

# Management of Device Infections



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## KEYWORDS

• Pacemaker • Defibrillator • Infection • Endocarditis

## KEY POINTS

- The rate of cardiac implantable electronic device (CIED) infection has increased disproportionately to that of implantation.
- Device-related infections are most commonly due to perioperative contamination. Notably, early pocket re-exploration and upgrade procedures are at particularly high risk for infection.
- Risk factors for CIED infection include diabetes, heart failure, and renal disease.
- Confirmed infection of a CIED requires prompt removal of the entire system (generator and leads) in combination with antimicrobial therapy.
- An understanding of the risks of CIED infection and using preventive measures is critical for the implanting physician.

## INTRODUCTION

Because of the expanding indications and longer life expectancy, implantations of cardiac implantable electronic devices (CIEDs) have increased dramatically over the past 2 decades. Infection represents a potential complication of CIED implantation that can have severe consequences. Although most infections are limited to the generator pocket, systemic infection and endocarditis associated with device implantation has been recognized since the early days of permanent pacemaker (PPM) placement and occurs in nearly 10% of device-related infections.<sup>1</sup> Such complex infections can be associated with substantial morbidity and mortality. The rate of CIED infection has increased disproportionately to that of implantation.<sup>2,3</sup> Here the authors provide a contemporary review of the pathogenesis, management, and prevention of CIED infection.

## PATHOGENESIS AND MICROBIOLOGY

Device-related infections are most commonly due to perioperative contamination, either during initial

implantation or at times of subsequent surgical manipulation (eg, generator replacement).<sup>4</sup> Infection can also occur because of a breach of the skin barrier in the setting of generator or lead erosion. A less common mechanism of CIED infection is the hematogenous spread of bacteria from another site with secondary involvement of the device components.<sup>5</sup>

Staphylococcal species are the predominant organisms isolated in large series of CIED infection, accounting for 60% to 80% of cases (Fig. 1).<sup>1,6,7</sup> Of these, *Staphylococcus aureus* and coagulase-negative staphylococci are the most frequent culpable isolated organisms. Gram-positive bacilli (*Corynebacterium* spp, *Propionibacterium* spp), *Pseudomonas* spp, and Enterobacteriaceae are less commonly involved in CIED infections. Polymicrobial involvement has been described. Rarely, fungi (*Candida* spp) or molds are identified as causative organisms.<sup>7,8</sup> A minority of patients will have negative cultures despite signs and symptoms of clinical infection, including some patients that demonstrate localized inflammation of the generator pocket or device erosion.<sup>6</sup>

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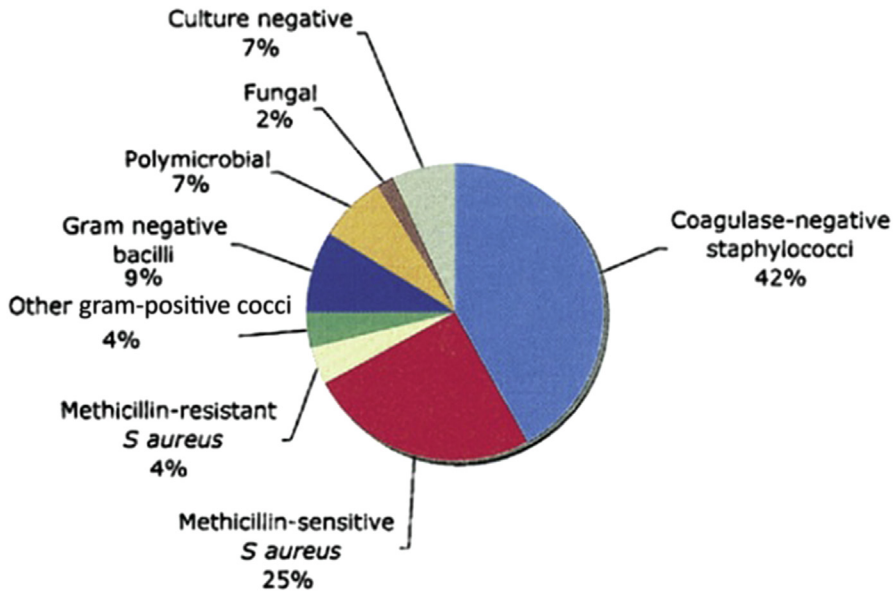


Fig. 1. Microbiology of cardiac implantable endocardial device infections. (From Sohail MR, Uslan DZ, Khan AH, et al. Management and outcome of permanent pacemaker and implantable cardioverter-defibrillator infections. *J Am Coll Cardiol* 2007;49(18):1853; with permission.)

## EPIDEMIOLOGY (INCIDENCE AND RISK FACTORS)

It is difficult to accurately estimate the exact incidence of CIED infection because of the universal deficiencies in standardized registries and limitations associated with long-term surveillance. Reported incidence rates differ among observational studies because of the variation in definitions and follow-up duration. Infection risk after PPM implant is estimated to be 0.5% to 1.0% within the first 12 months.<sup>9–11</sup> Implantable cardioverter defibrillators (ICDs) carry a higher risk of infection than PPMs, although this higher risk might be partially explained by the fact that ICD patients are generally sicker and carry more comorbidities than PPM patients.<sup>12</sup> Infection risk also seems to increase in conjunction with the procedural complexity of the implanted CIED system.<sup>13–16</sup> In an analysis of device-related infections in the National Cardiovascular Data Registry (NCDR) ICD database, the infection rates were 1.4%, 1.5%, and 2.0% for single, dual, and biventricular ICDs, respectively.<sup>16</sup> CIED replacements and upgrades are associated with an even higher risk of infection than de novo implants.<sup>10,16</sup> In the NCDR, generator replacement had a higher rate of infection compared with initial implant (1.9% vs 1.6%;  $P < .001$ ).<sup>16</sup> Reimplantation or device upgrade has been independently associated with infection in both ICD (odds ratio [OR] 1.354 [95% confidence interval [CI], 1.196–1.533;  $P < .0001$ ]) and PPM patients (OR 2.79 [95% CI 2.38–3.28;  $P < .001$ ]).<sup>10,16</sup>

The rate of CIED infection seems to be increasing.<sup>17</sup> It is thought that expanded indications for CIED implantation (ICD and biventricular devices) combined with an older and sicker patient population, in part, contributes to this increased rate. Multiple risk factors and comorbidities have been associated with CIED infections in several case series. These factors can be grouped into patient-, procedure-, or device-related factors (Table 1).<sup>18</sup> In a contemporary cohort of patients with CIED infection, 7 independent risk factors predicted infection: early pocket re-exploration, male sex, diabetes, upgrade procedure, heart failure, hypertension, and glomerular filtration rate less than 60 mL/min.<sup>19</sup> In a multicenter, French nationwide, prospective cohort study, secondary procedures, such as pulse generator replacements, were associated with an almost 2-fold risk of device infection as compared with de novo implants. Notably, early reinterventions for hematoma or lead dislodgment were the leading risk factors of infection in this cohort.<sup>9</sup>

## CLINICAL PRESENTATION AND DIAGNOSIS

CIED infection can have varying presentation, ranging from isolated superficial infection to more complex deep infection (Table 2).<sup>5</sup> Uncomplicated pocket infections involve the subcutaneous pulse generator pocket and the extravascular portion of the transvenous leads. Typical pocket infection signs are local erythema, warmth, pain, and swelling. Less commonly, adherence of skin to the device with incipient or overt erosion of skin

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