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Catheter Associated Urinary Tract Infections – A Guide To Assessment And Management Strategies

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A B S T R A C T

One of the most frequent diseases that patients in healthcare institutions get is a urinary tract infection linked to the use of an indwelling urine catheter. The length of catheterisation is a crucial factor in the development of bacteriuria, as biofilm eventually forms on all of these devices. Despite the low percentage of bacteriuric people who have symptoms, the high frequency of indwelling urinary catheter usage indicates that these infections are responsible for a significant burden of disease. About 20% of incidents of healthcare-acquired bacteremia in acute care facilities and more than 50% in long-term care facilities are caused by catheter-acquired urine infections. Limiting the use of indwelling catheters and, when required, stopping their use as soon as it is clinically practicable are the most effective ways to avoid bacteriuria and infection. Healthcare institutions' infection control systems must put methods in place and keep an eye on them in order to reduce catheter-acquired urinary infections. These tactics include monitoring catheter use, ensuring that indications are suitable, and keeping an eye out for problems. At the end, developing catheter materials that inhibit biofilm formation through technological advancements will be necessary to prevent these infections.

Keywords: Urinary catheter, Bacteriuria, Urinary tract infection, Health care acquired infection, Indwelling urethral catheter

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INTRODUCTION

One of the most frequent infections obtained in medical settings is catheter-acquired urinary tract infection [1, 2], with 70–80% of cases linked to the use of an indwelling urethral catheter. According to recent prevalence studies, the most prevalent indwelling device is a urinary catheter, which is present in 17.5 % of patients in 66 hospitals in Europe and 23.6 % of patients in 183 hospitals in the US [1 - 2]. 45 – 79 % of patients on adult critical care units, 17 % of patients on medical wards, 23 % of patients on surgical wards, and 9 % of patients on rehabilitation units had an indwelling catheter, according to the NHSN 2021 surveillance report [3]. Consequently, the use of indwelling urethral catheters is very prevalent in healthcare settings. One of the main objectives of health-care infection prevention programs is the prevention of infections caused by these devices. Urinary catheters that are in place for longer than 30 days are usually classified as chronic or long-term, while those that are in place for less than 30 days are classified as short-term [4]. While long-term care facility residents are more likely to utilise chronic catheters, indwelling catheter usage is often temporary in acute care facilities. Different factors may apply to short and long-term catheters. Asymptomatic bacteriuria (CA-ASB) is the most common manifestation of a urinary catheter acquired infection. People who have a symptomatic infection are referred to as having a catheter-associated urinary tract infection (CA-UTI) [4]. However it was sometimes not possible to distinguish between asymptomatic and symptomatic catheter-acquired infections in the early studies. Men's external catheters or intermittent catheter usage for either gender will not be included in this study; it solely focusses on indwelling urethral catheters.

BURDEN OF ILLNESS

Asymptomatic bacteriuria - The most significant factor influencing bacteriuria is the length of catheterisation [4]. When an indwelling catheter is in place, the daily chance of contracting bacteriuria is 3 - 7%. Women and elderly people have greater acquisition rates [4]. After a catheter is in place for a few weeks, bacteriuria develops everywhere. It is considered that patients with long-term indwelling catheters are consistently bacteriuric. Antimicrobials are given to 60–80% of hospitalised patients who have an indwelling catheter, mainly for purposes other than urinary tract infections [5]. Antimicrobial resistant organisms are commonly identified from the urine of catheterised persons due to their high exposure to antibiotics. In Michigan, a state-wide monitoring program for carbapenemase-resistant Enterobacteriaceae (CRE) revealed that 61 % of isolates were from urine cultures, and 48% of these patients had a urinary catheter [6]. Acute care institutions have documented that outbreaks of resistant organisms can originate from bacteria colonising the drainage bags of catheterised patients [4, 7]. The most frequent location where resistant gramme negative organisms are isolated in nursing homes is from the urine of individuals who have persistent indwelling catheters [8, 9].

Symptomatic urinary tract infection - CA-UTI is the most prevalent adverse event associated with indwelling urinary catheter usage, but only a small fraction of acute care unit individuals with CA-ASB acquire symptomatic infection [10]. Urinary tract infections accounted for 1.3 % of all patients in the European Prevalence Survey, making them the third most common infection overall and 17.2 % of all illnesses acquired in hospital settings [1]. The number of intrusive devices, such as indwelling urethral catheters, was shown to be independently correlated with the occurrence of any healthcare-acquired infection; however, the percentage of patients who had both a catheter and a urinary infection was not disclosed. Urinary tract infections accounted for 12.9 % of healthcare infections, according to a recent US point prevalence study; 67.7 % of these patients had a urinary catheter [2]. Urinary tract infections are the fourth most prevalent kind of infection. 0.3 % of all urinary catheter days at one Veteran Affairs (VA) hospital had a symptomatic UTI [11]. A British investigation that compared several kinds of catheters found that 10.6 % - 12.6 % of catheterised patients had CA-UTI, while only 3.2 % - 5.0 % of infections had microbiologic confirmation [12].

Table 1: Incidence of symptomatic catheter-acquired urinary infection (CA-UTI)

Country	Population	CA-UTI rate/1000 catheter days	References
France	ICU	14.8 (1995), 8.8 (2004)	[13]
Germany	ICU	1.39 (before 2000), 0.83 (2001, 2002), 0.68 (2003 or later)	[14]
15 developing countries	ICU	7.86 (pre-intervention) 4.95 (post-intervention)	[15]
US NHSN	Critical Care Medical Surgical Burn Postpartum Rehabilitation	1.2 – 4.1 1.5 3.2 4.8 0.5 3.1	[10]
Cyprus	ICU	2.0 – 3.0	[16]

Among various adult ICUs, the reported CA-UTI rates in hospitals decreased by 18.5 % - 67 % between 1990 and 2007 [17]. Over the course of a 10 years observation period, a 66% drop was documented in France [13]. More intensive preventative measures are partly to blame for this decline, although definition changes to exclude asymptomatic bacteriuria have also played a role. 3–10% of people in long-term care institutions in the USA are kept on chronic indwelling catheters [18]. According to European surveillance reports, 10.1% of patients in 40 facilities in Germany [21], 12.3 % of residents in 92 homes in Italy [20], and 12 % of residents in 10 nursing homes in the Netherlands [19] had indwelling catheters. In 78 Swedish nursing facilities, the percentage of residents with chronic indwelling catheters was 7 % overall, but just 3 % for women and 16 % for males [22]. Persistent catheter users are more likely to experience symptoms of a urinary tract infection. In Idaho's long-term care institutions, CA-UTI rates ranged from 0 - 7.3/1000 catheter days (mean 3.2/1000) reported [23]. Three times as many residents get fever from a suspected urine source (0.7–1.1/100 catheter days) as those who have bacteriuria but do not have a urinary catheter [24, 25].

Bacteremia - Although less than 3% of patients with CA-ASB get bacteremia from the urine isolate [10], CA-UTI is one of the most frequent causes of secondary bloodstream infections in acute care hospitals due to the high rate of indwelling urinary catheter usage. In Quebec, urine sources accounted for 21% of healthcare-acquired bloodstream infections over a three-year period, with devices contributing to 71% of these cases. Urinary bloodstream infections occurred 1.4 times for every 10000 patient days. In patients with CA-UTI bacteremia, the 30-day all-cause death rate was 15% [26]. More than 50% of bacteremia events in long-term care settings are caused by CA-UTI [4, 27]. In these settings, patients with indwelling catheters had a 3 to 36 fold increased incidence of bacteremia compared to those without one [28].

Other morbidities - Additional infectious problems that are typically found in patients who have a persistent indwelling catheter include gland abscesses, bladder urolithiasis, blockage of the urinary catheter, purulent urethritis, and prostatitis in men [24]. The following non-infectious side effects of an indwelling urinary catheter have been reported: urethral strictures, nonbacterial urethral inflammation, mechanical stress, and decreased mobility [29, 30]. 1.5 % of catheter days with prospective daily catheter surveillance revealed genitourinary damage related to the indwelling catheter [11]. Numerous research findings indicate a correlation between CA-UTI and elevated death rates as well as extended stays in acute care hospitals. With little to no mortality directly related to CA-UTI in critical care unit patients, these relationships are probably due to confounding by unmeasured covariates [31]. Residents of long-term care facilities who have chronic indwelling catheters die at a higher rate than residents who do not have a catheter; however this finding can also be attributed to confounding from different patient characteristics rather than a clear link to urinary tract infections [32].

PATHOGENESIS OF INFECTION

Biofilm - The primary cause of bacteriuria is biofilm development along the catheter surface [33]. Microorganisms developing in colonies within an extracellular mucopolysaccharide substance make up biofilm, a complex organic material. This substance contains elements of urine, such as calcium and magnesium ions, as well as Tamm-Horsfall protein. As soon as the catheter is inserted, organisms attach themselves to a conditioning coating of host proteins that develops along the catheter's surface, which is when biofilm development starts. Catheter surfaces on the inside as well as the outside are affected. Typically, bacteria come from the periurethral region or go up the drainage tube after colonising the drainage bag. The introduction of periurethral organisms into the bladder after catheter placement is the cause of only around 5 % of CA-ASB incidents. The habitat that biofilm-growing organisms are in protects them from host defences and antimicrobials. When an indwelling catheter is inserted, the first episode of bacteriuria often corresponds to a single species. In the event that the catheter stays in place and a mature biofilm forms, polymicrobial bacteriuria will often occur. Three to five organisms are often isolated for patients with long-term indwelling catheters [34, 35]. While the catheter is in place, the microbiology of the biofilm on an indwelling catheter is dynamic due to the ongoing turnover of organisms in the biofilm [36]. New organisms continue to be acquired by patients at a rate of around 3 - 7% every day. There is a lack of clarity on the causes of CA-UTI. Catheter trauma and blockages are known precipitating events. According to reports, male sex, renal illness, and neutropenia are risk factors for bloodstream infection from a urine source in acute care patients [37]. According to a research, bacteremia is not a serious side effect of long-term indwelling catheter replacement [28].

Microbiology - *Escherichia coli* is the most frequent bacteria that cause infection [4]. *Pseudomonas aeruginosa*, other non-fermenters, *Candida spp*., coagulase negative Staphylococcus, and other Enterobacteriaceae are also commonly isolated [24]. Organisms resistant to antibiotics are widespread. In both acute and long-term care settings, the urine of patients who have indwelling catheters is the primary location of isolation of resistant gram-negative organisms, including CRE [6] and Enterobacteriaceae that produce extended spectrum beta-lactamases (ESBL) [8]. In acute care hospitals, *E. Coli* is often the most common species isolated from bacteremic CA-UTI patients. At one US tertiary care academic centre, however, *Enterococcus spp.* (28.4 %) and *Candida spp.* (19.7 %) were shown to be the most prevalent [38].

Table - 2: Species isolated from bacteremia attributed to catheter-acquired urinary infection

Population	US* [38]	UK [39]	Quebec [26]	US [40]**	Europe [40]**	Spain [41]
E. coli		43.4%	47%	69.3%	71.3%	42%
Klebsiella spp		7.5%		16.7%	11.2%	15%
Enterococcus spp	28.4 %	6%	8%			12%
P. mirabilis		13.3%		6.4%	5.0%	7%
P. aeruginosa		10.8%			4.1%	12%
Candida spp	19.7 %		2%			3%
*Tertiary care academic centre **Report for gram negative isolates only						

An organism of particular significance for patients requiring long-term indwelling catheters is *Proteus mirabilis*. Patients undergoing short-term catheterisation are not likely to have this species since it is seldom identified after the first colonisation of the urinary system by catheterisation [42]. The likelihood of *P. mirabilis* is higher the longer a catheter is left in place. About 40% of urine samples taken from individuals who have chronic indwelling catheters contain this bacterium [43]. Compared to other bacteria *P. mirabilis* generates abundant amounts of biofilm and these strains also have a longer half-life [36]. A crystalline biofilm may be more easily formed by urease-producing bacterial species [44, 45]. This substance is comparable to struvite (infection) stones seen in urolithiasis patients. The main reason chronic indwelling catheters get obstructed is crusts of this substance that develop along the catheter. Catheter blockage occurs in around half of patients with long-term indwelling catheters at some point, and in certain individuals, the obstruction occurs quickly and often [46, 47]. Compared to urease generated by other species, *P. mirabilis* urease hydrolyses urea several times more quickly [48]. Eighty percent of blocked catheters include this species [49]. *P. aeruginosa*, *Klebsiella pneumoniae*, *Morganella morganii*, more Proteus species, some *Providencia spp*., and certain strains of *Staphylococcus aureus* and coagulase negative staphylococci are among the other species that produce urease. Numerous species, such as *K. pneumoniae*, *P. aeruginosa*, and *M. morganii*, produce alkaline urine when they produce urease, which is why these strains are rarely linked to significant encrustation on catheters [50].

DIAGNOSIS OF CA-UTI

Microbiological diagnosis - To keep the drainage system closed, urine specimens for culture should be taken straight from the catheter or tubing. These can be gathered via the catheter collection port or by using a needle to puncture the tubing [4]. When a patient with no symptoms associated with a urinary infection has one or more organisms at quantitative counts ≥105 cful/ml from a properly obtained urine specimen, CA-ASB is diagnosed [4]. Prior to the presence of ≥105 cfu/ml, urine specimens may have lower quantitative counts isolated from them; however, these lower counts most likely indicate the presence of organisms in biofilm developing along the catheter, not bladder bacteriuria [5]. After the catheter has been in place for more than two weeks, a mature biofilm normally forms. The organisms found in the biofilm contaminate the urine that is collected through these catheters. When bladder urine is collected simultaneously with these specimens, a higher number of species and quantity of organisms are isolated. Therefore, before starting antimicrobial therapy for a symptomatic infection, it is advised that the catheter be taken out and replaced with a new one, and that a specimen be taken from the newly implanted catheter [4]. From the replacement catheter, isolated organisms with quantitative numbers less than 105 cfu/ml usually do not survive [51].

Clinical diagnosis - When a patient has symptomatic CA-UTI, the diagnosis is frequently one of exclusion [4, 24]. A fever without any localising symptoms is how CA-UTI often manifests. Although they are only present in a small percentage of cases of suspected symptomatic infection, localising signs or symptoms including catheter blockage, acute haematuria, recent trauma, suprapubic pain, or costovertebral angle discomfort or soreness are helpful in determining a urinary cause of fever. Fever in individuals with bacteriuria should only be attributed to urine infection in cases when no other possible cause is identified, if localising genitourinary signs are absent. In the absence of a different cause for the bacteremia, a diagnosis of CA-UTI is assumed when the same organism is identified from both the urine and a concurrent blood culture.

Pyuria - Patients with bacteriuria typically develop pyuria regardless of symptoms. Because the indwelling catheter itself may induce bladder inflammation, patients may experience pyuria in addition to bacteriuria [10]. Additional non-communicable reasons for pyuria consist of kidney disorders such interstitial nephritis. Pyuria in urine samples taken from patients who have an indwelling urinary catheter does not, therefore, indicate the existence of a symptomatic infection in a bacteriuric individual or the need for antibiotic therapy [4, 28].

PREVENTION OF CATHETER ACQUIRED URINARY TRACT INFECTIONS

Guidelines - The creation and upkeep of CA-UTI prevention programs are advised by a number of evidence-based guidelines [4, 7, 52-54]. Preventive measures include avoiding the use of catheters, procedures for their insertion and upkeep, the selection of catheters, monitoring CA-UTI and catheter use, and suggestions for quality indicators.

Program implementation - Limiting CA-UTI should be part of the facility's infection prevention and control program. There have been reports of improved results after implementing these programs [15, 55-57]. Each institution should have a customised program that takes into account the resources, demographic features, and local expertise. Leadership at the senior management level is a crucial component of every program [58]. The establishment of guidelines for catheter indications, selection, insertion, and maintenance is part of the infrastructure needed to support a successful program [4, 7, 52]. In addition to access to sufficient and suitable materials, there must be qualified staff members. It is important to create a method for recording the usage of urinary catheters, including the indications and the dates of insertion and removal. When using an electronic patient record, it is important to include information on the usage of the catheter as well as automated reminders to remove it. It has been explained how "bundles" were created and put into use to avoid urinary tract infections brought on by catheter use. A 37% decrease in the rate of CA-UTIs was seen after a urinary catheter bundle that includes education, recommendations for catheter placement and maintenance, and surveillance for CA-UTIs was introduced in critical care units across 15 developing nations [15]. A CA-UTI bundle containing particular, actionable suggestions addressing implementation under the principles of "engage and educate," "execute," and "evaluate" was offered as part of a state-wide program in Michigan [59].

Avoidance of catheter use - Refusing to use an indwelling urinary catheter is the single most significant measure to prevent CA-UTI. Catheter usage has just a small number of approved indications [46] –

a) Monitoring of hourly urine output in acutely ill patients.
b) Perioperative use for selected surgical procedures.
c) Urologic surgery -

- Surgery on contiguous structures of the genitourinary tract
- Large volume infusions or diuretics during surger.
- Requirement for intraoperative monitoring of urine output

a) Management of acute urinary retention and urinary obstruction.

b) To facilitate healing of open pressure ulcers or skin grafts in selected patients with urinary incontinence.

c) In exceptional circumstances (e.g. end-of-life care), at patient request to improve comfort.

When feasible, it is best to employ alternative voiding management techniques for such intermittent catheterisation. In order to reduce the risk of urine retention, institutional rules should also encourage the early removal of catheters following procedures and when feasible, utilise ultrasound bladder scanners to monitor bladder volume and restrict catheter reinsertion. When a catheter is recommended, it should be taken out as soon as it is no longer needed. When an indwelling catheter is no longer necessary, patients having them should be found, evaluated, and monitored regularly. There have been reports of catheters being left in place longer than required, sometimes due to medical staff being unaware that the catheter is there [7, 52]. The intervention of a "stop order" to facilitate prompt removal of unnecessary catheters reduced the duration of catheter use by 1.06 days, and the use of either catheter reminders or stop orders decreased the CA-UTI rate by 53%, according to a systematic review of catheter discontinuation strategies for hospitalised patients [60].

Selection of urinary catheter - To reduce urethral damage, the lowest gauge catheter need to be utilised [4, 52]. Whether a silicone or latex catheter has a hydrogel coating or not, the chances of infection remain the same. With silicone catheters, obstructions are less common in residents with long-term catheters; however, this finding is more likely due to the catheter's greater bore size than its composition. Catheters coated with silver alloy do not reduce the incidence of CA-UTI [12, 61–63]. Catheters coated with nitrofurazone have been linked to a slight reduction in CA-UTI [12], but they also come with higher pain and frequent catheter removal. Accordingly, there is currently insufficient data to justify the regular use of antimicrobial-coated catheters [52].

Catheter insertion and maintenance - The following are recommended procedures for inserting and maintaining catheters: [4, 7, 52]. Although keeping a closed drainage system has been shown to reduce the rate of bacteriuria acquisition, these suggestions are mostly based on consensus. Antiseptics added to the drainage bag and regular daily periurethral cleansing with soap, normal saline, or an antiseptic [52, 64] had no advantages.

1. **Catheter insertion:**

- Appropriate hand hygiene
- Choice of catheter
- Aseptic techniques/sterile equipment
- Barrier precautions
- Antiseptic meatal cleaning

2. **Catheter maintenance:**

- Appropriate hand hygiene
- Secure catheter
- Closed drainage system
- Obtain urine samples aseptically
- Replace system if breaks in asepsis
- Avoid irrigation for purpose of prevention of infection

Monitoring of infection - In order to record the facility's CA-UTI rate, evaluate the success of therapies, and enable comparison with benchmark rates, it is crucial to monitor catheter use and complications [7, 52]. In German critical care units, surveillance with benchmarking has been shown to reduce infection rates on its own, but with a less pronounced effect on CA-UTI than on ventilator-associated pneumonia or main blood stream infections [14]. It is recommended to employ standardised surveillance criteria for infections [52]. In order to facilitate efficient surveillance, it is necessary to gather essential data such as catheter indication, dates of insertion and removal, urine culture results, and bacteremia monitoring. The frequency of CA-UTI, the incidence of CA-UTI bacteremia, and the percentage of indwelling catheter usage that complies with recommended guidelines are pertinent quality indicators. A denominator of device days is used to explain the outcomes of bacteremic infection and CA-UTI [52]. On the other hand, as fewer low-risk patients would have catheters, an efficient infection prevention program will reduce catheter use, which might result in higher device day infection rates overall [65, 66]. As a result, the standardised infection ratio—an outcome determined by the total number of patient days should also be disclosed [7]. Committees and other relevant parties should evaluate the surveillance data and carers on patient wards should be informed of any observations made [7, 52].

Prevention of CA-UTI in long term care facilities - Residents with a chronic indwelling catheter are the main target population for CA-UTI prevention in long-term care settings [4, 24, 28]. Every resident who has a chronic indwelling catheter should have their condition reviewed often and systematically to see if the catheter is still required. It is impossible to prevent bacteriuria in these inhabitants. When possible, interventions should concentrate on removing the catheter, reducing catheter trauma, and identifying catheter occlusion early on. Regular replacement of chronic indwelling catheters is not recommended. Only in cases of blockage or other malfunction, or before starting antimicrobial medication for the treatment of a symptomatic urinary infection, should they be changed [52]. To help with mobility, residents who have chronic catheters may utilise a leg bag for drainage. Reusability, cleaning, and replacement of the leg bags should be covered by facility policies [67]. Antimicrobial therapy did not reduce CA-UTI when used to treat bacteriuria in long-term care individuals with persistent indwelling catheters; however, it does increase the isolation of resistant organisms. As a result, it is best to avoid treating bacteriuria that shows no symptoms [24].

DISCUSSION AND CONCLUSION

One significant device-associated illness related to healthcare is CA-UTI. Increased incidences of bacteremia and symptomatic urinary tract infections, as well as higher morbidity from non-infectious consequences, are linked to the use of an indwelling urethral catheter. To reduce infections brought on by the use of these devices, infection controls programs must create, put into place, and oversee rules and procedures. Reducing the number of indwelling urethral catheters and quickly removing them when no longer needed should be the main goals of these initiatives. Ultimately, nevertheless, the development of biofilm-resistant catheter materials will probably be necessary to prevent CA-ASB.

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