Catheter-Associated Urinary Tract Infections: Diagnosis, Treatment, and Prevention

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Abstract

The most common type of healthcare-associated infection (HAI) is a urinary tract infection (UTI), and 80 percent of these are associated with the use of indwelling urinary catheters (IUCs). These are termed catheter-associated urinary tract infections (CAUTIs). It has been estimated that about 25 percent of all hospitalized patients have an IUC placed during their hospital stay. In addition to the morbidity and mortality that may be associated with a CAUTI, there are also financial consequences. This is particularly true since as of October 1, 2008, the Centers for Medicare and Medicaid Services stopped reimbursing hospitals for several types of infections acquired during a hospital stay, including CAUTIs. In United States (U.S.) the estimated annual cost of treating these CAUTIs is $350 million. It has been proposed that a large percentage of CAUTIs should be preventable. This article will discuss the diagnosis, treatment, and prevention of CAUTIs.

Introduction

Based on data submitted to the National Healthcare Safety Network (NHSN) of the Centers for Disease Control and Prevention (CDC) and the Emerging Infections Program Healthcare Associated Infections Community-Interface (EIPHAIC), in 2011 there were 722,000 HAIs in acute care hospitals [1]. On a typical day approximately 4 percent of patients in acute care hospitals have an least one HAI [1,2]. The development of an HAI is associated with increased hospital length of stay (LOS), and also increased morbidity and mortality [2]. HAIs are among the top ten causes of death in the United States [2], and this is reflected by the fact that in 2011, 75,000 patients with HAIs died during their hospital admission. The direct medical cost of treating HAIs is substantial, with estimates as high as between $28 billion to $45 billion in U.S. hospitals [3]. While other estimated costs of treating HAIs may not be as high as these amounts, they are still high enough to impose a significant financial burden on the health care system [4]. In addition to direct costs to acute care hospitals, HAIs lead to financial losses by affected patients, due to their decreased productivity [3].

The most common type of HAI is the UTI, and 70 to 80 percent of these are due to the use of an IUC [5,6]. This type of infection is termed a CAUTI, and it is responsible for 30 to 40 percent of HAIs [6,7]. In 2011 there were 99,000 CAUTIs in acute care hospitals in the United States [8]. CAUTIs occur more commonly in females compared with males [10,11], and this may be due to some degree, to the shorter urethra that is present in the former. The morbidity and mortality that are associated with CAUTIs are substantially less in comparison with other HAIs that are device-associated, such as ventilator-associated pneumonia (VAP), and central line-associated bloodstream infection (CLABSI) [5].

The extent to which the development of a CAUTI may lengthen a patient's LOS [5,12] or increase mortality [5,7,9,13,14,15] is uncertain. Some authors have concluded that CAUTIs do not contribute to increased mortality in patients who are critically ill [9]. The estimated costs of treating CAUTIs are variable, but symptomatic episodes can cost between $749 to $1007 for each case [2]. While the cost of treating each CAUTI may not be overwhelming, the high frequency at which this type of HAI occurs magnifies its significance.

During the past few years, many HAIs including CAUTIs, have come to be regarded as preventable complications rather than unavoidable outcomes of medical care [14,16,17,18,19]. This change in perspective has created an impetus to substantially reduce the incidence of CAUTIs, and multiple strategies have been explored to achieve this goal [20,21,22,23,24,25]. It has been estimated that more than 55 to 70 percent of device-associated infections, including CAUTIs, are preventable through the implementation of uncomplicated procedures [2,16]. However, since these procedures are not routinely followed, preventable HAIs continue to develop [2].

Factors That Contribute To Cauti Development

The risk of developing a CAUTI is directly related to a longer duration of IUC placement [26,27]. For catheterized patients, the rate of development of bacteriuria is approximately 3 to 10% per day [7,13,28,29]. There is a 100% estimated likelihood of developing a CAUTI, for a patient who requires an IUC for greater than or equal to 30 days [28,29]. Bacteremia develops in 4% of patients who acquire CAUTIs [5]. The two most important factors that lead to the development of CAUTIs are: (1) the inappropriate placement of an IUC, and (2) once an IUC has been placed, leaving it inserted for too long a period of time [27,31].

In order to ensure the timely removal of an IUC, it is important to routinely assess the ongoing need for its continued presence [31]. Unfortunately, 38% of attending physicians are unaware that their patients have an IUC in place [32], and even when they do know that it is present, the physician may not be fully aware of the infectious and noninfectious consequences that may be associated with its ongoing use. Between 20-50 percent of the time that IUCs are placed, there is no justification for their use [2,7]. Appropriate indications for the placement of an IUC include the following [20]:

- accurate measurement of urinary output in severely ill patients.
- improve comfort for patients receiving end-of-life care.
- acute urinary retention or bladder outlet obstruction.
- the need for a period of prolonged immobilization (e.g. if a patient has a potentially unstable lumbar or thoracic spine, or has multiple traumatic injuries).

- selected surgical procedures. These include urologic surgeries, as well as those that:
  - are expected to have a prolonged duration
  - require intraoperative monitoring of urine output
  - require the administration of either large volumes of intravenous infusions or diuretics
- To promote healing of open perineal or sacral ulcers.

There are multiple risk factors in a host that can promote the development of a CAUTI [15], but the most important and possibly adjustable one is the length of time that a patient is catheterized. Other risk factors for the development of CAUTI include the following: female gender, urinary tract instrumentation (including the placement of ureteral stents), diabetes mellitus, malnutrition, colonization of the drainage bag, renal disease, pregnancy, azotemia, and catheter insertion outside of the operating room [11,15,33,34].

The formation of bacterial biofilms on the inner and outer surfaces of IUCs is critical for the development of CAUTIs [35,36,37,38,39]. Biofilms are communities of microbes in which the cells are adherent to the IUC surface as well as to each other [35,36]. Almost all bacteria will develop biofilms; however, the organisms that are most commonly develop biofilms on IUCs are *Staphylococcus epidermidis*, *Enterococcus faecalis*, *Escherichia coli*, *Proteus mirabilis*, *Pseudomonas aeruginosa*, *Klebsiella pneumoniae*, as well as other gram negative microbes [35, 38,39]. Selected organisms, particularly *Proteus mirabilis*, produce larger amounts of biofilm [40,41].

The bacteria that are present in the biofilm tend to exhibit slow growth, and they grow within a polysaccharide substance. The milieu of the biofilm is such that organisms within it tend to be protected from exposure to antibiotics [35,39]. These characteristics cause the organisms to be less susceptible to antibiotics [36]. The biofilm can serve as an important reservoir of multidrug resistant bacteria [40], and when a mature biofilm has formed, effective treatment necessitates removal of the IUC [42]. The presence of biofilms can contribute to misleading urine culture results [36], in part because the bacteria that comprise it often cannot be cultured [36].

Diagnosis Of CAUTI

In 2015 the NHSN changed the definition of a CAUTI [8], so that the following criteria be met :

It should also be noted that with this updated definition, Candida species (or yeast not otherwise specified), mold, dimorphic fungi, and parasites cannot be used to meet the CAUTI criteria.

Prior to starting antimicrobial therapy, a urine culture should be collected. This is imperative to allow for identification of the causative organism, especially in view of the possibility that it may be resistant to multiple antibiotics [21]. However, it should be recognized that obtaining urine cultures from patients with long-term IUCs will often yield positive results, but since this often represents colonization, treatment is not warranted in an asymptomatic patient.

It is important to be aware that while pyuria (i.e. $\geq$ 10 leukocytes/μL) does not confirm the presence of either bacteriuria or a symptomatic UTI, its absence should lead to consideration of alternative diagnoses [43], such as urethritis. Also, it should be recognized that patients with an IUC who develop a CAUTI typically are asymptomatic [44], that is, they do not exhibit the symptoms that are commonly observed with cystitis, such as urgency, dysuria, urinary frequency, or tenderness in the suprapubic area [21,28]. However, after removal of the IUC, the symptoms that are commonly associated with cystitis may develop. Many of the signs and symptoms that occur in patients with CAUTIs are imprecise. Autonomic dysreflexia, a feeling of unease, or increased spasticity may be observed in spinal cord injury patients who develop a CAUTI [21].

Treatment

The optimal duration of antimicrobial therapy for a CAUTI is unclear [21].

If an IUC has been in place for greater than 2 weeks, and is still needed in a patient who requires treatment for a CAUTI, then it should be removed, and replaced with a new one prior to initiating antibiotic therapy [15,21]. This strategy accelerates symptom resolution, and also reduces the likelihood of developing another CAUTI [21]. Collection of a urine culture from the newly placed catheter should be completed before administering the first dose of antimicrobial therapy [21].

Antimicrobial therapy should be selected based on the urine culture results [15,21,45]. However, it is often necessary to initiate antimicrobial therapy empirically, i.e. before the causative organism that has identified. In such instances, the choice of antibiotic therapy will need to be adjusted when the urine culture results become available. The utilization of either a local or regional antibiogram is a very useful tool to guide appropriate selection of the most effective antibiotic therapy. In order to reduce the likelihood of the development of resistance to antibiotics, when feasible antimicrobials that have a narrow spectrum of coverage are preferred over those with a very broad range of coverage.

For patients who have short-term IUCs (i.e. those placed for less than 30 days), *Escherichia coli* is the most common cause of CAUTIs [34]. Other organisms that cause CAUTIs less frequently in patients with short-term catheters include *Pseudomonas aeruginosa*, other Enterobacteriaceae (such as Klebsiella spp. and Enterobacter spp.), Enterococcus spp. , yeast spp*., and Staphylococcus aureus* [34].

CAUTIs that develop in patients who have long-term IUCs (i.e. those placed for 30 days or longer), tend to be polymicrobial [34]. Additionally, the isolated pathogens often exhibit resistance to multiple antibiotics [21]. In addition to the organisms that commonly cause CAUTIs in patients with short-term catheters, *Proteus mirabilis*, *Morganella morganii*, and Providencia spp are frequent causes of CAUTIs in those with long-term IUCs [34].

The Infectious Diseases Society of America (IDSA) recommends that for patients whose symptoms respond promptly to the prescribed antibiotic regimen, a seven day course of treatment is adequate [21]. However, a ten to fourteen day course of treatment is recommended for patients4who have a tardy response to their antibiotic therapy [21]. The length of treatment remains the same whether or not the patient remains catheterized [21]. The strength of the evidence supporting these two recommendations is A-III [21]. The IDSA has suggested that a five day course of Levofloxacin (Levaquin) may be adequate for a patient with a CAUTI who is not severely ill. The strength of the evidence supporting this recommendation is B-III [21]. For a woman who is $\leq$65 years old and develops a CAUTI which is not associated with symptoms in her upper urinary tract, a three day course of antibiotics may be sufficient, that is, after removal of the IUC. The strength of the evidence that supports this recommendation is B-II [21].

Antifungal therapy is not always necessary for patients who have asymptomatic funguria, since this finding may be due to colonization [46,47]. However, for patients who have symptomatic funguria or are hemodynamically unstable, treatment with an antifungal agent is appropriate [46]. Either removal or replacement of the IUC is important for the treatment of patients with funguria, since for between 20-40 percent of patients doing so will promote its clearance, i.e. without the administration of antifungal therapy [46,47]. Treatment options that are available for the treatment of funguria include: fluconazole (which is favored for the treatment of funguria), flucytosine (which must be used with caution, due to its toxicity), amphotericin B, and echinocandins (which have a less clear role than the three aforementioned agents).

STRATEGIES TO HELP PREVENT THE DEVELOPMENT OF CAUTIS

Guidelines to reduce the CAUTI rate have been published by the U.S. Centers for Disease Control and Prevention (CDC), European Association of Urology (EAU), Healthcare Infection Control Practices Advisory Committee (HICPAC), Infectious Diseases Society of America (IDSA), and Society for Healthcare Epidemiology of America (SHEA) [20,21,22,23,24,25,26].

Since placement of an IUC is necessary for the development of a CAUTI, if possible, an alternative means to drain the urinary bladder, such as a condom catheter, or intermittent catheterization, should be considered [27,48]. Both of these alternatives are associated with a reduced CAUTI risk, compared with prolonged placement of an IUC [27]. A substantial decrease in UTI (33 versus 12 percent; P = 0.03) was found when comparing intermittent versus indwelling urinary catheterization [49]. Patients also have expressed a preference for the use of intermittent catheterization compared with indwelling catheterization [50]. Bladder scanning can reduce the CAUTI rate by decreasing the rate of IUC placement [15].

The use of condom catheters rather than IUCs has been associated with favorable outcomes. A randomized trial [51] demonstrated that the likelihood of developing bacteriuria or symptomatic UTI, or experiencing death was five times higher with the use of an IUC, compared with a condom catheter. Patients also found that the condom catheter was less uncomfortable than the IUC [51].

Proper aseptic technique must be followed for IUC insertion, and appropriate catheter care is necessary to reduce the risk of CAUTI development [20]. Catheter care includes maintenance of a closed drainage system, such that replacement of both the catheter and the collection system is necessary, if any defect in the closed drainage system is noted [27].

The use of antibiotic-impregnated catheters does not lead to clinically significant reductions in CAUTI rates [53]. Biofilms, which are the pathogenic basis for the development of CAUTIs [54], colonize all types of catheters, including those that are either silver-coated or antibiotic-impregnated. It has been demonstrated that antibiotic-impregnated catheters decrease the risk of developing a CAUTI only during the first week of IUC placement [37]. Similarly, silver alloy catheters show efficacy for reducing the CAUTI rate only during the first two weeks of catheterization [37].

Nurse-driven protocols and checklists provide nurses with a degree of autonomy to remove IUCs that no longer need to remain inserted [55,56]. Utilization of such protocols has been associated with a reduction in the use of unnecessary catheters, as well as lower CAUTI rates [55,56].

Although they are commonly used by only a relatively small percentage of hospitals [57], the use of automatic stop orders and catheter removal reminders are useful to reduce the duration of IUC placement [27,57,58,59]. Catheter removal reminders can be physical, e.g. a paper-based reminder [60] or virtual, where an electronic device prompts physicians and nurses to consider removal of the IUC [27].

It has been shown that inadequate nurse staffing is another factor that can contribute to an increased rate of CAUTIs (as well as other HAIs) [61]. A definite association between the occurrence of CAUTIs, and the patient-to-nurse ratio has been demonstrated [61], and it has been suggested that taking steps to reduce "burnout" in nursing staff may be beneficial to reduce infection rates.

Unfortunately, many hospitals still do not accurately document which patients have IUCs in place, or their length of use of IUCs [57]. Also, it has been observed that hospitals tend to be more aggressive about implementing steps to reduce the rates of more costly HAIs, such as VAPs (ventilator-associated pneumonias) and CLABSIs (central line-associated bloodstream infections), compared with those that would positively impact the CAUTI rate [58]. Since CAUTIs are largely preventable, concerted efforts to follow recommendations to reduce their incidence would be expected to yield significant reductions in the rate of this type of HAI.

Summary

CAUTIs are the most common type of HAI, and they may be associated with increased morbidity, hospital LOS, and patient costs. In many instances, CAUTIs are preventable. The CDC, EAU, HICPAC, IDSA, and SHEA have formulated extensive guidelines that can be implemented to reduce the CAUTI rate [20,21,22,23,24,25,26].

The two most important actions that can be taken to reduce the incidence of CAUTIs are to limit the placement of IUCs to instances of true necessity, and also to reduce the duration of IUC placement to the short possible length of time. The use of proper techniques for the insertion and maintenance of IUCs is also recommended to help reduce CAUTI rates.

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