Review

The Diagnosis and Management of Life-threatening Urologic Infections

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Genitourinary infections are commonly encountered and managed in inpatient, outpatient, and emergency settings. Fournier's gangrene, emphysematous pyelonephritis, and obstructive pyelonephritis represent the most serious urologic infections and have a high risk of mortality if not managed promptly. Due to the rarity of these infections, the evidence for specific treatment strategies is scattered. This review aims to provide comprehensive, evidence-based recommendations for the diagnosis and management of these life-threatening urologic infections. UROLOGY 156: 6–15, 2021.

Genitourinary infections are commonly managed in inpatient, outpatient, and emergency settings by a range of providers including primary care and emergency physicians, internists, urologists, and intensivists. Fournier's gangrene (FG), emphysematous pyelonephritis (EPN), and obstructive pyelonephritis (OPN) represent the deadliest of urologic infections and are distinct from other causes of sepsis from a urinary source in that they require prompt surgical source control.[1–3] Urologists, general surgeons, and interventional radiologists are all called to intervene on these patients, but given the rarity of these infections, treatment standards vary widely. Furthermore, due to a lack of access to emergency urologic care, patients are often transferred to tertiary and quaternary medical centers, centralizing familiarity with these conditions to a smaller number of providers.[4] In this review, we provide comprehensive, evidence-based recommendations for the diagnosis and treatment of these conditions to serve as a central, accessible resource to standardize their care.

SEPSIS

Patients presenting with FG, EPN, and OPN are at high risk for developing sepsis, a "life-threatening organ dysfunction caused by a dysregulated host response to infection."[5] The urologists' primary role is source control. However, a complete understanding of these infections cannot be over-valued as decisions about medical management will influence both initial surgical planning as well as subsequent management and follow-up.

The diagnosis of sepsis is defined as a Sequential Organ Failure Assessment score of 2 or more and imparts a 10% mortality for all comers.[5] Septic shock is defined as sepsis associated with circulatory collapse and profound metabolic abnormalities and carries a >20% mortality.[6] At the time of urologic consultation, patients should have been initiated on goal-directed sepsis pathways. The most basic elements of these care pathways include obtaining serum lactate and blood cultures, the initiation of broad-spectrum antibiotics, and appropriate fluid resuscitation[1] for hypotension or lactate ≥4 mmol/L.[7] Regardless of the source of infection, urologists should confirm that these steps have been taken at the time of their assessment and enact them if not. Further management should be performed in concert with critical care and infectious disease specialists.[5,7]

FOURNIER'S GANGRENE

Presentation and Diagnosis

FG is a necrotizing soft tissue infection (NSTI) of the perineum and genitals along fascial planes. Patient presentations vary widely. Delays in presentation may lead to fever and hemodynamically instability, but earlier subacute presentations are common, requiring a high index of suspicion as these patients will become septic if not treated aggressively.[8] Physical exam is paramount for diagnosis of FG. While early manifestations of the disease include pain out-of-proportion to exam, advanced presentations are characterized by paresthesias as the neurovascular supply to the superficial soft tissue becomes compromised.[3] Exams are often notable for foul odor, erythema, and induration of affected skin, and sometimes frank necrosis and skin sloughing (Fig. 1A).[9] Due to the suprafascial infectious spread of FG, visual inspection often underestimates the affected tissue, and palpation for crepitus gives a better indication of the extent of the infection.[3] Gently probing visible wounds often leads to easy tissue dissection beyond what outwardly appears involved.[9]

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[1] *30 mL/kg of crystalloid solution.*

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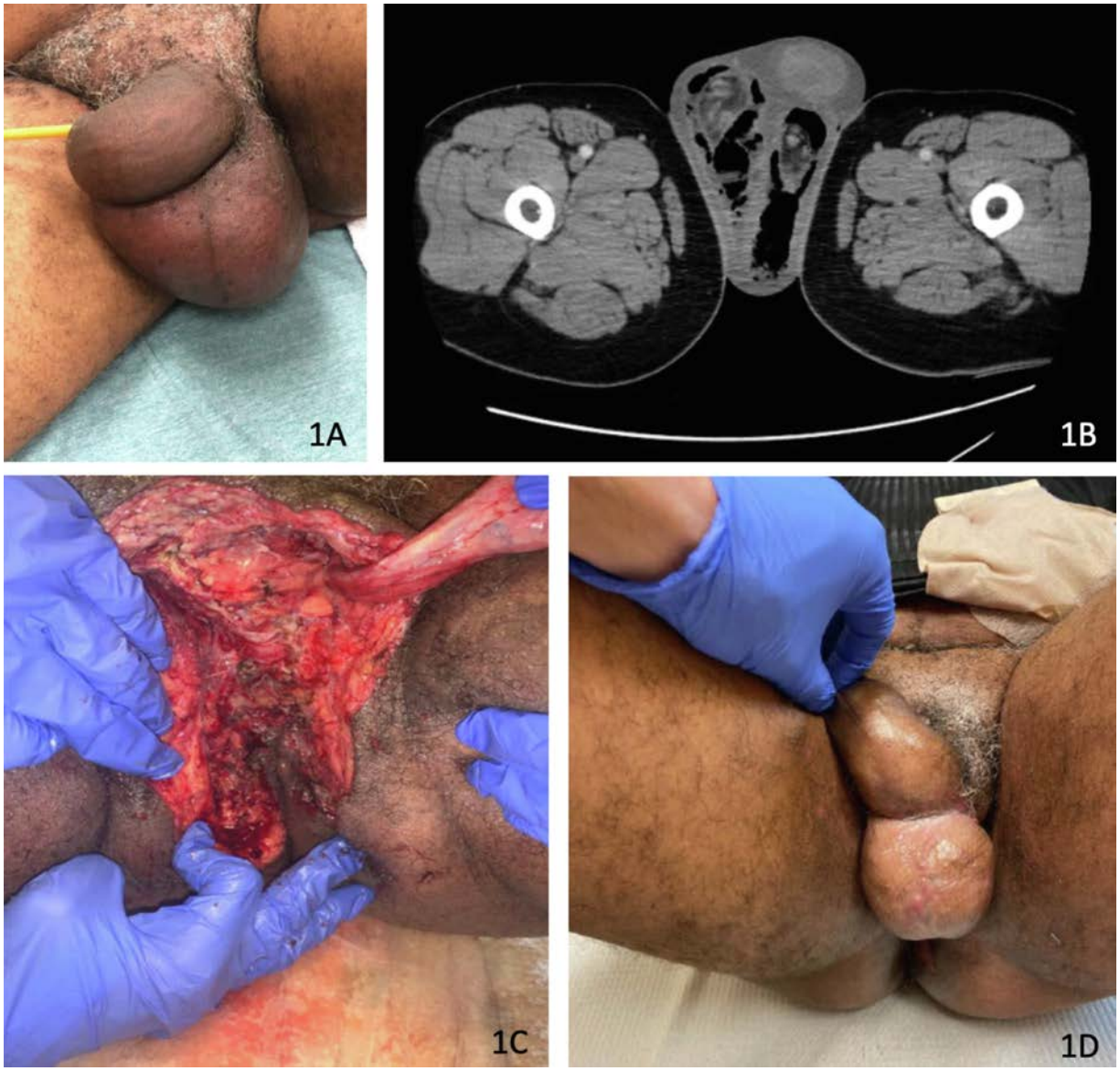

Figure 1. Fournier's gangrene. (**A**) Physical exam showing swelling, edema, and erythema. (**B**) Soft-tissue gas in the scrotum on CT. (**C**) Healthy wound bed following debridement. (**D**) Healed scrotal skin graft. (Color version available online.)

The diagnosis of FG is a clinical one and a lack of imaging should not delay surgical debridement. However, computed tomography (CT) is 100% sensitive and 98% specific for NSTIs with a 100% negative predictive value and can elucidate the extent of disease and equivocate borderline cases.[10] Positive imaging with CT will show gas in the soft tissues of the scrotum and perineum (Fig. 1B).

The Laboratory Risk Indicator for Necrotizing Fasciitis (LRINEC, Supplementary Table 1) has been proposed to aid in the diagnosis of NSTIs, and the Fournier's Gangrene Severity Index (FGSI, Supplementary Table 2) assists in prognostication.[11,12] Patients with an LRINEC score greater than 6 are at high risk of having an NSTI. While its original description by Wong et al. reported 90% sensitivity and 95% specificity, subsequent studies have demonstrated a more modest sensitivity of 60% and specificity approaching 80%.[11,13] While it is often discussed in FG literature, the LRINEC score is rarely essential to the decision to intervene in contemporary practice.[13] The FGSI described by Laor et al. uses both clinical findings and lab values to predict survival. Scores of less than 9 portend a 78% likelihood of survival while scores greater than 9 predict a 75% likelihood of death. These cutoffs have been validated in multiple series.[12,14] Biomarkers like C-reactive protein (CRP), procalcitonin (PCT), white blood cell (WBC) count, and platelet count are often included in various NSTI and FG scoring systems, but they should not be used to drive clinical decisions in isolation.[15,16]

A population-based study of FG by Sorensen and Krieger from 2016 reported an incidence rate of 1.6 cases per 100,000 males, annually.[17] Average patient age was 50-60 years, while race and ethnicity varied geographically.[18,19] Fournier's is less frequently reported in women, but there is believed to be a 4:1 male predominance.[19,20] Major risk-

factors include diabetes (37%-71%), obesity (11%-40%), tobacco use (22%-71%), heart disease (38%), and hypertension (38%).[17,19,20] Classically the mortality has been as high as 40%-50%, but contemporary series describe a 5%-20% risk of mortality.[14,17]

Pathophysiology

As much as 79%-90% of FG cases are attributed to local skin trauma, such as minor abrasions, injection sites for intravenous drug use, insect bites and pimples, or recent surgical incisions.[9,19,21] The remaining 10%-20% are thought to arise from similar mechanisms but are unidentifiable given massive tissue destruction at diagnosis. These wounds seed the tissue with bacteria, which propagate rapidly in the setting of a weakened immune response due to microvascular disease from diabetes, cardiovascular comorbidities, and tobacco use. FG differs from cellulitis in that it tracks along all tissues deep to the skin and superficial to underlying muscles.[9] Its rapid spread along this high volume of tissue leads to systemic toxicity. The pathognomonic spread of NSTIs causes thrombosis and destruction of perforating vessels to the superficial soft tissue, meaning that the infection and resultant debridements undermine the normal-appearing surrounding tissue.[3] The majority of infections are polymicrobial (54%-86%), and the most commonly isolated microorganisms are *Escherichia coli*, *Streptococcus*, *Clostridium*, *Bacteroides*, *Enterobacter*, *Staphylococcus*, *Enterococcus*, *Candida*, *Prevotella*, and *Pseudomonas*.[18–20]

Management

The paradigm of treatment of FG is early antibiosis and surgical debridement of all involved soft tissue (Fig. 2).[9] Initial antibiotic choices should cover the broadest possible range of gram-positive and gram-negative organisms, given the synergistic polymicrobial nature of most NSTIs. The Infectious Disease Society of America (IDSA) recommends empiric coverage with vancomycin or linezolid for gram-positive coverage and either piperacillin-tazobactam, a carbapenem or a combination of ceftriaxone and metronidazole for gram-negative and anaerobic coverage.[9] IDSA guidelines also recommend a protein synthesis inhibitor such as clindamycin to combat bacterial toxin-mediated tissue destruction for the first 48 hours.

Early debridement is essential due to the rapid progression of NSTIs as well as the unsalvageable nature of involved superficial tissue once its vascular supply has been compromised.[3,9] As soon as the patient is safe for anesthesia during the initial resuscitation, they should be taken to the OR. Delays in debridement lead to further tissue loss and a higher risk for circulatory collapse, despite broad antibiotic coverage. Involved tissue is identified during debridement by its characteristic brown, stringy appearance.[9] Necrotic tissue easily yields to blunt dissection, and this should guide the surgical team as they define the margins of the debridement.[9] Tissue should be sharply cut away until healthy, bleeding edges are encountered (Fig. 1C). When dissection includes the abdominal wall or anorectal region, general surgery should be consulted. As the lower extremities are encountered, orthopedic surgery should be consulted. Bowel and urinary diversions to avoid wound contamination are controversial and are reserved for particularly difficult to manage wounds.[22] Tissue cultures should be obtained during debridement to guide subsequent antibiotic therapy.[9] Debridement rarely involves the deeper penile structures or the testicles and spermatic cords as they lie in a separate fascial compartment with a distinct neurovascular supply. At the conclusion of the initial debridement, the wound bed should be packed with wet-to-dry dressings with saline. If the tunica vaginalis has been resected, the testicles may be wrapped in non-adherent gauze before including them in these dressings. Negative-pressure dressings are rarely feasible due to difficulties maintaining a seal, but are appropriate when possible.

After the initial debridement, patients should be further resuscitated before a second debridement within 24-72 hours, and then daily until all nonviable tissue is removed.[9] Antibiotics should continue but can be narrowed based on tissue cultures and clinical response. After complete debridement of all involved tissues, antibiotics should be continued until patients show clinical signs of improvement. This includes a down-trending leukocytosis and remaining afebrile, after which antibiotics may be stopped.[9] Biomarkers such as CRP and PCT can be used as adjuncts when determining if patients are appropriate for antibiotic de-escalation.[16] Friederichs et al[15] found that in a cohort of 38 patients treated for NSTI, a PCT ratio of >1.14 from postoperative day 1 to 2 was 83.3% sensitive and 71.4% specific for delineating adequate surgical debridement. At our institution, down-trending WBC count and CRP are included in the algorithm for determining antibiotic duration, but it is important to stress that individual biomarkers should not drive treatment decisions independent of clinical status. Antibiotic decisions in cases of bacteremia or osteomyelitis should include infectious disease consultation and will likely require an extended duration.

Soft tissue defects following debridement can be large and should be managed with a combination of delayed-primary closure, skin grafting, and healing by secondary intention. A study of 168 patients by Lauerman et al[23] found that 39.9% could be completely closed primarily with another 30.4% undergoing partial closure. Factors associated with complete primary closure were male gender, lower Sequential Organ Failure Assessment score (1.7 vs 3.0), wounds confined to the perineum, and fewer debridements (2.4 vs 2.8). Time-to-closure was not reported. Split-thickness skin grafting has become more commonly utilized in this setting for wounds that cannot be closed primarily. Alwaal et al[24] published a report of 54 patients who underwent genitourinary skin grafting, 10 (18.5%) of which had originally presented with FG. Wound complications in the FG group were observed in only 10% of these patients at 2 years. The technique described by Alwaal involves using local tissue flaps for as

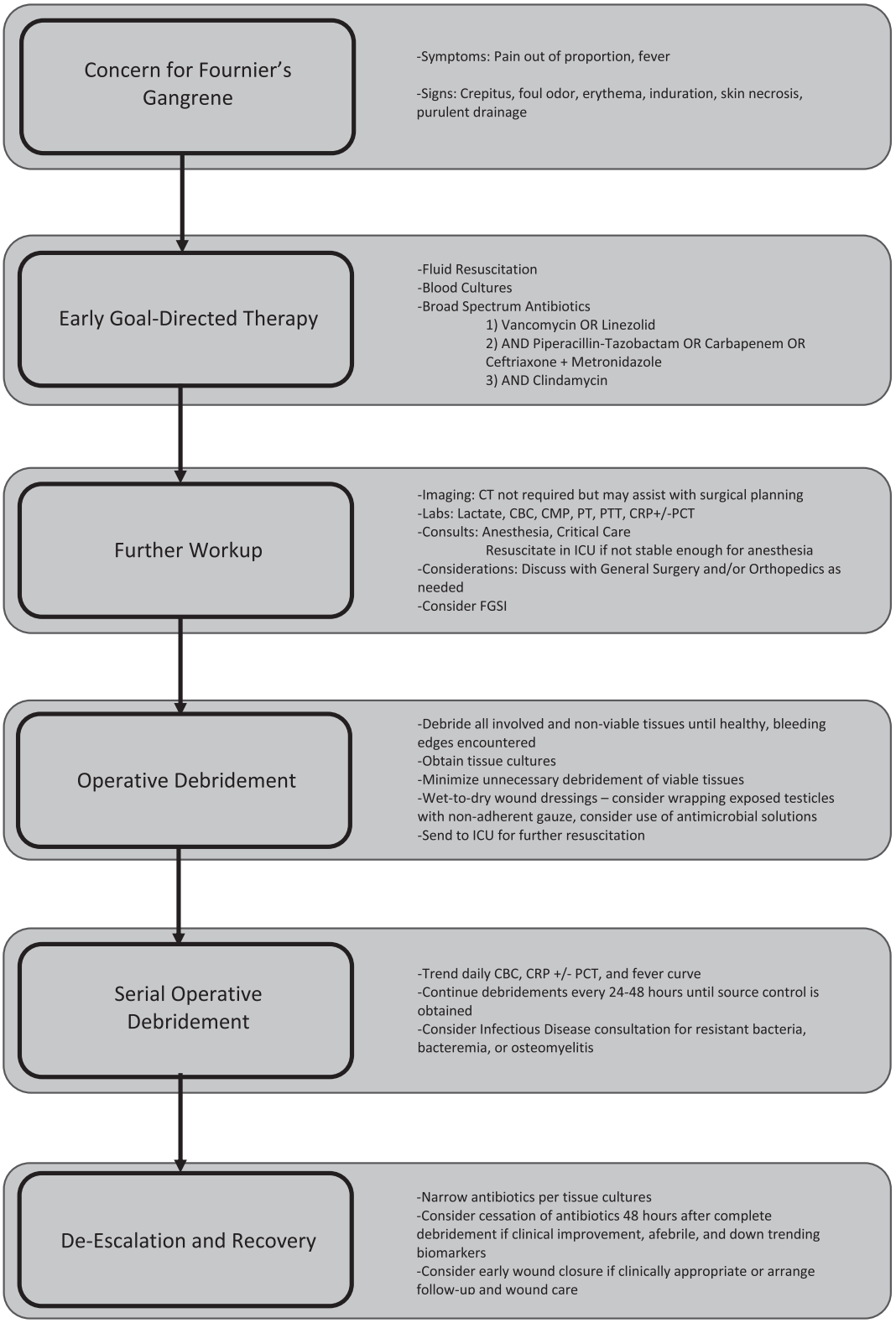

Figure 2. Fournier's gangrene care pathway.

much coverage as possible, followed by a 0.015-inch thickness graft from a thigh donor site for both the penis and scrotum. For grafts designed to recreate the scrotum, the testicles should be sutured together to avoid the development of a bifid scrotal sac (Fig. 1D). Previously, testicles were often implanted into subcutaneous thigh pouches when defects were large, either pending scrotal reconstruction or in lieu of it for comorbid or uninterested patients. While thigh pouch implantation is easily accomplished by most urologists without reconstructive training, and thus employable even in rural areas without access to plastic surgery assistance, it often offers poor cosmetic results and

issues with testicular pain, temperature regulation, and impaired function. Given these concerns, thigh pouches have generally fallen out of favor, although they continue to have a role in select patients.[25]

For the penis, nonmeshed grafts are preferred due to improved skin stretch and cosmesis.[24] However, if extensive tissue coverage is required, grafts can be meshed to minimize the morbidity from larger or multiple graft harvests. Overall, there are various schools of thought regarding graft preparation, and each surgeon should rely on their own experience to optimize outcomes.

EMPHYSEMATOUS PYELONEPHRITIS

Presentation and Diagnosis

EPN is a necrotizing, gas-forming infection of the renal parenchyma and perirenal tissue. Patient presentation is nonspecific with the most common symptoms being fever, flank pain, and nausea. Patients may describe a recent history of renal colic or hematuria, as ureteral obstruction due to nephrolithiasis or malignancy is common.[26,27] Physical exam is not sensitive for EPN, as the retroperitoneal location of the kidneys makes palpation for crepitus difficult, although palpable soft tissue gas is reported in 12% of patients.[28] Urinalysis reveals pyuria in most cases, and patients frequently have elevated creatinine levels.[26,29] Thrombocytopenia, acute kidney injury, and altered mental status have all been cited as poor prognostic indicators.[26,27]

Gas in the parenchyma distinguishes EPN from *emphysematous pyelitis*, a gas-forming infection in the collecting system only, and *pyelonephritis*, a non-gas-forming infection of the renal parenchyma.[30] CT imaging is key to this differentiation with a sensitivity of 100% compared to ultrasonography (69%) and plain film radiography (65%).[1] While emphysematous pyelitis was once thought to be a variant of EPN, it is now recognized as a radiographic phenomenon sometimes associated with upper tract urinary tract infections (UTI). The clinical distinction between these entities is important for both prognostication and treatment. Whereas EPN historically carried a mortality risk of 21% and requires immediate procedural intervention, emphysematous pyelitis is successfully treated with antibiotics alone and carries a similar prognosis to pyelonephritis.[1] Before this difference was understood, Huang and Tseng[26] devised a classification for EPN based on CT findings consisting of 5 classes of increasing severity (1: Emphysematous pyelitis, 2: EPN with parenchymal gas, 3A: EPN with perirenal gas, 3B: EPN with pararenal gas, and 4: bilateral EPN). Recent studies have questioned the utility of this system given the benign course of emphysematous pyelitis and the lack of data demonstrating different outcomes for each grade.[26,31] Given this paucity of evidence, it is our practice to treat emphysematous pyelitis as a complicated UTI, and EPN as a single entity regardless of CT classification (Supplementary Figure 1). Similar to emphysematous cystitis, a relatively benign complicated UTI presenting as a gas-forming infection of the bladder wall, emphysematous pyelitis may also require short-term foley catheter drainage to help clear infected urine from the urinary tract.[32]

EPN is more common in women with a 4:1 predominance, and older patients with an average age of 57.[33] The most common risk factor for EPN is diabetes (75%-96%) with an average hemoglobin A1C of 9.2.[1,33] Obstructive uropathy (29%-49%) and hypertension (39%) are also common in this population.[1,33] While only 5.9% of patients with EPN have had urologic procedures within the previous year, 29.4% have been hospitalized and prescribed antibiotics within a year.[33] Pontin and Barnes[34] described a study of 52 patients with EPN in which all 6 nondiabetic patients were found to be immunocompromised from various conditions including alcohol abuse, HIV, and tuberculosis.

Pathophysiology

Facultative anaerobes, which are common uropathogens, are typical for EPN with *E. coli* most frequently isolated (49%-67%), followed by *Klebsiella* (20%-24%), *Proteus* (5%-18%), *Enterococcus* (14%), and *Pseudomonas* (5%). Unlike FG, polymicrobial infections are only found in 4%-24% of patients.[1,33,35] Given that diabetes is almost universal in EPN, high tissue glucose levels and poor tissue oxygenation due to microvascular disease are thought to be key to facultative anaerobic propagation and disease progression.[1] Likely due to the vascular nature of the kidney, up to 54% of patients with EPN are found to be bacteremic at presentation.[33]

Management

Initial management with tight blood glucose control and broad-spectrum antibiotics should be initiated, but procedural source control must also be pursued (Fig. 3). In a series of 51 patients from 2016, Lu et al[33] described a 79.1% resistance to ampicillin, 22.7% resistance to gentamycin, 17% resistance to fluoroquinolones, and 10.9% resistance to third-generation cephalosporins. However, only third-generation cephalosporin resistance was associated with an increased risk of mortality. Major risk factors for third-generation cephalosporin resistance were hospitalization or antibiotic use within the same year, need for emergent hemodialysis, and disseminated intravascular coagulation. Thus, Lu et al. proposed that patients with EPN be empirically prescribed a third-generation cephalosporin plus an aminoglycoside at presentation, or a carbapenem plus vancomycin if they presented with risk factors for resistance to third-generation cephalosporins. Given that most infections are not polymicrobial or gram-positive, it is the general practice at our institution to cover empirically with either a fourth-generation cephalosporin or piperacillin-tazobactam. We also add vancomycin for hemodynamically unstable patients and then narrow antibiotics based on culture results. Decisions regarding the

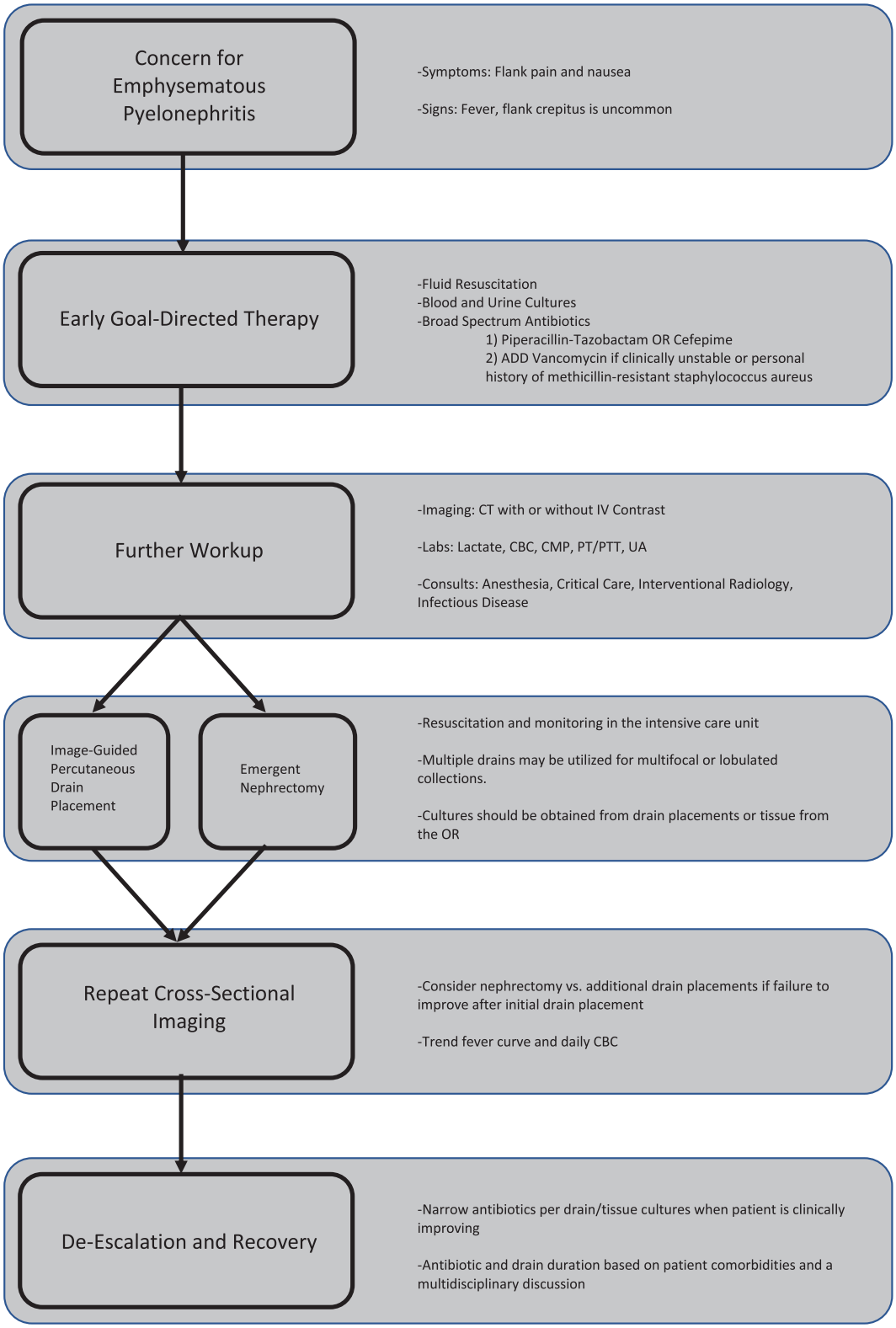

Figure 3. Emphysematous pyelonephritis care pathway.

duration of antibiotics should be made in concert with an infectious disease specialist.

Medical management with antibiotics alone is not sufficient for EPN and carries a 50% risk of mortality.[1] Historically, source control was achieved with emergent nephrectomy, however, this approach carried a 25% mortality risk.[1] More recently minimally invasive interventions have provided improved outcomes. While there is inherent bias in studies comparing immediate surgical intervention to percutaneous intervention, a combination of broad-spectrum antibiotics and percutaneous drainage has been associated with a decreased mortality to 9.8%-

13.5%.[1,33] Percutaneous, image-guided drains should target fluid and air collections in the emphysematous tissue, as opposed to the collecting system. Loculation is not a contraindication to drain placement and should not preclude a minimally invasive approach.[36] Drain placement combined with delayed nephrectomy for partial responders has further shown a mortality risk of only 6.6% in one systematic review, suggesting that initial attempts with nonsurgical intervention may be warranted even in patients who ultimately proceed to nephrectomy.[1] Stent or nephrostomy tube placement is only necessary for obstruction, most commonly from kidney stones.[26,37] Follow-up imaging within 1 week of percutaneous drainage was recommended by Chen et al., especially for patients with ongoing signs and symptoms of infection.[36] Follow-up imaging can identify patients who may benefit from further intervention with either a second drain or nephrectomy. Using this approach, mortality has decreased 10-fold from medical management alone, and patients have been able to retain more long-term renal function.[1,36]

OBSTRUCTIVE PYELONEPHRITIS

Presentation and Diagnosis

OPN refers to an acute infection of the kidney in the setting of compromised upper urinary tract drainage. Patients with OPN present with fever, ipsilateral colicky flank pain, nausea and vomiting.[38,39] Physical exam is notable for costovertebral angle tenderness, and urine may be notable for turbidity or hematuria. Common lab abnormalities include leukocytosis and elevated creatinine levels.[39] CRP, PCT, hypoalbuminemia, and thrombocytopenia have all been associated with septic shock in patients with OPN and may be useful as risk indicators for clinical deterioration.[40-42] It is essential that a urinalysis and urine culture be drawn as early as possible to avoid sterilization by antibiotic administration.[38] While most urine samples will show elevated leukocytes and positive nitrites, high-grade upper tract obstruction may lead to sterile urine from voided samples.[43] This was demonstrated by Marien et al[39] who showed a 25% discordance rate between voided urine and renal pelvis cultures in OPN. Wymer et al. recently described a 4 variable risk score to predict UTI in cases of concern for OPN. The combination of elevated CRP and PCT, fat-stranding on CT, and positive urine gram stain predicted a UTI in patients with obstructive nephrolithiasis in 68% of patients with 3 of 4 risk factors and 100% for 4 of 4 risk factors. While this score may aid in the decision to pursue surgical decompression, it remains essential that urine cultures be collected from both the voided urine and the renal pelvis at the time of stent or nephrostomy tube placement to guide further antibiotic treatment.

Noncontrasted CT is the gold standard for nephrolithiasis, the most common cause of OPN, but contrasted CT scans are often performed in the emergency department when a broader differential diagnosis is still being considered.[44] Yagihashi et al[45] reported in a series of 250 patients that a delayed nephrogram or excretory phase was associated with a 6.7-fold higher risk of bacteremia in OPN. CT imaging may also be notable for ipsilateral hydronephrosis and fat stranding in the retroperitoneum. It should be noted that hydronephrosis may not be present in the first 24-48 hours of ureteral obstruction and thus its absence does not exclude OPN.[45] CT is also helpful in distinguishing OPN from Xanthogranulomatous Pyelonephritis, a chronic renal infection, often with associated stone disease, that results in diffuse renal destruction.[46] While Xanthogranulomatous Pyelonephritis can also present with obstructive nephrolithiasis and a UTI, poor renal function and the chronic nature of this process result in much less acute presentations which can often be treated with antibiotics and interval percutaneous drainage or nephrectomy.

A population-based analysis of US patients from 2007 to 2009 by Borofsky et al[2] showed an 11% risk of mortality for OPN with associated ureteral calculi. Mortality was independently associated with age, with patients older than 75 more than 3 times as likely to die than patients younger than 45, irrespective of treatment. Across multiple series, average age ranges from 52 to 67 years old, with a female predominance between 3-4:1.[38,40,41,45] OPN carries a high risk of septic shock with 25.2%-33.3% of patients meeting criteria. Yamamichi et al[40] reported a 3.6-fold greater likelihood of developing septic shock for diabetic patients. Tambo et al[41] also reported an association between pre-existing diabetes and septic shock, as well as between shock and poor performance status using the World Health Organization performance status scale.

Pathophysiology

Upper urinary tract obstruction can be due to both intrinsic and extrinsic causes and can be chronic, as in the case of ureteropelvic junction obstruction, or acute, as in the case of nephrolithiasis. Rapid progression to bacteremia in OPN is thought to stem from bacterial translocation due to increased intrapelvic pressure.[45] Increased intrapelvic pressures from obstruction lead to hematogenous spread of bacteria via pyelovenous backflow. Yagihashi et al[45] attributed their dramatically higher likelihood of bacteremia in patients presenting with a delayed nephrogram to this phenomenon. OPN is most commonly associated with obstruction from ureteral stones (65%) or malignancy (21%). Bacteria associated with OPN are generally gram-negative urinary pathogens including *E. coli* (47%-56%), *Proteus* (8%-16%), *Klebsiella* (7%-9%), *Streptococcus* (5%-8%), *Enterococcus* (6%-19%), and *Pseudomonas* (3%-5%), but gram-positives have been described. Polymicrobial infections occur in 16%-28% of patients.[38,45]

Management

Treatment of OPN consists of broad-spectrum antibiotics, subsequently narrowed per urine and blood cultures, and urgent urinary tract drainage with a ureteral stent or percutaneous nephrostomy tube (Fig. 4).[47] Antibiotics alone

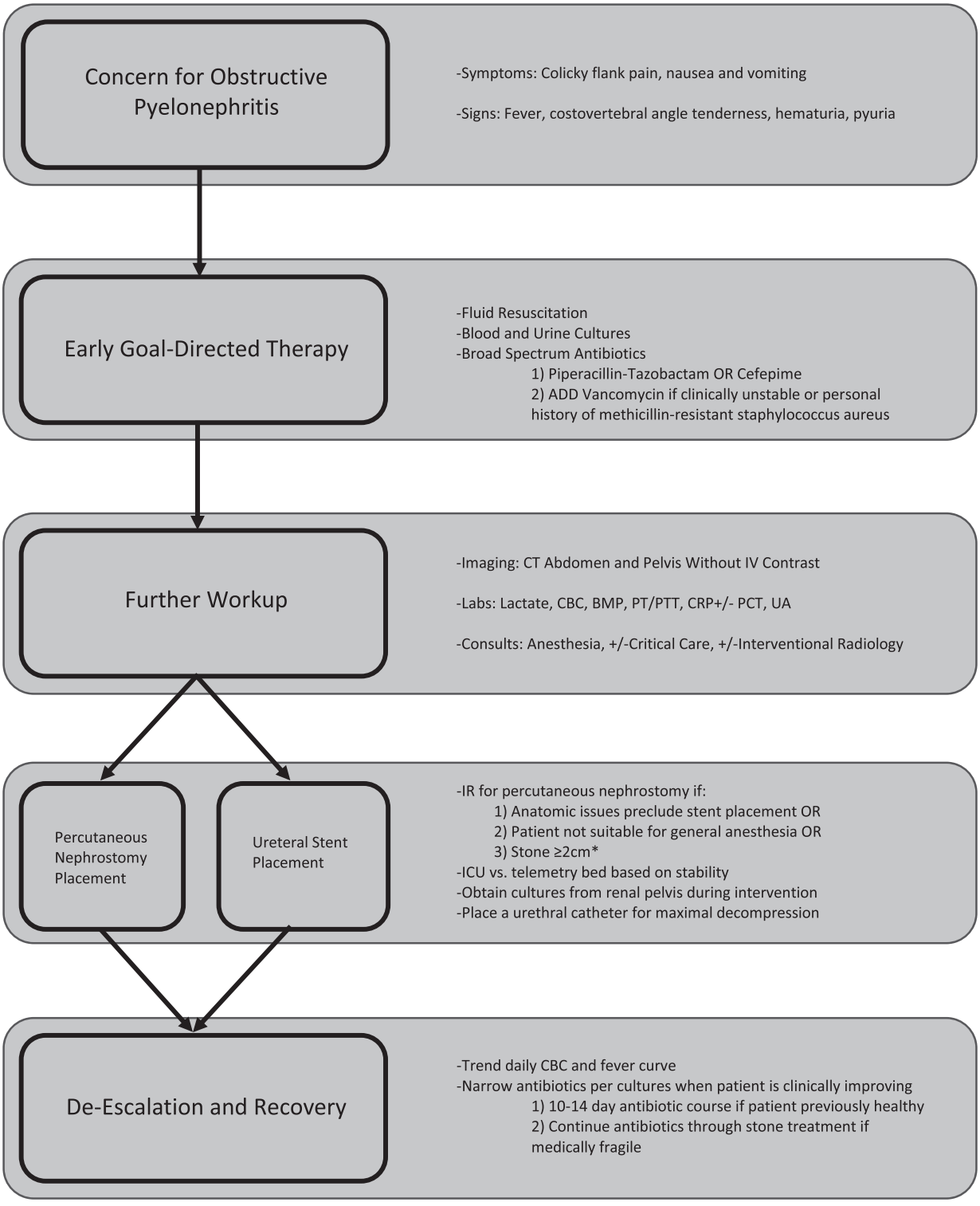

Figure 4. Obstructive pyelonephritis care pathway.

are not sufficient and carry a mortality risk of 19%, compared with 9% after relief of the obstruction with a stent or nephrostomy tube.[2] In a randomized trial of ureteral stent placement versus percutaneous nephrostomy tube for OPN by Pearle et al., neither method was superior in terms of patient recovery (defined as time to normal temperature and WBC count), but percutaneous nephrostomy was less costly while ureteral stent placement occurred more quickly. In a study aimed at decreasing the time to decompression for OPN, Haas et al. reported a significantly faster time from urology consultation to decompression (5.4 to 4.5 hours) after implementation of a

hospital-wide protocol that designated patients for a nephrostomy tube if they had anatomic variants precluding retrograde access, severe hydronephrosis, hemodynamic instability precluding general anesthesia or a failed attempt at retrograde stenting, while all others went for ureteral stent placement. The postintervention analysis described an 8% increase in the odds of an admission lasting longer than 5 days for every hour of delay in decompression.[48] The need for timely decompression was further demonstrated by Silva et al[49] who described an increased complication rate (10% vs 26%) and length of stay (3.8 vs 7.6 days) for patients before and after the COVID-19 pandemic due to delayed presentation (4.3 days vs 7.8). It is our institutional practice to pursue stent placement except in cases of anatomic considerations precluding retrograde access, failed retrograde access, the inability to tolerate general anesthesia, or in cases of obstruction from a stone that will likely require percutaneous access for eventual treatment (2 cm of total stone burden as a general rule).

Neither the American Urological Association nor the IDSA has published recommendations for antibiotic regimens for OPN. Given that pathogens in OPN are overwhelmingly gram-negative, it is our practice to cover patients empirically with either a fourth-generation cephalosporin or piperacillin-tazobactam, with vancomycin added for hemodynamically unstable patients. Due to the high discordance between voided and renal pelvis cultures and the high rate of antibiotic resistance noted in OPN, it is important to consider all cultures, as well as the local antibiogram, when narrowing antibiotics.[39] Furthermore, infectious disease consultation should be pursued for patients who are bacteremic and who do not respond to prompt drainage and broad-spectrum antibiotics. For previously healthy patients who respond appropriately, antibiotics should be continued for 10-14 days, but consideration should be made to continue antibiotics through stone treatment for medically frail patients.[50]

CONCLUSION

FG, EPN, and OPN are rare, but life-threatening urologic infections that require immediate intervention. Contemporary, evidence-based management strategies have decreased the risk of mortality for each of these three conditions.[1,2,14] Mainstays of treatment include source control and broad-spectrum antibiotic coverage, guided by cultures, and the local antibiogram. FG must be treated with emergent and aggressive debridement, but novel primary closure and skin grafting techniques are decreasing the burden of long-term wound care for large tissue defects.[23,24] Percutaneous drainage has become an initial option in treating EPN, dramatically reducing the risk of mortality, and improving long-term renal functional outcomes in patients who are able to avoid nephrectomy.[1,36] Both percutaneous nephrostomy and ureteral stenting are appropriate for OPN. Resistance patterns and causative organisms may be up to 25% discordant between voided urine and renal pelvis cultures, and both should be considered when tailoring antibiotic therapy for OPN. While FG, EPN, and OPN are dangerous urologic conditions, adherence to contemporary, evidence-based guidelines will assist in optimizing patient outcomes.

SUPPLEMENTARY MATERIALS

Supplementary material associated with this article can be found in the online version at https://doi.org/10.1016/j.urology.2021.05.011.

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