Complicated Urinary Tract Infections

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The definition of complicated versus uncomplicated urinary tract infection (UTI) is one of practicality and necessity, and as such, it accomplishes several goals. First, complicated UTI describes a group of patients that usually need a prolonged course of antimicrobial therapy, with all its attendant morbidities, costs, and outcome differences. Second, it selects patients who may need interventional therapeutics, including surgery, endoscopy, or other modalities. Third, it follows that the patients denoted by this definition will most likely need to be managed, at least to some extent, by a trained urologic surgeon. With that prologue, a definition of complicated urinary tract infection must define the patient population, clinical conditions, and minimum necessary evaluation. A complicated urinary tract infection is that which occurs in a patient with an anatomically abnormal urinary tract or significant medical or surgical comorbidities [1]. Whereas this definition may not cover each and every situation, it does serve to encompass the great majority of these patients and guide their care. Both parts are necessarily broad, to assure that these potentially complex patients are appropriately managed.

There are a number of characteristics that may serve to describe complicated UTIs (Box 1). The first is that they, like uncomplicated UTIs, are almost always ascending in nature [2,3]. The periurethral tissues become colonized and the urethra eventually becomes involved. From there, the bladder in a female is colonized, or the prostate in a male. The organism, once it reaches the bladder, usually has little difficulty in establishing a stronghold and either invading or further ascending, or both. There are a few exceptions to this rule, renal infection in intravenous drug abuse among them. The most common organisms in this scenario are the skin flora, more specifically, Staphylococcus aureus. A second exception consists of patients with miliary infections that start elsewhere, at another point of entry, and then are hematogenously transported to the kidneys. Because the blood supply is so exuberant, a common sequela is renal. The prototypical infection of this type is Mycobacterium tuberculosis, but others may cause this as well from varied sources, spanning the common bacteria to the fungi and fastidious microorganisms. In the incipience, Escherichia coli tends to be the first infection in many cases [3], but subsequent infections may be anything, often with a varying resistance by antibiogram. Polymicrobial infections are the exception rather than the rule, and most of the time there is a solitary microbe. A notable exception to this is in patients with a chronic indwelling catheter, because they may have a number of organisms present by culture. The challenge in this circumstance is to discern which organism is the one that is actually causing the infection.

Because defining which antimicrobials are of the utmost importance, the clinician must often use the broadest spectrum of drugs, or even multiples. With this in mind, there is often a wider array of pathogens that may be operative in complicated UTIs [4]. This is a result of several factors. This first of these is location of patient exposure. Nosocomial infections, by the sheer volume of susceptible individuals and variety of organisms present, are common [5]. A second reason is that because many more of those microorganisms may have access to the patient and persistence is common, there may be more varied
etioologic agents. A third is that because some of these microbes have a limited ability to infect immunologically sound patients, and by definition some of the patients included in the category of complicated UTIs have compromised immune systems, they may have greater access to hosts. Drug resistance tends to be more common in patients with complicated UTIs [6–8], which may be caused by exposure to more antibiotics, and thus the selective process may have a major role. The place of acquisition of the infection must be factored in also, as accessibility to susceptible host is a key contribution. Because bacteria are known to exchange DNA with one another, using the analogy of sexually transmitted diseases, more organisms may gain resistance, thus acquiring a survival advantage. Hospitals and nursing homes are the places where these circumstances abound [9].

**Host factors: which patients are at risk for complicated UTI**

**Intubated urinary tract**

The patient with an intubated urinary tract, whether it is an indwelling catheter (urethral, suprapubic, nephrostomy, or others) or an internal one, such as a ureteral or urethral, would always be included in this group of patients at risk for complicated UTI (Box 2) [10,11]. The first reason for this is that they are always at increased risk for infection and, with subsequent exposure to multiple courses of antibiotics, prone to infections with resistant organisms. The second reason, at least at first examination, is that urinary findings of infection may be indistinguishable from those with sterile urine, from the perspective of the urinary chemistry (leukocyste esterase, nitrite, hemoglobin, and others), as well as the microscopy of the urinary sediment. It has been shown that in the presence of an indwelling catheter, the urine will become colonized, if not infected by the 2-week time period. Rarely is the urinary tract sterile beyond this epoch. The usual organisms tend to be uropathogens, but occasionally skin flora or vaginal organisms predominate. Often it is difficult to distinguish colonization from frank infection in the setting of an indwelling catheter.

**Urine obstruciton**

The patient with a known urinary obstruction, whether it involves the upper or lower urinary tract, must be similarly included [4], even if it is a patient who has had prior treatment for their obstruction. It should be assumed that even a corrected obstruction might not have rendered the problem completely resolved. Obstruction allows for the prolongation of bacteruria by mechanical means, but also interferes with the local and systemic immune response, preventing its functioning at optimal levels. Lastly, the bacteria themselves are capable of effectively altering their microenvironment, which allows for prolongation of bacterial survival, improved colonization, and growth enhancement. There are a number of mechanisms by which this is accomplished and will be covered later in this article. The infectious process in and of itself increases the degree of obstruction. This is accomplished by bacterial alterations of the environment in the course of the infection, resulting in swelling and prevention of peristalsis [12]. In addition, there are a number of products produced by the bacteria that paralyze the urinary tract. The presence of obstruction causes the kidney to have a reduced ability to excrete and concentrate antibiotics as well, and may reduce the

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<th>Box 1. Characteristics of complicated UTI</th>
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<td>2. Defined susceptible population</td>
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<td>3. Drug resistance common</td>
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<th>Box 2. Complicating factors</th>
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<td>Indwelling catheters</td>
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ability of the drug to function because of the extended presence of bacterial products in the environment. In the setting of obstruction, an infection may be viewed as an undrained abscess. This would naturally depend upon the degree of obstruction and also the level of the urinary tract where the obstruction has occurred. In most cases, however, drainage is indicated, usually on an urgent or even emergent basis.

**Male gender**

Most clinicians would suggest that male gender alone is criteria for being a complicated UTI [1,13]. This would be especially true in the mature individual who likely would have some element of benign prostatic hyperplasia, and thus presumably a lower urinary tract obstruction [14]. It could be postulated that because males have several advantages over females when it comes to urinary tract infection susceptibility, an infection in this gender should raise suspicion of an underlying condition. The presence of an elongated urethra (enhanced mechanical barrier) and the antibacterial nature of prostatic secretions combine to reduce the incidence of UTIs in this group as a whole [15]. Thus, infection in a male suggests mitigating influences, causing a condition where these enhanced defuse symptoms have been a complicated situation. Knowing that infection of the prostate gland can require a longer course of therapy further solidifies these patients in the complicated category.

**Age**

Age is always a consideration when considering the existence of a complicated UTI. Infections in childhood portend certain abnormalities of the genitourinary tract [16,17]. Vesicoureteral reflux, urethral valves, ureteropelvic obstruction, or ureterovesical obstruction are all relatively common conditions where there is a penchant for an increased incidence of urinary tract infections, as well as increased severity. What is more, UTIs in adults may be, at least in part, caused by behavioral circumstances such as sexual activity, which are less likely scenarios in the child. Gender here is important as well, in that, for the most part, congenital genitourinary abnormalities are more common in boys than girls. When discussing UTIs in children, the subject always surfaces regarding the role of circumcision. It is clear that circumcised boys rarely have UTIs, but that routine prophylactic circumcision to avoid UTIs is not indicated. There are instances in which circumcision may be indicated for boys with certain congenital urologic conditions, in whom UTIs are more ominous, and therefore circumcision is indicated from a preventative prospective [18].

**Diabetes**

A number of medical conditions have been shown to be risk factors for UTIs, and moreover, lead to a more protracted course of therapy with potentially adverse outcomes because of specific complications. One of the most important of these is diabetes mellitus (DM). Not only are these patients more susceptible to UTIs in general, but also some of the complications are observed far more often in these patients [19–21]. Perinephric abscesses are rarely seen in patients without obstruction, except in the setting of diabetes, particularly when there is poor glucose control. This is also true for lobar nephronia, intrarenal abscesses, or carbuncles. One condition that is almost exclusive to diabetics is emphysematous pyelonephritis [22]. This is a specific case of renal infection that is manifested by the presence of gas in the renal parenchyma. The condition has a mortality rate that exceeds 40% and often results in loss of the affected kidney. Secondary obstruction may also be seen in DM because of the sloughing of papillae. This results in obstruction of the upper urinary tract by mechanical means. The pathophysiology is a result of pyelonephritis in a patient with compromised intrarenal blood flow, as is often the case with diabetics. This, then, presents an emergency requiring immediate drainage by either a retrograde or antegrade technique. Lastly, patients with DM have a strong predilection for having asymptomatic bacteriuria. This always presents the clinician with a dilemma as to whether to treat the patient with antibiotics or not. No good data as to the management exists, but if a patient has a history of febrile UTIs or any other comorbidity, the risk inherent in nontreatment is unacceptably high [23].

**Renal insufficiency**

Patients with renal insufficiency are another high-risk group, and must be included in the discussion of complicated UTIs [24,25]. The reason for this is because of the reduction in renal blood flow that most often accompanies this disease. The secondary effects of this include a reduced immune response, both on the local and systemic level. Depending on the degree of
reduced renal function, there may also be a reduced urinary volume, which can impair host defenses and increase the bacterial capability to colonize the urinary tract. The changes that take place in the urine itself are that concentrating ability is reduced and the subsequent marshalling of substances inhibitory to bacterial growth are limited. Uremia itself impairs the immune system and may make it difficult to clear infections. In the end stages of renal failure, complicated UTIs increase, as does the morbidity. The delivery of antibiotics anywhere in the urinary tract, from the kidney to the urethra, is compromised, making eradication of infection a daunting proposition. That, coupled with the reduced immune response, makes the morbidity and mortality very high. When there is a bladder infection in an anuric or severely oliguric patient, it is extremely difficult to clear and often requires intervention, including surgery. Lastly, patients on both hemodialysis and peritoneal dialysis have an increased incidence of UTIs, and doubtless some are secondary to infections elsewhere [26].

**Immunosuppression**

Patients who are immunosuppressed, either by medications or by other comorbid conditions, must always be treated aggressively [27]. There are a number of drugs in which immunosuppression is the desired outcome, but a secondary effect is increased infections throughout the body, including the urinary tract. The prototype of these is corticosteroids. There are a number of ways that these drugs are delivered, namely orally, parenterally, nasally, cutaneously, and others. All cause immunosuppression in a dose dependent fashion by reducing the cell-mediated immune responses and local immune reaction. There is also an effect on the humoral immune system, although this is not as pronounced. Many drugs exist that are intended to abrogate the immune response (IR) caused by the condition being treated. Patients undergoing organ transplantation are the most obvious of the category, as they may be taking corticosteroids as well. Drugs such as the calcineurine inhibitors (cyclosporine and tacrolimus) are cell-mediated immunity specific [28,29]. Additionally, monoclonal antibodies are currently being used to treat transplant rejection, and have profound effects on the treatment of UTI. The immunosuppressant drugs, such as muromonab-CD3 and a host of others, fit into this category. The cell-cycle nonspecific drugs, such as azathioprine and mycophenolate mofetil, are also a concern, as they are not only used in treatment of organ transplantation, but also in other diseases.

**Urolithiasis**

Urolithiasis is certainly one of the medical conditions that confers the designation of “complicated” [30]. The most ominous complication of stones is obstruction. The association of an obstructing calculus along with febrile UTI is usually considered an emergency, because of the risk of sepsis. Intervention is mandatory in most cases, specifically by employing either a nephrostomy tube or a ureteral stent. Moreover, stones may prolong the treatment of UTIs if they are infected. The bacteria become ensconced in the interstices of the stone and, usually, by establishing their own biofilm environment [31], become difficult or even impossible to eradicate without removal of the calculus. Stones also cause injury to the urinary tract, and the damage can give bacteria a place to establish colonization. This is especially true if intervention has become necessary to effect calculus removal. Certain stones are a direct result of infections, specifically magnesium ammonium phosphate or calcium carbonate stones. Urea-splitting microorganisms, by altering their microenvironment, facilitate precipitation of these salts, promoting de novo stone formation and thus persistence of infection. If the bacteria come in contact with other types of stones and establish a nidus for infection, they may lay down new matrix upon the existing stone, creating an eclectic mix of calculus material.

**Surgery of the urinary tract**

Whenever surgery of the urinary tract becomes necessary, whether for obstruction, calculus, or other causes, the urinary tract becomes more susceptible to UTIs and persistence or recurrence thereof. Disruptions or irregularities of the urothelium may serve as an initiation point for UTIs or the creation of obstruction. The underlying abnormality may not have been entirely corrected, and originally may have been a risk factor for infection itself. Furthermore, from time to time sutures may persist in the urinary tract, even when the material is designed to dissolve. If sutures remain long enough, colonization may occur, and even stones have been observed. In the setting of a person presenting with a UTI, this history may be critical to the treatment and long-term management.
Functional and anatomical abnormalities of the urinary tract

There are a number of functional and anatomical abnormalities of the urinary tract that confer complicated status upon UTIs. Most of these are congenital and present early in life with imperfections or voiding dysfunction [32]. Vesico-ureteral reflux, ureteropelvic junction obstruction, urethral valves (anterior or posterior), and congenital megareter are some of the most common of these abnormalities. All have been associated with an increased incidence of UTIs, as well as a need for prolonged antibiotic therapy or intervention. Correction of these abnormalities may reduce the risk of UTIs, but their occurrences in the setting of an infection implies a complicated label [33]. Other structural abnormalities include polycystic kidney disease, renal artery stenosis, renal vein varices or thrombosis, calyceal diverticula, medullary sponge kidney, and others. Whereas some of these may be corrected or near-corrected with surgery and medications, the risk for a complicated UTI remains greater in these cases than among the general population, and should be managed accordingly.

Pregnancy

Pregnancy always confers complicated status on any UTI [34,35]. The risk to the fetus alone would serve as an adequate descriptor, but it is even more complicated because of the pregnant woman’s anatomic and endocrinologic milieu. The gravid uterus, depending of course on the trimester, will cause an anatomic alteration that involves a relative obstructive uropathy. It is unusual that drainage is needed, but this must always be a consideration. After clearance of the UTI, some decision regarding prophylactic antibiotics should be made. The hormone status also has a significant bearing on the infection management. A reduction in smooth muscle contractility, not only of the uterus, but also of the ureter and bladder, may confer a degree of obstructive uropathy. It has been shown that progesterone levels correlate closely with reduced ureteral motility and may both predispose to UTIs and prolong their treatment. The voiding dysfunction that almost invariably accompanies a pregnancy also negatively impacts the resistance to and treatment of UTIs. Most pregnant patients have frequency and urgency, along with stress incontinence, all leading to voiding dysfunction. For those circumstances where there is an increase in bladder pressure, this may lead to a reduction in the local defense mechanisms against UTI. Venous congestion may further contribute to the increased susceptibility. It has been shown that these conditions disrupt the tight junctions in the bladder epithelium, and that the uromucoid (a protective layer of mucus, Tamm-Horsfall protein, and other substances) is damaged by the high pressures and fails to protect.

Voiding dysfunction

Patients with voiding dysfunction, including those with neurogenic bladders, comprise a significant proportion of complicated UTIs [36–38]. Two characteristics of this problem are the prime reasons to be included in the group referred to as “complicated.” The first of these is the frequent presence of residual urine. Conditions such as low spinal cord injury, myogenic atony, spina bifida, sacral agenesis, and a host of others may allow for incomplete emptying and thus an enhanced milieu for bacterial growth. This can also be a result of bladder outlet obstruction, either anatomic or physiologic. These conditions add the complication of high pressure voiding, which is the second characteristic. The high pressure contributes on several levels. The first is a reduction in blood supply, impairing IR and host response. Second, the high pressures disrupt the uromucoid layer and may separate the urothelial cells, all causing a facilitation of bacterial binding and ultimately colonization. Last, over time, bladder damage, with cellules and diverticula may emerge, as does secondary vesicoureteral reflux. These lead to incomplete emptying, which greatly contributes to the sequestration of bacteria, establishment of individual microbial ecosystems, and reduced clearance by drugs, as well as renal insufficiency.

Environment

The place where a particular UTI is acquired must be factored into the equation. Infections that are generated in the community at large tend to be uncomplicated [39,40]. The organisms that come from this vast pool are the most common because of their particular proclivity and survival advantages. Just because of the numbers alone the most common organisms will have an advantage. The more unusual or resistant bacteria have less of a survival advantage in the community at large, and thus are not as prevalent. Hospital acquired or nosocomial infections all must be considered
complicated because of a host of factors [5,6,8,41]. The susceptible population is very large, and even their different susceptibilities tend to be greater and of more importance. Indwelling catheters and other breaks in the body’s integument provide for initiation points of the infection. The enormous amount of antibiotics present in this environment not only selects bacteria that are resistant, but also exerts selective pressure on the environment as a whole, fostering emergence of greater and greater resistance. Hospitalized patients contracting UTIs are particularly worrisome, in that the mortality rate for this particular infection may be upwards of 30% [10].

Another location for complicated UTIs to break out is in nursing homes [42]. In this environment, not only are there a large number of highly susceptible patients in very close propinquity, but also many have a compromised genitourinary tract because of indwelling catheters, skin breakdown, or loss of urinary or bowel control with the attendant prolonged exposure. Another problem tends to be cross contamination from patient to patient transmitted by the health care providers themselves. Whereas increased attention focused on hand washing may reduce this to a degree, the number of chances for exposure are often overwhelming. As the population ages and this type of long-term care becomes increasingly prevalent and popular, these infections will certainly be perpetuated.

Occasionally patients who travel to certain parts of the globe may be exposed to an increased variety of infective agents. With the exceptions of sexually transmitted diseases and some very regional infections, such as schistosomiasis, these tend to be very unusual. Unusual pulmonary and dermatologic infections are much more commonly contracted in countries other than the United States. The involvement of the urinary tract is secondary to spread in a miliary fashion from the point of entry. In any case, the degree to which this type of infection contributes to the overall numbers is very small, although significant.

Pathogenic factors: organism-related factors contributing to complicated UTI

The organisms that are typically found in complicated UTIs are varied. The initial infection typically is caused by *Escherichia coli*. This organism is the most common facultative aerobic organism in the gastrointestinal tract, as it sits in proximity to the genitourinary tract. In addition, *E. coli* has a number of survival advantages to establishing a colony, and ultimately an infection, over other Gram-negative species. Many subtypes are imbued with surface structures that bind to specific locations on the urothelial cell surface. Perhaps the most important of these are fimbria, most notably type I fimbriae, which are inhibited by mannose and avidly bind to latex catheters and urothelial cells [12]. In addition, there are P-fimbriae, which bind to a urothelial cell surface receptor referred to as the P-blood group antigen present in the majority of the world population and located on the urothelial cells as well [12]. Because *E. coli* is the most common organism in the intestine, other than anaerobes, it stands to reason that it would be the most common in all types of UTIs, especially given its survival advantages. Those with the P-blood group antigen are able to ascend the urinary tract easily, even in the anatomically normal system.

A host of other Gram-negative species may also be found in the complicated UTI group. Many of these are nosocomially acquired, and as such will reflect the local hospital environment. These will be highly specific to the particular hospital or nursing home where the host is exposed. Because complete eradication is often a problem, and because the local microenvironment may undergo change based upon numerous factors, the individual patients may have more than one bacteria that is causing the UTI. These still are in the minority with one notable exception, namely the infection in the setting of an indwelling catheter that has contact with the outside (urethral or suprapubic catheter). Over time, multiple species may colonize the catheter, and thus the urine. Not all of these species are capable of causing a true infection, but they may complicate the circumstances in other ways.

One of these is the sharing of genetic material, both chromosomal or naked DNA, often in defined entities referred to as “plasmids.” These are readily spread throughout a bacterial population by conjugation and other means, resulting in multiple antibiotic resistant infections [9]. As certain plasmids exert a survival advantage in the setting of antimicrobial drug treatment, the population may grow rather quickly. The main reasons that these highly resistant organisms don’t proliferate outside the hospital environment are the lack of selective antibiotic pressure in the community, the high degree of dilution (given the much greater population), and the fact that
maintenance of the specific resistance itself requires extra metabolic energy in a given bacterium. Thus, in the absence of specific antibiotics, the organism is actually at a survival disadvantage.

Another property of bacteria that causes certain species to have a great survival advantage is matrix or glycocalyx synthesis (also referred to as biofilm) [11,43,44]. Certain bacteria, the prototypic one being *Pseudomonas aeruginosa*, are able to synthesize a substance into their microenvironment, which forms a protective shell around themselves. This serves three major functions, all promoting survival. The first is protection from the body’s immune response: the leukocytes cannot penetrate the covering and are rendered ineffectual. The second is exclusion of antibiotics that, if capable of penetrating this layer, may not be capable of concentrating there. An exception to this is the 5-fluoroquinolone ciprofloxacin [45]. The third property is that the bacteria have a much greater control over their microenvironment, concentrating nutrients, excluding toxic substances, preventing dilution of products needed for metabolism, all serving to allow the bacterium to stabilize and improve its metabolic rate. The advantage of this is to let it reduce its susceptibility to antibiotics or the IR in a state of relative hibernation, emerging when the external environment is more conducive to growth and division. The organisms capable of this synthesis are the same ones that tend to harbor antibiotic resistances as well.

Other than *Staphylococcus saprophyticus*, infections caused by Gram-positive species are more commonly seen in complicated UTI groups [8,13,33]. The occasional simple UTI will be caused by group D streptococci (enterococci), but not as commonly as the former. The reasons that most of these species lack the external appendages to bind avidly to the urothelial cell surface, and thus have a lower probability of establishing a colony to initiate the infectious process. Second, they are not as ubiquitous in the area in and near the urethral opening. Similarly, they are not seen in the colon or mucosal surfaces either. Third, they often lack specific virulence factors for the urinary tract, to allow them to establish a colony and invade. One of the reasons that the Gram-positive organisms are grouped under the complicated UTI definition is that they may be spread via the hematogenous route, and they tend to be a result of a significant insult to the body’s defense mechanisms. An example of this is *Staphylococcus aureus* infection, which often can come from an infected site elsewhere in the body, causing bacteremia and therefore seeding of the kidney [46]. This may also occur in the circumstance of an intravenous drug abuser or someone who has an infected indwelling line. These infections may progress to some of the significant sequelae of complicated UTIs, specifically lobar nephronia (renal carbuncle) or perinephric abscess, requiring long-term antibiotics or intervention, either endoscopic or surgical.

Another group of pathogens that are included in the complicated group are the fungi. The most common of this group, by far, is the genus *Candida*, with the species *albicans*, *tropicalis*, and *kruezi* predominating. These yeast forms are frequently found in the urinary tract as a colonizing agent, rather than an infecting organism [47]. It may, however, denote a polymicrobial urinary environment, and in the setting of an intubated urinary tract, may be of greater significance. In any case, *Candida* accounts for less than 5% of complicated UTIs. The other fungi comprise a very tiny percentage, with isolated case reports of prostatitis, pyelonephritis, and other infections caused by fungi other than *Candida*.

**Evaluation of the patient with complicated UTI**

Patients fitting the group of high risk for complicated UTI need an expeditious evaluation, specifically designed to limit the short and long-term morbidity and mortality. The first step in the priority of these patients is an accurate history and physical. This will help stratify the risks for the various confounding variables seen in this population. Secondly, a urine culture is mandatory, as opposed to uncomplicated UTIs, where empiric therapy is always instituted and frequently completed by the time a urine culture would be finalized. An assessment of the patient’s general medical status, specifically hematologic profiles and complete serum chemistries, are usually required for management. Lastly, some imaging study should be mandatory, to discern whether other complicating issues coexist. This is especially true in patients who are known to have congenital malformations of the kidney and the immunocompromised or elderly. There was a time when ultrasound was probably the most desirous examination, because of cost, access, lack of radiation exposure, absence of contrast
complications, and availability [48]. Most recently, computerized axial tomographic scanning (CT) has supplanted most of these tests, because the improved technology and advanced imaging, which has cut the acquisition time drastically. The CT also affords improved detail and image resolution, and can diagnose essentially all pathology identified by the ultrasound. Other studies may be necessary, but if either the ultrasound or CT is negative for correctable pathology, then other imaging studies are not warranted [49].

There are a number of sequelae from complicated UTIs that may have serious or fatal consequences [50]. The most worrisome is urosepsis. While this is certainly more likely in immunocompromised patients, all patients with complicated UTIs are at risk. This is far more common with Gram-negative organisms and may be fatal. The hypotensive effects of the bacterial cell wall (endotoxin), coupled with a wide array of externally synthesized enzymes and other biologically active products, results in profound hemodynamic changes, multiple organ failure, and often death. Use of antibiotics in the environment for other problems further complicates the circumstances by limiting the available treatment options.

Another ominous side effect of complicated UTIs is renal failure. This may be acute or chronic and may be permanent or self-limited. Pre-existing renal insufficiency is a predisposing factor, as is obstruction. From there, abscesses may develop. One particular complication, emphysematous pyelonephritis, occurs in diabetics far more commonly than it does in patients with normal glucose control. This entity is characterized by the finding of air in the renal parenchyma, identified by CT, ultrasound, or abdominal radiographs. Intervention is always required and even if instituted in a timely fashion, there is a high mortality rate. Xanthogranulomatous pyelonephritis and mala-koplakia are relatively uncommon complications, but almost always result in renal loss.

Treatment of the patient with complicated UTI

Several principles guide the treatment of complicated UTIs. The first of these is to minimize the effects of obstruction or other obfuscating anatomic abnormality. Relief of obstruction is the primary way this is accomplished, but others are employed as needed. Second, aggressive use of antibiotics is mandatory. This means appropriate use of broad-spectrum drugs in appropriate dosages, adjusted for renal or hepatic insufficiency [51,52]. It is always necessary to not only cover Gram-positive and Gram-negative bacteria, but also to choose the specific drugs based upon the antibiogram available in the hospital or area. It is probably appropriate to consider prophylactic coverage of yeast, at least empirically, especially with an indwelling catheter or in the diabetic patient. Once the cultures and sensitivities have returned, adjustments must be made to ensure coverage. The same effort should also be made to reduce the development of resistance [7,52,53]. This involves not overusing a particular agent or using it inappropriately. The older antibiotic agents (eg, penicillins and aminoglycosides) should remain as first-line options. This should preserve the activity of the newer agents (eg, newer generations of cephalosporins and so forth). The problem is that resistance will tend to increase to the older agents over time, rendering them less effective. A very effective modality is to use combination therapy, not only for the additive effects but also for potential synergy. This is especially true when antibiotics from different classes are used together, because they work on different sites in the bacterium. The clinician should employ agents that have an advantageous pharmacokinetic profile, and a better pharmacodynamic profile against the pathogens that are suspected.

There is a little doubt that complicated UTIs will continue to increase in prevalence, because of an increase in the subpopulations of patients who are at risk. The average age of citizens is increasing, as is the likelihood of contacting those diseases that are associated with aging. The treatments for these diseases, from diabetes to renal calculi continue to increase this pool. It is incumbent, then, on the medical community to not only diagnose this condition in an expeditious fashion, but also to treat aggressively and intelligently to not only shorten the disease course, but also to minimize antimicrobial resistance.

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