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Catheter-associated Urinary Tract Infections

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Abstract

Catheter-associated urinary tract infections (CAUTIs) are a major source of nosocomial infections and represent a significant burden in morbidity and costs. Although several different approaches to disease prevention are being investigated, the most effective methods of prevention are to avoid unnecessary catheterisations and to remove catheters as soon as possible. An optimal catheter material or coating is still awaited. The growing number of publications regarding implementation of reminder systems and infection control programs shows the importance of these measures, which can effectively decrease the rate of CAUTIs. Systemic antibiotic prophylaxis is not recommended for long-term indwelling catheterisation. Treatment of catheter-related asymptomatic bacteriuria should be avoided, as this may increase the rate of antibiotic resistance without eradicating the bacteria. Systemic antibiotic treatment is indicated only for symptomatic CAUTIs. Alternative methods of urinary drainage may be preferable to indwelling urethral catheterisation. Evidence-based catheter management and treatment of CAUTIs are mandatory.

Patient summary: This review summarises different management options for the prevention and treatment of catheter-associated urinary tract infections. Treatment for bacteria in catheterised urine in the absence of symptoms should be avoided, as this may increase the rate of antibiotic resistance without eradicating the bacteria. Systemic antibiotic treatment is indicated only for symptomatic infections. The most effective methods of prevention are to avoid unnecessary catheterisation and to remove catheters as soon as possible.

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1. Introduction

Urinary tract infections (UTIs) are among the most common bacterial infections worldwide and represent approximately 40% of hospital-acquired infections [1], with significant consequences for morbidity and mortality and substantial financial implications. The urinary tract is considered one of the most important sources of health care–associated infections [1], and the presence of a urinary catheter is a major risk factor, as it is associated with up to 80% of health care–associated UTIs [2]. Moreover, 30% of initial urinary catheterisations are unjustified in a standard hospital setting. Catheter-associated UTIs (CAUTIs) are the most preventable type of health care–associated infection [3]. Therefore, appropriate prevention and management of CAUTIs are of utmost importance for every urologist and other health care personnel.

The aim of this review is to summarise latest advances in the field and give evidence-based recommendations for the prevention and management of catheter-associated

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bacteriuria and UTIs. The recommendations are rated according to the Oxford Centre for Evidence-based Medicine modification of the US Department of Health and Human Services classification [4].

2. CAUTI pathogenesis

The first step in CAUTI pathogenesis is the development of biofilms on the surfaces of catheters. Biofilms are structured communities of microorganisms encapsulated within a self-developed polymeric matrix that adheres to a surface, and they have a major impact on foreign bodies, implants, and devices placed in the human body [5]. Biofilm bacteria may differ from their planktonic counterparts in antibiotic susceptibility and phenotype, explaining why antimicrobial therapies effective against planktonic bacteria frequently fail to eradicate bacterial biofilms on catheters and other urologic devices. Approximately 20% of patients are colonised immediately at the time of catheter insertion, as bacteria can ascend through the catheter lumen via reflux of urine from contaminated bags (intraluminal route) or from the urethra along the extraluminal catheter-urethral surface. The risk of bacteriuria increases by 3–10% for every day after catheter insertion, and bacteriuria is considered universal after 30 d [6].

3. Definition and diagnosis

In the case of asymptomatic catheter-associated bacteriuria (CAB), bacteria are present in the urine of an asymptomatic catheterised patient. The National Healthcare Safety Network (NHSN), the patient safety surveillance system of the Centers for Disease Control and Prevention (CDC), defines CAUTI as a UTI episode for which an indwelling catheter was in place for >2 d on the date of diagnosis (day of device placement being day 1), and an indwelling urinary catheter was in place on the date of the event or the day before. If an indwelling catheter was in place for >2 d and then removed, the UTI criteria must be met on the day of discontinuation or the next day [7]. In 2009, the NHSN removed asymptomatic bacteriuria removed from the CAUTI definition. This change should be considered in longitudinal monitoring of CAUTI rates, as it can lead to a potential decrease in the incidence of documented CAUTIs and CAUTI-related outcomes in hospital systems [8].

In 2010 the European Association of Urology (EAU) published a new classification of UTIs based on the clinical presentation, availability of appropriate antimicrobial therapy, and risk factors (ORENUC) [9]. In this new classification system, asymptomatic bacteriuria is a urologic risk factor, but is not regarded as a separate type of UTI. Likewise, the presence of a long-term indwelling catheter represents a special risk factor (urinary catheter and nonresolvable urologic risk factors with risk of more severe outcome).

When an indwelling catheter is in place, pyuria and bateriuria are universal, so routine urinalysis or cultures are not recommended, except in cases of symptomatic infections.

4. Prevention of CAB and CAUTI

Great efforts have been invested and many different approaches have been investigated in the last few decades to prevent or at least delay CAB and CAUTI. Although an ideal solution has not yet been identified, many important issues regarding catheter care and catheter-related infections have been clarified. The following general recommendations are commonly used [10] (III):

- A closed catheter system should be used (B).
- The duration of catheterisation should be minimal (A).
- Catheters should be introduced under antiseptic conditions (B).
- There is limited evidence that the risk of bacteriuria is equally high if a sterile or clean technique or an antiseptic gel is used (IIa).
- The drainage bag should be kept below the level of the bladder and the connecting tube (B).
- An indwelling catheter should always be introduced by trained personnel.
- Urethral trauma should be minimised by the use of adequate lubricant and the smallest possible catheter calibre.

4.1. Reminder systems and infection control programs

Prevention of CAB and CAUTI starts with prevention of unnecessary catheterisation. In addition, catheters are often left in place in patients without purpose. The use of different reminder systems (eg, electronic, nurse-based) is recommended by the guidelines to decrease catheterisation duration [10,11]. Institutions that have implemented and evaluated such monitoring systems uniformly reported reductions in catheterisation duration and CAUTI incidence [12–14].

Institutional infection control programs and catheter care practice bundles (education for catheter insertion, management, and removal; improving hand hygiene) can effectively reduce the rate of CAUTIs and CAUTI-related complications [12,15,16].

Despite clear guideline recommendations, unnecessary antibiotic treatment of asymptomatic bacteriuria is a common mispractice worldwide and is associated with morbidity and cost. There is evidence showing that implementation of interventional bundles (eg, educational seminars, promotional letters, stickers, pocket cards, vignettes) on this issue as part of an infection control program can effectively reduce inappropriate treatment of asymptomatic bacteriuria and associated costs [17,18].

4.2. Modifications of catheter materials or surface properties

Since biofilm formation and biofilm-associated infections represent a major problem for all implants and biomaterial devices, many efforts have been made to modify biomaterial surfaces to effectively delay biofilm formation. Such an ideal coating should be able to prevent bacteria from

adhering to the catheter and inhibit bacterial growth, thus preventing or at least delaying the onset of bacteriuria. A variety of approaches have been designed for this purpose, including [19–23]:

- Controlled release of antimicrobial agents incorporated in the device material (minocycline, rifampicin, nitrofurantoin);
- Surface coatings with antiseptic materials (silver alloy);
- Surface modifications to change hydrophobicity or to create functional groups with intrinsic antimicrobial activity; and
- Antiadhesive surfaces such as heparin and phosphorylcolin.

Although most of the modifications can reduce the development of bacteriuria in the case of short-term catheterisation (<1 wk), their long term efficacy in preventing bacteriuria or more importantly symptomatic infections could not be proven [5]. Therefore, their routine use is not recommended (B) [10].

In the case of clean intermittent catheterisation (CIC), hydrophilic-coated catheters are widely used in urologic practice. Although most of the literature supports this practice [24,25], there are also results showing no significant difference in the rate of symptomatic UTIs when compared to conventional catheters [26]. A 2013 meta-analysis by Li et al [27] revealed that UTIs occur less frequently with hydrophilic-coated catheters for CIC in patients with spinal cord injury, confirming the usefulness of these catheters.

There are some new, mostly experimental methods for preventing CAB without reliable human clinical long-term results to date (eg, bacterial interference, vibroacoustic stimulation, iontophoresis, bacteriophages). These methods are described in detail in an excellent review by Siddiq and Darouiche [28].

4.3. Antibiotic prophylaxis

A 2005 Cochrane review [29] revealed only weak evidence that antibiotic prophylaxis reduces the rate of symptomatic UTIs compared to giving antibiotics when clinically indicated in patients who have undergone abdominal surgery and had a urethral catheter in place for 24 h. There was limited evidence that prophylactic antibiotics reduce bacteriuria in nonsurgical patients (Ia). Therefore, according to the relevant EAU and CDC guidelines, routine prophylaxis is not recommended for short-term catheterisation (A). In a 2013 meta-analysis by Lusardi et al [30], antibiotic prophylaxis was associated with a lower rate of bacteriuria and febrile mortality among surgical patients with short-term catheterisation (up to 2 wk). There was limited evidence that prophylactic antibiotics reduced bacteriuria in nonsurgical patients. The data on prophylaxis in the case of long-term catheterisation are sparse (Ia) [31], so no recommendation can be made (D). Cycling of antibiotics on a weekly basis is a possible way to reduce the risk of resistance, but further research is needed before a recommendation can be made.

There are no clear recommendations on whether antibiotic prophylaxis should be applied at the time of catheter removal, but this is not a common practice. According to a meta-analysis by Marschall et al [32], patients receiving prophylaxis during catheter removal experienced fewer symptomatic UTIs; however, the meta-analysis finding must be tempered by possible publication bias towards positive studies, the limitations of the studies included, and practical considerations regarding encouragement of more widespread antibiotic use.

According to a 2012 Cochrane review by Niel-Weise et al [33] on antibiotic prophylaxis for patients using intermittent catheterisation, the data are inconsistent about the effect of prophylaxis on symptomatic UTIs. Therefore, routine antibiotic prophylaxis is currently not recommended for patients using intermittent catheterisation [10].

4.4. Additional methods of prevention

A Cochrane review concluded that the use of cranberry products did not reduce CAUTI rates in patients with neurogenic bladder requiring intermittent or indwelling catheterisation [34], so their use is currently not recommended (A).

Catheter irrigation with antiseptics or antibiotics is not effective in preventing CAB in patients with an indwelling catheter [35], so their use is not recommended (B).

5. Treatment of asymptomatic CAB

As already mentioned, routine antibiotic treatment of asymptomatic CAB is usually not beneficial. Bacteriuria cannot be eradicated in the long term, and antimicrobial therapy may lead to the selection of resistant organisms and to adverse reactions. There is no evidence indicating that antimicrobial therapy of CAB decreases UTI-related morbidity or mortality in catheterised patients [36]. Antimicrobial treatment of CAB is only recommended in the following circumstances [6,37,38]:

- Before urologic surgery or implantation of prostheses (A);
- In pregnancy (B);
- In patients who have a high risk of serious infectious complications (C); and
- For infections with strains causing a high incidence of bacteraemia, such as *Serratia marcescens* (B).

6. Treatment of CAUTI

In cases of symptomatic CAUTI, systemic antibiotic treatment is indicated [33]. The most frequent clinical sign of a symptomatic UTI in a patient with an indwelling catheter is fever. Since the result of a urine culture will be universally positive for patients with long-term catheters, it has a very limited value in the differential diagnosis of fever. If a febrile catheterised patient does not show any localising genitourinary symptoms (obstruction, haematuria, or

costovertebral angle tenderness) or no bacteraemia due to the same urinary pathogen, a definitive diagnosis of the source of the infection remains problematic, and alternative diagnoses must be considered.

A urine culture (and haemoculture for septic patients) must be taken before any antibacterial therapy is started (C). Empirical treatment should be started with broad-spectrum antibiotics according to local susceptibility patterns, and then targeted therapy should be initiated according to urine culture results (A). Inappropriate initial empirical treatment is associated with poorer outcomes and higher mortality [39]. Because of the possibility of biofilm formation on the catheter surface, it may be reasonable to replace the catheter before the therapy if it has been in place for >7 d (B) [40].

There is no general consensus about the length of therapy for CAUTI. Antimicrobial treatment usually varies from 5 to 21 d, depending on the organism, comorbid conditions, and patient response [41,42].

7. Alternative methods of urinary drainage

It is important to consider alternatives to indwelling urethral catheters that are less prone to causing symptomatic infection. The decision has to be made according to patient expectations, compliance, and further treatment plans. Suprapubic catheters, condom drainage systems, and intermittent catheterisation are preferable alternatives to indwelling urethral catheterisation.

Suprapubic catheterisation has several advantages (patient comfort) over urethral catheters, and is recommended by guidelines as an alternative to urethral catheters [10,11]. There is some low-quality evidence, mainly for short-term bladder drainage, that they can reduce the risk of CAB and CAUTI [10,11]. In a prospective study by Bonkat et al [43], bacteriuria was observed for 95% of suprapubic catheters, which is comparable to the rate of bacteriuria seen for indwelling catheters.

Condom catheters can be a good alternative in male patients without significant bladder outlet obstruction. Their use can decrease rates of CAB and CAUTI in men without cognitive impairment [44–46].

Intermittent catheterisation is a safe and effective method of bladder management for voiding dysfunction due to a wide variety of causes, including neuropathic bladder. The rate of bacteriuria is approximately 1–5% per catheterisation, and it is considered universal by the end of the third week (III) [47–49]. There are no good-quality data on the rates of symptomatic infections compared to indwelling catheterisation. A randomised study showed no difference in symptomatic UTIs between clean and sterile intermittent catheterisation [50]. The use of prophylactic antibiotics and antiseptic substances (bladder instillation, oral methenamine) is not recommended.

8. Future research

The scientific and methodological quality of available studies regarding urinary catheters and catheter-related infections are generally low. The main reason for this is that most studies used only the CAB rate as the outcome, and did not report on rates of symptomatic UTIs, which is the most important and relevant clinical outcome. Therefore, it is highly recommended that future studies on catheter materials or other CAUTI prevention approaches report symptomatic UTIs as the primary outcome.

9. Conclusions

CAUTIs are a major source of nosocomial infections. Although several different approaches to disease prevention are being investigated and some promising results have been obtained, the most effective methods of prevention are to avoid unnecessary catheterisation and to remove catheters as soon as possible. An optimal catheter material or coating is still awaited. The goal is to identify effective mechanisms for prevention and control of biofilm formation and to develop antimicrobial agents effective against bacteria in biofilms. The growing number of publications on implementation of reminder systems and infection control programs shows the importance of these measures, which can effectively decrease the rate of CAUTIs. Evidence-based catheter management and adherence to guidelines are mandatory for every urologist.

Conflicts of interest

Peter Tenke was member of the International Advisory Board on Catheter Associated Urinary Tract Infections, AstraTech AB, Copenhagen, in 2011. The remaining authors have nothing to disclose.

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