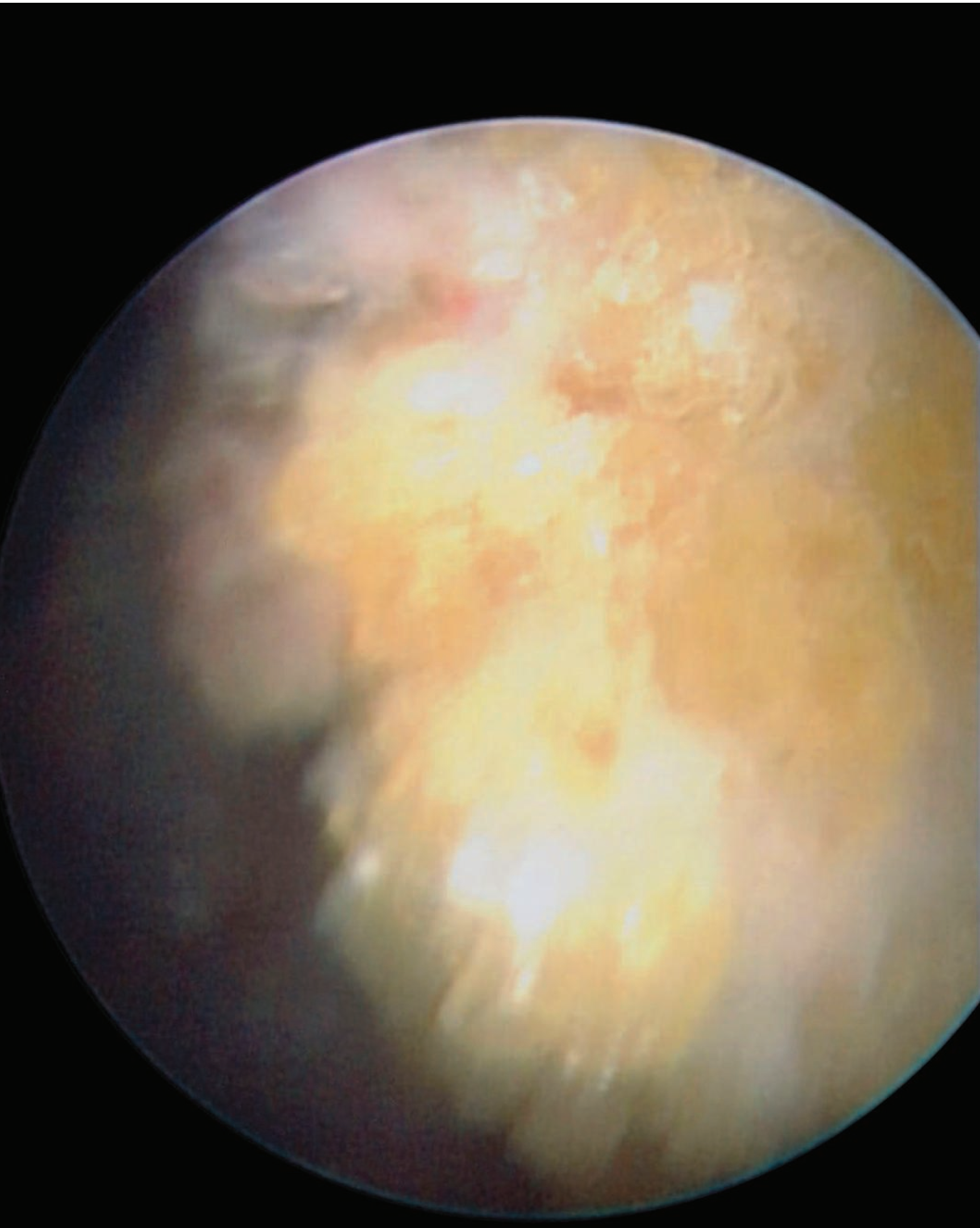

Renal Autotransplantation—Past, Present and Future:

SEVEN CASE STUDIES OF PATIENTS AT CLEVELAND CLINIC

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INTRODUCTION

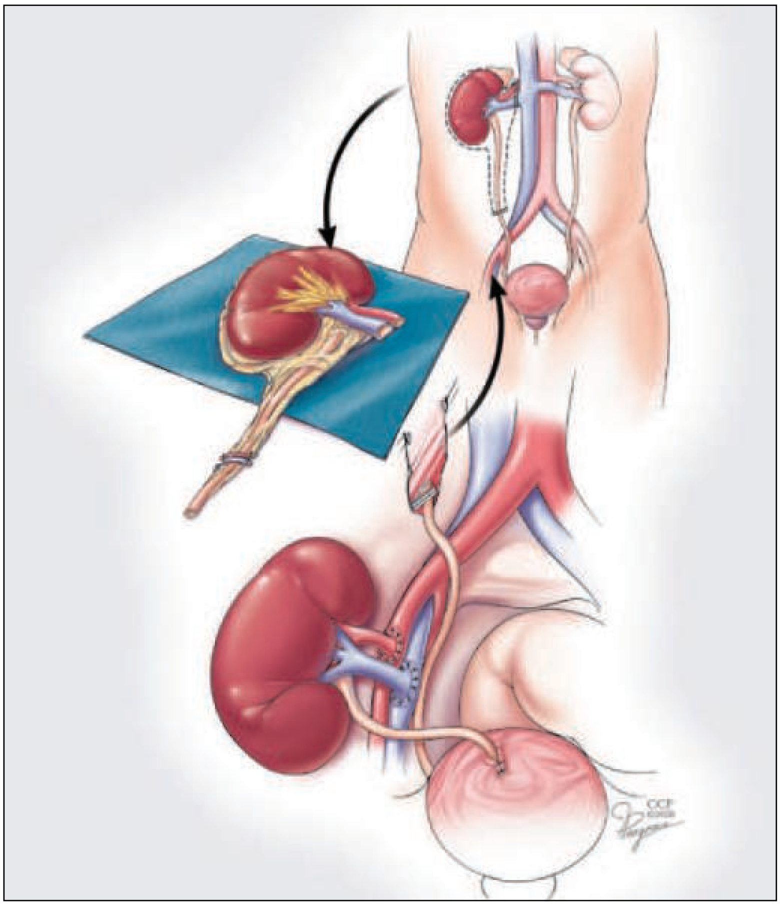
Renal autotransplantation is a method of removing a kidney from its place of origin, repairing it, and transplanting it in another location of the body (most commonly, the iliac fossa) of the same patient. This procedure was first performed by James Hardy, MD, at the University of Mississippi Medical Center in 1963.[3]

Since Hardy's landmark surgery for management of a high ureteral injury, renal autotransplantation has been described in the treatment of renal arterial disease (eg arterial aneurysm), complex urological reconstruction (eg ureteral stenosis due to retroperitoneal fibrosis), renal cell carcinoma (primarily in patients with a solitary kidney), advanced nephrolithiasis, and loin pain hematuria syndrome.[1,4,7,8,9,11]

During the 1980s, numerous journal articles on the subject of renal autotransplantation were published. During the 1990s, though, there were few new developments in the field, and few articles were published. This reduction in literature could be due in part to the introduction of laparoscopic urologic surgery.[5]

With the introduction of laparoscopic surgery, the number of open autotransplantation procedures was greatly reduced. Laparoscopy became an alternative way of performing complex ureteral procedures and partial nephrectomies that once could be completed only by open autotransplantation.

By the start of the new millennium, a newfound interest in autotransplantation was sparked by the use of new laparoscopic techniques. In an article written in 2000, Gill described the use of laparoscopic retroperitoneal nephrectomy for autotransplantation.[2] Nephrectomy of the kidney needing repair was performed under direct laparoscopic vision. A Gibson incision was made for extraction of the kidney.



Renal autotransplantation.

The kidney was removed, perfused with Collins solution, and repaired via an extracorporeal operation (an operation performed with the organ removed from the body) and performed on a separate "bench" table. While the kidney was being "benched," the Gibson incision was extended to allow visualization of the external iliac vessels for future transplantation. Laparoscopic assisted renal autotransplantation allowed the patients in Gill's article to benefit from decreased morbidity rates and shortened hospital stays as compared to those associated with open autotransplantation.

This article will introduce the reader to current techniques used during autotransplantation procedures by focusing on the author's experience in assisting with extracorporeal and laparoscopic operations performed on seven patients at the Cleveland Clinic from January through October, 2006.

The author will also show the difference in total ischemic times as they relate to open vs laparoscopic autotransplantation techniques.

CASE STUDIES

From January through October, 2006, the Cleveland Clinic performed seven autotransplantation procedures. Six of these procedures (Cases One through Six) were done utilizing current open techniques, and one (Case Seven) was performed utilizing laparoscopic techniques.

Of the six procedures done utilizing the open technique, two (Cases Two and Three) utilized a flank incision over the eleventh rib with the patient positioned in a right flank position. The four remaining open procedures were performed with use of an extended midline incision. In the case utilizing the laparoscopic technique (Case Seven), the patient was positioned in a 45-degree flank position with the left side up.

PROCEDURE

For all of the open autotransplantation procedures (Cases One through Six), the kidney was removed and placed in a basin of slush and cold, normal saline solution. The kidney was then taken to a separate "bench" table for intra-arterial perfusion. The renal artery was cannulated utilizing the tip of a 2.5-mm uncuffed endotracheal tube or a 14-gauge Angiocath™ catheter attached to cystoscopy tubing. The kidney was then perfused with 1000 cc of Collins intracellular electrolyte solution to remove contents.

The extracorporeal operation was begun utilizing techniques described by Novick in 1981.[10] The renal artery and renal vein were mobilized by sharp and blunt dissection, and perinephric fat was removed. To maintain hemostasis, venous branches not affecting the function of the kidney were tied with silk ties and dissected.

After extracorporeal surgical repair of the kidney, it was transplanted into the patient's iliac fossa by attaching the renal vein and artery to the external (or common) iliac vein and artery, respectively. Clamps placed on the hypogastric artery and external iliacs were removed. Blood flow was slowly returned to the kidney by removing a bulldog clamp from the renal artery. After vascular anastomosis, the ureter was reattached to the bladder.

Techniques used during the laparoscopic procedure will be described in Case Seven.

CASE ONE

The patient is a 32-year-old male with a history of renal insufficiency, nephrolithiasis and ureteral reflux who underwent bilateral ureteral implants at the age of three. He did well with this surgery until 1998 when he presented with left renal colic and underwent left ureteral reimplantation. He continued to have constant left renal pain and had problems emptying his bladder. The patient had normal blood urea nitrogen and creatine levels at preadmission.

During the procedure, access to the kidney was made via a midline excision from xiphoid to pubis. Upon entry into the peritoneum, many adhesions from prior operations were observed. These adhesions were taken down, and the surgery progressed to visualization of the renal artery, renal vein, and ureter. Once identified, the native ureter, renal artery, and renal vein were dissected. The kidney was removed from the patient's abdomen and placed in a basin of sterile slush.

The extracorporeal surgery was performed using techniques previously described. A 2-mm renal artery originating from the upper pole was sacrificed, which left a 2-cm area of ischemia. The ureteral stump was resected to its anastomosis with the native renal pelvis. The ileum was completely removed from the native renal pelvis, as well as the stump left on the bladder due to ischemia.

The renal artery and vein were retransplanted via an end-to-side anastomosis into the corresponding external iliac artery and vein. Due to the complex repair of the ureter and the adhesions from previous surgeries, the kidney was exposed to two hours and 46 minutes of cold ischemic time. Total revascularization of the kidney took 43 minutes. Total ischemic time was three hours and 33 minutes. No postoperative complications were noted.

CASE TWO

The patient is an 18-year-old female with a history of Gardner's syndrome who developed a retroperitoneal desmoid tumor, which caused a right ureteral obstruction. She had been previously managed by ureteral stents and percutaneous nephrostomy; both of which failed. The patient's BUN and creatine levels were normal at preadmission.

During the procedure, the kidney was removed from the patient's right flank and was perfused with techniques previously mentioned. Due to a large entry into the pleura, a thoracostomy tube was inserted, and the incision was closed. The patient was placed in a supine position, prepped and draped, and a left lower quadrant incision was made to gain access to the iliac fossa for transplantation.

Due to patient repositioning, the kidney was exposed to a total of four hours and 29 minutes of ischemic time. Total revascularization time of the kidney was 55 minutes. The patient did well without any complications reported.

CASE THREE

The patient is a 26-year-old female who suffered from the same condition as mentioned in Case Two with a primary diagnosis of bilateral ureteral obstruction. Prior to her right kidney autotransplantation surgery, she had been managed with bilateral percutaneous nephrostomy tubes. She also had undergone a left renal autotransplantation into the right iliac fossa. The patient's BUN and creatine levels were normal at preadmission.

During the procedure, the kidney was removed from the patient's right flank and perfused as mentioned in Case Two. This kidney contained two small renal arteries—one main renal artery, which contained an early bifurcation, and a smaller renal artery leading to the lower pole of the kidney. Due to the early bifurcation of the main renal artery, it was decided to utilize the right gonadal vein as an extension graft.

After determining proper orientation and flow of the gonadal vein, it was anastomosed to the arteries utilizing 7-0 Prolene.™ The graft was tested for patency and leaks using heparinized saline. The patient was returned from the right flank position to a supine position. A Gibson incision was made and dissected down until there was exposure of the iliac vessels. The kidney was then transplanted using the methods described previously.

When the clamps were removed, the kidney was slow to pink appropriately. Papaverine and verapamil were given to prevent vasospasm of the kidney and to increase blood flow. Upon palpation, a pulse could not be felt on the lower pole artery. A sterile Doppler wand was utilized to locate a signal in the lower pole artery. Upon placement, Doppler signals were heard in both the upper and lower poles of the kidney.

Due to repositioning and extensive arterial reconstruction on the "bench" table, total ischemic time was six hours and 14 minutes. Total revascularization of the kidney took one hour and five minutes. No postoperative complications were noted.

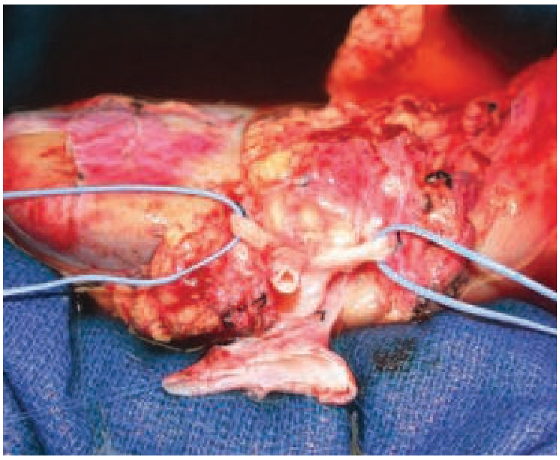


FIGURE 1: Renal artery aneurysm intimately attached to renal vein.

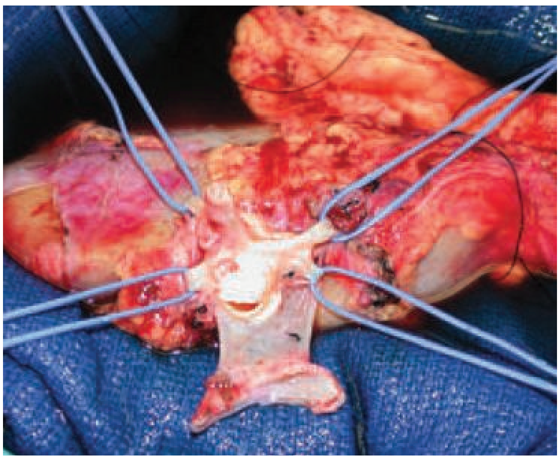


FIGURE 2: Renal artery branches marked with vessel loops.

CASE FOUR

The patient is a 48-year-old female who complained of right flank pain. During evaluation for her pain, a 2.3-cm noncalcified renal arterial aneurysm was found. A renal angiogram was performed and showed that there were two saccular aneurysms originating along the bifurcation of the right renal artery. BUN and creatine levels were normal at preadmission.

The kidney was removed and perfused as previously described. Perirenal fat was dissected off the kidney to maintain a hypothermic core temperature. The renal vein was dissected utilizing sharp and blunt dissection. Venous branches not affecting the function of the kidney were tied with silk ties and dissected. While continuing the dissection, it was observed that the vein was intimately attached to the aneurysm (Figure 1).

At this point, the aneurysm sac was opened in order to preserve a patch of the aneurysm wall close to the venotomy. Four segmental branches of the renal artery that arose distally to the aneurysm were observed. These were identified and marked with vessel loops (Figure 2).

The aneurysm was carefully dissected to preserve all four arterial branches. A hypogastric artery graft was utilized in order to accurately perform the anastomosis of the four renal arterial branches. After deciding placement of the arterial branches on the hypogastric artery graft, anastomosis began by utilizing 8-0 and 7-0 Prolene with an end-to-end and end-to-side anastomosis (Figure 3). After anastomosis, the graft with the connected renal artery branches was flushed with heparinized saline to check for patency and leakage.

After all branches and grafts were checked, the kidney was transplanted into the iliac fossa as described previously. When clamps were removed, there was prompt arterial inflow, and all of the branches were patent (Figure 4). Due to the complex anastomosis of the renal artery, there was a total ischemic time of four hours and 38 minutes. Revascularization of the kidney took 25 minutes. No postoperative complications were noted.

FIGURE 3: Anastomosis of renal artery branches to hypogastric artery graft.

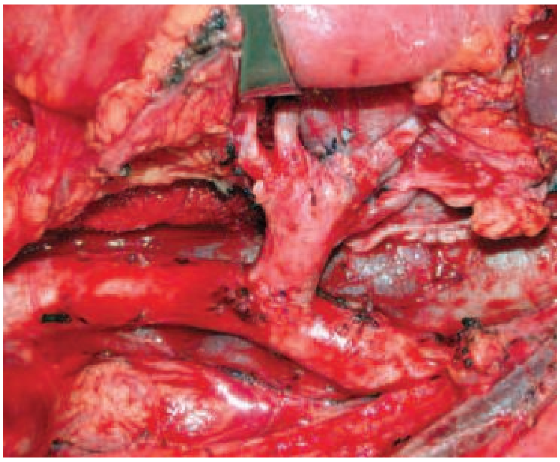


FIGURE 4: Kidney in situ after anastomosis in the external iliac vein and artery.

CASE FIVE

The patient is a 35-year-old female with a primary diagnosis of a left, mid-ureteral stenosis and a secondary diagnosis of nephrolithiasis. The patient has a surgical history of multiple cystoscopies and ureteroscopies for treatment of the ureteral stenosis. The most recent of these surgical procedures occurred two months prior to the autotransplantation procedure. She also has a history of extensive extracorporeal shock wave lithotripsy (ESWL) treatments for her nephrolithiasis. The patient's BUN and creatine levels were normal at preadmission.

During the procedure, the kidney was removed via a midline incision from xiphoid to pelvis. Once the kidney was removed, it was perfused using Collins solution.

After mobilization of the renal artery and renal vein, it was decided to perform a pyeloplasty with ureteroureterostomy. The ureter was spatulated to the renal pelvis utilizing Metzenbaum and Potts scissors. No ureteral stones were visualized, but observation of the spatulated ureter showed a presence of dense, fibrous scar tissue that contributed to the patient's diagnosis of ureteral stricture.

After performing the pyeloplasty, the kidney was transplanted into the iliac fossa. Since the ureter could not be reconnected using normal anastomosis techniques, it was reconnected to the bladder utilizing a psoas hitch with a Boari-Ockerblad flap. To create the psoas hitch, the bladder is moved slightly so that the psoas muscle can be attached to the wide portion of the injured ureter. The Boari flap—a type of extension—is created by elongating part of the bladder to form a tube, which is then attached to the shortened ureter.

Due to the complexity of the repair of the ureter, total ischemic time was three hours and 28 minutes. Total revascularization of the kidney took one hour and 30 minutes. No postoperative complications were noted.

CASE SIX

The patient is a 32-year-old male who presented with a primary diagnosis of a solitary left kidney with cystinuria/amino acid transport disorder and a secondary diagnosis of advanced nephrolithiasis. The patient also complained of severe left flank pain and had intermittent hydronephrosis.

Since the patient had lost his right kidney prior to this procedure, it was important to maintain the function of the left kidney, in order to avoid dialysis and placement on the United Network for Organ Sharing (UNOS) kidney trans-

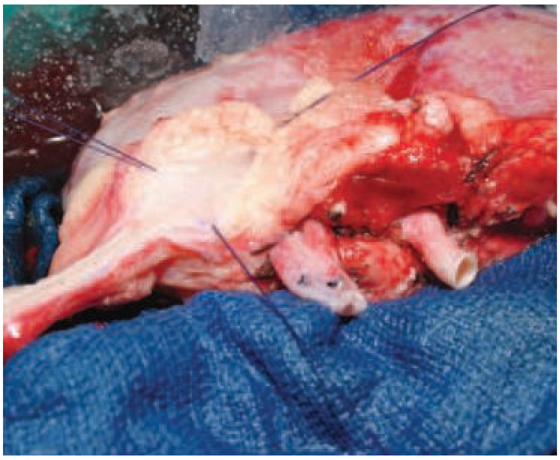


FIGURE 5: Renal artery and vein mobilized after dissection. Ureter opened to renal pelvis.

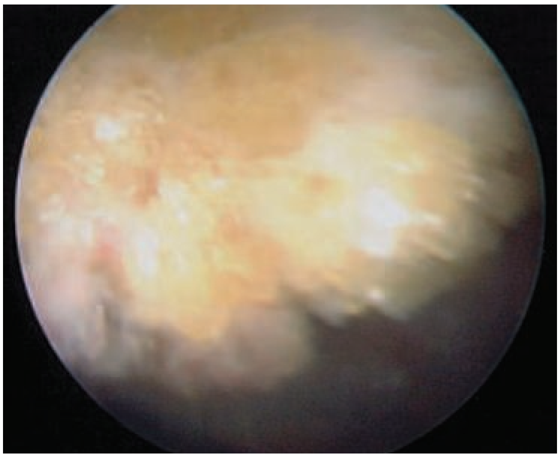


FIGURE 6: Calculus as seen by flexible ureteroscope.

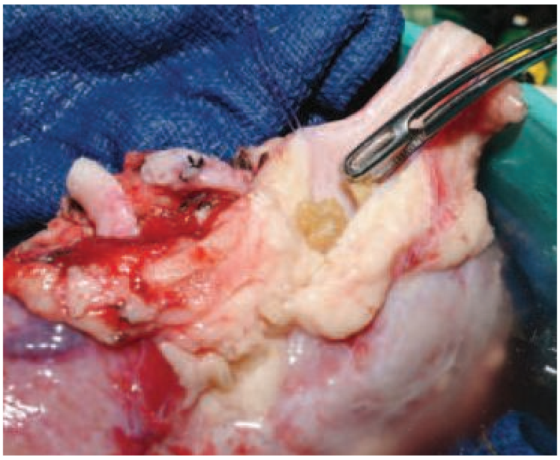


FIGURE 7: Stone fragments removed via Randal stone forceps.

plant waiting list. Preadmission BUN and creatine levels were unknown.

The kidney was removed via a midline incision from xiphoid to pubis. Once removed, it was placed in a basin of sterile slush and perfused with 1000 cc of cold Collins solution. The renal artery and vein were mobilized to allow easier transplantation of the kidney (Figure 5). Once dissection was complete, efforts focused on the ureter and the condition of nephrolithiasis.

While maintaining cold ex vivo perfusion of the kidney, the ureter and the renal pelvis were opened posteriorly in a longitudinal fashion (done for preparation of the pyelocystostomy) (Figure 5). Ex vivo perfusion continued to be maintained utilizing cold Collins solution, cold lactated Ringers solution, and cold sterile water. After the incision of the ureter, a rigid and flexible nephroscopy was performed.

An infundibular stricture was observed in the upper part of the renal pelvis. In order to pass the nephroscope, the stricture was dilated utilizing a 30-Fr Amplatz™ dilatation system with a pressure syringe. The balloon was inflated to 16 atmospheres for two minutes. Subsequently, the sheath-less nephroscope was passed into the upper pole of the kidney.

Upon entering the upper pole of the kidney, a large calculus was found (Figure 6). In order to shatter it, a LithoClast® fragmenting device was used. This device was also used to shatter some of the calculi in the remaining branches of the renal collecting system.

The large stone fragments were tediously and meticulously removed with a Randal stone forceps (Figure 7) and endoscopically by utilizing a lithotripsy basket (Figure 8). All large fragments were removed, and small fragments were irrigated and suctioned out. After removing all the stones, the pyelotomy proximal to the renal pelvis was closed utilizing 3-0 Vicryl™.

Transplantation of the kidney into the external iliac vessels was then begun. Since the external vessels were small in caliber, the kidney would be anastomosed to the common iliac vein and artery (Figure 9). The kidney was perfused without leakage or vasospasm.

After successful anastomosis and visualization of potent blood flow to the kidney, the ureter was anastomosed to the bladder utilizing a psoas hitch with a Boari flap. In addition, a nephrostomy tube was inserted into the kidney and irrigated to facilitate the removal of small stones and sand that were not able to be removed on the "bench" table.

Due to the complexity of the dilatation, lithotripsy, and stone extraction, the total ischemic time was three hours and 16 minutes. Total revascularization time for the kidney was 57 minutes. No postoperative complications were noted.

CASE SEVEN

Unlike the previously discussed cases, Case Seven was performed utilizing laparoscopic techniques.

In an article written in 2001, Meraney described a new technique for total laparoscopic renal autotransplantation that was performed while maintaining the kidney in situ.[6] This procedure was performed on six female farm pigs with uneventful recovery in five of the six animals.

On September 22, 2006, the first successful human laparoscopic autotransplantation was performed at Cleveland Clinic.

The patient is a 25-year-old female with a history of left flank pain, which led to a diagnosis of loin-pain hematuria syndrome. Her physicians believed that autotransplantation via laparoscopic technique would provide relief of her symptoms by dissecting the nerves leading from the left flank into the kidney. This procedure would also provide the patient the opportunity for a shorter hospital stay with limited scarring. The patient's BUN and creatine levels were normal at preadmission.

The patient was positioned in a 45-degree flank position, with her left side up. A 2-mm Veress needle was used to achieve proper insufflation of the abdomen with carbon dioxide. The Veress needle was replaced with a 12-mm port, and two other 10-mm ports were inserted. The colon and spleen were then dissected from the left kidney.

The renal vein and artery were skeletonized, and the adrenal, gonadal, and lumbar attachments of the renal vein were clipped and cut. A 2-mm port was placed below the costal margin in order to retract the ureter laterally. A second 2-mm port was placed to provide insertion of an angioplasty balloon catheter later on in the procedure.

After the structures were dissected and visualized, two laparoscopic bulldog clamps were placed close to the abdominal aortic side of the renal artery, and one laparoscopic bulldog was placed close to the vena caval side of the renal vein.

FIGURE 8: Stone fragments removed via lithotripsy basket.

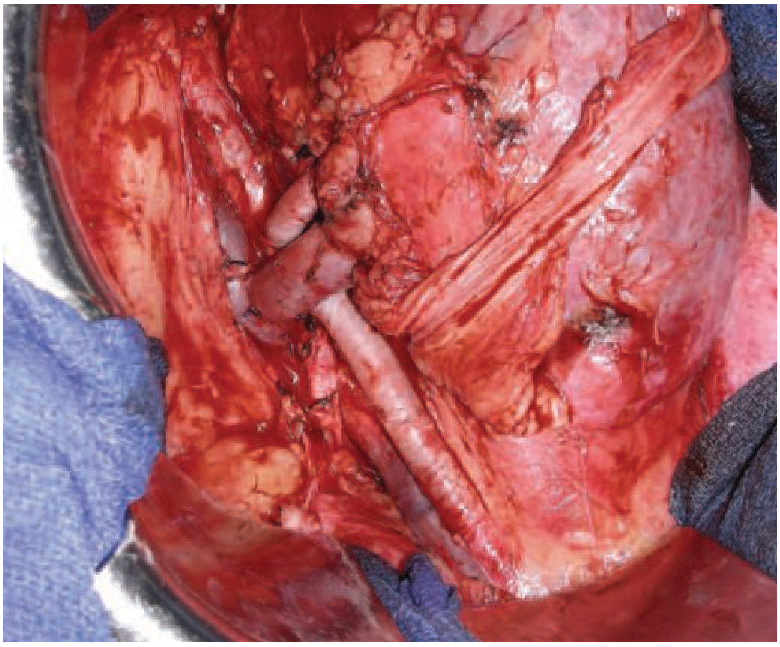


FIGURE 9: In situ view of kidney anastomosed to common iliac vein and artery.

The renal artery was cut approximately 50% of the circumference, leaving a stump on the abdominal aorta for later anastomosis. An angioplasty balloon catheter with a 0.035″ guidewire was inserted into the renal artery. The guidewire was removed, and the catheter was immediately attached to a 1000-cc bag of cold Collins solution via a cystoscopy "Y" connector and a double line perfusion set.

The balloon was inflated along its entire 2-cm length in order to dilate the renal artery, as well as to keep the catheter in position during perfusion. A thermocouple probe was used and inserted in the lower pole of the kidney.

Once perfusion of the renal artery commenced, a small cut was made in the renal vein in order to aid in the ventilation of the kidney. As the kidney was perfused, its core temperature was documented and recorded. The starting core temperature at pre-perfusion was 37° C. This temperature became steadily hypothermic to a core temperature of 18° C post-perfusion.

Instead of transplanting the kidney into the iliac fossa as mentioned in Meraney's article, the kidney was reanastomosed to stumps left at the point of dissection. After removing the catheter, the renal artery was irrigated with heparinized saline and was anastomosed to the aortic stump utilizing 5-0 double-armed Prolene.

After the artery had been totally anastomosed, the renal vein was anastomosed to the vena caval stump in the same way, utilizing 5-0 double-armed Prolene.

The bulldog clamps were removed from the vena caval and aortic stumps. The kidney appeared soft and looked as if there was insufficient blood flow to it. A laparoscopic bulldog clamp was replaced on the renal artery, and the artery was partially reopened.

A small piece of adipose tissue was found within the lumen of the renal artery, which was then removed with a Maryland dissector. Once the adipose tissue was removed, the catheter was reinserted into the renal artery, which was then reperfused using cold lactated Ringers solution. Three interrupted 5-0 Prolene stitches were used to close the defect, and the renal bulldog clamp was removed.

The kidney appeared to be well perfused, and pinked up immediately with good outflow from the renal vein. A small defect in the renal vein was visualized and repaired with a simple 5-0 Prolene stitch.

The ureter was attached to the bladder by spatulating the ureter laterally and performing a pyeloplasty-type closure of the ureter with 4-0 Vicryl. An intraoperative renal ultrasound was performed with Doppler flow to ensure good blood flow to the kidney.

Total ischemic time was one hour and 32 minutes. Total revascularization of the kidney took one hour and 15 minutes.

The patient developed a retrograde fever post-operatively. An ultrasound of the kidney was performed and showed a possible thrombosis. It is believed that this was not a thrombosis, but the anastomosis site. This error could be attributed to the radiologist's inexperience in seeing this type of anastomosis. The patient was placed on preventative anticoagulants and was scheduled for follow-up.

Table 1: Total ischemic time in presented autotransplantation procedures.

Case Number (Open/Laparoscopic)	Warm Ischemic Time	Cold Ischemic Time	Revascularization Time	Total Ischemic Time
Case One (Open)	4 min	2 hrs, 46 min	43 min	3 hrs, 33 min
Case Two (Open)	5 min	3 hrs, 29 min	55 min	4 hrs, 29 min
Case Three (Open)	2 min	5 hrs, 7 min	1 hr, 5 min	6 hrs, 14 min
Case Four (Open)	3 min	4 hrs, 10 min	25 min	4 hrs, 38 min
Case Five (Open)	2 min	1 hr, 56 min	1 hr, 30 min	3 hrs, 28 min
Case Six (Open)	3 min	2 hrs, 16 min	57 min	3 hrs, 16 min
Case Seven (Laparoscopic)	7 min	10 min	1 hr, 15 min	1 hr, 32 min

DISCUSSION

As demonstrated in the case studies, there has been successful progress in the field of autotransplantation since it was first performed in 1963. As shown in Table 1, the use of new laparoscopic techniques for autotransplantation has lowered the amount of cold ischemic time placed on the kidney.

The more cold ischemic time placed on an organ, the higher the risk of decreased function. In addition, laparoscopic autotransplantation has given a relatively safe alternative to open autotransplantation techniques.

CONCLUSION

Renal autotransplantation still remains a last resort procedure for complex urological conditions. With current techniques in autotransplantation procedures, urological laparoscopic surgery may soon become common treatment for many of these conditions.

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References

1. Bodie B, Novick AC, Rose M, Straffon RA. Long-Term Results with Renal Autotransplantation for Ureteral Replacement. *Journal of Urology*. 1986; 136:1187-1189.
2. Gill IS, Uzzo RG, Hobart MG, et al. Laparoscopic Retroperitoneal Live Donor Right Nephrectomy for Purposes of Allotransplantation and Autotransplantation. *The Journal of Urology*. 2000;164:1500-1504.
3. Hardy JD, High Ureteral Injuries. Management by Autotransplantation of the Kidney. *JAMA*. 1963;184:97-101.
4. Jackson CL, Novick AC. Renal Autotransplantation: A Reappraisal. *World Journal of Urology*. 1988;6:129-135.
5. Janetschek G, Marberger M. Laparoscopic Surgery in Urology. *Current Opinion in Urology*. 2000;10:351-357.
6. Meraney AM, Gill IS, Kaouk JH, et al. Laparoscopic Renal Autotransplantation. *Journal of Endourology*. 2001;15:143-149.
7. Novick AC, Jackson CL, Straffon RA. The Role of Renal Autotransplantation in Complex Urological Reconstruction. *The Journal of Urology*. 1990;143:452-457.
8. Novick AC, Straffon RA Stewart, BH. Experience with Extracorporeal Renal Operations and Autotransplantation in the Management of Complicated Urologic Disorders. *Surgery, Gynecology & Obstetrics*. 1981;153:10-18.
9. Novick AC. Microvascular Reconstruction of Complex Branch Renal Artery Disease. *Urologic Clinics of North America*. 1984;2:465-475.
10. Novick, AC. Role of Bench Surgery and Autotransplantation in Renal Calculous Disease. *Urologic Clinics of North America*. 1981;8:299-312.
11. Rose MC, Novick AC, Rybka, SJ. Renal Autotransplantation in Patient with Retroperitoneal Fibrosis. *Cleveland Clinic Quarterly*. 1984;51:357-363.