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Prevention of Catheter-Associated Urinary Tract Infections

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1. Introduction

Urinary catheter placement is an extremely common medical intervention. It can be used either temporarily, for example to drain a full bladder, to monitor urine output or it can be indwelling for long term drainage. While urinary catheters are a safe medical practice, complications can and do arise from their use and can be a source of morbidity for hospital or nursing home residents. The term “catheter fever” was used for the first time in 1883 [1] and it has been 50 years since Beeson, et al., recognized the potential harms arising from urethral catheterization and penned an editorial to the American Journal of Medicine titled “The case against the catheter” [2]. Nowadays, it is well recognized that catheter-associated infections (CAUTIs) cause the vast majority of nosocomial urinary tract infections (UTIs) [3, 4]. Designing an effective strategy for prevention of CAUTI presupposes an in depth knowledge of epidemiology, pathogenesis, microbiology and risk factors for all medical personnel.

2. Epidemiology

Generally, UTIs comprise the 40% of hospital-acquired infections [5-9] and 80% of them are CAUTIs [10-11]. CAUTIs are directly related with the use of indwelling urinary catheters [12, 13]. Up to 25% of patients have an indwelling catheter placed at some time during their hospital stay [3]. CAUTIs are associated with increased morbidity, mortality, length of hospital stay and cost. It has been estimated that one episode of nosocomial acquired UTI adds 1–3 days of extra hospital stay [3]. Moreover, the annual cost of CAUTIs is estimated to be \$340-370 million [14, 15].

The prevalence of nosocomial-acquired UTIs in Urology departments was estimated to be 10% in the Pan European Prevalence study and 14% in the Pan Euro Asian Prevalence study [16]. In the same study, the largest group was that of asymptomatic bacteriuria (29%) followed by cystitis (26%), pyelonephritis (21%), and urosepsis (12%). There were 0.61 catheters per patient. 51% of the catheters were transurethral with continuous drainage, 10% transurethral with open drainage, 2% clean intermittent catheterization, 11% suprapubic catheters, 12% nephrostomy tubes and 14% ureteral stents [16].

Urinary catheters are responsible for nearly 97% of UTIs in ICUs [12, 13]. Recently published data, regarding device-associated infections within intensive care units (ICUs) collected by hospitals participating in the International Nosocomial Infection Control Consortium (INICC) between January 2003 and December 2008, showed an overall mean CAUTIs rate from 0.4 to 13.9 per 1000 urinary catheter-days [17]. The distribution was lower in the surgical-cardiothoracic ICUs and higher in the Neurosurgical ICUs. Mean crude mortality and mean excess mortality rate for CAUTIs in ICUs were 32.9% and 18.5% respectively. Surgical-cardiothoracic and Neurosurgical ICUs had the highest urinary catheter utilization ratios (0.93 and 0.86 respectively). Pediatric ICUs had the lowest mean CAUTI and mean catheter utilization ratios (4.4 and 0.17 respectively) [17].

It has also been reported that 7.5% and 5.4% of nursing home residents in the USA and Europe respectively are long-term catheterized [18, 19]. Indwelling catheters in nursing home residents are used more commonly in men than in women with the most common indication that of urinary retention in men (87%) and in women (58%) [20]. In a web-based survey among nursing home residents, the percentage of residents with indwelling/suprapubic catheters and infections was 21.7% [21]. The overall incidence and prevalence of symptomatic UTs in the studied population were 29.2% and 1.64% respectively.

3. Pathogenesis-mechanisms

The main route of infection in CAUTI is ascending. This happens by two main mechanisms: Firstly, extraluminally through migration of bacteria along catheter surfaces and secondly due to colonization of the catheter bag or contamination of the junction between the catheter and the catheter bag [22, 23].

In an animal model, it was found that in short-term catheterization, less than 7 days, contamination of the drainage spout or accidental disconnection of the drainage tube resulted in bacteriuria within a short time (32-48 hours). If a strict sterile closed drainage system was maintained, the extraluminal route assumed more importance in the development of bacteriuria; however this pathway was considerably slower (72-168 hours) [22].

In a prospective clinical study, 66% of the infections were extraluminally acquired and 34% were derived from intraluminal contaminants [23]. Gram-positive cocci and yeasts were more likely to be extraluminally acquired than were gram-negative bacilli, which caused CAUTIs by both routes equally. In the same study, there were no significant differences in pathogenetic mechanisms between the two sexes.

Origination of bacteria is from endogenous organisms either from rectum or colonizing the patient's perineum [23-25]. In one of these studies, colonization of periurethral area was more prevalent in women than in men [23].

Bacteria adhere to catheters via a variety of molecules such as fimbriae, hemagglutinin or capsular polysaccharide [26]. Once bacteria have attached to surfaces of catheters, they grow in glycocalyx-enclosed microcolonies and produce a biofilm on the catheter surface which is associated with CAUTIs [27]. Studies have shown that bacteria in this microenvironment are resistant to antibiotics for two reasons [28-30]. Firstly, they are metabolically inactive, perhaps due to low concentration of oxygen [28] and secondly, biofilm acts as a physical barrier to diffusion of antibiotics and host defense mechanisms [29-31]. On the contrary, planktonic-free floating bacteria in urine are susceptible to antibiotics [32-33]. It is worth noting that these two populations are not always identical.

Indwelling catheters not only act as a nidus for bacteria but they also cause physical trauma to normal urothelium, they may promote inflammatory reaction, alter metabolic activity and cell proliferation which facilitates bacterial infection [26]. Recently, an in vitro study which used bladder cancer cell cultures found that catheters are involved in disruption of bladder epithelial cell membranes as a result of physical abrasion which was followed by delayed inflammation in response to bacterial infection [34].

Figure 1 presents schematically all the possible mechanisms involved in pathogenesis of CAUTIs.

4. Microbiology of CAUTIs

The majority of uropathogens are fecal contaminants or skin residents from the patient's own native or transitory microflora that colonize the periurethral area. As it has already been mentioned CAUTIs caused by gram-positive cocci and yeasts are far more likely to be extraluminally acquired than were gram-negative bacilli, which caused CAUTIs by both routes equally [23].

CAUTIs in short-term catheterization is usually produced by single species and *Escherichia coli* remains the most common infecting organism. However, a wide variety of other gram negative microorganisms may be isolated like *Klebsiella* spp., *Enterobacter* spp, and *Serratia* spp [35, 36]. Gram positive cocci including coagulase-negative staphylococci and *Enterococcus* spp have also been isolated [37, 38]. Other species commonly found in patients with short-term catheterization are *Proteus* spp. and *Morganella morganii* [37]. *Proteus mirabilis* is isolated more frequently than *E. coli* in men. Anaerobic organisms also contribute to infection [39]. Colonization with methicillin-resistant *S. aureus* (MRSA) occurs frequently in institutions with endemic MRSA [40, 41]. Although initially biofilms contain single species of microbes, they progressively become polymicrobial, especially in long term-catheterization [39].

P. aurignosa, enterococci and *Candida* spp. are more commonly found in ICUs [17, 42]. *Providencia stuartii* has been isolated in nursing home residents as a result of cross infection [43].

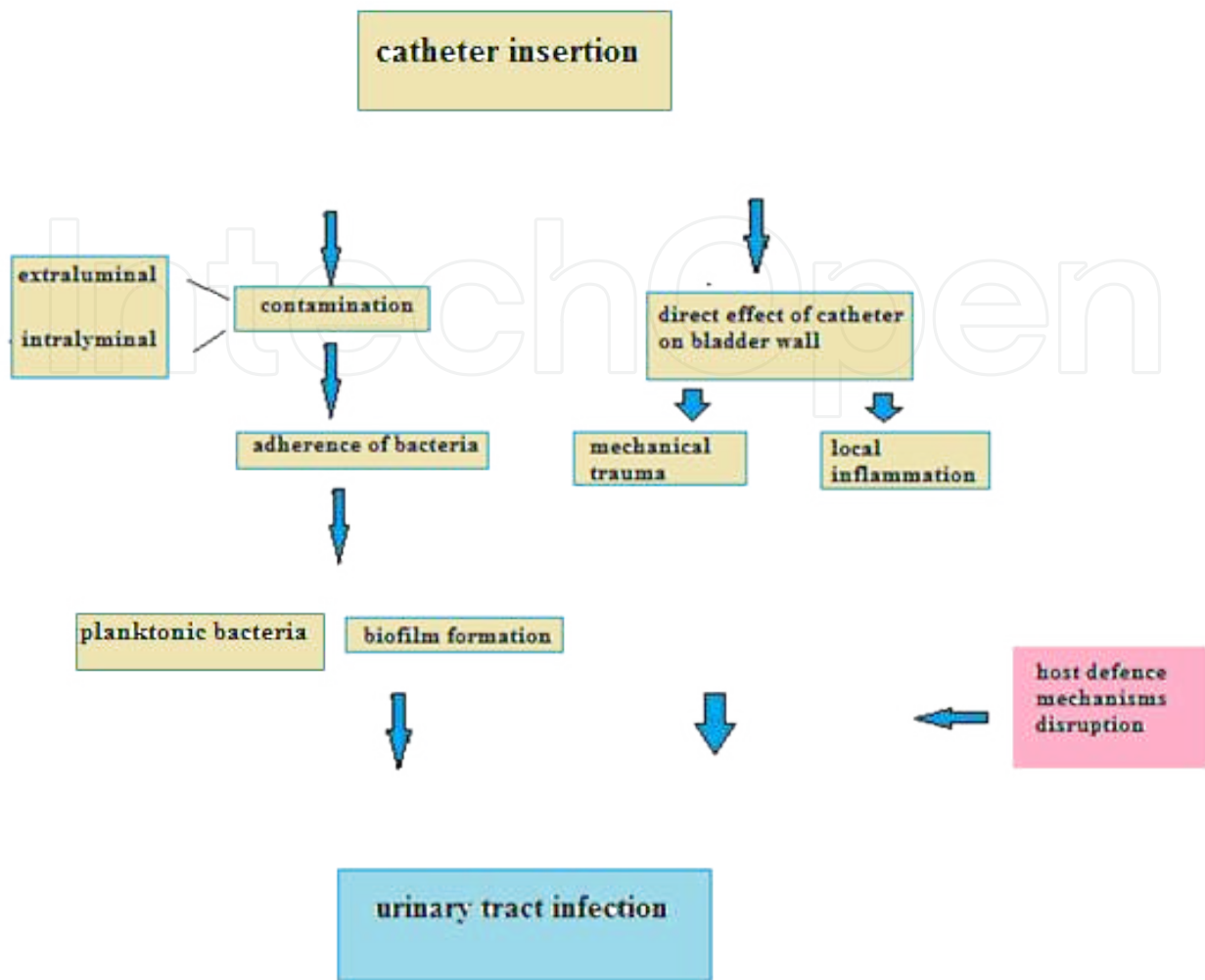


Figure 1. Pathogenesis of CAUTIs.

For some species of bacteria, it has been shown that the longer an indwelling catheter is in place, the greater the concentration of bacteria in urine. This number decreases when the catheter is replaced by a new one [44]. In particular, higher concentration was observed before catheter replacement for species such as *P. mirabilis*, *P. stuartii*, *M. morgani*, *P. aeruginosa*, and enterococci, whereas concentrations of *E. coli* and *K. pneumoniae* were similar in the 2 specimens [44].

Patients with blocked catheters are also more often colonized with *Proteus mirabilis* and *Providencia stuartii* than are patients without blocked catheters [45].

5. Risk factors War

Warren found that patients with indwelling bladder catheters had a 3% to 10% incidence of bacteria growth per day with development of bacteriuria in most within one month [46]. Several

prospective clinical studies have evaluated the risk factors for development of nosocomial UTI, catheter acquired bacteriuria and CAUTI [47-52]. All the risk factors are presented in table 1.

Catheter-related	Patient-related	Environment/Personnel-related
Duration of catheterization [48-50]	Female [47, 48, 50]	Hospitalization in Orthopedic department [49]
Lack of urimeter drainage [48]	Elderly [47]	Hospitalization in Urology department [49]
Colonization of drainage bag [48]	Critical ill [47]	Insertion after the 6th day of hospitalization [49]
Reason for catheterization [48]	Diabetes mellitus [48]	Catheterization outside the operating theatre [49]
Breaks in closed system [47]	Renal failure (Cr>2mg/dl) [48]	Lack of antibiotics (only for the first 4 days of catheterization) [47-50]
	Periurethral colonization [53]	Improper care [47, 49]

Table 1. Risks factors for development of CAUTI.

Many of these factors have been evaluated in more than one clinical trial. The duration of catheterization is the most important risk factor. The daily risk for acquiring bacteriuria was higher among patients ultimately catheterized for greater than or equal to 7 days than among those ultimately catheterized for less than 7 days [49]. Systematic antibiotic use exerts a protective use only for short-term catheterization (16% versus 32%) but has not been proven of value for long-term drainage [47-50].

Also increased risk has been found among women. This is probably due to their anatomy, causing an easier access of the perineal flora to the bladder along the catheter as it traverses the shorter female urethra and absence of prostatic secretions. Diabetic patients have susceptibility in acquiring urinary infection, probably due to increased prevalence of perineal colonization by potential pathogens, and increased ability of the urine of some diabetics to support microbial growth. Chronic renal failure is another risk factor for the development of urinary infections as a result of metabolic disorders which promote in secondary disorders of all components of immunity [54].

Finally, critically ill patients (uremic encephalopathy, viral encephalitis, bacterial peritonitis, diabetic ketoacidosis, stroke, and alcoholic liver disease with septicemia) are more susceptible to UTIs especially to candidal UTIs [55].

6. Prevention and control of CAUTIs

6.1. Indications for Indwelling catheter insertion

Selection of patients for catheterization should be standardized and reserved for certain medical conditions. Appropriate indications for the use of catheters are acute urinary retention

for temporary relief of anatomical (e.g. BPH, urethral stricture) or functional obstruction (e.g. neurogenic bladder), perioperative in select procedures (e.g. after major surgical procedures or cases performed under spinal anesthesia), and the frequent, accurate measurement of urine output in critically ill patients e.g. hemodynamic unstable [55-64].

Other appropriate uses are for patient's comfort at the end of life, patients who are incontinent and there is a risk of contamination with sacral, perineal wound or buttock trauma, and prolonged immobilization under conditions such as unstable spine or pelvic fracture [57-64].

The catheter should remain in place only as long as the reason for insertion is still present. For example, postoperatively as a patient has been mobilized, the catheter is no longer necessary to remain. Clinicians should avoid use of indwelling catheters for management of convenience of personnel and urine measurement [55, 63-64]. Urine output monitoring in oliguric patients is not an indication for indwelling catheter. It can be measured, using either bladder scanner or condom catheters [65]. Urine residual can be estimated with a bladder scanner as well. Patients with BPH and bladder outlet obstruction, who are not candidates for definite surgical procedure, can be managed effectively with minimal invasive techniques e.g. bladder neck incision, prostatic stent placement [66].

6.2. Right catheter practice

Aseptic catheter insertion remains one of the cornerstones in preventing CAUTI. Initially, perform hand hygiene immediately before and after insertion or any manipulation of the catheter device or site. Ensure that only properly trained persons (eg, hospital personnel, family members, or patients themselves) familiar with proper aseptic catheter insertion and maintenance are given this responsibility. In the acute care hospital setting, insert the smallest urinary catheter whenever possible, using aseptic technique and sterile equipment. Smaller catheters (14 French or 16 French) and 10-ml balloons should be utilized, as larger catheters have been shown to be a risk factor for the development of UTI [56]. These larger catheters tend to increase the amount of residual urine that can lead to the reinoculation of the bladder and increase the risk of blockage of the periurethral glands that leads to UTI, urethral irritation, and erosion. Instead large-bore catheters are appropriate for short-term practice e.g. management of hematuria, postoperatively after urologic procedures.

Sterile equipment includes necessary for catheterization: sterile gloves, disposable fenestrated drape, sponges, an appropriate antiseptic or sterile solution for periurethral cleaning, and a single-use packet of lubricant jelly for insertion. After insertion secure the catheter to prevent movement and urethral traction and keep the urine bag below the level of the bladder with a urine bag hanger [67].

It is important to remember that hands are colonized by resident and transient bacteria and for this reason they should be cleaned before and after every patient contact and before an aseptic technique is carried out, even when sterile gloves are also used [68].

It is not necessary to use an antiseptic preparation to clean the urethral meatus before catheter insertion. However, to avoid contamination of the sterile procedure field, it is advisable to use a sterile solution to cleanse the urethral meatus. Sterile saline or water may be considered [69].

An appropriate lubricant from a single-use container should be used during catheterization to minimize trauma and infection [70]. A number of studies considered the use of lubricants in urological procedures, concluding that the vulnerable urothelium can only be protected by an unbroken film of lubricant [71]. The method of dipping the catheter tip in the lubricant gel does not meet the requirement to coat the urethra and should be discouraged [70, 71]. The lubricant can be wiped off at the entry to the urethra and, therefore, will not reach the narrow more vulnerable parts. The urethra is not dilated by the insertion of a lubricating gel, allow for the comfortable passage of the catheter. There is potential for infection because of contamination of the container from repeated use.

Wherever the procedure is performed, especially in nurse home residents, hazardous waste, wet or soiled dressings and soiled incontinence pads must be removed from the immediate area. In some cases, general cleaning may be required to ensure that there is an appropriate area in which to establish the sterile field [72].

6.3. Special types of catheters

Latex and polytetrafluoroethylene-coated are appropriate for short-term drainage instead of silicon and hydrogel-coated which are appropriate for long term use. Collectively, these data are presented on table 2 [73]. Studies have shown that gram negative bacteria adhere less to siliconized rubber than to other catheter materials [74]. *Proteus mirabilis* have showed the greatest adherence from the gram-negative bacteria and like most bacteria has the most marked adherence to the red rubber catheter [75]. They can be used to reduce the risk of encrustation in long-term catheterized patients who have frequent obstruction [64].

Bacterial adherence is even more decreased in hydrophilic catheter surface and this effect is more pronounced for enterococci [76]. Hydrophilic catheters might be preferable to standard catheters for patients requiring intermittent catheterization [63, 64].

Catheter material	Length of use
Latex or plastic	Short term (up to 14 days)
Polytetrafluoroethylene-coated latex	Short term (up to 28 days)
All silicone	Long term (up to 12 weeks)
Silicone elastomer-coated latex	
Hydrogel-coated latex	
Hydrogel-coated silicone	

Table 2. Different types of catheters [73].

In a recent meta analysis, Schumm et al concluded that silver oxide catheters were not associated with a statistically significant reduction in bacteriuria in short-term catheterized hospitalized adults [76]. Instead, silver alloy catheters (silver-latex-hydrogel) were found to significantly reduce at least a half the incidence of asymptomatic bacteriuria in hospitalized adults catheterized for <1 week in comparison to standard catheters. At >1 week of catheterization the estimated effect was smaller but still less in the silver alloy group [77]. Also, it has

been shown that hydrogel coated and silver-hydrogel-latex catheters had little difference in bacterial adherence [76].

According to above findings and considering the extra cost of silver alloy catheters of 80%-130% compared to standard ones [79], most of the guidelines do not recommend their use in standard practice [78].

Antibiotic-coated catheters were also developed in an effort to prevent or delay the onset of catheter-associated bactiuria. Nitrofurazone impregnated catheters has been more detailed studied in antibiotic trials and they suggest benefit in terms of a decreased risk of asymptomatic bactiuria during the first week [77]. Initially, nitrofurazone diffuses from the catheter surface producing inhibition zones but this effect is progressively lost and bacteria attach and proliferate due to concentration reduction [76]. Overall antibiotic impregnated catheters regardless of antibiotic type reduce bactiuria in hospitalized adults who are catheterized for < 1 week however further research is needed on this field [77].

6.4. Closed drain systems

All guidelines advised on maintaining a closed sterile drainage system (figure 2) for indwelling catheters [78]. Also, the three most recent guidelines recommend the use of preconnected catheter and drainage system with sealed junctions [78]. If breaks in aseptic technique, disconnection, or leakage occur, replace the catheter and collecting system using aseptic technique and sterile equipment [63, 64].

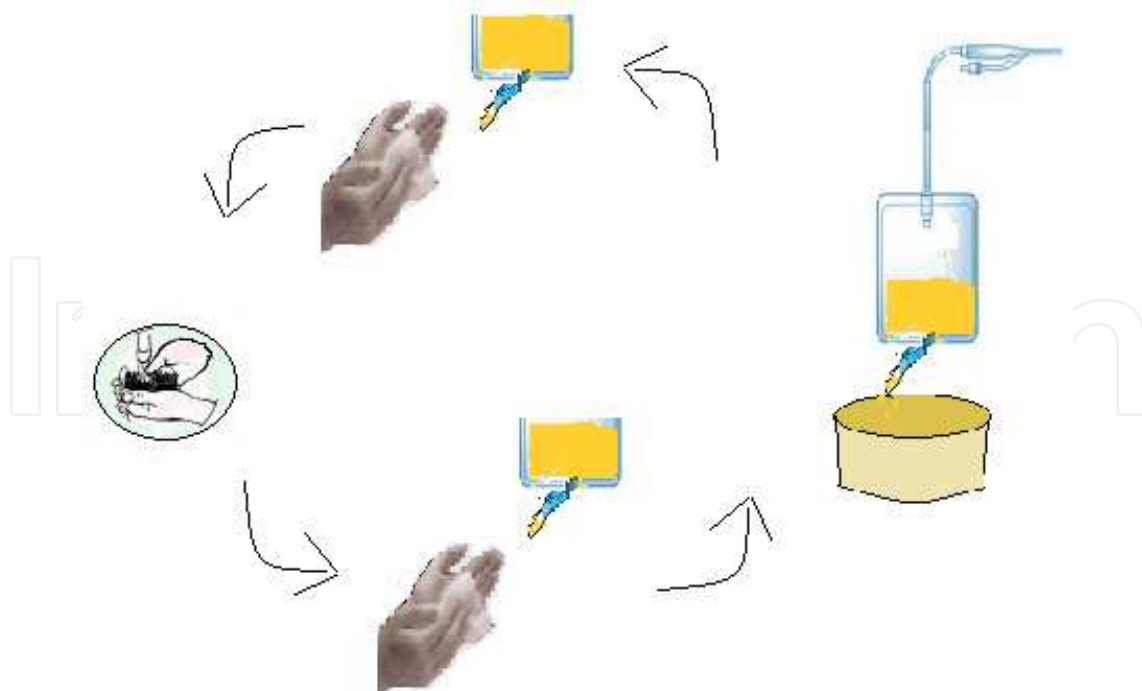


Figure 2. Maintenance of closed system: Handwashing before and after contact with catheters and drainage bags and before opening and after closing of the outlet tap is cleaned with a 70% isopropyl alcohol swab.

6.5. Alternative techniques of urine drainage

Alternative methods of catheterization that potentially reduce the risk of CAUTIs, including condom and suprapubic catheters and intermittent catheterization are available. Condom catheters, while useful for male patients with functional disabilities such as restricted mobility or dementia plus incontinence, who lack bladder outlet obstruction, require meticulous care to avoid complications such as skin maceration [80, 56]. They are ideal for nighttime use and are more comfortable, less painful, and less restrictive than indwelling catheters [81]. The condom catheter must be changed every day. In a descriptive point-prevalence survey in hospitalized patients the risk of UTI was higher in those wearing condom catheters than in those with a chronic indwelling catheter [82]. In contrast, in another study in home nursing home residents, the incidence of UTI was lower in men wearing external condom catheters than in men with indwelling catheters [83]. Randomized control studies are required to clarify further this field. Condom catheters may be preferable for incontinent men who will not manipulate their catheter frequently [84].

According to IDSA guidelines, suprapubic catheterization may be considered as an alternative to short-term indwelling urethral catheterization to reduce catheter associated bacteriuria [63]. In a meta analysis, comparing transurethral and suprapubic catheter for short-term use found that the latter one had reduced microbiologic morbidity [85]. However, data are insufficient to make a recommendation as to whether suprapubic catheterization is preferable to long-term indwelling urethral catheterization for reduction of catheter associated-bacteriuria or CAUTI [63]. Advantages of suprapubic route are: comfort and less local complications such as meatal erosion, prostatitis and epididymitis [85, 86].

Intermittent catheterization is the preferred method of catheterization in patients who have bladder dysfunction, specifically neurogenic bladder. Common causes of neurogenic bladder are spinal cord injury and myelomeningocele. Intermittent catheterization should be considered an alternative to short-term or long-term indwelling urethral catheterization to reduce catheter associated-bacteriuria and an alternative to short-term or long-term indwelling urethral catheterization to reduce CAUTI. Data are insufficient to make a recommendation as to whether intermittent catheterization is preferable to suprapubic catheterization for reduction of catheter associated bacteriuria or CAUTI [63].

6.6. Chemoprophylaxis

Most experts do not recommend routinely using prophylactic antibiotics for catheterized patients because of their cost, potential adverse effects and role in encouraging antibiotic drug resistance [87-89]. Prophylactic antibiotic drug therapy may be appropriate for those who require relatively short-term, 3-14 days, catheterization and are at high risk for complications from a UTI [24, 89]. In a recent double-blind, placebo-control randomized trial a single dose of prophylaxis did not affect the rate of bacteriuria and UTI 14 days after the catheter removal [90]. Thus, prophylaxis might not be needed for routine removal of urinary catheters in otherwise healthy non-genitourinary surgical patients postoperatively. However, this rule does not apply to individuals undergoing surgery of the urinary tract, where factors such as

intact urothelium, antegrade flow, foreign bodies and urine pH may all be altered and correspondingly require antimicrobial use around the time of catheter removal [91].

If bacteriuria occurs prior to removal of the catheter, the patient should be treated with appropriate antimicrobial therapy. Urinalysis or urine cultures should be obtained following removal of the catheter to assure sterility of the urinary tract. [89]. Prophylaxis with trimethoprim-sulphamethoxazole should be given to patients undergoing renal transplantation and requiring catheterization. Also data from randomized control trials suggest that systemic antibiotic prophylaxis is justified for transurethral resection of prostate in men with an indwelling catheter or bacteriuria before surgery [92, 93].

For those requiring long-term catheterization prophylactic antibiotics only postpone at best bacteriuria [84].

6.7. Intravesical instillation of prophylactic factors

Antibiotic and antiseptic solution instillation either continuously or intermittently has been studied in the past for prevention of CAUTIs [94, 95]. Although bladder irrigation with topical antimicrobial agents (e.g. neomycin, polymyxin B) have demonstrated some value in preventing UTI when an open drainage system was used, little overall benefit has been seen with closed systems. So in view of the potential for local toxic effects and the complexity of this method, antibacterial irrigation currently cannot be recommended [84].

6.8. Prevention of CAUTIs in general surgery

The urinary bladder is routinely catheterized during major surgery to monitor urine output throughout the perioperative period and to avoid the risk for urinary retention and bladder over distension. Traditionally, the catheter is inserted in the patients' bladder at the beginning of surgery and stays for a few days according to postoperative course and local policy.

It is also common practice to catheterize the bladder in those surgical patients receiving epidural analgesia and to leave the catheter in situ as long as epidural analgesia is maintained due to high rate of postoperative urinary retention (24%) [96, 97]. When local anesthetics are injected in the epidural space act on the sacral and lumbar nerve fibers in the spinal cord, blocking the transmission of afferent and efferent nervous impulses from and to the bladder. This results in decreased sensation of urgency and impaired bladder detrusor contraction.

Late studies on these target groups encourage early catheter removal [98, 99]. These studies have shown that early removal of the catheter was not associated with a higher incidence of recatheterization and UTIs, implying that catheter can safely be removed on the first postoperative day [98]. Leaving the bladder catheter as long as the epidural analgesia is maintained results in a higher incidence of UTI and prolonged hospital stay [99].

Early removal of urinary catheters is a part of modern postoperative management named by many authors as "fast-track surgery" and has truly reduced the rate of UTIs from 24% to 4% [100]. As it has already been mentioned, routine antibiotic prophylaxis might not be needed

for removal of urinary catheters in non-urological surgical patients postoperatively with intact urothelium [90].

6.9. Prevention of CAUTIs in neurogenic bladder

Intermittent catheterization is one of the most effective and commonly used methods of bladder management in patients with a neurogenic bladder. Regular bladder emptying reduces intravesical bladder pressure and improves blood circulation in the bladder wall, making the bladder mucous membrane more resistant to infectious bacteria (figure 3) [101]. So inserting the catheter several times during the day, episodes of bladder over distention are avoided.

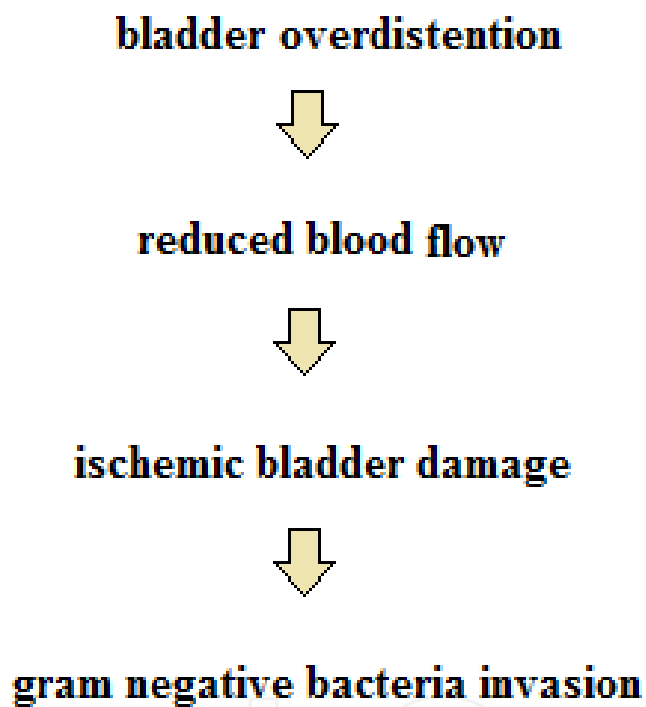


Figure 3. Pathogenesis of UTIs in patients with neurogenic bladder according to Lapedes et al theory [101].

Measures that decrease the incidence of UTIs in patients with neurogenic bladder are: Adherence to strict basic daily protocol with solid education and understanding about intermittent catheterization technique helps and avoids most of UTIs in this category of patients [102, 103]. It was also been proven that catheterization between at least four times for most individuals helps them to maintain a mean volume of catheterization of less than 400ml and reduces the incidence of UTIs [104].

According to Cochrane Review Database, there are no definitive studies showing the incidence of UTIs is improved with any catheter technique, type, or strategy [105]. Regarding the use of cranberry, there is limited evidence from clinical trials that suggests that they don't seem to be effective in preventing or treating UTIs in spinal cord population [106].

6.10. Prevention of CAUTIs in elderly with long-term catheter

Elderly are prone to long-term catheterization for many reasons and many of them are either surgically correctable e.g. a large symptomatic cystocele in women can easily be corrected with pelvic floor reconstruction or medically associated e.g. due to antihistamines, anticholinergics or tricyclic antidepressants and may be managed with medication discontinuation or treatment modification.

Long-term catheters are almost always associated with bacteriuria [107]. Strategy for prevention in these cases includes [108]: Hydration in order to promote washout of bacteria and maintain proper function of catheter. Routine catheter exchange e.g. every 4-6 weeks, depending on each patient. Patients with tendency to catheter encrustation require more frequent catheter exchange. Routine antibiotic prophylaxis is not required as it has already mentioned above it inevitably leads to development of drug resistant bacteria [87, 88, 89].

6.11. Local policy development for reduction of CAUTIs

Development of a local strategy from hospitals may contribute in reduction in the incidence of CAUTIs. The components of this policy are presented on table 3 [109].

Periodic training in aseptic technique, maintenance and removal
Education about CAUTIs and alternatives to indwelling catheter
Implement a system for documenting: indications for catheter insertion, date and time of catheter insertion, individual who performed insertion, date and time of catheter insertion, date and time of catheter removal
Use of standardized methodology for performing CAUTI surveillance
Family and caregiver teaching, discharge instructions
Use of removal triggers
Early catheter removal program

Table 3. Components of a local policy in reduction of CAUTIs [109].

Most of them have been evaluated in a number of studies and have shown their effectiveness in reduction of CAUTIs. For example, the utility of various reminder systems, physical or virtual, has been examined in a number of studies with encouraging results [110-116]. In one study paper based prewritten 'stop orders' or protocols and stickers to encourage clinicians to insert catheters only when absolutely necessary and remove as soon as no longer proved useful in reduction of CAUTIs [110]. Bruminhent et al. [111] found that placing reminder stickers on patient medical records significantly reduced the rate of CAUTIs (7.02 vs. 2.08, $P < 0.001$) after 3 months. This study was also associated with lower antibiotics costs and no impact on overall mortality. Another study by Loeb et al. [114] randomized 692 patients with indwelling catheters to usual care vs. prewritten orders for catheter removal if specified criteria are not present. This study reported a significant reduction of duration of inappropriate urinary catheterization in hospitalized patients but did not reduce urinary tract infections. Virtual

reminders involve the use of electronic devices to remind nurses and clinicians about catheter removal [117]. Automatic stop orders can be tied to computerized catheter orders or reminders can be sent via pagers [115]. However, these systems contribute to higher costs as they involve more time and manpower resources. A systemic review by Blodgett [116] found three trials on virtual reminders that were associated with reduction in the rates of CAUTI, duration of catheterization and overall costs.

7. Conclusion

Prevention is the main step against CAUTI. Priorities with proven value are the appropriate use and early removal of catheters, aseptic insertion, the maintenance of a closed urinary drainage system and implement of a structured local policy. However, there are still many challenges that need more clarification from research and well designed randomized control trials.

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