REVIEW ARTICLE

Prevention of Bacterial Infections in Patients with Cardiac Implantable Devices: Old Traditions Meet New Technology

J. RYAN JORDAN, MD and HEATHER L. BLOOM, MD

1Department of Medicine, Division of Cardiology, Emory University School of Medicine, Atlanta, GA
2Division of Cardiology, Atlanta Veterans Administration Medical Center, Atlanta, GA

ABSTRACT. Cardiovascular implantable electronic devices (CIEDs) have become increasingly important in the management of cardiac disease. Unfortunately, infection rates of CIEDs are increasing disproportionately to the rise in implantation rates. Infection is the most serious complication of CIED implantation, often requiring explantation of all hardware and sometimes resulting in death. Improved antimicrobial prophylaxis is one approach to reducing morbidity, mortality, and expense associated with infection after CIED implantation. Several new technologies are available as adjunctive therapies to parenteral antibiotics and may further help prevent implantable device infections. Additionally, adherence to the recently updated American Heart Association guidelines should further reduce the incidence of infection in patients undergoing CIED implantation.

KEYWORDS. infection, prevention and control, artificial cardiac pacing, defibrillators.

Background

Cardiovascular implantable electronic devices (CIEDs) have become increasingly important in the management of cardiac disease and help reduce mortality and/or morbidity in appropriately selected patients. Recent trials have vastly expanded the use of implantable cardioverter-defibrillators (ICDs) and cardiac resynchronization therapies (CRTs) in patients with impaired left ventricular function, showing clear benefit. As a result, CIED implantation rates have increased significantly in the last decade. Along with the aging of the general population and increasing availability of implanting physicians, expanding indications for CIEDs have caused exponential growth in CIED implantation rates. The National Hospital Discharge Survey found a 49% increase in the number of new CIED implantations, including both permanent pacemakers (PPM) and ICDs, in the United States between 1999 and 2003.

However, these beneficial procedures are associated with risks, including infection. Like any other foreign bodies, CIEDs can become infected. Infection is the most serious complication of CIED implantation and requires explantation of all hardware, with fatalities in 3–19% of patients. Infections of CIEDs are associated with significant morbidity, mortality, and expense, which can attenuate the benefits. Despite improvements in CIED design and the application of timely infection control practices, CIED infections continue to occur and can be life-threatening. Infection rates for device implantation vary significantly between studies but are commonly reported to be between 1% and 7%. Between 1990 and 1999, CIED infection rates in Medicare beneficiaries increased by 124%. As the population of candidates for CIEDs expands to include patients with more comorbidities, this trend is likely to continue.

The current American Heart Association (AHA)/Heart Rhythm Society (HRS) recommendation for prophylaxis at the time of CIED placement is an antibiotic that possesses in vitro activity against staphylococci. Recent large studies indicate that the vast majority of patients receive antimicrobial prophylaxis with CIED placement. However, despite the widespread use of appropriate antimicrobial prophylaxis, CIED infection rates are increasing disproportionately to implantation rates. More effective antimicrobial
Prophylaxis could help reduce CIED infections and improve clinical outcomes.

Description of surgical site infections

Surgical site infections (SSIs) are the second most common healthcare-associated infection. Although usually localized to the incision site, surgical wound infections can also extend into adjacent deeper structures, and hence the term surgical wound infection has now been replaced with the more appropriate name, surgical site infection. The Centers for Disease Control and Prevention (CDC) has developed criteria for defining SSIs, which have become the national standard and are widely used by surveillance and surgical personnel.

These criteria define SSIs as infections related to the operative procedure that occur at or near the surgical incision (incisional or organ/space) within 30 days of an operative procedure or within 1 year if an implant is left in place. More specifically, incisional SSIs are further divided into those involving only skin and subcutaneous tissue (superficial incisional SSIs) and those involving deeper soft tissues of the incision (deep incisional SSIs). Organ/space SSIs involve any part of the anatomy (e.g. organ or space), other than incised body wall layers, that was opened or manipulated during an operation. The definitions should be followed universally for surveillance, prevention, and control of SSIs.

More specifically, cardiac device infections can be classified into pocket infections and deeper infections. The term pocket infection is used when the infection involves the subcutaneous pocket containing the device and the subcutaneous segment of the leads. The term deeper infection is applied when the infection involves the transverse portion of the lead, usually with associated bacteremia and/or endovascular infection. Alternatively, device infections may be classified by the mode of infection. Primary infections, in which the device and/or pocket itself is the source of infection, are usually due to contamination at the time of implant. Secondary infection occurs when the leads (and sometimes the device and the pocket) are seeded due to bacteremia from a different source (i.e. hemodialysis vascular access or dental abscesses).

Microbiology of CIED infections

The majority of CIED infections are caused by staphylococcal species, which account for 60–80% of cases in most reported series (Table 1). Coagulase-negative staphylococcal (CoNS) species, often S. epidermis, are the most common pathogens (42%) described to cause CIED infections. Staphylococcus aureus is the second most common pathogen (25%). Oxacillin resistance among staphylococcal strains has varied among studies; however, it is prevalent and should be assumed until tests demonstrate oxacillin susceptibility. Initial empiric antibiotic therapy for CIED infection should take this into account. Episodes of infection arising within 2 weeks of implantation are more likely to be due to S. aureus than CoNS. Likewise, seeding of the device from systemic bacteremia primarily occurs with S. aureus infections.

Additional pathogens including Corynebacterium species, Propionibacterium acnes, Gram-negative bacilli (e.g. Pseudomonas aeruginosa), and Candida species account for a minority of CIED infections. Pathogenic microorganisms may be acquired either endogenously from the skin of patients or exogenously from the hospital inanimate environment or from the hands of hospital workers.

Pathogenesis of CIED infections

CIED pocket infection is usually ascribed to contamination of the wound with skin flora at the time of implantation or replacement, resulting in presentation soon after the procedure. Other studies have also found a relatively large proportion of late infections more than 3 months after implantation. Chua et al noted that 25% of device infections occurred within 28 days, 33% between 1 month and 1 year, and 42% after more than 1 year. Another study of lead endocarditis found that 72% of patients presented more than 6 weeks after surgery. Chronic low-grade infection and hematogenous spread to implanted hardware are the most probable mechanisms of late device infection. Certain risk factors increase the risk of delayed infections. Renal insufficiency, for example, impairs both cellular and humoral immunity. This immune dysfunction increases risk of both indolent infection and bacteremia and may be an important contributor to late device infection.

Infection of the intravascular component of a CIED occurs primarily on the intracardiac portion of the lead along the right atrium, the tricuspid valve, or the right ventricular contact point. These infections may track intravascularly from infection of a subcutaneous pacer component or may arise from bacteremic seeding from a remote site.

Risk factors for CIED infections

Several host factors associated with a greater risk of CIED infection have been described (Table 2). In a small single-center case-control study, patients with long-term corticosteroid use (OR=13.9) and the presence of more.

Table 1: Microbiology of CIED infections

<table>
<thead>
<tr>
<th>Species</th>
<th>Percentage</th>
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<tbody>
<tr>
<td>Coagulase-negative staphylococci</td>
<td>42%</td>
</tr>
<tr>
<td>Oxacillin-sensitive Staphylococcus aureus</td>
<td>25%</td>
</tr>
<tr>
<td>Oxacillin-resistant S. aureus</td>
<td>4%</td>
</tr>
<tr>
<td>Other Gram-positive cocci</td>
<td>4%</td>
</tr>
<tr>
<td>Gram-negative bacilli</td>
<td>9%</td>
</tr>
<tr>
<td>Polymicrobial</td>
<td>7%</td>
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<tr>
<td>Fungal</td>
<td>2%</td>
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<tr>
<td>Culture-negative</td>
<td>7%</td>
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From Sohail, et al. 2007.

CIED = cardiovascular implantable electronic device.
than two pacing leads (OR=5.41) were identified as independent correlates of PPM infection. Oral anticoagulant use has been identified as an associated risk for CIED infection. In a single-center case–control study, case patients were more likely to have diabetes mellitus, to have heart failure, to have undergone generator replacement, and to have renal dysfunction (defined as glomerular filtration rate <60 mL/min/1.73 m²), of which renal dysfunction had the strongest association (OR=4.8) with CIED infection. Renal dysfunction was also associated with CIED infection in a more recent case–control study.

Procedural characteristics may also play an important role in the development of CIED infection. In a large prospective cohort of 6,319 patients receiving CIED implantation in 44 medical centers, Klug et al identified 42 patients who developed CIED infection during 1 year follow-up. Fever within 24 h before implantation (OR=5.83), use of preprocedural temporary pacing (OR=2.46), and early reintervention after prior infection (OR=15.04) were associated with an increased risk of CIED infection. Reintervention, defined as a new procedure after the index implantation to manage a non-infectious complication, was defined as early when occurring before hospital discharge. Implantation of a new system (OR=0.46) and use of preprocedural antimicrobial prophylaxis (OR=0.40) were both associated with a lower risk of infection. Other studies also support the use of perioperative antimicrobial prophylaxis for CIED infection prevention.

Recent manipulation of the device (e.g. newly implanted device, device or lead revision, generator exchange) is the most clearly identified and causal risk factor. Device revision is also associated with CIED infection in another recently described investigation. Similarly, the incidence of explantation due to infection was significantly higher after replacement procedures than after a first implantation (2.06% versus 0.75%, p<0.01) in a large Danish Pacemaker Register of 36,076 patients.

Physician experience with implantation may also play a role in CIED infection. In a study of Medicare administrative data, Al-Khatib et al found a significantly higher risk of CIED infection (within 90 days of implantation) and increased rates of mechanical complications (at 90 days) when comparing physicians in the lowest quartile to physicians in the highest quartile of implantation volume.

Among patients with bloodstream infection, the specific organism determines the likelihood of subsequent manifestation of CIED infection, even in patients with no other evidence of CIED infection. In a cohort of 33 patients with CIEDs and subsequent S. aureus bacteremia, 45% had confirmed CIED infection. Alternatively, the risk of device infection with Gram-negative bacilli bacteremia was substantially lower. Individual virulence characteristics, such as biofilm formation, may account for these differences.

Several small studies suggest that pectoral transvenous device implantation is associated with significantly lower rates of CIED infection than for those implanted abdominally or by thoracotomy.

### Prevention

Prevention of CIED infections should be addressed before, during, and after device implantation. The most important factors in the prevention of SSIs are meticulous operative techniques (including sound judgment and proper technique of the surgeon and surgical team), and timely administration of effective preoperative antibiotics as well as the general health and disease state of the patient. A number of interventions listed in Table 3 have been used over the years to reduce the risk of SSIs. Most interventions were developed to reduce contact with flora from hospital personnel, which were believed to be the source of microorganisms causing SSIs.

### Preoperative infection prevention

As previously described, fever within 24 h before implantation is associated with the development of CIED infection. Therefore, it is prudent to screen patients for evidence of infection prior to implantation. Patients with evidence of active infection prior to elective surgical procedures should complete treatment for the infection prior to surgery, particularly in circumstances when placement of prosthetic material, such as CIEDs, is anticipated. All remote infections should be adequately treated before elective operations, and implantation should be postponed until the infection has resolved. For circumstances in which urgent surgery is required, the risk of infection must be weighed with the timing of surgical intervention on an individualized basis.

### Skin antisepsis

Application of antiseptics to the skin can reduce the burden of skin flora, although preoperative antiseptic agents cannot sterilize bacteria in hair follicles and

<table>
<thead>
<tr>
<th>Table 2: Risk factors associated with a greater risk of CIED infection</th>
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<tbody>
<tr>
<td>• Advanced patient age</td>
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<tr>
<td>• Congestive heart failure</td>
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<tr>
<td>• Device revision/replacement</td>
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<tr>
<td>• Diabetes mellitus</td>
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<tr>
<td>• Immunosuppression (renal dysfunction and corticosteroid use)</td>
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<td>• Operator inexperience</td>
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<td>• Oral anticoagulation use</td>
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<tr>
<td>• Patient coexisting illnesses</td>
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<tr>
<td>• Periprocedural factors (including failure to administer perioperative antimicrobial prophylaxis)</td>
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<tr>
<td>• Preprocedural temporary pacing</td>
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<tr>
<td>• Recent manipulation of the device (e.g. elective generator exchange)</td>
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<tr>
<td>• Renal dysfunction (glomerular filtration rate &lt;60 mL/min)</td>
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<tr>
<td>• The amount of indwelling hardware</td>
</tr>
<tr>
<td>• The microbiology of bloodstream infection in patients with indwelling CIEDs</td>
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<tr>
<td>• Underlying malignancy</td>
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Modified from Baddour, et al. 2010.

CIED = cardiovascular implantable electronic device.
sebaceous glands. The CDC recommends that patients should be required to shower or bathe with an antiseptic agent at least the night before surgery. However, the benefit of bathing with an antiseptic preparation prior to surgery to reduce the risk of SSIs has been questioned. In a meta-analysis of six trials involving 10,007 participants, preoperative bathing with chlorhexidine conferred no benefit over preoperative bathing with other products (i.e. non-antiseptic washing agent) for reduction of SSIs. The CDC also recommends thoroughly washing and cleaning at and around the incision site to remove gross contamination before performing an antiseptic skin preparation.

Application of antiseptics to the skin immediately prior to surgery is a routine practice in most operating rooms, and perioperative antiseptic preparation of the skin of the surgical site should be done with an approved agent. The antiseptic should be applied over the incision site in concentric circles starting from the incision site and moving toward the periphery. Preoperative skin cleansing with chlorhexidine-alcohol is superior to povidone-iodine, which was shown in a trial of 849 patients undergoing clean-contaminated surgery. The overall rate of SSI was significantly lower in the chlorhexidine-alcohol group than in the povidone-iodine group (9.5% versus 16%). Chlorhexidine-alcohol may be superior to iodine-alcohol because chlorhexidine is not inactivated by blood or serum.

Hair removal

It is not recommended to remove hair perioperatively unless the hair at or around the incision site will interfere with the operation. Previously, hair removal was commonly performed before many surgical procedures with the thinking that this would provide a clean field and to prevent hair from entering the surgical site. However, most studies have shown an increased risk for SSIs in patients undergoing preoperative hair removal. In one study, the rates of SSIs were highest when shaving was performed compared with clipping the hair or use of depilatory creams (5.6% compared with 1.7% and 0.6%, respectively). The timing of hair removal is also important. The lowest rates of SSIs were reported when hair was removed just prior to the surgical incision. If hair is removed, it should be removed immediately before the operation, preferably with electric clippers.

Antimicrobial prophylaxis

Systemic prophylactic antibiotics at the time of pacemaker implantation are effective and recommended. However, there are no guidelines on systemic prophylactic antibiotic use in pacemaker implantation and no trials comparing systemic prophylactic antibiotic regimens. It is recommended that an antibiotic, which has in vitro activity against staphylococci, be administered parenterally 1 h before the procedure. Most experts advocate a first-generation cephalosporin, such as cefazolin, for use in prophylaxis. Data from a meta-analysis, two case–control studies, and a large randomized control trial strongly support the administration of antibiotic prophylaxis for CIED implantation. Antibiotic prophylaxis is also recommended if subsequent invasive manipulation of the CIED is undertaken. Vancomycin can be used as an alternative in patients who are allergic to cephalosporins and should be administered 90–120 min before the procedure. Although not generally recommended, some authorities advocate the use of vancomycin instead of cefazolin in centers where oxacillin resistance among staphylococci is high, or in patients undergoing cardiac, vascular, and orthopedic procedures and/or implantation of prosthetic material that also have risk factors for postoperative methicillin-resistant S. aureus infection (such as recent hospitalization, renal disease, or diabetes). The CDC recommends that vancomycin should not be used routinely for antimicrobial prophylaxis.

Hyperglycemia and diabetes control

Hyperglycemia and diabetes have been identified as risk factors for deep sternal site infection after coronary artery bypass graft (CABG). In a single-center case–control study, 141 case patients with CIED infection were more likely to have diabetes mellitus. The studies in CABG patients have suggested that a preoperative blood glucose level of ≥200 mg/dl (OR=10.2), or postoperative hyperglycemia (OR=2.0) is associated with an increased risk of SSIs. The CDC recommends that serum blood glucose levels be adequately controlled in all diabetic patients and that preoperative hyperglycemia, in particular, be avoided.

Tobacco cessation

Health-care providers should encourage tobacco cessation prior to surgery. The CDC recommends instructing patients to abstain from smoking cigarettes, cigars, pipes, or any other form of tobacco consumption (e.g. chewing/dipping) for at least 30 days (at minimum) before elective operation.

Staphylococcus aureus decolonization

Nasopharyngeal carriage of S. aureus is a risk factor for SSI. Nasopharyngeal decontamination, with mupirocin nasal ointment and chlorhexidine soap, may be effective for reducing the risk of postoperative infection in some situations. One large trial of 6,771 patients undergoing surgery with anticipated hospital stay ≥4 days identified 1,251 patients who were positive for S. aureus (all strains were susceptible to methicillin and mupirocin). Of these, 918 patients were randomized to receive either placebo or decolonization with intranasal mupirocin twice a day for 5 days and daily baths with chlorhexidine soap. The intervention reduced the rate of S. aureus infection from 7.7% to 3.4% (RR=0.42; 95% CI, 0.23 to 0.75). Staphylococcus aureus decolonization with
intrasal mupirocin and chlorhexidine baths may be appropriate for surgical patients known to be nasal carriers of S. aureus with a high risk of deleterious outcomes should S. aureus infection develop at the surgical site. This includes patients who are immunocompromised, undergoing cardiac surgery, and/or undergoing implantation of a foreign device. There is no role for routine decolonization. In the most recent guidelines, the CDC did not provide any recommendations regarding the use of preoperative intranasal mupirocin for SSI prevention, citing insufficient data.

**Intraoperative prevention**

**Barrier devices**

The primary role for barrier devices (masks, caps, gowns, drapes, and shoe covers) is to protect operating room personnel from exposure to infectious blood or body fluids. Their role in SSI prevention is not supported by rigorous study.

**Surgical hand hygiene**

Prior to surgery, physicians should perform surgical scrub, including hands and forearms, for at least 2–5 min with an appropriate antiseptic agent. This is an accepted practice, and guidelines support using either an antimicrobial soap or an alcohol-based hand rub with persistent activity for surgical hand antisepsis. It is recommended to clean underneath each fingernail prior to performing the first surgical scrub of the day. After performing the surgical scrub, physicians should keep their hands up and away from their body. Hands should be dried with a sterile towel before donning a sterile gown and gloves.

**Surgical technique**

There is general agreement that good surgical technique (see Table 4) reduces the risk of SSI. However, the role of these techniques in SSI prevention for CIEDs is not supported by rigorous study. Intraoperatively, compulsive attention to sterile technique is mandatory. In patients with limited subcutaneous tissue, a retropectoral pocket should be considered. Hematoma formation should be avoided by meticulous cautery of bleeding sites as hematoma with the pocket has been identified as a risk factor for device placement. Therefore, prevention of hematoma during the procedure is desirable. Additional techniques to prevent hematoma formation include packing the pocket with antibiotic-soaked sponges to provide tamponade while leads are being placed, and the application of topical thrombin, which may be particularly helpful in anticoagulated patients. Frequent irrigation of the pocket is useful to remove tissue debris and may reveal persistent bleeding that could lead to a pocket hematoma. Alternatively, pocket irrigation with an antimicrobial-containing solution has been used and may also prevent infection. Although almost universally used, there are no randomized-controlled trials studying the effectiveness of prophylactic intrapocket antibiotics (e.g., gentamicin) in pacemaker implantation. The presence of antibiotics in irrigation solutions is unlikely to be necessary, rather the mechanical action of debris removal and dilution of any contaminant are due to the flow and volume of irrigation. The use of monofilament suture for closure of the subcuticular layer may avoid superficial postoperative cellulitis due to ease of absorption. A pressure dressing applied postoperatively for 12–24 h after skin closure may help to prevent infection and further decrease the risk of hematoma formation.

**Postoperative prevention**

In the immediate postoperative period, low-molecular weight heparin predisposes to hematoma formation and should be avoided. If present, it is recommended that the hematoma only be evacuated when there is increased tension on the skin, suggesting risk of dehiscence. In general, needle aspiration should otherwise be avoided because of the risk of introducing skin flora into the pocket, which may subsequently develop into infection. Recent AHA guidelines recommend that both early follow-up in a clinic setting and thorough patient education should be conducted for early identification of CIED-related infectious complications. Postimplantation prophylactic systemic antibiotics are commonly used, although there is wide variation in the duration of treatment, ranging from 6 h to 7 days (168 h) in one study. There is only one study investigating duration of postimplantation antibiotics, and this looked at short-term (2 days) versus longer-term (7 days) use. The study suggested that a short course is just as effective as a longer course in preventing pacemaker infections. Additional studies that specifically investigate the effectiveness of prophylactic antibiotics postimplantation are needed. Currently, there is insufficient evidence to support the administration of prophylactic antibiotic therapy, and the use of postimplantation antibiotics is not recommended in the recently updated AHA guidelines. There is currently no scientific basis for the use of prophylactic antibiotics before routine

<table>
<thead>
<tr>
<th>Table 3: Interventions that have been used to reduce the risk of SSI</th>
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<tbody>
<tr>
<td>* Preoperative showering with antimicrobial soaps</td>
</tr>
<tr>
<td>* Preoperative application of antiseptics to the skin of the</td>
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<tr>
<td>patient</td>
</tr>
<tr>
<td>* Washing and gloving of the surgeon’s hands</td>
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<tr>
<td>* Use of sterile drapes</td>
</tr>
<tr>
<td>* Use of gowns and masks by operating room personnel</td>
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**Table 4** shows the general agreement that good surgical technique reduces the risk of SSI. However, the role of these techniques in SSI prevention for CIEDs is not supported by rigorous study. Intraoperatively, compulsive attention to sterile technique is mandatory. In patients with limited subcutaneous tissue, a retropectoral pocket should be considered. Hematoma formation should be avoided by meticulous cautery of bleeding sites as hematoma with the pocket has been identified as a risk factor for device placement. Therefore, prevention of hematoma during the procedure is desirable. Additional techniques to prevent hematoma formation include packing the pocket with antibiotic-soaked sponges to provide tamponade while leads are being placed, and the application of topical thrombin, which may be particularly helpful in anticoagulated patients. Frequent irrigation of the pocket is useful to remove tissue debris and may reveal persistent bleeding that could lead to a pocket hematoma. Alternatively, pocket irrigation with an antimicrobial-containing solution has been used and may also prevent infection. Although almost universally used, there are no randomized-controlled trials studying the effectiveness of prophylactic intrapocket antibiotics (e.g., gentamicin) in pacemaker implantation. The presence of antibiotics in irrigation solutions is unlikely to be necessary, rather the mechanical action of debris removal and dilution of any contaminant are due to the flow and volume of irrigation. The use of monofilament suture for closure of the subcuticular layer may avoid superficial postoperative cellulitis due to ease of absorption. A pressure dressing applied postoperatively for 12–24 h after skin closure may help to prevent infection and further decrease the risk of hematoma formation.

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Prevention of Bacterial Infections in Patients with CIEDs

New products: AIGISRx

CIED infection rates are on the rise, and new developments that reduce the risk of CIED infection would be welcomed. More effective antimicrobial prophylaxis may help reduce CIED infections and improve clinical outcomes. At least one-half to two-thirds of CIED infections are caused by S. aureus and CoNS. In vitro, methicillin-resistant strains of S. aureus, and many strains of CoNS, are susceptible to a combination of two antibiotics with distinct mechanisms of actions: minocycline (inhibits t-RNA/ribosomal binding) and rifampin (inhibits DNA-dependent RNA polymerase). The AIGISRx antibacterial envelope (TYRX Pharma, Inc., Monmouth Junction, NJ) is an FDA-cleared polypropylene mesh envelope that releases minocycline and rifampin in the generator pocket after implantation with a CIED. The CIED generator is first placed in the polymer mesh envelope, and then both the generator and mesh envelope are subsequently positioned in the generator pocket at the time of implantation. After implantation, the mesh envelope releases the two antibiotics.

Preclinical studies demonstrated that the antibacterial envelope reduced the risk for infection by several pathogens, including S. epidermidis, within CIED implant pockets. Randomized controlled trials demonstrate that the combination of rifampin and minocycline significantly reduces device-associated infections of central venous, hemodialysis, and cerebrospinal fluid drain catheters, especially those due to S. aureus and CoNS. The results of a large retrospective study of the antibacterial envelope indicate that it is associated with a high rate of successful CIED implantation (>99%) and a low risk of infection (<0.5%) in a population at significant risk for CIED infection (unpublished). In the future, a prospective randomized controlled trial of the antibacterial envelope would be useful to further evaluate the performance of the antibacterial envelope. In the meantime, early results of the AIGISRx antibacterial envelope are promising, and it is reasonable to incorporate this technology into the therapeutic armamentarium against CIED infections.

New products: Arglaes

It has been known for many years that silver has antimicrobial properties. Arglaes (Medline Industries, Inc., Mundelein, IL) dressings use silver antimicrobial technology and are designed to prevent SSIs. The dressings are transparent, designed for wound care, and were the first antimicrobial, sustained-release dressings on the market. Arglaes provides a continuous and controlled release of silver ions, which act as an antibacterial agent. The ionic silver creates an environment that is hostile to bacteria and fungi, yet nontoxic (e.g. will not harm healthy tissue), and the sustained-activity ionic silver maintains full efficacy for up to 7 days. According to the manufacturer, Arglaes reduces the bio-burden on skin, including a broad spectrum of bacteria and fungi, and appears to control bacteria in wounds and prevent bacterial contamination. Arglaes also provides a moist environment for the healing process, is suitable for many wound types, and is available as a transparent film dressing, with or without an alginate pad, as well as a powder.

Results from independent studies confirm Arglaes' in vitro antimicrobial activity against the pathogens (S. aureus, E. coli, fecal Streptococcus) commonly associated with wound infections. Arglaes has been shown to inhibit bacterial growth in as little as 24 h with a lasting effect over 12 days. Although initially designed for wound care, the Arglaes dressings are also now used to cover intravenous exit sites. In one small prospective randomized trial, 31 patients were randomized to Tegaderm (3M, St. Paul, MN), a transparent polyurethane dressing, or Arglaes dressing after insertion of an arterial line or central venous catheter in the intensive care unit. Skin swabs were taken from the insertion sites prior to catheterization and on removal of the intravascular device to measure skin colonization rate between the two dressings. The catheter tips were also cultured on removal. Surprisingly, no statistical differences were found in bacterial growth between the two dressings. This product has vast potential, especially with the emergence of resistant organisms (e.g. methicillin-resistant S. aureus), particularly as there is no known antimicrobial resistance to silver. Other similar FDA-approved products on the market include: Silverlon CA (Argentum Medical, Chicago, IL), Aquacel Ag (Conva Tec USA, Skillman, NJ), and Silvercel (Systagenix, Quincy, MA).

Clinical implications/conclusions

ICD implantation for primary prevention of sudden cardiac death requires careful judgment, as the survival benefit, when expressed in absolute terms, is relatively modest. Palliation of congestive heart failure symptoms...
with cardiac resynchronization is another example of a complex procedure in patients with a poor prognosis. Comorbidities that limit life expectancy and quality of life may contraindicate this type of device therapy. The presence of risk factors for CIED infection defines a group at high risk for life-threatening device-related infection. An appreciation of the fact that these risk factors increase the likelihood of infection should be part of the risk–benefit consideration in such patients. Improved antimicrobial prophylaxis is one approach to reducing morbidity, mortality, and expense associated with infection after CIED implantation.

References


Prevention of Bacterial Infections in Patients with CIEDs


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