STATE OF THE SCIENCE

Clinical and economic consequences of nosocomial catheter-related bacteriuria

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Indwelling catheters are strongly associated with the development of bacteriuria, which can lead to significant morbidity in hospitalized patients. This report, a review of the literature, evaluates the infectious outcomes of patients with indwelling catheters to determine the precise clinical and economic impact of catheter-related infection. Statistical pooling was used to estimate the incidence of bacteriuria in hospitalized patients with indwelling catheters. In addition, the proportion of patients with catheter-related bacteriuria in whom symptomatic urinary tract infection and bacteremia will develop was estimated through quantitative synthesis of previous reports. Costs were estimated by using microcosting techniques.

Of patients who have indwelling catheters for 2 to 10 days, bacteriuria is expected to develop in 26% (95% confidence interval [CI], 23% to 29%). Among patients with bacteriuria symptoms of urinary tract infection will develop in 24% (95% CI, 16% to 32%), and bacteremia from a urinary tract source will develop in 3.6% (95% CI, 3.4% to 3.8%). Each episode of symptomatic urinary tract infection is expected to cost an additional $676, and catheter-related bacteremia is likely to cost at least $2836. Given the clinical and economic burden of urinary catheter-related infection, infection control professionals and hospital epidemiologists should use the latest infection control principles and technology to reduce this common complication.

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Each year, millions of Americans undergo catheterization of their urinary bladder, to up to 25% of hospitalized patients having a urinary catheter placed at some time during their stay. Indwelling urinary catheters are a leading cause of morbidity in acute care settings, accounting for up to 40% of nosocomial infections. Catheter-related infection accounts for the vast majority of nosocomial urinary tract infections (UTIs). More than 17% of cases of nosocomial bacteremia are attributed to the urinary tract; only intravascular catheters lead to more cases of nosocomial bacteremia.

Given the high incidence of catheter-related infection in American hospitals and the enhanced emphasis on the quality and costs of health care, it is appropriate to assess the clinical and economic consequences of catheter-related infection. In so doing, infection control professionals and decision makers will gain an improved understanding of the importance of preventing catheter-related infection in hospitalized patients. This quantitative review will address the following questions: (1) What is the incidence of catheter-related bacteriuria? (2) In what proportion of patients with bacteriuria will symptoms of UTI develop? (3) What proportion of patients with bacteriuria will have bacteremia? (4) What is the attributable mortality associated with catheter-related infection? and (5) What are the costs of catheter-related infection?

DEFINITIONS

The definition of catheter-related UTI used in published reports varies and, unfortunately, the terms "urinary tract infection" and "bacteriuria" are often used interchangeably. This practice leads to unnecessary confusion. In this report, "bacteriuria" will be used to indicate significant growth of bacteria in the urine not associated with symptoms. The amount of growth probably is not vital, inasmuch as low-level growth from a catheterized specimen (ie, 10² colony-forming units [CFU]/mL) usually progresses within days to concentrations of more than 10⁶ CFU/mL, unless antibiotic therapy is given. Thus, most would agree that growth of ≥ 10⁵ CFU/mL of a predominant pathogen from a catheterized urine specimen represents significant bacteriuria.
"Symptomatic UTI" will be used when bacteriuria leads to either local symptoms of infection (eg, lower abdominal pain or discomfort, flank pain) or systemic symptoms (eg, nausea, vomiting, fever). Catheter-related bacteremia occurs when a patient's blood and urine cultures reveal growth of the same organism. In general, patients with bacteremia related to a urinary catheter have clinical manifestations of systemic infection.

After 1 month of indwelling catheterization, bacteriuria develops in nearly all patients, making this a convenient dividing line between short- and long-term catheterization. The focus of this review will be on the consequences of short-term catheterization (ie, catheterization for fewer than 30 days). In addition, although external or condom catheters are occasionally used in the acute care setting, indwelling catheters are used much more often and the data pertaining to their effects are much better known. Thus, indwelling catheters will be the area of focus for this report.

METHODS

Relevant reports were located by several methods. The computerized MEDLINE database of English language articles published between January 1966 and November 1998 was searched with use of the Medical Subject Headings (MeSH) "urinary tract infections" or "urinary tract," combined with the keyword "catheter#." The MEDLINE database also was searched for articles written by selected authorities in the field of catheter-associated infection. Finally, other potential references were identified by review of references cited in retrieved articles, review articles, and consensus statements. Both peer-reviewed publications and reports published as theses or in abstract form were considered. Although most relevant reports were probably located by using these methods, this review does not represent a formal meta-analysis (or a series of meta-analyses) in which every possible report was located and reviewed.

When appropriate, the results from several studies were statistically combined to provide an pooled estimate of the clinical parameter of interest. In addition, 95% CIs were calculated. The method used for combining the estimates of cumulative incidence from several studies was based on standard formulas for combining proportions in which the weighted averages and variance are calculated. These analyses were performed using STATA 5.0 (College Station, Texas). Estimates of effect derived by using statistical techniques for pooling data are useful within economic models that assess the cost-effectiveness of various interventions. The economic estimates were derived by using microcosting techniques, with costs from the University of Michigan Health System serving as a reference.

Estimates for length of stay and utilization were based on both review of the literature and, when the literature was limited, expert opinion. Hospital room charges and Current Procedural Terminology-based charges of laboratory tests were converted to costs using the University of Michigan Health System’s Medicare cost-to-charge ratio of 0.57. Antimicrobial costs were based on the University of Michigan Health System’s pharmacy costs. Of note, a conservative bias was used for all cost estimates. Thus, the economic consequences of catheter-related bacteriuria should be interpreted to likely indicate the minimal cost associated with catheter-related infection.

INCIDENCE OF CATHETER-RELATED BACTERIURIA

Several prospective studies have assessed patients with indwelling catheters daily to ascertain the incidence of bacteriuria. These studies, outlined in Table 1, are of two types: natural history evaluations and randomized trials using controls that compare various methods of preventing bacteriuria. This report focuses on patients with standard, noncoated indwelling catheters using closed drainage systems who were not receiving systemic antimicrobials or other interventions (eg, silver-alloy urinary catheters) to prevent bacteriuria. Most of the patients evaluated in the studies had catheters in place for 2 to 10 days. The pooled cumulative incidence of developing bacteriuria in patients with indwelling catheters for this duration was found to be 26% (Table 2). The 95% CI ranges from 23% to 29%. This estimate of bacteriuria incidence after 2 to 10 days of catheterization approximates the 3% to 10% daily estimate of bacteriuria that others have cited after multiplying the number of catheterized days by the daily incidence.

Several preventive measures have been evaluated in those requiring an indwelling catheter, including bladder irrigation, antibacterial instillation in the urinary collecting bag and conscientious daily meatal cleaning, and silver-coated urinary catheters. In addition, alternative methods of urinary collection, such as condom catheters and suprapubic catheters have been evaluated to ascertain the incidence of infectious complications. The merits of these preventive methods recently have been reviewed and, thus, will not be discussed further in this report.

An important but underappreciated consideration in hospitalized patients is the effect of systemic antimicrobial therapy in modifying the incidence of catheter-related bacteriuria. Approximately 80% of patients admitted to American hospitals receive systemic antimicrobials during their stay. Several prospective studies have used multivariate logistic regression to
control for several potential covariates, allowing the protective effect of systemic antibiotics to be estimated. The pooled risk ratio for systemic antibiotics is 0.35 (95% CI, 0.27 to 0.47), indicating that the incidence of catheter-related bacteriuria is decreased by approximately 65% in patients receiving systemic antimicrobial therapy. The 95% CI indicates that the protective effect of systemic antimicrobials ranges from 53% to 73%. Although systemic antibiotics decrease the risk of bacteriuria developing, most experts do not recommend the routine use of prophylactic antimicrobials for patients with catheters because of the extra cost, potential adverse side effects, and their role in encouraging antibiotic resistance. 

**INCIDENCE OF SYMPTOMATIC CATHETER-RELATED URINARY TRACT INFECTION**

Most patients with catheter-related bacteriuria remain free of symptoms. In many patients, however, local and systemic symptoms occur that indicate the patient may have a UTI. The proportion of patients with bacteriuria in whom symptomatic UTI develops was estimated by combining the only 2 prospective studies that were found in which this outcome was reported. Garibaldi and colleagues found that 25 of 77 patients (32%) with bacteriuria at the University of Utah Medical Center had symptomatic UTI develop. Symptomatic UTI in this evaluation was defined as temperature of 100.0°F or higher for 12 or more hours in the absence of other sites of infection, or when the patient complained of symptoms referable to the urinary tract. Hartstein et al evaluated seriously ill medical and surgical patients and found that 3 out of 25 patients with bacteriuria had a symptomatic UTI develop. Hartstein defined symptomatic UTI as presence of fever with symptoms suggesting lower UTI (e.g., bladder discomfort, dysuria), no other likely focus of infection, and negative blood cultures. The results of statistically

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**Table 1.** General characteristics of 10 prospective studies used to estimate the cumulative incidence of bacteriuria in patients with indwelling catheters

<table>
<thead>
<tr>
<th>Source</th>
<th>Number of patients*</th>
<th>Number (%) with bacteriuria</th>
<th>Definition of bacteriuria</th>
<th>Patient population</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lundeb erg⁷²</td>
<td>51</td>
<td>17 (33%)</td>
<td>≥10⁵ CFU/mL</td>
<td>Urology or surgery</td>
</tr>
<tr>
<td>Huth et al⁵⁹</td>
<td>59</td>
<td>17 (29%)</td>
<td>≥10⁴ CFU/mL</td>
<td>Any service</td>
</tr>
<tr>
<td>Huth et al⁴⁵</td>
<td>164</td>
<td>56 (34%)</td>
<td>≥10⁴ CFU/mL</td>
<td>Any service</td>
</tr>
<tr>
<td>Liedberg and Lundeb erg⁹⁰</td>
<td>60</td>
<td>22 (37%)</td>
<td>&gt;10⁵ CFU/mL</td>
<td>Urology or surgery</td>
</tr>
<tr>
<td>Liedberg and Lundeb erg²⁰</td>
<td>30</td>
<td>15 (50%)</td>
<td>&gt;10⁴ CFU/mL</td>
<td>Urology or surgery</td>
</tr>
<tr>
<td>Liedberg and Lundeb erg⁷¹</td>
<td>96</td>
<td>23 (24%)</td>
<td>&gt;10⁴ CFU/mL</td>
<td>Medicine, urology, or surgery</td>
</tr>
<tr>
<td>Shapiro et al²⁸</td>
<td>57</td>
<td>22 (38%)</td>
<td>&gt;10³ CFU/mL</td>
<td>Neurology, neurosurgery, urology, cardiology, surgery, or orthopedics</td>
</tr>
<tr>
<td>Platt et al⁶⁰</td>
<td>108</td>
<td>29 (27%)</td>
<td>&gt;10⁴ CFU/mL</td>
<td>Any service</td>
</tr>
<tr>
<td>Platt et al⁵⁷</td>
<td>217</td>
<td>39 (18%)</td>
<td>≥10³ CFU/mL</td>
<td>Any service</td>
</tr>
<tr>
<td>Hiley et al⁶⁸</td>
<td>117</td>
<td>25 (21%)</td>
<td>&gt;10⁴ CFU/mL</td>
<td>Medicine or surgery</td>
</tr>
</tbody>
</table>

*The number of patients given urethral catheters and not receiving other interventions to prevent bacteriuria (eg, systemic antimicrobials, silver alloy urinary catheters).

**Table 2.** Estimates of the clinical consequences of catheter-related infection

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Pooled estimate (95% CI)</th>
<th>Reference(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Probability of development of bacteriuria in patients not receiving systemic antimicrobials and given indwelling catheters for 2 to 10 days</td>
<td>26% (23%-29%)</td>
<td>Huth et al,⁶⁶ Huth et al,⁴⁶ Platt et al,⁶⁶ Platt et al,²⁹ Riley and Lundeberg,²⁰²¹ Liedberg and Lundeberg,²⁰²¹ Liedberg et al,²¹ Lundeberg²⁴ Hartstein et al²⁹</td>
</tr>
<tr>
<td>After development of bacteriuria, probability of development of symptomatic UTI without bacteremia</td>
<td>24% (16%-32%)</td>
<td>Garibaldi et al,²⁴ Hartstein et al²⁹</td>
</tr>
<tr>
<td>After development of bacteriuria, probability of development of bacteremia</td>
<td>3.6% (3.4%-3.8%)</td>
<td>Krieger et al,² Garibaldi et al,²⁴ Bryan and Reynolds,⁶⁶ Emori et al,⁵⁷ Horan et al⁵⁶</td>
</tr>
</tbody>
</table>

*95% CI not reported in article.
pooling these 2 studies showed that approximately 24% of patients with bacteriuria had symptomatic UTI develop (Table 2). The 95% CI ranges from 16% to 32%. Although these findings are consistent with the estimates of symptomatic UTI provided by qualitative review articles,14-15 it should be noted that this estimate is relatively imprecise, as it is based on limited data.

**INCIDENCE OF BACTEREMIA IN PATIENTS WITH BACTERIURIA**

Catheter-related bacteremia occurs infrequently; however, when it complicates bacteriuria it is invariably consequential. Urinary catheter-related bacteremia is diagnosed when the same organism is isolated from both the urine and the blood cultures in the absence of other likely sources of infection. Clinical manifestations of bacteremia may include fever, chills, confusion, hypotension, and leukocytosis. Five studies have assessed the risk of bacteremia in patients with bacteriuria.4.5.42-44 As can be seen in Table 3, the estimates from each study are similar and range from 2.6% to 4.0%. The pooled estimate is 3.6% with a 95% CI of 3.4% to 3.8% (Table 2). Thus, bacteremia will develop in almost 1 of every 27 patients with bacteriuria.

**DEATH CAUSED BY CATHETER-RELATED INFECTION**

Catheter-related bacteriuria is associated with an increased risk of death. Whether this relationship is causal is a matter of some controversy. Some believe that patients in whom catheter-related infection develops are fundamentally different from those in whom this catheter-related complication does not develop and, thus, may have a higher risk of dying because of these intrinsic factors. Proponents of this view would argue that acquisition of bacteriuria is merely a marker of severe underlying disease or deficient immunity and not an independent risk factor for death.

On the other hand, those who argue that catheter-related bacteriuria leads to increased mortality point to important studies performed by Platt et al.16-19 In a prospective evaluation of 1458 hospitalized patients, 136 of whom had bacteriuria develop, Platt et al.19 used multivariate logistic regression to identify risk factors for dying. After controlling for severity of illness, duration of catheterization, hospital service, comorbid illnesses, and other factors that could potentially confound the association between bacteriuria and death, they found that nosocomial bacteriuria was associated with a 2.8-fold increased risk of dying.19 Even stronger evidence for causality was provided by the same investigators as part of a randomized trial evaluating the efficacy of sealed urinary catheter junctions.19 Their finding that the degree of bacteriuria reduction corresponded closely with the degree of mortality reduction bolsters the hypothesis that catheter-related bacteriuria causes excess mortality, at least in some populations.16

Bryan and Reynolds,56 by attempting to quantify the attributable mortality caused by catheter-related bacteremia, focused on the increased risk of death result-
ing from this important complication. Between 1977 and 1981, they observed 1520 episodes of hospital-acquired bacteremia at the 4 major hospitals of Columbia, South Carolina. Of these bacteremic episodes, 221 were attributed to the urinary tract. These investigators found that 30.8% of the patients with nosocomial urinary tract-related bacteremia died, estimating that the attributable mortality of urinary tract-related bacteremia was 12.7% after review of each medical record (Table 2). This estimate of attributable mortality was based in part on the clinical judgment of the investigator performing the medical record review.

**ECONOMIC CONSEQUENCES OF CATHETER-RELATED INFECTION**

The clinical consequences of catheter-related infection undoubtedly increase health care costs for affected patients. The extent of this economic burden is unclear for several reasons. First, most of the economic evaluations performed in this area have become dated, given that changes in health care delivery and financing have led to substantial decreases in length of stay for most hospitalized patients. Second, previous evaluations often relied on billing data from hospitals and thus determined the additional charges rather than the additional costs associated with catheter-related infection. Third, several earlier studies found an association between increased costs and asymptomatic bacteriuria, because screening for bacteriuria was often routinely performed in patients with catheters. Such routine screening is rarely performed now; therefore, these data may no longer be relevant. The above limitations notwithstanding, some of the studies that have evaluated the additional length of stay and costs for patients with catheter-related infection do provide some useful estimates.

For the purposes of this review, asymptomatic bacteriuria will be assumed not to lead to additional costs. Although this assumption may be controversial, it is reasonable; because routine screening is rarely performed now, urine cultures will not be obtained in most patients with asymptomatic bacteriuria. Thus, physicians are unlikely to alter their management of patients with asymptomatic bacteriuria, as the presence or absence of bacteriuria will be unknown.

Symptomatic UTI in patients with catheters, on the other hand, definitely is associated with increased costs. The increase in length of hospital stay for affected patients ranges from 1 extra day to 2 extra days. The exact increase in cost will vary depending on the individual hospital and the evaluation and management style of the attending physician. Using the University of Michigan Health System as an example, the minimum cost associated with symptomatic UTI can be derived by adding the costs of the individual tests necessary to confirm the diagnosis to the cost of treating the patient. These additional steps would conservatively include a urinalysis and urine culture and sensitivity test, 1 extra day in the hospital, and an oral fluorquinolone antimicrobial for 7 days. Thus, the minimum additional cost of evaluating and treating a patient with hospital-acquired symptomatic UTI at the University of Michigan Health System would be $676 (Table 4).

The additional cost of catheter-related bacteremia can be estimated in an analogous manner. Although no study was found that directly measured the increased costs attributable to bacteremic catheter-related UTI, several studies have estimated the increased morbidity and costs associated with nosocomial bacteremia from any source. Using data gathered between 1972 and 1974, Rose et al estimated that a patient with nosocomial bacteremia had an excess hospital stay of 19 days and accrued 3 times more charges than a similar patient without nosocomial bacteremia. In a case-control study also performed between 1972 and 1974,
Spengler and Greenough\(^4\) reported that the excess hospital stay for patients with nosocomial bacteremia (in which 16% originated from the genitourinary tract) averaged 17 more days than matched patients without nosocomial infection.

Excess stay and costs attributed to nosocomial bacteremia also have been reported in patients in intensive care units, an import venue for nosocomial infections, given that as many as 25% of nosocomial infections occur in the critically ill.\(^6\) Pittet et al.\(^7\) in a matched case-control study in a surgical intensive care unit between 1988 and 1990, found that the extra hospital and intensive care unit lengths of stay attributable to bacteremia were 24 and 8 days, respectively. The extra charges attributable to the infection averaged $40,000 per survivor.\(^8\)

Using these studies as background, at a minimum the estimated additional cost of bacteremia would include the cost of urinalysis, urine culture and sensitivity, 2 sets of blood cultures, 3 days of intravenous antimicrobials (eg, ceftriaxone and gentamicin), 11 days of oral trimethoprim-sulfamethoxazole, 2 extra days on the hospital ward, and 1 extra day in the intensive care unit. The extra intensive care unit day may be expected because some patients with urinary catheter-related bacteremia would be critically ill when the infection occurred and already in an intensive care unit, whereas other patients—those on the general ward—would require transfer to the intensive care unit for treatment of hypotension or other bacteremic complications. Again, with costs from the University of Michigan Health System used as an example, the minimum cost of evaluating and treating a patient with urinary catheter-related bacteremia is $2836 after adding the costs of the additional laboratory tests and therapies listed above (Table 4). Note that these costs for both symptomatic UTI and bacteremia are likely to be underestimated, as they do not include physician charges or the costs of other tests likely to be ordered (eg, complete blood cell count, chemistry panel, chest radiograph). In addition, the estimates of the extra length of stay and extra cost attributable to bacteremia are substantially less than those provided in the previously mentioned evaluations of nosocomial bacteremia.\(^9\)\(^-\)\(^11\)

**CONCLUSIONS**

Indwelling catheter use is widespread in acute care settings across the United States. Although often a necessary intervention, urinary catheters unfortunately are the leading cause of UTIs in hospitalized patients. This quantitative synthesis of the literature estimates both the incidence of bacteriuria and the clinical consequences of bacteriuria by using accepted methods of statistical pooling. In addition, this report attempts to ascertain the economic burdens associated with catheter-related infection. The analysis found that catheter-related bacteriuria is common and is likely to occur in about 1 in 4 patients who have catheters in place from 2 to 10 days. Although most patients with catheter-related bacteriuria remain free of symptoms, symptoms of local infection develop in approximately 1 in 5. In addition, bacteremia from the same urinary tract organism will develop in 1 of 27 patients with bacteriuria. The attributable mortality associated with catheter-related infection is approximately 13%; however, this estimate is based on limited data. Costs associated with symptomatic UTI and urinary catheter-related bacteremia were found to be substantial, despite a conservative bias in the analysis.

Infection control professionals and hospital epidemiologists play an important role in reducing the incidence of this important complication by emphasizing the use of aseptic technique in catheter insertion and maintenance, and by advocating for methods with demonstrated effectiveness in preventing this complication.\(^4\) In the future, it is hoped that new technologies will be developed that will reduce the significant health care burden of urinary catheter-related infection.

**References**


