

Role of the Echocardiography Laboratory in Diagnosis and Management of Pacemaker and Implantable Cardiac Defibrillator Infection

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A 68-year-old male patient presented with several weeks of fatigue, progressing to subjective fever and chills. For several days before admission he noted progressive dyspnea, and for this reason presented to the emergency department. Blood cultures grew *Staphylococcus aureus*.

Pertinent history included an implantable cardiac defibrillator (ICD) implantation in the left chest 25 months earlier for inducible ventricular tachycardia and an ischemic cardiomyopathy. History included that of diabetes mellitus, hypertension, hypercholesterolemia, and end-stage renal disease (ESRD) for which he received chronic hemodialysis via dialysis catheter, which had been inserted 1 year earlier.

Physical examination was unrevealing for source of infection. Particularly, the ICD pocket appeared unremarkable with no discomfort, fluctuance, erythema, or warmth noted.

By transthoracic echocardiography (TTE) no definite abnormality was found, but electrode reverberations made imaging difficult. Subsequently, transesophageal echocardiography (TEE) revealed several mobile vegetations attached to electrodes within the right atrium (Fig. 1 and Video Fig. 1).

The entire ICD system was surgically removed. Several large vegetative lesions were noted attached to the electrodes, which subsequently also grew *Staphylococcus aureus*. At surgery the generator pocket appeared unremarkable and cultures were sterile. The

dialysis catheter was also removed. It grossly appeared normal and culture of the catheter was negative. The patient completed a full course of antibiotic therapy and then received a new ICD device, implanted on the opposite side of the chest.

The reported incidence of pacemaker and ICD (PM/ICD) cardiac device infection (CDI) varies from 0.13% to as high as 19.9%¹⁻⁷ for pacemakers, and 0.8%–1.3% for transvenous ICDs.⁸⁻¹¹ The high incidence of pacemaker infection reported of 19.9% appears to be inordinately high,³ with most reports finding an incidence on the order of $\leq 1\%$.

CDI is defined as infection involving either the generator pocket or device electrodes (electrode endocarditis). Most infections occur within the generator pocket, with PM/ICD electrode infection accounting for about 10% of CDIs.¹² Electrode infection usually can be diagnosed using the Duke criteria¹³; hence, positive blood cultures and vegetations noted on the electrode will confirm the diagnosis.^{14,15}

About 70% of patients with *S. aureus* bacteremia and a PM/ICD have a CDI.^{6,16} As noted above, 90% of these infections involve the generator pocket, of which 60% have no clinically detectable localizing signs of generator pocket infection. It should be noted that these statistics for *S. aureus* cannot be extended to infection due to other organisms and rate of CDI infection.¹⁶ As 60% of generator infections may not demonstrate localizing signs, radionuclide studies with Tc-99m labeled white blood cells or gallium may be of some help.¹⁶

The risk of CDI developing after a bout of *Staphylococcus* bacteremia is unknown, but did

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ICD ELECTRODE INFECTION

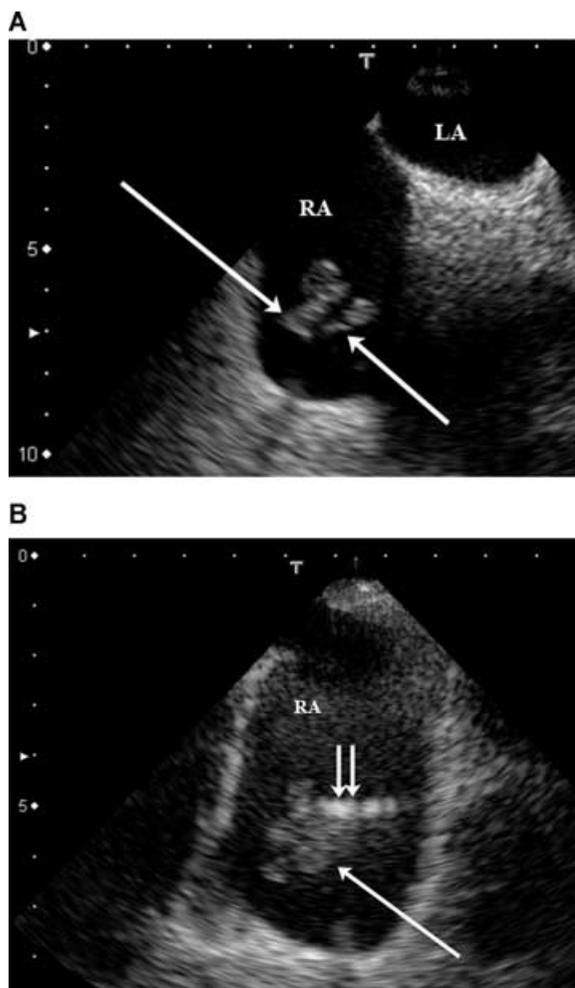


Figure 1. Transesophageal echocardiography from the midesophagus revealed highly mobile vegetations (arrows) attached to leads (double vertical arrows) within the right atrium. Images are from (A) longitudinal (90°) and (B) 60°. LA = Left atrium; RA = right atrium.

develop in 29% of 21 patients in which a device was implanted greater than 1 year prior.¹⁶ Generally, diagnosis of CDI should be considered in a patient with a PM/ICD and unexplained fever.¹⁴

In addition to an anatomical classification (generator pocket or electrodes), CDI is also classified by time of onset following implantation/manipulation. Early infection is defined as developing within the first month, late infection from 1 to 12 months, and delayed infection beyond 12 months of implantation/manipulation.^{15,17,18}

Source of CDI includes pocket contamination at the time of generator implant, or from a

slow generator cutaneous erosion. Early infection of the generator pocket is most often due to *S. aureus*, and late infection by coagulase-negative Staphylococcus or other skin flora.^{14,18} *S. aureus* CDI may occur at any time, however, after device insertion, as a result of transient bacteremia, as this organism has an increased propensity to adhere to foreign body material.^{14,18-20}

Electrode infection appears to develop by one of 2 mechanisms. Most often (over 80% of cases) late-occurring transient bacteremia from the generator or a distant infection site may seed the electrode. The bacteremic source (2/3 of cases) is most often unidentified. The other etiology of electrode infection occurs from direct generator pocket infection.^{14,19}

Septic pulmonary emboli (SPE) may provide evidence of electrode infection.^{18,21} A chest x-ray may demonstrate multiple focal infiltrates or poorly defined lung nodules, but are most often nonspecific in appearance (Fig. 2).²²

By computed tomography (CT), lesions most often appear multiple and nodular. They tend to be located peripherally and cavitate.^{21,23,24} Various stages of cavitation with noted “feeding vessels” is characteristic (Fig. 3).²⁵

TTE and TEE are important imaging modalities for diagnosis of electrode vegetations.^{15,19,20,26-28} Sensitivity of TEE (91%–96%)

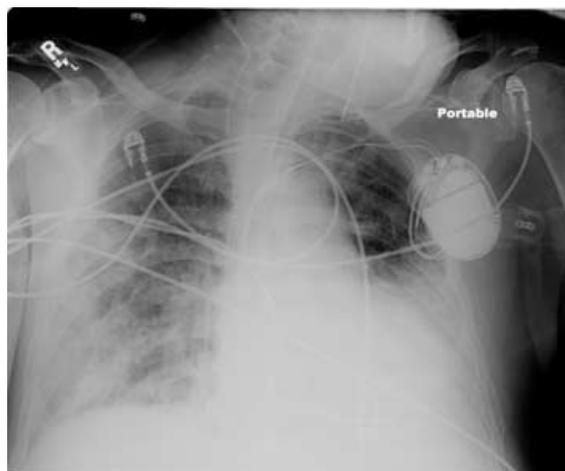


Figure 2. Portable chest x-ray in a patient with septic pulmonary emboli from an ICD implanted over one year before presentation. Bilateral infiltrative processes, suggesting bilateral pneumonia was initially suspected. TEE documented vegetations on ICD electrodes, and blood cultures grew *Staphylococcus aureus*. An ICD device is noted in the left chest and central venous catheter ending in the superior vena cava. An endotracheal tube is also noted.

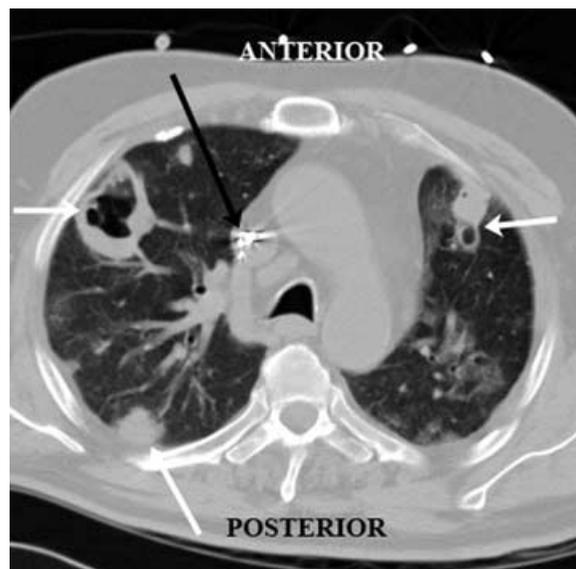


Figure 3. Computed tomography image of the chest (non-contrast) in a patient with *Staphylococcus aureus* septic pulmonary emboli from an ICD electrode. Multiple pulmonary cavitating lesions, consistent with septic emboli are noted (as shown in text). ICD leads are noted within the superior vena cava (black arrow), and septic lesions in the lung parenchyma (white arrows).

is better than TTE (23%–30%) for detection of vegetations.^{5, 14, 19, 26, 28} In addition, the specificity and positive predictive value of TEE appears to be nearly 100%.²⁶

Most often arising from the electrode, vegetations may additionally arise from the tricuspid valve leaflet. Vegetations may be found attached to the electrode within the right atrium or right ventricle, at the level of the atrioventricular plane, or even at the ostium of the coronary sinus.²⁶ More often, however, they will be attached to an electrode within the right atrium.¹⁹ Rarely vegetations have been noted on the tricuspid valve but not electrode. Also, pulmonic valve endocarditis in association with electrode infection has been noted.¹⁹

Vegetations may be single (a single “strip” or round-shaped lesion on a pedicle), or multiple (variably lobular sized or multiple “strips”). They often are of variable echogenicity and may be highly mobile.¹⁹ Two orthogonal imaging planes should be used to characterize lesions as to size, shape, mobility, and texture.^{28, 29}

In distinction to vegetations, noninfected “strands” attached to electrodes are fairly common.^{19, 26} In one study they were noted in 29% of a control group as 1–2 mm in width and 3–5

mm in length. Only noted in the right atrium, no more than 2 were described in a patient.²⁶ Another study noted strands as 1–2 mm in width and up to several centimeters in length.¹⁹ In distinction, however, a pathologic infected long “filament” (3 mm width and 20 mm length) was described, in ~6% of patients with infection.¹⁹

It is generally recommended that once a CDI is diagnosed, the PM/ICD system should be removed. With antibiotic treatment alone, there exists a high rate of recurrent bacteremia and a higher mortality rate (31%–66% mortality vs. 18% with device removal).¹⁴ Even with complete device removal relapse occurs frequently. In addition, when placing a new device at a later date, a new pocket site should be chosen,^{14, 15} but reassessment of the patient may reveal that further device therapy is unneeded.¹⁸

Electrode removal is often performed with specific instruments designed for percutaneous removal. Surgical removal has been reserved for “very large” and “highly mobile” vegetations noted by TEE, or when concomitant valve surgery is necessary.¹⁹

Summarizing points include:

1. CDI may be classified anatomically (generator pocket or electrodes/tricuspid valve) and by time of onset (early, late, delayed).
2. Generator pocket infection may not manifest any abnormality by physical examination (up to 60% of pocket infections). Radionuclide studies may be of some help in localizing a generator pocket infection.
3. *S. aureus* usually is noted with early infection and coagulase-negative *Staphylococcus* often with late infection.
4. Generator pocket infection occurs in 90% and electrode infection in 10% of cases of CDI.
5. About 70% of patients with *S. aureus* bacteremia and a PM/ICD have a CDI.
6. It appears that CDI may develop in a significant number of patients after a bout of *Staphylococcus* bacteremia (29% of patients in one study).
7. Electrode infection appears to develop from a transient bacteremia (>80% late-occurring transient bacteremia) from a generator infection or distant infection site. The bacteremic source is unknown in 2/3 of cases.
8. SPE may provide evidence of electrode infection. Chest x-ray findings are often non-specific, but CT findings are characteristic.

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9. TTE and TEE are important for diagnosis of electrode vegetations. However, TTE sensitivity is <30%, but TEE >90%.
10. Vegetations may be located anywhere attached to an electrode or other structures including the tricuspid and pulmonic valves, or ostium of the coronary sinus. Most often, however, vegetations will be found attached to an electrode within the right atrium.
11. Vegetations may be single or multiple, of variable echogenicity and may be highly mobile. Two orthogonal imaging planes should be used to characterize lesions.
12. Noninfected strands (1–2 mm width and 3–5 mm length) may be common. In one study, strands were found in 29% of a control group, and only in the right atrium. Infected “nontypical” vegetations have been described, however, as filaments of 3 mm width and up to 20 mm length.
13. It appears that once a CDI is diagnosed, the PM/ICD system should be removed.
14. Surgical PM/ICD removal may be reserved for TEE defined “very large” and “highly mobile” vegetations, or when concomitant valve surgery is necessary.

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Supplementary Material

Video Clip 1 Transesophageal echocardiography from the midesophagus revealed highly mobile vegetations attached to leads within the right atrium. **(A)** Longitudinal (90°) and **(B)** 60°.