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# Management of cardiac device-related infections: A review of protocol-driven care

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ABSTRACT

*Background:* The prevalence of cardiac device-related infections (CDIs) has mirrored the unprecedented increase in device usage. CDIs are currently one of the leading indications for extraction. Despite this, there is limited data regarding the clinical trends, management and outcomes associated with this complication.
*Methods:* A review of a prospective registry of all patients undergoing device extraction between January 1, 2004, and June 15, 2009, at a single high-volume tertiary referral center was performed.
*Results:* A total of 506 consecutive patients were identified. From these, 350 patients were identified as having a CDI (205 ICD, 145 PPM). The mean age was 69.9 ± 13.7. Although most patients presented clinically with signs of a pocket infection (PI) (42%), the most common final diagnosis was cardiac device infective endocarditis (CDIE) (57%). The two most common pathogens were methicillin-resistant *Staphylococcus aureus* (27%) and methicillin-resistant *Staphylococcus epidermidis* (23%); they accounted for 69% of all deaths. Cultures taken from pocket tissue as opposed to exudates displayed higher concordance with lead-tip cultures (56% and 31% respectively). The mean time from explantation to device reimplantation for PIs, bacteremia and CDIE was 6.7 ± 4.7, 10.25 ± 4.7 and 11.39 ± 16.6 days respectively.
*Conclusion:* CDIs are a serious complication associated with device usage. Diagnosis and management protocols for CDIs should feature transesophageal echocardiography; complete hardware extraction; broad-spectrum antibiotics that cover methicillin-resistant Staphylococci and cultures derived from lead-tips and preferably pocket tissue. Immediate device reimplantation is possible in noninfectious cases; several factors should be considered regarding reimplantation in cases involving CDIs.


## 1. Introduction

The past twenty years have witnessed an unprecedented increase in the use of implantable cardiac devices in the United States [1]. This increase is reflected in both the expansion of indications and guidelines regarding device usage, in addition to the latest Medicare expenditure data [2]. The use of implantable cardiac defibrillators has increased 11-fold in the last 15 years while the use of pacemakers has increased 22% throughout the same time period. The treatment of arrhythmias and conduction disorders currently ranks as one of the top areas of Medicare expenditure, totaling over $500 million annually [2]. Unfortunately, the rate of device infections has mirrored the increased use of implantable cardiac devices — some studies suggest that the rate of device infections has increased out of proportion to the increase in implantation rate [3,4]. Cardiovascular implantable electronic device (CIED) infections are associated with a high cost, both with respect to resource utilization and patient mortality. The mean cost for a hospitalization attributed to a CIED infection ranges from $31,149 to $55,003; moreover, CIED infections are associated with an 8.4 to 11.6 fold increase in mortality when compared to hospitalizations attributed to noninfectious, cardiac device complications [5].

Device infections are one of the leading indications for extraction [6]. The term device infection can be subdivided into several categories, depending on what anatomical structures or device components are affected. These categories include pocket infections, characterized by involvement of the device pocket and surrounding soft tissue, with or without the presence of bacteremia; cardiac device-related infective endocarditis (CDIE), characterized by involvement of the device leads and endocardial tissue, with or without the presence of bacteremia; and bacteremia with the absence of any other signs of device infection.

The proper management of patients experiencing device infections is essential in order to avoid potentially serious consequences. CDIE, an example of a deep-seated infection, is generally considered one of the most devastating presentations and constitutes anywhere from 10% to 23% of all cardiac device related infections [7,8,9,10]. CDIE is associated with a mortality rate of up to 66% if the device is not extracted, and around 13–21% in the setting of complete device extraction coupled with antimicrobial therapy [9].

The optimum strategy regarding the management of patients with cardiac device related infections is an area that has only recently been explored in literature; obstacles such as the historical lack of a

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universal definition for cardiac device infective endocarditis served to seriously impede earlier efforts [9]. Currently, there is limited data within literature involving large cohorts of patients that are managed using uniform diagnostic and treatment protocols — protocols that address the full spectrum of infection associated with implantable cardiac devices. Most of the literature concerning the trends associated with and the management of device infections involves the use of several different centers; operators; protocols and infectious disease consult services. These factors may serve to increase the number of confounding variables, potentially distorting the conclusions or observations recorded in the study.

The aim of this study was to describe the trends and outcomes associated with a uniform diagnostic and management protocol for a large population of patients presenting with an infection of an implantable cardiac device. This protocol was created at a single high-volume tertiary cardiovascular referral center which had a prospective registry in place. The management of these patients featured the use of cultures drawn from several sources; the use of both transesophageal and transthoracic ECHOs; complete device extraction performed by a single operator and the use of a single infectious disease consultation service. The clinical outcomes associated with these interventions were subsequently compared, when appropriate, to historical cohorts.

## 2. Materials and methods

### 2.1. Patient population

We reviewed a prospective registry for all patients undergoing removal of an implantable cardiac device at a single high-volume tertiary cardiovascular referral center between January 1, 2004 and June 15, 2009. Any subject who underwent extraction of a cardiac device, regardless of indication, met the criteria for inclusion in this review. 506 consecutive patients underwent device extraction during this time period. From this population, a total of 350 patients were then identified as having a suspected or confirmed infection on the basis of a combination of clinical, laboratory and imaging data. Information such as patient demographics; co-morbidities; procedure characteristics; extraction techniques; hospital outcomes and data pertaining to follow-up visits were included in a comprehensive database.

### 2.2. Study protocol

A prospective and well-defined care protocol was implemented for patients undergoing device extraction due to a suspected or confirmed infection. All patients upon admission had chest X-rays, PA and lateral, and some had CAT scans. Transthoracic echocardiograms were done in all patients. Blood and exudate (when present) cultures along with transesophageal echocardiograms (TEEs) were performed preoperatively in all the patients. In the operating room, all patients underwent complete hardware extraction; leads were removed through the use of locking stylets and traction or by using laser extraction (Spectranetics©). En-bloc capsulectomy was performed in all patients. In the majority of cases, specimens were collected intraoperatively from pocket tissue, exudate, lead tips, vegetations and blood; a second TEE was also performed in most patients during the extraction procedure. The wounds were closed primarily with 2–0 nylon and subcutaneous drains were used. If the patient was pacer-dependent, a temporary pacer was placed during device extraction.

Throughout the entire admission, a single infectious disease consultation service was utilized; a uniform antimicrobial approach was tailored to each patient using operative, echocardiographic and microbiologic data. In the cases where reimplantation was necessary, the timing of the procedure was dependent on several factors. In non-infectious cases, reimplantation was performed nearly immediately after extraction. In cases involving a pocket infection, the clinical assessment of cellulitis in addition to negative blood cultures was used to determine the timing of reimplantation (the mean period being approximately 7 days). In cases involving bacteremia, the presence of negative blood cultures was a key determinant (the mean period ranging from 7 to 15 days). In cases involving CDIE, the presence of negative blood cultures in addition to the overall clinical assessment of the patient and a decreased burden of vegetation were key factors in determining the timing of device reimplantation (the mean period ranging from 7 to 15 days). In patients that had CDIE and vegetations, every attempt was made by the operator to remove the vegetation percutaneously during device extraction. In cases where the patient had a vegetation during reimplantation, the device leads were placed on the epicardium; the presence of vegetations alone did not delay reimplantation, instead it served to change the approach regarding lead implantation — from transvenous to epicardial.

### 2.3. Definitions

The terms extraction, procedural clinical success, procedure failure, and major and minor complications were defined in accordance with the Heart Rhythm Society Expert Consensus document from 2009 [11]. Pocket infection was defined as clinical evidence of infection at the generator site, including erythema; warmth; tenderness; fluctuation; wound dehiscence; and device erosion or purulent drainage [12]. Cardiac device-related infective endocarditis (CDIE) was defined as the presence of vegetation on a device lead or a valve along with clinical or microbiological evidence of device associated infection, namely the presence of a pocket infection; bacteremia or systemic inflammatory response syndrome [12]. Relapse of infection was defined as a recurrence of infection with the same organism and similar antibiogram within 6 months of device extraction. Re-infection was defined as infection with a new organism subsequent to device extraction.

### 2.4. Statistical analysis

Variable distributions were determined. Continuous variables were expressed as mean values and standard deviations. Categorical variables were expressed as percents. Continuous variables were compared using t-tests for independent samples. Categorical variables were compared using the Chi-square test or Fisher's exact test if expected cell values were less than 5. The level of significance was set at alpha = 0.05. All analyses were conducted using IBM SPSS Statistics v. 18 (Chicago, IL).

## 3. Results

### 3.1. Baseline characteristics (Table 1)

A total of 506 patients underwent device extraction; from this population, 350 patients underwent extraction due to the presence of a device infection. Table 1 provides a summary of several descriptive variables.

### 3.2. Clinical presentation (Table 2)

The mean time from device implantation to removal for the total population was 30.4 months, 9.4 months for an infectious indication (n = 350) and 38.2 months for a non-infectious indication (n = 156). Sufficient data was available to establish both an initial and final diagnosis in 467 patients. From these patients, symptoms consistent with a pocket infection was the most common presentation (42%). 125 patients (26%) presented initially due to seemingly non-infectious reasons, namely lead failure; device malfunction; and pain or endocardial perforation. 63 patients (13%) presented with an initial diagnosis of CDIE based on data obtained from cultures and echocardiography performed at other institutions or in an

**Table 1**
Baseline characteristics of subjects undergoing extraction of ICD due to device infection (n = 350).

| Characteristic | Value |
|---|---|
| Age (years) | 69.9 (SD ± 13.7) |
| Gender | |
| Male | 265 (76%) |
| Female | 85 (24%) |
| Race | |
| Caucasian (including Hispanic) | 302 (86%) |
| African American | 45 (13%) |
| Asian | 3 (1%) |
| Device | |
| Implantable cardioverter-defibrillator | 134 (38%) |
| Permanent pacemaker | 143 (41%) |
| CRT-defibrillator | 71 (20%) |
| CRT-pacemaker | 2 (1%) |
| Co-morbid conditions | |
| Hypertension | 304 (87%) |
| Coronary artery disease | 240 (69%) |
| Diabetes mellitus | 177 (51%) |
| Chronic kidney disease | 90 (26%) |
| Hemodialysis | 69 (20%) |
| Congenital heart disease | 7 (1%) |