

# New Approaches to Decrease Cardiac Implantable Electronic Device Infections

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## KEYWORDS

- Cardiac implantable electronic devices (CIEDs) • Pacemaker • Implantable cardioverter defibrillator
- Infection • Complication • Endocarditis

## KEY POINTS

- Cardiac implantable electronic device (CIED) infections are becoming increasingly more common.
- CIED infections are associated with considerable morbidity, mortality, and cost.
- Rates of CIED infections are lowest when devices are implanted in high-volume centers by experienced operators.
- Careful antimicrobial stewardship at the time of CIED implantation is crucial to prevent infections.
- Evidence-based strategies to prevent CIED infections include the use of prophylactic antibiotics, chlorhexidine-alcohol skin preparation, and antibiotic-impregnated pulse generator envelopes.

## INTRODUCTION

The number of cardiac implantable electronic devices (CIEDs) implanted in the United States has grown rapidly over the past 2 decades. This trend is due to expanding indications, based on findings from landmark clinical trials that have shown the benefits of cardiac resynchronization therapy (CRT) and prophylactic implantable cardioverter-defibrillators (ICDs), as well as the need for permanent pacing in our aging patient population.<sup>1–3</sup> As a result, CIEDs are implanted in increasingly complex patients with multiple comorbidities. Accordingly, CIED infections, defined broadly as infections involving the generator implant site (pocket) and/or intravascular hardware, have become increasingly common. In fact, the increase in incidence of CIED infections has outpaced the growth in device implantation, in large part due to the medical

complexity of today's CIED patients.<sup>2,4,5</sup> The incidence in large registries and controlled trials ranges from 1.6% to 3%.<sup>4,6–8</sup> Infected patients present with a spectrum of signs and symptoms that might be localized to the device generator pocket or represent life-threatening systemic illness (**Box 1**).<sup>9,10</sup>

CIED infections are associated with increased morbidity, mortality, and health care expenditures.<sup>1,4,7,11</sup> As a result, the importance of preventing CIED infections cannot be overstated. Most CIED infections occur because of bacterial seeding at the time of implantation, revision, or generator replacement. Therefore, careful “antimicrobial stewardship” is crucial for prevention. Important methods include meticulous sterile technique; appropriate training and supervision of electrophysiology (EP) laboratory personnel, fellows,

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**Box 1**  
**Signs and symptoms of CIED infection**

- Pain, erythema, edema at generator site
- Discharge from incision or fistula
- Wound dehiscence or device erosion
- Fever, leukocytosis
- Unexplained bacteremia
- Sepsis/septic shock
- Systemic embolism (L-sided IE)
- Peripheral edema (R-sided IE)
- Pulmonary embolism

and students; minimization of procedure times; implantation by board-certified electrophysiologists at high-volume centers; and timing of device implantation to occur just before discharge for inpatients. Recent controlled trials have identified additional methods for preventing CIED infections and are reviewed here.

### RISK FACTORS FOR CIED INFECTIONS

The recent increase in CIED infections is likely due to implantation in younger patients with multiple comorbidities, who subsequently require serial device generator changes and lead revisions. Patient and procedural characteristics that are risk factors for infection have been described and are presented in **Table 1**. A recent review of device-related infections in Medicare patients by Arnold Greenspon and colleagues demonstrated an exponential rise in the odds of a CIED-related

**Table 1**  
**Risk factors for cardiac implantable electronic device infection**

Risk Factor	Odds Ratio	References
Diabetes	3.2–3.4	6,24
Renal insufficiency	4.6–6.3	6,24,25
Systemic anticoagulation	2.8–3.4	6,24
Chronic steroid therapy	13.9	26
Preimplant fever	8.7	27
Prior device infection	—	26
Three or more leads	5.4	26
Early pocket reentry	7–16.3	14,27
Device revision/generator change	1.7–3.1	6,14,24

infection with each subsequent pocket entry (ie, 3rd, 4th, 5th device pulse generator change associated with up to 16.9-fold increase in infection rate, **Table 2**).

### PREVENTION OF CIED INFECTIONS

Optimal skin preparation is crucial for preventing surgical site infections. Chlorhexidine-alcohol scrub has been shown to be superior to povidone-iodine at preventing surgical infections (41% relative risk reduction).<sup>12</sup> In addition, perioperative antibiotics play an important role in the prevention of surgical site infection for many types of procedures.<sup>13</sup> de Oliveira and colleagues<sup>14</sup> conducted a randomized, placebo controlled trial of perioperative cefazolin at the time of CIED implantation or generator exchange. The trial was stopped early due to an 81% reduction in CIED infections in the cefazolin group. We routinely administer cefazolin (or vancomycin for penicillin-allergic patients) at the time of device implantation, revision, or generator exchange. However, some investigators have advocated the routine use of vancomycin for prophylaxis, given temporal trends in bacterial drug resistance (**Table 3**). Jan and colleagues<sup>15</sup> evaluated microbiological isolates in a large cohort of patients with confirmed CIED infections, showing that 86% of isolates were *Staphylococcus* species with a 30.5% rate of resistance to oxacillin. Conversely, 100% of Staph isolates were susceptible to vancomycin. In a separate single center study of patients who suffered from a CIED infection, 78% of culture-positive cases had *Staph* isolates, and the proportion of all

**Table 2**  
**Risk of cardiac implantable electronic device infection as a function of the number of subsequent procedures (eg, pulse generator exchanges) after index procedure**

Effect	Level	Hazard Ratio	P-value
Age	80–84 vs 65–69	0.766	.0172
	>85 vs 65–69	0.677	.0061
Renal failure	Yes vs No	1.56	<.0001
No. of operation	2 vs 1	2.886	<.0001
	3 vs 1	8.15	<.0001
	4 vs 1	14.4	<.0001
	5 vs 1	16.9	<.0001

Data from Patel JP, Kurtz SM, Lau E, et al. Removal/replacement procedures and deep infection risk for pacemakers and ICDs in the United States: Medicare Analysis from 1997 to 2010. Denver (CO): Heart Rhythm Scientific Sessions; 2013.

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