Medical Device–Associated Infections in the Long-Term Care Setting

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Long-term care facilities (LTCFs) are heterogeneous in size and the populations they serve. Although the number of LTCFs and bed capacity in the United States dropped by 9% and 13%, respectively, from the years 1999 to 2008, the overall number of individuals who spent at least some time in a LTCF actually increased from 3.09 million residents in 2004 to 3.27 million residents in 2008.1 Economic forces driving reduced hospital length of stay have shifted an increasing amount of complex medical care to the ambulatory setting and skilled nursing facilities (SNF).2 The resulting rise in the number of postacute residents in LTCFs has also increased use of indwelling medical devices in this setting. LTCF residents with indwelling medical devices have a significantly higher risk of developing a healthcare-associated infection (odds ratio [OR] 3.65; \( P<0.001 \))3 and such devices have consistently been shown to be a risk factor for colonization or infection with multidrug-resistant bacteria, such methicillin-resistant Staphylococcus aureus (MRSA) and resistant gram-negative bacteria.4–7

It is imperative that clinicians who practice in LTCFs have a comprehensive

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understanding of the risks of infection associated with indwelling medical devices, the practices to reduce these risks, and the best way to intervene when prevention efforts fall short.

**USE OF INVASIVE MEDICAL DEVICES IN LTCFs**

An increasing variety of indwelling medical devices are encountered in LTCFs (Box 1). The most detailed data on the use of indwelling medical devices in LTCFs to date come from the Veterans Affairs (VA) Community Living Centers (CLCs).\textsuperscript{3,8} In two system-wide point prevalence studies, Tsan and colleagues\textsuperscript{3,8} found that approximately 25\% of residents in VA CLCs had at least one invasive medical device (Fig. 1). Data on the use of indwelling medical devices in non-VA LTCFs are less comprehensive. Increasing external regulatory oversight\textsuperscript{9} and public reporting of quality measures for SNFs has led to a reduction in the use of chronic urinary catheters and feeding tubes in long-term stay residents. For example, the proportion of long-term stay residents with a chronic urinary catheter decreased from 8.6\% in 1991 to 4.8\% by 2010.\textsuperscript{10,11} Similarly, the prevalence of feeding tubes dropped from 4.4\% in 1999 to 3.1\% in 2008.\textsuperscript{1} In contrast to the encouraging patterns seen in long-term stay residents, an increasing number of postacute-care residents are admitted to LTCFs with an indwelling medical device already in place. Approximately 12.6\% of residents newly admitted to a LTCF were found to have an indwelling urinary catheter in a recent survey across five states\textsuperscript{12} and the number of SNFs that provide infusion-related services has increased during the past decade resulting in an increased prevalence of intravascular catheters in this setting.

**INFECTION OF INDWELLING URINARY CATHETERS**

**Use and Risk of Infection**

Symptomatic urinary tract infection (UTI) is the second most common infectious complication encountered in LTCFs with reported incidence density rates ranging from 0.2 to 2.2 per 1000 resident-days.\textsuperscript{13} Use of a urinary catheter is the predominant risk factor for UTI\textsuperscript{14,15} and catheter-associated UTI (CAUTI) is the most common cause of bacteremia in LTCFs.\textsuperscript{15,16} Studies performed before the current decade documented high rates, ranging from 7\% to 12\%, of chronic urinary catheter use in

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**Box 1**

Types of invasive medical devices typically encountered in residents of LTCFs

<table>
<thead>
<tr>
<th>Indwelling urinary device</th>
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<tbody>
<tr>
<td>Urethral catheter</td>
</tr>
<tr>
<td>Suprapubic catheter</td>
</tr>
<tr>
<td>Feeding tube</td>
</tr>
<tr>
<td>Percutaneous endoscopic gastrostomy tube</td>
</tr>
<tr>
<td>Nasogastric tube</td>
</tr>
<tr>
<td>Central venous catheter</td>
</tr>
<tr>
<td>Peripherally inserted central venous catheter</td>
</tr>
<tr>
<td>Cuffed and tunneled Hickman-like catheter</td>
</tr>
<tr>
<td>Hemodialysis catheter</td>
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<tr>
<td>Tracheostomy tube</td>
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</table>
More recent data put the proportion of residents with a chronic urinary catheter at approximately 5%, although almost 13% of postacute care residents have a urinary catheter present at the time of admission to a LTCF. Higher use rates are seen in VA CLCs where approximately 14% of residents either had an indwelling urethral or suprapubic urinary catheter during point prevalence surveys in 2005 and 2007.

Pathogenesis

The pathogenesis of CAUTI is discussed in greater detail elsewhere in this issue. Briefly, organisms present on the periurethral mucosa may ascend to the bladder either on the outside of the catheter or may ascend on the inside of the catheter after contamination of the collecting system during manipulation by a healthcare worker (Fig. 2). Bacterial introduction into the urinary tract occurs at a rate of 3% to 7% per day of catheterization, which means that bacteriuria is universal among residents catheterized for 30 days or more. Once introduced, invading bacterial species uniformly reach high levels (>10^5 colony forming units) in the presence of an indwelling device and often persist as they become incorporated into the biofilm that inevitably develops on the surface of the indwelling device.

Diagnosis

Urine should always be sent for analysis and culture when considering antimicrobial treatment for suspected CAUTI. Ideally, this specimen should be obtained after placement of a new catheter to more accurately determine if recovered uropathogens localize to the bladder or are simply incorporated in the catheter biofilm. Bacteriuria
is extremely prevalent in chronically catheterized individuals and most also have pyuria and elevations in urinary nitrites; therefore, an abnormal urinalysis or positive urine culture should never be used as the sole criteria for making a diagnosis of CAUTI (Table 1). Many cognitively impaired LTCF residents are unable to adequately articulate the presence of urinary symptoms and it is well-known that the fever response to infection can be attenuated in the elderly.22,23 This has engendered the widespread belief that more subtle geriatric symptoms (eg, confusion, falls, or new urinary incontinence) are often the only manifestation of CAUTI in the LTCF setting.24 However, there is no evidence that UTI is associated with the development of isolated geriatric symptoms,25 nor is there any convincing published evidence that antimicrobial therapy leads to improvements in residents with bacteriuria and isolated geriatric symptoms.26 The authors and others27–29 believe it is important that at least one objective sign of infection (eg, evidence of systemic inflammation or localizing urinary signs or symptoms; see Table 1) be present before arbitrarily ascribing a resident’s geriatric symptoms to CAUTI. Observation while awaiting the results of urine culture and pursuing alternative explanations for the change in condition is often warranted in residents with isolated geriatric manifestations of illness.

**Treatment**

Antimicrobial therapy of asymptomatic bacteriuria does not reduce the frequency of symptomatic infection and serves only to select for resistant uropathogens that make treatment of symptomatic infections more difficult.30–32 For these reasons,
treatment of asymptomatic bacteriuria should be reserved for patients scheduled to undergo a urologic procedure.14

Patients with suspected CAUTI should have their urinary catheter changed before obtaining urinary cultures. This practice has also been shown to hasten the resolution of symptoms and reduce the frequency of 28-day relapse rates in at least one randomized trial.33 Data on the optimal length of therapy for CAUTI and its attendant complications are limited. Current guidelines recommend that therapy for CAUTI be given for at least 7 days. Clinicians should consider the possibility of prostatitis, nephrolithiasis, or a perinephric abscess in residents whose symptoms are slow to respond despite appropriate coverage of organisms recovered from culture. In these cases, the antimicrobial therapy should be continued while additional diagnostic studies are explored.

Prevention

Guidelines for the prevention of CAUTI were recently updated by the Infectious Disease Society of America.34 These guidelines appropriately emphasize limiting the use of indwelling urinary devices to well-defined clinical situations (Table 2). Notably, urinary incontinence is not considered an appropriate indication for chronic indwelling urinary catheterization unless there is a superimposed wound or palliative care need. With this more restrictive view of the appropriate use, as many as half of residents recently transferred from an acute-care facility do not qualify for continued catheterization.35 It is imperative that LTCFs make expedited removal of unnecessary urinary devices a prominent component of any comprehensive CAUTI prevention program. To facilitate this objective, clinicians should consider the use of incontinence pads, intermittent urethral catheterization, or an external collecting device (eg, condom catheter) as alternatives.34 Additional CAUTI prevention practices are detailed in Box 2.

Anti-infective catheters, which have been shown to reduce rates of bacteriuria in hospitalized patients with short-term urinary catheters,19 have little role in patients with a chronic indwelling urinary catheter. Likewise, suppressive systemic antibiotics, urinary sterilizing agents (methenamine salts), or cranberry products, which may have situational applicability, have not been shown to reliably reduce the risk of CAUTI in the
chronically catheterized patient and their routine use is discouraged in consensus guidelines.\textsuperscript{19} The use of a suprapubic catheter rather than a urethral catheter has not convincingly been shown to reduce the risk of CAUTI but may be considered in the male resident with epididymitis or repeated urethral trauma with catheter exchanges or self-removal.

The well-known risk of catheter blockage from encrustations that form in the presence of urease-producing bacteria, such as \textit{Proteus mirabilis},\textsuperscript{39} has given rise to two catheter management strategies of dubious benefit, at least with regard to the prevention of CAUTI. Routine irrigation of the catheterized bladder with saline,\textsuperscript{40} antibiotics,\textsuperscript{41} or antiseptic-containing solutions\textsuperscript{42} has not been shown to reduce the frequency of obstruction or the risk of CAUTI in randomized trials. Similarly, routine replacement of the urinary catheter at a standard interval (every 2–4 weeks), which may reduce the risk of catheter obstruction,\textsuperscript{43} has not clearly been shown to reduce CAUTI risk.\textsuperscript{44} Admittedly, studies of this latter catheter maintenance practice are lacking. Future studies should strive to determine if there is true value to continuing this widely followed practice or whether it should go the way of other “standard practices” that were subsequently discarded after rigorous investigation.\textsuperscript{45} Some experts advocate treatment of asymptomatic bacteriuria before urinary catheter exchange based on data demonstrating transient bacteremia and a higher incidence of fever among residents who have recently undergone placement of a urinary catheter.\textsuperscript{46,47} However, there are no data that suggest that hard resident outcomes are improved by this practice and current guidelines discourage the routine use of antimicrobials with catheter exchange.\textsuperscript{34}

### INFECTION OF PERCUTANEOUS ENDOSCOPIC GASTROSTOMY TUBES

Since its introduction in the 1980,\textsuperscript{48} placement of the percutaneous endoscopic gastrostomy (PEG) tube has become one the most widely performed medical procedures in the United States with an estimated 160,000 to 200,000 procedures performed annually.\textsuperscript{49} PEG tubes may be placed using either a transoral or a transabdominal approach.\textsuperscript{50} Although the cannulation success rate with either approach seems to

<table>
<thead>
<tr>
<th>Indication</th>
<th>Comment</th>
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<tbody>
<tr>
<td>Bladder outlet obstruction</td>
<td>When surgical correction is not considered feasible.</td>
</tr>
<tr>
<td>Neuronic bladder with urinary retention</td>
<td>In residents with complete loss of bladder function who are unable to perform intermittent self-catheterization.</td>
</tr>
<tr>
<td>Urinary incontinence</td>
<td>As part of a comprehensive wound care plan in residents who have an open sacral or perineal wound or those individuals who have undergone select urologic or gynecologic surgery. In residents who are on hospice or comfort care who fail less invasive methods (eg, behavioral or pharmacologic, incontinence pads) and are not candidates for external collecting.</td>
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</table>

\textsuperscript{a} Does not encompass appropriate indications for short-term urinary catheterization, such as management of acute urinary retention or monitoring of urinary output during aggressive diuresis or fluid challenge.
be equivalent, insertion by the transoral route remains the predominant method in the United States.

**Use in LTCFs**

The overall proportion of residents in LTCFs with a PEG tube is approximately 3.1% in non-VA LTCFs and runs close to 5.5% in VA CLCs (see Fig. 1). However, the prevalence of PEG tubes among LTCF residents with cognitive impairment is significantly higher. Approximately one-third of United States nursing home residents with advanced dementia undergo feeding tube placement with an estimated incidence of 53.6 insertions per 1000 residents.

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**Box 2**

Desirable components of a comprehensive program to prevent CAUTI in LTCFs

**INSTITUTION-SPECIFIC URINARY CATHETER POLICIES AND PROCEDURES SHOULD BE DEVELOPED**

*Development of information systems that lead to actionable data:*

1. Ongoing surveillance for catheter-associated urinary tract infections (per 1000 resident-days or 1000 catheter-days) using standard surveillance definitions that are reported back to front-line staff on a regular basis
2. Audit and feedback of inappropriate urinary catheter use
3. Reorganization of the medical record to make prior antimicrobial history and urine culture results readily available to clinicians when a resident develops signs or symptoms consistent with
4. Development of a facility-specific antibiogram of urinary isolates that is reviewed on a regular basis to identify resistance trends

*Clinical staff should receive education, training, and regular reinforcement of the following concepts and practices:*

1. The appropriate indications for initiating urinary catheterization
2. Proper aseptic technique when inserting a urinary catheter
3. Proper catheter maintenance practices:
   a. Hand hygiene and glove use whenever handling the urinary catheter or drainage system
   b. Keeping the urinary drainage bag below the level of the bladder at all times
   c. Properly secure indwelling catheters to prevent movement and urethral traction
   d. Minimizing handling and disconnections of the catheter from the drainage system
4. The importance of reassessing the continued need for a urinary catheter on a regular basis

*Reduce unnecessary urinary catheterization through use of:*

1. Checklists that provide clinicians with the appropriate indications for inserting a urinary catheter
2. Alternative methods for controlling urinary incontinence:
   a. Incontinence pads
   b. Intermittent catheterization
   c. External drainage device
3. A reminder system that prompts clinicians to evaluate the continued need for a urinary catheter in their residents

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Device-Related Infections in Nursing Homes
**Peristomal Wound Infections**

Infectious complications after placement of a PEG tube occur most commonly within the month following insertion but can occur at any time. Most infections involve the peristomal skin, which complicates approximately 4% to 25% of insertions. These infections usually are mild and typically manifest with localized pain, purulent drainage from around the tube, and erythema that extends outward from the insertion site. Systemic signs and symptoms, including fever and leukocytosis, are often absent and their presence, particularly when coupled with more severe or diffuse abdominal pain, should raise concern about the presence of an abscess, fasciitis, or peritonitis.

Although peristomal wound infections in patients with tubes placed by the transabdominal approach are typically caused by organisms of cutaneous origin, infections after tube insertion by the transoral approach derive from oropharyngeal organisms that contaminate the catheter during its transoral passage to the stomach. Rates of peristomal wound infection seem to be significantly higher with the transoral rather than the transabdominal approach for PEG tube insertion. Other features of the insertion and characteristics of the patient undergoing the procedure also seem to influence the risk of infection (Table 3).

Clinicians treating a patient with a suspected peristomal wound infection should perform a careful physical examination to assess for the presence of a more complicated process (abscess, peritonitis, or necrotizing fasciitis) and to rule out the presence of a more benign process (dermatitis or superficial yeast infection) that does not require systemic antibiotics. It is recommended that a white cell blood count be obtained when evaluating fever and infection in the LTCF setting and cultures of wound drainage should be sent based on published studies documenting high recovery rates of drug-resistant bacteria, such as MRSA and *Pseudomonas aeruginosa* (Fig. 3). In patients with localized skin and soft tissue findings, it is reasonable to empirically start an oral agent that provides coverage for susceptible staphylococci, streptococci, and Enterobacteriaceae while awaiting culture. Patients with more severe manifestations, particularly those with systemic signs of illness, should be covered for MRSA and *P aeruginosa* pending the results of cultures. Most patients respond rapidly to oral agents, which should be given for 7 to 10 days. Complicated infections should be suspected in patients who present with significant systemic signs of infection or in those who fail to respond to oral therapy that has adequate activity against the organisms recovered from culture.

<p>| Table 3 |</p>
<table>
<thead>
<tr>
<th>Factors associated with an elevated risk of developing a peristomal infection after placement of a percutaneous endoscopic gastrostomy tube</th>
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<tbody>
<tr>
<td><strong>Patient-Related Factors</strong></td>
</tr>
<tr>
<td>Diabetes mellitus</td>
</tr>
<tr>
<td>MRSA colonization</td>
</tr>
<tr>
<td>Obesity</td>
</tr>
<tr>
<td>Malnutrition</td>
</tr>
<tr>
<td>Corticosteroid use</td>
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<tr>
<td>Malignancy</td>
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</table>

Abbreviation: MRSA, methicillin-resistant *Staphylococcus aureus.*
Complicated PEG Tube Infections

Serious infectious complications after PEG tube insertion are uncommon. Abscess at the insertion site has been described as a rare event (<1%) in most published series, although one longitudinal study in a LTCF reported that 6 (10.3%) of 58 residents with a PEG tube developed an abscess at the insertion site during 4 years of follow-up. When suspected, imaging with ultrasound or CT should be performed to confirm the presence of an abscess along with an aspiration to identify the causative pathogens. Most peristomal abscesses require surgical debridement or placement of a percutaneous drain, although small fluid collections can sometimes be managed conservatively with parenteral antimicrobials and repeat imaging.

Peritonitis occurs in 0.5% to 2% of PEG tube insertions in published series and may occur early as a complication of insertion or later during tube dislodgements or reintroductions that are traumatic enough to disrupt the mature tract between the gastric and parietal peritoneal walls. A tube contrast imaging study is useful for determining if a disrupted tract or gastric leak is the cause of peritonitis. Surgical intervention is almost always required when disruption of the tract is documented.

Necrotizing fasciitis is an extremely rare complication associated with PEG tube placement. It should be an early consideration in patients with systemic symptoms out of proportion to their local clinical examination and, when considered, should prompt abdominal imaging to identify air in the abdominal wall. Even with early and aggressive surgical debridement, mortality often exceeds 50%.

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**Fig. 3.** The proportion of different microbial pathogens recovered from wound culture in patients diagnosed with peristomal wound infections. Data are derived from 107 microbiologically confirmed cases from six published studies. COLI, Escherichia coli; ENT, Enterobacter sp; KLEB, Klebsiella sp; MRSA, methicillin-resistant Staphylococcus aureus; MSSA, methicillin-sensitive S aureus; PROT, Proteus mirabilis; PSEU, Pseudomonas aeruginosa; STREP, Streptococcus sp. (Data from references 57–59, 62–64)
Prevention

The use of cephalosporin-based prophylaxis at the time of transoral PEG tube insertion is now considered a standard of care and can reduce the risk of peristomal wound infection by nearly 70% compared with procedures in which no antibiotics are used (OR 0.31; 95% confidence interval, 0.22–0.44). MRSA colonization has been identified as a significant risk factor for peristomal wound infection after PEG tube insertion. Some centers have reported significant reductions in rates of infectious complications by screening and decolonizing patients before PEG tube insertion, although this has not yet become a standard of care in published guidelines. Using a protective sheath to minimize catheter contamination during transoral tube placement has also been shown to significantly reduce the risk of infection, but such a device is not yet commercially available in the United States. Using the transabdominal approach for tube insertion seems to substantially reduce the risk of peristomal wound infection but is not widely performed, perhaps because of perceptions of a higher risk of balloon rupture or deflation with the transabdominal catheters used in early studies.

INFECTION OF INTRAVASCULAR DEVICES

Use

In the LTCF setting, most intravascular devices (IVDs) are intended for long-term (>10 days) rather than short-term use. Approximately 3.6% of the residents in VA CLCs had a long-term IVD present during a point-prevalence study performed in 2005 and a follow-up study found that use had increased to 4.5% by 2007. The use of indwelling hemodialysis catheters was stable across the two surveillance periods (1.7%). To the authors’ knowledge, the extent of IVD use in non-VA LTCFs has not been reliably quantified. However, the continued expansion of postacute-care services in LTCFs in response to existing financial incentives supports the notion that IVD use in these facilities is increasing.

Risk and Pathogenesis of Infection

Prospective studies, in which every attempt was made to conclusively identify the presence of an IVD-related bloodstream infection (IVDR BSI), show that every type of IVD carries some risk, although the magnitude varies. Although host characteristics, such as critical illness, neutropenia, and AIDS, can modify the risk of IVDR BSI, the characteristics of the IVD and the features of its insertion and maintenance seem to have a far greater impact on the overall risk of infection.

<table>
<thead>
<tr>
<th>Device Type</th>
<th>Rate per 1000 Device Days</th>
<th>Pooled Mean</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peripherally inserted central catheters</td>
<td>1.0</td>
<td>0.8–1.2</td>
<td></td>
</tr>
<tr>
<td>Cuffed and tunneled Hickman-like catheters</td>
<td>1.6</td>
<td>1.5–1.7</td>
<td></td>
</tr>
<tr>
<td>Cuffed and tunneled hemodialysis catheters</td>
<td>1.6</td>
<td>1.5–1.7</td>
<td></td>
</tr>
<tr>
<td>Subcutaneous central venous ports</td>
<td>0.1</td>
<td>0.0–0.1</td>
<td></td>
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For microorganisms to cause catheter-related infection they must first gain access to the extraluminal or intraluminal surface of the device where they can adhere, produce, and subsequently become incorporated into a biofilm that allows sustained infection and hematogenous dissemination. Microorganisms may colonize an IVD by a variety of mechanisms (Fig. 4). With short-term devices, infection most commonly arises extraluminally as a result of bacterial colonization or infection at the skin insertion site. In contrast, BSI associated with long-term IVDs, the type most commonly used in LTCFs, almost always arises intraluminally from contamination of the catheter hub and the luminal fluid.

**Microbiology**

The microbial profile of IVDR BSI varies considerably based on the duration of catheterization (Fig. 5). Although gram-positive organisms cause nearly two-thirds of the microbiologically confirmed short-term IVD infections, these organisms are recovered in half of documented long-term IVD infections (see Fig. 5). The opposite relationship is seen with the gram-negative bacteria, which cause 15% of the short-term IVD BSIs but more than a third of long-term infections (see Fig. 5).

**Diagnosis and Treatment**

The diagnosis and treatment of IVDR BSI is discussed briefly. Infections associated with *S. aureus* and gram-negative pathogens are typically abrupt in onset and patients almost always have signs of a systemic inflammatory response. In contrast, IVDR BSI caused by coagulase-negative staphylococci and enterococci may manifest in a more indolent fashion. IVDR BSI should always be considered in the LTCF resident with a vascular catheter. Although current guidelines discourage their routine collection in LTCF residents with fever, blood cultures, including one obtained from the

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**Fig. 4.** The potential sources by which an intravascular device may become infected. HCW, healthcare worker. (Adapted from Crnich CJ, Maki DG. The promise of novel technology for the prevention of intravascular device-related bloodstream infection. I. Pathogenesis and short-term devices. Clin Infect Dis 2002;34(9):1232–42; with permission.)
Empiric antimicrobials that provide coverage for MRSA and *P. aeruginosa* should be administered to residents with fever and systemic signs of inflammation and the catheter should be removed at the outset if there is evidence of a tunnel infection, thrombophlebitis, or severe sepsis. Empiric antimicrobials may generally be withheld in otherwise clinically stable LTCF residents with isolated fever pending the results of blood cultures. Therapy should be targeted to the pathogens recovered after cultures have confirmed the diagnosis of IVDR BSI.

**Fig. 5.** Microbial pathogens recovered in patients with bloodstream infections associated with short- and long-term intravascular devices (IVDS). (Data from Maki DG, Kluger DM, Crnich CJ. Microbiology of intravascular device-related infection in adults: an analysis of 159 prospective studies and implications for treatment [abstract]. In: Proceedings and Abstracts of the 40th Annual Meeting of the Infectious Disease Society of America. Chicago: Infectious Disease Society of America; 2002.)
Prevention

The Centers for Disease Control and Prevention’s Healthcare Infection Control Practices Advisory Committee and the Society for Healthcare Epidemiology of America have recently released evidence-based guidelines focused on the prevention of IVDR BSI. Given the pathogenesis of infection with long-term IVDs, the primary focus for providers in LTCFs should be on minimizing contamination of the IVD hub and its luminal contents. LTCFs that provide infusion services should develop and regularly update their IVD maintenance policies and procedures. Similarly, facilities should ensure that staff members have received education and demonstrated their competency in IVD care and maintenance.

The basic foundation of preventing IVDR BSI rests with removing catheters when they are no longer needed and ensuring that providers adhere to recommended hygienic practices at all times. Specifically, it is important that LTCF staff always perform hand hygiene and wear clean or sterile gloves whenever handling the catheter or changing administration sets. Similarly, an appropriate antiseptic should always be used to swab the septum of the needless connector attached to the catheter whenever the port is being accessed. This is of particular importance, because suboptimal disinfection of needleless connectors before access has been linked to an increased risk of IVDR BSI.

The use of novel technology to further reduce the risk of IVDR BSI has been an area of intense activity in recent years. Anti-infective lock solutions are the best studied of these technologies. A recently published meta-analysis found that vancomycin-containing lock solution reduced the risk of IVDR BSI by 66% (OR 0.34; 95% confidence interval, 0.12–0.98). Similar benefits have been documented with other types of anti-infective lock solutions. Nevertheless, none of these products have yet been commercialized and none are approved by the Food and Drug Administration for marketing. As a result, current guidelines recommend that anti-infective lock solutions be reserved only for individuals who have a history of recurrent IVDR BSI.

The development of a needleless connector that is intrinsically resistant to bacterial colonization is another technology of considerable interest. Studies have shown that differences in connector design can influence the risk of internal surfaces becoming contaminated after a microbial challenge of the device. Connectors impregnated with silver have been approved for commercial use; however, clinical trial data demonstrating their impact on risk of IVDR BSI are lacking. Paradoxically, the introduction of certain types of positive-pressure needleless connectors has been convincingly implicated as a cause of IVDR BSI in several hospitals and negative or neutral-pressure devices may pose a similar risk. Whether these studies represent a problem that is specific to certain manufacturers or is suggestive of a problem that can be generalized to all mechanical needleless connectors is not clear. What is clear is that facilities need to perform a comprehensive product assessment before introducing new technology, and further reinforces the need for LTCFs that provide infusion services to develop and maintain a surveillance system for IVDR BSI.

Infection of Tracheostomy Devices

Tracheostomy devices are placed for (1) relief of upper airway obstruction, most commonly caused by tumor or surgery; (2) access for suctioning and removal of airway secretions in individuals who cannot clear them on their own; or (3) provision of a stable airway in individuals who require prolonged mechanical ventilation. Approximately 10% of hospitalized patients who require mechanical ventilation receive a tracheostomy and rates of tracheostomy procedures in the United States have increased dramatically during the past 15 years. Individuals with
tracheostomy devices receive their care in a wide variety of institutional and ambulatory care settings; this section focuses on the infectious complications associated with the use of these devices in SNFs and long-term acute care (LTAC) facilities.

**Use in LTCFs**

Approximately 1.4% of residents in VA CLCs have a tracheostomy device (see Fig. 1), although most do not require mechanical ventilation. A similar accounting of the use of tracheostomy devices in non-VA LTCFs is not readily available. However, in a recent study performed in North Carolina, the incidence rate of tracheostomy procedures in patients requiring prolonged mechanical ventilation increased 188% from the years 1993 to 2002. Over half of these patients were discharged to a LTAC or rehabilitation facility. These data are consistent with studies from other states that have documented large increases in the number of individuals receiving posthospitalization mechanical ventilation in LTCFs.

**Clinical Presentation of Infection**

Infection in patients with a tracheostomy device may manifest as either pneumonia or tracheobronchitis and requires more than simply recovering a pathogen from culture because airway colonization is ubiquitous in this population. Although some question whether tracheobronchitis exists in the ICU setting, most authorities accept it as a real clinical entity among patients requiring chronic ventilatory support.

The diagnosis of pneumonia in these patients should be based on a combination of cough; increasing purulent secretions; systemic signs of inflammation, such as fever and leukocytosis; impairments in gas exchange; localized auscultory findings; and the presence of an infiltrate on chest imaging. Patients with tracheobronchitis may present in a similar manner but do not typically have impairments in gas exchange and should not have localizing examination and imaging findings.

**Incidence of Infection**

Almost 50% to 60% of patients receiving prolonged ventilatory support develop pneumonia, although the daily risk of infection is lower than among patients receiving ventilatory support in the ICU. For example, in two recently published studies, the incidence density rate of pneumonia in patients receiving chronic ventilatory support in LTAC and spinal cord injury facilities was 1.67 and 1.74 per 1000 ventilator-days, respectively. These numbers are similar to rates of pneumonia reported in patients receiving home ventilatory support but are substantially lower than rates of pneumonia reported in acute care facilities. Similar to studies performed in the intensive care unit (ICU) setting, impairments in neurologic function and duration of mechanical ventilation have been identified as consistent risk factors for pneumonia in patients requiring prolonged mechanical ventilation.

The incidence of an early stomal infection in days after percutaneous trachecotomy ranges from 0% to 5% (mean, 2.3%) for percutaneous tracheostomy and 0% to 33% (mean, 10.7%) for open surgical tracheostomy. Data on the rate of tracheobronchitis in patients with an established tracheostomy device are more limited. Niederman and coworkers reported that 9 of 15 subjects with a tracheostomy residing in a local rehabilitation facility developed clinical evidence of tracheobronchitis and that risk of this complication seemed to be associated with chronic upper airway colonization with *P aeruginosa*. In a study of 39 nonhospitalized patients with a tracheostomy, 30 episodes of infection requiring antibiotic treatment (5 pneumonias and 25 episodes of tracheobronchitis) occurred during 1 year of follow-up. Finally, Palmer and coworkers reported that all of the seven chronically ventilated patients whom...
they followed for 6-months required treatment for tracheobronchitis; however, none developed pneumonia.

**Treatment of Infection**

Empiric antimicrobial therapy guided by local microbial patterns and the patient’s prior culture results should be initiated in patients with systemic signs of infection after performing a thorough examination and sending respiratory specimens for culture. The authors recommend withholding empiric therapy from patients with isolated respiratory symptoms (increasing purulence of respiratory secretions) in the absence of impairments in gas exchange or systemic signs of illness. This subset of patients often improves with more aggressive pulmonary toilet. However, if symptoms progress, the culture results then allow the initiation of targeted therapy and avoid several days of unnecessarily broad coverage.

A detailed discussion of the therapy of pneumonia and tracheobronchitis is beyond the scope of this article. Monotherapy targeted against the pathogens recovered from culture is sufficient in most situations, although combination therapy or the adjunctive use of aerosolized agents may be necessary for particularly problematic multidrug-resistant organisms. Airway eradication is almost impossible because of avid adherence of organisms to tracheobronchial cells and their incorporation into the biofilm on the tracheostomy device. The purpose of antimicrobial therapy is to facilitate the patient’s return to their baseline status rather than sterilizing the respiratory tract. Whether replacement of the tracheostomy device during episodes of infection can accelerate the resolution of symptoms and reduce the frequency of recurrent infections is an unresolved issue and not routinely recommended. Further studies on the optimal treatment of pneumonia and tracheobronchitis in this population are warranted.

**Prevention of Infection**

Minimizing sedation and providing good oral care are cornerstones of pneumonia prevention in patients with an indwelling respiratory device. Patients with a chronic indwelling tracheostomy device should have an individualized treatment plan to address airway secretions and humidity because inadequate removal of secretions and failure to maintain adequate airway humidity can lead to insipidation and mucosal injury that facilitates infection. Staff providing respiratory care must be trained and educated in the appropriate handling of respiratory therapy equipment and be absolutely meticulous with hand hygiene and glove use during manipulation of the tracheostomy device.

Weaning and eventual decannulation have the greatest impact on reducing an individual patient’s future risk of infection, although this is not feasible in many. Therapist-driven protocols have been shown to shorten the time taken to wean from the mechanical ventilator in the ICU setting, but a more individualized approach may be required in weaning patients after prolonged mechanical ventilation.

Novel approaches for reducing the risk of tracheostomy infections have been explored on a limited basis. The topical application of polymyxin E–tobramycin paste to the tracheostoma seemed to reduce the risk of airway colonization and infection in one small nonrandomized study of children requiring long-term mechanical ventilation. Similarly, the use of prophylactic aerosolized antibiotics has been shown to reduce the risk of ventilator-associated pneumonia in patients in the ICU but, to the authors’ knowledge, has not been studied in ventilated patients outside of the ICU setting. The high probability of resistance emerging with the anti-infectives used in both of these studies likely limits the clinical applicability of either approach.
SUMMARY

Clinicians in LTCFs are likely to continue to encounter an increasing array of patients with indwelling medical devices. Understanding the appropriate use and maintenance of these devices and working aggressively to remove them when no longer needed are key components of preventing infectious complications associated with indwelling medical devices.

REFERENCES


