feasible, safe, and has favorable outcomes similar to RAKT from living donors[21,26]. Although we do not have an experience of RAKT from deceased donors, a program will be set up for RAKT from deceased donors.

Not all kidney transplantations can be performed using robot-assisted techniques; however, a select group of patients benefits from undergoing RAKT. Particularly, RAKT could improve access to kidney transplantation in morbidly obese patients due to the low rate of surgical complications[6-8] Recently, it was reported that RAKT with regional hypothermia was associated with a lower incidence of post-transplant complications and improved patient comfort compared with open KT[27]. Considering the lower risk of surgical complications, favorable cosmetic aspects, and earlier recovery, as well as comparable clinical outcomes with conventional open techniques, the indications for RAKT may be expanded regardless of obesity.

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DISCLOSURES:

The authors have no conflicts of financial and non-financial interests to disclose.

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Figure 1

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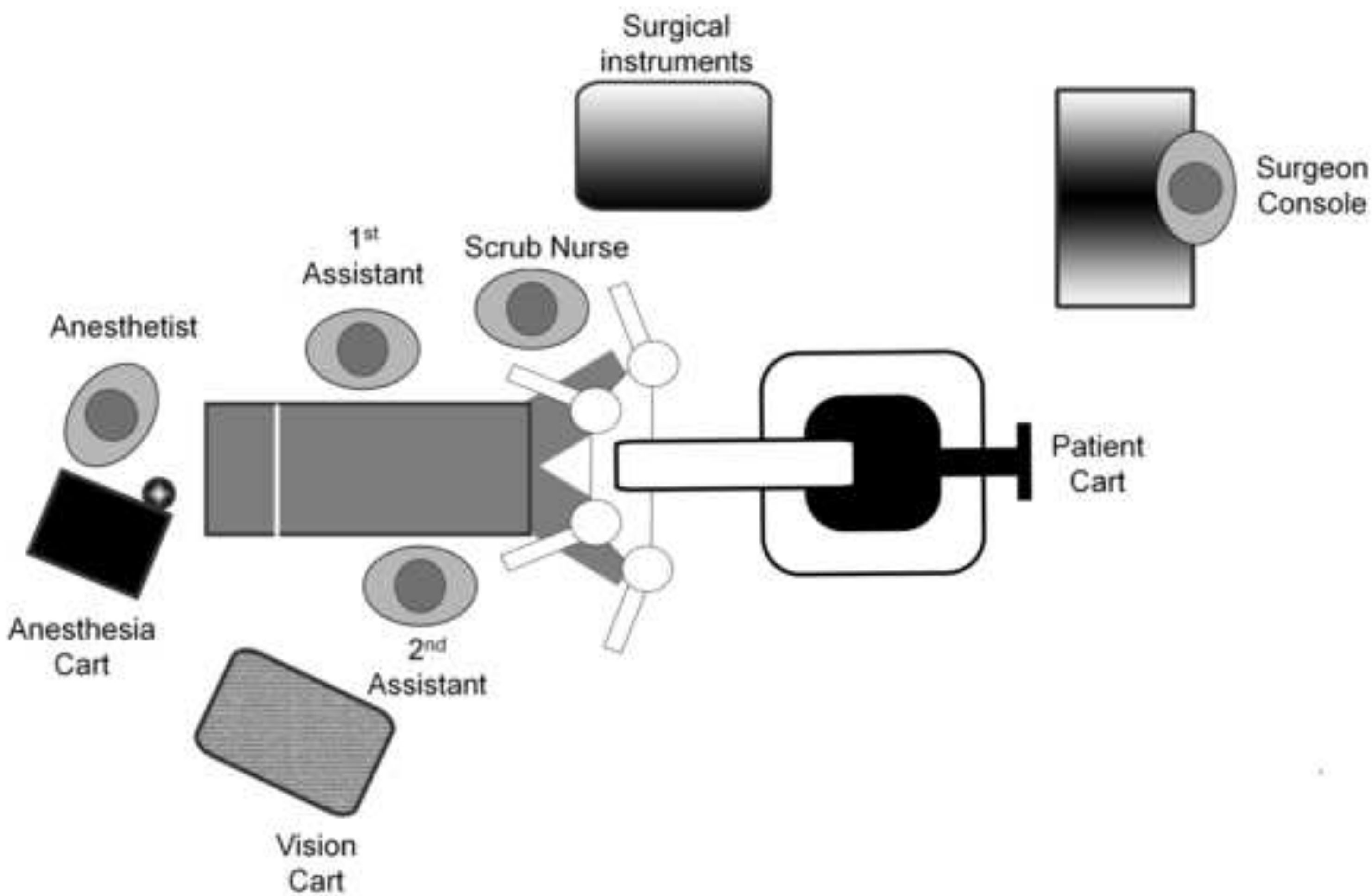

Figure 2

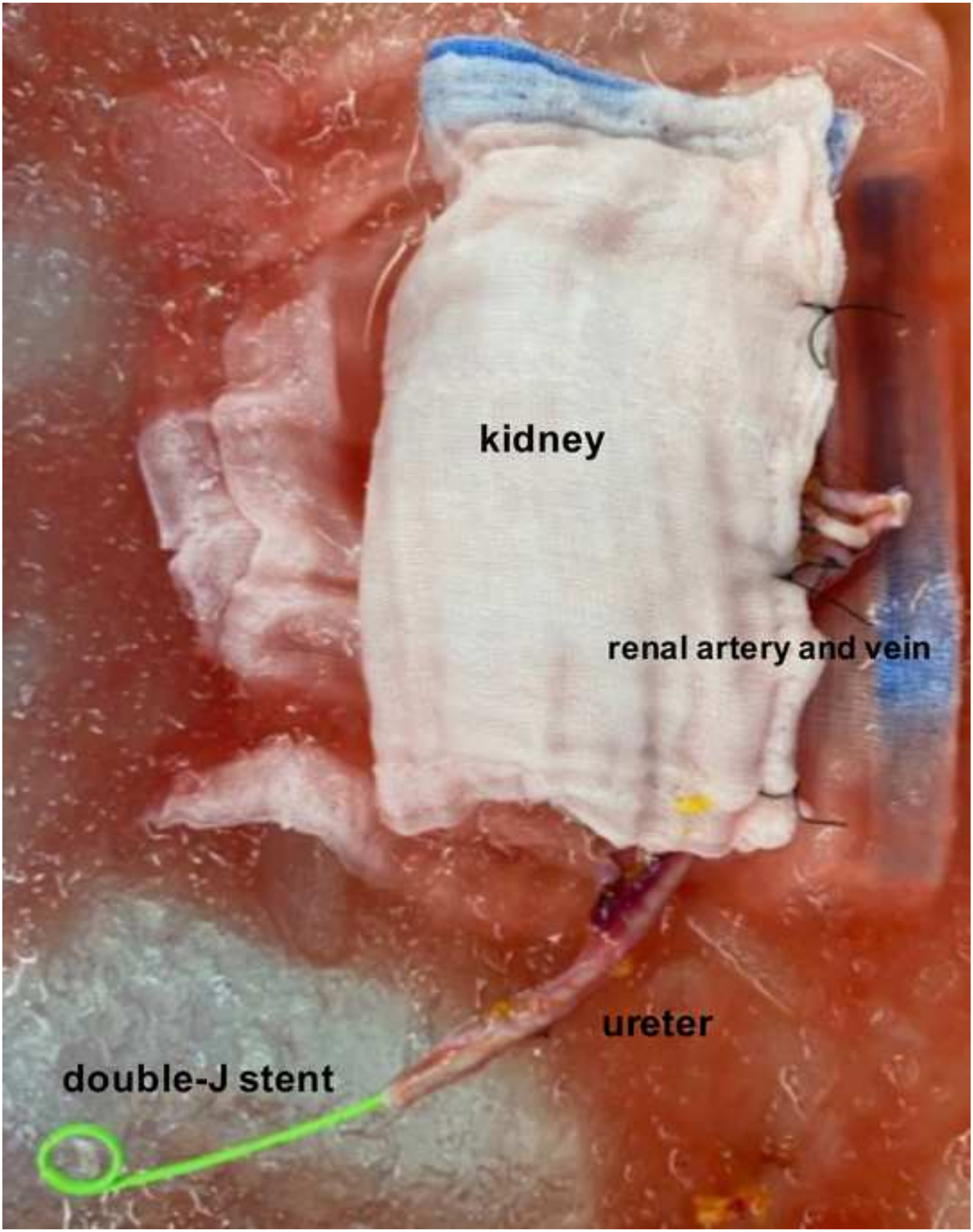

Figure 3

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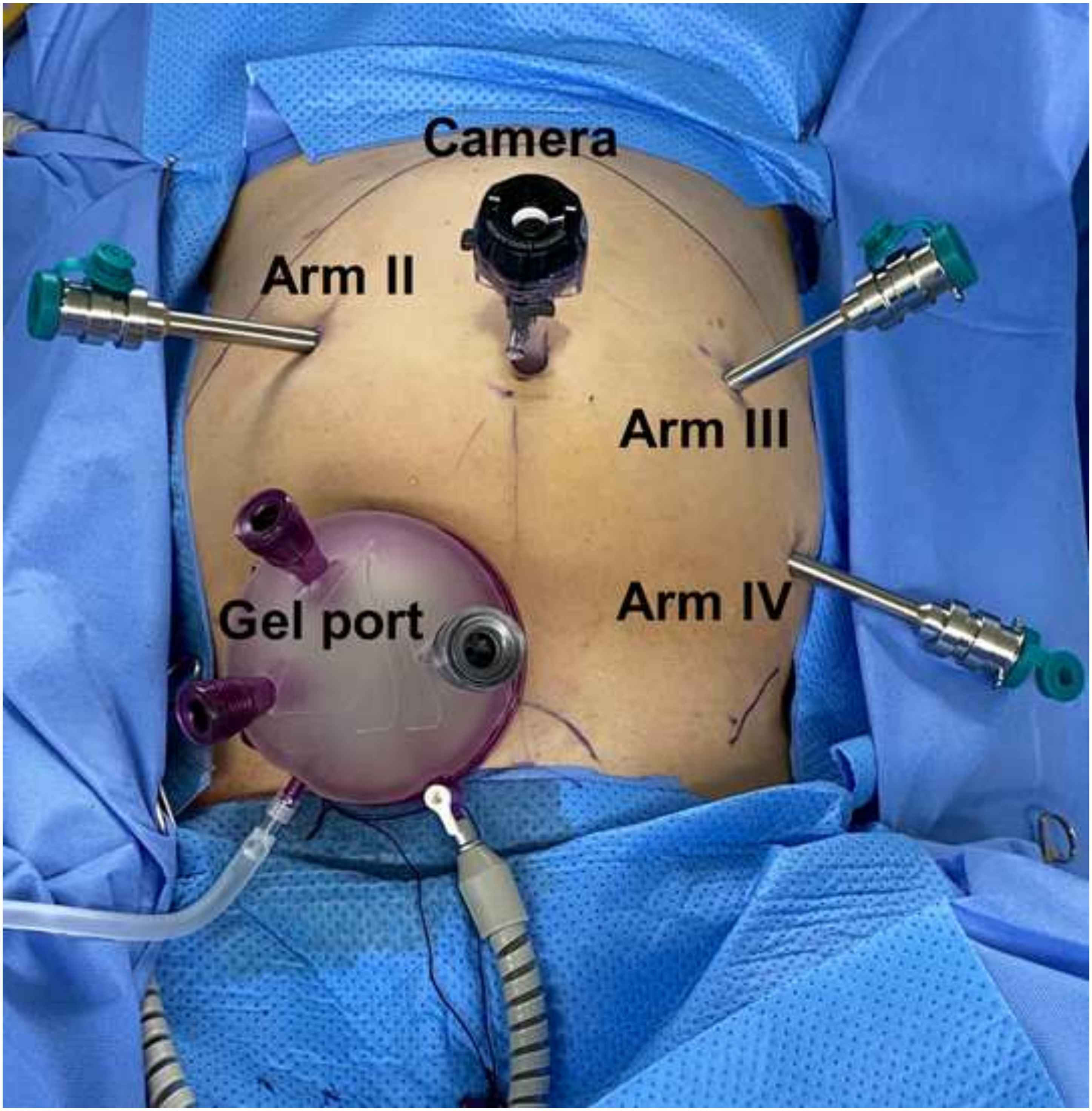

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Table 1: Baseline characteristics and results of 21 consecutive robot-assisted kidney transplantation

	N=21
Recipient	
Mean age, y (range)	40.5 (16-58)
Female gender, n (%)	10 (47.6)
Body mass index, kg/m^2 (range)	23.2 (16.0-41.2)
Preemptive transplant, n (%)	11 (52.4)
Number of HLA mismatch (ABDR), (range)	3.0 (0-5)
Number of HLA mismatch (DR), (range)	1.0 (0-2)
Number of HLA mismatch (DQ), (range)	0.9 (0-2)
Pretransplant DSA, n (%)	4 (19.0)
Flow cytometry-positive KT, n (%)	3 (14.3)
ABO-incompatible KT, n (%)	6 (28.6)
Immunosuppressants	
Induction, n (%)	
Basiliximab	18 (85.7)
Thymoglobulin	3 (14.3)
Calcineurin inhibitor, n (%)	
Cyclosporine	0
Tacrolimus	21 (100)
Donor	
Mean age, y (range)	47.5 (22-67)
Female gender, n (%)	13 (61.9)
Body mass index, kg/m^2 (range)	24.1 (18.0-35.8)
Relation to a recipient, n (%)	
Living-related	15 (71.4)
Living-unrelated	6 (28.6)
24 h creatinine clearance, mL/min (range)	111.3 (70.9-156.6)
24 h urine protein, mg/day (range)	74.5 (50.7-103.0)
Left kidney donation, n (%)	14 (66.7)
Number of renal artery, n (%)	
Single	16 (76.2)
Double	5 (23.8)
Operative results	
Cold ischemic time, min (range)	129.2 (55-253)
Vascular anastomosis time, min (range)	54.4 (38-69)
Rewarming time, min (range)	73.8 (44-119)
Operative time, min (range)	334.8 (238-422)
Angioplasty of renal artery, n (%)	4 (19.0)

Angioplasty of renal vein, n (%)	7 (33.3)
Hospitalization after KT	7.4 (6-25)
eGFR (CKD-EPI) one month after KT, mL/min/1.73m^2	74.9 (47.0-101.0)
Delayed graft function, n (%)	0
Primary non-function, n (%)	1 (4.8)
Conversion to open surgery	1 (4.8)

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Reviewer response form

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<Reviewer #1>

1. The authors report that "We propose to place the allograft on the peritoneal pouch lateral to iliac vessels. Although it may be safe procedures to put an allograft medially during anastomosis and flip it to peritoneal pouch, this technique may be not familiar for inexperienced surgeons. Furthermore, it is more natural to perform vascular anastomosis with the allograft in the peritoneal pouch and renal vessels in proper position". Why didn't the authors follow the established technique for RAKT as described by Menon et al. and Breda et al.? Why introducing this novelty, which may expose to more challenges when performing the vascular anastomoses? Please also take into consideration that the "standard" technique for RAKT leads to an optimal "extraperitonealization" of the graft in the early postoperative period (please refer to Campi R, Vignolini G, Savi E, Sessa F, Agostini S, Serni S. Robotic kidney transplantation allows safe access for transplant renal biopsy and percutaneous procedures. Transpl Int. 2019 Dec;32(12):1333-1335. doi: 10.1111/tri.13517. Epub 2019 Oct 4. PMID: 31483897).

Response : We appreciate the Reviewer's opinion. It was not our intention that we would not follow the established technique for RAKT as described in previous reports. Instead, we tried to introduce an alternative technique for RAKT which can be performed safely and easily according to our experiences. To resolve a possible misunderstanding, we have modified sentences as follows; "Although it is more common to place the kidney allograft in the pelvis medially during vascular anastomosis according to previous reports, we suggest that it is an alternative method to place the allograft on the peritoneal pouch lateral to iliac vessels. Although it may be safe procedures to put an allograft medially during anastomosis and flip it to peritoneal pouch, it is also feasible to perform vascular anastomosis with the allograft in the peritoneal pouch and renal vessels in proper position with safety and ease."

In addition, we adhere to the standard technique of the Vattikuti-Medanta for an optimal extraperitonealization of the graft by reapproximating two peritoneal flaps prepared at the beginning of surgery as the Reviewer suggested. Therefore, we have modified sentences as follows; "After creating an extraperitoneal pouch for the kidney allograft by raising peritoneal flaps on both sides over the psoas muscle, iliac vessels and bladder are dissected." "The peritoneum is incised along the right paracolic gutter to make an extraperitonal pouch for the kidney allograft with monopolar curved scissors (Arm II), fenestrated bipolar forceps (Arm III), and Prograsp forceps (Arm IV)."

2. Please clarify the reason for stating: "RAKT may be not considered if a recipient is younger than ten or is older than 70 years old" and "RAKT is not recommended if a patient has a history of major abdominal surgery or severe intraperitoneal adhesion".

Response: We see the Reviewer's point. Considering the inclusion/exclusion criteria of previous reports, we have changed the exclusion criteria in terms of age as follows; "RAKT may be not considered if a recipient is younger than eighteen years old."

In addition, we have modified the next sentence as follows; "RAKT is not recommended if a patient has multiple previous abdominal surgeries or severe intraperitoneal adhesion."

3. Why did the authors use 2 bed-side assistants for RAKT?

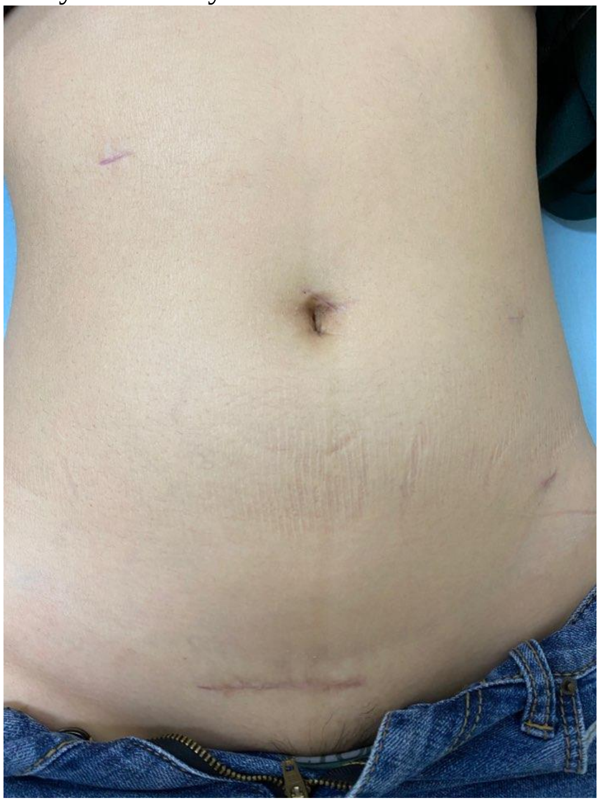
Response: As we commented in the Discussion, we do not usually use a 12-mm laparoscopic port for the assistants. Instead, we make two or three ports on the gel port for assistants. It is possible to perform RAKT with only one bed-side assistant. However, it is more effective if another assistant can help on the opposite side of the first assistant when the direction of laparoscopic equipment matters.

4. "Consider arterial reconstruction if there are multiple renal arteries". Please specify (see reference 24)

Response: We appreciate the Reviewer's recommendation. We have modified the sentence as follows; "Consider arterial reconstruction if there are multiple renal arteries such as side-to-side anastomosis, end-to-side anastomosis of polar artery into main renal artery, and polar artery anastomosis to the inferior epigastric artery."

5. Why did the authors place the gel port (6cm Pfannenstiel incision) on the right suprapubic area (the target anatomy) instead of in the middle suprapubic area? This may lead to inferior cosmetic results.

Response: We see the Reviewer's point. We make Pfannestiel incision on the right lower abdomen rather than on the midline for easier access to the operative field for the assistants or for any emergent situation as we commented in the Discussion. We think that Pfannestiel incision near the target anatomy is more useful especially when the recipient is obese. We don't think that 6cm Pfannenstiel incision on the right suprapubic area may lead to inferior cosmetic results. That incision is usually covered by the underwear.



6. "Keep the allograft as cold as possible with cold normal saline". Please clarify.
Response: We see the Reviewer's point. We think that it is possible to use cold normal saline as well as slushed ice through gel port. Therefore, we have modified the sentence as follows; " Keep the allograft as cold as possible with either slushed ice or cold normal saline."

7. REPRESENTATIVE RESULTS: why did the authors first report one case and then discuss the results of the whole RAKT series (n=21) at their Institution? Please report only the aggregate data from the whole series (there is no benefit of describing a single case and the whole series thereafter).
Response: We understand the Reviewer's opinion. As the Reviewer's recommendation, we have deleted the single case report and modified the paragraph.

8. "Considering the learning curve in RAKT, our performances are not inferior with previously reported data". This statement should be removed as the authors could not investigate this point in their study and the study was not designed to answer this clinical question.
Response: As the Reviewer suggested, we have removed the statement.

9. Please provide a brief video accompanying the manuscript to show exactly how RAKT is performed, especially considering the technical modifications made by the authors as compared to the "gold standard" technique for RAKT described by previous groups.
Response: As the Reviewer suggested, we have provided a brief video of our own RAKT.

10. Please add this reference: Ahlawat R, Sood A, Jeong W, Ghosh P, Keeley J, Abdollah F, Kher V, Olson P, Farah G, Wurst H, Bhandari M, Menon M. Robotic Kidney Transplantation with Regional Hypothermia versus Open Kidney Transplantation for Patients with End Stage Renal Disease: An Ideal Stage 2B Study. J Urol. 2021 Feb;205(2):595-602. doi: 10.1097/JU.0000000000001368. Epub 2020 Sep 16. PMID: 32941100.
Response: As the Reviewer recommended, we have added the reference as follows; "Recently, it was reported that RAKT with regional hypothermia was associated with a lower incidence of post-transplant complications and improved patient comfort compared with open KT.[27]"

<Reviewer #5>
1. In the PROTOCOL section 4.3., How was the peritoneum incised when the bladder was dissected? Was it connected to the peritoneal incision on the graft bed?
Response: We see the Reviewer's point. Dissection of the bladder is performed for ureteroneocystostomy which is separated from peritoneal incision for the kidney allograft.

2. In the PROTOCOL section 5.4. and 5.10., please describe the anastomosis procedures in more detail. For example, how did the authors use the stay sutures? Or was it a parachute anastomosis without any stay sutures? Did the authors suture the posterior wall intraluminally? Did the authors use any everting technique to make the intimas adhere to each other?

Response: We see the Reviewer’s point. After making a knot at the caudal end of veins or arteries, the posterior wall is sutured intraluminally in a continuous manner. Thereafter, the anterior wall is sutured in a continuous manner.

3. In the PROTOCOL section 5.9., the author should describe that they did create a round-shaped hole with Potts scissors and without an arterial punch.
Response: As the Reviewer recommended, we have added a comment.

4. In the PROTOCOL section 5.5., 5.11., and 5.16., how did the authors put the saline? Was it by the first assistant's irrigation tube or opening the gel port?
Response: We see the Reviewer’s point. As we commented in the Discussion, we do not usually use a 12-mm laparoscopic port for the assistants. Instead, we make two or three ports on the gel port for assistants. We flush the vascular lumen with heparinized normal saline just before knotting the anastomosis using a silastic tube through the gel port. In addition, warm normal saline is applied on the allograft with an irrigation tube through the gel port.

5. Didn't the authors check the renal blood flow by ultrasonography after the vascular anastomosis was completed?
Response: We do not routinely check the renal blood flow by intraoperative ultrasonography after the vascular anastomosis is completed. Instead, renal Doppler ultrasonography is performed one day post-transplant.

6. In the PROTOCOL section 6.3., what did the semicontinuous suture mean? The continuous suture with two stay sutures?
Response: We see the Reviewer’s point. We don’t think ‘semicontinuous suture’ is a right term. We have changed ‘semicontinuous’ to ‘continuous’.