Catheter-associated urinary tract infection in adults

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INTRODUCTION — Urinary tract infections (UTI) associated with urinary catheters are the leading cause of secondary healthcare-associated bacteremia. Approximately 20 percent of hospital-acquired bacteremias arise from the urinary tract, and the mortality associated with this condition is about 10 percent [1].

Issues related to symptomatic UTI and asymptomatic bacteriuria in patients with indwelling bladder catheters will be reviewed here.

Issues related to asymptomatic bacteriuria and cystitis in other circumstances, and the indications for placement, methods of catheterization, and management and complications of bladder catheters are discussed separately. (See "Approach to the adult with asymptomatic bacteriuria" and "Acute uncomplicated cystitis and pyelonephritis in women" and "Acute uncomplicated cystitis, pyelonephritis, and asymptomatic bacteriuria in men" and "Placement and management of urinary bladder catheters" and "Complications of urinary bladder catheters and preventive strategies" and "Acute complicated cystitis and pyelonephritis".)

DEFINITIONS — Because the presence of bacteria in a urine sample may represent contamination by bacteria colonizing the periurethral area in addition to bladder bacteriuria, thresholds for bacterial growth from a urine sample that is likely to represent true bladder bacteriuria in specific contexts have been suggested by various expert groups. The Infectious Diseases Society of America (IDSA) guidelines define catheter-associated bacteriuria as follows [2]:

- **Symptomatic bacteriuria (urinary tract infection [UTI])** — Culture growth of ≥10^3 colony forming units (cfu)/mL of uropathogenic bacteria in the presence of symptoms or signs compatible with UTI without other identifiable source in a patient with indwelling urethral, indwelling suprapubic, or intermittent catheterization. Compatible symptoms include fever, suprapubic or costovertebral angle tenderness, and otherwise unexplained systemic symptoms such as altered mental status, hypotension, or evidence of a systemic inflammatory response syndrome.

- **Asymptomatic bacteriuria** — Culture growth of ≥10^5 colony forming units (cfu)/mL of uropathogenic bacteria in the absence of symptoms compatible with UTI in a patient with indwelling urethral, indwelling suprapubic, or intermittent catheterization.

Patients who are no longer catheterized but had urethral, suprapubic, or condom catheters within the past 48 hours are also considered to have catheter-associated UTI or asymptomatic bacteriuria if they meet these definitions.

Because periurethral contamination is less likely in catheterized specimens, a relatively low threshold for bacteria growth in a symptomatic patient is likely to represent true bladder bacteriuria. Although the IDSA guidelines acknowledge that growth as low as 10^2 cfu/mL has been associated with bladder bacteriuria in the setting of symptoms, the threshold of 10^3 cfu/mL was chosen since many labs do not quantify growth below that threshold.

In contrast, use of a higher threshold in asymptomatic patients is reasonable given the low rate of complications in this setting and the desire for increased specificity to reduce the overuse of antimicrobials, even if bacterial growth does represent bladder bacteriuria. (See 'Asymptomatic bacteriuria' below.)

These definitions are different from those used by the United States Centers for Disease Control and Prevention (CDC) National Health Safety Network, which were created for surveillance purposes, not specifically for clinical care [3]. The CDC uses the same basic definition for asymptomatic bacteriuria but defines catheter-associated UTI as the presence of fever, suprapubic tenderness, or costovertebral angle pain in the setting of urine culture with bacterial counts ≥10^5 cfu/mL of no more than two organism species OR counts ≥10^3 but <10^5 cfu/mL with a positive finding on urinalysis (ie, pyuria, leukocyte esterase, nitrite). The CDC definitions also make attempts to distinguish between hospital-acquired and pre-existing UTIs.
EPIDEMIOLOGY

Incidence — Bacteriuria in patients with indwelling bladder catheters occurs at a rate of approximately 3 to 10 percent per day of catheterization [4,5]. Of those with bacteriuria, 10 to 25 percent develop symptoms of urinary tract infection (UTI) [6-8].

This translates into a substantial burden of catheter-associated UTIs in hospitalized patients. In the United States, based on surveillance data reported to the CDC National Healthcare Safety Network, the incidence of catheter-associated UTIs in 2012 was 1.4 to 1.7 per 1,000 catheter days in inpatient adult and pediatric medical/surgical floors [9].

Risk factors — The duration of catheterization is an important risk factor for catheter-associated bacteriuria and UTI and is a major target of prevention efforts [10,11]. (See 'Prevention' below.)

Other risk factors include [12-14]:

- Female sex
- Older age
- Diabetes mellitus
- Bacterial colonization of the drainage bag
- Errors in catheter care (eg, errors in sterile technique, not maintaining a closed drainage system, etc)

PATHOGENESIS — Urinary tract infection (UTI) associated with catheterization may be extraluminal or intraluminal. Extraluminal infection occurs via entry of bacteria into the bladder along the biofilm that forms around the catheter in the urethra [15-18]. Intraluminal infection occurs due to urinary stasis because of drainage failure, or due to contamination of the urine collection bag with subsequent ascending infection. Extraluminal is more common than intraluminal infection (66 versus 34 percent in one study) [19].

Rarely, there can be purple discoloration of the urine, collecting bag, and tubing (the purple urine bag syndrome) [20]. The purple color of the urine is due to metabolic products of biochemical reactions formed by bacterial enzymes in the urine. Gastrointestinal tract flora break down the amino acid tryptophan into indole, which is subsequently absorbed into the portal circulation and converted into indoxyl sulfate. Indoxyl sulfate is then excreted into the urine, where it can be broken down into indoxyl if the appropriate alkaline environment and bacterial enzymes (indoxyl sulfatase and indoxyl phosphatase) are present. The breakdown products, indigo and indirubin, appear blue and red, respectively [21,22]. Bacteria capable of producing these enzymes include Providencia spp, Klebsiella, and Proteus.

MICROBIOLOGY

Spectrum of organisms — The causative pathogens in catheter-associated urinary tract infection (UTI) and asymptomatic bacteriuria are similar to those that are associated with complicated cystitis in general. Specifically, Escherichia coli and other Enterobacteriaceae are common, but Pseudomonas aeruginosa, enterococci, staphylococci, and fungi are also significant causes. (See "Acute complicated cystitis and pyelonephritis", section on 'Microbiology'.)

As an example, of approximately 20,000 catheter-associated UTIs reported by acute care hospitals and long-term acute care facilities to the US National Healthcare Safety Network (NHSN) between 2009 and 2010, the most common causative pathogens identified were [23]:

- E. coli — present in 27 percent of cases
- Enterococcus spp — 15 percent
- Candida spp — 13 percent
Ambulatory patients with indwelling catheters tend to acquire urinary bacteria similar to those found in hospitalized patients rather than the types usually seen in the outpatient setting. Prolonged catheterization can be associated with polymicrobial bacteriuria or changing urinary flora.

Some of these organisms associated with catheter-related bacteriuria or funguria may lack some of the virulence factors that allow the usual uropathogens to adhere to uroepithelium, but they take advantage of easy access to the bladder via the catheter. A good example of such an organism is Candida spp, which almost never cause UTI in the absence of an indwelling catheter. In contrast, candiduria is a common finding in patients with indwelling bladder catheters, particularly in those who are taking antimicrobials or are diabetic [24]. However, most patients are asymptomatic, funguria merely represents colonization, and progression to candidemia is uncommon (1.3 percent in one series) [24]. This problem is discussed in detail separately. (See "Candida infections of the bladder and kidneys", section on 'Infection versus colonization'.)

**Antimicrobial resistance** — Organisms that cause catheter-associated UTI and asymptomatic bacteriuria are increasingly resistant to antimicrobial agents.

Of the 5660 E. coli catheter-associated isolates reported to the US NHSN between 2009 and 2010, 31 percent were resistant to fluoroquinolones, and 12 percent to advanced generation anti-pseudomonal cephalosporins (ie, cefepime and ceftazidime) [23]. Of 2300 Klebsiella isolates, 12.5 percent were resistant to carbapenems.

**Clinical Features**

**Symptoms and signs** — Symptoms of catheter-associated urinary tract infection (UTI) are protean and do not necessarily refer to the urinary tract. Fever is the most common symptom [2,6,25]. Localizing symptoms may include flank or suprapubic discomfort, costovertebral angle tenderness, and catheter obstruction. Nonspecific findings include new-onset delirium or other systemic manifestations that suggest the possibility of infection.

However, many catheterized patients without evidence of UTI or even bacteriuria may have similar symptoms. As an example, in an observational study that included 89 hospitalized patients who developed bacteriuria following placement of a urethral catheter, 18 percent had a temperature >38.5 C (101.3 F) and only 6 percent each had dysuria or urinary urgency [6]. These symptoms were present in the same proportion of 945 catheterized patients without bacteriuria.

Patients with spinal cord injury may have especially atypical and nonspecific symptoms, including increased spasticity, malaise/lethargy, and autonomic dysreflexia. Individuals who develop UTI soon after removal of a catheter may be more likely to have the typical urinary symptoms of dysuria, frequency, and urgency.

Many patients believe that a cloudy appearance or foul smell of the urine is suggestive of the presence of a UTI. However, neither of these findings has been demonstrated to be clearly associated with either bacteriuria or a UTI [2,25].

Rarely, purple discoloration of the urine, collection bag, and tubing (purple urine bag syndrome [PUBS]) can occur due to metabolic byproducts of certain bacteria that may be present in the system [20]. Risk factors include bacteriuria, constipation, and female gender. PUBS is benign and has not been demonstrated to have any implication other than the possibility of a UTI. (See 'Pathogenesis' above.)

**Laboratory findings** — Pyuria is a common finding in catheterized patients with bacteriuria, whether they are symptomatic (ie, have UTI) or not. However, in a series of 761 catheterized patients, quantitative urine WBC >10 cells/microL had low sensitivity for predicting growth of >10^5 colony forming units (cfu)/mL (47 percent) [26]. Specificity, on the other hand, was 90 percent. The vast majority of these patients had no symptoms attributable to UTI.

By definition, all patients with catheter-associated UTI have bacteriuria or funguria. The vast majority of patients with symptomatic bacteriuria (ie, UTI) have bacterial culture growth ≥10^5 cfu/mL or fungal growth in urine, although occasionally bacterial counts as low as 10^2 cfu/mL have also been described in individuals with UTI in the absence of
a catheter [27,28]. The frequency of low count bacteriuria in the setting of catheter-associated UTI is not clearly defined but expected to be very low [2,29]. The spectrum of associated pathogens is discussed elsewhere. (See ‘Spectrum of organisms’ above.)

**DIAGNOSIS**

**General approach** — The diagnosis of a catheter-associated UTI is made by the finding of bacteriuria in a catheterized patient who has signs and symptoms that are consistent with UTI or systemic infection and are otherwise unexplained. A UTI diagnosed in a patient who had a catheter removed within the past 48 hours is also considered a catheter-associated UTI. (See ‘Definitions’ above.)

Consistent findings may be specific to the urinary tract (eg, costovertebral angle tenderness) or may be more general, such as fever, leukocytosis, malaise, delirium, fall in blood pressure, metabolic acidosis, or respiratory alkalosis. If the diagnosis is based on such nonspecific findings, the evaluation should rule out the possibility of other infections (eg, bacteremia, pneumonia, skin or soft tissue infection) prior to attributing them to a catheter-associated UTI.

Because the symptoms and signs of catheter-associated UTI can be nonspecific, a fair amount of clinical judgment and individualization is required. As an example, although urine bacterial counts as low as $10^2$ cfu/mL have been associated with UTI without catheterization, the vast majority of patients with catheter-associated UTI have counts $\geq 10^5$ cfu/mL; thus it is reasonable to have a higher threshold for attributing nonspecific symptoms to a UTI in the setting of lower bacterial counts, particularly if the isolated organisms are not Enterobacteriaceae.

Certain findings, such as pyuria and the appearance or smell of the urine, should not be used to diagnose a UTI when found in isolation. Pyuria is frequently found in catheterized patients with bacteriuria, whether they have symptoms or not, and odorous or cloudy urine has not been demonstrated to be indicative of either bacteriuria or UTI. On the other hand, the absence of pyuria in a symptomatic catheterized patient suggests a diagnosis other than UTI. (See ‘Clinical features’ above.)

**Specimen collection** — Ideally urine samples for culture should be obtained by removing the indwelling catheter and obtaining a midstream specimen. If ongoing catheterization is needed, the catheter should be replaced prior to collecting a urine sample for culture, to avoid culturing bacteria present in the biofilm of the catheter but not in the bladder.

Many systems have a "needleless" site that can be cleansed prior to specimen collection. If a sample is being collected without catheter removal, urine should be obtained from the port in the drainage system (figure 1) [29]. For circumstances in which the above approaches are not possible, the culture should be obtained by separating the catheter from the drainage system. Although this approach is associated with some risk of introducing microbes into the closed system, culture results from urine collected from the drainage bag cannot be used to guide treatment.

In the setting of condom catheters, it can be difficult to distinguish true infection from skin and mucosal contamination [16,30]. In these cases, a clean catch midstream specimen should be obtained, or urine should be collected from a freshly applied condom catheter after cleaning the glans [30]. (See "Sampling and evaluation of voided urine in the diagnosis of urinary tract infection in adults").

**TREATMENT** — The approach to treatment of catheter-associated urinary tract infection (UTI) includes antimicrobial therapy and catheter management.

**Antimicrobial therapy** — Antimicrobial therapy of catheter-associated UTI is similar to that for acute complicated cystitis. This is discussed in detail elsewhere. (See ‘Acute complicated cystitis and pyelonephritis’, section on ‘Treatment’.)

Antimicrobial selection should be based upon the culture results when available. However, in some cases (eg, in septic or otherwise seriously ill patients, in the presence of major comorbidities) prompt treatment is warranted prior to the availability of culture data. In such cases, empiric antimicrobial choice should be tailored to results of past cultures, use of prior antimicrobial therapy, community prevalence of antimicrobial resistance, and antimicrobial allergies of the patient. Urine Gram stain, if available, can also guide empiric antimicrobial choice. If not available, empiric therapy should provide coverage against gram-negative bacilli.

If the patient is not seriously ill, and one does not suspect multi-drug resistance, gram-negative bacilli may be treated empirically with a third-generation cephalosporin (eg, ceftriaxone 1 g IV once daily or cefotaxime 1 g IV every eight
hours) or a fluoroquinolone (eg, ciprofloxacin at 500 mg PO or 400 mg intravenously twice a day or levofloxacin 250 to 500 mg PO or IV once daily). If the patient is more seriously ill or if presence of multi-drug resistance is suspected (eg, any patient in the ICU or a patient who has been in the hospital for several days), then broader spectrum empiric regimens should be used. As an example, if Pseudomonas aeruginosa is suspected, treatment with ciprofloxacin, ceftazidime (1 g IV every eight hours) or cefepime (1 g IV every 12 hours) may be administered. If an extended-spectrum beta-lactamase (ESBL) producing organism if suspected (usually based on prior cultures), treatment options are generally limited to a carbapenem. (See "Acute complicated cystitis and pyelonephritis", section on 'Treatment'.)

Gram positive cocci on urine Gram stain may represent enterococci or staphylococci; empiric management with vancomycin is generally appropriate pending further susceptibility data. (See "Treatment of enterococcal infections".)

Once culture and susceptibility results are available, the antimicrobial regimen should be tailored to the specific organism isolated. The optimal duration of therapy is uncertain. Depending on the clinical response, the infecting organism, and the agent used for treatment, 7 to 14 days of therapy is generally appropriate (with use of the longer end of this range for patients who respond slowly) [2]. Oral therapy can be used for some or all of the treatment course if the organism is susceptible and the patient is well enough to take oral medication with adequate absorption.

**Catheter management** — The optimal approach to catheter management in the setting of urinary tract infection (UTI) is uncertain, although minimization of the use of indwelling catheters, when possible, is preferred. In general, patients who no longer require catheterization should have the catheter removed and receive appropriate antimicrobial therapy [31,32]. Patients who require extended catheterization should be managed with intermittent catheterization, if possible. (See "Placement and management of urinary bladder catheters", section on 'Catheter removal' and "Placement and management of urinary bladder catheters", section on 'Clean intermittent catheterization'.)

Intermittent catheterization is associated with a lower rate of bacteriuria and UTI than long term indwelling catheterization [33]. If long term catheterization is needed and intermittent catheterization is not feasible, the catheter should be replaced at the initiation of antimicrobial therapy [34]. Catheter replacement is associated with fewer and later relapses than retaining the original catheter, as biofilm penetration of most antimicrobials is poor [35].

**COMPLICATIONS** — Important complications of catheter-associated urinary tract infections (UTIs) include bacteremia and involvement of the upper urinary tract.

Approximately 20 percent of healthcare-associated bacteremias arise from the urinary tract, and the mortality associated with this condition is about 10 percent [1]. In the intensive care unit setting, a lower proportion of bacteremia is attributable to catheter-associated UTIs [2].

Upper tract infection is another important consequence of catheter associated urinary tract infection. In an autopsy series of 75 nursing home patients, the incidence of renal parenchymal inflammation was higher in those with a catheter in place at the time of death than in those who were not catheterized (38 versus 5 percent) [36]. The implications of this finding are not known.

**ASYMPTOMATIC BACTERIURIA** — Bacteriuria in the absence of symptoms is very common among catheterized patients [6]. Treatment of asymptomatic bacteriuria does not affect patient outcomes, including the risk of complications and or the subsequent development of UTI symptoms, and increases the likelihood of emergence of resistant bacteria [2,37,38]. Thus, with few exceptions, screening and treatment for asymptomatic bacteriuria in catheterized patients is not indicated. (See "Approach to the adult with asymptomatic bacteriuria", section on 'Whom not to treat'.)

Evaluating for asymptomatic bacteriuria in patients with indwelling catheters is warranted only in the setting of pregnancy or prior to urologic procedures for which mucosal bleeding is anticipated because of very specific risks of bacteriuria in these particular populations. (See "Urinary tract infections and asymptomatic bacteriuria in pregnancy", section on 'Asymptomatic bacteriuria' and "Approach to the adult with asymptomatic bacteriuria", section on 'Urologic intervention'.)

**PREVENTION** — In general, the most important aspects of prevention of catheter-associated urinary tract infections (UTI) are avoidance of unnecessary catheterization, use of sterile technique when placing the catheter, and removal of the catheter as soon as possible. There is no clear benefit to using either antibiotic-coated urinary catheters or
prophylactic antibiotics to reduce the risk of catheter-associated urinary tract infection. These and other issues related to catheter care for prevention of UTI are discussed in detail separately. (See "Placement and management of urinary bladder catheters", section on 'Catheter care' and "Placement and management of urinary bladder catheters" and "Placement and management of urinary bladder catheters", section on 'Catheter removal' and "Placement and management of urinary bladder catheters", section on 'Prophylactic antibiotics'.)

RECOMMENDATIONS OF OTHERS — Several expert and governmental groups have released guidelines or recommendations on the identification, management, and prevention of catheter-associated urinary tract infections (UTIs) [1,2,11,39]. All of them stress restricting the use of indwelling catheters and those that address treatment recommend avoidance of unnecessary antimicrobial use for asymptomatic bacteriuria.

The Infectious Diseases Society of America (IDSA), in collaboration with other international expert groups, released practice guidelines on the diagnosis, prevention, and treatment of catheter-associated UTI in 2009 [2]. The discussion in this topic is generally consistent with those guidelines.

In 2014, a collaborative panel sponsored by the Society for Healthcare Epidemiology of America (SHEA) released recommendations on the prevention of catheter-associated UTI [11]. This publication highlighted the importance of the judicious use of urethral catheters only for appropriate indications, adequate expertise and sterile technique for insertion, continued assessment of the necessity of catheterization, and maintenance of a sterile, continuously closed drainage system that allows unobstructed urine flow.

SUMMARY AND RECOMMENDATIONS

● Catheter-associated urinary tract infections (UTIs) are a common healthcare-associated infection. Bacteriuria in patients with indwelling bladder catheters occurs at a rate of approximately 3 to 10 percent per day of catheterization. Of those with bacteriuria, approximately 10 to 25 percent develop UTI. The most important risk factor is the duration of catheterization. Other risk factors include errors in catheter care. (See 'Epidemiology' above.)

● Fever is the most common symptom of catheter-associated UTI. Pyuria is usually present. Localizing symptoms may include flank or suprapubic discomfort, costovertebral angle tenderness, and catheter obstruction. Nonspecific findings include new-onset delirium or other systemic manifestations that suggest the possibility of infection. However, these symptoms are not specific to UTI and may be seen in catheterized patients without bacteriuria. Pyuria is also common in catheterized patients with bacteriuria without UTI. (See 'Clinical features' above.)

● The diagnosis of a catheter-associated UTI is made by the finding of bacteriuria in a catheterized patient who has signs and symptoms that are consistent with UTI or systemic infection and are otherwise unexplained. Consistent findings may be specific to the urinary tract or may be more general, such as fever, leukocytosis, malaise, or signs of sepsis. If the diagnosis is based on such nonspecific findings, the evaluation should rule out the possibility of other systemic infections (eg, bacteremia, pneumonia, skin or soft tissue infection) prior to attributing them to a catheter-associated UTI. (See 'Diagnosis' above.)

● Ideally, urine samples for culture should be obtained by removing the indwelling catheter and obtaining a midstream specimen or, if ongoing catheterization is warranted, a specimen through a new catheter. When this is not possible, the culture should be obtained through the catheter port, not the drainage bag. (See 'Specimen collection' above.)

● Antimicrobial selection should be based upon the culture results when available. However, in some cases, prompt treatment is warranted prior to the availability of culture data. In such cases, empiric antimicrobial choice should be tailored to results of past cultures, use of prior antimicrobial therapy, community prevalence of antimicrobial resistance, and antimicrobial allergies of the patient. Urine Gram stain, if available, can also guide empiric antimicrobial choice. Depending on the clinical response, the infecting organism, and the agent used for treatment, 7 to 14 days of therapy is generally appropriate. (See 'Antimicrobial therapy' above.)
In general, patients with infection who no longer require catheterization should have the catheter removed and receive appropriate antimicrobial therapy. Patients who require extended catheterization should be managed with intermittent catheterization, if possible. If long term catheterization is needed and intermittent catheterization is not feasible, the catheter should be replaced at the initiation of antimicrobial therapy. (See ‘Catheter management’ above.)

Evaluating for asymptomatic bacteriuria in patients with indwelling catheters is warranted only in the setting of pregnancy or prior to urologic procedures for which mucosal bleeding is anticipated. For other asymptomatic patients with indwelling catheters, routine urine cultures and urinalyses are not warranted and treatment of incidentally discovered asymptomatic bacteriuria is not indicated. (See ‘Asymptomatic bacteriuria’ above.)

Avoidance of unnecessary catheterization, use of sterile technique for insertion, and removal as soon as possible are essential to the prevention of catheter-associated UTI. Antimicrobial agents have no role in prevention of infection for the majority of patients with urinary catheters. (See ‘Prevention’ above and "Placement and management of urinary bladder catheters").

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REFERENCES


Ideally urine samples for culture should be obtained by removing the indwelling catheter and obtaining a midstream specimen. If ongoing catheterization is needed, ideally the catheter should be replaced prior to collecting a urine sample for culture, to avoid culturing bacteria present in the biofilm of the catheter but not in the bladder. Many systems have a "needleless" site that can be cleansed prior to specimen collection. If a sample is being collected without catheter removal, urine should be obtained from the port in the drainage system. For circumstances in which the above approaches are not possible, the culture should be obtained by separating the catheter from the drainage system. Although this approach is associated with some risk of introducing microbes into the closed system, culture results from urine collected from the drainage bag cannot be used to guide treatment.