CHAPTER 86 UROLOGIC SURGERY AND TRAUMA

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IMMEDIATE CONCERNS

Primary emergency considerations in urology from the critical care perspective include hemorrhagic, obstructive, infectious, and ischemic processes, in addition to a wide variety of general postoperative difficulties that may warrant emergent intervention. Oncologic emergencies also arise in urology and may require urgent critical care management. Urologic trauma (addressed in a separate section, below) encompasses a wide variety of injuries that may vary from life-threatening issues to those impacting functional outcomes.

Gross hematuria is an alarming symptom to the patient and the medical practitioner, and may mandate immediate critical care intervention depending on the magnitude of the hematuria and details of the individual case [1]. Patients presenting with gross hematuria to the emergency center may have a defined cause (e.g., known radiation cystitis, recurrent benign prostatic hypertrophy [BPH]-related bleeding) or may be reporting a new sign not previously evaluated. Immediate urologic intervention is necessary if the patient has clot retention (unable to void or empty adequately due to the presence of clots in the bladder), is bleeding severely (which may be difficult to judge), has significant pain, is infected, has coagulopathy, or has other underlying medical factors with increased risk of further complications. Vital sign measurement, physical examination, and basic laboratory studies including complete blood count (CBC), coagulation functions, electrolyte and renal function testing, urinalysis, and culture will often answer the above questions and determine the need for immediate intervention. Palpation and percussion of the bladder may reveal bladder distention with or without tenderness. Bladder ultrasound units (BladderScan) or other readily available ultrasound instruments may rapidly answer the question of whether the bladder is distended. In the setting of gross hematuria and a distended bladder, a catheter must be inserted. Often too small a catheter is placed, which does not allow adequate irrigation of clots; clots must be fully evacuated to allow proper catheter drainage as well as to determine the degree of bleeding and continuation of bleeding. Small clots may be evacuated via an 18 to 20 French catheter; large clots require a bigger catheter (22–24 French) for satisfactory evaluation. The catheter should be irrigated to and fro with a piston syringe using 60 to 120 mL of normal saline. When no more clots can be retrieved, the irrigation efflux should become clear if bleeding is not ongoing. If the efflux remains bloody despite complete clot evacuation or if new clots continue to form, there is ongoing bleeding and input from the urologist is needed. One can change the patient to a three-way catheter in the setting of continuing bleed-

ing in order to keep the catheter patent, but this decision is best made along with urologic consultation. There are risks involved in the implementation of continuous bladder irrigation, including bladder rupture if the outflow lumen becomes occluded without recognition and the inflow of irrigant continues. It is preferable to diagnose early with definitive intervention as cystoscopic examination and fulguration may solve the problem with less morbidity and less blood replacement than more conservative approaches. Gross hematuria in the urologic postoperative setting will be addressed in more detail below.

Other hemorrhagic urologic problems requiring immediate critical care intervention include renal or perirenal bleeding (e.g., spontaneous hematoma in the anticoagulated patient or the renal tumor patient) or scrotal hematoma. Bleeding in these sites is often trauma related (see below).

Urosepsis is another concern. Sepsis of the urinary tract or urogenital origin may present in a most precipitous and potentially life-threatening manner, or may be indolent [2]. It is essential to understand the importance of the combination of infection and obstruction in producing a dangerous septic state. A common scenario is the patient presenting with an obstructing ureteral calculus. Typical symptoms of ureteral colic include flank pain (often radiating to the lower quadrant, and ipsilaterally to the genitalia with distal stones), irritative voiding symptoms (when the stone is distal in the intramural ureter), nausea, vomiting, or distention (due to ileus). These symptoms can be extremely distressing and require urgent medical attention, but the most critical emergency seen in such a setting occurs when these symptoms are accompanied by infection and sepsis. The combination of infection and obstruction of the urinary tract (upper or lower) is a veritable surgical emergency requiring immediate action. Septic shock may unfold rapidly in such situations with a significant mortality rate, even in the otherwise healthy host. We teach our residents that the sun should never set on an undrained, infected obstructed urinary tract.

Other infectious states requiring urgent critical care intervention include renal or perirenal abscess, scrotal abscess, acute epididymo-orchitis, and Fournier gangrene (see below).

Obstruction of the urinary tract and urinary retention may require critical care intervention independent of the presence or absence of hematuria or infection. Upper or lower tract obstruction can result in acute or chronic renal failure, mandating prompt drainage to control metabolic instability. Acute urinary retention with bladder distention is a miserable experience for the patient, and must be promptly relieved by introduction of a catheter into the bladder, preferably by a transurethral route, or alternatively by a suprapubic route if the urethra is impassable.
Ischemic states represent another form of pathology for which immediate intervention is essential\(^1,3,4\). The quintessential example in our discipline is that of testicular torsion. Delayed diagnosis of torsion is a common cause of unnecessary testicular loss (as well as avoidable litigation). After 8 hours, the likelihood of testicular salvage decreases significantly. A high index of suspicion is necessary when addressing “the acute scrotum,” with accurate history and physical examination forming the core of this assessment, with diagnostic imaging (mainly scrotal ultrasound, occasionally computed tomography [CT] scanning when extension from an intra-abdominal process is suspected). When clinical suspicion of acute testicular torsion is high, surgical exploration should not be delayed to obtain confirmatory imaging that is not readily and rapidly available. The outcome with regard to testicular salvage is critically time sensitive. The occasional negative exploration or the finding of some other cause of the acute scrotum is appropriate, similar to the principles of exploration for the acute abdomen and for acute appendicitis. Naturally, proper patient education is important preoperatively in addressing the differential diagnosis and both the possibility of finding a lesion, which might have been manageable without surgery, as well as the possibility of orchectomy. The differential diagnosis of the acute scrotum includes incarcerated or strangulated inguinal hernia for which urgent surgical management is also critical. Physical and sonographic findings are usually diagnostic preoperatively.

Other ischemic states of critical care relevance in urology include the ischemic kidney (due to atherosclerotic or embolic disease or pedicle injury from trauma). The kidney begins to undergo irreversible loss of function following approximately 30 minutes of warm ischemia time; thus, rapid action is necessary.

Oncologic emergencies in urology often involve hemodynamic, obstructive, and infectious problems. Other emergencies include neurologic compromise and pain management issues. Prostate cancer may metastasize preferentially to the skeletal system. In prior eras, presentation with extensive spinal involvement was much more common than in current practice; however, sudden neurologic compromise from spinal cord compression due to prostate cancer is still seen. Sensory loss, paraplegia, and loss of urinary, bowel, and sexual function may be manifestations of neurologic compromise from malignant involvement of the central nervous system. When observed, immediate neurosurgical consultation should be obtained to determine if corticosteroids, emergency radiation therapy, or decompensative laminectomy is indicated. In addition, medical oncology input is valuable. Commencing antiandrogen therapy emergently may be of great value when prostate cancer patients present with complications such as neurologic or urinary obstructive compromise. Intramuscular levamisole hormone-releasing hormone (LH-RH) agonists such as leuprolide acetate may be started immediately; to prevent transient worsening from the androgen flare that accompanies the initiation of such regimens, an antiandrogen drug such as bicalutamide should be commenced simultaneously or prior to the LH-RH analog.

### POSTOPERATIVE MANAGEMENT

Both major and minor urologic surgery may present critical care issues that require rapid and accurate assessment and intervention. While the postoperative considerations following major retroperitoneal or pelvic surgery will be familiar to the surgical critical care specialist as they mirror the issues relevant to general and vascular surgery, there are special considerations in urologic patients. Patients undergoing endoscopic surgery and gynecologic surgery may present with postoperative issues less familiar to the critical care teams, and it is important to understand the anatomy and the issues that may require expeditious intervention. Currently, many urologic procedures that have traditionally been performed through open surgical approaches are now commonly being approached via laparoscopic, robotic, and other minimally invasive techniques, which being with them their own set of postoperative challenges. We will address the more common and important types of urologic procedures with relevance to the critical care provider.

Upper abdominal surgery in urology usually involves extirpative procedures on the adrenal gland, kidney, or ureter and/or reconstructive procedures on these structures. Patient position and selection of incision are relevant to the postoperative management. While the anterior midline incision is often favored by general surgeons for intraperitoneal procedures, urologists often prefer to operate through the flank or through other incisional approaches to the upper abdomen. Flank surgery is an art that is mastered through extensive experience: exactly how and where to make an incision reflects one’s training and the task to be accomplished. Large renal tumors are often approached through a thoracoabdominal incision, which may enter the chest through the bed of the 8th to 11th rib through a rib resection or intercostal technique. Smaller or lower pole tumors are commonly approached through a subcostal flank or anterior incision, which generally does not enter the thoracic cavity. Such incisions may be developed through an extraperitoneal exposure or through a transperitoneal route. The critical care provider in these postoperative patients should know how the patient was positioned, what kind of incision was made, and whether it was transthoracic and intra- or extraperitoneal. These details allow one to anticipate the types of problems that may arise postoperatively. In flank surgery, it is not uncommon to encounter a “down-lung” syndrome, with postoperative atelectasis involving the lung positioned downward against the operating table, particularly when the operation is prolonged and the patient is large. Occasionally lobar or complete lung atelectasis may be noted and may require bronchoscopic intervention. If a tube thoracostomy is placed following urologic surgery, the standard problems typical of the use of such tubes can occur; rarely, lung resection is performed as part of a urologic procedure (e.g., wedge resection of a solitary metastasis from renal cell carcinoma) and problems related to air leak or postoperative intrathoracic bleeding may be encountered. Excellent pulmonary toilet is critical following upper abdominal and flank urologic surgery and ideally should be initiated preoperatively, with patients being medically optimized and being taught to use an incentive spirometer, and then being closely monitored for pulmonary difficulties with early intervention as indicated. Postoperative pain from flank surgery can be a major problem and can require expert pain management intervention, continuous epidural analgesic strategies, subcutaneous pain pumps, and patient-controlled intravenous analgesic. Appropriate pain control is also key to minimizing pulmonary complications by aiding respiratory and coughing efforts.

Following surgery that involves removal or manipulation of the adrenal gland, the possibility of an early postoperative...
hypoadrenal state should be considered, including the poten-
tial for Addisonian crisis. These entities may be unsuspected
and may be missed or noted with a delay in diagnosis when as-
sessing postoperative electrolyte and hemodynamic abnormal-
ities and other nonspecific signs that may be consistent with
critical care specialist should know if the adrenal was removed along with a
nephrectomy procedure and whether there is any reason to sus-
pected hypofunction or absence of the contralateral gland.

Acute renal insufficiency may occur following any major
surgery, and is of particular concern following renal surgery.
Partial nephrectomies may be performed using warm or cold ischemia techniques.
When the latter approach is used, the pa-
tient’s kidney is packed in saline slush following noncrushing occlusion of the renal artery and the excisional procedure is
completed in a setting of local hypotherma. While the objec-
tive in such surgery is to minimize the negative impact on the
function of the operated kidney, some degree of postoperative acute tubular necrosis (ATN) may still occur. Whether this is
clinically noted or relevant depends largely on the state of the
contralateral kidney, and standard management principles for
acute renal insufficiency are applicable.

Bleeding following renal or other upper abdominal urologic
surgery is of vital importance. Postoperative bleeding may be
manifested by hemodynamic changes, acute anemia, physical
findings such as palpable flank hematomata or ecchymoses, or
radiologic findings of blood in the renal fossa, chest (after a
transthoracic procedure) or peritoneal cavity (after a transperi-
toneal procedure). If a drain is left in place following surgery,
elevated output of bloody fluid is important to monitor. Follow-
up is provided by monitoring postoperative bleeding and
most commonly arises from arterial branch vessels within the
renal parenchyma at the resection site. An effort is made intra-
operatively to suture significant parenchymal bleeding points,
sometimes supplemented by the use of additional bolstering sutures,
hemostatic agents, and coagulation instruments (e.g., Argon
beam coagulator). If significant bleeding occurs following re-
nal surgery, expectant management with transfusion and cor-
rection of any coagulopathy, return to the operating room for
re-exploration, angiographic embolization, or CT scanning to
assess the specific anatomic site of bleeding and judge the size of the
hematoma are options to consider. The choice between
these measures is individualized based on the severity of the
bleeding, patient condition and physiologic reserve, and access to imaging, interventional radiologic, and surgical resources.
If there is evidence that major early postoperative bleeding oc-
curs that may be due to an uncontrolled renal pedicle, rapid
surgical re-exploration is the best approach. If bleeding oc-
curs subacutely and renal parenchymal bleeding is suspected,
interventional radiology (IR) is usually favored. The patient
should be maintained in a fluid-resuscitated state when a re-
nal bleeding issue is evolving, with the hemoglobin at a level
that would allow the patient to tolerate continued blood loss
without catastrophic decompensation.

Urinary extravasation following upper urinary tract surgery
may be manifested by increased drainage from suction drains for
which creatinine determination confirms the fluid’s identity as
urine. Urologic input should be sought as to whether the re-
gions is well drained, whether the leak is expected, and whether
intervention versus observation is indicated.

Pelvic surgery procedures requiring postoperative critical
care include exenterative procedures for malignancies (radical
prostatectomy or cystectomy), simple open prostatectomy for
benign prostatic hyperplasia, and reconstructive pelvic surg-
eries for incontinence. Critical care issues typically relate to
standard postoperative abdominal surgical concerns such as
pain, bleeding, and ileus. Specifically with pelvic urologic pro-
cedures, management of tubes and drains and recognizing
when urinary extravasation arising in the postoperative period
requires urgent attention or can be managed expectantly are
important. Patients that have undergone major surgery involving
an open bladder (open prostatectomy, bladder stone removal,
etc.) may have significant bladder spasms postoperatively re-
quiring anticholinergic medication. Bleeding following major
urologic pelvic surgery may result in Foley catheter occlusion
with clot, and it should be established with the urologist how
much hematuria is acceptable and what measures should be
taken if failure of catheter drainage develops. Catheter manip-
ulation should be pursued only with the input of the urologist.
Significant bleeding from the catheter is relatively uncommon
following radical prostatectomy, while dramatic hematuria is
much more common following an open simple prostatectomy
performed for BPH, in which the adenoma is enucleated from the
prostatic capsule by finger dissection, leaving a raw vascular
space bed. Urologic input is needed for problematic bleeding in
such patients.

The possibility of anastomotic leakage or a missed injury to
the ureter exists in the radical prostatectomy patient. If inordin-
ately high pelvic suction drainage is noted, the fluid should be
sent for creatinine level to determine if a urine leak is present.
If well drained, no immediate intervention may be necessary,
but radiographic studies may be indicated to localize the site of
extravasation and prevent postoperative bleeding.

Following radical cystectomy for bladder cancer, compli-
cations may include urinary extravasation from the urinary
diversion reconstruction, pelvic bleeding, ileus, bowel obstruction,
or anastomotic leak, and pelvic lymphocele accumulation.
These patients invariably require stays in the intensive care unit
(ICU) postoperatively, due to the length and complexity of the
surgery, potential for postoperative bleeding, and general med-
cal management. Patients undergoing major urologic surgery,
and especially patients undergoing cystectomy and urinary di-
version, may require nutritional support. These patients, who
have had both a major exenterative procedure as well as com-
plex bowel surgery, may have a prolonged ileus, develop partial
small bowel obstruction, and be dehydrated, and will often re-
quire aggressive nutritional supplementation, which should be
begun early when a prolonged recovery is anticipated, to avoid
the healing problems seen with development of a progressive
catabolic state.

Deep venous thrombosis (DVT) and pulmonary embolism
are risks of many urologic surgical procedures, and urologists
are acutely aware of the issues related to DVT prophylaxis. Be-
cause major retroperitoneal or pelvic surgery also presents sig-
ificant risks for postoperative bleeding, a judicious approach
to postoperative anticoagulation is applied, with careful assess-
ment of DVT risk factors and risk–benefit analysis. Radical
cystectomy is the procedure with the greatest DVT risk of the
urologic operations, as an extensive pelvic lymphadenectomy
is also typically included, and many urologic oncologists will
start low-molecular-weight heparin regimens 24 hours follow-
ing surgery if there are no bleeding issues.

Other pelvic surgical procedures the critical care provider
may encounter include the wide range of pelvic floor

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reconstructive operations performed for management of prolapse or stress incontinence. The traditional subvesical sling or retropubic bladder neck suspension procedures, and particularly some of the newer procedures that involve passage of artificial tape and mesh materials either via the retropubic space, through a transobturator approach, or through other transvaginal techniques, may introduce the risks of enteric pelvic injury or major pelvic vascular injury. If major bleeding occurs following these types of procedures, either via the surgical incisions or resulting in large pelvic hematoma and hemodynamic instability, pelvic exploration or angiographic study may be indicated and vascular surgical expertise may be necessary.

Endoscopic upper and lower urinary tract surgery encompasses a wide variety of commonly performed procedures, including diagnostic cystoscopy (rigid, flexible), cystoscopic surgery (bladder biopsy, transurethral resection of prostate or bladder tumor [TURP, TURBT]), ureteroscopy (rigid, flexible, diagnostic alone, or with stone manipulation or biopsy/f fulguration), and percutaneous renal access surgery (percutaneous nephrostolithotomy). Each of these varieties of urologic instrumentation can be simple or complicated, and can raise problems for the critical care provider.

Lower tract endoscopy for diagnostic purposes is usually performed in an office setting, using a flexible cystoscope (some urologists use the rigid cystoscope in the female, as it is well tolerated due to short length and straight orientation of the female urethra; most male cystoscopy utilizes the flexible cystoscope). Lidocaine jelly is usually used as a local anesthetic, typically instilled with a prepackaged applicator (Uro-jet). The procedure causes minor discomfort, and postprocedure infection can occur, but the risk is small if the urine is sterile preprocedure. Prophylactic oral antibiotics are often administered for all endourologic procedures to minimize the infection risk. Gross hematuria can occur following simple diagnostic cystoscopy, but is usually self-limiting and minimal, especially when the flexible cystoscope is used. Cystoscopic surgery, on the other hand, is generally performed under regional or general anesthesia, and specific issues exist.

When cutting or resection is required, a resectoscope is used, which is a rigid instrument that employs a cutting loop or cutting blade. When performing a traditional TURP, normal saline is not used as an irrigant, as the electrolyte solution will cause dissipation of electric current and prevent effective cutting or coagulation. The most common irrigant used for TURP is a 1.5% glycine solution, which is iso-osmolar and iso-tonic to plasma. This irrigant allows the electrosurgery system to function properly while avoiding hemolysis if intravascular extravasation occurs, a problem seen historically when sterile water was used. Cystoscopic surgery using glycine result in significant hyponatremia if major absorption occurs, either directly into the vasculature (as with cutting into a periprostatic venous sinus during a TURP) or into interstitial tissues (as with fluid entering the retropubic space or infiltrating under the bladder trigone). As hyponatremia develops, the patient may develop altered mental status, headache, hypertension, and respiratory compromise. If under general endotracheal anesthesia, foamy material may be noted in the breathing circuit. Severe hyponatremia may cause cerebral edema and grand mal seizures, and may be life threatening. Some intravesical extravasation has been shown to occur during TURP even without capsular or venous perforation but it does not cause morbidity if minimal. If this problem is recognized intraoperatively, the procedure may need to be prematurely terminated. Diuretics with normal saline administration should be administered intravenously may be indicated, depending on the clinical manifestations. The more abrupt the development of the hyponatremia and the lower the serum sodium, the more dramatic the clinical manifestations are. TURB procedures are sometimes performed using sterile water as the irrigant of choice in order to minimize cell implantation risk, but there is a lack of data to support this concept, and extravasation of sterile water could introduce both a hyponatremia and a hemolysis risk. We strongly recommend avoiding sterile water as an irrigant for operative cystoscopy, confining its use to simple diagnostic cystoscopy. If bladder perforation occurs during TURP or bladder biopsy procedures, there is the potential for significant irrigant extravasation to occur rapidly. If the perforation is intra-peritoneal, management with catheter drainage will suffice and the fluid is usually reabsorbed without sequelae unless the volume is very large, in which case placing a drain into the retroperitoneal space to evacuate the fluid may be indicated. Minimal intra-peritoneal resectoscopic injuries may be manageable with catheter drainage alone. If problems arise (abdominal distention, persistent extravasation) with this nonoperative approach to intraperitoneal bladder perforation, laparoscopic or open surgical repair should be performed. (This situation is very different from the intraperitoneal bladder rupture due to blunt trauma, which typically results in a large defect in the bladder dome, consistently requiring suture repair to prevent urinary ascites and sepsis.)

Bleeding may be a problem following either TURP or TURBT. Urologists are well trained to deal with this problem and distinguish arterial bleeding, which will likely warrant return to the operating room for a second look and fulguration attempt, from acceptable venous bleeding, which is self-limiting. Often three-way catheter continuous bladder irrigation is employed following these procedures to maintain catheter patency and prevent clot formation postoperatively. While these devices are valuable adjuncts in our management of such patients, they introduce the potential for postoperative difficulties with occlusion of the outflow channel from clot, while irrigant inflow continues. Bladder distention and bladder rupture can result in this situation. When managing any continuous bladder irrigation system, the critical care provider must closely monitor the inflow and output, and palpate the lower abdomen on a regular basis to be certain that occlusion does not occur. If uncertain as to whether the three-way catheter is draining properly, the inflow should be turned off while the catheter is irrigated or urologic assistance is obtained. Only normal saline should be used as irrigant for continuous bladder irrigation systems. For TURP procedures, catheter traction may help control bleeding from within the prostatic fossa. Only the urologist should implement or adjust the traction system. For TURBT procedures, catheter traction is of no value, as the bladder body cannot be compressed, so a lower threshold to take the patient back to surgery for a second look is safer for post-TURBT bleeding. If a catheter needs to be changed in the early postoperative period following a TURP or TURBT, this should be done by the operating urologist’s team or on their specific order. Newer technologies for TURP and TURBT employ laser energy to ablate, vaporize, or coagulate tissue endoscopically. These approaches usually result in less bleeding than the traditional electrosurgical approaches. Complications usually relate to obstruction...
following catheter removal or to iatrogenic injury from the laser energy being misdirected.

Upper tract endoscopy (ureteroscopy, percutaneous nephroscopy) has progressed greatly in the last two decades, with the current instrumentation allowing complex upper tract procedures to be performed with low morbidity. Ureteroscopy is often performed for hematoma evaluation, treatment of ureteral or renal stones, endoscopic assessment, and treatment of upper tract urothelial neoplasms, and for addressing obstructive lesions with laser or other incision procedures. Normal saline is used for most such procedures, although glycine may be needed when electrofulguration in the upper tract is planned. Problems that the critical care provider may encounter usually relate to ureteral perforation, gross hematuria with stent occlusion or “clot colic,” or obstructive problems related to retained stone fragments. Percutaneous renal surgery may be accompanied by problems related to having surgery in the prone position, a high access traversing or affecting the chest, and postoperative bleeding. Percutaneous nephrolithotomy or nephrolithotomy (PCNL) involves gaining access to the collecting system through the flank with the patient in the prone position. A needle, guidewire, and balloon or other dilating system is utilized to place a hollow plastic working sheath through the renal parenchyma into the collecting system, through which a flexible or rigid working nephroscope can be advanced. Laser, electrohydraulic, ultrasonic, or pneumatic devices are used to fragment and remove stone, or resection, incision, or fulguration instruments can be introduced to deal with neoplastic or obstructive lesions. Depending on the task to be accomplished, the access for percutaneous renal surgery may be obtained by the interventional radiologist or by the urologist. If entry into the upper pole calyx is needed for stone access, a supracostal puncture may be required (above the 12th rib). The risk exists to traverse the chest cavity resulting in pneumothorax or hydrothorax, which may require tube thoracostomy postoperatively. If elevated airway pressures and difficulty with ventilation is encountered, these possibilities should be entertained and managed acutely. As the kidney is a very vascular organ and the access traverses the renal parenchyma, significant bleeding can occur intraoperatively, perioperatively, or days or weeks postoperatively at the time of nephrostomy removal. Occasionally angiographic embolization may be necessary for major renal bleeding associated with PCNL. If brisk bleeding with hemodynamic instability occurs via an indwelling nephrostomy tube, the tube can be clamped while urologic input is urgently obtained. When removing a nephrostomy tube following PCNL, a tamponade catheter should be immediately available to place into the tract and inflate if dangerous bleeding ensues following tube removal.

While not strictly endoscopic surgery, extracorporeal shock wave lithotripsy (ESWL) is another common procedure for stone management that the critical care provider may encounter. This procedure involves the noninvasive fragmentation of renal or ureteral calculi with a shock wave generator system under fluoroscopic or ultrasound guidance. The procedure commonly produces transient gross hematuria, which is rarely troublesome, as ESWL does result in some mild blunt trauma to the kidney. The typical procedure involves administering approximately 3,000 shocks to the stone(s). Following ESWL, colic can occur due to passage of fragments. Whether manageable expectantly or requiring stent insertion depends on the stone burden, the amount of debris created, the size of residual fragments, the degree of symptoms, and whether there are signs of infection and septic shock.

Laparoscopy in urologic surgery has come into its own in recent years and has become a major element of our approach to a wide range of surgical tasks that previously were performed solely through major open approaches. In many centers, the open radical retroperitoneal prostatectomy (RRP) has been nearly replaced by the robotic-assisted laparoscopic prostatectomy (RARP), and kidney surgery done through a flank incision has been largely replaced by laparoscopic approaches. The same special considerations that are relevant to all laparoscopic surgeries are important to urologic laparoscopy. Such common issues include postoperative ileus, CO2 retention, venous CO2 embolism, postoperative bleeding, unrecognized intraoperative urologic injury, and trochar and port-site complications (5).

In laparoscopy for renal surgery, there are two potential major sites of postoperative bleeding: the renal pedicle and the renal parenchyma (relevant for partial nephrectomy). The traditional means of controlling vessels in open surgery, using suture and ligation, is often replaced in laparoscopic surgery with vascular stapling devices and instruments like the harmonic scalpel. The technology has advanced rapidly with these tools, and they are generally reliable and secure. There are, however, user-dependent factors and there is a learning curve involved in mastering the use of these devices. Bleeding can occur immediately postoperatively or in a more delayed fashion, and be manifested by hemodynamic and laboratory changes or visible bleeding from instrument ports or incisions. When precipitous and life threatening, a quick return to the operating room with either laparoscopic or open re-exploration may be the most appropriate course. When more gradual and when the luxury of the opportunity for further evaluation is appropriate, postoperative CT scanning to determine if there is a renal or perirenal hematoma may be relevant prior to a surgical effort. Bleeding occurs from the cut surface of the kidney following either open or laparoscopic partial nephrectomy, angiography with selective embolization is often the preferred approach.

Drains left within the abdomen following laparoscopic procedures are often placed intraperitoneally, as opposed to the case in extraperitoneal flank surgery, where the drain is often not within the peritoneal cavity. As such, intraperitoneal drains may drain retained irrigant or peritoneal fluid in copious amounts following surgery. If there is uncertainty as to the significance of increased drain output, fluid may be sent for chemical analysis (creatinine to determine if fluid is urine, amylase to rule out pancreatic fluid leak). Leakage of urine following laparoscopic urologic surgery may not require immediate intervention if the leak is well drained. If action is needed, postoperative ureteral stent insertion (along with a urethral Foley catheter or in some cases nephrostomy insertion) will often allow the collecting system to heal without sequelae. In general, drains should be removed as early as possible, as they have the downside of potentially allowing the entry of bacteria into the abdominal cavity.

In the course of dissection during laparoscopic urologic surgery, especially if electrocautery is extensively utilized, the risk of unrecognized bowel injury must be appreciated. The presentation of such complications may be subtle, with low-grade fever, minimal diffuse tenderness, which may be consistent with the expected postsurgical state; or delayed return of bowel function or persistent anorexia. A high degree of suspicion is important when patients fail to thrive following

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laparoscopic surgery, and postoperative CT scanning may demonstrate a fluid collection in an unexpected location or inflammatory changes in or near the intestine that would not be otherwise anticipated.

As robotic surgery for radical prostatectomy is rapidly becoming commonplace, the critical care provider may encounter such patients in the postoperative period. The same considerations noted above apply to the RALP patient with regard to suspecting and identifying inadvertent injuries. Gross hematuria causing catheter occlusion is important to recognize, as the vesicourethral anastomosis in these patients is quite delicate and usually performed with a running suture. Clot retention from catheter occlusion can result in bladder distention, which may strain or cause dehiscence of the anastomosis. Clear instructions from the urologist should be noted regarding catheter management, what to expect regarding volume and appearance of efflux, and appropriate interventions. If a catheter fails to drain following RALP, judicious irrigation with normal saline is generally safe, using no more than 60 mL. If a small clot is present and this maneuver results in normal clear efflux, no further action is necessary. Otherwise, the urologist should be informed and should provide specific intervention instructions or deal with the situation personally. Under no circumstances should anyone but the operating urologist ever remove and attempt replacement of an indwelling urethral catheter during the early perioperative period following major lower tract urologic surgery, especially when a fresh anastomosis or reconstructive site is present; such manipulation without direct visualization may disrupt the reconstruction site and cause major additional complications.

Gastrointestinal surgery issues that may arise in the critical care setting may relate to penile, sphincter, and testicular prosthetic implants; neurologic stimulator implants; or complications of the wide range of other genital procedures urologists perform. Dressings on the genitalia should be inspected for bleeding or excessive tightness, which can cause vascular compromise, especially if applied circumferentially around the penis. Any major local complaint by a patient following genital surgery should be referred to the urologic surgeon for input. It is important for the critical care provider to know when a patient has a genitourinary prosthesis implanted. Obviously, there should never be any needle placement or incisional procedure performed by a nonurologist in the region of the genitalia in the setting of a prosthetic implant, as the fluid-filled components are prone to damage. If a patient with an artificial urinary sphincter (AUS) device needs a Foley catheter inserted, it is important that the device be deactivated (i.e., locked in an open position) by cycling the device and pressing the deactivation button on the pump once the pump has cycled full of fluid. Forcibly passing a Foley catheter into the urethra of an AUS patient risks damage to the urethra and the device. Infection and erosion can occur with any of the urologic prostheses, rarely resulting in abscess formation and major soft tissue infections and sepsis. Exploration and drainage procedures may be necessary, which require urologic surgical expertise. If uncertain as to how to approach any genitourinary prosthesis, obtain urologic expertise.

Other genital surgery procedures such as vasectomy, testicular biopsy, reconstructive microsurgery for fertility treatment, and orchectomy for tumor or benign disease can be complicated by bleeding or infection. If marked swelling occurs following genital surgery, the urologist should be immediately made aware. Orchectomy for tumor is performed through a groin incision and involves removing the testis, its investing tunics (intact), and the spermatic cord to the level of the internal inguinal ring. If bleeding occurs from the stump of the spermatic cord, the hematoma can develop in the retroperitoneum and require high exploration for control.

### Urologic Trauma

Trauma centers vary markedly with regard to the role played by the urologist in trauma management. Some highly respected trauma centers utilize the urologist’s expertise on a regular basis for assistance with the management of genitourinary injuries, while others rarely include the urologist. At our trauma center, the urology service plays a central role in the assessment and management of urologic injuries, participating in the selection and interpretation of imaging studies, the decision of when to operate, and the operative intervention itself. As such, we have achieved a high level of cooperation between our service and the trauma surgery and critical care services. This discussion will address the basic approach to the diagnosis and management of urologic trauma, with a recommendation that the urologist be included whenever possible in management decisions. The urologist’s experience in elective urologic surgery; endoscopic, radiologic, and open surgical interventions; reconstructive approaches; and management of complications may be very helpful to the trauma and critical care teams when faced with the multiply injured patient or with solitary urologic organ trauma. When no urologist is available, however, or critical care decisions need to be made in the absence of urologic input, the critical care provider must have a working knowledge of the approach to the most common and important types of urologic trauma. We will address management of iatrogenic urinary tract trauma, followed by trauma from external violence for renal, ureteral, bladder, urethral, and genital injuries with regard to assessment and management, and discuss the relevance of damage control strategies in urologic trauma.

### Iatrogenic Injury Management

The occurrence of an iatrogenic urologic injury provokes significant anxiety in the surgical team. Having a basic concept of the standard approach to management is essential in maintaining a focus on prompt resolution of the problem.

For bladder injuries, simple closure is feasible as long as the injury involves the upper bladder segment, the trigone is uninjured, and there is not significant tissue loss. We try to perform a running, two-layer closure using heavy absorbable suture. A generously sized Foley catheter should be used (20 French or larger) to allow drainage of bloody efflux and allow efficient irrigation when needed. If the bladder wall surrounding the injury is markedly abnormal (fibrotic, friable, irradiated), a two-layer closure may not be feasible. In these cases, we prefer a one-layer, interrupted closure with heavy suture, with a plan to leave the bladder catheterized for a longer period of time.

If there is involvement of the trigone, ureteral orifices, or intramural ureters, the situation is more complex, and ureteral stent insertion or ureteral reimplantation may be needed. This is best accomplished with urologic support, and may
involve placing an externalized single-J or internalized double-J ureteral stent, then suturing the bladder injury, taking care not to include the ureter in the sutures. If a structure ultimately forms, endoscopic management or delayed elective ureteral reimplantation is always an option. Feeding tubes may also be temporarily passed up the ureters during the bladder repair to identify and potentially protect the ureters and support performing a safe cystostomy. Prophylactic insertion of externalized ureteral catheters prior to complex pelvic or retroperitoneal surgery may be helpful in avoiding surgical injury to the ureter.

For iatrogenic ureteral injuries, the repair approach depends on the level of injury, whether there is loss of ureteral length, the condition of the ureter and surrounding tissue, and the comfort of the surgeon. Traditional urologic teaching states that if the ureter is transected caudal to the crossing of the internal iliac artery, a reimplant rather than a primary anastomosis should be performed. This policy reflects the concern for the viability of the distal uretal stump in the setting of abnormal pelvic anatomy and surgical insult. The reimplant can be performed with or without a psoas hitch depending on ureteral length and bladder status. For injuries in the mid- or upper ureter, primary, spatulated anastomosis performed over an indwelling stent is the preferred solution. As long as one is dissecting outside the ureteral adventitial sheath, substantial length can be gained by mobilizing the ureter toward the kidney and deep into the pelvis with devascularization unlikely to be a concern. If primary repair is not possible, the options include ligation followed by nephrostomy insertion and planned delayed reconstruction, transureteroureterostomy, renal autotransplantation (from appropriate in the acute care surgery setting), or deal ureteral replacement (also seldom appropriate in the acute care surgery setting).

When dissecting in the groin, especially in the setting of a redo hernia, the spermatic cord is at risk for injury. If there is injury to cord vasculature, precise suture ligation of bleeding points should occur, as a hematoma around the cord is very problematic. If there is concern for devascularization of the testis, use of a fine-tipped Doppler probe to detect an arterial waveform is preferable. Blunt trauma to the perineum with confirmation by either standard radiographic or CT cystography. Adequate bladder filling must be accomplished to demonstrate extravasation and minimize false-negative studies. When urethral injury is suspected (following pelvic fracture or perineal or genital trauma), especially when blood is exiting from the urethra or present at the urethral meatus, retrograde urethrography should be performed prior to any attempt at urethral catheterization. For genital trauma, scrotal ultrasonography may be of great value in diagnosing testicular rupture from blunt forces; in penetrating genital trauma, surgical exploration is usually necessary and one can usually forego imaging studies.

Urethral injuries should be suspected in cases of pelvic fracture, particularly with severe pubic diastasis and vertical sheath injuries. A urethrogram that demonstrates contrast extravasation is diagnostic (10). Some urologists may be comfortable with a careful attempt at catheter insertion under cystoscopic guidance or a fluoroscopically and endoscopically guided catheter realignment procedure, though whether this approach provides an advantage over traditional suprapubic diversion remains controversial. The standard approach remains suprapubic (SP) tube insertion; certainly any nonurologist should handle such injuries with placement of a suprapubic catheter, obtaining urologic consultation when available. Suprapubic cystostomy insertion may be accomplished using trochar-based percutaneous systems if the bladder is adequately distended. If not, an open surgical approach in the operating room is preferable. Blunt trauma to the perineum with complete urethral rupture is also best handled with suprapubic diversion. Penetrating injuries to the urethra can also be managed in a delayed fashion with suprapubic diversion, or, if the injury is readily apparent, direct suture repair with fine absorbable suture may be attempted in the stable patient. All such injuries can be managed in a delayed fashion as long as proximal urinary diversion is achieved acutely.

Bladder injuries from blunt trauma are diagnosed on cystography (11), and can usually be managed with catheter drainage alone, if the injury is extraperitoneal. Adequate-bore catheters (20 French or larger) are preferable to evacuate grossly bloody efflux. If there is failure of catheter management (continued profuse hematuria with repeated occlusion of the catheter), continued urine extravasation), surgical repair may be necessary. If it is necessary to surgically repair such an injury, a high midline cystotomy should be made to avoid entering into a fresh retroperitoneal hematoma, which may produce problematic bleeding. The laceration may be sutured in a single layer transversely by placing retractors into the bladder and exposing the injury. Other cases of extraperitoneal bladder injury that benefit from surgical repair include those which involve communication with a vaginal or rectal injury. A suprapubic tube, in addition to the urethral Foley catheter, may be left...
indwelling in cases in which the repair is tenuous or prolonged tube drainage is anticipated (e.g., closed head or spinal cord injury). In the uncommon case of performing a contrast cystogram at approximately 10 to 14 days postinjury and prior to catheter removal ensures complete healing before stressing the bladder.

For intraperitoneal bladder injuries, direct suture repair is required. These injuries invariably occur in the bladder dome, and result from sudden compression of the full bladder. Transabdominal suture repair is straightforward. We generally do not use suprapubic tubes in such cases.

Ureteral injury is usually noted upon abdominal exploration in the penetrating trauma setting, or may be noted on preoperative CT scanning (12). It is necessary to obtain a delayed excretory phase on the CT such that the excreted contrast column has transited the entire ureter, or the risk of missing a ureteral injury is significant. Injuries from penetrating trauma are managed similarly to the approach described above for iatrogenic injuries, or by applying damage control techniques when necessary (see below). For gunshot wounds to the mid- and upper ureter, limited debridement to viable ureter, careful extra-adventitial mobilization, and spatulated suture anastomosis is appropriate. For distal ureteral injuries, reimplantation into the bladder ("ureteroneocystostomy") is a more dependable approach, as the problem of the distal stump having impaired vascularity is avoidable. Ureteral injuries from blunt trauma are rare. Exceptions would include the pediatric population, where ureteropelvic avulsion injuries or renal pelvic lacerations may occur following blunt injuries. When major injury occurs to the urinary tract following seemingly trivial trauma, one should be suspicious of a previously undetected underlying pathology of the urinary tract such as neoplasm or ureteropelvic junction obstruction.

Renal injuries are typically staged by contrast-enhanced CT using the American Association for the Surgery of Trauma (AAST) Organ Injury Scaling system (13,14). Renal injuries are managed according to a multifactorial decision process that considers grade and whether they are due to blunt or penetrating forces, and is based on patient clinical status and hemodynamic stability. In general, for blunt renal injury, grade I, II, and III injuries are routinely managed nonoperatively. Grade IV injuries, which involve deeper, significant parenchymal injury and laceration to the collecting system, require a selective approach, largely influenced by hemodynamic parameters and degree of progressive blood loss, and often warrant monitoring to address whether continued bleeding or urinoma formation occurs, which may warrant delayed intervention (15). The majority of such injuries in most series do not require early exploration, and the observation of extravasation from the collecting system is not, in itself, a strong indication for surgical exploration. If there is extensive medial extravasation on CT, retrograde pyelography may be indicated to exclude a major injury to the renal pelvis or proximal ureter. Grade V injuries from blunt trauma routinely require surgical exploration and often nephrectomy, and most reported results of attempts to manage true grade V injuries nonoperatively have not resulted in good outcomes. Renal pedicle injuries, which are considered in both the grade IV and V groups, require careful consideration to select appropriate management. When the kidney suffers a pedicle stretch injury from deceleration trauma, resulting in arterial intimal disruption, the artery can thrombose, resulting in renal devascularization (16). This can be diagnosed on CT scan with the finding of renal nonperfusion. If the vessels are thrombosed but not avulsed or lacerated, the decision of whether to operate to revascularize the kidney depends on how much time has elapsed, which predicts renal salvage, as well as the patient's other injuries and ability to tolerate a laparotomy. After 10 minutes of warm ischemia, irreversible renal damage begins; by 3 hours, the kidney is not retrievable. If there is a pedicle avulsion injury, surgery is mandatory to prevent delayed catastrophic bleeding.

For penetrating renal trauma, the standard approach traditionally has been surgical exploration and repair or nephrectomy. This view has evolved over the past two decades, however, with reports demonstrating favorable outcomes from nonoperative management of carefully selected penetrating injuries. It has been reported that up to 30% of renal stab wounds and over 20% of renal gunshot wounds may be successfully managed nonoperatively. When comparing the approach to blunt versus penetrating trauma, one must consider the high likelihood of there being associated injuries in penetrating trauma. Still, a fully staged penetrating kidney injury (based on CT) may be appropriately managed nonoperatively if certain conditions are met. These include, in our view, a lateral or polar parenchymal injury, which spares the renal sinus or deep central region of the kidney; in a hemodynamically stable patient; and with low suspicion of injury to the extrarenal collecting system or ureter. The larger the renal hematoma, the less comfortable we are with nonoperative management of a penetrating renal injury. Proactive angiography may be considered when weighing the safety of a nonoperative approach to the penetrating renal injury in selected cases, and admission to the ICU is essential to monitor the presence of previously undetected active extravasation (15). It should be stated for the critical care provider that the default mode for penetrating trauma to genitourinary organs is operative exploration and repair; departure from this approach is appropriate when complete staging information is available that predicts a favorable outcome for a specific injury with a nonoperative approach, the patient is hemodynamically stable, and careful monitoring for failure of nonoperative management can be carried out. Criteria and a plan for changing to an operative strategy should exist.

Genital injuries require specialized care and should be handled by practitioners experienced in genital surgery. As a general principle, a very conservative approach to genital debridement should be maintained, with tissues of questionable viability reassessed in a delayed fashion. Nearly all penetrating genital injuries should be surgically explored acutely assuming the patient is sufficiently stable to undergo a reconstructive effort. Penetrating penile injuries are repaired surgically by closing lacerations in the corpus cavernosum, urethral repair, and skin and soft tissue reconstruction. Penetrating testicular injuries can usually be repaired by closing the tunica albuginea of the testis after debriding nonviable testicular parenchyma. Blunt fracture of the penis, which results from forcible flexion of the penile shaft during erection (often due to trauma during intercourse), should be explored and repaired acutely, upon presentation, to achieve the most favorable cosmetic and functional outcome. For blunt scrotal injury, it is often useful to assess the patient with scrotal ultrasonography to determine if testicular rupture is present, as it may be difficult to determine this on physical exam if there is scrotal wall swelling, which makes identification of internal structures difficult. Ultrasound is quite accurate for detecting testicular rupture; loss

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of capular continuity or marked heterogeneity of testicular parenchyma is predictive of rupture. Testicular salvage is enhanced by early exploration and repair.

**Damage Control Strategies for the Management of Urologic Injury in the Unstable Patient**

Damage control approaches to the management of the unstable trauma patient have become well accepted in the trauma center setting. This concept refers to abbreviating the initial operative effort in order to minimize the effects of prolonged surgery, which results in progressive metabolic deterioration. Critical injuries (surgical bleeding, fecal contamination sources) are addressed, while noncritical injuries are handled in a delayed fashion, on a subsequent visit to the operating room after stabilization in the ICU. This approach avoids development of the “lethal triad” of progressive acidosis, hypothermia, and coagulopathy, which occurs in critically injured patients when initial surgical efforts are prolonged. Many urologic injuries are quite amenable to initial management by applying damage control strategies (17). With the exception of severe renal or bladder bleeding cases, urinary tract injuries do not directly result in early mortality. When, in the surgeon’s judgment, the patient would not tolerate the magnitude of reconstructive effort needed to deal definitively with a urologic injury at initial laparotomy (due to pattern of injury, hypothermia, acidosis, coagulopathy, or other parameters that mandate a damage control approach), certain temporary solutions may be very desirable (18). We have gained substantial experience with such approaches in our center and have achieved an effective working relationship with the trauma surgeons in patient selection and technical approach for such cases.

Renal injuries that are incompletely staged or unstaged may be approached with delayed assessment and exploration, as long as a determination is made that early exsanguinating bleeding from the injury is unlikely. In the absence of significant bleeding from the renal fossa into the peritoneal cavity, a large midline hematoma, or an expanding or pulsatile renal hematoma, one can elect to leave the perinephric hematoma undisturbed and either obtain postoperative imaging during the resuscitation phase following initial laparotomy or explore at the time of a second-look procedure. If the kidney is already surgically exposed, hemostasis for major bleeding from parenchyma or branch renal vessels can be readily obtained. If a major reconstructive effort is still needed in the unstable patient, packing the kidney and returning for reconstructive interventions later is also an option.

Ureteral injuries may be initially managed with externalized stenting, ligation, or simple local drainage. Of these options, we favor externalized stenting, as it allows control of the urinary output, minimizes ongoing urinary extravasation, and can be maintained for several days until the patient is stable enough to return to surgery for definitive reconstruction. A 7 French or 8.5 French single-J urinary diversion stent can be placed into the tube. In addition, externalized drains are often placed near the site of urologic surgery or injuries and employed for various purposes including drainage of blood, infectious fluid, lymph, or extravasated urine. The general principles behind urologic tube drainage along with specific management considerations for the different types of tube mentioned above will be addressed in this section (19).

Tubes placed within the urinary tract may be intended as temporary or permanent solutions to various urologic problems, including bladder muscle failure and obstructive upper or lower tract lesions. Patients with detrusor muscle failure require regular bladder emptying, which may be managed by intermittent catheterization (typically utilizing a clean/nonsterile technique) or by an indwelling catheter. In the case of indwelling catheters, the options include a transurethral Foley catheter or a suprapubic cystostomy tube. In the male, due to the potential morbidity of a long-term indwelling urethral catheter (including urethral erosion, periurethral abscess, epididymitis, and traumatic hypospadia), the SP tube is often favored. All patients with indwelling bladder catheters of either variety will become bacteriuric, but patients with SP tubes are less likely to develop the list of catheter-related complications noted above. In women, long-term urethral catheters are better tolerated, though the urethra may gradually become dilated and capacious, resulting in troublesome leakage around the tube.

**Urethral catheter placement techniques are well known. If a standard Foley catheter is needed but resistance is met during placement, it is important not to force the catheter into the urethra, which risks urethral mucosal perforation, creation of a false passage, and bleeding, which greatly complicates further catheterization attempts. This principle is relevant both to the trauma and nontrauma setting. A catheter balloon should not be inflated until urine return is ensured; if no urinary drainage occurs upon catheter insertion, aspiration of the catheter using...**
Once in place, a SP tube should generally be left indwelling for at least a week so that an established track forms between the skin and the bladder lumen. If prematurely removed, extravasation of urine into the retroperitoneal and perivesical space may occur, which can result in urine absorption, azotemia, or urosepsis. A long-term indwelling SP tube through an established track is usually easy to change by simple removal and replacement with the same caliber and type of tube. Occasionally the track may be oblique or tortuous and direct visualization with a flexible cystoscope by a urologist and placement of the new tube over a guidewire may be necessary. If a SP tube is inadvertently removed or displaced, the track may close within a matter of hours or certainly over the course of a day, even when the tube has been in place long term. It is important that tube replacement be accomplished promptly to avoid track closure and the need to re-establish access in a more invasive manner.

It is important to realize, as noted above, that nearly all indwelling urinary tract tubes that communicate with the external environment will result in bacteriuria, often within about 10 days of tube placement. In most cases this is a harmless process and does not result in clinical infection. If, however, urinary tract manipulation or an invasive urinary tract procedure is planned, instrumentation in the face of such bacteriuria may precipitate urosepsis, and the tissues are vulnerable to intravasation of bacteria when a chronic catheter has been present. It is beneficial to obtain urine culture data and institute therapy with culture-specific agents prior to significant instrumentation of the chronically catheterized urinary tract, to minimize the risk of iatrogenically induced clinical infection or urosepsis. The same principle applies when considering removal of an indwelling bladder tube, especially when there is the potential for the patient failing a voiding trial and developing urinary retention following catheter removal (as in BPH patients with episodic retention who may or may not pass a voiding trial). If a patient with catheter-related bacteriuria develops urinary retention upon catheter removal, the risk of clinical infection or urosepsis is significant. These patients as well should have coverage with culture-specific antibiotics whenever possible, or at least have the provision of empiric broad-spectrum urinary antibiotics (fluoroquinolone or extended-spectrum penicillin derivative) prior to a voiding trial. Such patients are likely to have resistant organisms, as they have often been in the hospital environment.

Nephrostomy tubes are placed directly through the renal parenchyma into the collecting system to provide proximal ipsilateral urinary tract drainage and diversion. They may be placed percutaneously under fluoroscopic, CT, or ultrasound guidance in an interventional radiology suite, or in the operating room as part of a urologic surgical procedure through radiologic, endoscopic, or open techniques. Several types of tube are available and critical care practitioners should know what type of tube they are dealing with. Most commonly used are the loop nephrostomy tubes, which have some type of retention system, usually consisting of a pull-string that is deployed upon tube placement to allow it to be retained effectively within the collecting system. Percutaneously placed tubes are usually in the range of 8 to 12 French in size and are attached to drainage bags with connector tubing. Tubes placed as part of percutaneous stone or other upper tract surgical procedures may be larger; often Foley catheters ranging from 16 to 24 French in size are often employed. In such cases the tube is usually sutured.
to the skin for retention, as inflating the balloon is problematic in the renal collecting system and may impair drainage or stress on the delicate collecting system wall. Critical care practitioners should be entirely clear as to what is expected with regard to such tubes under their care; a conversation with the urologist or whoever is responsible for the tube insertion and familiar with its specific purpose is desirable. Is it expected to drain continuously? What action should be taken if it fails to drain? How should bloody efflux be interpreted or acted upon? The purposes of these tubes may vary from providing a large-bore drain after a bloody percutaneous lithotripsy to a small tube placed only to drain urine for an obstructed ureter. It may be safe to irrigate nephrostomy tubes if they fail to drain, but again, this should be arranged by specific order, and assumptions regarding the purpose and management approach to such tubes introduce unnecessary risk. When irrigating a nephrostomy when it is determined that doing so is safe and appropriate, a small volume of saline (5 to 10 mL) should be utilized. If, in the postoperative urologic surgery setting, a nephrostomy tube begins to drain blood at an alarming rate, the best course of action may be to clamp the tube, address hemodynamics urgently, and urgently call the urologist for instructions. As for other tubes mentioned above, the collecting system will become colonized with bacteria after being indwelling for a week, and clamping trials, manipulation, or tube removal is best done following institution of culture-specific antibiotics.

Internal ureteral stents are commonly used in urology, often for the purpose of relieving ureteral obstruction, but also following urologic surgery or trauma to allow low-pressure drainage or provide urinary diversion while the trauma of surgery or local edema or inflammatory changes are allowed to resolve. The most common variety of stent is the double-J or pigtail stent. These stents have a loop in the bladder and a loop in the kidney. They are placed either retrograde via cystoscopy or antegrade during open or percutaneous surgery, over a guidewire. The proximal and distal coils form upon removal of the guidewire. Typical sizes in adults are 6 to 8 French caliber and 22 to 28 cm length, depending on the patient’s height and ureteral length and tortuosity. Some stents include a pull-string on the distal coil, which, at the urologist's discretion, may be either cut short or allowed to exit the external urethral meatus to aid in subsequent removal without requiring repeat cystoscopy. Patient care personnel should be instructed as to the presence of a pull-string and should be aware of the importance of not pulling on it or allowing the patient to do so. Stents are of great value in urologic surgery but they do have their pitfalls, mainly related to their small caliber and proneness to obstruction, the potential for them to migrate and become malpositioned, their tendency to cause unpleasant flank or bladder symptoms, and the risk that they may be forgotten and lost to follow-up. In the critical care setting, the major issues relate to obstruction, migration, or infection. Significant flank pain, chills or fever, or a change in stent position on serial abdominal radiographs should prompt urologic consultation to address these stent-related complications. As discussed in the Immediate Concerns section above, stent occlusion in the setting of obstruction is a surgical emergency that may result in septic picture and require immediate endoscopic stent replacement or urgent nephrostomy insertion. Stents are typically certified for a 3- to 6-month maximum indwelling time, after which they need to be changed to avoid calcification and obstruction. Some stents are specifically designed for long indwelling times (e.g., persistent obstructive states such as benign or malignant retroperitoneal fibrosis or postradiation strictures) of up to 12 months. There are stents that combine the function of an externalized nephrostomy and an internal stent; these are usually termed nephrostents or “universal stents.” They can be capped at the flank entry point and made to drain internally, or may be uncapped to drain as an externalized nephrostomy tube.

Nephrostomy change or removal and stent change or removal should only be performed by a urologist or interventional radiologist or upon his or her specific direction.

For a patient presenting with upper tract obstruction, the option often exists to observe, or provide relief with stent insertion or nephrostomy placement (21). The decision of how to manage such patients acutely depends on the ability to get the patient to either the cystoscopy suite or the IR suite more expediently, the expertise available, and the clinical picture. For patients seriously ill with an obstructed, infected upper tract, many urologists prefer to have IR place a nephrostomy tube percutaneously, control the infection, and then reserve any retrograde instrumentation for an elective setting. If the patient is coagulopathic or anticoagulated, a retrograde cystoscopic approach may be safer, as the radiologist will be quite reticent to enter the kidney percutaneously when the coagulation functions are abnormal for fear of creating a major hemorrhagic complication.

Closed suction drains or Penrose drains may be left in place following urologic surgery to allow external drainage of blood, urine, lymph, or infectious fluid. From the critical care viewpoint, the urologist should be asked specifically what should be expected regarding appropriate function of the drain and exactly what parameters should be a cause for concern. Is significant blood output expected? Is continuous drainage important? Under what circumstances should the surgeon be informed urgently? Urine leaks following certain types of urologic surgery, such as some partial nephrectomies for trauma, may be expected, and if adequately drained externally, seldom constitute an emergency. Elevated blood output may be an indication of internal bleeding and should prompt a call to the surgeon if there is any doubt as to whether the situation is acceptable.

As a general statement to the critical care team, urologic drainage tube have widely varying purposes and specifications and should be managed in concert with the surgeon who placed them or is responsible for them to avoid confusion and preventable complications. Any of these tubes may become malpositioned or occluded (often with blood clots or mucus from the bowel segment), requiring intervention.

**URINARY DIVERSION MANAGEMENT FROM THE CRITICAL CARE PERSPECTIVE**

Beyond the considerations regarding tube diversion or drainage, some patients under the critical care team’s care may have undergone, either acutely or remotely, a surgical urinary diversion procedure. The variety of such diversions is considerable, and the critical care team deserves a full explanation of the patient’s anatomy and how to deal with any problems that may arise. Problems include urinary outflow obstruction,
intra-abdominal urinary extravasation, infectious complications, and problems with the intestinal anastomosis.

One can divide urinary diversion procedures into conduits and reservoirs (and reservoirs into cutaneous and orthotopic). Conduits are simple surgical reconstructions that allow urine to exit to the outside and do not involve an internal urinary reservoir.

An ileal conduit is one of the most commonly encountered urinary diversions, often performed following cystectomy for lower urinary tract cancer, but also at times for neurogenic or inflammatory disease. In this procedure, a segment of distal ileum is isolated from the fecal stream, followed by a small bowel anastomosis to re-establish intestinal continuity. One end of the isolated segment is closed, and the other end is brought to the skin of the abdominal wall as a stoma. The ureters are sutured into the conduit intra-abdominally to route the urinary stream externally. Most ileal conduits seen acutely by the critical care team in the immediate postsurgical period have indwelling tube drainage present—often externalized segments that enter the stoma, travel up each ureter to allow the ureteroileal anastomosis to heal, and avoid obstruction or urinary extravasation in the early postoperative period. A second tube, often a simple straight catheter segment, may also be placed from outside the stoma to assist the conduit beneath the abdominal wall fascia to allow conduit drainage.

Other conduits employed in urologic surgery may utilize other bowel segments, including jejunum and descending or transverse colon, especially when there has been extensive inflammatory disease. In this procedure, a segment of distal ileum is isolated from the fecal stream, followed by a small bowel anastomosis to re-establish intestinal continuity. One end of the isolated segment is closed, and the other end is brought to the skin of the abdominal wall as a stoma. The ureters are sutured into the conduit intra-abdominally to route the urinary stream externally. Most ileal conduits seen acutely by the critical care team in the immediate postsurgical period have indwelling tube drainage present—often externalized segments that enter the stoma, travel up each ureter to allow the ureteroileal anastomosis to heal, and avoid obstruction or urinary extravasation in the early postoperative period. A second tube, often a simple straight catheter segment, may also be placed from outside the stoma to assist the conduit beneath the abdominal wall fascia to allow conduit drainage.

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Reservoirs (neobladders) involve the use of larger segments of intestine to fashion a neobladder internally, along with some form of urinary efflux mechanism, often designed to create a continence diversion that the patient can catheterize (and not wear a urinary collection appliance) or that is sutured to the native urethra (in the male or female) to allow restoration of voiding. These issues require specialty input and prompt urologic consultation. The issue of pouch rupture, however, deserves special attention. Gastric or ileal resection may cause vitamin B12 deficiency, which can lead to megaloblastic anemia and peripheral nerve dysfunction. B12 nutritional supplementation may be indicated.

Other complications include stomal complications, recurrent upper tract urinary infection and deteriorating renal function, and calculus formation in the upper tract or the diversion conduit or reservoir. Stomal stenosis may cause obstructive uropathy requiring catheterization and stomal revision. Catheter insertion into a conduit or reservoir construct may be challenging; if difficulty is encountered, a small-bore coude catheter may be useful, as may use of fluoroscopy to guide catheter positioning. Stomal bleeding is usually superficial and manageable with local compression or minimal cautery when necessary. Parastomal hernias may occasionally become incarcerated requiring urgent surgical intervention. Anemia and upper tract dilation may be problematic, especially when more than 10 years have elapsed since the diversion. Upper tract deterioration is seen in at least 50% of patients who have undergone urinary diversion during childhood or young adult years, and the risk of developing chronic renal insufficiency is increased in such patients. Calculi occur in roughly 8% to 10% of urinary diversion or bladder substitution patients, where urease-producing organisms (Proteus, Pseudomonas, Klebsiella, etc.) are common affecting organisms.

**UROSEPSIS AND COMPLEX UROGENITAL INFECTION IN THE CRITICAL CARE SETTING**

Urosepsis has been addressed in several sections within this chapter, related to immediate concerns, urologic tubes and drains, and below in renal failure management. It is also addressed elsewhere in this text with regard to general management principles for sepsis and septic shock (2,25,26). In...
addition, there are several specific urologic infectious disease phenomena that warrant specific mention.

**Specific Infectious Processes of the Upper and Lower Urinary Tract**

The combination of obstruction and infection of the upper and lower urinary tract requires urgent drainage, antibiotic therapy, and supportive care. Initial empiric antibiotic therapy for presumed urosepsis must address the likely offending organisms and must consider the “worst-case scenario” from the bacteriologic standpoint. While awaiting culture data, Gram stain findings can also be very helpful in selecting initial therapy. Broad-spectrum antibiotics that cover aerobic Gram-negative rods and the typical Gram-positive cocci that appear as uropathogens are critical. If the patient has been recently instrumented, has been recently hospitalized, or has other risk factors for having sepsis due to atypical or resistant pathogens, coverage should be expanded accordingly. The newer-generation cephalosporins, imipenem and related drugs, aminoglycosides, and vancomycin are commonly used in such circumstances. It may be necessary in certain situations to consider the presence of anaerobic infections of the genitourinary system. Septic following transrectal prostate biopsy procedures (typically ultrasound guided and office based) may introduce the risk of anaerobic infection. We are aware of mortality cases where a patient presented with urosepsis and retroperitoneal cellulitis following a needle biopsy of the prostate, in which anaerobic coverage was not provided and ultimately death followed. Anaerobic infections of the urinary system have also occurred, particularly in the elderly. It may be necessary in certain situations to consider the presence of anaerobic infections of the genitourinary system do also occur, particularly in the elderly or immunocompromised population, or in patients who have intravascular manipulation, which may result in the entry of skin flora into the urinary system (percutaneous lithotripsy, suprapubic cystostomy tube presence). When a Gram-positive coccus is noted on stained urine or infectious fluid, vancomycin is an appropriate empiric choice for sepsis of urinary tract origin, as both appropriate empiric choice for sepsis of urinary tract origin, is noted on stained urine or infectious fluid, vancomycin is an appropriate empiric choice for sepsis of urinary tract origin, and anaerobic coverage was not provided and ultimately death followed. Anaerobic infections of the urinary system do also occur, particularly in the elderly or immunocompromised population, or in patients who have intravascular manipulation, which may result in the entry of skin flora into the urinary system (percutaneous lithotripsy, suprapubic cystostomy tube presence). 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a septic picture may resolve with antibiotic treatment alone. Large parenchymal abscesses or perinephric collections usually require drainage, which in most cases can be appropriately attempted by CT- or ultrasound-guided percutaneous drainage. When multiloculated or when inadequately drained by the percutaneous route, an open surgical drainage procedure may be necessary.

Acute prostatitis may be categorized by etiology (bacterial, abacterial) or clinical course and manifestations (acute, chronic) (33,34). Acute bacterial prostatitis can present with a septic picture. Common symptoms include dysuria, frequency, urgency, chills and fever, elevated white blood count on CBC, and infected urine. Some urologists believe that urethral catheterization and instrumentation should be avoided in such patients due to concern of worsening sepsis. If the patient is emptying adequately, antibiotic administration is usually adequate without catheter drainage. If the patient is in acute urinary retention, bladder drainage is needed; one can proceed either with a gentle attempt at Foley catheter passage per urethra or with percutaneous suprapubic cystostomy placement. Our view is that urethral catheterization is usually preferable and is less invasive. For patients presenting with acute prostatitis or other complex lower tract infection who do not respond appropriately to antibiotic therapy, or for those with suspicious findings on a digital rectal examination (DRE), prostatic abscess should be suspected. The findings of concern on DRE would include unusual tenderness and/or an area of fluctuance on prostatic palpation. One should avoid an aggressive prostate exam on such patients, and it is generally ill-advised to put significant digital pressure on the tender, acutely infected prostate to obtain a sample of prostatic secretion as is often done in the chronic prostatitis patient. Acute prostatitis patients usually have infected urine and culture information from prostatic secretions is usually not necessary. Transrectal ultrasound or CT scanning of the pelvis will usually confirm the presence of a prostatic abscess when present, and can also guide therapy by revealing whether the abscess cavity may be best drained through a transurethral, transperineal, or transrectal route. We usually prefer the transurethral approach if the cavity is abutting the prostatic urethral lumen. A transperineal drainage procedure can be performed under ultrasound guidance if the abscess is deep and a transurethral approach is deemed too risky. Unless the abscess has already started to drain spontaneously into the rectal lumen, we do not favor this approach to prostatic abscess drainage.

Acute infectious conditions involving the genitalia and perineum are important both with regard to the challenges sometimes faced in differential diagnosis (e.g., epididymitis vs. torsion, trauma, or incarcerated hernia) and systemic management as in some conditions (e.g., Fournier gangrene). Acute epididymitis or epididymo-orchitis may be due to standard enteric bacteria (more common in patients over age 35 and those with obstructive urethral or prostatic disease) or to venereal transmission of chlamydia or gonococcal infection. Mild epididymitis can be treated on an ambulatory basis with antibiotics (often fluoroquinolone if enteric infection is suspected, tetracycline derivative if venereal transmission is more likely, or a combination of two drugs if coverage for both entities is desired while awaiting culture data). Severe epididymo-orchitis is manifested by global enlargement of the hemiscrotal contents and loss of palpable anatomic landmarks, often with skin fixation and marked redness and tenderness. Such patients find it very painful to walk or stand, and may be best managed by hospitalization, bedrest, scrotal elevation, anti-inflammatory drugs, and broad-spectrum antibiotics until improvement is observed. Scrotal ultrasound examination may be useful for clarifying the diagnosis and excluding the presence of abscess formation, which may require surgical drainage and sometimes orchectomy.

Urologic Involvement in Complex Soft Tissue Infectious Processes

Urologic involvement with such entities as perirectal abscess or Fournier gangrene is common. Fournier gangrene may be idiopathic with no identifiable point of origin, or may be due to extension from primary rectal, urinary, intra-abdominal, or retroperitoneal processes. Diabetics are at increased risk for this disease. When there is genital, perineal, or groin involvement in such processes, several applicable management principles may be of value to the critical care provider or acute care surgeon. Such patients should be treated with broad-spectrum (“triple antibiotic”) regimens that cover aerobes, anerobes, and Gram-positive and -negative organisms, as polymicrobial infection is the norm. These patients require a combination of aggressive antibiotic therapy, metabolic and fluid resuscitation, and prompt and aggressive surgical debridement and drainage. These infectious processes can progress very rapidly, and delays in bringing the patient to surgery may result in loss of otherwise salvageable tissues and increased mortality. The surgical approach for this entity in our institution is based on the areas of involvement and typically includes the urology and general surgery teams in a close collaboration to address our areas of anatomic specialty expertise (surgery performing proctoscopy and addressing debridement of involved abdominal wall, rectal, ischiorectal fossa, thigh, or buttock tissues; urology performing cystoscopy as indicated and addressing genitai and perineal debridement). We believe the advantages of this specialty focus assists in functional and organ preservation, and subsequent reconstructive efforts. When an abscess or necrotizing process extends into the region of the perineum or genital soft tissues, incision or debridement of scrotal or penile skin and underlying dartos may be necessary. In the scrotum, we try to establish a dissection plan just superficial to the parietal tunica vaginalis and keep this membrane, which surrounds the testes, intact. The testes are rarely involved in these soft tissue infections, and not directly exposing the testes to the wound will aid in subsequent wound management and avoid the pain and desiccation that occurs when the tests is exposed externally. On the penis, necrotic skin and darts may be debrided up to the corona sulcus when necessary, taking care to stay superficial to the Buck fascia (deep fascial layer) of the penis, to avoid injury to the corpora and the dorsal neurovascular bundle, which lies in a wide band across the center on the top of the penis. Fournier gangrene may occasionally arise from a urethral source (such as a perirethral abscess or perforated stricture or diverticulum). Debridement of urethral tissue should be avoided unless it is grossly necrotic, as a superficial excudate may create the appearance of marginally perfused tissue; such changes can be reassessed on take-back to the operating room and allowed to declare themselves further into the course of the disease. If the surgeon must enter the scrotal wall for drainage of a local...
abscess, it is best to avoid deep incision into the tunica vagi-
nalis compartment to avoid preventable injury to the scrotal contents.

As general considerations for the patient with urosepsis, there is the potential that the patient's hemodynamics and de-
gree of severity of sepsis may transiently worsen following needed urinary tract drainage or manipulation. A low thresh-
old to have such patients in an ICU setting is appropriate even if they are not so critically ill that they initially clearly need ICU management. For example, if we perform percuta-
neous nephrostomy insertion or ureteral stent placement in a patient with infection, an obstructing stone, tachycardia, and fever, especially when addressed “after hours,” we will arrange ICU observation overnight to ensure that any deterioration is promptly recognized and managed. When culture data become available, broad-spectrum empiric antibiotic regimens should be simplified based on bacteriologic identification and sensi-
tivities. Tubes that are placed into the urinary tract to drain infected spaces must be appropriately secured to the patient to avoid inadvertent malposition or removal and observed to avoid kinking or occlusion of outflow systems, which may pre-
vent low-pressure drainage and exacerbate sepsis.

UROLOGIC CAUSE OF RENAL FAILURE

The urologist’s view of renal failure is usually focused on “postrenal” factors, as this is the setting in which we are typi-
cally consulted. At times, however, it is unclear whether a pa-
tient with acute renal failure is suffering from an obstructive process, whether the process is remediable, and how best to approach therapy.

Assessment and management of acute renal failure are cov-
ered in detail elsewhere in this text. The urologist is typically consulted when there is suspicion or evidence that the state of renal failure is due to a mechanical or vascular etiology usually manifested by significant oliguria and distention of some level of the urinary tract.

If a Foley catheter is in place in a patient with impaired urine output, palpation of the lower abdomen to detect bladder dis-
tention, ultrasound assessment of bladder volume, and/or irri-
tation of the catheter to ensure patency are appropriate initial steps. Management of catheter-related dysfunction is discussed in detail above. If uncertainty remains as to the appropriate positioning or function of an indwelling catheter, urologic con-
sultation should be obtained.

If lower tract or bladder catheter malfunction has been excluded, one must exclude upper urinary tract obstruction. Renal ultrasound or noncontrast CT scanning is commonly employed for this purpose. The findings of hydronephrosis or ureteral dilatation raise concerns about the possibility of postrenal failure. It is important to appreciate that ureteral obstruction can exist without significant collecting system di-
latation in some cases, particularly if the obstructive process is of very recent onset. Patients with two normally functioning kidneys should not develop renal failure in the face of unilat-
eral upper tract obstruction; in fact, complete obstruction of one ureter often causes little or no change in serum creatinine if the contralateral kidney is functionally normal. Unilateral upper tract obstruction involving a solitary kidney (or marked hypofunction of the contralateral kidney) may result in anuria and renal failure. In most such cases, radiographic evidence of underlying inadequacy of the contralateral kidney (atrophy, long-standing obstruction with hydronephrosis and marked parenchymal thinning). In entities that can cause asym-
metric and asynchronous development of obstructive uropathy (advancing prostate cancer with trigonal invasion, progressive pelvic lymphadenopathy, asymmetric retroperitoneal fibrosis with extrinsic ureteral compression), unrecognized loss of func-
tion of one kidney may result from obstruction without symp-
toms or much change in serum creatinine. Only when the re-
mainin kidney becomes obstructed and renal failure ensues is the entire process recognized.

When evidence of upper tract obstruction is noted, one must expeditiously implement a strategy to determine definitively if postrenal obstruction is present, and choose the least morbid means of relieving it. The gold standard for such determination is to perform cystoscopy and retrograde pyelography. This pro-
cedure can be performed in the operating room setting using static or fluoroscopic imaging capability, or at the bedside in the ICU. We have successfully performed flexible cystoscopy, retrograde pyelography, guidewire insertion and manipulation past a point of obstruction, and internal or externalized stent placement in the ICU. This approach is especially applicable in the hemodynamically unstable patient for whom movement to the operating room may be hazardous. The newer digital X-ray units are ideally suited for such procedures, as the digi-
tal plate is placed beneath the patient once, allowing multiple images to be obtained and viewed on the monitor almost im-
mediately. If an obstructed or tortuous ureter is encountered, the area of difficulty may be navigated using a 5 French open-ended catheter through which an angle-tipped guidewire is advanced. Rotating the guidewire may allow passage across an area of ureter that is not possible using straight wires or catheters. Once a guidewire has been advanced past the com-
p lex ureter into the kidney, either an open-ended catheter or a double-J type internal stent may be inserted over the wire. Open-ended catheters may be tied to a Foley catheter for sta-
bility and attached to an external drainage appliance.

An alternative to achieving upper tract drainage cystoscop-
ically is to have a percutaneous nephrostomy tube placed through interventional radiology techniques. It is important that the patient's coagulation functions be normal when pur-
suing such an approach, and it is also important to verify that there is, in fact, upper tract obstruction present, before introducing the risk of a percutaneous puncture. In the ap-
propriate clinical setting, where there is certainty that up-
per tract drainage is needed, PCNL is an important option, and may be preferable to achieving drainage through lower tract instrumentation when dealing with urosepsis or challeng-
ing lower tract anatomy where manipulation may be difficult (gross hematuria, some cases of prior lower tract surgery, per-
mament urinary diversion states). It is usually necessary for the patient to be prone on the radiology table to accomplish PCNL placement, and one must determine if such a position is safe or advisable. Respiratory compromise, recent abdominal surgery, or body habitus may create major challenges in placing the patient prone for such a procedure.

When lower or upper tract drainage is achieved in the set-
ting of postrenal failure, one must observe the patient closely for transient worsening of urosepsis and for the possibility of pathologic postobstructive diuresis. Worsening of sepsis can
result from instrumenting the infected urinary tract, and sup-
portive measures may be necessary, including the institution of pressure support. Adequate hydration prior to urinary tract ma-
nipulation and provision of prophylactic antibiotics will mini-
mize the risk of worsening sepsis with instrumentation. Patho-
logic postobstructive diuresis may occur when there is a major solute load and severe obligatory water loss occurs following relief of obstruction. This can be seen with lower tract or bilateral upper tract obstruction. Fluid and electrolyte monitoring and judicious fluid replacement may be necessary during the diuresis period.

Acute papillary necrosis may result in acute renal failure. Papillary necrosis may develop as a gradually progressive, in-
dolent process, recognized by the classic cavitary appearance of the renal calyces on contrast studies, or may present as a ful-
mintant, infectious course with urosepsis and obstruction from sloughed papillae. Relief of obstruction, treatment of infection, and supportive care are indicated.

Other entities for which urologic input may be valuable when acute renal failure occurs include vasculogenic renal fail-
ure (due to renal artery or renal vein thrombosis) and ab-
dominal compartment syndrome-related renal failure. Both are covered elsewhere in this text. An important pitfall in diagno-
sis occurs when a patient presents with abrupt onset of flank pain, nonfunction of the ipsilateral kidney is noted in intra-
venous pyelography, and the presumptive diagnosis of renal colic from stone is declared. In fact, complete nonfunction is as uncommon as an IVP finding from ureteral obstruction; more commonly, a persistent nephrogram with delayed excretion is observed. Complete nonfunction may be due to vascular com-
mpromise whenever acute onset of flank pain occurs. Contrast-enhanced CT scanning is diagnostic, as the affected kidney will fail to opacify. When vascular compromise of the kidney occurs, urgent vascular surgical and interventional ra-
cadiologic consultation should be obtained to determine if imme-
diate revascularization is feasible and warranted.

SUMMARY

Critical care issues in urology are many and varied. The critical care provider must be familiar with the anatomic and physi-
ologic factors that are relevant to urologic disease, and must have a low threshold to request urologic consultation when specialty expertise may be of value to the patient. Recognition of obstructive, infectious, and ischemic entities for which timely intervention is important is most essential for the crit-
ical care provider. In the postoperative setting, issues common to other surgical specialties are relevant to urology patients, and various specialty-specific problems may also arise, often related to renal dysfunction, the complexities of endoscopic and reconstructive surgery, and perioperative infection. Uro-
logic residency training in the United States provides a strong background in critical care knowledge and skills, as all urol-
ogy residents spend 1 to 2 years in general surgery and related specialties, including exposure to surgical intensive care expe-
rience. The field of critical care requires an enormous breadth of knowledge and capability, however, and the practicing urol-
ogist and his or her patients may benefit greatly from the input and expertise of those specializing in the care of critical care patients. A close collaboration between these specialties greatly enhances the quality of urologic patient care.

References

7. Cohen M, Gozariu WL. Complications in gastrointestinal trauma. In: Mat-
28. Watson RA, Esposito M, Richter F, et al. Percutaneous nephrostomy as ad-
33. Ludwig M. Diagnosis and therapy of acute prostatitis, epididymitis and or-