Pacemaker system infection

A scientific statement from AHA 2010

- Endorsed by HRS의 내용을 중심으로

단국대학교 이명용

Circulation
JOURNAL OF THE AMERICAN HEART ASSOCIATION
American Heart Association®
Learn and Live℠

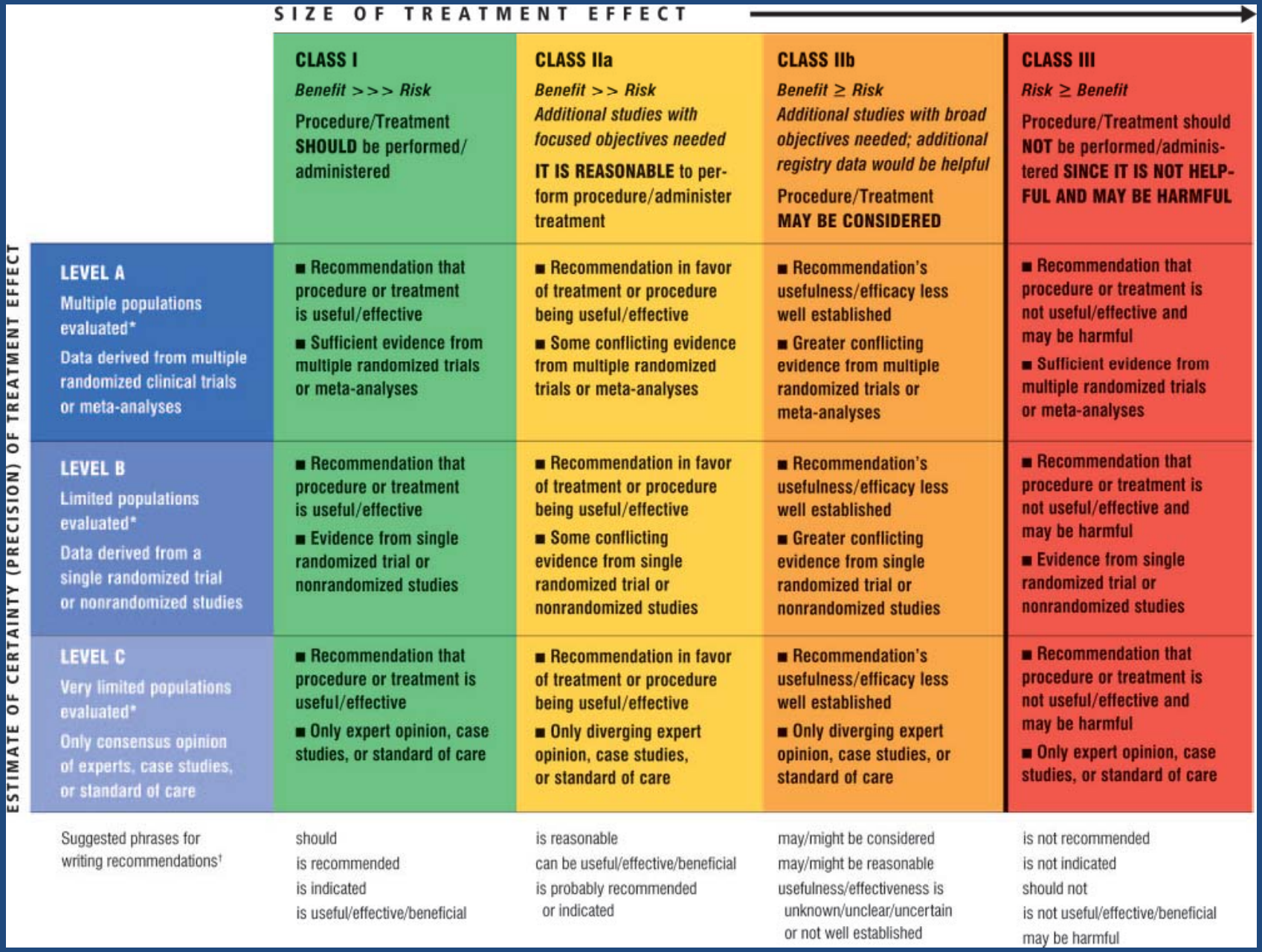
Update on Cardiovascular Implantable Electronic Device Infections and Their Management

A Scientific Statement From the American Heart Association

Endorsed by the Heart Rhythm Society

Larry M. Baddour, MD, FAHA, Chair; Andrew E. Epstein, MD, FAHA, FHRS; Christopher C. Erickson, MD, AHA; Bradley P. Knight, MD, FHRS; Matthew E. Levison, MD; Peter B. Lockhart, DDS; Frederick A. Masoudi, MD, MSPH; Eric J. Okum, MD; Walter R. Wilson, MD; Lee B. Beerman, MD; Ann F. Bolger, MD, FAHA; N.A. Mark Estes III, MD, FAHA, FHRS; Michael Gewitz, MD, FAHA; Jane W. Newburger, MD, MPH, FAHA; Eleanor B. Schron, PhD, RN, FAHA; Kathryn A. Taubert, PhD, FAHA; on behalf of the American Heart Association Rheumatic Fever, Endocarditis, and Kawasaki Disease Committee of the Council on Cardiovascular Disease in the Young; Council on Cardiovascular Surgery and Anesthesia; Council on Cardiovascular Nursing; Council on Clinical Cardiology; and the Interdisciplinary Council on Quality of Care and Outcomes Research

Circulation 2010;121;458-477; originally published online Jan 4, 2010;
DOI: 10.1161/CIRCULATIONAHA.109.192665



Baddour et al. Circulation 2010;121:458-477

Cardiovascular Implantable Electronic Devices (CIED)

- Include non-valvular implantable devices
  - Permanent pacemaker (PPM)
  - Implantable cardioverter-defibrillator (ICD)
  - Cardiac resynchronization systems
- Exclude
  - Implantable loop recorders
- Key massage from the AHA scientific statement in 2003*
  - No prophylactic antibiotics are needed for routine dental, GI and GU procedures

* Baddour LM et al. *Circulation 2003;108:2015-2031*

Use of CIEDs

- implantations in the US between 1997 and 2004[*1]
  - PPM and ICD increased by 19% and 60%
  - 70% of recipients were ≥ 65 years of age
  - ≥ 75% of them had ≥ 1 coexisting illness
  - Dual chamber pacing has become used much more frequently
  - ICD implantation in elderly (70-79) and very elderly (80-89); 20-35% in very elderly patients

- The national hospital discharge survey between 1999 and 2003[*2]
  - 49% increase in PPM and ICD implantation
    - PPM and ICD 180,284 and 57,436
    - Increased 31% and 160%

*1 Chan C et al. *J Gen Intern Med 2007;23(supp I):13-19*
*2 Voigt A et al. *J Am Coll Cardiol 2006;48:590-591*

CIED infections

- In earlier years (PPM)
  - Incidence between 0.13% and 19.9% [*1-2]
  - Most infections are limited to the pocket
  - Frank endocarditis; 10% of CIED infections [*3]
- Fully transvenous ICD
  - Infection incidence was < 7% (1.2-1.8%) [*4]
  - Abdominal vs. pectoral system; 3.2% and 0.5%
- Medicare beneficiaries study 1990-1999 [*5]
  - CIED infections 0.94 → 2.11/1,000 beneficiaries (124% increase)
  - Frank endocarditis 0.26 → 0.39 (50% increase)

*1 Conklin EF et al. *J Thorac Cardiovasc Surg 1975;69:1-7*
*2 Bluhm G et al. *Acta Scand Med suppl 1985;699:1-62*
*3 Arber N et al. *Medicine (Baltimore) 1994;73:299-305*
*4 Mela T et al. Am J Cardiol 2001;88:750-753
*5 Cabell et al. Am Heart J 2004;147:582-586

- Olmsted study 1975-2004 *1
  - 1,524 patients, 7,578 person-times with CIED
  - CIED infection; 1.9/1,000 device-year (95% CI 1.1-3.1)
  - Pocket infection alone; 1.37/1,000 device-year (95% CI 0.62-0.75)
  - ICED related endocarditis; 1.14/1,000 device-year (95% CI 0.47-2.74)
  - Higher in patients with ICD than PPM

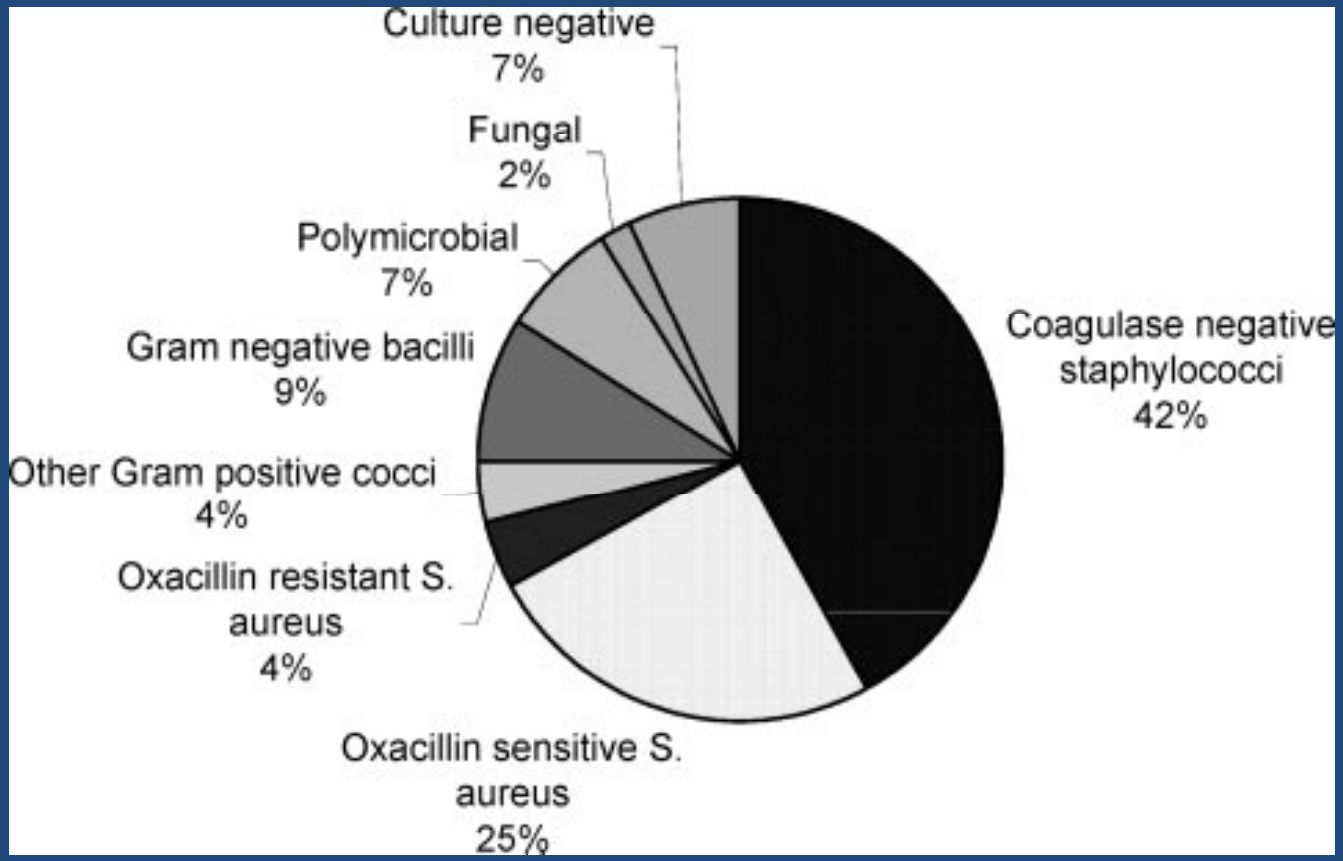
- National hospital discharge survey 1996-2003 *2
  - CIED infections increased 3.1 fold
    - 2.8 fold for PPM
    - 6.0 fold for ICD
  - In-hospital mortality increased by > 2.0 fold

*1 Uslan DZ et al. *Arch Intern Med 2007;1671669-675*
*2 Voigt A et al. *J Am Coll Cardiol 2006;48:590-591*

Risk Factors

- Immunosuppression
  - Renal dysfunction; odd ratio 4.8
  - long-term corticosteroid use; OR 13.9
- Oral anticoagulation
- Coexisting illnesses
  - Fever within 24 hours; OR 5.83
  - Preprocedural temporary pacemaker; OR 2.46
  - Diabetes mellitus and congestive heart failure
- Periprocedural factors
  - Failure to use prophylactic antibiotics; OR 5.83
- Device revision/replacement
  - Early reintervention; OR 15.04
  - First implantation 0.75%, replacement 2.06% and reintervention due to recall 5.8% of major complication
- The amount of indwelling hardware; OR 5.41
- Operator experience
- Microbiology of bloodstream infection
  - *Staphylococcus aureus* bacteremia

Microbiology



* Sohail MR et al. *J Am Coll Cardiol 2007;49:1851-1859*

Pathogenesis; Device Factors

- Plastic polymer
  - More adherence for polyvinyl chloride than Teflon (duPont, Wilmington, Del)
  - Polyethylene > Polyurethane
  - Silicon > Polytetrafluoroethylene
  - Latex > Silicon
- Surface irregularities and shape
- Hydrophobicity

* Darouiche RO. *Clin infect Dis 2001;33:1567-1572*

Pathogenesis; Microbial Factors

- Adherence
  - Directly via fimbria-like surface protein or capsular polysaccharide/adhesin (Coagulase negative Staphylococcus species, CoNS)
  - MSCRAMM; microbial surface components reacting with adherence matrix molecules
- Biofilm formation
  - Polysaccharide intercellular adhesin
  - Phenotypic shift; free-floating organism → biofilm
  - More resistant to antibiotics and host immunity
- Microbial persistence

Pathogenesis; Host Factors

- Renal failure
- Long-term corticosteroid use
- Hematoma formation
- Oral anticoagulation
- DM
- CHF

Diagnosis

- Local changes
  - Local inflammatory changes
  - Erosion with exposure of the generator/leads
- Symptoms
  - Fever ; frequently absent
  - Vague symptoms; malaise, fatigue, anorexia
  - Fever of undefined origin
- Blood cultures; at least 2 sets
  - *S aureus* bacteremia
- Transesophageal echocardiography (TEE)
  - Right-sided and/or left-sided endocarditis
  - Proximal superior vena cava
  - Prognostic features
    - PE, ventricular dysfunction and dyssynchrony, pulmonary hypertension
- Culture of generator pocket-site tissue and electrode tips
  - Gram staining and aerobic and anaerobic cultures
  - Fungus, mycobacterium

Recommendations for Diagnosis of CIED Infection and Associated Complications

Class I

1. All patients should have at least 2 sets of blood cultures drawn at the initial evaluation before prompt initiation of antimicrobial therapy for CIED infection. (*Level of Evidence: C*)
2. Generator-pocket tissue Gram's stain and culture and lead-tip culture should be obtained when the CIED is explanted. (*Level of Evidence: C*)
3. Patients with suspected CIED infection who either have positive blood cultures or who have negative blood cultures but have had recent antimicrobial therapy before blood cultures were obtained should undergo TEE for CIED infection or valvular endocarditis. (*Level of Evidence: C*)
4. All adults suspected of having CIED-related endocarditis should undergo TEE to evaluate the left-sided heart valves, even if transthoracic views have demonstrated lead-adherent masses. In pediatric patients with good views, transthoracic echocardiography may be sufficient. (*Level of Evidence: B*)

Class IIa

1. Patients should seek evaluation for CIED infection by cardiologists or infectious disease specialists if they develop fever or bloodstream infection for which there is no initial explanation. (*Level of Evidence: C*)

Class III

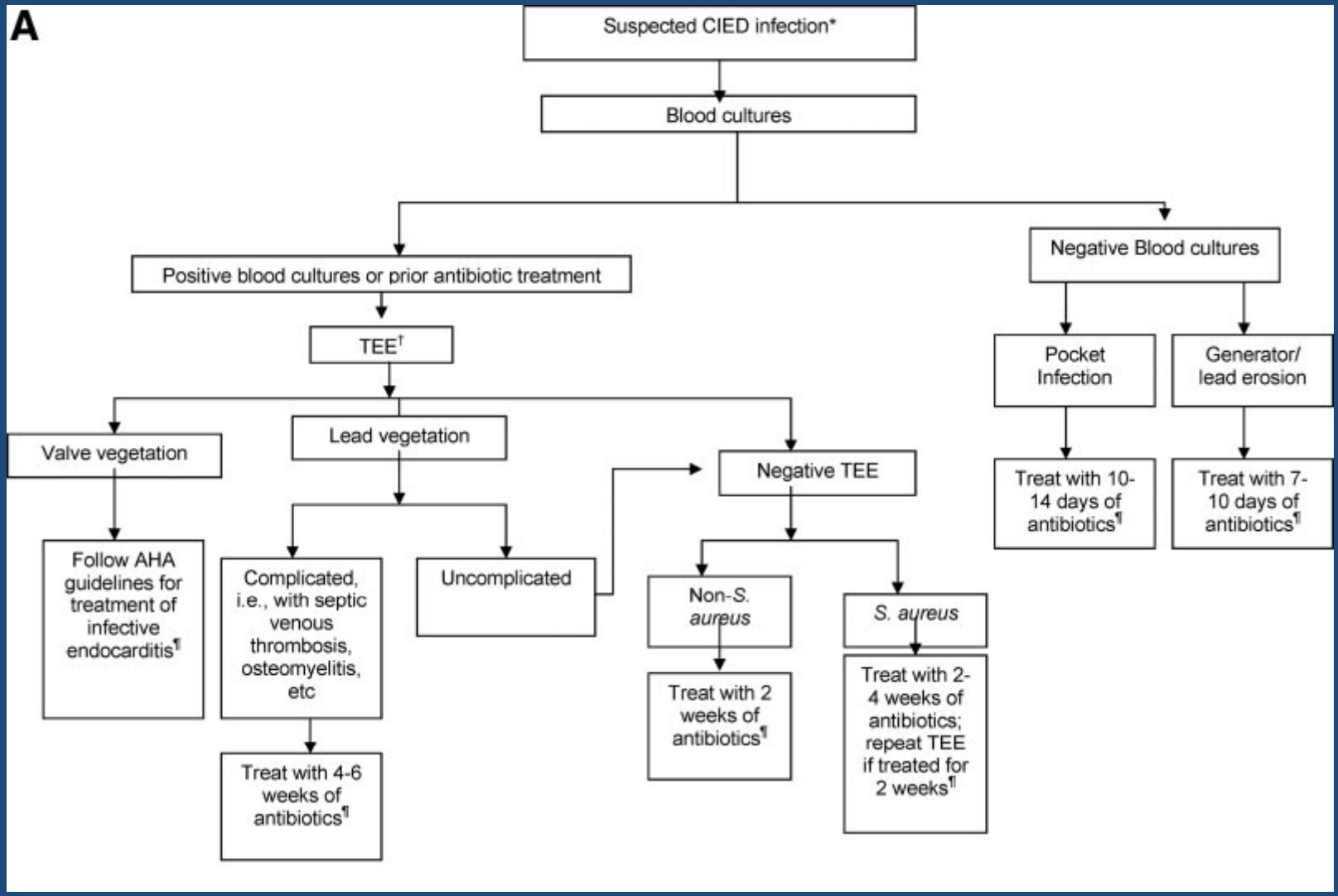
1. Percutaneous aspiration of the generator pocket should not be performed as part of the diagnostic evaluation of CIED infection. (*Level of Evidence: C*)

Management

- Superficial or incisional infection
  - CIED removal is not required
  - Oral antibiotics (against staphylococci) for 7-10 days
- Established CIED infection
  - Complete removal of all hardware
  - Includes localized pocket infection
  - Regardless of location of infection

- Antimicrobial therapy
  - Empiric vancomycin
  - Oxacillin-sensitive staphylococcus; cefazolin or nafcillin alone after discontinuation of vancomycin
  - Oxacillin-resistant staphylococcus; continue vancomycin
  - Optimal duration; no clinical study
    - Limited to pocket site with erosion; 7-10 days after removal
    - Limited pocket site, otherwise; 10-14 days
    - Blood stream infection; at least 14 days
    - Positive blood culture after removal; at least 4 weeks even if another TEE is negative for vegetations
- Timing for a new device? Appropriate generator-capsule debridement? Device removal with remaining lead remnants

- Blood stream infection without sign of CIED infection?
  - Relapsing bacteremia after a course of appropriate antibiotic therapy
  - No other source for bacteremia
  - Bacteremia persist > 24 hours
  - CIED is ICD
  - Prosthetic cardiac valve(s)
  - Bacteremia < 3 months of CIED implantation



* Sohail MR et al. *J Am Coll Cardiol 2007;49:1851-1859*

Recommendations for Antimicrobial Management of CIED Infection

Class I

1. Choice of antimicrobial therapy should be based on the identification and in vitro susceptibility results of the infecting pathogen. (*Level of Evidence: B)*
2. Duration of antimicrobial therapy should be 10 to 14 days after CIED removal for pocket-site infection. (*Level of Evidence: C)*
3. Duration of antimicrobial therapy should be at least 14 days after CIED removal for bloodstream infection. (*Level of Evidence: C)*
4. Duration of antimicrobial therapy should be at least 4 to 6 weeks for complicated infection (ie, endocarditis, septic thrombophlebitis, or osteomyelitis or if bloodstream infection persists despite device removal and appropriate initial antimicrobial therapy. (*Level of Evidence: C)*

Recommendations for Removal of Infected CIED

Class I

1. Complete device and lead removal is recommended for all patients with definite CIED infection, as evidenced by valvular and/or lead endocarditis or sepsis. (*Level of Evidence: A)*
2. Complete device and lead removal is recommended for all patients with CIED pocket infection as evidenced by abscess formation, device erosion, skin adherence, or chronic draining sinus without clinically evident involvement of the transvenous portion of the lead system. (*Level of Evidence: B)*
3. Complete device and lead removal is recommended for all patients with valvular endocarditis without definite involvement of the lead(s) and/or device. (*Level of Evidence: B)*
4. Complete device and lead removal is recommended for patients with occult staphylococcal bacteremia. (*Level of Evidence: B)*

Class IIa

1. Complete device and lead removal is reasonable in patients with persistent occult Gram-negative bacteremia despite appropriate antibiotic therapy. (*Level of Evidence: B)*

Class III

1. CIED removal is not indicated for a superficial or incisional infection without involvement of the device and/or leads. (*Level of Evidence: C)*
2. CIED removal is not indicated for relapsing bloodstream infection due to a source other than a CIED and for which long-term suppressive antimicrobials are required. (*Level of Evidence: C)*

New Device Implantation

- Careful assessment of need for a new CIED
  - 1/3 to ½ of patients will not require a new CIED
  - assessment before the removal of infected CIED in pacemaker-dependent patients
  - Temporary pacemaker with active fixation leads

- Optimal timing?
  - A 1 stage simultaneous contralateral replacement [*1]
  - 24 hours after removal
  - Sohail et al [*2]
    - 7 days for non-bacteremia, 13 days for bacteremia patients
    - 7 days for CoNS vs. 12 days for S aureus infection
  - Negative blood culture for at least for 72 hours

*1 Nandyala R et al. *Pacing Clin Electrophysiol* 2006;29:393-396
*2 Sohail MR et al. *J Am Coll Cardiol 2007;49:1851-1859*

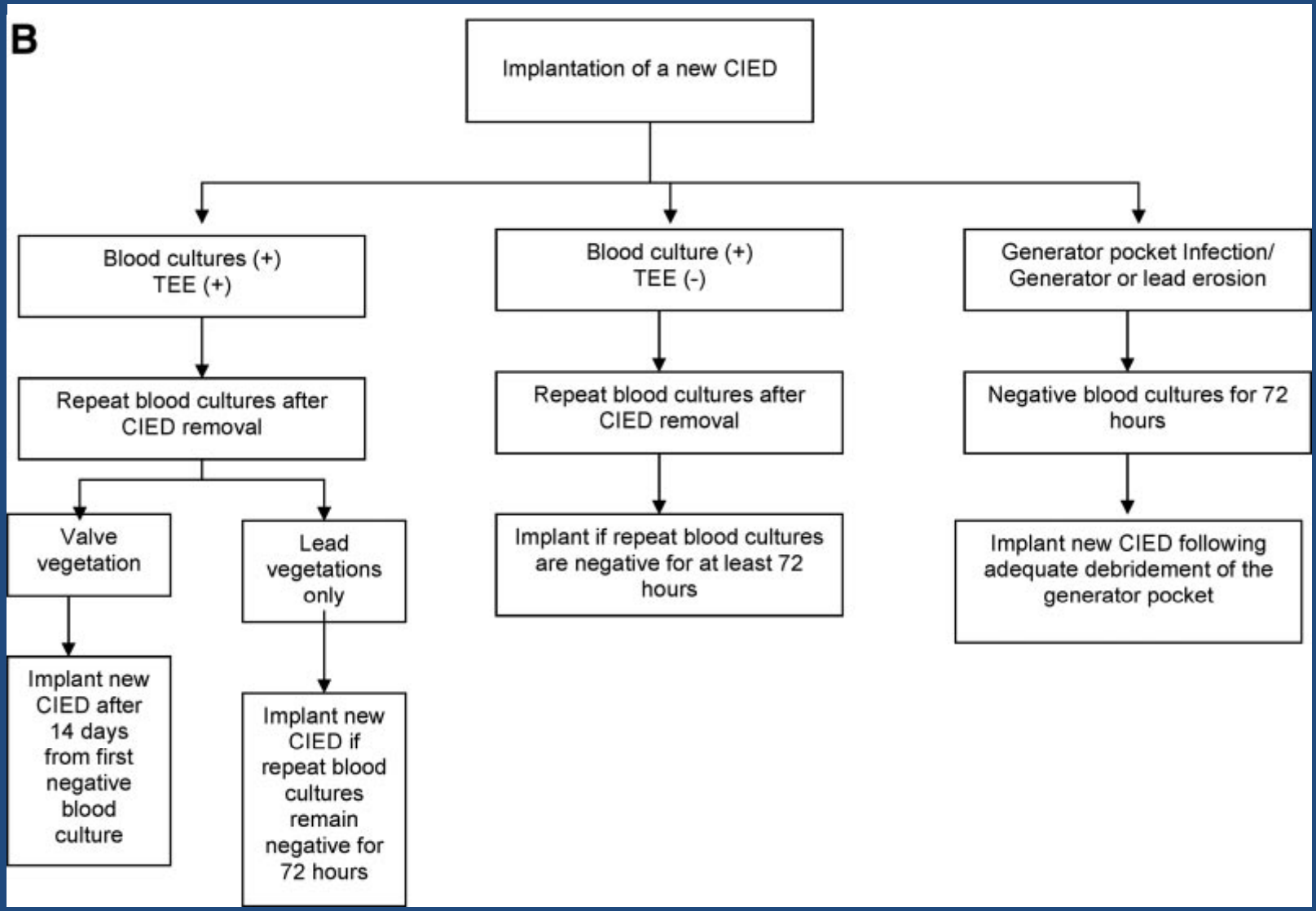
Recommendations for New CIED Implantation After Removal of an Infected CIED

Class I

1. Each patient should be evaluated carefully to determine whether there is a continued need for a new CIED. (*Level of Evidence: C)*
2. The replacement device implantation should not be ipsilateral to the extraction site. Preferred alternative locations include the contralateral side, the iliac vein, and epicardial implantation. (*Level of Evidence: C)*

Class IIa

1. When positive before extraction, blood cultures should be drawn after device removal and should be negative for at least 72 hours before new device placement is performed. (*Level of Evidence: C)*
2. New transvenous lead placement should be delayed for at least 14 days after CIED system removal when there is evidence of valvular infection. (*Level of Evidence: C)*



* Sohail MR et al. *J Am Coll Cardiol 2007;49:1851-1859*

Long-term Suppressive Antimicrobial Therapy

- Usually not indicated
- If the patients are not candidate for complete removal (limited life expectancy or refuse CIED removal)
  - Stable cardiovascular status
  - Clinical improvement with initial antimicrobial therapy
  - Clearance of bloodstream infection
- Relapse rate; unknown

Recommendations for Use of Long-Term Suppressive Antimicrobial Therapy

Class IIb

1. Long-term suppressive therapy should be considered for patients who have CIED infection and who are not candidates for complete device removal. (*Level of Evidence: C)*

Class III

1. Long-term suppressive therapy should not be administered to patients who are candidates for infected CIED removal. (*Level of Evidence: C)*

Complications of CIED Infection

- Contiguous complications
  - Chest wall abscess, septic thrombophlebitis, right-sided endocarditis
- Remote complications
  - Skeletal; local (clavicular osteomyelitis and sternoclavicular arthritis) and remote (metastatic osteomyelitis, discitis and septic arthritis)
  - Cardiopulmonary; septic pulmonary embolism, mycotic aneurysm, left-sided endocarditis
- Metastatic
  - Sepsis, soft tissue/organ/muscle abscess

Outcomes

- Higher mortality in patients with CIED endocarditis without device removal
- All-cause mortality; 18%
- Risk factors
  - Systemic embolization
  - Moderate to severe tricuspid regurgitation
  - Abnormal right ventricular function
  - Abnormal renal function

* Baman TS et al. *Circ Arrhythm Electrophysiol* 2009;2:129-134

Prevention

- No clinical sign of infection before CIED implantation
- Prophylactic antibiotics
  - 1st generation cephalosporin (cefazolin) 1 hour before the procedure
  - Vancomycin 90-120 minutes before the procedure
- Antiseptic preparation of the skin, sterile technique
- Avoid hematoma
  - Cautery and topical thrombin
  - Packing the pocket with antibiotic-soaked sponges
- Irrigation of the pocket with antibiotic-containing solution
- Monofilament suture
- Pressure dressing
- Early follow-up and patient education

Recommendations for Antimicrobial prophylaxis at the Time of CIED Placement

Class I

1. Prophylaxis with an antibiotic that has in vitro activity against staphylococci should be administered. If cefazolin is selected for use, then it should be administered intravenously within 1 hour before incision; if vancomycin is given, then it should be administered intravenously within 2 hours before incision. (*Level of Evidence: A)*

Antibiotic Prophylaxis for Invasive procedures

- There is no case of hematologic infection from dental, GI or GU procedure since 1950

Recommendations for Antimicrobial Prophylaxis for Invasive Procedures in Patients With CIEDs

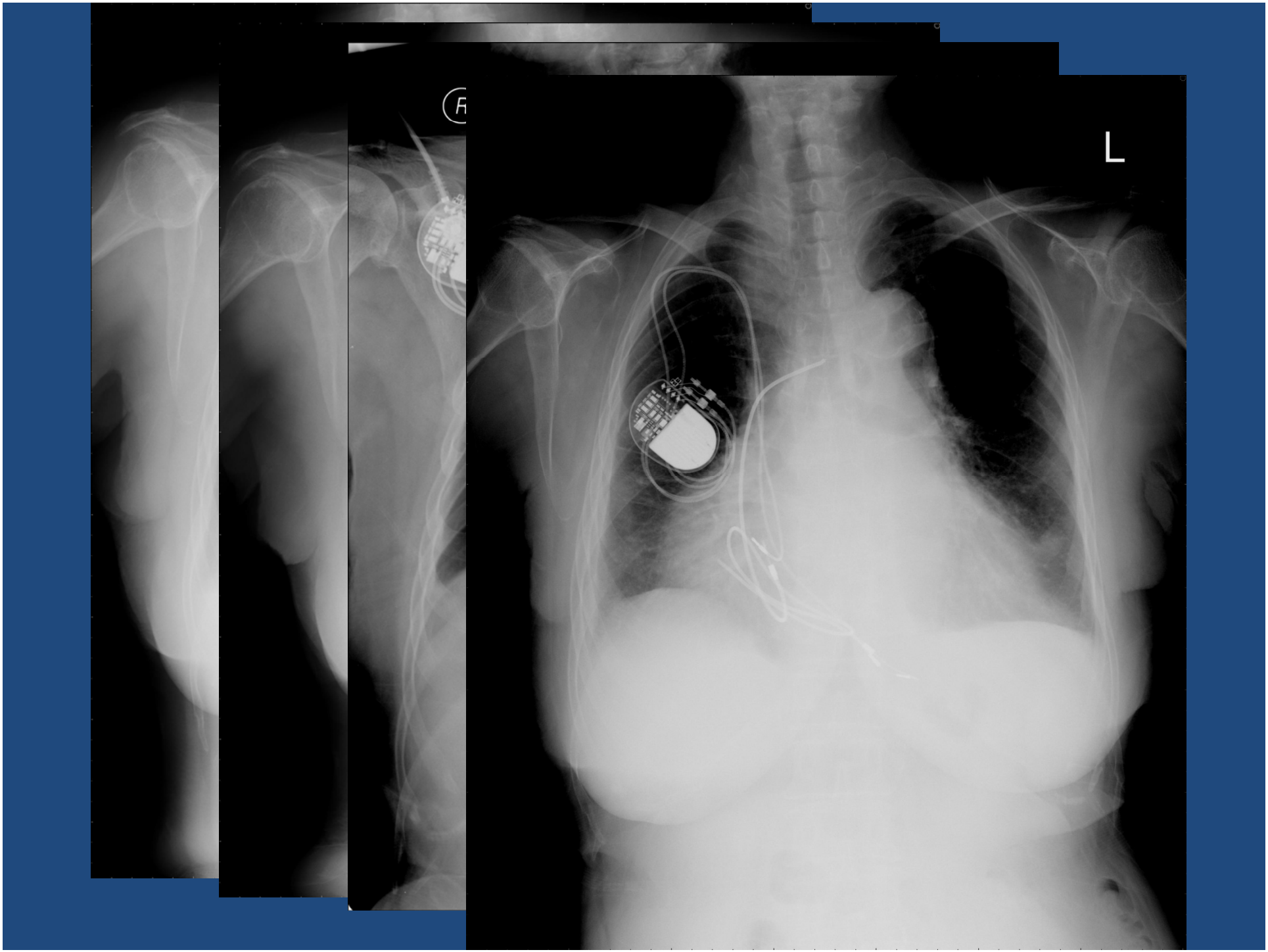
Class III

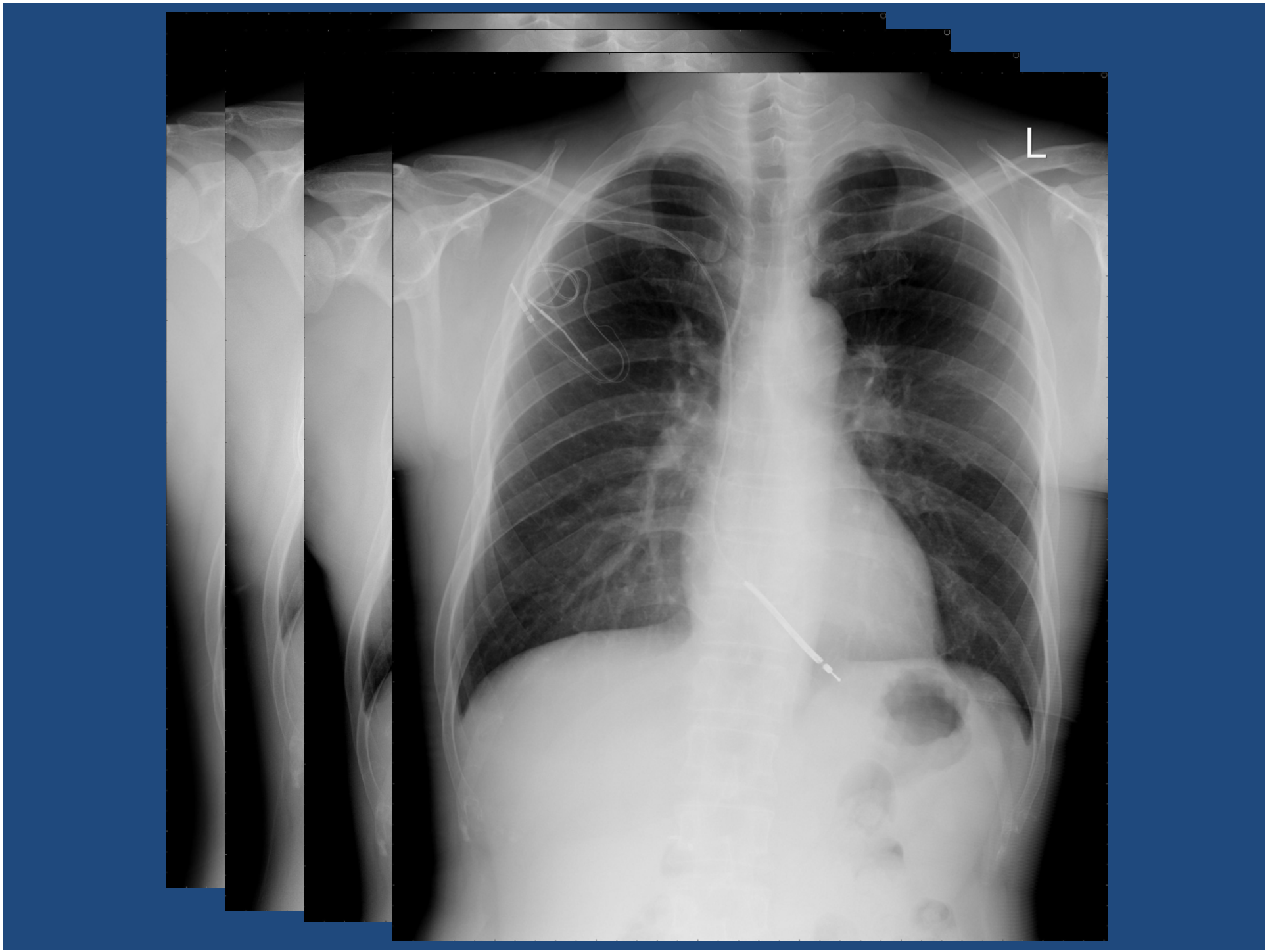
1. Antimicrobial prophylaxis is not recommended for dental or other invasive procedures not directly related to device manipulation to prevent CIED infection. (*Level of Evidence: C*)

Emerging Technology

- Biological pacemaker [*1-2]
  - Biologic tissue that can be implanted in the heart
- Gene and cell transfer therapy
  - Restore myocardial function
  - Inhibit ventricular arrhythmias
  - ↓ Need for ICD
- Totally subcutaneous ICD
- A leadless pacing system

*1 Rosen MR et al. *J Interv Card Electrophysiol* 2008;22:87-98
*2 Gepstein L. *Ann N Y Acad Sci* 2008;1123:224-231


L


L