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European and Asian guidelines on management and prevention of catheter-associated urinary tract infections☆

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Abstract

We surveyed the extensive literature regarding the development, therapy and prevention of catheter-associated urinary tract infections (UTIs). We systematically searched for meta-analyses of randomised controlled trials available in Medline giving preference to the Cochrane Central Register of Controlled Trials and also considered other relevant publications, rating them on the basis of their quality. The studies' recommendations, rated according to a modification of the US Department of Health and Human Services (1992), give a close-to-evidence-based guideline for all medical disciplines, with special emphasis on urology where catheter care is an important issue. The survey found that the urinary tract is the commonest source of nosocomial infection, particularly when the bladder is catheterised (IIa). Most catheter-associated UTIs are derived from the patient's own colonic flora (IIb) and the catheter predisposes to UTI in several ways. The most important risk factor for the development of catheter-associated bacteriuria is the duration of catheterisation (IIa). Most episodes of short-term catheter-associated bacteriuria are asymptomatic and are caused by a single organism (IIa). Further organisms tend to be acquired by patients catheterised for more than 30 days. The clinician should be aware of two priorities: the catheter system should remain closed and the duration of catheterisation should be minimal (A). While the catheter is in place, systemic antimicrobial treatment of asymptomatic catheter-associated bacteriuria is not recommended (A), except for some special cases. Routine urine culture in an asymptomatic catheterised patient is also not recommended (C) because treatment is in general not necessary. Antibiotic treatment is recommended only for symptomatic infection (B). Long-term antibiotic suppressive therapy is not effective (A). Antibiotic irrigation of the catheter and bladder is of no advantage (A). Routine urine cultures are not recommended if the catheter is draining properly (C). A minority of patients can be managed with the use of the non-return (flip) valve catheter, avoiding the closed drainage bag. Such patients may exchange the convenience of on-demand drainage with an increased risk of infection. Patients with urethral catheters in place for 10 years or more should be screened annually for bladder cancer (C). Clinicians should always consider alternatives to indwelling urethral catheters that are less prone to causing symptomatic infection. In appropriate patients, suprapubic catheters, condom drainage systems and intermittent catheterisation are each preferable to indwelling urethral catheterisation (B).

Keywords: Catheter-associated urinary tract infections; Catheter care; Methods of prevention

Summary of Recommendations

General aspects

1. Written catheter care protocols are necessary (B).
2. Health care workers should observe protocols on hand hygiene and the need to use disposable gloves between catheterised patients (A).

Catheter insertion and choice of catheter

3. An indwelling catheter should be introduced under antiseptic conditions (B).

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4. Urethral trauma should be minimised by the use of adequate lubricant and the smallest possible catheter calibre (B).
5. Antibiotic-impregnated catheters may decrease the frequency of asymptomatic bacteriuria within 1 week. There is , however, no evidence they decrease symptomatic infection. Therefore, they cannot be recommended routinely (B).
6. Silver alloy catheters significantly reduce the incidence of asymptomatic bacteriuria, but only for less than 1 week. There was some evidence of reduced risk for symptomatic UTI. Therefore they may be useful in some settings (B).

Prevention

7. The catheter system should remain closed (A).
8. The duration of catheterisation should be minimal (A).
9. Topical antiseptics or antibiotics applied to the catheter, urethra or meatus are not recommended (A).
10. Benefits from prophylactic antibiotics and antiseptic substances have never been established, therefore they are not recommended (A).
11. Removal of the indwelling catheter after non-urological operation before midnight may be beneficial (B).
12. Long-term indwelling catheters should be changed in intervals adapted to the individual patient, but must be changed before blockage is likely to occur (B), however there is no evidence for the exact intervals of changing catheters.
13. Chronic antibiotic suppressive therapy is generally not recommended (A).

Diagnostics

14. Routine urine culture in asymptomatic catheterised patients are not recommended (B).
15. Urine, and in septic patients also blood for culture must be taken before any antimicrobial therapy is started (C).
16. Febrile episodes are only found in less than 10% of catheterised patients living in a long-term facility. It is therefore extremely important to rule out other sources of fever (A).

Treatment

17. Whilst the catheter is in place, systemic antimicrobial treatment of asymptomatic catheter-associated bacteriuria is not recommended (A), except in certain circumstances: especially prior to traumatic urinary tract interventions (A).
18. In case of asymptomatic candiduria, neither systemic nor local antifungal therapy is indicated (A), but removal of the catheter or stent should be considered (C).
19. Antimicrobial treatment is recommended only for symptomatic infection (B).
20. In case of symptomatic catheter associated UTI it may be reasonable to replace or remove the catheter before starting antimicrobial therapy if the indwelling catheter has been in place for more than 7 days (B).
21. For empiric therapy broad-spectrum antibiotics should be given based on local susceptibility patterns (C).
22. After culture results are available antibiotic therapy has to be adjusted according to sensitivities of the pathogens (B).
23. In case of candiduria associated with urinary symptoms or if candiduria is the sign of a systemic infection, systemic therapy with antifungals are indicated (B).
24. Elderly female patients may need treatment if bacteriuria does not resolve spontaneously after catheter removal (C).

Alternative drainage systems

25. There is limited evidence that post-operative intermittent catheterisation reduces the risk of bacteriuria compared with indwelling catheter. No recommendation can be made (C).
26. In appropriate patients suprapubic, condom drainage system or intermittent catheter are preferable to indwelling urethral catheter (B).
27. There is little evidence suggesting that antibiotic prophylaxis decreases bacteriuria in patients using intermittent catheterisation, therefore it is not recommended (B).

Long-term follow up

28. Patients with urethral catheters in place for 10 years or more should be screened for bladder cancer (C).

1. Introduction

Approximately 40% of nosocomial infections originate in the urinary tract. Most patients with nosocomial urinary tract infections (UTIs) have either had genitourinary or urological manipulation (ca. 10–20%) or permanent urethral catheterisation (ca. 80%), or both [1–5] (III). Most catheter-associated UTIs derive from the patient's own colonic flora [6] (IIb). In two recent prevalence studies on nosocomial UTI, one hospital-wide (7) and one in urology departments only [8] it was shown that most of nosocomial UTIs were catheter associated, 63% and 74%, respectively. Patients with urinary catheter of any type had an increased risk of UTI due to *Pseudomonas* sp. A written protocol for catheter care was associated with a lower incidence of catheter-related UTI [7,8]. The aim of this article is to give a close-to-evidence-based guideline for all medical disciplines, with special emphasis on urology where catheter care is an important issue, and to assist and to encourage urological departments to establish written guidance on catheter care on evidence-based grounds.

2. Methods

We surveyed the extensive literature regarding the development, therapy and prevention of catheter-associated UTIs. We systematically searched for meta-analyses of randomised

Table 1
Level of evidence and grade of guideline recommendations [9]

(A) Level of evidence

Level	Type of evidence
Ia	Evidence obtained from meta-analysis of randomised trials
Ib	Evidence obtained from at least one randomised trial
IIa	Evidence obtained from one well-designed, controlled study without randomisation
IIb	Evidence obtained from at least one other type of well-designed, quasi-experimental study
III	Evidence obtained from well-designed, non-experimental studies such as comparative studies, correlation studies and case reports
IV	Evidence obtained from expert committee reports or opinions or clinical experience of respected authorities

(B) Grade of guideline recommendation

Grade	Nature of recommendations
A	Based on clinical studies of good quality and consistency addressing the special recommendations and including at least one randomised trial
B	Based on well-conducted clinical studies, but without randomised clinical trials
C	Made despite the absence of directly applicable clinical studies of good quality

controlled trials available in Medline by giving preference to the Cochrane Central Register of Controlled Trials and also considered other relevant publications until March 2007. The studies cited from the literature and their recommendations were rated according to a modification of the US Department of Health and Human Services [9] (Table 1).

3. History

In the 1920s, Foley introduced the self-retaining catheter. Initially it was used with open drainage, and bacteriuria was virtually universal by the end of the fourth day [10]. With the introduction and development of modern biomaterials technology and the design of suitable receptacles, closed-catheter systems were introduced. Development of bacteriuria was delayed but was still universal after 30 days [1,11,12] (IIa, III). A controlled trial comparing open with closed catheters was never performed. There was little point in stating the obvious and the closed system became the standard. A recent relaxation of the closed-system principle occurred with the development of a so-called flip (non-return) valve, allowing a patient to void intermittently on demand through an open catheter.

4. Risk of bacteriuria

The presence of an indwelling urethral catheter allows continuous access of organisms into the urinary bladder. Multivariate analyses have emphasised that the duration of catheterisation is the most important risk factor in the development of catheter-associated bacteriuria [6,13–16] (IIa, III).

The duration of catheterisation depends on the indication: (i) routine surgery, 1–7 days; (ii) measurement of urine output in the context of critical care, 7–30 days; (iii) acute and chronic urinary retention, 1 day to >30 days; and (iv) urinary incontinence, >30 days.

Other risk factors include [15–19] (IIa): (i) colonisation of the drainage bag, catheter and periurethral segment; (ii) diabetes mellitus; (iii) female sex; (iv) renal function impairment; and (v) poor quality of catheter care including insertion outside of an operating room; and (vi) lack of antimicrobial therapy.

5. Pathogenesis

The urethral catheter can inhibit or bypass certain defence mechanisms that would normally prevent or minimise bacteria–epithelial cell interactions, e.g. the glycosaminoglycan (GAG) layer, biofilm formation.

Bacteria can enter the urinary tract in catheterised patients at the time of catheter insertion. This is especially common in patients who have inadequate cleansing of the perineum and distal urethra, especially in patients on intermittent clean catheterisation where only a limited attempt is made to cleanse the ‘entry points’ before introduction of the catheter. It is, however, doubtful whether such cleansing is in general of any benefit, but in hospitalised patients introduction of organisms at the time of catheterisation could be critical. Up to 20% of individuals will be colonised immediately after catheterisation [6,15] (IIa, III).

In males the predominant route of invasion is the intraluminal, suggesting an exogenous source. It is demonstrated that the intraluminal ascent of bacteria is faster (32–48 h) than the extraluminal route (72–168 h) [11]. The taps of the urine drainage bags commonly become contaminated during use and their regular opening to drain the urine also affords the bacteria access to the bag and migrate to the drainage tube, the catheter and bladder right after. Disconnection of

the catheter from the drainage tube has also been shown to lead to contamination of the system.

Catheterisation will promote the development of a biofilm between the catheter and urethral mucosa. This provides a favourable environment for bacterial invasion and proliferation via the extraluminal route. A greater proportion of bacteriuria is found in women (70–80%) than in men (20–30%) [16–18] (III).

Biofilm is defined as an accumulation of microorganisms and their extracellular products that form a structured community on a solid surface. Biofilms are ubiquitous. In the context of urological practice they can be demonstrated on catheters, drainage bags and other foreign bodies and prostheses [20]. They can also be found within scar tissues at sites of chronic infection (e.g. chronic infection in renal scars, prostatitis and epididymitis) (IIb).

Biofilm is composed of three layers: (i) the linking film, attached to the surface tissue or biomaterial; (ii) the basal layer; and (iii) the surface film adjacent to the lumen, from which planktonic organisms can be released.

Organisms within the biofilm are well protected from mechanical flushing by urine flow, other host defences and antibiotics. Conventional laboratory testing can easily detect planktonic free-floating bacteria within the urine or occasionally in the tissue. However, sessile pathogens from the biofilm will not be detected with routine methods [20–25] (IIa, IIb, III).

6. Methods of catheterisation and the risk of UTI

6.1. Single (straight) catheterisation

After single (straight) catheterisation, bacteriuria develops in ca. 1–5% of cases [12,16,17] (III). The risk of infection is increased in female patients, patients with urinary retention, in peripartum catheterisation, in men with prostatic obstruction, in diabetes mellitus and in debilitated and elderly patients [26] (III).

6.2. Short-term catheterisation

Short-term catheterization is usually defined as catheter in place for less than 7 days [16]. Indications for short-term bladder catheterisation are to monitor urine output (i) in acutely ill patients, (ii) for urinary obstruction and (iii) in the perioperative period. Between 15% and 25% of patients admitted to hospital may be catheterised for 2–4 days during their stay [12,16] (III). Between 10% and 30% will develop bacteriuria [3,27,28] (IIa, III).

Most episodes of short-term catheter-associated bacteriuria are asymptomatic and are caused by single organisms; 15% may be polymicrobial [5] (III), reflecting the prevailing flora in hospital or community environments. Therefore, the most common species are *Escherichia coli*, *Pseudomonas aeruginosa*, *Klebsiella pneumoniae*, *Proteus mirabilis*, *Staphylococcus epidermidis*, *Enterococcus* spp. and *Candida* spp. [12,16,17] (IIb). Most catheter-associated bacteriuria is accompanied by pyuria which however varies by organism.

Although there is extensive literature on the type, maintenance and techniques for the insertion of urinary catheters, little attention is paid to their removal. The importance of short-term urethral catheter management is recognised; however, there is no consensus about the optimal time and method for removal of indwelling urethral catheters.

According to the Cochrane database [29], there is not sufficient evidence of the benefit of using a catheter for a period after operation (such as 24 h) compared with immediate removal after operation, but there is some evidence that there is less need for re-catheterisation following hysterectomy if there is a short period of continuous drainage. Eleven trials considering the duration of catheterisation after surgery showed considerable heterogeneity and did not prove that any one policy was better than another. In general, fewer UTIs occurred when the catheter was removed as soon as possible.

Removal of the indwelling urinary catheter before midnight may be beneficial (C). There are some resource implications but their magnitude is not defined. Patients stay in hospital for a shorter period of time after early, rather than delayed, catheter removal, but the effects on other outcomes are unclear [29].

6.3. Long-term catheterisation

When indwelling catheterisation lasts for more than 28 days it is defined as ‘long-term’ or ‘chronic’. Unfortunately, there is no consensus on the classification of indwelling catheters in place for 8-29 days. The patient with a long-term indwelling catheter is at high risk of morbidity due to this procedure. Bacteriuria with at least one strain is universal, whilst most patients are infected with two or more strains [30,31] (IIb). The commonest infecting organism is *E. coli*. Persistence is related to the presence of type 1 pili, an adhesin for uroepithelium and the Tamm–Horsfall protein. Another organism rarely found outside of the catheterised urinary tract is *Providencia stuartii* [30] (IIb, III). For this organism, the adhesins MR/K are more common [32,33] (IIb). Other associated flora include *Pseudomonas*, *Proteus*, *Morganella* and *Acinetobacter*, *Enterococcus and Candida* spp. Bacteriuria is polymicrobial in up to 95% of urine specimens from long-term catheterised patients [12,16,17,33,34] (IIb, III). One-quarter of organisms in catheter urine are not present in urine simultaneously obtained by suprapubic bladder puncture, suggesting that some organisms colonise the catheter only [35] (IIb).

The incidence of bacteraemia is significantly high in patients with chronic catheterisation undergoing instrumentation for endoscopic surgery, e.g. transurethral resection of the prostate (TURP) [36] (IIb) and in presence of bacteriuria the risk of genitourinary infectious complications is increased by a factor close to 10 times [37]. Despite the high level of

bacteriuria in patients with long-term indwelling catheters, symptomatic manifestations, either through ascending infection or through bacteraemia, are unusual. Studies in a long-term facility identified UTIs as a source of febrile episodes in less than 10% of patients [16] (III). It is therefore extremely important to rule out other sources of fever (A).

Transient asymptomatic bacteraemia is common during initial catheter insertion or during catheter exchange in chronically catheterised patients [38] (III). The risk of bacteraemia during initial catheter insertion is similar, whether there is a pre-existing UTI (7%) or sterile urine (8.2%) [39,40] (IIa). The relatively low incidence of febrile UTI and bacteraemia may be due to the fact that colonisation of urethral catheters is caused mainly by less virulent organisms. It has been shown that colonising *E. coli* strains lack P fimbriation in a catheter-associated infection [41] (IIb).

The contribution of catheter-associated UTI to mortality is unclear. Prospective, or case–controlled, studies revealed that catheter-associated UTIs are usually not associated with excess mortality [42–44] (IIa, III). On the other hand, data from the National Nosocomial Infections Surveillance (NNIS) survey and from other studies indicate that catheter-associated infections have a low risk of mortality even in elderly patients [42-45] (IIa, III). The contributable mortality varies between 9% and 13% [32,46]. Other risk factors include severity of co-morbid disease, inappropriate antibiotic therapy, remote infection and the presence of an unrecognised urological abnormality [47] (III). However, the death rate following TURP and similar operations is approximately doubled in catheterised patients.

Chronic catheterisation can lead to obstruction of the lower urinary tract owing to catheter blockage as well as to urinary tract stones, epididymitis, prostatitis and scrotal abscess [11,16,17,48–51] (IIa, III). Up to 50% of patients undergoing catheterisation for more than 28 days experience recurrent encrustation and catheter blockage [48–51] (IIa). Intermittent urinary retention can lead to vesicoureteric reflux and ascending complicated infection. Infecting organisms often include *P. mirabilis*, a potent urease producer, which promotes the development of struvite stones by hydrolysis of urea to ammonium [12,16,17,48–51] (IIb, III).

Bladder catheterisation for more than 10 years, e.g. in patients with spinal cord injury, may be associated with an increased risk of bladder cancer [52,53] (IIa). Therefore, patients with urethral catheters in place for 10 years or more should be screened for bladder cancer (C).

7. Alternative methods of urine drainage

Prevention of catheter-associated infection may be accomplished by alternatives to indwelling catheterisation. The advantages and disadvantages of the various catheter modalities for bladder drainage are listed in Table 2.

7.1. Intermittent catheterisation

Intermittent catheterisation is popular in the management of voiding dysfunction due to a wide variety of causes, including a neuropathic bladder. It is a safe and effective method of bladder management for four groups of patients: children with neuropathic bladder dysfunction (e.g. spina bifida); women with incontinence caused by uncontrolled reflex detrusor contraction; women and men with urinary retention due to ineffective or absent detrusor contraction; and males with bladder outlet obstruction who are not fit for surgery [54]. Bacteriuria is acquired at the rate of ca. 1–3% per catheterisation. Therefore it is universal by the end of the third week [55–58] (III). It may be expected that local periurethral infection, febrile episodes, stones and deterioration of renal function are less common than in patients permanently catheterised, but there are no well-designed comparative studies. Complications include bleeding, urethral inflammation, stricture, false passage, epididymitis, bladder stone and hydronephrosis.

Three trials compared indwelling urethral catheterisation with intermittent catheterisation. In two trials there were fewer cases of bacteriuria in the intermittent catheterisation group (relative ratio 2.90, 95% confidence interval 1.44–5.84). Cost analyses of these trials favoured the indwelling catheter. A randomised study showed no difference in symptomatic UTIs between clean and sterile intermittent catheterisation, although obviously the former was associated with reduced costs [59] (1b). There was limited evidence that post-operative intermittent catheterisation reduced the risk of bacteriuria (asymptomatic and symptomatic) in patients with hip or knee surgery compared with indwelling catheterisation, therefore no recommendation can be made (C). Benefits from prophylactic antibiotics and antiseptic substances, such as oral methenamine or bladder instillation of povidone–iodine and chlorhexidine, have never been established. Therefore they are not recommended (A).

7.2. Suprapubic catheterisation

Suprapubic catheterisation is used mainly in patients undergoing urological or gynaecological procedures. It offers several advantages over urethral catheterisation, particularly in terms of patient comfort. Clamping of the suprapubic catheter facilitates testing of voiding through the urethra. According to the Cochrane review there is evidence that suprapubic catheters are superior to indwelling urethral catheters in terms of bacteriuria (asymptomatic and symptomatic) and re-catheterisation. There was some evidence that the results are better in a suprapubic catheter group with regard to patient tolerance and catheter obstruction [60–65,65a] (III). However, convincing randomised trials are still missing that demonstrate the advantage of suprapubic catheters compared with transurethral indwelling catheters.

Table 2
Advantages and disadvantages of various catheter modalities for bladder drainage

Advantages	Disadvantages
Transurethral indwelling catheter	
– only few contraindications, e.g. urethral stricture, urethral trauma	– local infection (urethritis)
– installation by trained nurse	– urethral trauma, stricture and paraurethral abscess
– catheters with several luminal seizes	– prostatitis, epididymitis, pyelonephritis, urosepsis
– special catheters for flushing the bladder	– high rate of nosocomial UTI
– special catheters for permanent bladder irrigation	– residual urine measurement not possible
– catheter insertion usually not very traumatic using optimal technique	– more troublesome for the patient
	– higher amount of nursing workload
Suprapubic catheter	
– no urethral interference (no urethritis, prostatitis, epididymitis)	– installation by physician
– no urethral stricture	Relative contraindications:
– lower rate of nosocomial UTI	– bladder shrinkage
– spontaneous micturition and residual urine measurement	– suprapubic scars
– transurethral diagnostic procedures, e.g. cystoscopy, urethrogramme	– meteorism
– less troublesome for the patient	– pregnancy
– lower amount of nursing workload	– obesity
	Absolute contraindications:
	– bladder volume <200 ml
	– bladder tumor
	– bladder displacement, e.g. by intraabdominal tumor
	– anticoagulation therapy, haemorrhagic tendency, gross haematuria
	– skin diseases in the puncture area
Intermittent catheterisation	
– less local periurethral infection, febrile episodes, stones and deterioration of renal failure	– elevated urethral trauma
– clean catheterization	– urethral stricture
	– false passage
	– urethritis, epididymitis, prostatitis
	– cooperative and skilled patient
	– difficult process in men
Condom catheter	
– lower incidence of bacteriuria	– cooperative and skilled patient
– no urethral interference (no urethritis, prostatitis, epididymitis)	– obesity
– no urethral stricture	– short penis
– less painful procedure	– skin maceration and ulceration
Urethral stent/prosthesis	
– lower incidence of bacteriuria	– difficulty in proper placement, changing or removal
– less troublesome for the patient	– high migration rate
– less urethral stricture	– high level of scar formation
	– secondary stricture
	– calcification

7.3. Condom catheters

Condom catheters can be useful in male patients without outlet obstruction. However, condom drainage may be unsatisfactory in confused or uncooperative patients or where there is obesity and/or a short penis. Skin maceration and ulceration can occur. Daily changing of the condom catheter is recommended, although changes every other day are not associated with increased infection rates [66]. Condom catheters offer a lower incidence of bacteriuria compared with long-term urethral catheterisation [51,67] (III).

7.4. Urethral stents/prostheses

Urethral stents/prostheses are often inserted into the prostatic urethra for a variety of indications, including neurogenic bladder dysfunction, prevention of strictures, treatment of urinary retention. In stress incontinence approximately 50% achieved satisfactory control [68] (III). Bacteriuria, which is usually asymptomatic, occurs in 10–35% of patients [68–75] (III). There are no well-designed studies investigating the significance of bacteriuria or symptomatic UTI in correlation with various urethral inserts and stents in comparison with other drainage methods.

7.5. General recommendations

As indwelling urethral catheters are prone to cause symptomatic infection, clinicians should always consider alternatives. In appropriate patients, suprapubic catheters, condom drainage systems or intermittent catheterisation are preferable to indwelling urethral catheterisation (B).

8. Prevention of bacteriuria

8.1. Catheter care

The following recommendations are commonly used [11,16,53] (III). An indwelling catheter should be introduced under antiseptic conditions (B). Urethral trauma should be minimised by the use of adequate lubricant and the smallest possible catheter (A). A limited study indicates that the risk of bacteriuria is equally high if a sterile or clean technique or an antiseptic gel is used [76,77] (IIa). The clinician should be aware of two priorities: the catheter system should remain closed (A) and the duration of catheterisation should be minimal (A).

There is a resurgence of interest in the use of the convenient flip valve as a replacement for the daytime catheter bag. It is expected that the risk of colonisation of such a device will be a problem, although a randomised controlled study of 100 patients comparing the use of catheter valve with standard drainage systems showed no difference in the incidence of UTIs [78]. Adequate urine flow must be ensured. The patient should receive sufficient fluids given orally to maintain an output of more than 50–100 mL/h. Bacteraemia is not prevented by topical antiseptics or antibiotics applied to the catheter, urethra or meatus.

There is no consensus as to the time in which routine catheter changes have to be made. This may be dictated by the manufacturer's instructions and conditions for indemnity. Shorter periods may be necessary if there is catheter malfunction or leakage. In general, long-term indwelling catheters must be changed before blockage occurs or is likely to occur. The time differs very much from one patient to another. Some patients form deposit in the catheter lumen very quickly [53,79]. These individuals ('blockers') need to have catheter changes more frequently than 'non-blockers', i.e. weekly or even twice weekly [46,49]. Some authors advise leaving the catheter out for at least 1 h, but no longer than 2 h, when a long-term indwelling catheter is changed, to allow the urethral glands to drain [53]. However, this method has no evidence-based support.

According to the Cochrane database for patients using intermittent catheterisation, there is limited evidence suggesting that antibiotic prophylaxis decreases the rate of bacteriuria (asymptomatic and symptomatic). Therefore it is not recommended (B). For patients using permanent urethral catheterisation, no data are available [80].

8.2. Additional methods of prevention

Scientists who deal with catheter materials have varied the physical and chemical composition and coatings in the manufacture of catheters and stents. The objective is to delay the onset of bacteriuria and to prevent bacterial adherence and growth.

The local host inflammatory response and tissue necrosis associated with catheter use are greatest with natural rubber, but less with latex and minimal with silicone [81] (IIa). Latex catheters are the least expensive but irritation and allergic reaction may occur [46] (IIa). Silicone catheters are more biocompatible than normal latex ones and therefore are better choices for long-term usage. Silicone catheters obstruct less often than latex. Teflon- or silicone-coated latex catheters in patients are prone to catheter encrustation [82–86] (IIa). Polyvinyl chloride is a strong material that often composes the three-way catheters used for bladder irrigation and washout. On the other hand, there is not enough evidence to define whether any standard catheter was better than another in terms of reducing the risk of UTI in hospitalised adults catheterised short-term. There is still no consensus as to which catheter is the best in which circumstances. The choice depends on the clinical indication, cost, availability and personal preference [86].

Other strategies include biocides or antibiotics incorporated into the catheter material, or materials with surface properties preventing adherence of bacterial cells. A thin layer of polymer matrix covering the biomaterial surface may assist the metered release of drugs into the urine. Only one small trial justified some impact on bacteriuria in the antibiotic-impregnated catheter group but only within 1 week of catheterisation [87–89]. The Cochrane review suggested that while the use of antibiotic-impregnated catheters may decrease the frequency of bacteriuria, there is no evidence that they decrease symptomatic infection [86].

Silver oxide coating may delay bacteriuria in short-term use, but silver alloy-coated catheters appear to be more effective by precipitating membrane proteins of surface-associated bacteria and inhibiting colonisation. Silver ions bound to murein are bacteriostatic, whereas in higher silver concentrations the silver ions may be bactericidal [90,91] (IIb). According to the Incontinence Group of the Cochrane Database, silver oxide catheters did not show significant reduction in bacteriuria in short-term catheterised patients in hospital, but the confidence intervals were wide. In contrast, silver alloy catheters significantly reduced the incidence of asymptomatic bacteriuria under the same conditions, but only for less than 1 week. There was also a reduced risk of symptomatic UTIs [86]. Phosphorylcholine and heparin coating may also inhibit encrustation and biofilm formation [92–94] (IIa).

However, so far none of the above methods showed any advantage in long-term prevention of bacteriuria, but it may be effective during short-term catheter use, particularly in intensive care units [86] (IIa). In summary, antimicrobial

urinary catheters can prevent or delay the onset of catheter-associated bacteria, but the effect on morbidity is not known [94a].

Continuous electric current applied to the catheter surface (i.e. electromechanical dissociation) [95] may also be of advantage, however no device has been developed for clinical use yet.

9. Treatment

9.1. Treatment of asymptomatic bacteriuria

Generally, asymptomatic bacteriuria should not be treated (A) because bacteriuria will either not be eradicated or will return rapidly. However, antimicrobial therapy may contribute to the selection of resistant organisms and to adverse reactions. There is no evidence that antimicrobial therapy decreases morbidity or mortality from UTI in catheterised patients [96], therefore systemic antimicrobial treatment of asymptomatic catheter-associated bacteriuria is only recommended in the following circumstances [11,16,25,97–99]: (i) patients undergoing urological surgery or implantation of prostheses (A); (ii) treatment may be part of a plan to control nosocomial infection due to a particularly virulent organism prevailing in a treatment unit (B); (iii) patients who have a high risk of serious infectious complications, e.g. patients who are immunosuppressed (C); and (iv) infections caused by strains causing a high incidence of bacteraemia, e.g. *Serratia marcescens* (B).

If the catheter drains properly, routine urine cultures in asymptomatic catheterised patients are also not recommended (B) because treatment generally is not necessary. Also, it has not been shown that a uropathogen cultured from an asymptomatic patient will be the causative organism when a symptomatic episode occurs. Following catheter removal in ca. one-third to one-half of cases, the urinary tract will clear bacteria spontaneously [53,99] (III). Spontaneous clearance occurs more commonly in women under 65 years of age or when *S. epidermidis* is the infecting organism [53]. However, one study shows that elderly females may need treatment if bacteriuria does not resolve spontaneously [100] (IIa) or if symptomatic infection occurs.

9.2. Treatment of symptomatic UTI

The most frequent clinical manifestation of symptomatic UTI in catheterised residents is fever. Some patients may also become septic with at least two of the followings symptoms: hypothermia, tachycardia (> 90/min), tachypnoea (>20/min and/or pCO_2 <33 Hgmm), leucocytosis (>12/nl) or leucopenia (<4/nl). Since patients with long-term indwelling catheters always have positive urine cultures, a definite diagnosis of the source of infection remains problematic in a febrile or septic catheterized patient without localising genitourinary symptoms and if not bacteraemic due to the same urinary pathogen. UTI may be the source of fever; if there are no localising features such as obstruction, haematuria or costovertebral angle tenderness, alternative diagnoses must be considered. Observation, rather than immediate antimicrobial therapy, should be considered when the patient is clinically stable and the fever is of low grade [17].

Antibiotic treatment is recommended only in symptomatic infection (bacteraemia, pyelonephritis, epididymitis, prostatitis) (B). Systemic antibiotics should be used for catheterised patients who are febrile and appear to be ill, because of the possibility of UTI-related bacteraemia or pyelonephritis (B). Owing to the likelihood of bacteria sequestered in a biofilm on the catheter surface, it may be reasonable to replace or remove the catheter (if the indwelling catheter has been in place for more than 7 days) before the therapy of symptomatic catheter-associated bacteriuria [53,101–103]. After initiation of empirical treatment usually with broad-spectrum antibiotics based on local susceptibility patterns (C), the choice of antibiotics may need to be adjusted according to urine culture results (B). Therefore, urine, and in septic patients also blood for culture, must be taken before any antibacterial therapy is started (C).

Although there are no adequate clinical studies to guide the length of therapy for catheter-related symptomatic UTI, antimicrobial treatment usually varies from 5 days to 21 days depending on the organism, co-morbid conditions and patient response [100,102,104] (I, III). Chronic antibiotic suppressive therapy is not effective and generally not recommended (A). Catheterised urine cannot be permanently sterilised [11,16,17,102,105,106] (IIa, III).

Occasionally, the culture shows candiduria, which is usually asymptomatic and often resolves without treatment. In this case neither systemic nor local (bladder irrigation) antifungal therapy is indicated [107,108] (Ib) (A), but removal of the catheter or stent should be considered (C). If the infection is associated with urinary symptoms or candiduria is the sign of a systemic infection, systemic therapy with antifungals are indicated [109–111] (IIa) (B).

10. Prevention of cross-infection

Healthcare workers should be constantly aware of the risk of cross-infection between catheterised patients. They should observe protocols on handwashing and the need to use disposable gloves (A).

The periurethral bacterial flora, surfaces of the catheter system and the persistent, huge reservoir of contaminated urine as well as the skin of the patient are sources for contamination of the hands of medical personnel who may carry the bacteria to other patients [97,99,106,112] (IIb, III). This may be reduced by treating the catheterised urinary tract as an open wound. It is therefore essential to use gloves after handwashing in antiseptic solutions [102,113,114] (IIa, III).

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