Technical Aspects of Renal Transplantation

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Renal transplantation is the preferred treatment method of end-stage renal disease (ESRD). It is more cost-effective than is maintenance dialysis [1] and usually provides the patient with a better quality of life [2]. Adjusted mortality risk ratios indicate a significant reduction in mortality for kidney transplantation recipients when compared with that for patients receiving dialysis and patients receiving dialysis who are on a waiting list for renal transplantation (Fig. 14-1) [3].

The indication for renal transplantation is irreversible renal failure that requires or will soon require long-term dialytic therapy. The evaluation of candidates for renal transplantation is discussed in Chapter 12. Generally accepted contraindications are noncompliance, active malignancy, active infection, high probability of operative mortality, and unsuitable anatomy for technical success [4]. The technical aspects of kidney transplantation are discussed, primarily through the illustrations of kidney preparation and of a living donor renal transplantation.

Kidneys from living donors require little preparation by the transplantation team because most of the dissection has already been done during the nephrectomy. Further separation of the renal artery or arteries from the renal vein(s) will allow separation of the arterial and venous suture lines in the recipient and will prevent the technical inconvenience of side-by-side anastomoses. The right kidney from a living donor usually has a cuff of the inferior vena cava attached to the renal vein. This provides the recipient team with maximum renal vein length and a wide lumen for anastomosis. The renal arteries in a kidney graft from a living donor are not attached to aortic patches as they usually are in the cadaveric kidney. The technical aspects of living-donor harvesting are not illustrated here.

CHAPTER

14

ADJUSTED MORTALITY RISK RATIOS FOR END-STAGE RENAL DISEASE BY TREATMENT MODALITY

Treatment modality	Risk ratio
All patients on dialysis	1.0
Patients on dialysis who are on a waiting list	0.48
Cadaveric kidney transplantation recipients	0.32
Living-donor related kidney transplantation recipients	0.21

Data from US Renal Data System [3].

FIGURE 14-1

The adjusted mortality risk ratio for patients on dialysis placed on the renal transplantation waiting list is greater than that for kidney transplantation recipients, suggesting transplantation itself results in a reduced mortality risk for patients with end-stage renal disease who are treated [3].

TECHNICAL CONSIDERATIONS FOR RECIPIENTS OF KIDNEY TRANSPLANTATION

Kidney graft	Recipient
Right or left	Abdominal wall anatomy
Gross appearance and size	Size
Arterial anatomy	Arterial anatomy
Venous anatomy	Venous anatomy
Ureteral anatomy	Urinary tract anatomy and function
	Gender

FIGURE 14-2

A number of factors concerning the kidney graft and recipient determine the technique of renal transplantation in each recipient. Placement of the kidney graft in the contralateral iliac fossa is preferable because the renal pelvis becomes the most medial of the vital renal structures and thus readily available for future reconstruction if ureteral stenosis occurs. Areas of previous abdominal surgery such as ileostomy, colostomy, renal transplantation, or a peritoneal dialysis exit site are avoided, if possible. A kidney too large for the recipient's iliac fossa is usually placed in the right retroperitoneal space and revascularized with the aorta or common iliac artery and interior vena cava or common iliac vein. Pelvic vascular disease and previous renal transplantation determine whether the aorta or internal iliac, external iliac, common iliac, native renal or splenic artery will be selected for renal artery anastomosis. The use of both internal iliac arteries in serial renal transplantations in men is avoided to prevent impotence [5]. The method of urinary tract reconstruction depends primarily on the status of the recipient's bladder, continent reservoir, or incontinent intestinal conduit.

Cadaveric Kidney Graft

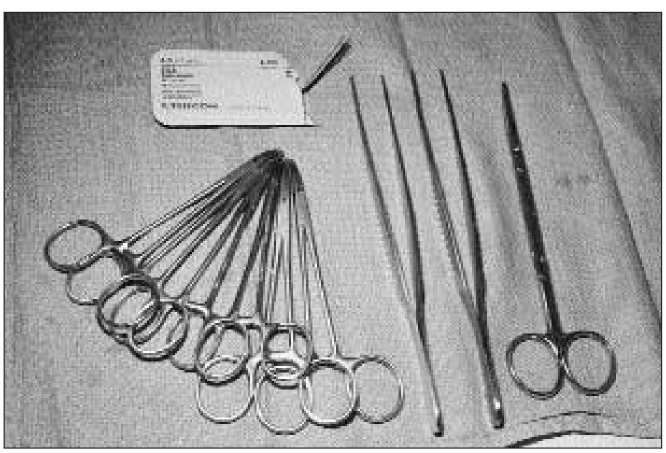

FIGURE 14-3

Instrument setup for cadaveric kidney graft preparation. The towel prevents renal movement during dissection.

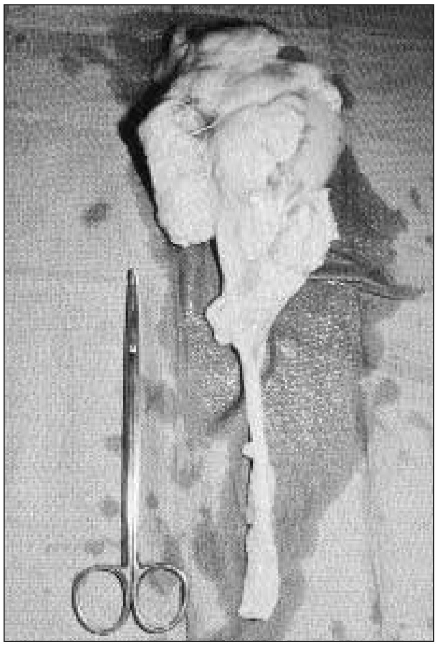

FIGURE 14-4
Preparation of a left cadaveric kidney graft. The kidney and its vital structures are surrounded by other tissues. The cadaveric kidney graft can require an hour of preparation time because the specimen usually includes a portion of the inferior vena cava, an aortic cuff, the adrenal gland, variable amounts of perinephric tissue, sometimes pieces of muscle, and occasionally damaged renal vessels.

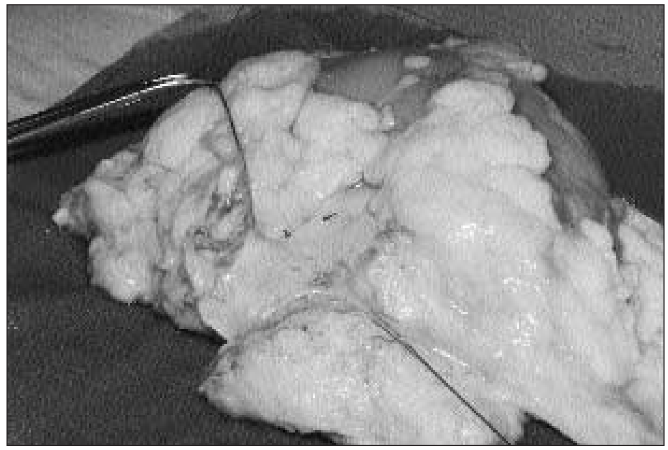

FIGURE 14-5
Renal vein dissection. The adrenal and gonadal veins have been isolated. They will be divided between ligatures.

FIGURE 14-6
Renal artery dissection. In this posterior view, the aortic patch and main renal artery have been separated from the surrounding tissues.

FIGURE 14-7
Left cadaver kidney graft after preparation. The adrenal gland and excess perinephric tissue have been removed. Fibrofatty tissue is left around the renal pelvis and ureter to ensure blood supply to the ureter. The aortic patch, renal vein, and ureter will be further modified to provide a “best fit” in the recipient.

Preparation of Kidney Graft Vessels

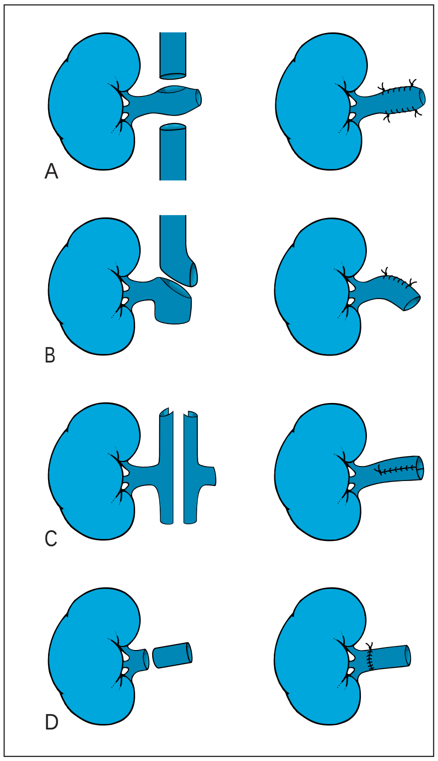

FIGURE 14-8

Venoplasties for right renal vein extension of a cadaveric kidney graft [6–8]. **A–C**, Use being made of the inferior vena cava. **D**,Use being made of the external iliac vein of the cadaveric donor.

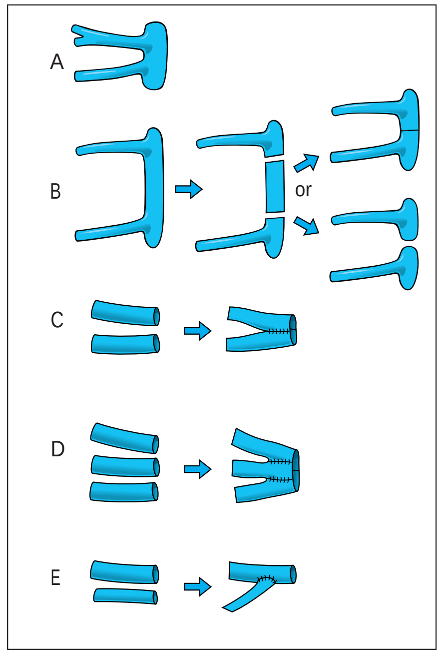

FIGURE 14-9

Preparation of the renal allograft with multiple renal arteries [9]. **A** and **B,** The use of aortic patches when the kidney is from a cadaveric donor is demonstrated. **C** and **D,** The possibilities that exist when an aortic patch is not part of the specimen, such as when the kidney is from a living donor. **E,** The segmental renal artery also can be anastomosed to the inferior epigastric artery using an end-to-end technique.

The Kidney Transplantation Operation

DIVISION OF OPERATING ROOM RESPONSIBILITIES FOR RECIPIENTS OF KIDNEY TRANSPLANTATION

Anesthesiologist	Surgeon
Anesthetic induction	Patient position
Placement of central venous access line	Bladder catheterization
Administration of antibiotics	Initial skin preparation
Administration of immunosuppressants	Incision and exposure of operative site
Administration of heparin	Renal revascularization
Assurance of conditions for diuresis	Urinary tract reconstruction
	Wound closure

FIGURE 14-10

After the induction of anesthesia, the anesthesia team places a double- or triple-lumen central venous access catheter, usually via the internal jugular vein. While that is taking place, the surgical team places a retention catheter (usually 20F with a 5-mL balloon), fills the bladder to 30 cm H_2 pressure or 250 mL (whichever occurs first), connects the catheter to a three-way system or clamped urinary drainage system, and places the clamp(s) within reach of the anesthesiologist for control during the operation. The preoperative antibiotic is administered by the anesthesia team. The surgical team shaves both sides of the patient's abdomen from just above the umbilicus to the distal edge of the mons pubis. The skin is wiped with alcohol, and the nursing team completes the skin preparation. The skin over both iliac fossae is prepared in the event an unexpected vascular contraindication is detected on the chosen side. If immunosuppressant therapy has not been administered, the anesthesia team begins that protocol.

Adult Recipient

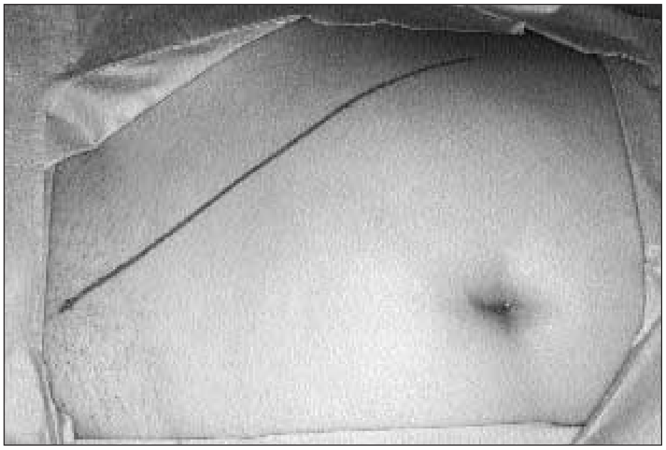

FIGURE 14-11

Surgeon's view of the right iliac fossa operative site. In this procedure, a 40-year-old man will be receiving his brother's left kidney, which has a single artery, single vein, and single ureter. The renal vessels will be anastomosed to his right external iliac artery and vein, and urinary tract reconstruction will be by extravesical ureteroneocystostomy [10,11]. The patient is positioned with the head slightly down, supine, and rotated toward the surgeon, who is standing on the patient's left side.

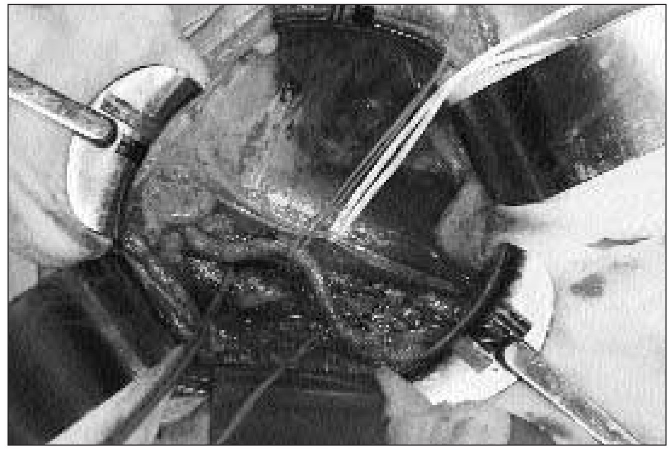

FIGURE 14-12 (*see* Color Plate)

Exposure of the right iliac fossa. The contents of the iliac fossa are exposed by incising the skin, subcutaneous tissues, anterior rectus sheath, external and internal oblique muscles, and the transversalis muscle and fascia. The inferior epigastric artery is divided between ligatures, the spermatic cord is preserved (in women, the round ligament is divided between ligatures), and the rectus muscle and peritoneum are retracted medially. This exposes the genitofemoral nerve (*white umbilical tape*), the external iliac vein (*blue tape*), and the external and internal iliac arteries (*red tapes*).

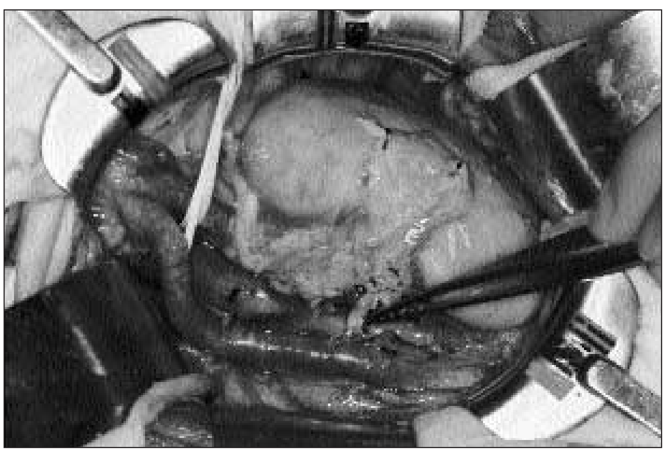

FIGURE 14-13

Determining "best fit." The kidney graft is placed in the wound and the renal vessels stretched to the recipient vessels to determine the best sites for the arterial and venous anastomoses.

FIGURE 14-14

Isolation of the arteriotomy site. Heparin (30–50 U/kg) is administered intravenously, and vascular clamps are placed on the external iliac artery. The distal clamp is applied first so that the arterial pressure will distend the targeted artery. The external iliac artery is incised longitudinally, the lumen is irrigated with heparinized saline, and fine monofilament vascular sutures are placed in four quadrants to receive the spatulated renal artery. When the recipient artery has significant arteriosclerosis, an endarterectomy can be done or a 5- or 6-mm aortic punch can be used to create a smooth round arteriotomy.

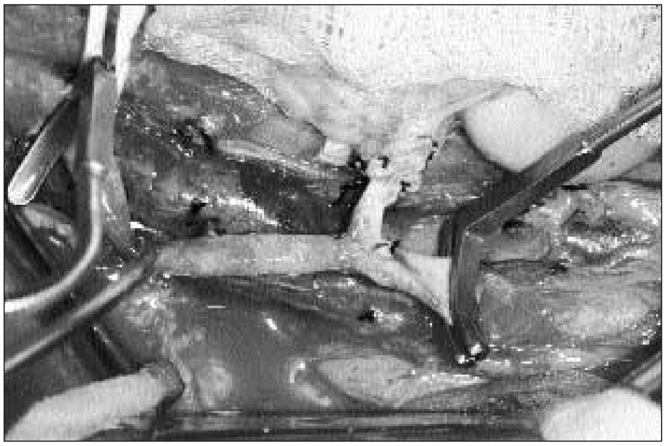

FIGURE 14-15
Completed end-to-side renal artery–to–external iliac artery anastomosis. Many surgeons perform the arterial anastomosis first because it is smaller than is the venous anastomosis. Thus, the kidney can be moved about more easily to expose the arterial anastomosis when it is not tethered by a previously completed venous anastomosis. An ice-cold electrolyte solution is periodically dripped onto the kidney graft to keep it cold during vascular reconstruction.

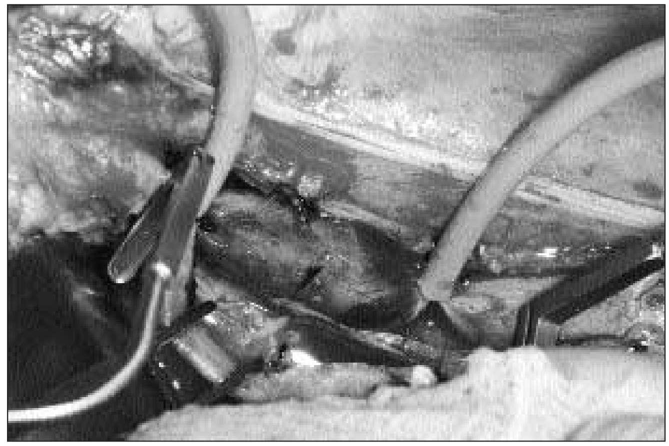

FIGURE 14-16
Isolation of the right external iliac vein. The kidney is retracted medially, and a segment of the external iliac vein is isolated between Rumel tourniquets. The cephalad tourniquet is applied first so that increased venous pressure will dilate the vein.

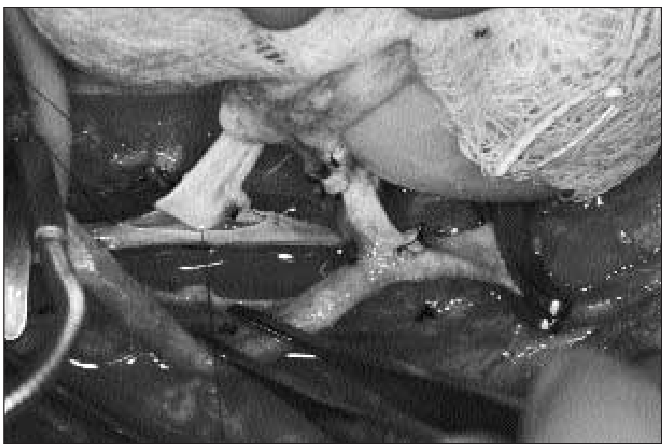

FIGURE 14-17
Renal vein anastomotic setup. The renal vein is anastomosed to the side of the external iliac vein with the same suture technique that was used for the arterial anastomosis.

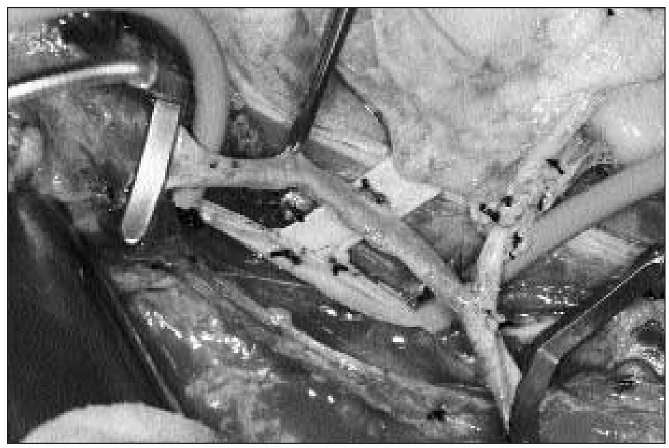

FIGURE 14-18
Completed venous and arterial anastomoses.

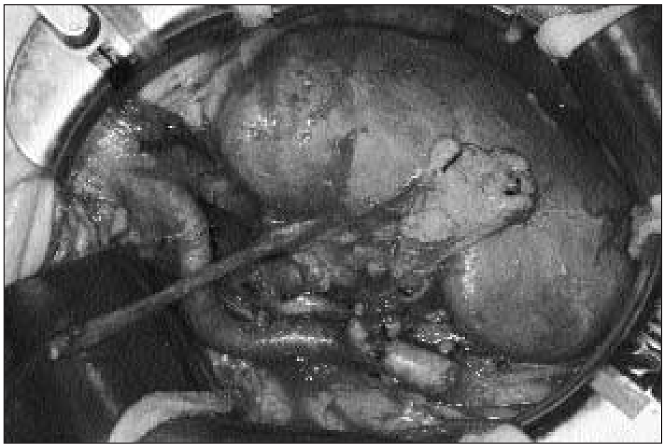

FIGURE 14-19

Revascularized kidney transplantation. The usual clamp release sequence is as follows: proximal vein, distal artery, proximal artery, and distal vein. Arterial spasm is treated by subadventitial injection of papaverine.

FIGURE 14-20

Urinary tract reconstruction [10–11]. Unstented parallel incision extravesical ureteroneocystostomy requires a bladder full of antibiotic solution, clearance of fat from the superolateral surface of the bladder, and placement of the ureter under the spermatic cord to prevent ureteral obstruction. Parallel incisions are made 2 cm apart in the seromuscular layer of the bladder to expose the bladder mucosa.

FIGURE 14-21

Submucosal tunnel creation. A right-angle clamp is used to develop the tunnel and to pull the transplantation ureter through it.

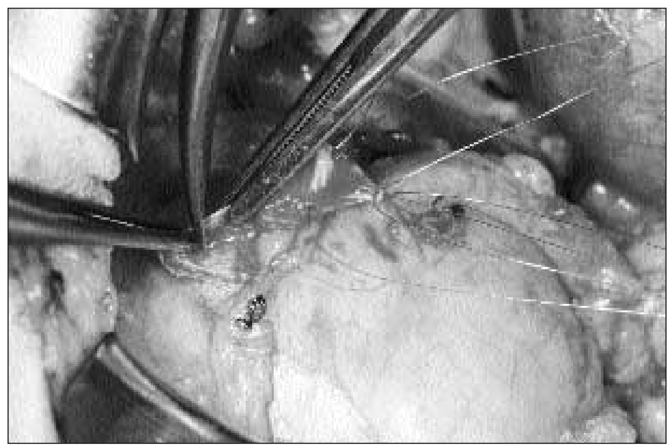

FIGURE 14-22

Bladder mucosa incision. After the ureter is spatulated on its ventral surface, single-armed 5-0 absorbable sutures are placed in the “heel” and in each of the “dog-ears” of the ureter. A double-armed horizontal mattress suture of the same material is placed in the “toe” of the ureter so that the needles exit on the mucosal side. The bladder is drained by unclamping the catheter tubing, and the bladder mucosa is incised.

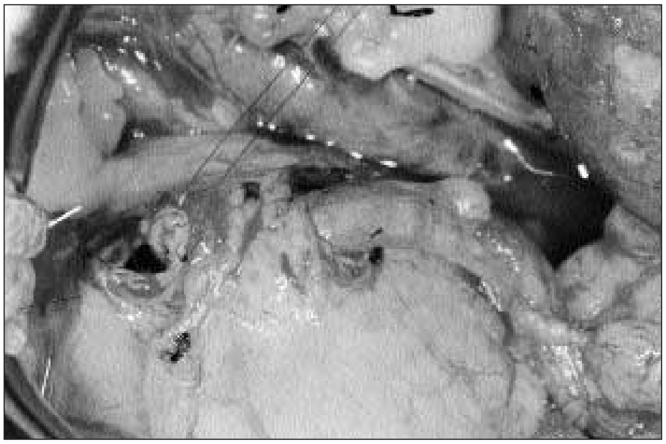

FIGURE 14-23

Partially completed ureteral anastomosis. The "heel" and "dog-ears" of the spatulated ureter have been sutured to the bladder mucosa. The horizontal mattress suture will be passed through the full thickness of the bladder wall and tied distal to the seromuscular incision. This will close the "toe" and anchor the ureter to the bladder.

FIGURE 14-24

Completed ureteroneocystostomy. The distal seromuscular incision has been closed over the ureter, which now lies in a submucosal tunnel.

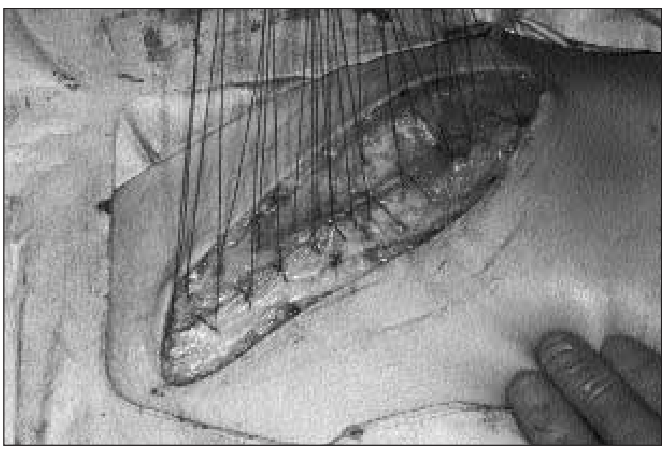

FIGURE 14-25

Deep wound closure. A suction drain has been placed around the kidney graft deep in the wound, and the musculofascial interrupted sutures are ready to be tied.

FIGURE 14-26

Completed wound closure. Scarpa's fascia has been closed over the musculofascial sutures, and the skin has been closed with a 4-0 absorbable subcuticular suture. This procedure accurately approximates the skin and eliminates subsequent staple or skin suture removal.

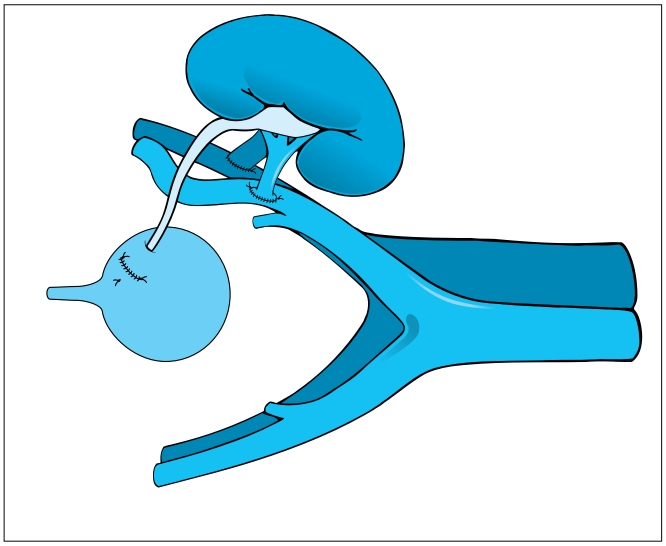

FIGURE 14-27
Artist's depiction of the completed kidney transplantation.

DIURESIS ENHANCEMENT IN KIDNEY TRANSPLANTATION

Living-donor kidney transplantation	Cadaveric kidney transplantation
Maintain CVP 5–10 cm H_2O	Same
Maintain MAP ≥ 60 mm Hg	Same
Maintain SBP ≥ 90 mm Hg	Same
Mannitol, 0.20 g/kg, IV over 1 h, start with first vascular anastomosis	Increase mannitol dose to 1 g/kg (maximum 50 g) IV
Furosemide, 0.20 mg/kg, IV during second half of second vascular anastomosis	Increase furosemide dose to 1 mg/kg IV
	Albumin, 1 g/kg (to 50 g), IV over 2–3 h
	Verapamil, 0–10 mg, into renal artery based on blood pressure and weight

CVP—central venous pressure; IV—intravenous; MAP—mean arterial pressure; SBP—systemic blood pressure.

Modified from Dawidson and Ar'Rajab [12].

FIGURE 14-28
Maneuvers for diuresis enhancement [12]. Several intraoperative maneuvers can be used to promote diuresis.

Child Recipient

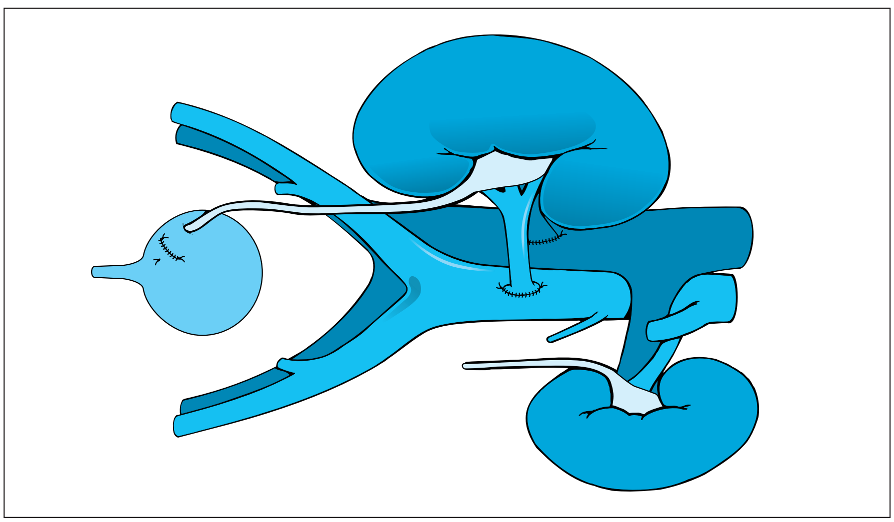

FIGURE 14-29
Transplantation of a kidney from an adult into a small child. The technique is modified for transplantation of a large kidney into a small recipient. The renal artery is anastomosed to the distal aorta or common iliac artery, and the shortened renal vein is anastomosed to the interior vena cava or common iliac vein.

Postoperative Care

POSTOPERATIVE CARE DURING HOSPITALIZATION AFTER KIDNEY TRANSPLANTATION

Foley catheter	Remove on 5th postoperative day, administer dose of antibiotic
Ureteral stent, if used	Remove 6–12 wk postoperatively in clinic
Suction drain(s)	Remove when ≤ 30 mL/24 h or in 3 wk if volume > 30 mL/24 h
Antibiotics	Discontinue in 24–48 h (check intraoperative culture results first)
Pain control	Patient-controlled analgesia
Intravenous fluids	Living donor: fixed rate of 125–200 mL/h of D5W in 0.45% normal saline
	Cadaveric donor: replace insensible loss with D5W, replace urine output mL for mL with 0.45% normal saline
Immunosuppressants	Protocol (covered in Chapter 11)
Infection prevention	Protocol (covered in Chapter 10)
Peptic ulcer prevention	Protocol (covered in Chapter 12)

IV—intravenous.

FIGURE 14-30
Postoperative clinical pathway.

Urologic Complications

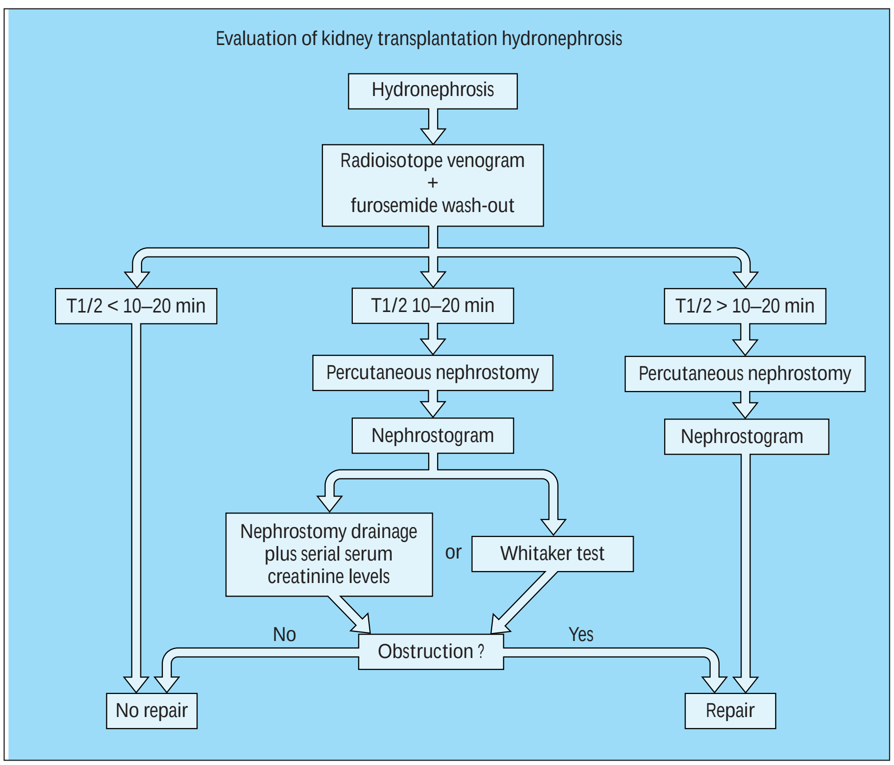

FIGURE 14-31
Algorithm for evaluation of kidney transplantation hydronephrosis [9]. The generally accepted criterion for exclusion of upper urinary tract obstruction is a washing out of half of the radioisotope from the renal pelvis in less than 10 minutes. Obstruction is considered to be present when this value is over 20 minutes. Percutaneous nephrostomy allows anatomic definition of the obstruction and temporary drainage of the hydronephrotic kidney. A generally accepted criterion for the diagnosis of obstruction with the percutaneous pressure-flow Whitaker test is fluid infusion into the pelvis at the rate of 10 mL/min, resulting in a renal pelvic pressure over 20 cm H_2O.

CAUSES OF KIDNEY TRANSPLANTATION URETERAL OBSTRUCTION

Cause	Early	Late
Blood clot	X	
Edema	X	
Technical error	X	
Lymphocele	X	X
Ischemia		X
Periureteral fibrosis		X
Stone		X
Tumor		X

FIGURE 14-32

Causes of renal transplantation ureteral obstruction. Hydronephrosis owing to ureteral obstruction is one of the two most common urologic complications for which invasive therapy is required, the other being perigraft fluid collection. Early causes of ureteral obstruction are usually apparent within the first few days after renal transplantation. Late causes become apparent weeks to years later.

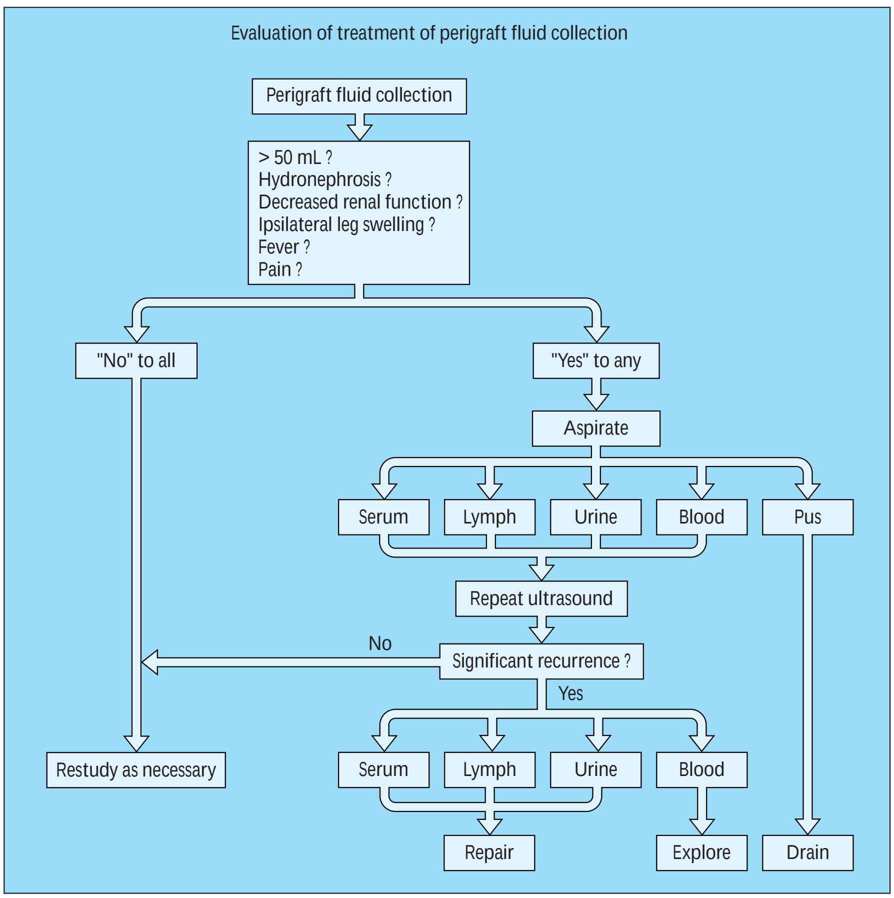

FIGURE 14-33

Algorithm for evaluation and treatment of perigraft fluid collection [9]. Perigraft fluid collection is one of the two most common urologic complications for which invasive therapy is required, the other being hydronephrosis owing to ureteral obstruction. Serum, urine, lymphatic fluid, blood, and pus can be differentiated by creatinine and hematocrit determinations and by microscopic examination of the fluid. Urine has a high creatinine level, serum and lymphatic fluid have low creatinine levels, and blood has a relatively high hematocrit level. Lymphocytes are present in lymphatic fluid, and polymorphonuclear leukocytes with or without organisms are present in pus. Open surgical drainage is usually necessary for fluid collections showing infection. Significant lymphoceles have been successfully treated with percutaneous sclerosis or by marsupialization into the peritoneal cavity by either a laparoscopic or open surgical technique. Persistent urinary extravasation often requires open surgical repair. Significant bleeding requires exploration and control of bleeding.

Results of Renal Transplantation

US KIDNEY GRAFT SURVIVAL RATES FOR TRANSPLANTATIONS DONE FROM 1991 TO 1995

Donor	Number	1 y, %	5 y, %	10 y (projected), %
Cadaver	36,417	84	60	43
Living	13,771	92	75	62

Data from Cecka [13].

FIGURE14-34

The 5-year patient survival rates for recipients of cadaveric and living-donor kidney transplantations were 81% and 90%, respectively [13]. Kidney transplantation survival rates have steadily improved since the 1970s because of the following: careful recipient selection and preparation, improvement in histocompatibility techniques and organ sharing, contributions from our colleagues in government and the judiciary, improvements in immunosuppressive therapy and infection control, careful monitoring of recipients, and refinement of surgical techniques. What we accomplish today as a matter of routine was only imagined by a few just decades ago.

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