

# Preventing Catheter-Related Bacteriuria

## Should We? Can We? How?

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Up to 25% of hospitalized patients undergo urinary catheterization, and about 5% develop bacteriuria each day of catheterization. Catheter-related bacteriuria is associated with increased morbidity and mortality. We performed an evidence-based synthesis of the literature on preventing catheter-associated urinary tract infections (UTIs) to develop recommendations for clinicians. Catheterization should be avoided when not required and when needed, should be terminated as soon as possible. Use of suprapubic and condom catheters may be associated with a lower risk of UTI than use of urethral catheters. Aseptic catheter insertion and a properly maintained closed drainage system are crucial to reducing the risk of bacteriuria. Instillation of antimicrobial agents into the bladder or urinary drainage bag and rigorous meatal cleansing seem to be of little benefit. Use of urinary catheters coated with silver alloy may reduce the risk of UTI. Systemic antimicrobial drug therapy seems to prevent UTIs, but primarily for patients catheterized for 3 to 14 days. Antibiotic drug prophylaxis is especially valuable in patients undergoing transurethral resection of the prostate or renal transplantation. Using these methods, urinary catheter-associated UTI can often be prevented for weeks, but not longer terms.

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Each year, millions of Americans undergo catheterization of the urinary bladder.<sup>1</sup> Although often a necessary intervention, indwelling urinary catheters are a leading cause of nosocomial infection in short- and long-term care settings. Forty years ago, Beeson<sup>2</sup> was among the first to recognize the complications consequent to urethral catheterization, making “the case against the catheter.” Two decades ago, an editorial in *Lancet*<sup>3(p1003)</sup> opined that “replacement of open urine collection by closed drainage systems was a big advance but progress has been slow: there have been no well-controlled studies of the prevention of catheter-associated urinary infection.” In the past 20 years, numerous trials have evaluated methods to decrease the risk of catheter-associated urinary tract infection (UTI). How far have we come? How much farther can we go? This evidence-based synthesis of the lit-

erature on preventing catheter-associated UTI will provide clinicians with an overview of the advances made in the past 2 decades and highlights where further research is especially needed.

### METHODS

Relevant publications were located by several methods. The MEDLINE database of English-language articles published between January 1966 and January 1998 was searched using the subject headings “urinary tract infections” or “urinary tract” combined with the keyword “catheter.” Additional searches used a variety of keywords (eg, “silver” and “suprapubic”). The MEDLINE database was then searched for articles by authorities in catheter-associated UTI (eg, “Warren JW” and “Kunin CM”). Finally, other potential references were identified by expert consultation and a review of references that have been cited in retrieved articles, pertinent meta-analyses, review articles, and consensus statements. Preference was given to clinical trials that were randomized and

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double blinded, used intention-to-treat analysis, and were published in the past 20 years. If sufficient data to make a recommendation regarding catheter-associated UTI prevention could not be found, then other types of evidence, such as observational studies and nonblinded randomized trials, were considered. Data on prevention were summarized qualitatively. Reports relating to epidemiological findings, pathophysiological findings, and risk factors were included for discussion, depending on their importance as assessed by the authors.

## DEFINITION

The definition of catheter-related UTI varies in published reports and "bacteriuria" and "UTI" are often used interchangeably. Low-level growth from a catheterized specimen (ie,  $10^2$  colony-forming units [CFU]/mL) usually progresses within days to concentrations greater than  $10^4$  CFU/mL, unless antibiotic drug therapy is given.<sup>4</sup> Thus, most experts agree that a growth of  $10^2$  CFU/mL or greater of a predominant pathogen from a catheterized urine specimen, especially when associated with pyuria, represents catheter-related UTI.<sup>5</sup> Experts in rehabilitation medicine have suggested the following criteria for diagnosing bacteriuria from catheterized patients:  $10^2$  CFU/mL or greater from patients undergoing intermittent catheterization, any detectable growth from those with an indwelling catheter, and  $10^4$  CFU/mL or greater from a clean-voided specimen from a man using a condom catheter.<sup>6</sup>

## EPIDEMIOLOGICAL FINDINGS

Up to 25% of hospitalized patients have a urinary catheter placed during their stay. The overall incidence of nosocomial UTI among these patients is 3% to 10% (average, 5%) per day.<sup>7,8</sup> Thus, after a month of catheterization, nearly all will be bacteriuric, making this a convenient dividing line between short- and long-term catheterization.<sup>1</sup>

Urinary tract infections account for up to 40% of nosocomial infections,<sup>7,9</sup> and urinary catheter-related infection accounts for most nosocomial UTIs.<sup>10</sup> Bacteremia has

been estimated to complicate nosocomial UTI in up to 4% of cases.<sup>10,11</sup> More than 17% of cases of nosocomial bacteremia are attributed to the urinary tract; only intravascular catheters lead to more cases of nosocomial bacteremia.<sup>12</sup>

Patients who develop a nosocomial UTI have their hospital stay extended by approximately 3 days<sup>13,14</sup> and are nearly 3 times more likely to die during hospitalization than patients without such an infection.<sup>15</sup> The case-fatality rate from UTI-related nosocomial bacteremia is approximately 13%,<sup>11</sup> with severely ill patients at highest risk. Short-term catheterization may also be associated with fevers and acute pyelonephritis, whereas long-term catheterization may be complicated by catheter obstruction, urinary tract stones, and chronic renal inflammation.<sup>1</sup>

Another concern is that microorganisms causing nosocomial UTI are easily transmitted between patients. About 15% of episodes of nosocomial bacteriuria occur in such clusters,<sup>16</sup> and they often involve highly antibiotic-resistant organisms. Furthermore, results of most hospital-based outbreak investigations<sup>5</sup> indicate that lack of proper hand washing by health care personnel is largely responsible for the transmission of these organisms. Despite these "micro-epidemics," however, most cases of nosocomial UTI reflect endemic acquisition.

## RISK FACTORS

### For Bacteriuria

Several studies have prospectively evaluated risk factors for urinary catheter-related UTI. Most have reached similar conclusions, helping to clearly define the associated factors. The most important risk factor for bacteriuria is the duration of catheterization. More than 20 years ago, Garibaldi and colleagues<sup>8</sup> prospectively followed up 405 patients with an indwelling catheter from the time of hospital admission. Bacteriuria, defined as a growth of  $10^3$  CFU/mL or more of a predominant bacterial species, developed in 95 patients (23.5%). Statistically significant risk factors found on univariate analysis were female sex (relative

risk [RR] = 1.7), rapidly fatal underlying illness (RR = 2.5), age older than 50 years (RR = 2.0), lack of receipt of systemic antibiotic drug therapy (RR = 2), and nonsurgical disease (RR = 2.2).<sup>8</sup> Ten years later, Shapiro et al<sup>17</sup> prospectively collected data on 112 patients consecutively admitted to an Israeli hospital who had a urinary catheter in place for longer than 24 hours. Bacteriuria, defined as more than  $10^3$  CFU/mL of growth, developed in 36 patients (32.1%). Logistic regression identified the factors significantly associated with catheter-related bacteriuria: hospitalization on the orthopedic (RR = 51.0) or urologic (RR = 4.0) service, Arabic vs Jewish ethnicity (RR = 6.5), catheter insertion after the sixth day of hospitalization (RR = 8.6), catheter inserted outside the operating room (RR = 5.3), no receipt of systemic antibiotic medications (RR = 3.9), and prolonged duration ( $\geq 7$  days) of catheterization (RR = 6.8).<sup>17</sup> In a similar prospective study by Platt and colleagues,<sup>18</sup> 134 (9.2%) of 1458 adult inpatients acquired 136 UTIs (defined as  $\geq 10^5$  CFU/mL of growth) during 1474 indwelling bladder catheterizations. Factors found by multiple logistic regression analysis to be significantly associated with acquiring infection were increased duration of catheterization (odds ratio [OR] = 2.3-22.4, depending on duration), lack of systemic antibiotic drug therapy during short catheter courses (OR = 2.6), female sex (OR = 2.5), diabetes mellitus (OR = 2.3), and serum creatinine level greater than 177  $\mu\text{mol/L}$  ( $> 2.0$  mg/dL) at the time of catheterization (OR = 2.1).<sup>18</sup>

In a prospective trial comparing silver-coated with standard urinary catheters in 482 patients hospitalized for the short-term, Johnson and colleagues<sup>19</sup> found the following significant risk factors for acquiring catheter-related bacteriuria after multivariate analysis: absence of systemic antibiotic drug therapy (RR = 3.3), female sex (RR = 2.0), and serum creatinine concentration greater than 177  $\mu\text{mol/L}$  ( $> 2$  mg/dL) (RR = 2.6). Similarly, Riley et al<sup>20</sup> evaluated 1309 hospitalized patients and found that bacteriuria occurred in 158 patients (12.1%). Significant risk factors for catheter-associated bacteriuria after multi-

variate analysis included female sex, older age, lack of systemic antibiotic drug therapy, and longer duration of catheterization (**Table 1**).

### For Bacteremia

Catheter-associated bacteriuria is usually asymptomatic, uncomplicated, and resolves after the catheter is removed. Up to 30% of patients, however, have genitourinary or systemic symptoms.<sup>1,5</sup> The outcome of most clinical importance is probably urinary tract-related bacteremia, or urosepsis. Risk factors for UTI-related bacteremia are less clearly defined than for catheter-related bacteriuria, in part because it occurs less often. Because 4% or less of patients with catheter-related bacteriuria develop catheter-related bacteremia,<sup>10,11</sup> most prospective studies have insufficient statistical power to detect associations with bacteremia.

Some attempts have been made to assess risk factors for bacteremia. During a 23-month prospective study by Krieger et al,<sup>10</sup> 1233 patients with nosocomial UTI (defined as  $>10^5$  CFU/mL) were identified among 40 718 patients consecutively admitted to 1 hospital. Nosocomial bloodstream infections occurred in 565 patients, 32 (5.7%) of whom had a urinary tract origin. Among patients with a nosocomial UTI, 86% had an indwelling urinary catheter. Significant risk factors by univariate analysis for secondary nosocomial bloodstream infections were UTI caused by *Serratia marcescens* compared with other organisms (RR = 3.5) and male sex (RR = 2.0).<sup>10</sup> No other factors (age, race, underlying disease, and hospital service) were found to significantly predispose a bacteriuric patient to bacteremia.<sup>10</sup>

Jerkeman and Braconier<sup>23</sup> performed a retrospective case-control study in patients with a community-acquired UTI associated with fever. Univariate analysis was used to compare 80 patients who had a positive blood culture with 88 who did not. The bacteremic patients were significantly older (mean age, 74.7 vs 59.9 years), more often had a noninfectious urinary tract disease (eg, nephrolithiasis or prostatic hypertrophy), and more frequently had an

**Table 1. Significant Risk Factors for Developing Bacteriuria in Patients With an Indwelling Urinary Catheter**

Increasing duration of catheterization <sup>17,18,20,21</sup>
Not receiving systemic antibiotic therapy <sup>8,17-21</sup>
Female sex <sup>8,18-20</sup>
Older age <sup>8,20</sup>
Azotemia (serum creatinine concentration $>177$ $\mu$ mol/L [ $>2.0$ mg/dL]) <sup>18,19</sup>
Diabetes mellitus <sup>18</sup>
Rapidly fatal underlying illness <sup>8</sup>
Nonsurgical disease <sup>8</sup>
Faulty aseptic management of the indwelling catheter <sup>8</sup>
Bacterial colonization of the drainage bag <sup>18</sup>
Catheter not connected to a urine meter <sup>18</sup>
Periurethral colonization with uropathogens <sup>22</sup>

indwelling urinary catheter. Factors not predisposing to bacteremia included the presence of diabetes mellitus or an immunodeficiency disorder or a history of previous UTI.<sup>23</sup>

Risk factors that may predispose bacteriuric patients to bacteremia are summarized in **Table 2**. Given the limited data on causative agents for this clinically important outcome, we are conducting a case-control study to further clarify the risk factors of catheter-associated bacteremia in those with nosocomial bacteriuria.

### AVOIDING INDWELLING CATHETERIZATION

Indwelling urinary catheters are often needed for hospitalized patients; **Table 3** summarizes the generally accepted indications.<sup>24-26</sup> However, their use is often inappropriate. Because up to 80% of patients with a nosocomial UTI have an indwelling urinary catheter,<sup>10</sup> the best prevention strategy would be to avoid catheterization. A recent prospective study<sup>24</sup> found that patients had an indwelling urinary catheter for unjustified purposes for 41% of patient-days in a medical intensive care unit. The use of indwelling catheters was also found to be unnecessary for 58% of patient-days on the general medical ward. Inserting a catheter for the convenience of the nursing or medical staff is rarely appropriate. Another frequent problem is that, even

**Table 2. Significant Risk Factors for Developing Bacteremia in Patients With Bacteriuria**

Male sex <sup>10</sup>
Infection with <i>Serratia marcescens</i> <sup>10</sup>
Older age <sup>23</sup>
Noninfectious urinary tract disease (eg, nephrolithiasis or prostatic hypertrophy) <sup>23</sup>
Presence of an indwelling urinary catheter <sup>23</sup>

**Table 3. Appropriate Indications for Indwelling Urinary Catheter Use in Hospitalized Patients**

Bladder outlet obstruction
Temporary relief of anatomic or functional obstruction
Longer-term drainage if surgical correction is not indicated
Urinary incontinence (without obstruction)
In a patient with an open sacral or perineal wound
At a patient's request (primarily for patients at the end of life)
Urine output monitoring required
When frequent or urgent monitoring is needed, eg, in critically ill patients
When a patient is unable or unwilling to collect urine
During prolonged surgical procedures with general or spinal anesthesia

when a catheter is inserted appropriately, it is left in too long. When no longer required, it should be removed immediately.

If temporary or long-term urinary collection is required, options other than indwelling catheterization should be considered. Intermittent catheterization, ie, inserting and removing a sterile or clean urinary catheter several times daily, may reduce the risk of bacteriuria compared with an indwelling catheter. Because the incidence of bacteriuria is about 1% to 3% per insertion, however, most patients become bacteriuric within a few weeks.<sup>1</sup> Intermittent catheterization may also be associated with a lower risk of local and systemic complications of bacteriuria, but further studies are needed to assess these issues.

### Suprapubic Catheters

These devices have been compared with urethral catheters in several randomized<sup>27-32</sup> and nonrandom-

**Table 4. Selected Characteristics of Prospective Studies Comparing Suprapubic With Indwelling Urinary Catheters\***

Study	Randomized	Patient Population	Bacteriuria, No. † (%)		Odds Ratio (95% CI) ‡	Comments §
			Suprapubic Catheter	Indwelling Catheter		
Shapiro et al <sup>34</sup>	No	General surgical patients with urinary retention (M & W)	2/25 (8)	21/31 (68)	0.04 (0.01-0.24)	Suprapubic group had less pain but more mechanical complications
Andersen et al <sup>30</sup>	Yes	Women undergoing vaginal surgery	10/48 (21)	20/44 (45)	0.32 (0.11-0.86)	Patients rated acceptability of suprapubic catheters greater
Sethia et al <sup>27</sup>	Yes	General surgical patients requiring urine output monitoring (M & W)	2/32 (6)	16/34 (47)	0.08 (0.01-0.41)	Decrease in bacteriuria was more significant in woman than in men
Schiotz et al <sup>28</sup>	Yes	Women undergoing vaginal surgery	8/38 (21)	5/40 (12)	1.87 (0.48-8.01)	26% of suprapubic vs 5% of indwelling catheter group had mechanical complications
Horgan et al <sup>33</sup>	No	Men with acute urinary retention caused by prostatic enlargement	10/56 (18)	12/30 (40)	0.33 (0.11-0.99)	21% of suprapubic vs 3% of indwelling catheter group had catheter dislodgment
O'Kelly et al <sup>29</sup>	Yes	General surgical patients requiring abdominal surgery (M & W)	3/28 (11)	3/29 (10)	1.04 (0.13-8.51)	Suprapubic catheters caused significantly fewer days of catheter-related pain

\*CI indicates confidence interval; M & W, both men and women were enrolled.

†Number of patients who developed bacteriuria/total number of participants assigned to each group.

‡Odds of developing bacteriuria in the suprapubic vs indwelling catheter groups.

§Mechanical complications consisted of catheter dislodgment or obstruction and failed insertion attempt.

||Every third patient was allocated to urethral catheterization.

ized<sup>33,34</sup> studies with different patient populations and using different definitions of bacteriuria (**Table 4**). Although the results of the studies vary, the bulk of the evidence indicates that patients with suprapubic catheters have a lower risk of UTI<sup>27,30,33,34</sup> and a higher rate of satisfaction<sup>29,30,34</sup> with the device than those with indwelling catheters. In 3 studies,<sup>28,33,34</sup> however, mechanical complications were increased in patients receiving suprapubic catheters. For men who require long-term catheterization, suprapubic catheterization may also reduce the risk of local genitourinary complications such as meatal erosion, prostatitis, and epididymitis. Despite these data, suprapubic catheters are not commonly used. Perhaps clinicians should consider using a suprapubic catheter in patients without contraindications (eg, bleeding diatheses, previous lower abdominal surgery, morbid obesity, or radiation) who require long-term indwelling catheterization; however, this patient population has not been adequately studied.

#### External Condom Catheters

External urine collection systems may be associated with a lower risk of bacteriuria than indwelling catheters. Although devices have been developed for women, these systems are almost exclusively used with men.

The proper role of condom catheters in hospitalized patients remains unclear. One prospective study conducted in a Department of Veterans Affairs medical center<sup>35</sup> found that the risk of developing bacteriuria in men wearing a condom catheter was approximately 12% per month. The rate was substantially higher, however, in those who frequently manipulated their catheters. In 2 parallel cohort studies<sup>36,37</sup> in a Department of Veterans Affairs nursing home, the incidence of symptomatic UTI was about 2.5 times greater in men with a long-term indwelling catheter compared with those wearing a condom catheter. On the other hand, a recent cross-sectional study<sup>38</sup> in Denmark reported that the risk of UTI was higher in hospitalized patients wearing condom catheters than in those using indwelling catheters. In light of these conflicting data, a randomized trial comparing the safety and efficacy of these 2 devices is much needed.<sup>39</sup> We are currently conducting such a study at our Department of Veterans Affairs medical center.

#### PREVENTING UTI DURING INDWELLING CATHETERIZATION

Because of the high incidence, substantial morbidity, and occasional mortality associated with nosocomial UTI, several preventive measures have been evaluated in those re-

quiring an indwelling catheter. The most important infection control advance was the introduction approximately 3 decades ago of the closed catheter drainage system.<sup>40-43</sup> Proper aseptic techniques, including aseptic insertion and maintenance of the catheter and drainage bag, remain essential in preventing catheter-related UTI.<sup>5,44</sup> It is vital that health care workers wear gloves when manipulating or emptying the drainage bag and wash hands vigorously between patient contacts. Efforts to prevent bacteriuria also include irrigating the bladder, instilling antibacterial solutions in the urinary collecting bag, rigorous meatal cleaning, using silver-coated urinary catheters, and prescribing short-term prophylactic antibiotic medications. Each method will be briefly discussed below.

#### Bladder Irrigation

Another potential method of preventing catheter-associated UTI is to instill antibacterial agents, either continuously or intermittently, as bladder irrigation. Such agents include antiseptics (povidone-iodine or chlorhexidine digluconate) and antibiotics (neomycin or polymyxin B sulfate). Although this method demonstrated some value in preventing UTI when an open drainage system was used, little overall benefit has been seen in studies with closed systems.<sup>45-49</sup> Infection control prin-

**Table 5. Selected Characteristics of the 8 Randomized Trials of Silver-Coated Urinary Catheters in Hospitalized Patients**

Study	Catheter Coating	Patient Population	Bacteriuria, No.* (%)		Odds Ratio (95% CI)†
			Silver-coated Catheter	Control Catheter	
Lundeberg <sup>59</sup>	Silver alloy	Urologic or surgical service	6/51 (12)	17/51 (33)	0.26 (0.10-0.75)
Schaeffer et al <sup>60</sup>	Silver oxide‡	Spinal cord injury or neurosurgical service	11/41 (27)	18/33 (55)	0.30 (0.11-0.81)
Liedberg and Lundeberg <sup>61</sup>	Silver alloy	Urologic or surgical service	6/60 (10)	22/60 (37)	0.19 (0.07-0.52)
Liedberg et al <sup>62</sup>	Silver alloy	Urologic or surgical service	3/30 (10)	15/30 (50)	0.11 (0.03-0.45)
Johnson et al <sup>19</sup>	Silver oxide	Intensive care, neurology, or surgical service	19/207 (9)	28/275 (10)	0.89 (0.48-1.64)
Liedberg and Lundeberg <sup>63</sup>	Silver alloy	Medical, urologic, or surgical service	8/75 (11)	23/96 (24)	0.38 (0.16-0.90)
Takeuchi et al <sup>64</sup>	Silver oxide	Urologic or surgical service	7/26 (27)	4/11 (36)	0.64 (0.14-2.90)
Riley et al <sup>20</sup>	Silver oxide	Medical or surgical service	85/745 (11)	73/564 (13)	0.87 (0.62-1.21)

\*Number of patients who developed bacteriuria/total number of participants assigned to each group.

†Odds of developing bacteriuria in the silver-coated catheter vs control catheter groups; CI indicates confidence interval.

‡Intervention group also had a silver-coated adapter and trichloroisocyanuric acid in the drainage bag.

ciples would dictate that unidirectional flow from the bladder to the drainage bag is best. Furthermore, in view of the potential for local toxic effects and the complexity of this method, antibacterial irrigation currently cannot be recommended.

#### Antimicrobial Drugs in the Drainage Bag

In catheterized patients, UTIs may occur when bacterially colonized urine in a drainage bag refluxes into the patient's bladder. This is often a consequence of the bag being lifted above the level of the bladder, allowing a retrograde flow of urine. Thus, several studies<sup>50-56</sup> have evaluated the effect of adding various antibacterial agents (eg, chlorhexidine, hydrogen peroxide, and povidone-iodine) to the drainage bag. Several reports<sup>50-53</sup> suggest this intervention may prevent catheter-related UTI, but some<sup>50,52</sup> were flawed by using a before-and-after design or by using other interventions in addition to the drainage bag antibacterial agents.<sup>50,53</sup> Results of better-designed studies,<sup>54-56</sup> all of which were randomized, show no benefit to this method. Adding solutions to the drainage bag has the disadvantage of usually requiring the closed drainage system to be broken. The bulk of evidence does not favor this approach.

#### Rigorous Meatal Cleaning

One route to bladder infection occurs when bacteria colonizing the urinary meatus ascend along the external surface of the urinary cath-

eter into the bladder. As such, reducing bacterial colonization at the urethral meatus might decrease catheter-associated bacteremia. Despite the sound theoretical benefits of this intervention during indwelling catheter use,<sup>22</sup> results of at least 2 large randomized trials<sup>57,58</sup> show no benefit to rigorous meatal cleansing even when combined with a topical antibiotic drug therapy. In fact, in 1 trial,<sup>57</sup> there was an increased risk of bacteriuria in patients who were assigned to twice-daily meatal cleansing compared with control patients who received routine daily bathing. Thus, rigorous meatal cleansing is not recommended.

#### Silver-Coated Catheters

Silver is a highly effective antibacterial substance that can be applied to various types of catheters. Unlike the previously mentioned interventions, the use of certain types of silver-coated urinary catheters may be beneficial in preventing UTI. The results reported in 8 randomized controlled trials<sup>19,20,59-64</sup> of this device have been mixed. We recently performed a formal meta-analysis<sup>65</sup> of these studies and found that silver oxide catheters were not significantly better than control catheters but that silver alloy catheters were (**Table 5**). Clinical trials using silver alloy catheters and cost-effectiveness analyses are needed to assess whether these novel catheters should be used routinely. In the meantime, it would be reasonable to consider using a silver alloy catheter in patients who are at highest

risk for developing serious consequences from a UTI.

#### Systemic Antibiotic Drug Therapy

As early as 1955, Kass<sup>66</sup> demonstrated the value of prophylactic antibiotic drug therapy in catheterized patients. Because receiving systemic antibiotic drug therapy has been shown repeatedly to lower the risk for developing a UTI in catheterized patients,<sup>8,17,18,67</sup> several investigators have studied this intervention. Most studies of the past 15 years have used fluoroquinolone agents. Study designs were often retrospective, with variable inclusion criteria. Comparing results of these studies is further hampered by differences in definitions of UTI, timing and duration of antibiotic agents used, and outcomes measured. Studies with short-term catheterization were mainly in postoperative patients, whereas those with long-term catheters were largely in nursing home residents. Trials that randomized previously catheterized patients to either antibacterial drug prophylaxis or placebo yielded mixed results. In patient groups given prophylaxis at or shortly after catheter insertion, however, the efficacy was more convincing. When examined, low doses of antibiotic drugs were as effective as higher doses.<sup>21</sup> In general, systemic antibiotic drug therapy tends to be most useful in patients requiring urinary catheterization for 3 to 14 days.<sup>21,68-73</sup> Those catheterized for shorter durations are not at high enough risk

for UTI, and those with longer durations develop bacteriuria whether treated or not. Most experts do not recommend routinely using prophylactic antibiotic medications for catheterized patients because of their cost, potential adverse effects, and role in encouraging antibiotic drug resistance.<sup>40,74</sup> Results of several studies<sup>21,69,73</sup> demonstrate that antibiotic drug prophylaxis increased the rate of isolation of resistant organisms. Prophylactic antibiotic drug therapy may, however, be appropriate in those who require relatively short-term catheterization and are at high risk for complications from a UTI.<sup>75,76</sup> Most hospitalized patients—especially those in intensive care units—are already receiving antibiotic drug therapy for other reasons. The summary by Beeson<sup>2(p3)</sup> 4 decades ago of the value of systemic antibiotic drug therapy in patients with a long-term indwelling catheter still holds: “. . . chemoprophylaxis could not be expected to, and indeed does not, do anything but eradicate susceptible organisms and favor the establishment of an infection more difficult to treat.”

### Methenamine Hippurate

Methenamine is available as a salt of mandelate or hippurate. Methenamine hippurate has been used for preventing catheter-associated UTI for more than 30 years. Its antibacterial activity may be related to the breakdown of the compound to hippuric acid and formaldehyde. These products acidify urine and seem to reduce bacteriuria, pyuria, and urine viscosity.<sup>77</sup> Most studies of this agent have been small, nonrandomized trials in geriatric institutions. Using a before-and-after intervention design, oral methenamine hippurate therapy (2-6 g/d) was found to reduce the incidence of bacteriuria,<sup>77,78</sup> symptomatic UTI,<sup>79</sup> and pyuria.<sup>80</sup> One large, nonrandomized, comparative trial<sup>81</sup> found that patients receiving methenamine hippurate had significantly fewer courses of antibiotic drug therapy for symptomatic UTI and less frequent mechanical catheter complications. Other studies,<sup>82</sup> however, have not found any benefit of methenamine therapy in suppressing

catheter-associated bacteriuria. Because methenamine has antibacterial activity only at a urine pH below 6, ascorbic acid or ammonium chloride usually have to be given concomitantly to achieve sufficient urine acidification. Furthermore, the amount of time that any formaldehyde produced remains in the bladder in a catheterized patient is probably insufficient to be clinically effective. Although methenamine hippurate therapy is not recommended at this time, well-done randomized controlled trials evaluating this intervention should be considered.

### Other Interventions

Various other interventions to prevent catheter-related UTI have also been evaluated. Among those not clearly shown to be of benefit are metal lubricants and creams (antibacterial and nonantibacterial)<sup>83-87</sup> and urinary catheters coated with antibiotic drugs,<sup>83,88</sup> heparin sodium,<sup>89</sup> or polymer.<sup>90</sup> For men with prostatic enlargement that causes bladder outlet obstruction, many observational studies<sup>91-96</sup> describe the potentially promising intraprostatic spiral or intraurethral stent that allows bladder emptying without the need for bladder catheterization. Pending more rigorous evaluation, use of these devices may be considered in men with a contraindication to prostatic surgery but who have urinary retention despite pharmacological treatment.

### SPECIAL POPULATIONS

#### Systemic Antibiotic Prophylaxis for Transurethral Resection of the Prostate

Transurethral resection of the prostate is a common surgical procedure that generally requires urethral catheterization for at least a few days after surgery. This procedure is frequently complicated by bacteriuria, which are magnified by trauma that the operation causes to the urethra and prostatic bed. Thus, the many studies of antibiotic drug prophylaxis in these patients should be appraised separately from those in other catheterized patients. In

these investigations,<sup>97,98</sup> postoperative bacteriuria rates have nearly always been substantially lower in patients who receive systemic antibiotic drugs ( $\approx 10\%$ ) compared with those who do not ( $\approx 35\%$ ). Short-course, including single-dose, therapy has been as effective as longer courses. In the fewer studies<sup>98,99</sup> evaluating more clinically meaningful infectious complications, such as symptomatic UTI, bacteremia, or fever, the benefit of prophylactic antibiotic drug therapy is less evident. Overall, however, the available data from randomized controlled trials published in the past 2 decades suggest that antibiotic drug prophylaxis is justifiable for transurethral resection of prostate procedures, especially in men with an indwelling catheter or bacteriuria before surgery.<sup>100</sup> Rates of postoperative UTI can also be reduced by proper care and early removal of the urinary catheter.

### Other Urologic Procedures

Two prospective studies have evaluated the benefit of the combination of trimethoprim and sulfamethoxazole prophylaxis for patients receiving a renal transplant. A randomized controlled trial<sup>101</sup> with 52 patients evaluated the benefit of taking 1 tablet daily, beginning when the urethral catheter was removed (about 4 days after surgery) and continuing for 4 months. Compared with placebo, trimethoprim-sulfamethoxazole administration significantly reduced the incidence of UTIs, from 38% to 8%, and the incidence of graft rejection. The other study<sup>102</sup> found that, among 132 patients who received a transplant, those who received 1 trimethoprim-sulfamethoxazole tablet beginning the second postoperative day and continuing for at least 3 weeks (overall average, 8.5 months) experienced less than half as many hospital days with fever and about half as many bacterial infections during and after hospitalization. Although trimethoprim-sulfamethoxazole prophylaxis did not prevent UTI during the catheterization, it reduced the risk nearly 3-fold after catheter removal.<sup>102</sup> Trimethoprim-sulfamethoxazole use was well tolerated

in both studies and in 1 showed little effect on the patient's microbial flora. Thus, low-dose trimethoprim-sulfamethoxazole prophylaxis for a few months after renal transplantation seems appropriate.

One randomized controlled trial<sup>103</sup> of antibiotic drug prophylaxis among 270 abacteriuric patients undergoing extracorporeal shock wave lithotripsy compared either cefuroxime or ciprofloxacin therapy starting 30 minutes before the procedure with placebo. Neither antibiotic drug regimen significantly reduced the rate of bacteriuria (about 20%) compared with placebo 2 or 6 weeks after treatment.<sup>103</sup> Antibiotic drug prophylaxis in this setting, therefore, is unwarranted.

### RECOMMENDATIONS

Based on our review of the literature, we offer the following suggestions for preventing bacteriuria in adults who require a urinary catheter:

1. Avoid using a urinary catheter whenever possible. When catheterization is necessary, remove the device as soon as possible.

2. Always insert a catheter aseptically, use a closed drainage system, and properly maintain the catheter during use.

3. Consider using systemic antibiotic drug therapy only during short-term (3-14 days) catheterization of patients at high risk for complications of catheter-associated bacteriuria.

4. Consider using a silver alloy catheter in patients at high risk for complications of catheter-associated bacteriuria.

5. Use of suprapubic catheters may be desirable in patients requiring a long-term indwelling catheter because of bladder obstruction or urinary retention.

6. A condom catheter may be preferable for incontinent men who will not manipulate the device.

7. Prophylaxis with trimethoprim-sulfamethoxazole should be given to patients undergoing renal transplantation and requiring indwelling catheterization.

8. Systemic antibiotic drug prophylaxis should probably be

given to men undergoing transurethral resection of the prostate.

9. Bladder irrigation, antibacterial instillation in the drainage bag, rigorous meatal cleaning, and use of meatal lubricants and creams have not been clearly shown to prevent bacteriuria and should not be used.

### CONCLUSIONS

Interpreting data on preventing catheter-associated UTIs is complicated by important shortcomings in most published studies. First, many studies were not prospective, randomized, or controlled trials of a specific intervention. Second, the investigations were rather heterogeneous, consisting of a mix of medical and surgical patients, and often used different definitions of bacteriuria. Third, few studies took into account how often the closed drainage system was broken or entered for various reasons. Also, several studies were supported by the manufacturers of the drug or device being evaluated.

This overview itself also has several limitations. Although our distillation of the literature is evidence based, it does not provide the quantitative estimates of efficacy of a formal meta-analysis. Some studies of preventive measures discussed may be appropriate for pooling, but the heterogeneity of the interventions tested, patient populations studied, and outcomes measured often preclude quantitative analysis. Rather than provide exhaustive detail on each method of prevention, this review is a critical summary of many articles, with concise recommendations that should assist clinicians in assessing the potential value of each method discussed.

The available data suggest that urinary catheter-associated bacteriuria may be preventable for the short term (less than a few weeks) but is only postponed at best if the device is needed longer term. Furthermore, the complications of catheter-associated bacteriuria, including symptomatic UTI and bacteriuria, may be largely not preventable. Few of the approaches to prevent catheter-associated UTI have proven useful. Some, however, seem to have merit and should be considered in appro-

priate circumstances. More research, especially well-designed clinical trials, is needed to further define methods of decreasing this serious device-related complication.

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