HOSPITAL CHRONICLES 2014, VOLUME 9, SUPPLEMENT 1: 103–106

VIDEO SESSION

Infections Involving Cardiac Implantable Electronic Devices

Eleni Belesiotou, MD,[1] Efstathia Perivolioti, MD,[1]
Efthimia Rouska, MD,[2] Dimitrios Stalikas, MD,[2] Martha Nepka, MD,[1]
Maria Stampa, MD,[2] Antonis S. Manolis, MD[2]

[1]Department of Microbiology,
[2]Department of Cardiology,
Evagelismos General Hospital of Athens, Athens, Greece

KEY WORDS: *cardiac pacemaker; implantable cardioverter defibrillator; cardiac device infections; Staphylococcus aureus; pacemaker infection; endocardities; bacteremia*

ABBREVIATIONS
CDI = cardiac device infections
CIEDs = cardiac implantable electronic devices
CoNS = coagulase-negative Staphylococcus
ICD = implantable cardioverter defibrillator
MIC = minimal inhibitory concentration
MRSA = methicillin resistant Staphylococcus aureus
PPM = permanent pacemaker
VRE = vancomycin resistant enterococcus

Corresponding author:
Eleni Belesiotou, MD;
E-mail: beleselina@yahoo.com

INTRODUCTION

Infections of cardiac implantable electronic devices (CIEDs) are an emerging problem because of increasing implant rates and comorbidities. If undiagnosed and untreated, CIED infection is associated with high mortality. Following the new guidelines concerning the use of cardiac resynchronization therapy devices in patients with congestive heart failure,[1] CIED implantation has grown further. Unfortunately, this trend has been accompanied by an increase in infection rate, probably due to an increase in comorbidities. A recent analysis of US data[2] showed that infection rate grew from 1.61% in 1993 to 2.41% in 2008, possibly due to two factors: ageing of population and increased use of more complex devices. Several studies[3,4] have found that the most important risk factors for infection are re-intervention, with device replacement increasing with ageing of the population, and use of dual and triple chamber devices having increased over the last several years.

Early diagnosis and correct treatment of this situation is of great importance; if the local infection is not correctly treated and bacteremia or device endocarditis is present, in-hospital mortality can rise from 5% to 29%.[5] The presentation, consequences, and treatment of device infections vary according to the location and extent of infection and the clinical characteristics of the patient.[6,7]

Cardiac device infections (CDI) may be classified by the mode of infection as primary infections, in which the device and/or pocket itself is the source of infection, usually due to contamination at the time of implant, and secondary infection, in which the leads (and then sometimes the device and the pocket) are seeded due to bacteremia from a different source.

RISK FACTORS

A variety of factors and comorbid conditions have been associated with pacemaker and ICD infection.[8-11]

- Recent manipulation of the device, particularly elective secondary manipulations such as pulse generator replacement
- Temporary pacing prior to permanent device placement
- Diabetes mellitus
- Underlying malignancy
- Operator inexperience

- Advanced patient age
- Prior treatment with anticoagulants or glucocorticoids
- Pocket revision
- Heart failure
- Renal dysfunction (glomerular filtration rate <60 mL/min)
- Female gender

Device infections are generally considered in two categories:

- Pocket infections: the infection involves the subcutaneous pocket containing the device and the subcutaneous segment of the leads (i.e., not the transvenous segment). In some cases, part of the device or lead erodes through the overlying skin. Such an erosion can occur without overt evidence of infection, but there is inescapable contamination of the site and these cases are managed as pocket infections.
- Deeper infection: the infection involves the endovascular portion of the lead, usually with associated bacteremia and/or endovascular infection. Deep infection can occur with or without involvement of the generator pocket and can include device-related endocarditis in which there may be vegetations on the intracardiac portion of the lead.

The diagnosis of CIED infection is more obvious in patients with inflammatory findings at the generator pocket consistent with infection. In contrast, a diagnosis of CIED infection is difficult when there is blood stream infection, but no other discernible clinical or echocardiographic evidence of CIED involvement. Patients with suspected device-related endocarditis should have at least three sets of blood cultures obtained before antibiotics are initiated.[12] Staphylococcal species cause the bulk of CIED infections,[14-20] and account for 60% to 80% of cases in most reported series. A variety of coagulase-negative *Staphylococcus* (CoNS) species have been described to cause CIED infections.[21] CoNS is well recognized as a common cause of microbiological specimen contamination, and thus, repeated isolation of the same species of CoNS with an identical antibiotic susceptibility pattern is desired to support its role as an etiologic agent in CIED infections. Polymicrobial infection sometimes involves more than 1 species of CoNS.[16,20,21] The prevalence of oxacillin resistance among staphylococcal strains has varied among studies, but it is prevalent and should influence initial empirical therapy decisions in CIED infections. *Corynebacterium* species, *Propionibacterium acnes*, Gram-negative bacilli[16,17] including *Pseudomonas aeruginosa*,[23] and *Candida* species account for a minority of CIED infections. Fungi other than *Candida*[24] and nontuberculosis mycobacteria[25] are rarely identified as pathogens in CIED infection.

CIED INFECTION STUDY

PURPOSE

The purpose of this study was to assess recent data in a tertiary hospital for management of CIED infection according to the proper antibiotic therapy on the basis of the responsible micriobiological factors and antibiotic susceptibility testing.

METHODS

Over the last two years, clinical samples from patients with suspected CDI were examined with Gram stain, cultured in common and selective media and broths, in aerobic, microaerophilic and anaerobic conditions. The identification of the isolated microorganisms and the antibiotic susceptibility testing was performed with the automated system VITEK 2 and MIC E test strips *(AB Biodisk)*.

RESULTS

47 patients out of 82 (57.3%) suspected with CIED infection were confirmed microbiologically based on positive cultures from cardiac device specimens. A total of 28 out of 47 (59.6%) patients had pus discharged from the infected area and 19 (40.4%) had cardiac device infections, involving the pulse generator in 6 (2 defibrillators, 4 PPM), pocket (n=5) or other (n=2) tissue in 7, and electrode leads in 6. Polymicrobial infection was confirmed in 3/47 (6.3%) patients. A total of 35/82 (42.7%) suspected samples were negative (30 trauma infections, 3PPM, 2 pocket infections). Results are shown in Table 1.

No relapse or recurrence of the device infection was found with the same organism based on similar antibiogram.

TABLE 1. CIED Infections

suspected CDI	82
CIED infection	47 (57.3%)
pus discharged from the infected area	28 (59.6%)
cardiac device infection specimens	19 (40.4%)
generators	6
ICD	2
PPM	4
device pocket tissue	5
other tissue	2
electrode leads	6
polymicrobial infection	3 (6.3%)

CDI = cardiac device infection; CIED = cardiac implantable electronic device; ICD = implantable cardioverter defibrillator; PPM = permanent pacemaker.

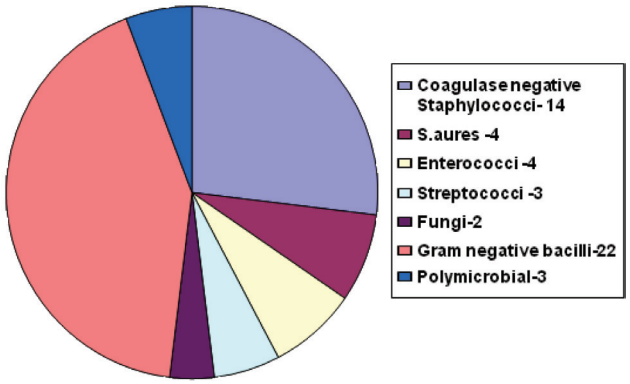

FIGURE 1. Microbiology of PPM/ICD infections (n=49).

TABLE 2. Microbiology of CIED Infections

Gram positive cocci 25	**Gram negative bacilli 22**
Fungi: Candida albicans 2	
Total microorganisms	**49**
Staphylococcus aureus oxacillin negative	3
Staphylococcus aureus oxacillin positive	1
Staphylococcus epidermidis	10
Other coagulase negative Staphylococci	3
Staphylococcus lugdunensis	1
Streptococcus viridans	1
Streptococcus sanguinis	1
Streptococcus agalactiae	1
Enterococcus faecalis	2
Enterococcus faecium	2
Proteus mirabilis	6
Acinetobacter baumannii	3
Enterobacter cloacae	3
Klebsiella pneumoniae	2
Pseudomonas aeruginosa	1
Citrobacter koseri	1
Serratia marcescens	1
Escherichia coli	1
Providencia stuartii	1

Thirty patients had CDI after initial device implantation and 3 patients after a revision (i.e., system upgrade, lead revision, or generator replacement).

CONCLUSIONS

CIED infection was confirmed microbiologically in 57.3% suspected CIED patients. The predominant causative CDI pathogens included common skin flora microorganisms, such as coagulase negative staphylococci (*CoNS), S. aureus,* and *Streptococcus spp*. The most frequent etiological agents were CoNS (14%) followed by gram-negative bacilli including *Klebsiella pneumoniae, Proteus mirabilis, Pseudomonas aeruginosa, Acinetobacter baumanii, Citrobacter koseri, Serratia marcescens, Escherichia coli, and Providencia stuartii.* No anaerobes or mycobacteria were detected as etiological agents.

The microorganisms that cause CIED infections may be acquired either endogenously from the skin of patients or exogenously from the hospital environment or from the hands of hospital workers. The *Enterococcus* strains were vacomycin resistant (VRE); 1 out of 4 strains of S. aureus was methicillin-resistant Staphylococcus aureus (MRSA) and with MIC vancomycin >1. The detection of these strains with low sensitivity to vancomycin is very important because if one uses vancomycin with MIC ≥1μg/ml, one may encounter therapeutic failure. That is why one could use a beta-lactam antibiotic (preferably daptomycin) (Grade 1B).

The presence of methicillin-resistant *S. aureus* (although in low concentrations) and the presence of multidrug resistant Gram negative baciili, such as *A. baumannii, K. pneumoniae* and *Serratia marcescens* which are present in the nosocomial environment suggest that a healthcare environment is the site of infection acquisition. As *Staphylococci* are the most common pathogens for CIED infections, empiric antibiotics for suspected CDI should include coverage for staphylococci, while awaiting microbiology culture results. These findings should assist clinicians in identifying CIED patients who are at increased risk of infection, as well as in developing strategies to minimize the modifiable risks.

All patients in the present study received antimicrobial treatment. Most patients (97%) received a combination of intravenous and oral antibiotics. Only 3% were treated with oral antibiotics alone. It is very important that patients with inescapable contamination of the site, when part of the device or lead erodes through the overlying skin without proven evidence of infection, must be treated as pocket infections. The development of resistance of some strains along with the incidence of these infections have to be dealt with continuous surveillance and wisely used therapy. Improvement of surveillance is crucial in recognizing emergence of highly resistant strains. Early recognition and prompt empirical treatment are essential to improve outcomes.

REFERENCES

1. Dickstein K, Vardas P, Auricchio A, et al 2010 Focused update of ESC Guidelines on device therapy in heart failure. *Eur Heart J* 2010; 12:1526-1536.
2. Greenspon AJ, Patel JD, Lau E, et al. 16-year trends in the infection burden for pacemakers and implantable cardioverter-defibrillators in the United States 1993 to 2008. *J Am Coll Cardiol* 2011; 58:1001–1006.
3. Nery PB, Fernandes R, Nair GM, et al. Device-related infection among patients with pacemakers and implantable defibrillators: incidence, risk factors and consequences. *J Cardiovasc Electrophysiol* 2010; 21:786–790.
4. Cengiz M, Okutucu S, Ascioglu S, et al. Permanent pacemaker and implantable cardioverter defibrillator infections: seven years of diagnostic and therapeutic experience of a single centre. *Clin Cardiol* 2010; 33:406–411.
5. Viganego F, O'Donoghue S, Eldadah Z, et al. Effect of early diagnosis and treatment with percutaneous lead extraction on survival in patients with cardiac device infections. *Am J Cardiol* 2012; 109:1466–1471.
6. Baddour LM, Epstein AE, Erickson CC, et al. Update on cardiovascular implantable electronic device infections and their management: a scientific statement from the American Heart Association. *Circulation* 2010; 121:458–477.
7. Baddour LM, Cha YM, Wilson WR. Clinical practice. Infections of cardiovascular implantable electronic devices. *N Engl J Med* 2012; 367:842.
8. Duval X, Selton-Suty C, Alla F, et al. Endocarditis in patients with a permanent pacemaker: a 1-year epidemiological survey on infective endocarditis due to valvular and/or pacemaker infection. *Clin Infect Dis* 2004; 39:68.
9. Eggimann P, Waldvogel F. Pacemaker and defibrillator infections. In: Infections Associated with Indwelling Medical Devices, Waldvogel FA, Bisno AL (Eds), American Society for Microbiology Press, Washington, DC 2000; p. 247.
10. Klug D, Balde M, Pavin D, et al. Risk factors related to infections of implanted pacemakers and cardioverter-defibrillators: results of a large prospective study. *Circulation* 2007; 116:1349.
11. Sohail MR, Henrikson CA, Braid-Forbes MJ, et al. Comparison of mortality in women versus men with infections involving cardiovascular implantable electronic device. *Am J Cardiol* 2013; 112:1403.
12. Baddour LM, Epstein AE, Erickson CC, et al. Update on cardiovascular implantable electronic device infections and their management: a scientific statement from the American Heart Association. *Circulation* 2010; 121:458
13. Camus C, Leport C, Raffi F, Michelet C, Cartier F, Vilde JL. Sustained bacteremia in patients with a permanent endocardial pacemaker: assessment of wire removal. *Clin Infect Dis* 1993; 17:46–55.
14. Klug D, Lacroix D, Savoye C, et al. Systemic infection related to endocarditis on pacemaker leads: clinical presentation and management. *Circulation* 1997; 95:2098–2107.
15. Da Costa A, Lelièvre H, Kirkorian G, et al. Role of the preaxillary flora in pacemaker infections: a prospective study. *Circulation* 1998; 97:1791–1795.
16. Fu EY, Shepard RK. Permanent pacemaker infections. *Card Electrophysiol Rev* 1999; 3:39–41.
17. Chua JD, Wilkoff BL, Lee I, Juratli N, Longworth DL, Gordon SM. Diagnosis and management of infections involving implantable electrophysiologic cardiac devices. *Ann Intern Med* 2000; 133:604–608.
18. Sohail MR, Uslan DZ, Khan AH, et al. Management and outcome of permanent and implantable cardioverter-defibrillator infections. *J Am Coll Cardiol* 2007; 49:1851–1859.
19. Villamil Cajoto I, Rodríguez Framil M, Van den Eynde Collado A, José Villacián Vicedo M, Canedo Romero C. Permanent transvenous pacemaker infections: an analysis of 59 cases. *Eur J Intern Med* 2007; 18:484–488.
20. del Rio A, Anguera I, Miró JM, et al; Hospital Clinic Endocarditis Study Group. Surgical treatment of pacemaker and defibrillator lead endocarditis: the impact of electrode lead extraction on outcome. *Chest* 2003; 124:1451–1459.
21. Kloos WE, Bannermann TL. Update on the clinical significance of coagulase-negative staphylococci. *Clin Microbiol Rev* 1994; 7:117–140.
22. Cacoub P, Leprince P, Nataf P, et al. Pacemaker infective endocarditis. *Am J Cardiol* 1998; 82:480–484.
23. Chacko ST, Chandy ST, Abraham OC, et al. Pacemaker endocarditis caused by Pseudomonas aeruginosa treated successfully. *JAPI* 2003; 51:1021–1022.
24. Kouvousis NM, Lazaros GA, Christoforatou EG, et al. Acremonium species pacemaker site infection. *Hellenic J Cardiol* 2003; 44:83–87.
25. Amin M, Gross J, Andrews C, Furman S. Pacemaker infection with Mycobacterium avium complex. *Pacing Clin Electrophysiol* 1991; 14:152–154.
26. Giannella M, Valerio M, Franco J, Marin M, Bouza E, Muñoz P. Pacemaker infection due to Mycobacterium fortuitum: the role of universal 16S rRNA gene PCR and sequencing. *Diagn Microbiol Infect Dis* 2007; 57:337–339.