The Importance of Echocardiography in Specific Settings:

In the study of Endocarditis in Implanted Cardiac Devices

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Disclosures

• No conflicts of interest
Overview

• Role of echocardiography in evaluation and management of patients with device related infection / endocarditis
## Major Criteria for IE Diagnosis

<table>
<thead>
<tr>
<th>Major criteria</th>
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<tbody>
<tr>
<td><strong>1. Blood cultures positive for IE</strong></td>
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<tr>
<td>a. Typical microorganisms consistent with IE from 2 separate blood cultures:</td>
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<tr>
<td>• <em>Viridans streptococci</em>, <em>Streptococcus galolyticus</em> (<em>Streptococcus bovis</em>), HACEK group, <em>Staphylococcus aureus</em>; or</td>
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<tr>
<td>• Community-acquired enterococci, in the absence of a primary focus; or</td>
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<tr>
<td>b. Microorganisms consistent with IE from persistently positive blood cultures:</td>
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<td>• ≥2 positive blood cultures of blood samples drawn &gt;12 h apart; or</td>
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<tr>
<td>• All of 3 or a majority of ≥4 separate cultures of blood (with first and last samples drawn ≥1 h apart); or</td>
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<tr>
<td>c. Single positive blood culture for <em>Coxiella burnetii</em> or phase 1 IgG antibody titre &gt;1:800</td>
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<td><strong>2. Imaging positive for IE</strong></td>
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<tr>
<td>a. Echocardiogram positive for IE:</td>
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<tr>
<td>• Vegetation;</td>
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<tr>
<td>• Abscess, pseudoaneurysm, intracardiac fistula;</td>
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<tr>
<td>• Valvular perforation or aneurysm;</td>
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<tr>
<td>• New partial dehiscence of prosthetic valve.</td>
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<tr>
<td>b. Abnormal activity around the site of prosthetic valve implantation detected by ¹⁸F-FDG PET/CT (only if the prosthesis was implanted for &gt;3 months) or radiolabelled leukocytes SPECT/CT.</td>
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<td>c. Definite paravalvular lesions by cardiac CT.</td>
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</tbody>
</table>
**Minor Criteria for IE Diagnosis**

<table>
<thead>
<tr>
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</thead>
<tbody>
<tr>
<td>1. Predisposition such as predisposing heart condition, or injection drug use.</td>
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<tr>
<td>2. Fever defined as temperature $&gt;38^\circ\text{C}$.</td>
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<tr>
<td>3. Vascular phenomena (including those detected by imaging only): major arterial emboli, septic pulmonary infarcts, infectious (mycotic) aneurysm, intracranial haemorrhage, conjunctival haemorrhages, and Janeway’s lesions.</td>
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<tr>
<td>4. Immunological phenomena: glomerulonephritis, Osler’s nodes, Roth’s spots, and rheumatoid factor.</td>
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<tr>
<td>5. Microbiological evidence: positive blood culture but does not meet a major criterion as noted above or serological evidence of active infection with organism consistent with IE.</td>
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</tbody>
</table>
**Definition of infective endocarditis according to the modified Duke criteria**

**Definite IE**

**Pathological criteria**
- Microorganisms demonstrated by culture or on histological examination of a vegetation, a vegetation that has embolized, or an intracardiac abscess specimen; or
- Pathological lesions; vegetation or intracardiac abscess confirmed by histological examination showing active endocarditis

**Clinical criteria**
- 2 major criteria; or
- 1 major criterion and 3 minor criteria; or
- 5 minor criteria

**Possible IE**
- 1 major criterion and 1 minor criterion; or
- 3 minor criteria

**Rejected IE**
- Firm alternate diagnosis; or
- Resolution of symptoms suggesting IE with antibiotic therapy for \( \leq 4 \) days; or
- No pathological evidence of IE at surgery or autopsy, with antibiotic therapy for \( \leq 4 \) days; or
- Does not meet criteria for possible IE, as above

Echocardiography in Infective Endocarditis

- Diagnosis / Prognosis / Risk of embolization
- Follow up during treatment
- Identify surgical indications
- Intraoperative reevaluation
- Follow up after treatment
Echo Features of Endocarditis

Vegetation

• Infected mass attached to an endocardial structure or on implanted intracardiac material

• Oscilating intracardiac mass on valve or other endocardial structure or implanted material
3-D Enhances Visualization and Sizing of Vegetations

Circ Cardiovasc Imaging. 2014;7:149-154
Echo Features of Endocarditis

**Abscess**

- Perivalvular cavity with necrosis and purulent material not communicating with the cardiovascular lumen.
- Thickened, not homogeneous perivalvular area with echodense or echolucent appearance.
Echo Features of Endocarditis

Pseudoaneurysm

- Perivalvular cavity communicating with the cardiovascular lumen
- Pulsatile perivalvular echo-free space, with colour-Doppler detected.
Echo Features of Endocarditis

Perforation / fistula

• Communication between two neighbouring cavities through a perforation.
• Colour-Doppler communication between two neighbouring cavities through a perforation.
Echo Features of Endocarditis

**Dehiscence** of a prosthetic valve
- Paravalvular regurgitation by TTE/TOE, with or without rocking motion of the prosthesis.
Implantable cardiac devices

- Pacemakers
- Implantable cardioverter defibrillators
  - Surgical prosthetic valves
  - Transcatheter heart valves
  - Mitraclips
- Devices used in congenital heart diseases
- Newer devices e.g. atrial appendage closure
Infection of Cardiac Implantable Electronic Devices (pacemaker systems)

• Over 4.2 million implantations in US 1993-2008
• Incidence of infection 1.9/1000 device-years
• Higher incidence with defibrillators vs. pacemakers
• Infection ➔ Severe disease with significant associated morbidity / mortality
  – Comorbidities, age, need for pacemaker system
• Prompt diagnosis and management critical for improved survival
Infection of Cardiac Implantable Electronic Devices (pacemaker systems)

- Local (pocket only)

- Deeper infection
  - Leads
  - Tricuspid valve leaflets
  - Endocardial surface of right atrium / ventricle (mural endocarditis)
  - Other valve involvement

⇒ Device related endocarditis
Clinical Characteristics and Outcome of Infective Endocarditis Involving Implantable Cardiac Devices

• N=177 patients with cardiac device endocarditis
• Coexisting valve involvement in (n=66) 37.3%
  – Most common the tricuspid valve
• Significant in hospital and 1-year mortality

JAMA. 2012;307(16):1727-1735
Role of Echocardiography in Device Related Endocarditis

Diagnosis

• Identify vegetations on leads
  – Always transthoracic, but transesophageal more sensitive
  – Sizing of vegetations
• Tricuspid valve involvement
  – Degree of regurgitation
Pacemaker lead infection: echocardiographic features, management, and outcome

F Victor, C De Place, C Camus, H Le Breton, C Leclercq, D Pavin, P Mabo, C Daubert

Multiple lobulated with pedicles
Single round shaped
Thick flat stripes

Heart 1999;81:82–87
Role of Echocardiography in Device Related Endocarditis

Diagnosis

• Identify vegetations on leads
• Always transthoracic, but transesophageal more sensitive

• Intracardiac echo even more sensitive than TEE
  – But invasive, costly, limited expertise
Usefulness of Intracardiac Echocardiography for the Diagnosis of Cardiovascular Implantable Electronic Device–Related Endocarditis

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Pasquale Santangeli, MD,‡∥ Rosalinda Palmieri, MD,* Christian Lauria, MS,*
Ghaliah Al Mohani, MD,* Francesca Di Clemente, MD,* Claudio Tondo, MD, PhD,†
Faustino Pennestri, MD,* Carolina Ierardi, MD,* Antonio G. Rebuzzi, MD,* Filippo Crea, MD,*
Fulvio Bellocci, MD,* Andrea Natale, MD,‡§ Antonio Dello Russo, MD, PhD†

Rome, Milan, and Foggia, Italy; and Austin, Texas

- N=152 patients with infection, possibly device related, referred for lead extraction

JACC Vol. 61, No. 13, 2013; 1398–405
Intracardiac Echo (ICE) increases diagnosis of lead related masses

- In those with **high clinical suspicion** (n=44) ICE identified masses on the leads in all patients vs. only in 73% for TEE
- In those with moderate suspicion (n=52) ICE identified 8 patients (15%) with masses on the leads when TEE was negative
- In those with low suspicion (n=56) no significant difference between TEE and ICE in detection of abnormal findings
Intracardiac Echo

Transesophageal Imaging

Intracardiac Imaging

JACC Vol. 61, No. 13, 2013; 1398–405
Important Considerations

- Not all masses on leads diagnostic of endocarditis...
- Biofilm on leads may harbor bacteria without evident masses...
- Clinical judgment (e.g. persistent fevers, blood culture results) to determine if cardiac implantable device needs to be extracted
Incidence and prognosis of pacemaker lead associated masses: a study of 1,569 transesophageal echocardiograms.

- N=125 patients with pacemaker or ICD leads in right atrium
  - 15 with echogenic masses on the leads
    - 9 with clinically suspected lead endocarditis
    - 6 with incidental finding of mass (5%)
- Benign clinical course in those with incidentally found masses on the lead

J Invas Cardiol 2006;18:599–601
Cardiac Device Related Endocarditis

- Microbiologic data critical
- Imaging with TTE → TEE → ICE
- SPECT / PET scanning for evidence of inflammation
Cardiac Implantable Electronic Device Infection → System Removal

- Percutaneous extraction in most patients
- If vegetations on leads >20mm and / or severe tricuspid IE → surgical consideration
Implantable cardiac devices

- Pacemakers
- Implantable cardioverter defibrillators
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Prosthetic Valve Endocarditis (PVE)

- Most severe form of infectious endocarditis
- Incidence 0.3-1.2% per patient-year
- PVE accounts for 10-30% of all endocarditis
  - Mechanical / Bioprosthetic affected equally
- Classified as
  - Early <60 days
  - Intermediate 60-365 days
  - Late >365 day
PVE Pathogenesis and Echo Findings

• *Perioperative* contamination, infection involves the junction between sewing ring and annulus ➔ Perivalvular abscess, dehiscence, pseudoaneurysms, fistulae

• *Late PVE*, infection at the leaflets of prosthesis ➔ vegetations, cusp rupture, perforation

New regurgitation most commonly, less likely stenosis due to large vegetation
Clinical suspicion of IE

TTE

- Prosthetic valve
  - Intracardiac device
- Non-diagnosis
- Positive
- Negative

TOE

If initial TOE is negative but high suspicion for IE remains, repeat TTE and/or TOE within 5–7 days

IE = infective endocarditis; TOE = transoesophageal echocardiography; TTE = transthoracic echocardiography.

*TOE is not mandatory in isolated right-sided native valve IE with good quality TTE examination and unequivocal echocardiographic findings.
Role of Echocardiography in Prosthetic Valve Endocarditis (PVE): Diagnosis

• Identify perivalvular complications
  – Anatomic (perforation, abscess, dehiscence)
  – Hemodynamic (regurgitation, fistulae)
• More challenging due to acoustic shadowing
  – TEE overcomes this to some degree
• Negative TEE does not exclude PVE
  – Need to repeat in 7-10 days
Role of Echocardiography in Prosthetic Valve Endocarditis (PVE): Follow up

- Echo re-evaluation if change in clinical status (new murmur, embolism, fever, AV block, worsening heart failure)
- Severe valve dysfunction
- Perivalvular complications
- Risk of embolization (if large size, or if prior embolic event)
Role of Echocardiography in Prosthetic Valve Endocarditis (PVE): Intraoperative

- Final reassessment of condition for any changes
- Evaluate result of surgical intervention
Examples of TAVR prosthetic valve endocarditis
Endocarditis in TAVR (I)

- 84 year old male
- Sapien XT 26mm for severe aortic stenosis
- Uneventful procedure
Endocarditis in TAVR (I)

- 84 year old male
- Sapien XT 26mm for severe aortic stenosis
- Uneventful procedure

- 4 months later...
- Fever and bacteremia with Staph. Epidermidis
- TEE
Endocarditis in TAVR (I)

- 84 year old male
- Sapien XT 26mm for severe aortic stenosis
- Uneventful procedure
- 4 months later...
- Fever and bacteremia with Staph. Epidermidis
- TTE
Early Prosthetic Valve Endocarditis in TAVR
Early Prosthetic Valve Endocarditis in TAVR

Rx with prolonged course of iv antibiotics and po suppressive therapy, clinically well at the 18-month follow up
Endocarditis and TAVR (II)

- 84 year-old male
- Difficult CoreValve 29mm implantation requiring extensive handling of the device
- Final successful, with PAR 2+
- At 80 days... Staph. Epidermidis bacteremia /sepsis
- TEE no vegetations
- Rx with iv antibiotics for early PVE
- Stable at the 12 month f/up

J INVASIVE CARDIOL 2011;23(12):E291-E292
Role of Echocardiography in Prosthetic Valve Endocarditis (PVE): Long term follow up

• Reassess presence / significance of any paraprosthetic leaks after surgical therapy
  – (often friable tissues and with difficulty in suturing the new valve in place)
  – If this occurs, and patient is symptomatic, then consider catheter based closure of leaks
Echocardiography Following Surgical Treatment of Prosthetic Valve Endocarditis: Significant Leak

- 75 male
- sAVR in 2012
- Endocarditis 15 months later with root abscess
- Redo sAVR → ATS 24
- **Follow up echo:** Significant paravalvular AR
- Rx with closure device
Closure of Paraprosthetic Leak

Baseline significant PVL

After closure with AVP II 10x7
In Summary

• Endocarditis due to infection of implantable cardiac devices is a serious complication
• Echocardiography is essential in early diagnosis, disease monitoring, complication assessment, guidance during surgery and long term follow up
• Important to have an “Endocarditis Team” to manage these often high risk patients
Ευχαριστώ!
Echocardiography in Suspected IE

- Patient at Risk or With Suspected NVE or PVE
  - Blood cultures × 2
    - TTE

- Non-diagnostic TTE
- Complications present or suspected
- Intracardiac lead present
- S. aureus bacteremia without known source
- Prosthetic valve with persistent fever
- Suspected paravalvular infection with inadequate TTE/TEE
- Nosocomial S. aureus bacteremia with portal of entry from known extra cardiac source
- Undergoing surgery for IE

- TEE* (I)
- TEE (IIa)
- Cardiac CT (IIa)
- TEE (IIb)
- Intraoperative TEE (I)
Role of Echocardiography in Infective Endocarditis

<table>
<thead>
<tr>
<th>Recommendations: echocardiography</th>
<th>Class</th>
<th>Level</th>
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<tbody>
<tr>
<td>A. Diagnosis</td>
<td></td>
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<tr>
<td>• TTE is recommended as the first-line imaging modality in suspected IE</td>
<td>I</td>
<td>B</td>
</tr>
<tr>
<td>• TEE is recommended in patients with high clinical suspicion of IE and a normal TTE</td>
<td>I</td>
<td>B</td>
</tr>
<tr>
<td>• Repeat TTE/TEE within 7–10 days are recommended in the case of an initially negative examination when clinical suspicion of IE remains high</td>
<td>I</td>
<td>B</td>
</tr>
<tr>
<td>• TEE should be considered in the majority of adult patients with suspected IE, even in cases with positive TTE, owing to its better sensitivity and specificity, particularly for the diagnosis of abscesses and measurement of vegetation size</td>
<td>IIa</td>
<td>C</td>
</tr>
<tr>
<td>• TEE is not indicated in patients with a good-quality negative TTE and a low clinical suspicion of IE</td>
<td>III</td>
<td>C</td>
</tr>
<tr>
<td>B. Follow-up under medical therapy</td>
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<tr>
<td>• Repeat TTE and TEE are recommended as soon as a new complication of IE is suspected (new murmur, embolism, persistent fever, heart failure, abscess, atrioventricular block)</td>
<td>I</td>
<td>B</td>
</tr>
<tr>
<td>• Repeat TTE and TEE should be considered during follow-up of uncomplicated IE, in order to detect new silent complication and monitor vegetation size. The timing and mode (TTE or TEE) of repeat examination depend on the initial findings, type of microorganism, and initial response to therapy</td>
<td>IIa</td>
<td>B</td>
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<tr>
<td>C. Intraoperative echocardiography</td>
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<tr>
<td>• Intraoperative echocardiography is recommended in all cases of IE requiring surgery</td>
<td>I</td>
<td>C</td>
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<tr>
<td>D. Following completion of therapy</td>
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<tr>
<td>• TTE is recommended at completion of antibiotic therapy for evaluation of cardiac and valve morphology and function</td>
<td>I</td>
<td>C</td>
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Adapted from Habib et al. [5]

TEE: transesophageal echocardiography, TTE: transthoracic echocardiography

Class of recommendation

Level of evidence