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Chapter 7

Unnecessary Complications: The Forgotten Indwelling Urinary Catheter

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Abstract

Complications of indwelling urinary catheters (IUCs) are common, with the infectious one accounting for 40% of all reported healthcare-associated infections. Myths and rituals exist among healthcare professionals in the application of the urinary catheter, and the catheter is often forgotten after the placement, resulting in a potentially significant impact on patient outcomes and healthcare cost. The implementation of institutional protocols through a bundled approach can significantly reduce forgotten IUCs and dramatically improve patient safety.

Keywords: urinary tract infection, indwelling urinary catheter, bacteremia, sepsis, risk factors

1. Introduction

Indwelling urinary catheters (IUC) are among the oldest of medical devices that continue to be used in therapy today. The earliest known documentation of transurethral catheterization is found in an Egyptian papyrus dating to 1500 BC. The report describes catheterization performed primarily to treat male urinary retention utilizing a variety of materials, including bronze tubes, reeds, straws and curled palm leaves [1]. Over the ensuing centuries, the catheterization process underwent several modifications, including the use of various manufacture materials, contours and fixation methods. Eventually, Dr. Frederic Foley developed a self-retaining, balloon-based latex catheter in 1929 while seeking a treatment of post-prostatectomy hemorrhage. With the invention and broad commercial production of the Foley catheter, the accepted indications for catheterization rapidly expanded to include post-surgical care

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and both short- and long-term treatment of urinary retention and incontinence from a variety of etiologies. IUCs quickly became an indispensable part of modern medicine, aiding the care and evaluation of critically ill patients while improving patient hygiene.

As the indications for and use of IUCs expanded during the twentieth century, so did the incidence and impact of complications of catheterization. In the 1980s, catheter-associated urinary tract infections (CAUTI) were identified as the most common nosocomial infection with estimates suggesting that CAUTIs comprised up to 40% of hospital-based infections [2]. With the advance of medical knowledge and technology, the incidence of CAUTIs has not significantly decreased [3].

The prevention and treatment of CAUTIs and bacteremia have become a favorite topic for clinical study, especially in the current era of exponentially increasing healthcare costs. Researchers have explored antibiotic impregnated catheters, various metal alloys and alternative drainage systems and nursing protocols to address the issue [4]. Through this scientific inquiry, one conclusion remains constant—the most reliable way to prevent complications is to limit the incidence and duration of the use of IUCs [5]. Over the last 20 years, concerted international efforts have been made to address both of these aims, yet the prevalence of IUCs that have been forgotten or remain past the limits of their original indication remains far too high. In this chapter, we discuss the complications of IUCs with special attention paid to IUCs that have been forgotten and strategies to address this substantial performance improvement and patient safety issue.

2. Clinical vignette

An elderly female is admitted to the surgical service for recurrent adhesive small bowel obstruction, due to open right hemicolectomy 15 years ago, and dehydration. Her past medical history is significant for COPD and congestive heart failure. Upon this current admission, she receives a nasogastric tube for decompression and an IUC for monitoring fluid resuscitation status. On her second day of hospitalization, the patient proceeds to the operating room for laparoscopic lysis of adhesions.

On postoperative day 2, the patient starts passing flatus, and the decision is made to remove her nasogastric tube. During morning rounds, the team notes that her respirations are labored and a chest X-ray reveals pulmonary vascular congestion. The decision is made to treat her with diuretics. The removal of the IUC is proposed, and the resident decides to keep it in place until after the diuretics take effect. The following morning the nurse notices that the team has again ordered furosemide for the patient. Remembering that the IUC remained in place the prior day due to diuretic use, the nurse sees no reason to remind the team that the IUC needs to be addressed. Two days later, a new nurse takes over care of the patient. During her initial assessment, she notes the IUC and mentions taking it out to the patient. The patient remembers that she has had bladder spasms previously. Her physical therapy was slow and painful yesterday, and she worries that she will not be able to get to the bathroom in time. As she becomes more anxious worrying about soiling herself and sitting in her own urine, the nurse takes pity on the elderly patient and decides not to mention it again.

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On postoperative day 7 (IUC day 10), while awaiting rehabilitation placement, the patient develops a fever and lower abdominal discomfort with worsening respiratory status and tachycardia, requiring transfer to the intensive care unit and IV antibiotics. The IUC remains in place for strict monitoring of urinary output. Blood and urine cultures grow *Escherichia coli*. The diagnoses of CAUTI and catheter-associated bacteremia are made, and the IUC is replaced. The patient improves on antibiotics and is discharged to a rehabilitation unit 5 days later.

3. Complications of urinary catheterization

3.1. Mechanical complications

While infectious complications of urinary catheterization, like those experienced by our patient above, have received the most research focus and media attention, clinicians cannot discount the potential noninfectious complications, as documented in **Table 1**. While the relative rates of the various mechanical complications of IUCs are unknown, obstruction, retained IUC due to balloon port obstruction and hematuria are frequently described [1, 6]. There have even been reports of life-threatening hemorrhage following traumatic catheter removal [7].

The original Foley catheter developed by Bard in the 1930s was made of latex. Due to its many beneficial mechanical properties, latex remained the only material of significance used in the

Complications
Mechanical
Obstruction with/without hydronephrosis
Hematuria
Retained catheter due to obstruction of balloon port
Retained balloon fragments
Bladder calculi
Pseudopolyp formation
Urethral or bladder neck stricture
Bladder trauma/rupture
Increased risk of bladder carcinoma
Infectious
Bacterial colonization/bacteriuria
CAUTI
Bacteremia
Epididymitis

Table 1. Complications associated with IUCs [1, 6, 7].

production of urinary catheters through most of the twentieth century. In the 1980s, increased rates of urethral strictures were attributed to the cytotoxic properties of latex [1]. Prolonged latex catheter use leads to chronic urethritis and fibrosis. This problem was addressed through the development of silicone-coated latex and silicone-based catheters that are frequently used today when long-term catheter requirement is suspected. Today, prolonged length of catheterization is known to be a significant risk factor for the development of bladder neck and urethral strictures, calculi and even squamous cell carcinoma of the bladder [6].

3.2. Bacterial colonization and bacteriuria

Asymptomatic bacteriuria, defined as isolation of $\geq 10^5$ colony forming units/mL in an asymptomatic patient, is extremely common among hospitalized patients with nearly half of all catheterized patients demonstrating bacteriuria after 5 days of IUC use and an incidence of bacteriuria onset of 3–8% per day of catheterization [5, 8]. Most clinical studies related to IUCs have been directed at decreasing the rates of bacterial colonization of IUCs. Studies have involved the use of antibiotic-coated and silver- and noble alloy-treated catheters. While some studies have showed decreases in bacteriuria and CAUTI rates in the short term, none of the studies were able to demonstrate durable benefits past 10 days of catheterization [4, 9–11].

Bacteriuria develops in catheterized patients due to the disruption of the of the natural defenses inherent to the urinary system. In the absence of a continuous drainage IUC, the regular distention and emptying of the bladder flush out any bacteria that migrate into the urethra or bladder. With a catheter in place, bacteria can migrate unobstructed from the urethral meatus to the bladder. Bacteria adhere to both the extra- and intraluminal surface of the IUC and secrete bacterial glycocalyces that form an extracellular matrix. This biofilm, thickest on the internal surface of the catheter, protects the colonized bacteria from antibiotic and mechanical eradication. As the biofilm becomes encrusted with struvite and apatite crystals, further complications, such as urethritis and increased retention of small amounts of urine around the catheter balloon, lead to increased bacterial growth and secondary infection [2, 12]

Prospective studies have demonstrated an increase in antibiotic-resistant organisms with antibiotic treatment of asymptomatic bacteriuria [13]. Given this evidence coupled with the cost of routine urinary cultures, the Infectious Diseases Society of America (IDSA guidelines) recommends against screening for and treating asymptomatic catheter-associated bacteriuria [5].

3.3. Catheter-associated urinary tract infection (CAUTI)

Among the adverse events attributed to IUC use, CAUTI is the most common. Reported rates of CAUTIs vary greatly between countries and among studies within a given country and time period [14]. Much of this variability was attributed to the lack of a universal consensus definition of CAUTIs. Several studies failed to differentiate between asymptomatic bacteriuria and symptomatic infection attributed to IUCs. Other reports of CAUTI prevalence were confounded by the presence of concurrent infections.

For the purposes of this chapter, we use the IDSA guidelines definition of CAUTI: the presence of $\geq 10^3$ colony forming units (CFU)/mL of ≥ 1 bacterial species in a single urinary culture in a patient

with concurrent signs or symptoms suggesting a UTI with no alternate source of infection identified. The patient must also have an IUC in place at that time or removed within the prior 48 h [5].

The signs and symptoms of a urinary tract infection in the catheterized patient are significantly different from that of the non-catheterized patient. Clinicians should look for suprapubic pain or tenderness, vague pelvic discomfort (as seen in the patient in the vignette), costovertebral tenderness and acute onset of hematuria. These findings, however, have poor sensitivity in the diagnosis of CAUTIs. Additionally, patients are often critically ill and intubated or sedated, or suffer from neurologic conditions that require long-term catheterization. Patients' underlying conditions can often impede their ability to appropriately communicate subjective symptoms and place them at high-risk for infection from multiple sources in addition to the urinary tract, representing a diagnostic conundrum. Subsequently, CAUTIs are often a diagnosis of exclusion [14].

When clinical findings suggest that a patient has developed CAUTI, it is important to obtain a urine sample prior to initiating appropriate antimicrobial therapy [15]. If an IUC has been in place for longer than 2 weeks, the presence of a mature biofilm can confound urinary culture results. To accurately identify bacteria responsible for urinary infection, the IUC should be replaced using standard sterile protocols prior to obtaining a sample for culture [5].

3.4. Catheter-associated bacteremia

While much less common than CAUTIs, catheter-associated bacteremia is an undeniable problem with greater than 50% of bacteremic episodes in long-term care facilities attributable to IUCs [14]. On the other hand, while the noninfectious complications of IUCs confer a burden on the patient and the medical system, they also increase the risk of infectious sequelae. The disruption of the urothelial lining associated with urethral trauma, stricture formation, bladder stone formation, retained balloon fragments and urethritis, along with the interventions required to treat them (e.g., urethral dilatation, cystoscopy and stone or balloon fragment retrieval) provides a potential route for bacterial access to the bloodstream from colonized IUCs.

Studies have shown that bacteremia associated with a urinary pathogen occurs in fewer than 5% of patients with documented catheter-associated bacteriuria but is associated with a 12–30% mortality rate [14, 16]. Unfortunately, it is difficult to predict which patients are at the greatest risk for developing bacteremia. Studies attempting to identify patients at the greatest risk for catheter-associated bacteremia have been performed with mixed results as presented in **Table 2**. As illustrated in the vignette, patients with bacteriuria do no reliably demonstrate signs and symptoms of CAUTI prior to progressing to bacteremia and sepsis. Furthermore, mortality among patients with bacteremia is not associated with symptomatic CAUTI versus asymptomatic bacteriuria [17].

To identify patients at increased risk of developing catheter-associated bacteremia, Conway et al. [18] performed a matched case-control study to identify independent predictors for development of bacteremia among patients admitted to an acute care hospital with documented nosocomial catheter-associated bacteriuria during the associated admission. Unlike previous studies, they looked at the risk of bacteremia when IUCs were continued after bacteriuria was demonstrated. Continued IUC use after demonstration of bacteriuria was associated with an

Study group	Time frame	Predictors identified	Odds ratio (95% CI)	*P* value*
Conway et al.	2006–2012	Male sex	2.76 (1.80–4.21)	<0.001
		Catheter in place bacteriuria	2.75 (1.65–4.56)	<0.001
		Urinary Tract Procedure	2.70 (1.09–6.74)	0.03
		Recent immunosuppressant use	1.68 (1.06–2.66)	0.03
		Diabetes mellitus	0.70 (0.42–1.18)	
Greene et al.	2000–2008	Neutropenia	10.99 (5.78–20.88)	<0.001
		Insulin administration	4.82 (2.52–9.21)	<0.001
		Underlying renal disease	2.96 (1.98–4.41)	<0.001
		Urinary Tract Procedure	2.49 (1.31–4.73)	
		Liver disease	2.34 (1.35–4.06)	0.003
		Male sex	2.18 (1.52–3.12)	<0.001
		Recent immunosuppressant use	1.53 (1.04–2.25)	
		Antibiotic use	0.66 (0.44–0.97)	
Saint et al.	1984–1999	Recent immunosuppressant use	8.13 (1.02–64.83)	
		Malignancy	1.94 (1.06–3.55)	
		Male sex	1.88 (1.62–2.18)	
		Smoking (last 5 years)	1.26 (1.01–1.57)	
		Antibiotic use	0.76 (0.68–0.85)	

*Where available and $P \leq 0.05$.

Table 2. Table Predictors for catheter-associated bacteremia [18–20].

increased risk of bacteremia with an odds ratio of 2.75. Male sex, younger age, recent immunosuppressant use and urinary tract procedure were also associated with increased risk of bacteremia [18].

Not only do IUCs increase the risk of bacteremia, but they are also associated with an increased disease severity. A 2017 study by Melzer and Welch [21] used multivariate logistic regression to demonstrate that bacteremia secondary to CAUTI is significantly more likely than bacteremia from other hospital-acquired sources to result in severe sepsis, as defined by a Pitt bacteremia score ≥ 2 (OR 3.94). Conversely, bacteremia secondary to a urinary source without an associated IUC was much less likely to result in severe sepsis, with an odds ratio of 1.27 [21].

While rare, bacteremia from an IUC has been clearly documented and is associated with increased severity of illness. The risk of catheter-associated bacteremia increases with the length of catheterization and specifically with continued catheterization after the diagnosis of bacteriuria has been established, suggesting a possible benefit to routine urine cultures in critically ill patients requiring long-term catheterization to identify patients that may ben-

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efit from an IUC holiday and intermittent catheterization [18]. The current IDSA guidelines published in 2010 recommend against routine screening for asymptomatic bacteriuria. This suggestion is based on the grounds that treatment of asymptomatic bacteriuria with a short course of antimicrobials and catheter replacement did not prevent the subsequent incidence of urosepsis or repeat bacteriuria [21]. Recent research developments suggested that these recommendations warrant further study.

4. The forgotten IUC

Performance improvement and patient safety studies relating to CAUTIs have identified two major areas for improvement to prevent potential complications: eliminating inappropriate use of IUCs and promoting the prompt removal of appropriately placed IUCs when no longer indicated. Today, the list of accepted indications for IUC placement is short and specific [5, 14]:

- Urinary tract obstruction and urinary retention
- Hourly urine output measurements in acutely ill
- Urinary incontinence in select patients:
  - Terminally ill
  - To facilitate healing of advanced open pressure ulcers or skin grafts.
- Patients requiring prolonged immobilization (e.g., severe pelvic fracture).
- Perioperative period for gynecologic, urologic and prolonged procedures requiring general anesthesia.

Unfortunately, as in the case of our patient at the beginning of this chapter, evidence suggests that IUCs are frequently used for reasons outside these accepted indications within the acute hospital setting. The Keystone Bladder Bundle Program designed to implement protocols to decrease inappropriate IUC use within Michigan hospitals found that only 44.3% of catheters were placed for appropriate indications prior to protocol implementation [22]. Current strategies to decrease the incidence of CAUTIs include ongoing efforts to develop and standardize protocols that encourage practitioners to carefully and critically consider the indications for catheterization prior to submitting the placement order.

Determining the reasons for inappropriately prolonged IUC use is a more complicated undertaking. Krein et al. [23] used a survey-based study design to explore the reasons for prolonged IUC use. They found that two of the major barriers to adequate implementation of a comprehensive CAUTI prevention protocol were poor healthcare staff engagement and patient or family request for IUC placement or continuance. Common reasons for prolonged catheterization use can be found in **Table 3**.

Among the nursing staff, Krein et al. [23] found that IUCs and the associated UTIs were perceived as common, benign and inevitable. They also revealed some nursing myths relating to

IUCs and their effect on patient care. Some nursing staff noted that IUCs were needed to keep the nursing workload manageable, stating that some patients required help with toileting on a more than hourly basis, detracting from the time allotted to perform other important and time-sensitive patient care tasks. Others reported that monitoring urine output and helping patients to get rest were much easier with an IUC in place. Staff also noted that the presence of an IUC could help prevent other "never events" and promote patient safety, referring to unsteady patients who attempt to get out of bed alone to go to the bathroom and risk patient falls [23]. These findings are supported by a study performed in 2010 in which registered nurses in Minnesota were surveyed regarding IUC practices [24]. RNs regularly reported, incorrectly, that inability to stand to void and new or increased diuresis were "sometimes" indications for urinary catheterization, and only 38% of the nurses surveyed reported having received continuing education related to IUCs.

On the other hand, poor physician involvement in infection prevention protocols was also identified as a significant roadblock to CAUTI prevention strategies [23]. Many protocols require physicians to document daily the ongoing indication for IUC use, sometimes by means of a checkbox in the electronic medical record. While these protocols have been demonstrated to decrease the number of inappropriate catheter days, they are subject to the human element. The unengaged, overworked or distracted physician can skip past these checkpoints without giving the matter critical thought. In a Japanese study, the most commonly cited reason for inappropriate IUC use was "convenience of care" [25]. The inadequately engaged or undereducated young resident physician is at risk of being susceptible to pressure from nursing staff to continue IUCs beyond the limits of the initial indication to aid in convenience.

Patients themselves are another source of inappropriate IUC use. In Krein et al.'s study, clinicians reported that patients demanded catheter placement or refused removal for a variety

Nursing factors
Lack of education regarding risks/invasiveness of Foley
Poor understanding of indications
Increased workload of urinary care
Prioritization of patient safety issues
Physician factors
Consider UTI prevention low priority
Poor hand offs between providers or services
Physician negligence/distraction
Patient factors
Postoperative pain control
Family concern for hygiene

Table 3. Causes of inappropriately long urinary catheterization [23–25].

of reasons [23]. Usually, the patients had incontinence or postsurgical pain that limited their mobility. With the increasing importance placed on patient satisfaction as a determinant of reimbursements, some clinicians are hesitant to ignore patient demands or spend significant amounts of time reasoning with or educating them.

Accurate data about the rates of inappropriately prolonged IUC use are not currently available. Partly, the problem at hand is often caused by a lack of recognition of the problem (forgotten IUCs) but also due to poor adherence to established CAUTI prevention programs and data reporting [3, 26]. It is also hard to compare unnecessary catheter-days between different patient populations, such as critical care, surgical or medical patients because these groups have inherently different rates of appropriately indicated IUC use [3]. Success of programs designed to decrease inappropriate IUC use was usually measured by the change in total catheter days because it was often difficult to determine the point at which the IUC's indication expires and it becomes forgotten.

5. Remembering the forgotten IUC (quality improvement)

In 2008, the Centers for Medicare and Medicaid Services in the United States announced a list of healthcare-acquired conditions that would no longer be eligible for reimbursement, including CAUTIs, as part of their Healthcare-Acquired Conditions (HAC) Initiative. With the introduction of this concept of "never events," the onus was placed on individual institutions to bear the cost of managing these conditions [27]. With CAUTIs estimated the financial impact of 27 million US dollars in 2009 in the United States alone [28], this policy provides a significant financial incentive for facilities to develop and support practices to limit the incidence of CAUTIs.

Several different methods to decrease the duration of urinary catheterization in the acute care hospital setting have been studied. Some of these included nurse-driven approaches such as automatic stop orders, nurse-driven protocols to remove IUCs that failed to meet specific checklist criteria and nurse-driven physician reminders [29]. Other programs were physician focused with IUC renewals as a required daily order or documentation of continued indication as a required part of the daily patient note [30, 31]. Most of the studies revealed a statistically significant decrease in both catheter-days and incidence of CAUTIs with the implementation of any protocol to increase awareness of the need to remove IUCs. The remaining studies revealed a decrease in CAUTIs that was not statistically significant [27, 30]. While the implementation of a CAUTI-prevention program clearly decreases catheter days and CAUTI rates, no single daily intervention has been shown to be superior. A nationwide survey in 2009 found that, among the several identified IUC removal and CAUTI-prevention techniques, none was used in greater than 50% of nonfederal United States hospitals [32]. Some practitioners support the use of external collection devices as an alternative to IUC use. An expert panel in 2016, however, concluded that there is inefficient literature at this time regarding efficacy and cost-effectiveness to make an educated recommendation, and further clinical studies are warranted [33].

Bundle protocols utilizing a multidimensional approach including education, patient care protocols, surveillance and local reporting of compliance and outcomes are generally accepted to

be the most effective way of minimizing CAUTIs. In Michigan, the Keystone Bladder Bundle Initiative was created in 2007 [22]. The Bundle used the concept of Engage, Educate, Execute and Evaluate and the Johns Hopkins University collaborative model to create a team at each hospital to spearhead and maintain the program [34]. A nationwide survey of 470 hospitals revealed that CAUTI incidence decreased by 25% in Michigan hospitals and by 6% in non-Michigan hospitals during the same period [29]. A big component of the success of this initiative was due to the appointment of "champions" that were responsible for addressing individual questions and encouraging continued engagement in the reduction of catheter use [23].

Often the reasons for prolonged urinary catheterization are related to lack of education at multiple levels (see **Table 2**). Education efforts need to focus on both the nursing and physician staff. Nurses are often the driving force in the decision to place or maintain IUCs, especially because physicians are frequently unaware which of their patients have IUCs [31]. Providing the nursing staff with education in techniques, such as scheduled toileting care, to limit the burden of incontinence management can help to change attitudes [23]. The nursing staff also serve as an invaluable resource to patients and their families. Properly educated and convinced nursing staff can help shoulder the burden of educating patients and families about the risks of and appropriate indications for IUCs. Physician education is no less valuable. A prospective study revealed that implementation of an education plan to increase physician awareness of inappropriate catheterization resulted in statistically significant decreases in IUC duration, CAUTI incidence and hospital length of stay [35]. A 2016 study showed that a brief education program provided to both nursing and physicians regarding proper IUC indications resulted in a significant decrease in the proportion of inpatient days with IUC in place [36].

According to a large-scale retrospective review of the rates of CAUTIs in the ICUs of 1166 US hospitals from National Database of Nursing Quality Indicators database from 2008 through 2010, there was a 10% decrease in the rate of change of CAUTIs after the implementation of Medicare's Healthcare-Acquired Conditions Initiative [37]. This was largely attributed to multifaceted prevention programs employing IUC removal protocols. Despite the strength of the evidence supporting the use of written and bundle protocols to fight the CAUTI epidemic, a study published in 2012 found that only 42% of ICUs had developed written policies to decrease urinary catheter days [29]. Bundled prevention programs rely heavily on continuing education and providing individual and group level feedback. Programs that require this level of institutional involvement can only be successful in an environment that supports the efforts from the top of the administration with the allocation of resources to support and reward education efforts.

6. Conclusion

IUC-related complications remain unchanged over last several decades. Several indwelling urinary catheter-related complications can be attributed to the forgotten indwelling urinary catheters, as seen in our clinical vignette patient. In a world with increasing prevalence of antimicrobial resistance, appropriate prevention of these complications is vital. IUCs should not be undertaken lightly. Before placing an IUC, clinicians must carefully weigh the indications and consider whether an alternative would be more appropriate. Fortunately, there remains

significant room for improvement in the initiative to eliminate forgotten IUCs and subsequently decrease the IUC-related complications. Healthcare professionals, physicians and nurses alike, should take it upon themselves to become champions of a CAUTI prevention program through development and effective use of evidenced-based, innovative, streamlined clinical bundle protocols to shorten patients' hospital stays and decrease healthcare costs.

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