Chapter 15. Prevention of Nosocomial Urinary Tract Infections

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Background

Many hospitalized patients require the placement of indwelling urinary catheters for days or even weeks at a time.[1] Only a minority of patients develop urinary tract infections because of the presence of these devices,[2,3] but the frequency of their use produces substantial overall morbidity for patients and costs to the health care system. Urinary tract infections (UTIs) account for up to 40% of nosocomial infections,[4,5] with urinary catheter-related infections causing the vast majority of nosocomial UTIs.[6] Each hospital-acquired UTI adds approximately $675 to the costs of hospitalization. When bacteremia develops, this additional cost increases to at least $2800.[2]

Because of the substantial complications and costs associated with the use of urinary catheters, a number of practices have been evaluated in an effort to reduce the incidence of urinary catheter-related infections. This chapter reviews the evidence supporting the use of silver alloy coated urinary catheters, and, because of its similarity, the recently described practice of using urinary catheters impregnated with the antibiotic combination of minocycline and rifampin. Subchapter 15.2 reviews the evidence supporting the use of suprapubic catheters as an alternative to urethral catheters.

Subchapter 15.1. Use of Silver Alloy Urinary Catheters

Practice Description

Silver is a highly effective antibacterial substance, which can be applied to various types of catheters. (See Subchapter 16.2 for a discussion of intravascular catheters coated with a combination of silver sulfadiazine and chlorhexidine). Multiple studies have suggested that silicone urethral catheters coated with hydrogel and silver salts reduce the risk of developing bacteriuria, compared with standard latex urethral catheters (Foley catheters). As shown in a recent meta-analysis, this benefit applies to catheters coated with silver alloy (which are coated on both internal and external surfaces of the catheter), but not silver oxide (which are coated on the external catheter surface only). Consequently, this chapter focuses only on studies evaluating silver alloy catheters, and the use of catheters coated with antimicrobials.[8]

Prevalence and Severity of the Target Safety Problem

Almost one million episodes of nosocomial UTI occur annually in the United States.[9] Each year approximately 96 million urethral catheters are sold worldwide. Of these, nearly 25% are sold in the United States.[3] The daily rate of bacteriuria in catheterized patients ranges from 3 to 10%, with the incidence directly related to the duration of catheterization.[4] Among patients with bacteriuria, 10 to 25% will develop symptoms of local urinary tract infection,[2,10] such as suprapubic or flank pain. The development of catheter-related bacteriuria carries with it a 2.8-fold increased risk of death, independent of other co-morbid conditions and disease severity.[11,12] Bacteremia results from catheter-related bacteriuria in approximately 3% of patients, and invariably represents a serious complication.[2,3]

Beyond the morbidity and mortality associated with indwelling catheters, catheter-related infection results in substantially increased health care costs. Data suggest that each episode of hospital-acquired symptomatic catheter-related UTI costs an additional $676, and each episode of catheter-related nosocomial bacteremia costs a minimum of $2836.[2]

Estimates from one university hospital, based on data from almost 20 years ago, were that hospital-acquired UTI led to approximately $204,000 in additional expenses per year.[13] More recent data are unavailable, but the institutional costs attributable to catheter-related infection are clearly substantial.

Opportunities for Impact

Since catheter-related UTI is the leading cause of nosocomial infection in the United States and is associated with increased morbidity and costs, any intervention that reduces the incidence of catheter-related UTI is potentially important. Currently, it is unknown what proportion of patients with indwelling catheters receives silver alloy catheters, however it is likely to be the minority.

Study Designs

As shown in Table 15.1.1, a meta-analysis[7] which included 4 randomized clinical trials,[14-17] compared the efficacy of silver catheters with standard, non-coated catheters. Five additional studies[18-22] have appeared since publication of this meta-analysis. In 3 of these studies,[18,20,22] the patient represented the unit of analysis. Another study employed a randomized crossover design (Level 1), randomizing wards rather than individual patients.[19] The final study used a prospective, before-after design at 5 different hospitals (Level 2).[21]

The patient populations for these studies included patients on various hospital services including urology, internal medicine, neurology, and the intensive care unit. In general, the studies included patients expected to be catheterized for at least 2 days. Since the patients resided in acute care hospitals rather than extended care centers, most were catheterized for 10 days or less. Several studies specified that patients given concomitant antibiotics were excluded.[15-18]

Study Outcomes

The individual trials and the meta-analysis focused primarily on the surrogate outcome of bacteriuria (Level 2). The definition of bacteriuria varied somewhat in the studies. However, low-level growth from a catheterized specimen (ie, 10^2 colony forming units (CFU) /mL) usually progresses within days to concentrations of greater than 10^4 CFU/mL unless antibiotic therapy is given.[23] Unfortunately, none of the studies was adequately powered to detect a significant difference in the clinically more important outcomes of catheter-related bacteremia or death. Though bacteriuria is a surrogate endpoint,[24] it is probably appropriate to use since it is a component of the only causal pathway in the disease process between catheterization and an important clinical outcome (eg, symptomatic UTI or catheter-related bacteremia). One study did report differences in secondary bloodstream infections.[19]

Evidence for Effectiveness of the Practice

The 4 clinical trials[14-17] of silver alloy catheters included in the meta-analysis[7] all showed a significant reduction in the development of catheter-associated bacteriuria. As shown in Table 15.1.1, studies published after the meta-analysis have reported more mixed results. Several of the studies have shown a statistically significant benefit of silver alloy catheters, but with a smaller relative risk reduction compared to that reported in the meta-analysis.[19,21,22] However, one study failed to find a significant benefit associated with silver alloy catheters,[20] and another found benefit from silver alloy catheters in those given such catheters for about 5 days, but not in those given the catheter for 14 days.[18] A formal update of the previous meta-analysis would be helpful, but is beyond the scope of the current report.

Potential for Harm

There is likely minimal harm from the use of silver alloy urinary catheters. The one theoretical harm involves the development of antimicrobial resistance. However, since silver is not used systemically in the form of an antimicrobial agent for treatment, the clinical significance of antimicrobial resistance to silver is unclear.

Costs and Implementation

Each silver alloy urinary catheter tray costs about $5.30 more than a standard, non-coated urinary catheter tray. However, a recent economic evaluation indicates that when all the clinical and economic costs are accounted for, silver alloy urinary catheters may provide both clinical and economic benefits in patients receiving indwelling catheterization for 2 to 10 days.[3] It should be noted that one of the major assumptions made in the economic evaluation is that a certain proportion of patients with bacteriuria develop the clinically important (Level 1) outcomes of symptomatic UTI or bacteremia. The economic analysis did not assign any costs to bacteriuria but did assign costs if patients developed these clinically important outcomes. Additionally, several of the very recent efficacy studies of silver alloy catheters[19,21,22] were not included in the economic analysis. A clinical study, adequately powered to detect both meaningful clinical and economic endpoints, would confirm the results of this economic evaluation that relied on modeling techniques. The overall cost of universal implementation of silver alloy catheters is unclear.

Comment

The data supporting the use of silver alloy urinary catheters to reduce urinary catheter-related bacteriuria is reasonably strong. As noted, the incidence of bacteriuria, while not extremely high, carries a high morbidity. It remains unclear whether silver alloy urinary catheters will also lead to decreases in the clinically more important outcomes of catheter-related bacteremia and mortality. Continuing investigation into the impact of silver alloy catheters on these important outcomes and their effect on the emergence of antibiotic resistance should be pursued.

Of note, catheters coated with antibacterial substances other than silver have also been evaluated. A recent randomized study[8] found that patients who received antimicrobial-impregnated catheters coated with minocycline and rifampin had significantly lower rates of gram-positive bacteriuria than a control group given standard, non-coated catheters (7.1% vs. 38.2%; $p < 0.001$). Both control and intervention groups had similar rates of gram-negative bacteriuria and candiduria (Table 15.1.1). However, the theoretical risk of developing antimicrobial resistance to minocycline and/or rifampin (2 agents occasionally used systemically) may limit the use of catheters coated with these antibiotics.

Table 15.1.1. Studies of silver alloy and antibiotic-impregnated urethral catheters*

Study	Description	Design, Outcomes	Results: Odds or Risk of Bacteriuria† (unless otherwise noted)
Saint, 1998[7]	Meta-analysis of 4 randomized controlled trials (n=453) of silver alloy vs. uncoated urinary catheters	Level 1A, Level 2	OR 0.24 (95% CI: 0.11-0.52)
Maki, 1998[22]	Prospective, randomized, double-blind trial of silver alloy (n=407) vs. standard Foley (n=443) catheters	Level 1, Level 2	RR 0.74 (95% CI: 0.56-0.99)
Verleyen, 1999[18]	Prospective, randomized study of medium-term catheterization with silver alloy (n=18) vs. silicone (n=17) catheters after radical prostatectomy	Level 1, Level 2	After 14 days, 50.0% vs. 53.3% (p=NS)
	Prospective, randomized study of short-term catheterization with silver alloy (n=79) vs. latex (n=101) catheters	Level 1, Level 2	On day 5, 6.3% vs. 11.9% (p<0.003)
Bologna, 1999[21]	Prospective, blinded study of silver alloy vs. standard latex Foley catheters in 5 hospitals. Baseline period ranged from 3-12 months (mean, 8 months); intervention period ranged from 7-19 months (mean, 10 months)	Level 2, Level 1	Unadjusted infection rate: 4.5 vs. 7.1 infections per 1000 catheter days (p<0.01) Adjusted infection rate: 4.9 vs. 8.1 infections per 1000 catheter days (p=0.13)
Karchmer, 2000[19]	12-month randomized crossover trial of catheter-associated urinary tract infections in patients with silver-coated and uncoated catheters. The ward was the unit of analysis. A cost analysis was also conducted.	Level 1, Level 1	Infection rate: 2.66 vs. 3.35 infections per 1000 patient-days, RR 0.79 (95% CI: 0.63-0.99) Infection rate: 1.10 vs. 1.36 infections per 100 patients, RR 0.81 (95% CI: 0.65-1.01) Infection rate: 2.13 vs. 3.12 infections per 100 catheters, RR 0.68 (95% CI: 0.54-0.86) Estimated hospital cost savings with silver-coated catheters: $14,456 to $573,293
Thibon, 2000[20]	Multicenter, prospective, randomized, double-blind trial of silver alloy (n=90) vs. standard (n=109) catheters in patients	Level 1, Level 2	After 10 days, 10% vs. 11.9% OR 0.82 (95% CI, 0.30-2.20)

	requiring catheterization for >3 days		
Darouiche, 1999[8]	Multicenter, prospective, randomized, blinded trial of medium-term catheterization (mean, 14 days) with minocycline-rifampin impregnated (n=56) vs. silicone (n=68) catheters after radical prostatectomy	Level 1, Level 2	Patients took longer to develop bacteriuria with antimicrobial-impregnated catheters than control catheters (p=0.006 by the log-rank test) Overall bacteriuria at day 7: 15.2% vs. 39.7% (p<0.05) Overall bacteriuria at day 14: 58.5% vs. 83.5% (p<0.05) Gram-positive bacteriuria: 7.1% vs. 38.2% (p<0.001) Gram-negative bacteriuria: 46.4% vs. 47.1% (p=NS) Candiduria: 3.6% vs. 2.9% (p=NS)

* CI indicates confidence interval; NS, not statistically significant; OR, odds ratio; and RR, relative risk.
† Results are reported as intervention group (silver alloy or minocycline/rifampin catheter) vs. control group.

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Subchapter 15.2. Use of Suprapubic Catheters

Background

As discussed in Subchapter 15.1, the use of indwelling urethral catheters results in substantial morbidity and mortality. Given the medical and social morbidity associated with urethral catheters, many clinicians have considered suprapubic catheterization as an alternative to catheterization via the urethra. Suprapubic catheters are inserted in the lower abdomen, an area with less bacterial colonization than the periurethral region, so that the risk for infection is thought to be lower than with urethral catheters. Furthermore, although the suprapubic placement of urinary catheters represents a minor surgical procedure, patients may find the result more comfortable[89] and, as reviewed below, the development of infectious complications is reduced. Subchapter 15.1 discusses the use of silver alloy urinary catheters. The focus of this chapter is the use of suprapubic catheters as compared with standard urethral indwelling catheters in adults.

Practice Description

Suprapubic catheterization typically involves the percutaneous placement of a standard urinary catheter directly into the bladder. The procedure is performed by urologists using sterile technique. It is generally performed in the operating room and is considered minor surgery.

Prevalence and Severity of Target Problem

In addition to the infectious complications (and their associated costs) discussed in Subchapter 15.1, the use of urethral catheters causes substantial patient discomfort. In a recent study at a Veteran Affairs Medical Center, 42% of catheterized patients surveyed reported that the indwelling catheter was uncomfortable, 48% complained that it was painful, and 61% noted that it restricted their activities of daily living.[7] Restricted activity reduces patient autonomy and may promote other nosocomial complications, such as venous thromboembolism and pressure ulcers. In addition, 30% of survey respondents stated that the catheter's presence was embarrassing, and in unsolicited comments that supplemented the structured questionnaires several noted that it "hurts like hell."[7]

Opportunities for Impact

Since catheter-related urinary tract infection (UTI) is the leading cause of nosocomial infection in the United States and is associated with increased morbidity and costs, any intervention that reduces the incidence of catheter-related UTI is potentially important. Currently, it is unknown what proportion of patients who require indwelling urinary catheters receive suprapubic catheters, however, this practice is uncommon.

Study Design

There have been twelve prospective studies,[8,9,11-17] all but one randomized,[15] comparing the efficacy of suprapubic catheters with standard, non-coated catheters (Table 15.2.1). In all of these studies, the patient was the unit of analysis. The patient populations for these studies varied but generally included patients with acute urinary retention and those undergoing various surgical procedures. Since most of the patients evaluated resided in acute care hospitals, the average duration of catheterization was generally less than 14 days.

Study Outcomes

All the trials focused on the outcome of bacteriuria. Several of the studies also assessed patient satisfaction and the incidence of mechanical complications. The definition of bacteriuria varied somewhat in the studies. However, low-level growth from a catheterized specimen (ie, 10^2 colony forming units (CFU)/mL) usually progresses within days to concentrations of greater than 10^4 CFU/mL, unless antibiotic therapy is given.[18] Unfortunately, none of the studies was adequately powered to detect a significant difference in the clinically more important outcomes of catheter-related bacteremia or death. Though bacteriuria is a surrogate endpoint,[19] it is probably appropriate to use since it is a component of the only causal pathway in the disease process between suprapubic catheterization and an important clinical outcome (eg, symptomatic UTI or catheter-related bacteremia).

Evidence for Effectiveness of the Practice

As shown in Table 15.2.1, studies comparing suprapubic catheterization with urethral catheterization have produced mixed results.[8,9,11-17,20-22] Six trials reported lower rates of bacteriuria in patients with suprapubic catheters,[11,13,15,16,21,22] and 4 trials indicated greater patient satisfaction with suprapubic as opposed to urethral catheters.[8,13,16,20] In 3 of the studies, however, mechanical complications were higher in those receiving suprapubic catheters.[12,15,16] Of note, 3 studies found that patients given suprapubic catheters have significantly decreased incidence of urethral strictures compared with patients who received urethral catheters.[15,23,24] However, the use of prophylactic antibiotics in patients receiving urethral catheters for transurethral resection of the prostate has been shown to significantly reduce the incidence of strictures in the anterior urethra.[25]

Potential for Harm

As stated above, the primary problem associated with suprapubic catheter use involves mechanical complications associated with insertion, most commonly catheter dislodgement or obstruction, and failed introduction. The safe insertion of suprapubic indwelling urinary catheters depends on trained personnel.

Costs and Implementation

The cost of each suprapubic urinary catheter tray is comparable to the cost of each standard, non-coated urethral catheter tray. However, the overall initial costs of using suprapubic catheters will no doubt be greater since procedure-related costs are substantially higher for suprapubic than urethral catheters. Nurses are able to place urethral catheters at the bedside, but urologists must place suprapubic catheters, and the procedure typically occurs in the operating room. Additionally, it is unclear whether urologists are currently proficient at the insertion of suprapubic catheters given how infrequently they are used. If suprapubic catheters are shown to be effective, they may have a positive impact on patient care. The cost of training individuals in inserting and maintaining the suprapubic catheter is likely to be substantial.

Comment

When compared with standard urethral indwelling catheters, suprapubic urinary catheters may reduce urinary catheter-related bacteriuria. Additionally, patient satisfaction may be greater with suprapubic catheters, although there is also evidence that patients placed with suprapubic catheters more frequently experience certain mechanical complications. On the other hand, urethral catheters are likely to lead to a higher incidence of urethral strictures. Given these mixed results, conclusions regarding the overall benefit of routine suprapubic catheterization cannot currently be made. However, it would be reasonable to consider conducting a formal meta-analysis of the published trials to answer the question, "Compared with urethral indwelling catheters, are suprapubic catheters less likely to lead to UTI (as measured by bacteriuria) and more likely to lead to enhanced patient satisfaction?" Using explicit inclusion criteria and accepted quantitative methods, a meta-analysis[26-28] can often help clarify the features of individual studies that have divergent results.[29] In addition, a possible interaction between gender of the patient and type of catheter is of interest since different pathophysiologic mechanisms underlie the development of urethral catheter-related infection in men and women.[30] The possibility of adequately evaluating effects within subgroups (eg, those undergoing certain surgical procedures) because of an increased sample size is one of the benefits of meta-analysis.[31]

If formal meta-analysis suggests that suprapubic catheters are less likely to lead to urinary tract infection and more likely to enhance patient satisfaction, at least in some clinical settings, then these catheters should be considered in the management of certain patients. On the other hand, if the meta-analysis finds that urethral catheters are superior to suprapubic catheters, then use of suprapubic catheters, albeit currently quite limited, should be further reduced.

Table 15.2.1. Prospective studies comparing suprapubic with urethral catheters

Study	Design, Outcomes	Patient Population*	Bacteriuria (%)†		Odds Ratio (95% CI)‡	Comments§
			Suprapubic	Urethral		
Shapiro, 1982[16]	Level 1, Level 2	General surgical patients with urinary retention	2/25 (8)	21/31 (68)	0.04 (0.01-0.24)	Pseudorandomized (urethral catheters used in every third patient) study; suprapubic group had less pain but more mechanical complications
Andersen, 1985[13]	Level 1, Level 2	Women undergoing vaginal surgery	10/48 (21)	20/44 (45)	0.32 (0.11-0.86)	Patients rated acceptability of suprapubic catheters greater
Ichsan, 1987[9]	Level 1, Level 2	Patients with acute urinary retention	3/29 (10)	11/37 (30)	0.27 (0.04-1.22)	None of the suprapubic group complained of discomfort compared with 17 of the patients given urethral catheters
Sethia, 1987[11]	Level 1, Level 2	General surgical patients requiring urine output monitoring	2/32 (6)	16/34 (47)	0.08 (0.01-0.41)	Decrease in bacteriuria was more significant in women than in men
Schiotz, 1989[12]	Level 1, Level 2	Women undergoing vaginal surgery	8/38 (21)	5/40 (12)	1.87 (0.48-8.01)	26% of suprapubic group versus 5% of urethral group had mechanical complications
Horgan, 1992[15]	Level 2, Level 2	Men with acute urinary retention due to prostatic enlargement	10/56 (18)	12/30 (40)	0.33 (0.11-0.99)	21% of suprapubic group versus 3% of urethral group had dislodgement; 0% of suprapubic group versus 17% of urethral group developed urethral strictures
O'Kelley, 1995[8]	Level 1, Level 2	General surgical patients requiring abdominal surgery	3/28 (11)	3/29 (10)	1.04 (0.13-8.51)	Study design unclear, but probably not randomized; suprapubic catheters caused significantly fewer days of catheter-related pain
Ratnaval, 1996[14]	Level 1, Level 2	Men undergoing colorectal surgery	1/24 (4)	3/26 (12)	0.33 (0.01-4.60)	Suprapubic group had fewer voiding difficulties

Bergman, 1987[21]	Level 1, Level 2	Women undergoing vaginal surgery for stress incontinence	4/24 (17)	17/27 (63)	0.26 (0.10-0.68)	Length of hospital stay was significantly less (by 1 day) in the suprapubic catheter group
Abrams, 1980[20]	Level 1, Level 2	Men with urinary retention	21/52 (40)	13/50 (26)	1.6 (0.88-2.75)	12% of suprapubic catheter group found catheter uncomfortable compared with 64% in the standard urethral catheter group (p<0.001)
Vandoni, 1994[22]	Level 1, Level 2	Patients requiring surgery for various indications	0/19 (0)	6/24 (25)	0 (0-0.95)	All patients given pre-catheterization antibiotics; slight decrease in pain and discomfort in suprapubic group but not significant (authors do not provide actual satisfaction data)
Perrin, 1997[17]	Level 1, Level 2	Patients undergoing rectal surgery	12/49 (24)	29/59 (49)	0.34 (0.13-0.83)	12% of suprapubic group reported catheter discomfort compared with 29% of urethral group

* Studies enrolled both men and women unless otherwise noted.
† Indicates the ratio of patients who developed bacteriuria to the total number of participants assigned to each group.
‡ Odds of developing bacteriuria in the suprapubic versus urethral catheter groups; CI indicates confidence interval.
§ Mechanical complications consisted of failed introduction of catheter, and catheter dislodgement or obstruction.

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