CHAPTER

31

Anesthesia for Genitourinary Surgery

KEY CONCEPTS

1. Next to the supine position, the lithotomy position is the most commonly used position for patients undergoing urological and gynecological procedures. Failure to properly position and pad the patient can result in pressure sores, nerve injuries, or compartment syndromes.
2. The lithotomy position is associated with major physiological alterations. Functional residual capacity decreases, predisposing patients to atelectasis and hypoxia. Elevation of the legs drains blood into the central circulation acutely. Mean blood pressure often increases, but cardiac output does not change significantly. Conversely, rapid lowering of the legs from the lithotomy or Trendelenburg position acutely decreases venous return and can result in hypotension. Blood pressure measurement should be taken immediately after the legs are lowered.
3. Because of the short duration (15–20 min) and outpatient setting of most cystoscopies, general anesthesia is often chosen, commonly employing a laryngeal mask airway.
4. Both epidural and spinal blockade with a T10 sensory level provide excellent anesthesia for cystoscopy.
5. Manifestations of TURP (transurethral resection of the prostate) syndrome are primarily those of circulatory fluid overload, water intoxication, and, occasionally, toxicity from the solute in the irrigating fluid.
6. Absorption of TURP irrigation fluid is dependent on the duration of the resection and the pressure of the irrigation fluid.
7. When compared with general anesthesia, regional anesthesia for TURP may reduce the incidence of postoperative venous thrombosis. It is also less likely to mask symptoms and signs of TURP syndrome or bladder perforation.
8. Patients with a history of cardiac arrhythmias and those with a pacemaker or internal cardiac defibrillator (ICD) may be at risk for developing arrhythmias induced by shock waves during extracorporeal shock wave lithotripsy (ESWL). Shock waves can damage the internal components of pacemaker and ICD devices.
9. Patients who are undergoing retroperitoneal lymph node dissection and who have received bleomycin preoperatively are at increased risk for developing postoperative pulmonary insufficiency. These patients may

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be particularly at risk for oxygen toxicity and fluid overload, and for developing acute respiratory distress syndrome postoperatively.

10 For patients undergoing renal transplantation, the preoperative serum potassium concentration should be below 5.5 mEq/L and existing coagulopathies should be corrected. Hyperkalemia has been reported after release of the vascular clamp following completion of the arterial anastomosis, particularly in pediatric and other small patients. Release of potassium contained in the preservative solution has been implicated as the cause of this phenomenon.

Urological procedures account for 10–20% of most anesthetic practices. Patients undergoing genitourinary procedures may be of any age, but many are elderly with coexisting medical illnesses, commonly renal dysfunction. The impact of anesthesia on renal function is discussed in Chapter 30. This chapter reviews the anesthetic management of common urological procedures. Use of the lithotomy and steep head-down (Trendelenburg) positions, the transurethral approach, and extracorporeal shock waves (lithotripsy) complicates many of these procedures. Moreover, advances in surgical technique and perioperative medical and surgical management allow more patients with coexisting disease to be considered acceptable candidates for renal transplantation and for extensive tumor debulking and reconstructive genitourinary procedures involving marked physiological trespass.

CYSTOSCOPY

Preoperative Considerations

Cystoscopy is the most commonly performed urological procedure, and indications for this investigative or therapeutic operation include hematuria, recurrent urinary infections, renal calculi, and urinary obstruction. Bladder biopsies, retrograde pyelograms, transurethral resection of bladder tumors, extraction or laser lithotripsy of renal stones, and placement or manipulation of ureteral catheters (stents) are also commonly performed through the cystoscope.

Anesthetic management varies with the age and gender of the patient and the purpose of the procedure. General anesthesia is usually necessary for children. Viscous lidocaine topical anesthesia with or without sedation is satisfactory for diagnostic studies in most women because of the short urethra. Operative cystoscopies involving biopsies, cauterization, or manipulation of ureteral catheters require regional or general anesthesia. Many men prefer regional or general anesthesia even for diagnostic cystoscopy.

Intraoperative Considerations

A. Lithotomy Position

1 Next to the supine position, the lithotomy position is the most commonly used position for patients undergoing urological and gynecological procedures. Failure to properly position and pad the patient can result in pressure sores, nerve injuries, or compartment syndromes. Two people are needed to safely move the patient's legs simultaneously up into, or down from, the lithotomy position. Straps around the ankles or special holders support the legs in lithotomy position (Figure 31–1). The leg supports should be padded wherever there is leg or foot contact, and straps must not impede circulation. When the patient's arms are tucked to the side, caution must be exercised to prevent the fingers from being caught between the mid and lower sections of the operating room table when the lower section is lowered and raised—many clinicians completely encase the patient's hands and fingers with

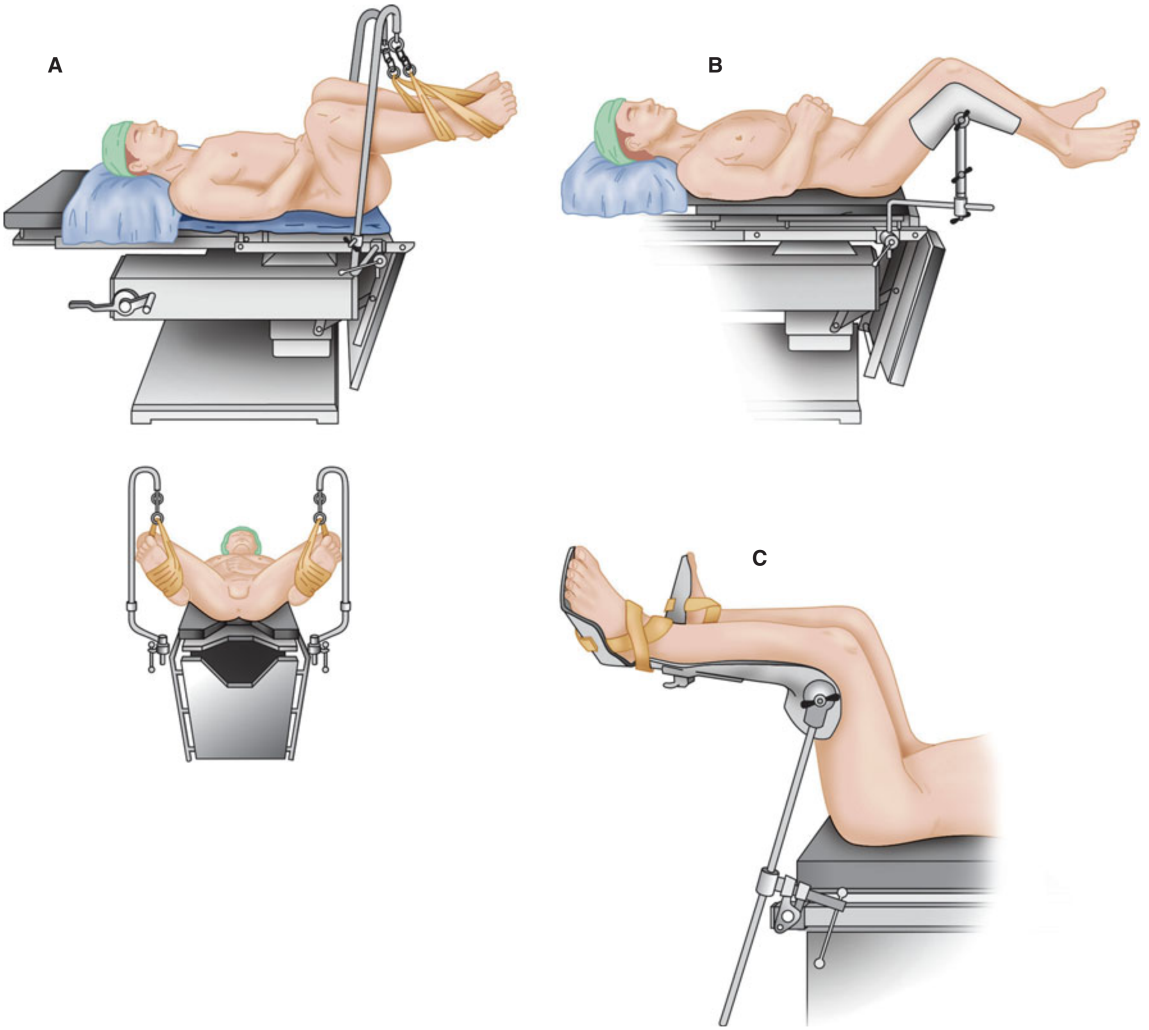

FIGURE 31–1 The lithotomy position. **A**: Strap stirrups. **B**: Bier–Hoff stirrups. **C**: Allen stirrups. (Reproduced, with permission, from Martin JT: *Positioning in Anesthesia*. W.B. Saunders, 1988.)

protective padding to minimize this risk. Injury to the tibial (common peroneal) nerve, resulting in loss of dorsiflexion of the foot, may result if the lateral knee rests against the strap support. If the legs are allowed to rest on medially placed strap supports, compression of the saphenous nerve can result in numbness along the medial calf. Excessive flexion of the thigh against the groin can injure the obturator and, less commonly, the femoral nerves. Extreme flexion at the thigh can also stretch the sciatic nerve. The most common nerve injuries directly associated with the lithotomy position involve the lumbosacral plexus. Brachial plexus injuries can likewise occur if the upper extremities are inappropriately positioned (eg, hyperextension at the axilla). Compartment syndrome of the lower extremities with rhabdomyolysis has been reported with prolonged time in the lithotomy position, after which lower extremity nerve damage is also more likely.

2 The lithotomy position is associated with major physiological alterations. Functional residual capacity decreases, predisposing patients

to atelectasis and hypoxia. This effect is amplified by steep Trendelenburg positioning (>30°), which is commonly utilized in combination with the lithotomy position. Elevation of the legs drains blood into the central circulation acutely and may thereby exacerbate congestive heart failure (or treat a relative hypovolemia). Mean blood pressure and cardiac output may increase. Conversely, rapid lowering of the legs from the lithotomy or Trendelenburg position acutely decreases venous return and can result in hypotension. Vasodilation from either general or regional anesthesia potentiates the hypotension in this situation, and for this reason, blood pressure measurement should be taken immediately after the legs are lowered.

B. Choice of Anesthesia

3 **1. General anesthesia—**Many patients are apprehensive about the procedure and prefer to be asleep. However, any anesthetic technique suitable for outpatients may be utilized. Because of the short duration (15–20 min) and outpatient setting of most cystoscopies, general anesthesia is often chosen, commonly employing a laryngeal mask airway. Oxygen saturation should be closely monitored when obese or elderly patients, or those with marginal pulmonary reserve, are placed in the lithotomy or Trendelenburg position.

4 **2. Regional anesthesia—**Both epidural and spinal blockade provide satisfactory anesthesia for cystoscopy. However, when regional anesthesia is chosen most anesthesiologists prefer spinal anesthesia because onset of satisfactory sensory blockade may require 15–20 min for epidural anesthesia compared with 5 min or less for spinal anesthesia. Some clinicians believe that the sensory level following injection of a hyperbaric spinal anesthetic solution should be well established ("fixed") before the patient is moved into the lithotomy position; however, studies fail to demonstrate that immediate elevation of the legs into lithotomy position following administration of hyperbaric spinal anesthesia either increases the dermatomal extent of anesthesia to a clinically significant degree or increases the likelihood of severe hypotension. A sensory level to T10 provides excellent anesthesia for essentially all cystoscopic procedures.

TRANSURETHRAL RESECTION OF THE PROSTATE

Preoperative Considerations

Benign prostatic hyperplasia (BPH) frequently leads to bladder outlet obstruction in men older than 60 years. Although increasingly being treated medically, some men require surgical intervention. Transurethral resection of the prostate (TURP) is the most common surgical procedure performed for bladder outlet obstruction due to BPH, and indications for TURP in this setting include obstructive uropathy, bladder calculi, and recurrent episodes of urinary retention, urinary tract infections, and hematuria. Patients with adenocarcinoma of the prostate may also benefit from TURP to relieve symptomatic urinary obstruction.

TURP requires regional or general anesthesia, and patients should be evaluated for coexistent major organ dysfunction. Despite advanced age (over half of TURP patients are older than 70 years) and prevalence of significant comorbidity in over two thirds of TURP patients, perioperative mortality and medical morbidity (most frequently myocardial infarction, pulmonary edema, and kidney failure) for this procedure are both less than 1%.

The most common surgical complications of TURP are clot retention, failure to void, uncontrolled hematuria requiring surgical revision, urinary tract infection, and chronic hematuria, although other, more rare, complications may include: TURP syndrome, bladder perforation, sepsis, hypothermia, and disseminated intravascular coagulation (DIC). A blood type and screen (see Chapter 51) is adequate for most patients, although crossmatched blood should be available for anemic patients and for patients with large glands in which extensive resection is contemplated. Prostatic bleeding can be difficult to control through the cystoscope.

Intraoperative Considerations

TURP is performed by passing a loop through a special cystoscope (resectoscope). Using continuous irrigation and direct visualization, prostatic tissue is resected by applying a cutting current to the loop. Because of the characteristics of the prostate and the large amounts of irrigation fluid often used, TURP

TABLE 31–1 Surgical complications associated with TURP.[1]

Most common
Clot retention
Failure to void
Uncontrolled acute hematuria
Urinary tract infection
Chronic hematuria
Less common
TURP syndrome
Bladder perforation
Hypothermia
Sepsis
Disseminated intravascular coagulation

[1]TURP, transurethral resection of the prostate.

can be associated with a number of serious complications (Table 31–1).

A. TURP Syndrome

Transurethral prostatic resection often opens the extensive network of venous sinuses in the prostate, potentially allowing systemic absorption of the irrigating fluid. The absorption of large amounts of fluid (2 L or more) results in a constellation of symptoms and signs commonly referred to as the TURP syndrome (Table 31–2). This syndrome presents intraoperatively or postoperatively as headache, restlessness, confusion, cyanosis, dyspnea, arrhythmias, hypotension, or seizures, and it can be rapidly fatal. 5 The manifestations are primarily those of circulatory fluid overload, water intoxication, and, occasionally, toxicity from the solute in the irrigating fluid. The incidence of TURP syndrome is less than 1%.

Electrolyte solutions cannot be used for irrigation during TURP because they disperse the electrocautery current. Water provides excellent visibility because its hypotonicity lyses red blood cells, but significant water absorption can readily result in acute water intoxication. Water irrigation is generally restricted to transurethral resection of bladder tumors only. For TURP, slightly hypotonic nonelectrolyte irrigating solutions such as glycine 1.5% (230 mOsm/L) or a mixture of sorbitol 2.7% and mannitol 0.54% (195 mOsm/L) are most commonly used. Less commonly used solutions include sorbitol 3.3%, mannitol 3%, dextrose 2.5–4%, and urea 1%.

TABLE 31–2 Manifestations of TURP syndrome.[1]

Hyponatremia
Hypoosmolality
Fluid overload
Congestive heart failure
Pulmonary edema
Hypotension
Hemolysis
Solute toxicity
Hyperglycinemia (glycine)
Hyperammonemia (glycine)
Hyperglycemia (sorbitol)
Intravascular volume expansion (mannitol)

[1]TURP, transurethral resection of the prostate.

Because all these fluids are still hypotonic, significant absorption of water can nevertheless occur. Solute absorption can also occur because the irrigation fluid is under pressure, and high irrigation pressures (bottle height) increase fluid absorption.

6 Absorption of TURP irrigation fluid is dependent on the duration of the resection and the pressure of the irrigation fluid. Most resections last 45–60 min, and, on average, 20 mL/min of the irrigating fluid is absorbed. Pulmonary congestion or florid pulmonary edema can readily result from the absorption of large amounts of irrigation fluid, particularly in patients with limited cardiac reserve. The hypotonicity of these fluids also results in acute hyponatremia and hypoosmolality, which can lead to serious neurological manifestations. Symptoms of hyponatremia usually do not develop until the serum sodium concentration decreases below 120 mEq/L. Marked hypotonicity in plasma ($[Na^+]$ <100 mEq/L) may also result in acute intravascular hemolysis.

Toxicity may also arise from absorption of the solutes in these fluids. Marked **hyperglycinemia** has been reported with glycine solutions and may contribute to circulatory depression and central nervous system toxicity. Plasma glycine concentrations in excess of 1000 mg/L have been recorded (normal is 13–17 mg/L). Glycine is known to be an inhibitory neurotransmitter in the central nervous system and has also been implicated in rare instances of transient blindness following TURP. Hyperammonemia, presumably from the degradation of glycine, has also been documented in a few patients with marked central nervous system toxicity following TURP. Blood ammonia levels in some patients exceeded 500 μmol/L (normal is 5–50 μmol/L). The use of large amounts of sorbitol or dextrose irrigating solutions can lead to hyperglycemia, which can be marked in diabetic patients. Absorption of mannitol solutions causes intravascular volume expansion and exacerbates fluid overload.

Treatment of TURP syndrome depends on early recognition and should be based on the severity of the symptoms. The absorbed water must be eliminated, and hypoxemia and hypoperfusion treated. Most patients can be managed with fluid restriction and intravenous administration of furosemide. Symptomatic hyponatremia resulting in seizures or coma should be treated with hypertonic saline (see Chapter 49). Seizure activity can be terminated with small doses of midazolam (2–4 mg). Phenytoin, 10–20 mg/kg intravenously (no faster than 50 mg/min), should also be considered to provide more sustained anticonvulsant activity. Endotracheal intubation may be considered to prevent aspiration until the patient's mental status normalizes. The amount and rate of hypertonic saline solution (3% or 5%) needed to correct the hyponatremia to a safe level should be based on the patient's serum sodium concentration (see Chapter 49). The rate of hypertonic saline solution administration should be sufficiently slow as to not exacerbate circulatory fluid overload.

B. Hypothermia

Large volumes of irrigating fluids at room temperature can be a major source of heat loss in patients. Irrigating solutions should be warmed to body temperature prior to use to prevent hypothermia. Postoperative shivering associated with hypothermia may dislodge clots and promote postoperative bleeding, as well as add deleterious physiological stress to the patient with coexisting cardiopulmonary disease.

C. Bladder Perforation

The incidence of **bladder perforation** during TURP is less than 1%. Perforation may result from the resectoscope going through the bladder wall or from overdistention of the bladder with irrigation fluid. Most bladder perforations are extraperitoneal and are signaled by poor return of the irrigating fluid. Awake patients will typically complain of nausea, diaphoresis, and retropubic or lower abdominal pain. Large extraperitoneal and most intraperitoneal perforations are usually even more obvious, presenting as sudden unexplained hypotension or hypertension, and with generalized abdominal pain in awake patients. Regardless of the anesthetic technique employed, perforation should be suspected in settings of sudden hypotension or hypertension, particularly with acute, vagally mediated bradycardia.

D. Coagulopathy

DIC has on rare occasion been reported following TURP and may result from the release of thromboplastins from prostate tissue into the circulation during the procedure. Up to 6% of patients may have evidence of subclinical DIC. A dilutional thrombocytopenia can also develop during surgery as part of the TURP syndrome from absorption of irrigation fluids. Rarely, patients with metastatic carcinoma of the prostate develop a coagulopathy from primary fibrinolysis due to secretion of a fibrinolytic enzyme. The diagnosis of coagulopathy may be suspected from diffuse, uncontrollable bleeding but must be confirmed by laboratory tests. Primary fibrinolysis should be treated with ε-aminocaproic acid (Amicar), 5 g followed by 1 g/h intravenously. Treatment of DIC in this setting may require heparin in addition to replacement of clotting factors and platelets, and consultation with a hematologist should be considered.

E. Septicemia

The prostate is often colonized with bacteria and may harbor chronic infection. Extensive surgical resection with the opening of venous sinuses can allow entry of organisms into the bloodstream. Bacteremia following transurethral surgery is common and can lead to septicemia or septic shock. Prophylactic antibiotic therapy (most commonly gentamicin, levofloxacin, or cefazolin) prior to TURP may decrease the likelihood of bacteremic and septic episodes.

F. Choice of Anesthesia

Either spinal or epidural anesthesia with a T10 sensory level, or general anesthesia, provides excellent anesthesia and good operating conditions for TURP. 7 When compared with general anesthesia, regional anesthesia may reduce the incidence of postoperative venous thrombosis. It is also less likely to mask symptoms and signs of TURP syndrome or bladder perforation. Clinical studies have failed to show any differences in blood loss, postoperative cognitive function, and mortality between regional and general anesthesia. The possibility of vertebral metastasis must be considered in patients with carcinoma, particularly those with back pain, as metastatic disease involving the lumbar spine is a relative contraindication to spinal or epidural anesthesia. Acute hyponatremia from TURP syndrome may delay or prevent emergence from general anesthesia.

G. Monitoring

Evaluation of mental status in the awake or moderately sedated patient is the best monitor for detection of early signs of TURP syndrome and bladder perforation. Tachycardia or decrease in arterial oxygen saturation may be an early sign of fluid overload. Perioperative ischemic electrocardiographic changes have been reported in up to 18% of patients. Temperature monitoring is standard of care for general anesthesia, and it should also be used in cases of lengthy resections under spinal or epidural anesthesia to detect hypothermia. Blood loss is particularly difficult to assess during TURP because of the use of irrigating solutions, so it is necessary to rely on clinical signs of hypovolemia (see Chapter 51). Blood loss averages approximately 3–5 mL/min of resection (usually 200–300 mL total) but is rarely life-threatening. Transient, postoperative decreases in hematocrit may simply reflect hemodilution from absorption of irrigation fluid. Less than 2% of patients require intraoperative blood transfusion; factors associated with need for transfusion include procedure duration longer than 90 min and resection of more than 45 g of prostate tissue.

LITHOTRIPSY

The treatment of kidney stones has evolved from primarily open surgical procedures to less invasive or entirely noninvasive techniques. Cystoscopic procedures, including flexible ureteroscopy with stone extraction, stent placement, and intracorporeal lithotripsy (laser or electrohydraulic), along with *medical expulsive therapy* (MET), have become first-line therapy. Extracorporeal shock wave lithotripsy (ESWL) is also utilized, primarily for 4-mm to 2-cm intrarenal stones, and percutaneous and laparoscopic nephrolithotomy for larger or impacted stones. MET has become the treatment of choice among many clinicians for acute episodes of urolithiasis: for stones up to 10 mm in diameter, administration of the α blockers tamsulosin (Flomax), doxazosin (Cardura), or terazosin (Hytrin) or the calcium channel blocker nifedipine (Procardia, Adalat) lessens the pain of acute urolithiasis and increases the rate of stone expulsion over a period of several days to several weeks.

During ESWL, repetitive high-energy shocks (sound waves) are generated and focused on the stone, causing it to fragment as tensile and shear forces develop inside the stone and cavitation occurs on its surface. Water or a conducting gel couples the generator to the patient. Because tissue has the same acoustic density as water, the waves travel through the body without damaging tissue. However, the change in acoustic impedance at the tissue–stone interface creates shear and tear forces on the stone. Subsequently, the stone is fragmented enough to allow its passage in small pieces down the urinary tract. Ureteral stents are often placed cystoscopically prior to the procedure. Tissue destruction can occur if the acoustic energy is inadvertently focused at air–tissue interfaces such as in the lung and intestine. The inability to position the patient so that lung and intestine are away from the sound wave focus is a contraindication to the procedure. Other contraindications include urinary obstruction below the stone, untreated infection, a bleeding diathesis, and pregnancy. The presence of a nearby aortic aneurysm or an orthopedic prosthetic device is considered a relative contraindication. Ecchymosis, bruising, or blistering of the skin over the treatment site is not uncommon. Rarely, a large perinephric hematoma can develop and may be responsible for a postoperative decrease in hematocrit.

Electrohydraulic, electromagnetic, or piezoelectric shock wave generators may be used for

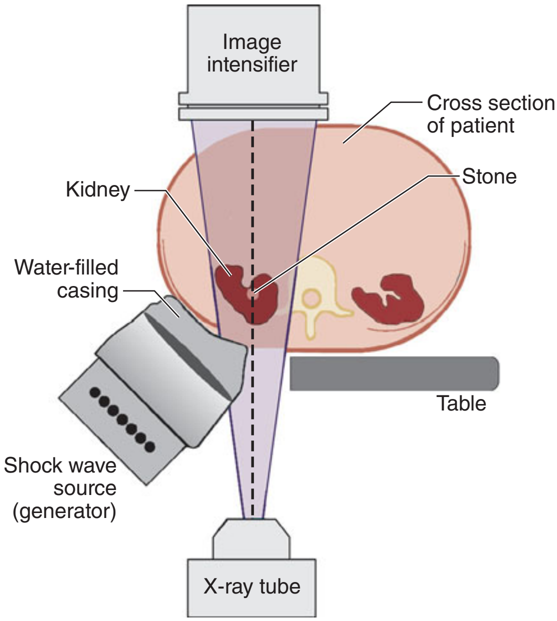

FIGURE 31–2 Schematic representation of a newer tubless lithotripsy unit.

ESWL. With older electrohydraulic units, the patient is placed in a hydraulic chair and immersed in a heated water bath, which conducts the shock waves to the patient. Modern lithotriptors generate shock waves either electromagnetically or from piezoelectric crystals. The generator is enclosed in a water-filled casing and comes in contact with the patient via a conducting gel on a plastic membrane (Figure 31–2). Newer units allow both fluoroscopic and ultrasound localization. In the case of electromagnetic machines, the vibration of a metallic plate in front of an electromagnet produces the shock waves. With piezoelectric models, the waves are the result of changes in the external dimensions of ceramic crystals when electric current is applied.

Preoperative Considerations

8 Patients with a history of cardiac arrhythmias and those with a pacemaker or internal cardiac defibrillator (ICD) may be at risk for developing arrhythmias induced by shock waves during ESWL. Synchronization of the shock waves with the electrocardiogram (ECG) R wave decreases the incidence of arrhythmias during ESWL. The shock waves are usually timed to be 20 ms after the R wave to correspond with the ventricular refractory period. Studies suggest that asynchronous delivery of shocks may be safe in patients without heart disease. Shock waves can damage the internal components of pacemaker and ICD devices. The manufacturer should be contacted as to the best method for managing the device (eg, reprogramming or applying a magnet).

Intraoperative Considerations

Anesthetic considerations for ureteroscopy, stone manipulation, and laser lithotripsy are similar to those for cystoscopic procedures. ESWL requires special considerations, particularly when older lithotriptors requiring the patient to be immersed in water are used.

A. Effects of Immersion During ESWL

Immersion into a heated water bath (36–37°C) initially results in vasodilation that can transiently lead to hypotension. Arterial blood pressure, however, subsequently rises as venous blood is redistributed centrally due to the hydrostatic pressure of water on the legs and abdomen. Systemic vascular resistance (SVR) rises and cardiac output often decreases. The sudden increase in intravascular volume and SVR can precipitate congestive heart failure in patients with marginal cardiac reserve. Moreover, the increase in intrathoracic blood volume reduces functional residual capacity 30–60% and may predispose some patients to hypoxemia.

B. Choice of Anesthesia

Pain during lithotripsy is from dissipation of a small amount of energy as shock waves enter the body through the skin. The pain is therefore localized to the skin and is proportionate to the shock wave intensity. Older water bath lithotripsy units require 1000–2400 relatively high-intensity shock waves, which most patients cannot tolerate without either regional or general anesthesia. In contrast, newer lithotripsy units that are coupled directly to the skin utilize 2000–3000 lower-intensity shock waves that usually require only light sedation.

C. Regional Anesthesia

Continuous epidural anesthesia is commonly employed when ESWL utilizes older water bath lithotriptors. Regional anesthesia with sedation greatly facilitates positioning and monitoring in this situation, and supplemental oxygen by face mask or nasal cannula is also useful in avoiding hypoxemia. A T6 sensory level ensures adequate anesthesia, as renal innervation is derived from T10 to L2. Supplementation of the block with epidural fentanyl (50–100 mcg) is often useful. When using the loss of resistance technique for placement of the epidural catheter, saline should be used instead of air during epidural catheter insertion; as air in the epidural space can dissipate shock waves and may promote injury to neural tissue. Foam tape should not be used to secure the epidural catheter as this type of tape has been shown to dissipate the energy of the shock waves when it is in their path. Spinal anesthesia can also be used satisfactorily but offers less control over the sensory level and an uncertain duration of surgery; for this reason, epidural anesthesia is usually preferred.

A major disadvantage of regional anesthesia or sedation is the inability to control diaphragmatic movement. Excessive diaphragmatic excursion during spontaneous ventilation can move the stone in and out of the wave focus and may prolong the procedure. This problem can be partially solved by asking the patient to breathe in a more rapid but shallow respiratory pattern. Bradycardia due to high sympathetic blockade also prolongs the procedure when shock waves are coupled to the ECG, and small doses of glycopyrrolate are often administered in this situation to accelerate the ESWL procedure.

D. General Anesthesia

General endotracheal anesthesia allows control of diaphragmatic excursion during lithotripsy using older water bath lithotriptors. The procedure is complicated by the inherent risks associated with placing a supine anesthetized patient in a chair, elevating and then lowering the chair into a water bath to shoulder depth, and then reversing the sequence at the end. A light general anesthetic technique in conjunction with a muscle relaxant is preferable. The muscle relaxant ensures patient immobility and control of diaphragmatic movement.

E. Monitored Anesthesia Care

Light intravenous sedation with midazolam and fentanyl is usually adequate for modern low-energy lithotripsy. Deeper sedation with low-dose propofol infusions with or without midazolam and opioid supplementation may also be used.

F. Monitoring

Standard anesthesia monitoring must be used for conscious or deep sedation, or for general anesthesia. **Even with R-wave synchronized shocks, supraventricular arrhythmias can occur.** With immersion lithotripsy, ECG pads should be attached securely with waterproof dressing. Changes in functional residual capacity with immersion mandate monitoring of oxygen saturation, particularly in patients at risk for developing hypoxemia. The temperature of the bath and the patient should be monitored to prevent hypothermia or hyperthermia.

G. Fluid Management

Intravenous fluid therapy is typically generous. Following an initial intravenous fluid bolus, an additional 1000–2000 mL of lactated Ringer's injection is often given with a small dose of furosemide to maintain brisk urinary flow and flush stone debris and blood clots. Patients with poor cardiac reserve require more conservative fluid therapy.

NONCANCER SURGERY OF THE UPPER URETER & KIDNEY

Laparoscopic urological procedures, including partial and total nephrectomy, live donor nephrectomy, nephrolithectomy, and pyeloplasty are increasingly utilized because of advantages that include relatively rapid recovery, shorter hospital stay, and less pain. Both transperitoneal and retroperitoneal approaches have been developed. A hand-assisted technique employs an additional larger incision that allows the surgeon to insert one hand for tactile sensation and facilitation of dissection. Anesthetic management is similar to that for any laparoscopic procedure.

Open procedures for kidney stones in the upper ureter and renal pelvis, and nephrectomies for nonmalignant disease, are often carried out in the "kidney rest position," more accurately described as the lateral flexed position. With the patient in a full lateral position, the dependent leg is flexed and the other leg is extended. An axillary roll is placed beneath the dependent upper chest to minimize the risk of brachial plexus injury. The operating table is then extended to achieve maximal separation between the iliac crest and the costal margin on the operative side, and the kidney rest (a bar in the groove where the table bends) is elevated to raise the nondependent iliac crest higher and increase surgical exposure.

The lateral flexed position is associated with adverse respiratory and circulatory effects. Functional residual capacity is reduced in the dependent lung but may increase in the nondependent lung. In the anesthetized patient receiving controlled ventilation, ventilation/perfusion mismatching occurs because the dependent lung receives greater blood flow than the nondependent lung, whereas the nondependent lung receives greater ventilation, predisposing the patient to atelectasis in the dependent lung and to shunt-induced hypoxemia. The arterial to end-tidal gradient for carbon dioxide progressively increases during general anesthesia in this position, indicating that dead space ventilation also increases in the nondependent lung. Moreover, elevation of the kidney rest can significantly decrease venous return to the heart in some patients by compressing the inferior vena cava. Venous pooling in the legs potentiates anesthesia-induced vasodilation.

Because of the potential for large blood loss and limited access to major vascular structures in the lateral flexed position, initial placement of at least one large-bore intravenous catheter is advisable. Arterial catheters are often utilized because of the need to closely monitor blood pressure and to frequently withdraw blood for laboratory analysis. Endotracheal tube placement may be altered during postinduction positioning of the patient for operation, and thus proper endotracheal tube placement must again be verified following final patient positioning prior to skin preparation and surgical draping. Intraoperative pneumothorax may occur as a result of surgical entry into the pleural space. Diagnosis requires a high index of suspicion. The pneumothorax may be subclinical intraoperatively but can be diagnosed postoperatively with a chest radiograph.

SURGERY FOR UROLOGICAL MALIGNANCIES

Demographic changes resulting in an increasingly elderly population, together with improved survival rates for patients with urological cancer following radical surgical resections, have resulted in an increase in the number of procedures performed for prostatic, bladder, testicular, and renal cancer. The desire for accelerated, less-complicated recovery with smaller, less painful incisions has prompted the development of laparoscopic pelvic and abdominal operations, including radical prostatectomy, cystectomy, pelvic lymph node dissection, nephrectomy, and adrenalectomy. Robotic-assisted technology has increasingly been applied to these procedures over the past decade.

Many urological procedures are carried out with the patient in a hyperextended supine position to facilitate exposure of the pelvis during pelvic lymph node dissection, retropubic prostatectomy, or cystectomy (Figure 31–3). The patient is positioned supine with the iliac crest over the break in the operating table, and the table is extended such that the distance between the iliac crest and the costal margin increases maximally. Care must be taken to avoid putting excessive strain on the patient's back. The operating room table is also tilted head-down to make the operative field horizontal. In the frog-leg position, a variation of the hyperextended supine position, the knees are also flexed and the hips are abducted and externally rotated.

FIGURE 31–3 The hyperextended position. (Reproduced, with permission, from Skinner DG, Lieskovsky G: *Diagnosis and Management of Genitourinary Cancer*. W.B. Saunders, 1988.)

1. Prostate Cancer

Preoperative Considerations

Adenocarcinoma of the prostate is the most common nonskin cancer in men and is second only to lung cancer as the most common cause of cancer deaths in men older than 55 years. Approximately one in six men will be diagnosed with prostate cancer in their lifetime. Because of the tumor's wide spectrum of clinical behavior, management varies widely from surveillance to aggressive surgical therapy. Important variables include the grade and stage of the malignancy, the patient's age, and the presence of medical comorbidity. Transrectal ultrasound is used to evaluate tumor size and the presence or absence of extracapsular extension. Clinical staging is also based on the Gleason score of the biopsy, computed tomography (CT) scan or magnetic resonance imaging (MRI), and bone scan.

Intraoperative Considerations

Patients with prostate cancer may present to the operating room for laparoscopic or robotic prostatectomy with pelvic lymph node dissection, radical retropubic prostatectomy with lymph node dissection, salvage prostatectomy (following failure of radiation therapy), or bilateral orchiectomy for hormonal therapy.

A. Radical Retropubic Prostatectomy

Radical retropubic prostatectomy is usually performed with pelvic lymph node dissection through a lower midline abdominal incision. It may be curative for localized prostate cancer or occasionally used as a salvage procedure after failure of radiation. The prostate is removed en bloc with the seminal vesicles, ejaculatory ducts, and part of the bladder neck. A "nerve-sparing" technique may be used to help preserve sexual function. Following prostatectomy, the remaining bladder neck is anastomosed directly to the urethra over an indwelling urinary catheter. The surgeon may ask for intravenous administration of indigo carmine for visualization of the ureters, and this dye can be associated with hypertension or hypotension.

Radical retropubic prostatectomy may be accompanied by significant operative blood loss. Direct arterial blood pressure monitoring may be utilized. Routine placement of a central venous catheter for central venous pressure monitoring and as an additional route for administration of fluid and blood products has also been advocated, although many large cancer treatment centers routinely utilize just two large-bore peripheral intravenous catheters. Operative blood loss varies considerably from center to center, with mean values less than 500 mL common. Factors influencing blood loss include positioning, pelvic anatomy, prostate size, duration of operation, and the skill of the surgeon. Blood loss and operative morbidity and mortality are similar in patients receiving general anesthesia and those receiving regional anesthesia. Neuraxial anesthesia requires a T6 sensory level, but these patients typically do not tolerate regional anesthesia without deep sedation because of the hyperextended supine position. The combination of a prolonged Trendelenburg position together with administration of large amounts of intravenous fluids may rarely produce edema of the upper airway. The risk of hypothermia should be minimized by utilizing a forced-air warming blanket and an intravenous fluid warmer.

Postoperative complications include hemorrhage; deep venous thrombosis; pulmonary embolus; injuries to the obturator nerve, ureter, and rectum; and urinary incontinence and impotence. Extensive surgical dissection around the pelvic veins increases the risk of thromboembolic complications. Epidural analgesia is used in some centers following retropubic prostatectomy and may improve analgesia and accelerate recovery. Although epidural anesthesia may reduce the incidence of postoperative deep venous thrombosis following open prostatectomy, this beneficial effect may be negated by the routine use of warfarin or fractionated heparin prophylaxis postoperatively. The risk of epidural hematoma in the setting of anticoagulation therapy, particularly with fractionated heparin preparations, must be kept in mind when postoperative epidural analgesia is contemplated. Ketorolac can be used as an analgesic adjuvant and has been reported to decrease opioid requirements, improve analgesia, and promote earlier return of bowel function without increasing transfusion requirements. A multimodal approach to postoperative analgesia is often optimal.

B. Robot-Assisted Radical Prostatectomy

Laparoscopic radical prostatectomy with pelvic lymph node dissection differs from most other laparoscopic procedures by the frequent use of steep (>30°) Trendelenburg position for surgical exposure. Patient positioning, duration of procedure, need for abdominal distention, and desirability of increasing minute ventilation necessitate the use of general endotracheal anesthesia. Nitrous oxide is usually avoided to prevent bowel distention. Most laparoscopic prostatectomies are performed with robotic assistance, and the majority of radical prostatectomies in the United States are now performed via robot-assisted laparoscopy. When compared with open retropubic prostatectomy, laparoscopic robot-assisted prostatectomy is associated with a longer procedure time but may have a lower rate of complications. It is also associated with less blood loss and fewer blood transfusions, lower postoperative pain scores and lower opioid requirements, less postoperative nausea and vomiting, and shorter hospital length of stay. The steep Trendelenburg position can lead to head and neck tissue edema and to increased intraocular pressure. Complications reported to be associated with such positioning include upper airway edema and postextubation respiratory distress, postoperative visual loss involving ischemic optic neuropathy or retinal detachment, and brachial plexus injury. The surgeon should be routinely advised as to the length of time during which steep Trendelenburg positioning is maintained, and some centers have abandoned the routine use of this positioning entirely.

Most clinicians use a single large-bore intravenous catheter, and an arterial catheter may be used if clinically indicated. The risk of hypothermia should be minimized by utilizing a forced-air warming blanket and an intravenous fluid warmer. Adequate postoperative analgesia is provided initially by intravenous opioids with ketorolac and/or intravenous acetaminophen, and subsequently by oral analgesic preparations. Postoperative epidural analgesia is not warranted because of relatively low postoperative pain scores and because patients may be discharged less than 36 h after surgery.

C. Bilateral Orchiectomy

Bilateral orchiectomy is usually performed for hormonal control of metastatic adenocarcinoma of the prostate. The procedure is relatively short (20–45 min) and is performed through a single midline scrotal incision. Although bilateral orchiectomy can be performed under local anesthesia, most patients and many clinicians prefer general anesthesia (usually administered via a laryngeal mask airway) or spinal anesthesia.

2. Bladder Cancer

Preoperative Considerations

Bladder cancer occurs at an average patient age of 65 years with a 3:1 male to female ratio. Transitional cell carcinoma of the bladder is second to prostate adenocarcinoma as the most common malignancy of the male genitourinary tract. The association of cigarette smoking with bladder carcinoma results in coexistent coronary artery and chronic obstructive pulmonary disease in many of these patients. Underlying renal impairment, when present, may be age related or secondary to urinary tract obstruction. Staging includes cystoscopy and CT or MRI scans. Intravesical chemotherapy is used for superficial tumors, and transurethral resection of bladder tumors (TURBT) is carried out via cystoscopy for low-grade, noninvasive bladder tumors. Some patients may receive preoperative radiation to shrink the tumor before radical cystectomy. Urinary diversion is usually performed immediately following the cystectomy.

Intraoperative Considerations

A. Transurethral Bladder Resection

TURBT differs from TURP in that the surgical resection is not necessarily carried out in the midline. Bladder tumors may occur at various sites within the bladder. Unfortunately, laterally located tumors may lie in proximity to the obturator nerve. In such cases, if spinal anesthesia or general anesthesia without paralysis is administered, every use of the cautery resectoscope results in stimulation of the obturator nerve and adduction of the legs. Urologists rarely derive amusement from having their ear struck by the patient's knee; thus, in contrast to TURP, TURBT procedures are more commonly performed with general anesthesia and neuromuscular blockade. TURBT, unlike TURP, is rarely associated with absorption of significant amounts of irrigating solution.

B. Radical Cystectomy

Radical cystectomy is a major operation that is often associated with significant blood loss. It is usually performed through a midline incision but is increasingly performed as a robot-assisted laparoscopic procedure. All anterior pelvic organs including the bladder, prostate, and seminal vesicles are removed in males; the bladder, uterus, cervix, ovaries, and part of the anterior vaginal vault may be removed in females. Pelvic node dissection and urinary diversion are also carried out.

These procedures typically require 4–6 h and frequently are associated with blood transfusion. General endotracheal anesthesia with a muscle relaxant provides optimal operating conditions. Controlled hypotensive anesthesia may reduce intraoperative blood loss and transfusion requirements. Many surgeons also believe controlled hypotension improves surgical visualization. Supplementation of general anesthesia with spinal or continuous epidural anesthesia can facilitate the induced hypotension, decrease general anesthetic requirements, and provide highly effective postoperative analgesia.

Close monitoring of blood pressure, intravascular volume, and blood loss is always appropriate. Direct intraarterial pressure monitoring is indicated in most patients, and central venous catheters are often placed. Urinary output should be monitored and correlated with the progress of the operation, as the urinary path is interrupted at an early point during most of these procedures. As with all lengthy operative procedures, the risk of hypothermia should be minimized by utilizing a forced-air warming blanket and an intravenous fluid warmer.

C. Urinary Diversion

Urinary diversion is usually performed immediately following radical cystectomy. Many procedures are currently used, but all entail implanting the ureters into a segment of bowel. The selected bowel segment is either left in situ, such as in ureterosigmoidostomy, or divided with its mesenteric blood supply intact and attached to a cutaneous stoma or urethra. Moreover, the isolated bowel can either function as a conduit (eg, ileal conduit) or be reconstructed to form a continent reservoir (neobladder). Conduits may be formed from ileum, jejunum, or colon.

Major anesthetic goals for urinary diversion procedures include keeping the patient well hydrated and maintaining a brisk urinary output once the ureters are opened. Neuraxial anesthesia often produces unopposed parasympathetic activity due to sympathetic blockade, which results in a contracted, hyperactive bowel that makes construction of a continent ileal reservoir technically difficult. Papaverine (100–150 mg as a slow intravenous infusion over 2–3 h), a large dose of an anticholinergic (glycopyrrolate, 1 mg), or glucagon (1 mg) may alleviate this problem.

Prolonged contact of urine with bowel mucosa (slow urine flow) may produce significant metabolic disturbances. Hyponatremia, hypochloremia, hyperkalemia, and metabolic acidosis can occur following construction of jejunal conduits. In contrast, colonic and ileal conduits may be associated with hyperchloremic metabolic acidosis. The use of temporary ureteral stents and maintenance of high urinary flow help alleviate this problem in the early postoperative period.

3. Testicular Cancer

Preoperative Considerations

Testicular tumors are classified as either seminomas or nonseminomas. The initial treatment for all tumors is radical (inguinal) orchiectomy. Subsequent management depends on tumor histology. Nonseminomas include embryonal teratoma, choriocarcinoma, and mixed tumors. Retroperitoneal lymph node dissection (RPLND) plays a major role in the staging and management of patients with nonseminomatous germ cell tumors. Low-stage disease is managed with RPLND or in some instances by surveillance. High-stage disease is usually treated with chemotherapy followed by RPLND.

In contrast to nonseminomas, seminomas are very radiosensitive tumors that are primarily treated with retroperitoneal radiotherapy. Chemotherapy is used for patients who relapse after radiation. Patients with large bulky seminomas or those with increased α-fetoprotein levels (usually associated with nonseminomas) are treated primarily with chemotherapy. Chemotherapeutic agents commonly include cisplatin, vincristine, vinblastine, cyclophosphamide, dactinomycin, bleomycin, and etoposide. RPLND is usually undertaken for patients with residual tumor after chemotherapy.

Patients undergoing RPLND for testicular cancer are typically young (15–35 years old) but are at increased risk for morbidity from the residual effects of preoperative chemotherapy and radiation therapy. In addition to bone marrow suppression, specific organ toxicity may be encountered such as renal impairment following cisplatin, pulmonary fibrosis following bleomycin, and neuropathy following vincristine.

Intraoperative Considerations

A. Radical Orchiectomy

Inguinal orchiectomy can be carried out with regional or general anesthesia. Anesthetic management may be complicated by reflex bradycardia from traction on the spermatic cord.

B. Retroperitoneal Lymph Node Dissection

The retroperitoneum is usually accessed through a midline incision, but regardless of the surgical approach, all lymphatic tissue between the ureters from the renal vessels to the iliac bifurcation is removed. With the standard RPLND, all sympathetic fibers are disrupted, resulting in loss of normal ejaculation and infertility. A modified technique that may help preserve fertility limits the dissection below the inferior mesenteric artery to include lymphatic tissue only on the ipsilateral side of the testicular tumor.

9 Patients receiving bleomycin preoperatively may be particularly at risk for oxygen toxicity and fluid overload, and for developing pulmonary insufficiency or acute respiratory distress syndrome postoperatively. Excessive intravenous fluid administration may be contributory. Anesthetic management should include use of the lowest inspired concentration of oxygen compatible with oxygen saturation above 90%. Positive end-expiratory pressure (5–10 cm H_2O) may be helpful in optimizing oxygenation.

Evaporative and redistributive fluid losses (“third spacing”) with open RPLND can be considerable as a result of the large wound and the extensive surgical dissection. Fluid replacement should be sufficient to maintain urinary output greater than 0.5 mL/kg/h; the combined use of both colloid and crystalloid solutions in a ratio of 1:2 or 1:3 may be more effective in preserving urinary output than crystalloid alone. Retraction of the inferior vena cava during surgery often results in transient arterial hypotension.

The postoperative pain associated with open RPLND incisions is severe, and aggressive postoperative analgesia is helpful. Continuous epidural analgesia, extended-release epidural morphine, or intrathecal morphine (or hydromorphone) should be considered. Because ligation of intercostal arteries during left-sided dissections has rarely resulted in paraplegia, it may be prudent to document normal motor function postoperatively prior to institution of epidural analgesia. The arteria radicularis magna (artery of Adamkiewicz), which is supplied by these vessels and is responsible for most of the arterial blood to the lower half of the spinal cord, arises on the left side in most individuals. It should be noted that unilateral sympathectomy following modified RPLND usually results in the ipsilateral leg being warmer than the contralateral one. Patients who have undergone RPLND frequently complain of severe bladder spasm pain in the postanesthesia care unit and postoperatively.

4. Renal Cancer

Preoperative Considerations

Renal cell carcinoma is frequently associated with paraneoplastic syndromes, such as erythrocytosis, hypercalcemia, hypertension, and nonmetastatic hepatic dysfunction. The classic triad of hematuria, flank pain, and palpable mass occurs in only 10% of patients, and the tumor often causes symptoms only after it has grown considerably in size. In fact, renal cell carcinoma is commonly discovered as an incidental finding in the course of working up a supposedly unrelated medical problem, such as in an MRI performed for evaluation of low back pain. This cancer has a peak incidence between the fifth and sixth decades of life, with 2:1 male to female ratio. Curative surgical treatment is undertaken for carcinomas confined to the kidney, but palliative surgical treatment may involve more extensive tumor debulking. In approximately 5–10% of patients, the tumor extends into the renal vein and inferior vena cava as a thrombus. Staging includes CT or MRI scans and an arteriogram. Preoperative arterial embolization may shrink the tumor mass and reduce operative blood loss.

Preoperative evaluation of the patient with renal carcinoma should focus on defining the degree of renal impairment, searching for the presence of coexisting systemic diseases, and planning the anesthetic management needs dictated by the scope of anticipated surgical resection. Preexisting renal impairment depends upon tumor size in the affected kidney as well as underlying systemic disorders such as hypertension and diabetes. Smoking is a well-established risk factor for renal carcinoma, and these patients have a high incidence of underlying coronary artery and chronic obstructive lung disease. Although some patients present with erythrocytosis, the majority are anemic. Preoperative blood transfusion to increase hemoglobin concentration above 10 g/dL should be considered when a large tumor mass is to be resected.

Intraoperative Considerations

A. Radical Nephrectomy

The operation may be carried out via an anterior subcostal, flank, or midline incision. Hand-assisted laparoscopic technique is often utilized for partial or total nephrectomy associated with a smaller tumor mass. Many centers prefer a thoracoabdominal approach for large tumors, particularly when a tumor thrombus is present. The kidney, adrenal gland, and perinephric fat are removed en bloc with the surrounding (Gerota's) fascia. General endotracheal anesthesia is used, often in combination with epidural anesthesia.

The operation has the potential for extensive blood loss because these tumors are very vascular and often very large. Direct arterial pressure monitoring should be used. Central venous cannulation is used for pressure monitoring and rapid transfusion. Transesophageal echocardiography should be strongly considered for all patients with extensive vena cava thrombus. Retraction of the inferior vena cava may be associated with transient arterial hypotension. Only brief periods of controlled hypotension should be used to reduce blood loss because of its potential to impair function in the contralateral kidney. Reflex renal vasoconstriction in the unaffected kidney can also result in postoperative renal dysfunction. Fluid replacement should be sufficient to maintain urinary output greater than 0.5 mL/kg/h.

If combined general–epidural anesthesia is employed, administration of epidural local anesthetic may be postponed until the risk of significant operative blood loss has passed as sympathectomy from epidural local anesthetic administration will potentiate the hypotensive effect of hemorrhage. As with all lengthy operative procedures, the risk of hypothermia should be minimized by utilizing a forced-air warming blanket and intravenous fluid warming. The postoperative course of open nephrectomy is extremely painful, and epidural analgesia is very useful in minimizing discomfort and accelerating acute postoperative convalescence.

B. Radical Nephrectomy with Excision of Tumor Thrombus

Some medical centers routinely perform complicated resections of renal cancers with tumor thrombus extending into the inferior vena cava. Because of the degree of physiological trespass and potential for major blood loss associated with this operation, the anesthetic management (as for nephrectomy) can be challenging. A thoracoabdominal approach allows the use of cardiopulmonary bypass when necessary.

The thrombus may extend only into the inferior vena cava but below the liver (level I), up to the liver but below the diaphragm (level II), or above the diaphragm into the right atrium (level III). Surgery can significantly prolong and improve quality of life in selected patients, and in some patients, metastases may regress after resection of the primary tumor. A preoperative ventilation-perfusion scan may detect preexisting pulmonary embolization of the thrombus. Intraoperative transesophageal echocardiography (TEE) is helpful in determining whether the uppermost margin of the tumor thrombus extends to the diaphragm, above the diaphragm, into the right atrium, or to the tricuspid valve. TEE can also be used to confirm the absence of tumor in the vena cava, right atrium, and right ventricle after successful surgery.

The presence of a large thrombus (level II or III) complicates anesthetic management. Invasive pressure monitoring and multiple large-bore intravenous catheters are necessary because transfusion requirements are commonly 10–15 units of packed red blood cells. Transfusion of platelets, fresh frozen plasma, and cryoprecipitate may also be required. Problems associated with massive blood transfusion should be anticipated (see Chapter 51). Central venous catheterization should be performed cautiously to prevent dislodgement and embolization of tumor thrombus. A high central venous pressure is typical in the setting of significant caval thrombus and reflects the degree of venous obstruction. Pulmonary artery catheters provide little information that cannot be obtained from a central line or TEE. Intraoperative TEE is preferable to a pulmonary catheter in every respect.

Complete obstruction of the inferior vena cava markedly increases operative blood loss because of dilated venous collaterals from the lower body that traverse the abdominal wall, retroperitoneum, and epidural space. Patients are also at significant risk for potentially catastrophic intraoperative pulmonary embolization of the tumor. Tumor embolization may be heralded by sudden supraventricular arrhythmias, arterial desaturation, and profound systemic hypotension. TEE is invaluable in this situation. Cardiopulmonary bypass may be used when the tumor occupies more than 40% of the right atrium and cannot be pulled back into the cava. Hypothermic circulatory arrest has been used in some centers. Heparinization and hypothermia greatly increase surgical blood loss.

RENAL TRANSPLANTATION

The success of renal transplantation, which is largely due to advances in immunosuppressive therapy, has greatly improved the quality of life for patients with end-stage renal disease. With modern immunosuppressive regimens, cadaveric transplants have achieved almost the same 80–90% 3-year graft survival rate as living-related donor grafts. In addition, restrictions on candidates for renal transplantation have gradually decreased. Infection and cancer are the only remaining absolute contraindications.

Preoperative Considerations

Current organ preservation techniques allow ample time (24–48 h) for preoperative dialysis of cadaveric recipients. Living-related transplants are performed electively with simultaneous donor and recipient operations. 10 The recipient's serum potassium concentration should be below 5.5 mEq/L, and existing coagulopathies should be corrected.

Intraoperative Considerations

Renal transplantation is carried out by placing the donor kidney retroperitoneally in the iliac fossa and anastomosing the renal vessels to the iliac vessels and the ureter to the bladder. Heparin is administered prior to temporary clamping of the iliac vessels. Intravenous mannitol administered to the recipient helps establish an osmotic diuresis following reperfusion. Immunosuppression is initiated on the day of surgery with combination medications which may include corticosteroids, cyclosporine or tacrolimus, azathioprine or mycophenolate mofetil, antithymocyte globulin, monoclonal antibodies directed against specific subsets of T lymphocytes (OKT3), and interleukin-2 receptor antibodies (daclizumab or basiliximab). The anesthetist should discuss in advance with the surgery team the timing and dosage of any immunosuppressive agents which will need to be given perioperatively. Recipient nephrectomy (with a failed transplant) is performed for intractable hypertension or chronic infection.

A. Choice of Anesthesia

Most renal transplants are performed with general anesthesia, although spinal and epidural anesthesia are also utilized. All general anesthetic agents have been employed without any apparent detrimental effect on graft function. Cisatracurium and rocuronium may be the muscle relaxants of choice, as they are not dependent upon renal excretion for elimination. Vecuronium may be used with only modest prolongation of its effects.

B. Monitoring

Central venous cannulation may be useful for ensuring adequate hydration while avoiding fluid overload, particularly in patients with impaired cardiac status. Central lines are also useful portals for the various infusions that these patients require in the first few days after transplant. Normal saline is commonly used. A urinary catheter is placed preoperatively, and a brisk urine flow following the arterial anastomosis generally indicates good graft function. If the graft ischemic time was prolonged, an oliguric phase may precede the diuretic phase, in which case fluid therapy must be appropriately adjusted. Administration of furosemide or additional mannitol may be indicated in such cases. Hyperkalemia has been reported after release of the vascular clamp following completion of the arterial anastomosis, particularly in pediatric and other small patients, and release of potassium contained in the preservative solution has been implicated as the cause of this phenomenon. Donor kidney washout of the preservative solution with ice-cold lactated Ringer's solution just prior to the vascular anastomosis may help avoid this problem. Serum electrolyte concentrations should be monitored closely after completion of the anastomosis. Hyperkalemia may be suspected from peaking of the T wave on the ECG.

CASE DISCUSSION

Hypotension in the Recovery Room

A 69-year-old man with a history of an inferior myocardial infarction was admitted to the recovery room following TURP under general anesthesia. The procedure took 90 min and was reported to be uncomplicated. On admission, the patient is extubated but still unresponsive, and vital signs are stable. Twenty minutes later, he is noted to be awake but restless. He begins to shiver intensely, his blood pressure decreases to 80/35 mm Hg, and his respirations increase to 40 breaths/min. The bedside monitor shows a sinus tachycardia of 140 beats/min and an oxygen saturation of 92%.

What is the differential diagnosis?

The differential diagnosis of hypotension following TURP should always include (1) hemorrhage, (2) TURP syndrome, (3) bladder perforation, (4) myocardial infarction or ischemia, (5) septicemia, and (6) disseminated intravascular coagulation (DIC).

Other possibilities (see Chapter 56) are less likely in this setting but should always be considered, particularly when the patient fails to respond to appropriate measures (see below).

Based on the history, what is the most likely diagnosis?

A diagnosis cannot be made with reasonable certainty at this point, and the patient requires further evaluation. Nonetheless, the hypotension and shivering must be treated rapidly because of the history of coronary artery disease. The hypotension seriously compromises coronary perfusion, and the shivering markedly increases myocardial oxygen demand (see Chapter 21).

What diagnostic aids would be helpful?

A quick examination of the patient is extremely useful in narrowing down the possibilities. Hemorrhage from the prostate should be apparent from effluent of the continuous bladder irrigation system placed after the procedure. Relatively little blood in the urine makes it look pink or red; brisk hemorrhage is often apparent as grossly bloody drainage. Occasionally, the drainage may be scant because of clots blocking the drainage catheter; irrigation of the catheter is indicated in such cases.

Clinical signs of peripheral perfusion are invaluable. Hypovolemic patients have decreased peripheral pulses, and their extremities are usually cool and may be cyanotic. Poor perfusion is consistent with hemorrhage, bladder perforation, DIC, and severe myocardial ischemia or infarction. A full, bounding peripheral pulse with warm extremities is suggestive of, but not always present in, septicemia. Signs of fluid overload should be searched for, such as jugular venous distention, pulmonary crackles, and an S_3 gallop. Fluid overload is more consistent with TURP syndrome, but may also be seen in myocardial infarction or ischemia.

The abdomen should be examined for signs of perforation. A rigid and tender or distended abdomen is very suggestive of perforation and should prompt immediate surgical evaluation. When the abdomen is soft and nontender, perforation can reasonably be excluded.

Further evaluation requires laboratory measurements, an ECG, a chest radiograph, and consideration of a transthoracic echocardiogram. Blood should be immediately obtained for arterial blood gas analysis and measurements of hematocrit, hemoglobin, electrolytes, glucose, platelet count, and prothrombin and partial thromboplastin tests. If DIC is suggested by diffuse oozing, fibrinogen and fibrin split product measurements will confirm the diagnosis. A 12-lead ECG should be evaluated for evidence of ischemia, electrolyte abnormalities, or evolving myocardial infarction. A chest film should be obtained to search for evidence of pulmonary congestion, aspiration, pneumothorax, or cardiomegaly. An echocardiogram helps determine end-diastolic volume, systolic function (particularly the presence or absence of regional wall motion abnormalities), and can detect valvular abnormalities; comparison to prior studies would be invaluable.

While laboratory measurements are being performed, what therapeutic and diagnostic measures should be undertaken?

Immediate measures aimed at avoiding hypoxemia and hypoperfusion should be instituted. Supplemental oxygen should be administered, and endotracheal intubation is indicated if significant hypoventilation or respiratory distress is present. Frequent blood pressure measurements should be obtained. If signs of fluid overload are absent, a diagnostic fluid challenge with 300–500 mL of crystalloid or 250 mL of colloid is helpful. A favorable response, as indicated by an increase in blood pressure and a decrease in heart rate, is suggestive of hypovolemia and may indicate the need for additional fluid boluses. Obvious bleeding in the setting of anemia and hypotension necessitates blood transfusion. The absence of a quick response to intravenous fluid volume challenge should prompt further evaluation. Administration of an inotrope, such as dopamine, is appropriate should ventricular dysfunction be detected by echocardiography. Direct intraarterial pressure measurement is invaluable in this setting.

If signs of fluid overload are present, intravenous furosemide in addition to an inotrope is indicated.

The patient's axillary temperature is 35.5°C. Does the absence of obvious fever exclude sepsis?

No. Anesthesia is commonly associated with altered temperature regulation. Moreover, correlation between axillary and core temperatures is quite variable (see Chapter 52). A high index of suspicion is therefore required to diagnose sepsis. Leukocytosis is common following surgery and is not a reliable indicator of sepsis in this setting.

The mechanism of shivering in patients recovering from anesthesia is poorly understood. Although shivering is common in patients who become hypothermic during surgery (and presumably functions to raise body temperature back to normal), its relation to body temperature is inconsistent. Anesthetics probably alter the normal behavior of hypothalamic thermoregulatory centers in the brain. In contrast, infectious agents, circulating toxins, or immune reactions cause the release of cytokines (interleukin-1 and tumor necrosis factor) that stimulate the hypothalamus to synthesize prostaglandin (PG) E_2. The latter, in turn, activates neurons responsible for heat production, resulting in intense shivering.

How can the shivering be stopped?

Regardless of its cause, shivering has the undesirable effects of markedly increasing metabolic oxygen demand (100–200%) and CO_2 production. Both cardiac output and minute ventilation must therefore increase, and these effects are often poorly tolerated by patients with limited cardiac or pulmonary reserve. Although the ultimate therapeutic goal is to correct the underlying problem, such as hypothermia or sepsis, additional measures are indicated in this patient. Supplemental oxygen therapy helps prevent hypoxemia. Unlike other opioid agonists, meperidine in small doses (25–50 mg intravenously) frequently terminates shivering regardless of the cause. Chlorpromazine, 10–25 mg, and butorphanol, 1–2 mg, may also be effective. These agents may have specific actions on temperature regulation centers in the hypothalamus. Shivering associated with sepsis and immune reactions can also be blocked by inhibitors of prostaglandin synthetase (aspirin, acetaminophen, and nonsteroidal antiinflammatory agents) as well as glucocorticoids. Intravenous acetaminophen is generally preferred perioperatively because it does not affect platelet function.

What was the outcome?

Examination of the patient reveals warm extremities with a good pulse, even with the low blood pressure. The abdomen is soft and nontender. The irrigation fluid from the bladder is only slightly pink. A diagnosis of probable sepsis is made. Blood cultures are obtained and antibiotic therapy is initiated to cover gram-negative organisms and enterococci, the most common pathogens. The patient receives empiric antibiotic coverage and a dopamine infusion is initiated. In settings of redistributive, vasodilatory shock, additional vasoconstrictors (eg, vasopressin) may be needed. The shivering ceases following administration of meperidine, 25 mg intravenously. The blood pressure increases to 110/60 mm Hg and the heart rate slows to 90 beats/min following a 1000 mL intravenous fluid bolus and initiation of a 5-mcg/kg/min dopamine infusion. The serum sodium concentration was found to be 130 mEq/L. Four hours later, dopamine was no longer needed and was discontinued. The patient's subsequent recovery was uneventful.

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