



REVIEW ARTICLE

Catheter-Associated Urinary Tract Infections & Health Care-Associated Infections (HAI) - Brief Review

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Abstract

Health care- associated infections (HCAIs) are infections that do while entering health care, developed in a sanitarium or other health care installation that first appear 48 hours or further after sanitarium admission, or within 30 days after having entered health care. Multiple studies indicate that the common types of adverse events affecting rehabilitated cases are adverse medicine events, HCAIs, and surgical complications. The US Center for Disease Control and Prevention identifies that nearly 1.7 million rehabilitated cases annually acquire HCAIs while being treated for other health issues and that further than cases (one in 17) die due to these. Several studies suggest that simple infection- control procedures similar as drawing hands with an alcohol-grounded hand irk can help help HCAIs and save lives, reduce morbidity, and minimize health care costs. Routine educational interventions for health care professionals can help change their hand-washing practices to help the spread of infection. In support of this, the WHO has produced guidelines to promote hand-washing practices among member countries.

Keywords: Health care-associated infections, central line-associated bloodstream infections, surgical site infections, catheter-associated urinary tract infections, ventilator-associated pneumonia

Introduction

Urinary tract infection or UTI is an infection that involves any part of the urinary system and accounts for 30-40% of healthcare-associated infections. According to the Centers for Disease Control and Prevention or CDC, UTIs are the most common type of healthcare-associated infection. Most of these infections result from inappropriate use or inadequate care of a urinary catheter [1-4].

Catheterization is a neurologic procedure wherein a hollow flexible tube called a catheter is inserted to drain urine from the bladder. Urinary catheterization dates to ancient times where Hippocrates used a urinary catheter to treat bladder stones. In the year 1935, Frederick Foley introduced the indwelling rubber balloon catheter. Later Dr. Jack Lapides, in the year 1972, described a procedure to perform clean intermittent catheterization. Ever since then, this method has become lifesaving for an individual who cannot empty their bladder [5]. Lapides et al. asserted that to reduce the urinary tract infection rate, improving the blood flow by decreasing the pressure in the bladder with intermittent catheterization is the most critical method [5,6].

The various catheters used to empty the bladder include:

Indwelling: Foley's catheter is a sterile tube that stays in the bladder. The tube is inserted directly into the bladder from the lower abdomen or through the tube. The balloon keeps the catheter from slipping out of the bladder [7].

External catheter (Condom catheter): In males, a condom-like device is slipped over the penis. The urine drains into the tube [8].

Self (clean intermittent): The catheter is inserted into the bladder regularly throughout the day. The catheter can be inserted by oneself or by a caregiver. Urine drains through the catheter into the collection bag or a container [9,10].

Catheter-Associated Urinary Tract Infection (CAUTI)

CAUTI is the presence of signs and symptoms of UTI in a patient with an indwelling catheter for longer than two days. The catheter should be in place on the day of the event or the day before it. The day of an event is when the signs and symptoms of UTI appear, and the catheter is in place for two days prior [11-15].

For surveillance, CDC NHSN has proposed a systematic criterion for catheter-associated urinary tract infection or CAUTI (Table 1 and Figure 1).

Microbiology

The most common causes of CAUTI are pathogens from the normal flora of the gut. *Escherichia coli* is the most common isolate. The second most common is *Candida* species [14].

The source of the infecting pathogen can either be:

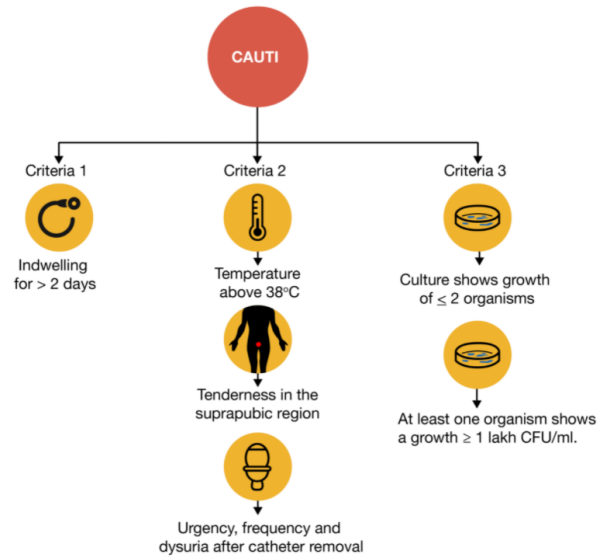


Figure 1: Criteria for CAUTI

Table 1: According to the CDC NHSN (Centers for Disease Control and Prevention) (National Health Safety Network) guidelines 2021, a patient with CAUTI must have all three of the following criteria:	
Criteria	UTI
SUTI 1a CAUTI in any age patient	<p>Symptomatic UTI (SUTI)</p> <p>One of the following criteria must be met</p> <p>The patient must meet 1, 2, and 3 below</p> <ul style="list-style-type: none"> • Indwelling catheter for a period greater than two days and it must be present on the day of the event or one day before • Patient must have any one of the following signs of infection: <ul style="list-style-type: none"> • Temperature above 38°C • Tenderness in the suprapubic region with no other recognized cause • Pain or tenderness in the costovertebral angle with no other recognized cause • Urgency after catheter removal • Frequency after catheter removal • Dysuria after catheter removal • Urine culture shows a growth of < 2 organisms of which at least one organism shows a growth $\geq 10^5$ CFU/ml
SUTI 1b Non-Catheter associated Urinary Tract Infection (Non-CAUTI) in any age patient	<p>Patient must meet 1, 2, and 3 below</p> <p>1. One of the following is true: Patient has/had an indwelling urinary catheter, but it has/had not been in place for more than two consecutive days in an inpatient location on the date of event</p> <p>OR</p> <p>2. Patient did not have an indwelling urinary catheter in place on the date of the event nor the day before the date of the event Patient has at least one of the following signs or symptoms:</p> <ul style="list-style-type: none"> • Fever ($>38^\circ\text{C}$) • Suprapubic tenderness • Costovertebral angle pain or tenderness • Urinary frequency • Urinary urgency • Dysuria <p>3. Patient has a urine culture with no more than two species of organisms identified, at least one of which is a bacterium of $\geq 10^5$ CFU/ml</p>
SUTI 2 CAUTI or Non-CAUTI in patients 1 year of age or less	<p>The patient must meet 1, 2, and 3 below:</p> <p>1. Patient is ≤ 1 year of age (with or without an indwelling urinary catheter)</p> <p>2. Patient has at least one of the following signs or symptoms:</p> <ul style="list-style-type: none"> • Fever ($>38.0^\circ\text{C}$) • Hypothermia ($< 36.0^\circ\text{C}$) • Apnea • Bradycardia • Lethargy • Vomiting • Suprapubic Tenderness <p>3. Patient has a urine culture with no more than two species of organisms identified, at least one of which is a bacterium of $\geq 10^5$ CFU/ml</p>

- Endogenous, from the flora of the urethra, rectum, and vagina
- Exogenous, from the hands of the healthcare worker or surface of contaminated equipment

The common pathogens causing CAUTI include:

- Escherichia coli
- Pseudomonas aeruginosa
- Enterococcus species
- Candida albicans
- Staphylococcus aureus
- Coagulase-negative staphylococci
- Enterobacter species
- Proteus species
- Acinetobacter species
- Klebsiella species
- Enterobacter species

Pathogenesis of CAUTI

During the insertion of a Foley catheter, bacteria can enter the bladder and colonize the urinary tract.

Pathogenic factors contributing to the development of CAUTI include:

- Contaminated tip of the catheter
- Contaminated hands of the healthcare worker
- Improper insertion technique
- Insufficient care of the catheter
- Biofilm formation by the organism
- Catheter material
- Residual urine in the bladder

The infecting organism may enter the bladder through any of the following routes:

During the insertion, the pathogens are pushed into the lower urinary tract (**Figure 2**)

- Via the external surface of the catheter (extraluminal)
- intraluminal by retrograde flow from the urine collection bag
- Hematogenous or lymphatic spread from a distant site

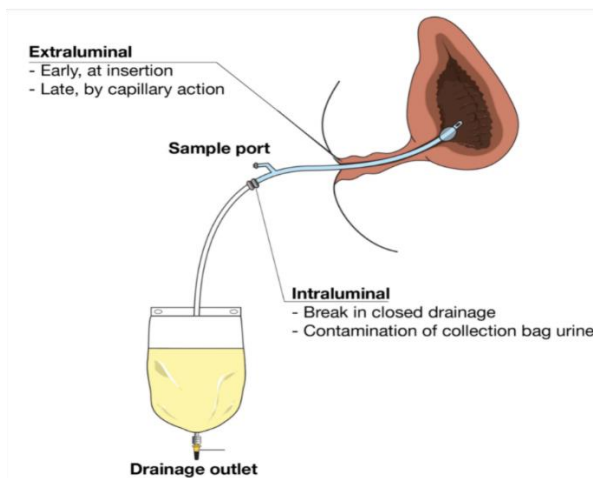


Figure 2: Pathogenesis of CAUTI

Initially, the infecting organism adheres to the epithelial cells of the lower urinary tract. Most organisms form a biofilm along the surface of the catheter. The biofilms protect them from immune attacks and antibiotics. Uropathogenic organisms invade the epithelial cells and cause inflammation and epithelial damage. The toxic material of the catheters can enhance the damage. The presence of residual urine in the bladder of catheterized patients further increases the risk of infection.

A higher risk of CAUTI is seen in the following situation:

- Catheterization for a long duration
- Colonization of the drainage bag
- Patients with diabetes
- Presence of diarrhea
- Absence of antibiotic therapy
- Women
- Renal disease
- Introduction of the catheter after a long stay in the hospital
- Immunocompromised or debilitated patients

CAUTI can further progress by a systemic spread of the infection. The complications that arise include:

- Cystitis
- Pyelonephritis
- Bloodstream infection
- Infections of the prostate, testis, and epididymis
- Endocarditis
- Meningitis
- Osteomyelitis
- Septic arthritis

Diagnosis

Laboratory Investigations

Collection of Urine for Culture

The closed system for the drainage of urine must be maintained throughout the entire period of the catheter in-situ. The sample for urine culture (**Figure 3**) must be collected from the tubing of the catheter and not from the drainage bag. Ideally, the urine must be aspirated using a sterile needle and syringe from a sampling port connected to the urine drainage system. The sampling port must be cleansed with an alcohol swab before aspiration

Some studies have shown the practice of puncturing the catheter tubing with a needle after cleansing with alcohol rub in institutions where a sampling port is not routinely available. But this is not an ideal practice, as a punctured tube can leak and lead to the entry of microorganisms into the catheter drainage system. Therefore, a punctured catheter tube must always be replaced. The urine sample collected must be transported to the laboratory in an icebox and refrigerated. Delayed processing of the urine sample beyond two hours for culture may result in overgrowth of the microorganisms and lead to false-positive results. 1% boric acid has been suggested as a preservative, but boric acid may

inhibit the growth of other bacteria and result in a false-negative result.

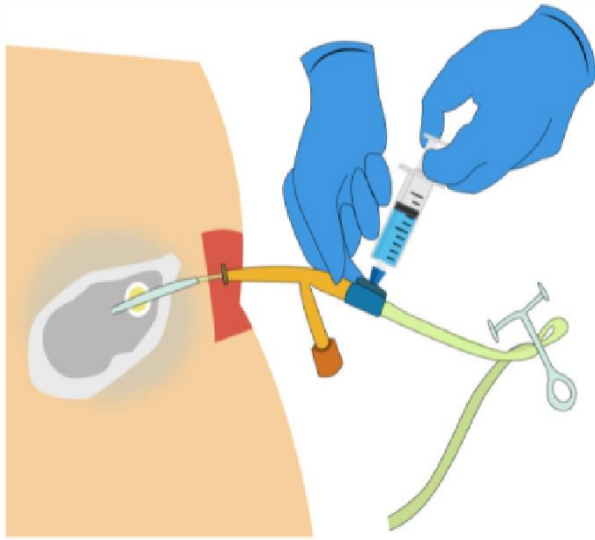


Figure 3: Sample collection for urine culture

The urine culture must show the growth of 2 or less than 2 microorganisms. At least one of the pathogens must show a heavy growth of greater than 1 lakh CFU/ml to fulfill the microbiological criteria for a diagnosis of CAUTI [16,17].

Clinical Diagnosis

Requirements for diagnosing CAUTI include clinical signs of infection and laboratory culture. Culture showing absence of clinical signs indicates asymptomatic bacteriuria. The most prominent sign of urinary tract infection is fever with chills and rigor. In the absence of other sources of infection, fever in a patient with an indwelling catheter and positive (according to the criteria) urine culture indicates CAUTI [18]. Other physical signs include suprapubic pain and costovertebral tenderness with no other recognizable cause. After removing the catheter, the patient may complain of urinary frequency, urgency, and dysuria. Altered mental status, lethargy, and pelvic discomfort are non-specific signs found in some patients.

Children below one year of age may have fever, apnea, bradycardia, vomiting, hypothermia, lethargy, or suprapubic tenderness.

Management

In most patients with asymptomatic bacteriuria, discontinuation of the catheter or replacement of the catheter will cause resolution of the bacteriuria. Though antibiotic treatment may be considered in patients with asymptomatic bacteriuria persisting beyond 48 hours, studies have shown that empirical therapy with quinolones for asymptomatic bacteriuria may not improve the long-term outcome [13,19].

Moreover, the Infectious Disease Society of America or IDSA does not recommend screening or treating asymptomatic

bacteriuria. A urine sample must be collected prior to the administration of antibiotics [20].

In patients with CAUTI, antimicrobial therapy must be continued for 7 days. In patients whom symptoms do not resolve spontaneously, or the response is delayed, the antibiotics may have to be continued for 10-14 days. Patients with bacteremia must also receive an extended duration of antibiotics [21-24].

A short course (5-day regimen) of quinolones may be considered in patients without serious illnesses or comorbidities.

Prevention

The risk for CAUTI increases with the prolonged duration of urinary catheterization. The risk increases by 5% per day as long as the catheter remains in the body. There is no single effective strategy to prevent CAUTI. However, CAUTI is categorized as a 'reasonably preventable' healthcare-associated infection. It means that if proper care is taken during catheter insertion and maintenance, CAUTI can be prevented [25].

Prevention of CAUTI calls for a **multimodal prevention approach** involving physicians, nurses, and patients as well. However, before moving into various steps involved in preventing CAUTI, it is necessary to understand the 'where' and 'when' of urinary catheterization [16].

Remember: The primary prevention strategy for CAUTI is to **avoid** unnecessary catheterization.

The World Health Organization or WHO has published a set of guidelines to prevent CAUTI, and these include

- Avoiding urinary catheterization as much as possible
- When feasible, use a two-person team to perform the insertion.
- Use sterile equipment and aseptic technique during insertion and aftercare/maintenance.
- Review the need for the catheter daily and remove it as soon as possible when no longer needed (ideally within 48 hours).
- Hand hygiene is critical.
- Don't change the catheter routinely if it is functioning properly.
- Maintain closed drainage.
- Bladder irrigation/washout and use of antiseptics/antimicrobial agents does not prevent CAUTI: do not use
- Empty drainage bag regularly into a clean receptacle used only on one patient.
- The clean receptacle should be changed daily.

Hand Hygiene Technique (Figure 4)

CAUTI Prevention Bundle is a set of structured guidelines for preventing CAUTI while improving healthcare and patient outcomes. The Bundle toolkit contains supporting resources for knowledge and tools for proper prevention.

The Components of the CAUTI Prevention Bundle include (Figure 5):

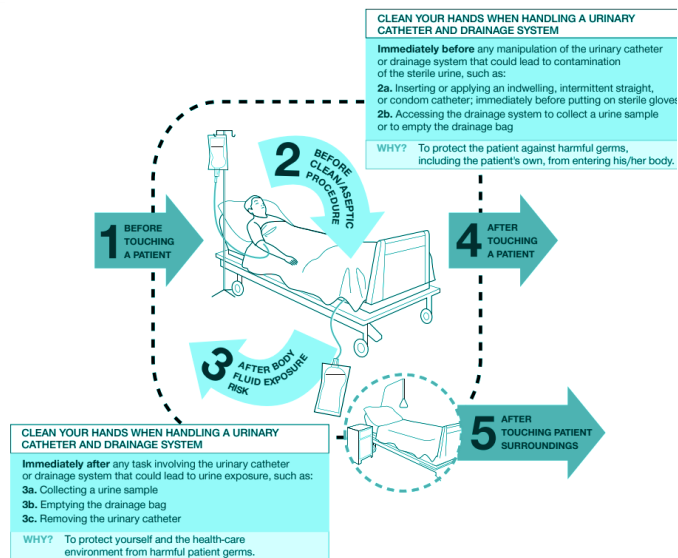


Figure 4: Hand Hygiene Technique

1. Prevent unnecessary urinary catheterization
2. Opt for alternatives to catheterization
3. Safe and aseptic insertion of catheters
4. Safe maintenance of indwelling catheters
5. Prompt discontinuation of catheterization, once the purpose is served

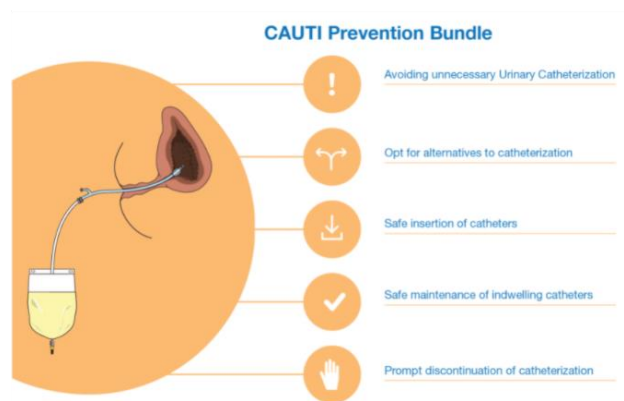


Figure 5: Components of the CAUTI Prevention Bundle include

1. Avoiding Unnecessary Urinary Catheterization:

As discussed, the legitimate use of urinary catheters will reduce the risk of CAUTI. No catheter, NO CAUTI. Literature shows that about 22%- 56% of catheterized patients would have no specific indication. Hence it is essential to avoid catheterization wherever it is not required.

Catheterization must be done only in necessary situations like

- Obstruction of bladder outlet
- Acute urinary retention
- Critically ill patients requiring accurate measurement of input and output

- Patients with spinal or pelvic fractures that require long-term immobilization
- Perioperative care in specific surgical procedures (urological surgery)
- Terminally ill patients receiving end of life care

Not all operative cases require an indwelling catheter. Judge wisely.

Avoid catheterization to manage incontinence in patients as a substitute for nursing care. Minimize the duration of urinary catheter use in post-operative cases. These must be removed as soon as possible, preferably within 24 hours. Do not use the catheter to obtain urine for diagnostic purposes if a patient can void voluntarily. Every healthcare center can create a policy reinforcing the accurate indications for urinary catheterizations, which helps avoid unnecessary catheterizations. Catheter restriction protocols, urinary retention protocols using portable bladder ultrasound units, and encouraging intermittent catheterization rather than prolonged indwelling catheterization are other prevention strategies to avoid unnecessary use of urinary catheterization.

2. Opt for Alternatives to Catheterization:

As discussed, no urinary catheter, no CAUTI. Hence, wherever possible, alternative methods of catheterization must be employed. There are various alternatives available for both males and females. In patients with no urinary retention or obstruction of the bladder outlet, external catheters can minimize the risk of CAUTI compared to indwelling catheters.

Other alternatives to urinary catheterization include

- Intermittent catheterization
- Condom catheterization
- Supra-pubic catheterization
- Incontinence pads and
- Bedside urinals/commodes.

3. Safe Insertion of Catheters:

Proper insertion of urinary catheters is essential in preventing CAUTI. Implement appropriate measures for infection control like appropriate sanitization of hands before inserting urinary catheters. A urinary catheter is inserted by trained and skilled personnel alone. Standard precautions and aseptic techniques must be followed during insertion. These include proper hand hygiene measures, sterile gloves, apron, and sterile or antiseptic solution for peri-urethral swabbing and sterile lubricant gel for insertion.

Antiseptic or antimicrobial-coated catheters may help in reducing CAUTI events. The catheter with the smallest bore must be used to prevent bladder neck trauma and urethral injuries. In non-emergency situations, clean intermittent catheterization may be performed at regular intervals as an alternative to indwelling catheters. After insertion, carefully secure internal catheters to prevent any movement of the catheter or urethral traction. Bladder ultrasound scanners may be used to measure urine volume and perform necessary intermittent catheter insertion.

4. Safe Maintenance of Indwelling Catheters:

Once the catheters are inserted, daily monitoring and proper catheter maintenance is a vital step in preventing CAUTI. The closed drainage system has to be maintained. If there is any breach or leakage from the catheter, replace it under sterile conditions. Ensure that the flow is always unobstructed due to any external pressure or kinking. Place the catheter in such a way that patient's legs do not compress it. Follow standard aseptic protocols for any manipulation. The collecting bag must always be maintained below the bladder level and should never be put on the floor. Collecting bags must be emptied on a regular basis. In case of anticipated obstruction, for example, after prostatic surgery, closed continuous irrigation is recommended. Routine bladder irrigation with antimicrobials or antiseptics is not advocated. Maintain unobstructed, gravity-dependent flow within the catheter. If any signs of obstruction, infection, or compromise of the closed system occur, then the entire closed drainage system must be replaced.

Standard precautions must be followed during any form of manipulation of the catheter.

Infection control nurses should monitor the catheterized patients

5. Prompt Discontinuation of Catheterization:

Urinary catheters have to be discontinued as soon as possible. However, often, urinary catheters are left in place even when they are no longer required. This is because every passing day with the urinary catheter in situ increases the risk of CAUTI.

Catheter reminder charts/protocols, daily maintenance checklist, stickers or markings on patient's chart, or electronic reminders will help remove catheters that are no longer needed. Usually, nurses get approval from the physicians to remove the unnecessary catheters. However, this usually takes a long time and delays the process of catheter removal. Hence administering nurse-driven protocols for the removal of urinary catheters will be helpful in healthcare setups to prevent the risk of CAUTI.

CAUTI Prevention Education and Training:

All healthcare workers must receive proper education and training in the appropriate insertion and care of the catheters to prevent the incidence of CAUTI. Also, educating patients about the risk of CAUTI after catheter insertion and possible hygiene measures will help in further prevention.

Table 2: HOUDINI Protocol

Step 1	Tick in the box, if patient meets the criteria	Yes/No
	Hematuria	
	Obstruction of urinary flow	
	Urologic operative procedure	
	Decubitus ulcer	
	Input & Output	
	Neurogenic dysfunction of the bladder	
	Immobilization; like in unstable fractures, severe trauma	
	In case if any criteria were met, DO NOT REMOVE the catheter	
Step 2	If none of the criteria are met, the catheter may be removed as per the nursing protocol	
Step 3	Monitor and evaluate the patient after removal of the catheter	
	Within 6 hours of removal, check for voiding	
	Notify the physician if the patient hasn't voided within 6 hours	
	If patient voids spontaneously within 6 hours, use a bladder scan to evaluate the volume	
	Volume if >200 mL and <300 mL, reassess after 2 hours	
	If volume is >300mL, straight catheterization, record the findings	

If bladder scan is not available, check for bladder distention, evaluate patient's comfort. Based on the assessment, perform straight catheterization

daily by conducting rounds and utilizing a checklist. Nurse-driven catheter removal protocols like '**HOUDINI urinary catheter removal protocols**' (Table 2) can be used. However, all catheters must be removed after informing the physician [26,27].

Healthcare workers and nurses should be aware of indications, proper insertion, and maintenance procedures. Education regarding the correct handling of catheters in aseptic conditions before insertion, daily monitoring, and fair maintenance practices will help infection prevention nurses to handle any adverse events.

Educating patients regarding maintenance of hygiene and preventing compression of the catheter tubes will also help prevent CAUTI.

Summary



Figure 6: Summary of CAUTI

CAUTI remains a persistent challenge to infection control practitioners and health care workers, though it is categorized as 'reasonably preventable' healthcare-associated infection. Strategies for the prevention of CAUTI can be implemented in

healthcare setups. All healthcare workers involved play an essential role in preventing this infection (Figure 6).

Limitations of the Study

The topic of HCAs is a very broad issue, and it has therefore not been possible to cover all aspects of HCAs in one paper; hence, we have been selective in selecting key aspects of the current debate.

Disclosure

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