4

Kidney Transplantation

Abhina Humar and Arthur J. Matas

Introduction

Benching the Kidney from a Deceased Donor
a) Procedure
Adult Kidney Transplant
a) Operative Procedure
Surgical Variations
a) Pediatric Recipient Kidney Transplant
b) Pediatric Donor En-Bloc Kidneys
c) Multiple Renal Arteries
Surgical Complications and Their Management
a) Hemorrhage
b) Renal Artery Thrombosis
c) Renal Artery Stenosis
d) Recipient Arterial Complications
e) Renal Vein Thrombosis
f) Venous Thromboembolism
g) Aneurysms and Fistulas
h) Urologic Complications
i) Lymphoceles
j) Wound Complications

Introduction

In the last 35 years, few fields of medicine have undergone the rapid advances that have been seen with kidney transplantation. From the development of the surgical techniques necessary for transplantation at the beginning of the century, to the dawn of modern transplantation with the introduction of immunosuppressants in the late 1950s, and to its current status as the treatment of choice for end-stage renal disease (ESRD), renal transplantation has enjoyed remarkable progress. The surgical techniques for organ transplantation, including methods of vascular anastomosis, were developed in animal models by Carrel and Guthrie in the early 1900s. The first clinical deceased renal transplant was performed in 1933 by the Ukrainian surgeon Vorono, with unsuccessful results secondary to the immunologic barrier. In the 1950s these obstacles were circumvented by performing the procedure between identical twins. The era of modern renal transplantation began with the introduction of the immunosuppressive agent azathioprine, and renal transplantation was established as a viable option for the treatment of ESRD.
For the majority of individuals with ESRD, transplantation results in superior survival, improved quality of life, and lower costs as compared with chronic dialysis. There are very few absolute contraindications and so most patients with ESRD should be considered as potential candidates. The surgery and general anesthesia, however, impose a significant cardiovascular stress. The subsequent lifelong chemical immunosuppression is also associated with considerable morbidity. Therefore, evaluation of a potential recipient must focus on identifying risk factors that could be minimized or may even contraindicate a transplant.

The preoperative evaluation can be divided into four phases: medical, surgical, immunologic, and psychosocial. The medical evaluation begins with a complete history and physical examination. Mortality after transplantation is just as likely to be due to underlying cardiovascular disease as to infectious and neoplastic complications of immunosuppression. Any history of congestive heart failure, angina, myocardial infarction, or stroke should be elicited. Patients with symptoms suggestive of cardiovascular disease or significant risk factors (e.g., diabetes, age over 50, previous cardiac events) should undergo further cardiac evaluation. Any problems identified should be treated appropriately (medically or surgically). Patients with suspected cerebrovascular disease should undergo evaluation with carotid duplex Doppler studies.

Untreated malignancy and active infection are absolute contraindications to transplantation because of the requisite lifelong immunosuppression. Following curative treatment of malignancy, an interval of 2 to 5 years is recommended prior to transplantation. This recommendation is influenced by the type of malignancy, with longer observation periods for neoplasms such as melanoma or breast cancer and shorter periods for carcinoma in situ or low-grade malignancies such as basal cell carcinoma of the skin. Chronic infections such as osteomyelitis or endocarditis must be fully treated. Other areas of the medical evaluation should concentrate on gastrointestinal problems such as peptic ulcer disease, symptomatic cholelithiasis, and hepatitis.

The surgical evaluation should concentrate on identifying vascular or urologic abnormalities that may affect transplantation. Evidence of vascular disease that is revealed by the history (e.g., claudication or rest pain) or the physical examination (e.g., diminished or absent pulse, bruit) should be evaluated further by Doppler studies or angiography. Severe aortoiliac disease may make transplantation technically impossible; one option in these patients is a revascularization procedure such as an aorto-bifemoral graft prior to the transplant. Areas of significant stenosis proximal to the planned site of implantation may need preoperative balloon angioplasty or stenting. Urologic evaluation should rule out chronic infection in the native kidney, which may require nephrectomy pretransplant. Other indications for nephrectomy include very large polycystic kidneys, significant reflux, and uncontrollable renal vascular hypertension. Children especially require a complete genitourinary tract examination to evaluate reflux and bladder outlet obstruction.

An assessment of the patient’s immunologic status involves determining blood type, tissue type [human leukocyte antigens (HLAs) A, B, DR], and the presence of any cytotoxic antibodies against HLAs (because of prior transplants, blood transfusions, or pregnancies).

A psychosocial evaluation is necessary to ensure that patients understand the nature of the transplant procedure, with its attendant risk. They must be capable of following the medical regimen after the transplant. Patients who have not been compliant with their medical regimen in the past must demonstrate a willingness and capability to do so, before they undergo the transplant.

Living donors are preferred over deceased donors. Recipients of living-donor organs enjoy improved long-term success, avoid a prolonged wait, and are able to plan the timing of their transplant in advance. Moreover, they have a significantly decreased incidence of delayed graft function. All of these advantages contribute to a lower incidence of early acute rejection and to improved graft and patient survival rates. While there is significant benefit for the recipient, there is no physical benefit for the living donor, only the potential for harm. Therefore, it is paramount that the risks of donation be acceptably low, and that the donor is fully aware of the potential risks and has freely given informed consent.
The surgical technique for renal transplantation has changed very little from the original pelvic operation described in 1951. The most common approach today is the standard pelvic operation, with retroperitoneal placement of the kidney, allowing easy access for percutaneous renal biopsy. Usually, the right iliac fossa is chosen because of the more superficial location of the iliac vein on this side. The procedure involves two vascular anastomoses (renal artery and vein) and the ureter to bladder anastomosis.

The initial postoperative care is not unlike that of other surgical patients. Fluid and electrolyte status, vital signs, central venous pressure, and urine output are carefully monitored. Special issues include immunosuppression and monitoring for transplant-related surgical and medical complications unique to these patients. Potential surgical complications specific to the kidney transplant include renal artery or vein thrombosis, ureteral leak, and ureteral stricture.

Outcomes after kidney transplantation have steadily improved over the past three decades, thanks to improvement in maintenance immunosuppression, antirejection therapy, organ retrieval techniques, perioperative care, and treatment of posttransplant infectious complications. Most centers now report patient survival rates exceeding 95% during the first posttransplant year for all recipients. Transplants from living donors have a clear advantage over those from deceased donors; reported 5-year patient survival rates after living and deceased donor transplants are approximately 90% and 80%, respectively. Compared with dialysis, the survival advantage after a transplant is probably greatest for diabetics.

**Benching the Kidney from a Deceased Donor**

Kidneys from a deceased donor are generally procured with a significant amount of the surrounding tissue including the surrounding perineal fat, the adrenal gland, and portions of the aorta and inferior vena cava (IVC). The two kidneys may also be procured en bloc. This wide dissection minimizes the risk of damage to the renal hilum at the time of procurement. Therefore, the first step of the deceased-donor kidney transplant procedure is to adequately prepare the graft to render it suitable for transplant. The basic steps involved are inspection of the organ, dissection of the artery and vein, and removal of the surrounding perirenal fat.
a) **Procedure**

1. The kidney is oriented in its anatomic position to allow for careful inspection of the renal artery (red arrow), the renal vein (blue arrow), the ureter, and the parenchyma. Placing a small clamp on the distal ureter (yellow arrow) is helpful in keeping the proper orientation of the kidney (Figure 4.1). The vessels are inspected for evidence of damage or atherosclerotic disease. The parenchyma should also be inspected for evidence of lesions or traumatic injury.
2. The renal artery is dissected free from the surrounding hilar tissue and an appropriate sized aortic patch is fashioned (Figure 4.2).
3. The renal vein is then similarly dissected for an adequate length. Branches including the adrenal, gonadal, and lumbar all need to be divided and ligated. These branches are usually present on the left renal vein, but the right renal vein usually has no branches. For a left kidney, there is usually adequate length so that the inferior vena cava does not need to be included (Figure 4.3).
4. With a right kidney, the right renal vein may sometimes be short. If so, it can be lengthened by using a segment of the IVC, transecting it transversely superior and inferior to the renal vein, and then closing the edges of the transected IVC using a fine running vascular suture (Figures 4.4 and 4.5).
5. The surrounding perineal fat is then removed from the kidney, taking care not to injure the capsule. This is started from the medial aspect of the upper pole, where the adrenal gland is identified and removed. The dissection continues along the upper pole and then the lateral aspect of the kidney (gray arrows). Care should be taken not to carry the dissection too extensively in the lower pole, as this may devascularize the ureter. The fat (black arrow) in the triangle formed by the lower pole, the hilar vessels, and the ureter (Figure 4.6) should not be separated from the kidney, to preserve blood supply to the ureter.
6. Minimal dissection should be done around the ureter, but the accompanying gonadal vein may be removed (Figure 4.7). The kidney is now ready for implantation.

**Adult Kidney Transplant**

The standard kidney transplant for an adult recipient is usually a heterotopic procedure with the kidney placed in a retroperitoneal location, either in the right or left iliac fossa. The right iliac fossa is usually preferred, unless a future pancreas transplant is planned, or a kidney transplant was previously performed in the right fossa. In these cases, the left fossa is chosen.
In certain situations, an intraperitoneal placement of the kidney may be the better option. If the procedure is performed with a simultaneous pancreas transplant, then the kidney is best placed intraperitoneally, on the opposite side of the pancreas. In very small pediatric patients (usually <20 kg), an intraperitoneal position usually allows for more space and anastomosis to larger vessels for inflow and outflow. Lastly, in the recipient with multiple previous transplants, or with other previous procedures on both the right and left iliac vessels, an intraperitoneal location allows one to stay away from the site of previous surgery, and use the distal aorta and IVC for graft implantation if necessary.

Regardless of the location of the kidney, for adult recipients the vascular anastomoses are generally performed to the iliac vessels. For arterial inflow, the common iliac artery, internal iliac artery, or external iliac artery may be used. Generally, the external iliac artery is preferred, but if it is diseased or small in caliber, then there should be no hesitation in using the common iliac artery. Ultimately, the best option is to place the kidney in the fossa prior to selecting a site for the anastomosis, and choose the site where the renal artery will lie most naturally without significant tension, redundancy, and angulation.

The iliac vein is used for venous outflow – again most commonly the external iliac vein. However, the optimal site should be chosen based on the position of the kidney. The branches of the iliac vein are more variable than the artery. There may be one dominant internal iliac vein or several smaller ones. If the graft renal vein is short, or the recipient iliac vein deep, then the branches of the iliac vein may be divided. This allows the vein to be brought up into a more superficial position, making the anastomoses simpler.

Urinary continuity is restored by connecting the transplant ureter to the bladder. This may be done with or without a stent. Several different techniques have been described for performing this anastomosis. The key goals are to ensure that the ureter is not under tension or too redundant, and that it is well vascularized and perfused at its most distal position where the anastomosis will be performed. It is advisable to create some form of tunnel for the distal aspect of the transplant ureter to diminish urinary reflux.

**a) Operative Procedure**

1. With the patient in the supine position, a “hockey-stick” - shaped incision is made in the lower quadrant (purple line) (Figure 4.8). The incision starts in the midline, one or two finger widths above the pubic bone (solid black line). The incision extends laterally, gently curving upward until the lateral edge of the rectus muscle is reached (broken red line). The incision is then extended superiorly along the lateral edge of the rectus.
2. The incision is deepened to the fascia. Starting medially, and going laterally, the anterior sheet of the rectus muscle is incised (Figure 4.9). At the lateral edge of the rectus muscle, the fascial incision is carried superiorly just lateral to the edge of the rectus muscle (broken line) (Figure 4.10). This is where the muscular layers of the lateral abdominal wall start to form the anterior and posterior sheets of the rectus muscle. Relatively little actual muscle needs to be divided with this approach. Medially it is usually not necessary to divide the rectus muscle, but mobilizing it down to its attachment to the pubic bone helps in later exposure of the bladder.
3. The inferior epigastric vessels are encountered in the middle to lower portion of the incision once the fascia is incised (broken blue line) (Figure 4.11). These vessels are divided between ligatures.

4. As the incision is deepened, the next structure to be encountered is the round ligament in females and the spermatic cord in males (broken yellow lines) (Figure 4.12). The round ligament can be divided, but the spermatic cord should be preserved and a vessel loop passed around it.
5. The peritoneum is then gently reflected medially toward the midline using one hand to retract the peritoneum (broken blue line) and the cautery to divide loose connections. This allows visualization of the retroperitoneal space, with the underlying psoas muscle (broken yellow line) (Figure 4.13).
6. A self-retaining retractor is inserted at this point. An outline of the iliac vessels (black arrow) can be seen at the base of the wound with the genitofemoral nerve (yellow arrow) laterally and the native ureter (blue arrow) medially (Figure 4.14). Where the ureter enters the pelvis is a good landmark to locate the bifurcation of the common iliac artery into its internal and external branches. Care should be taken to ensure that the blades of the retractor do not impinge and occlude the iliac vessels proximally.
7. The external iliac artery is dissected free and mobilized for an adequate length to allow for subsequent clamp placement and anastomosis. Lymphatics (yellow arrow) overlying the artery should be carefully ligated to diminish the risk of lymphocele formation (Figure 4.15).

8. The external iliac vein (blue arrow), usually lying just medial to the artery (yellow arrow), is subsequently isolated. If the iliac vein is deep, or the transplant renal vein short, the internal iliac venous branches can be divided to place the vein in a more superficial position.
position. It is usually a good idea once the vascular dissection is finished to place the kidney in the iliac fossa to determine the best location to perform the venous and arterial anastomosis. These locations can be marked with a marking pen (broken purple line) (Figure 4.16).

9. Usually the venous anastomosis is performed first. Clamps are placed proximally and distally on the vein and an appropriate-sized venectomy is made. There are several ways to perform the actual anastomosis. One technique is to place four sutures (Figure 4.17): one at the upper end of the anastomosis, one at the lower end (solid lines), and one each on the two sides (broken lines).

10. The four sutures are tied and the superior stitch is sewn circumferentially around the anastomosis, with the primary surgeon suturing his/her side and the assistant the
other side (Figure 4.18). In this manner the renal vein is anastomosed to the iliac vein in an end-to-side fashion (blue arrow) (Figure 4.19).
11. The arterial anastomosis can be performed in a similar fashion after clamping the artery and making an appropriate sized arteriotomy. If there is no aortic cuff present on the artery (as with a living donor transplant), then a small circular arteriotomy is made on the iliac vessel (yellow arrow) (Figure 4.20). A vascular punch device, as shown
(Figure 4.21), may be useful for this step. The clamps are removed after this anastomosis, and the kidney allowed to reperfuse.
12. If there is a patch present around the renal artery, then a straight arteriotomy can be made on the recipient vessel, and the patch sewn to the arterial wall (Figure 4.22).

13. There are several methods to perform the ureter to bladder anastomosis including the Ledbetter-Pollitano, Litch, and anterior one-stitch techniques. The latter two techniques are subsequently described. The distal ureter is adequately prepared by trimming to an appropriate length, ligating the accompanying ureteral vessels (black arrows), and spatulating the distal end (Figure 4.23).
14. The retractors are repositioned to expose the bladder (Figure 4.24). It is helpful to fill the bladder and clamp the urinary catheter at this point. An incision is made...
through the detrusor muscle, exposing the underlying mucosa, but not going through it (black arrow) (Figure 4.25).
15. The detrusor muscle is then gently separated from the underlying mucosa (Figure 4.26). This can be done bluntly with gauze (blue arrow). This step is useful for creation of the subsequent tunnel, which will cover the distal part of the ureter.

16. With the Litch technique, an incision is made in the bladder mucosa and the distal spatulated end of the ureter is anastomosed for the bladder mucosa using a fine running absorbable suture (Figure 4.27). Triangulating the anastomosis is a useful technique here. One suture is placed in the heel, and one at each of the two distal corners. The heel stitch is then tied and run toward the tops.
17. With an anterior one-stitch technique a double-ended suture is placed in the spatulated end of the ureter with the two needles on the “inside” aspect of the ureter (Figure 4.28a). These two sutures are then brought through a small opening made in the bladder mucosa with the needles exiting the bladder further distally (Figure 4.28b). These sutures are then used to pull the ureter into the bladder. The ureter is then secured to the anterior wall of the bladder by tying the anterior double-ended stitch (Figure 4.28c).
18. With either technique the detrusor muscle is then closed over the distal 5 to 6 cm of transplant ureter (broken blue line) to prevent reflux (Figures 4.29 and 4.30).
19. The kidney is then placed in a position such that there is no angulation or twisting of the renal artery (yellow arrow) or the renal vein (blue arrow) (Figure 4.31). The incision is then closed by approximating the fascia using a running or interrupted suture.

**Surgical Variations**

**a) Pediatric Recipient Kidney Transplant**

The surgical techniques for kidney transplantation in pediatric recipients, especially in the older child, are not very different from the techniques described for adult recipients.
1. For recipients ≤20 kg, we prefer an intraperitoneal approach using a kidney from an adult-sized living donor. The kidney is placed on the right side, behind the right colon (Figure 4.32). Anastomosis is generally to the distal aorta and cava.

2. The procedure is started with a long midline incision to enter the peritoneal cavity. The right colon (blue arrow) is mobilized and reflected medially to expose the right
retroperitoneal area, including the psoas muscle (black arrow) and the distal aorta/proximal iliac vessels (yellow arrow) (Figure 4.33).

3. The infrarenal cava (blue arrow), infrarenal aorta (yellow arrow), and proximal iliac vessels are isolated and encircled (Figure 4.34).
4. The renal artery is anastomosed to the distal aorta and the renal vein is anastomosed to the distal cava (Figure 4.35), in a manner similar to that described for adult recipients. The bladder anastomoses can also be performed as previously described for adults. The colon is then returned to its proper position, lying anterior to the transplanted kidney. The incision is then closed.

**b) Pediatric Donor En-Bloc Kidneys**

Kidney from small pediatric donors (<15 kg) can be used in adult recipients. In this situation, however, both kidneys should be transplanted en bloc into the one recipient.

1. The kidneys are prepared on the back table. The aorta and cava are left intact with the two kidneys. The proximal ends of the cava and aorta are oversewn (Figure 4.36). The distal ends can then be used to perform the anastomoses to the recipient vessels.
2. The anastomoses are performed to the iliac vessels of the recipient. The two ureters can be anastomosed separately into the recipient bladder (Figure 4.37).

c) Multiple Renal Arteries

Multiple renal arteries are present in 10% to 15% of cases. Many different options are possible for reconstruction, depending on size of the vessels, location of the vessels, donor source (living vs. deceased), and quality of the recipient vessels.
1. Often the two arteries (yellow and blue arrow) are implanted separately, either to the external or common iliac vessels (Figure 4.38) . . .

2. . . . or one to the external iliac and one to the internal iliac artery (Figure 4.39).
Surgical Complications and Their Management

Surgical complications remain an important potential cause of graft loss after kidney transplants. They may also result in graft dysfunction that must be differentiated from medical and immunologic causes of graft dysfunction. The initial presentation of surgical problems may be very similar to nonsurgical problems such as rejection or drug toxicity. Even if these complications do not affect graft function, they nonetheless may account for significant morbidity in the recipient, or may even result in death. For all of these reasons, it is crucial that all persons involved in the postoperative care of kidney transplant recipients be aware of the potential surgical complications that may occur, thus allowing for rapid diagnosis and initiation of treatment. Common surgical complications include the following.

3. The two vessels can be reconstructed on the back table so that only one anastomosis is required in the recipient. If an aortic patch is present on the two vessels, the two patches can be sewn together (Figure 4.40).

4. Another option is to connect one vessel to the other in an end-to-side fashion. As shown in this example with three renal arteries, artery 1 and 2 have been sewn together with a common patch (broken blue line), while artery 3 has been anastomosed to artery 1 in an end-to-side fashion (broken yellow line) (Figure 4.41).
a) **Hemorrhage**

Bleeding is uncommon after kidney transplants; it usually occurs from unligated vessels in the graft hilum or from the retroperitoneum of the recipient. Risk factors include recipient obesity, the presence of antiplatelet agents, and the need for anticoagulation. A falling hematocrit level, hypotension or tachycardia, and significant flank pain should all raise concern regarding the possibility of bleeding. Surgical exploration is seldom required, because the bleeding often stops spontaneously. However, ongoing transfusion requirements, hemodynamic instability, and compression of the kidney by hematoma are all indications for surgical reexploration.

b) **Renal Artery Thrombosis**

This complication usually occurs early posttransplant; it is an uncommon event, with an incidence of <1%. However, it is a devastating complication, usually resulting in graft loss. Typically, it occurs secondary to a technical problem, such as intimal dissection or kinking or torsion of the vessels. Presentation is with a sudden cessation of urine output. Diagnosis is easily made with color flow Doppler studies. Urgent thrombectomy is indicated, but the transplanted kidney has no collateral vessels, and its tolerance of warm ischemia is very poor. Therefore, most of these grafts cannot be salvaged and require removal.

c) **Renal Artery Stenosis**

Stenosis of the renal artery, a late complication, is generally much more common than renal artery thrombosis. Renal artery stenosis has a reported incidence of 1% to 10%. Most cases are identified within the first few years posttransplant. Recipients may present with poorly controlled hypertension, allograft dysfunction, and peripheral edema; physical examination may detect a bruit over the kidney. Doppler studies are a good screening tool with high sensitivity and specificity. A magnetic resonance angiogram or computed tomography (CT) angiogram can be performed to confirm the diagnosis.

First-line treatment for symptomatic lesions uses interventional radiologic techniques, usually angioplasty with or without a stent. Initial success rates of about 80% have been reported with angioplasty, albeit with a fairly significant recurrence rate. Some lesions are less amenable to angioplasty. For example, anastomotic strictures and long strictures are less likely to be treated successfully with angioplasty and have a higher risk of angioplasty complications. Potential complications with any angioplasty procedure include rupture or thrombosis of the vessel, which can lead to graft loss. Surgery is reserved for stenoses that do not respond to radiologic techniques. Possible options include reimplantation of the vessel, patch angioplasty, and surgical bypass. While the success rate with surgery is generally good, it may be technically very difficult because of the extensive fibrosis that often develops around the transplanted kidney. Graft loss at the time of attempted surgical correction is a potential risk.
1. If surgery is indicated, one useful technique is to use the internal iliac artery to bypass a proximal stenosis. The surgery should be approached from an intraperitoneal route. The transplant renal artery distal to the stenosis is isolated (broken blue line) (Figure 4.42). The internal iliac artery (broken yellow line) is isolated and mobilized deep into the pelvis. Here it is divided (black arrow) (Figure 4.43).
2. The transplant renal artery is then divided and anastomosed to the divided internal iliac artery (black arrow) (Figures 4.44 and 4.45).

d) Recipient Arterial Complications

Arterial complications that affect the recipient vessels (most commonly the iliac vessels) are much less common, but can be equally devastating. Early events, such as iliac artery thrombosis or intimal dissection, can be limb-threatening as well as potentially lead to
graft loss. Late complications, such as pseudoaneurysms or fistulas, can lead to significant hemorrhage. Predisposing risk factors include underlying peripheral vascular disease, deep infections, and insulin-dependent diabetes. Iliac artery thrombosis results in an ischemic extremity, which usually occurs very early postoperatively (at times, even intraoperatively). If the problem is recognized intraoperatively, it should be immediately resolved (e.g. an intimal dissection is repaired by tacking the intima to the arterial wall.) At the end of every transplant procedure, a quick vascular exam and inspection of the lower extremities should be performed. If an ischemic extremity is noted, immediate surgical exploration with balloon thrombectomy is essential to salvage the limb and prevent long-term sequelae.

Occlusive disease of the iliac artery proximal to the site of renal artery anastomoses may clinically mimic renal artery stenosis. Occlusive lesions may develop as a result of progressive peripheral vascular disease, or they may represent an injury from the vascular clamp placed on the artery at the time of the transplant. Patients may present with deteriorating renal function, hypertension, and buttock claudication. On physical examination of such patients, diminished femoral pulse should make the clinician suspicious of occlusive disease. This disease tends to be very amenable to treatment with radiologic techniques such as angioplasty and stenting.

e) Renal Vein Thrombosis

This complication, like its arterial counterpart, usually results in graft loss. Causes include angulation or kinking of the vein, compression by hematomas or lymphoceles, anastomotic stenosis, and extension of an underlying deep venous thrombosis. Most cases occur early, usually within the first 10 days posttransplant. Patients may present with a tender swollen graft and/or hematuria. Doppler studies are again the best diagnostic tool. Urgent thrombectomy is indicated, but for most patients, graft salvage is not possible; graft nephrectomy is usually required. However, graft salvage is possible if thrombectomy can be achieved soon after the event (usually within 1 hour). Even if graft salvage is not possible, urgent reexploration should be performed, because such grafts can become very swollen and edematous, with a risk for rupture and subsequent hemorrhage.

f) Venous Thromboembolism

Venous thromboembolic complications that affect the recipient vessels (deep venous thrombosis and pulmonary embolism) are not uncommon. The incidence of deep venous thrombosis is close to 5%; the incidence of pulmonary embolism is 1%. Usually two peaks in incidence are reported – one early in the postoperative period (likely related to operative factors) and a second peak at around 4 weeks (perhaps related to a rising hematocrit level). Risk factors include older recipient age, diabetes, thrombophilic disorders, and a history of deep venous thrombosis. For recipients with such risk factors, prophylaxis with low-dose heparin is recommended.

g) Aneurysms and Fistulas

Other potential vascular problems include arteriovenous fistulas and aneurysms. Most aneurysms that occur posttransplant are pseudoaneurysms, usually resulting from partial disruption of the arterial anastomosis. Some aneurysms are associated with a local infection, though this association is more common after pancreas transplants. Patients may be asymptomatic, with the abnormality being noted on a routine ultrasound exam. However, hypotension and abdominal pain due to rupture of the aneurysm may also occur. Sometimes, expansion of the aneurysm results in local pressure symptoms before rupture. Ultrasound is a good screening test, but a further definitive tool,
such as angiography, is necessary – unless the patient presents with a rupture, in which case an immediate repair is indicated. The technique of repair depends on the presence or absence of infection or if the patient presents with massive bleeding. If either infection or massive bleeding is present, graft salvage is usually not possible; instead, graft nephrectomy and repair of the recipient vessels with autogenous vein usually represents the best option. In a more elective setting without infection, pseudoaneurysm repair and graft salvage may be possible.

Arteriovenous fistulas may occur in the kidney graft parenchyma after a biopsy. They are easily detected by Doppler studies. Asymptomatic fistulas can simply be observed, because most will resolve spontaneously. Fistulas that occur with significant hematuria can be managed by selective arterial catheterization and embolization.

**h) Urologic Complications**

Urinary tract complications, manifesting as leakage or obstruction, generally occur in 2% to 10% of kidney recipients. The underlying cause is often related to poor blood supply and to ischemia of the transplant ureter. Rarely life-threatening, urinary tract complications can result in significant morbidity for immunocompromised recipients or in significant, long-term graft damage.

**Urine Leaks**

Leakage most commonly occurs early. It is usually from the anastomotic site. Causes other than ischemia include undue tension created by a short ureter, and direct surgical injury to the ureter (usually at the time of procurement). Presentation is usually early (before the 5th posttransplant week); symptoms include fever, pain, swelling at the graft site, increased creatinine level, decreased urine output, and cutaneous urinary drainage. Diagnosis can be confirmed with a hippurate renal scan. Early surgical exploration with ureteral reimplantation is indicated for very early leaks, for large leaks, or for leaks that do not respond to conservative measures. Many leaks, however, may be managed by using the principles of drainage and stenting. Drain placement to evacuate a urinoma and urinary tract stenting (usually by percutaneous nephrostomy and stent placement) can successfully manage many urine leaks posttransplant.

**Obstruction**

Obstruction may present early or late. Early obstruction may be due to edema, blood clots, hematoma, and kinking. Late obstruction is generally due to scarring and fibrosis from chronic ischemia. Presentation is usually with an elevated serum creatinine level. An ultrasound exam, assessing for hydronephrosis, is a good initial tool. A furosemide renogram is useful in less obvious cases of obstruction; a percutaneous nephrostogram is the most specific test. Initial treatment with percutaneous transluminal dilatation (PTD), followed by internal or external stent placement, has yielded good results. If such treatment is not successful, then surgical intervention is indicated. For very distal strictures, the transplanted ureter may be reimplanted into the bladder. If the stricture
is more proximal, then the native ureter can be used to bypass the obstruction (Figure 4.46).

**Hematuria**

Another potential urinary complication is hematuria. Mild hematuria is not infrequent. It is usually observed in the first 12 to 24 hours posttransplant. In most patients, it resolves spontaneously. More extensive bleeding may result in retained blood clots and urinary tract obstruction, which is the most common cause of sudden cessation of urine output immediately posttransplant. Continuous bladder irrigation usually restores diuresis, but if not, cystoscopy may be necessary to evacuate the clot and cauterize the source of the bleeding.

**Lymphoceles**

The incidence of lymphoceles (fluid collections of lymph that generally result from cut lymphatic vessels in the recipient) is 1% to 15%. Careful ligation of all lymphatics seen at the time of iliac vessel dissection can help minimize the incidence of lymphoceles. Lymphoceles usually do not occur until at least 2 weeks posttransplant. Symptoms, if present, are generally related to the mass effect and compression of nearby structures (e.g., ureter, iliac vein). An ultrasound exam confirms a fluid collection, but percutaneous aspiration may be necessary to rule out other complications such as urinoma, hematoma, or abscess.

Many lymphoceles are clinically asymptomatic; if so, they usually are less than 3 cm, resolve spontaneously over time, and do not require any therapeutic intervention.

Symptomatic lymphoceles require drainage, which can be achieved either by surgery or by percutaneous radiologic methods. The standard surgical treatment is creation of a peritoneal window to allow for drainage of the lymphatic fluid into the peritoneal cavity, where it can be absorbed. Either a laparoscopic or an open approach can be used. Another option is percutaneous insertion of a drainage catheter, with or without scle-
rotherapy; however, this option is associated with some risk of recurrence or infection. A variant approach is to initially drain the lymphoceles percutaneously after inserting a drainage catheter; sclerotherapy is then attempted via this catheter. If the lymphoceles continue to drain, if they recur, or if they were not amenable to percutaneous drainage initially, then a laparoscopic or open peritoneal window should be created surgically.

1. Laparoscopically the lymphocele is drained from the inside of the peritoneal cavity (Figure 4.47).
2. The lymphocele is identified from the inside of the peritoneal cavity by its bulging (solid arrows) (Figure 4.48a). Intraoperative ultrasound may be useful to identify the exact location of the lymphocele. A circular rim of peritoneum is excised (Figure 4.48b) to allow for internal drainage of the lymphocele (Figure 4.48c).

**Wound Complications**

Wound complications are now probably the most common types of complication posttransplant. They usually do not result in graft loss or death, but can result in
significant morbidity with prolonged hospitalization or rehospitalization. In certain situations, wound complications may also be associated with inferior graft survival rates. Wound complications can be broadly categorized into infectious and noninfectious complications.

**Wound Infections**

Wound infections generally occur earlier after a surgical procedure as compared with noninfectious wound complications. The incidence of wound infections after kidney transplants is about 5%, a figure consistent with that reported in the urologic literature for nontransplant procedures of similar magnitude. A kidney transplant is generally considered a clean–contaminated case: the bladder is opened, and some urine is usually spilled in the operative field. The added stress of immunosuppressive drugs, including prednisone, probably also has some impact on the risk for wound infections posttransplant.

Wound infections may be either superficial or deep (i.e., to the fascia). Deep infections are generally related to complications such as urinary leaks. Superficial infections, more common than deep infections, are related to contamination from skin organisms or from urine (during the bladder anastomosis). Obesity is probably the biggest risk factor for a wound infection posttransplant. Other risk factors include a urine leak, the need for a reoperation, and perhaps the use of the newer, more powerful immunosuppressive medications.

Treatment depends on whether the wound infection is superficial or deep. Deep infections are treated with drainage—either by surgery or by percutaneous drainage—and, usually, antibiotics. Superficial infections are usually treated by opening the surgical wound and allowing it to heal by secondary intention; antibiotics are usually not necessary, unless the recipient has significant cellulitis or systemic symptoms.

**Noninfectious Wound Complications**

These include early fascial dehiscence and late incisional hernias. Recipient obesity is the most significant risk factor. These will generally require surgical repair.

**Selected Readings**