Infective Endocarditis
Role of Echocardiography in Diagnosis and Management

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DISCLOSURES

Relevant Financial Relationship(s)
None

Off Label Usage
None
Infective Endocarditis

Diagnosis

Major Duke Criteria

- Positive blood cultures
- Evidence of endocardial involvement

## Infective Endocarditis: Microbiology

<table>
<thead>
<tr>
<th>Organism</th>
<th>Native valve</th>
<th>Prosthetic valve</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Community-acquired IE; %, (n = 1,201)</td>
<td>Healthcare-associated IE; %, (n = 370)</td>
</tr>
<tr>
<td>Staphylococcus aureus</td>
<td>21</td>
<td>45</td>
</tr>
<tr>
<td>Coagulase-negative staphylococci</td>
<td>6</td>
<td>12</td>
</tr>
<tr>
<td>Enterococcus</td>
<td>10</td>
<td>14</td>
</tr>
<tr>
<td>Viridans streptococci</td>
<td>26</td>
<td>10</td>
</tr>
<tr>
<td>Streptococcus bovis</td>
<td>10</td>
<td>3</td>
</tr>
<tr>
<td>HACEK</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>Fungi</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Other</td>
<td>13</td>
<td>7</td>
</tr>
<tr>
<td>Negative blood culture</td>
<td>11</td>
<td>7</td>
</tr>
</tbody>
</table>

Data obtained from Murdoch et al. (1), Benito et al. (11), Hill et al. (20,23) Wang et al. (21), and Lopez et al. (22).
Infective Endocarditis

Major Duke Criteria: Endocardial Involvement

Positive Echo for IE (Vegetation)

Oscillating intracardiac mass, without alternative anatomic explanation, involving:

- Valve
- Support structure
- Prosthetic/implanted device
- Path of regurgitant jet

Infective Endocarditis

Major Duke Criteria: Echocardiography

• Vegetation
• Peri-valvular abscess
• New partial dehiscence of prosthetic valve, or new regurgitation

Infective Endocarditis

Minor Duke Criteria:

1. Predisposing cardiac conditions
2. IV drug abuse (also #1 cause for recurrent IE)
3. Fever $\geq 38.0^\circ$C; persistent, and otherwise unexplained
4. Blood culture positivity (Not meeting major criteria)

Conditions Predisposing to Infective Endocarditis

Otto CM: Valvular Heart Disease, 2011
Infective Endocarditis

Minor Duke Criteria:

5. Vascular Phenomena

• Conjunctival hemorrhage
• Janeway lesions
• Systemic arterial embolism
• Pulmonary embolism / infarction
• Mycotic aneurysm
• Intracranial hemorrhage

Infective Endocarditis

Minor Duke Criteria:

6. Immunologic Phenomena

- Diffuse glomerulonephritis
- Osler’s nodes
- Roth spots
- Rheumatoid factor +

# Infective Endocarditis

## Physical Exam

<table>
<thead>
<tr>
<th>Condition</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fever</td>
<td>80 - 90%</td>
</tr>
<tr>
<td>Murmur</td>
<td>70 - 80%</td>
</tr>
<tr>
<td>New or changing murmur</td>
<td>10 - 40%</td>
</tr>
<tr>
<td>Splenomegaly</td>
<td>10 - 40%</td>
</tr>
<tr>
<td>Neurologic deficit</td>
<td>20 - 30%</td>
</tr>
<tr>
<td>Peripheral stigmata of IE</td>
<td>&lt;5 - 10%</td>
</tr>
</tbody>
</table>
  (Osler’s nodes, Janeway lesions, splinter hemorrhages, Roth spots)

Infective Endocarditis

Definite Diagnosis by Duke Criteria

- 2 Major
- 1 Major + 3 Minor
- 5 Minor

Infective Endocarditis

Possible Diagnosis by Duke Criteria

1 Major + 1 Minor

3 Minor

Detection of Vegetations
Transthoracic Echo (TTE)

Resolution size: 3 - 4 mm

Sensitivity: 62% - 82%*
Specificity: 91% - 100%

Jacob, S et al. Curr Opin Cardiol 17:478, 2002
Detection of Vegetations
Transesophageal Echo (TEE)

Resolution size: 1 - 2 mm

Sensitivity: 87% - 100%
Specificity: 91% - 100%

Jacob, S et al. Curr Opin Cardiol 2002;17: 478
Detection of Prosthetic Valvular Vegetations: TTE vs. TEE

Sensitivity

<table>
<thead>
<tr>
<th>TTE</th>
<th>TEE</th>
</tr>
</thead>
<tbody>
<tr>
<td>17-45%</td>
<td>82-100%</td>
</tr>
</tbody>
</table>

Note: 30% to 40% of cases of prosthetic valve endocarditis have no vegetations attached to the prosthesis, only peri-annular infection

Jacob, S et al. Curr Opin Cardiol 2002; 17: 478
51 y/o Man: Cardiogenic shock; blood cultures negative
Prior bioprosthetic MVR and AVR
51 y/o Man: Cardiogenic shock; blood cultures negative
Prior bioprosthetic MVR and AVR
51 y/o Man: Cardiogenic shock; blood cultures negative
Prior bioprosthetic MVR and AVR
51 y/o Man: Cardiogenic shock; blood cultures negative
Prior bioprosthetic MVR and AVR
Suspected Infective Endocarditis

Low Initial Patient Risk
- Unexplained fever
- Chronic murmur
- No stigmata of IE
- No high risk anatomy
- No prosthesis or device

High Initial Patient Risk
- Significant new murmur
- New heart failure
- Prosthetic valve/CIED
- Stigmata of IE / Prior IE
- High risk anatomy
- Staph aureus

Low Initial Patient Risk

- Initial TTE
  - Limited Images
  - High Risk Findings
  - TEE

High Initial Patient Risk

- Initial TEE
  - ? LV Function
  - ? Hemodynamics
  - TTE


High risk TTE Findings

- Large / Mobile Vegetations
- ? Perivalvular extension of infection
- Grade III-IV/IV Regurgitation
- New LV dysfunction

Which patient most likely has infective endocarditis?

1.

2.

3.

4.
Lambl’s excrescence, fenestration

Vegetation: Infective, Noninfective

Sclerosis / calcium artifact

Mobile Endocardial Echodensity

Thrombus (prosthesis)

Ruptured/retracted chordae

Papillary fibroelastoma, myxoma

Valvular Strands

Myxomatous tissue
## Echocardiographic Diagnosis of Vegetation

<table>
<thead>
<tr>
<th>Probable Vegetation</th>
<th>Improbable Vegetation</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Texture:</strong></td>
<td></td>
</tr>
<tr>
<td>tissue density</td>
<td>hyperrefractile</td>
</tr>
<tr>
<td><strong>Location:</strong></td>
<td></td>
</tr>
<tr>
<td>upstream side of valve; in jet trajectory</td>
<td>downstream side of valve</td>
</tr>
</tbody>
</table>
### Echocardiographic Diagnosis of Vegetation

<table>
<thead>
<tr>
<th>Probable Vegetation</th>
<th>Improbable Vegetation</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Shape:</strong></td>
<td><strong>Shape:</strong></td>
</tr>
<tr>
<td>lobulated</td>
<td>filamentous,</td>
</tr>
<tr>
<td>to amorphous,</td>
<td>discrete</td>
</tr>
<tr>
<td>multiple</td>
<td>nodule</td>
</tr>
<tr>
<td>Assoc’d findings:</td>
<td>Assoc’d findings:</td>
</tr>
<tr>
<td>regurgitation,</td>
<td>none</td>
</tr>
<tr>
<td>peri-valvular</td>
<td></td>
</tr>
<tr>
<td>complications</td>
<td></td>
</tr>
</tbody>
</table>
Predisposing conditions for endocarditis

Endothelial disruption

Valvular fibrin-platelet thrombus

Bacteremia

Infected valvular vegetation

Local tissue destruction

Perivalvular extension of infection

Embolic events
Complications of Infective Endocarditis

Local valvular tissue destruction

- Valve deformation
- Perforation
- Support disruption

Valvular regurgitation
Local Valvular Destruction in Infective Endocarditis (IE)

NYHA Class III-IV heart failure complicating native valve IE:
- Aortic: 30%
- Mitral: 20%
- Tricuspid: <10%

In-Hospital Mortality
- Medical: 50 – 60%
- Surgical: 20 – 25%

Kiefer T, et al. JAMA 2011; 306:2239
Infective Endocarditis
Valvular Regurgitation at Presentation

47 y/o Man: Staphylococcal bacteremia and shock
47 y/o Man: Staphylococcal bacteremia and shock
Acute Severe AR: Early mitral valve closure
Valvular Perforation in Infective Endocarditis
Sensitivity of TTE vs MP-TEE

Combined specificity: 98% for both TTE and MP-TEE

77 y/o Male: E. Coli septic shock after abdominal surgery
77 y/o Male: E. Coli septic shock after abdominal surgery
77 y/o Male: E. Coli septic shock after abdominal surgery
77 y/o Male: E. Coli septic shock after abdominal surgery
Valvular Dysfunction Complicating Infective Endocarditis

Class I Indication for Surgery

Early surgery* is indicated in patients with IE who present with valve dysfunction (usually severe regurgitation) resulting in symptoms of heart failure

(*during initial hospitalization before completion of a full therapeutic course of antibiotics)

Complications of Infective Endocarditis

Perivalvular Extension of Infection (PVEI)

- Phlegmon, Abscess
- Mycotic aneurysm
- Fistula, Shunt
Perivalvular Extension of Infection (PVEI)

<table>
<thead>
<tr>
<th>Native valve IE</th>
<th>10 - 30%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prosthetic valve IE</td>
<td>30 - 55%</td>
</tr>
</tbody>
</table>

Independent risk factors for PVEI:
- Aortic position
- Prosthetic valve
- Staphylococcal infection

Increased in-hospital mortality: 2-3 x

Perivalvular Extension of Infection

**TTE vs TEE** (118 Patients)


![Bar chart showing sensitivity and specificity for TTE and TEE](chart.png)
Peri-valvular Extension of Infection: Mitral - Aortic Intervalvular Fibrosa (MAIF)
Peri-valvular Extension of Infection: Mitral - Aortic Intervalvular Fibrosa (MAIF)
Peri-valvular Extension of Infection: Mitral - Aortic Intervalvular Fibrosa (MAIF)
Mitral - Aortic Intervalvular Fibrosa (MAIF)

Mycotic Pseudoaneurysm: Presentation

- Persistent signs of infection (39%)
- Heart failure (16%)
- Embolism (12%)
- Chest pain (10%)
- Asymptomatic (9%)
- Chest mass (1%)
- Sudden death (1%)
- Prosthetic valve dysfunction (12%)
Bioprosthetic AVR: Coag Negative Staph bacteremia
53 y/o Male: Fever, weight loss, and dyspnea; *Aggregatibacter Aphrophilus* bacteremia

10/22/13
53 y/o Male: Fever, weight loss, and dyspnea; Aggregatibacter Aphrophilus bacteremia
Persistent fever despite antibiotic therapy

10/30/13
Infective Endocarditis: Follow-up Imaging Reevaluation with TEE/TTE

Class I Indications

- A significant change in symptoms and/or clinical findings
- Evidence of persistent infection after ≥5 days of appropriate antibiotic therapy
- Initial imaging evidence of extensive/high risk infection (i.e., large, mobile vegetations)
- Infection with aggressive/resistant organisms (staphylococcal, enterococcal, fungal)

48 y/o Man: Fever and syncope s/p Carbomedics AVR one month ago; enterococcal bacteremia

MAIF mycotic aneurysm
52 y/o IV Drug Abuser: Prior CE AVR, fever/chills x 3 wks, H. Parainfluenza bacteremia
52 y/o IV Drug Abuser: Prior CE AVR, fever/chills x 3 wks, H. Parainfluenza bacteremia
Fever x 4 wks, SJ AVR (2005); Propionibacterium bacteremia
Fever x 4 wks, SJ AVR (2005); Propionibacterium bacteremia
Fever x 4 wks, SJ AVR (2005); Propionibacterium bacteremia
Perivalvular Extension of Infection Complicating Infective Endocarditis

Class I Indication for Surgery

Early surgery* is indicated in patients with IE complicated by heart block, annular or aortic abscess, or destructive penetrating lesions

(*during initial hospitalization before completion of a full therapeutic course of antibiotics)

Persistent Infection Complicating Infective Endocarditis

Class I Indication for Surgery

Early surgery* for IE is indicated in patients with evidence of persistent infection as manifested by persistent bacteremia or fever lasting longer than 5 days after onset of appropriate antimicrobial therapy

(*during initial hospitalization before completion of a full therapeutic course of antibiotics)

Aggressive or Resistant Organisms Complicating Infective Endocarditis

**Class I Indication for Surgery**

Early surgery* is indicated in patients with left-sided IE caused by *S. aureus*, fungal, or other highly resistant organisms (e.g., *Pseudomonas* species, VRE, Brucella)

(*during initial hospitalization before completion of a full therapeutic course of antibiotics)

Complications of Infective Endocarditis

- Embolism
  - Systemic
  - Cerebral
  - Pulmonary
Embolism in Infective Endocarditis

Incidence of embolic events: 20 – 50%

Clinically silent embolism: 15 – 25%

Clinically evident stroke: 10 – 20%


Screening brain MRI (12% with CNS Sxs)
Acute ischemic lesions - 52%, mycotic aneurysm – 8%

Embolic Event Risk in Infective Endocarditis
Multiplane TEE (178 Patients)

![Embolic events chart](chart1)

- Embolic events (%)
  - Absent
  - <10
  - 10-15
  - >15

![Vegetation size chart](chart2)

- Vegetation size (mm)
  - Absent
  - Mild
  - Moderate
  - Severe

**Di Salvo G et al: JACC 2001; 37: 1069**
Embolic Event Risk in Infective Endocarditis

Independent structural predictors:
- Large vegetations (length > 10 mm)
- Highly mobile vegetation(s)
- Anterior mitral valve leaflet location

Independent microbiologic predictors:
- Staph aureus or Strep bovis infection
- Delay in appropriate antibiotic therapy

Thuny F et al: Circulation 112:69, 2005
Embolism Complicating Infective Endocarditis
Multicenter European Study (384 Patients)

Thuny F et al: Circulation 2005; 112: 69
Systemic Embolism Complicating Infective Endocarditis

Class IIa Indication for Surgery

Early surgery* is reasonable in patients with IE who present with recurrent emboli and persistent vegetations despite appropriate antibiotic therapy

(*during initial hospitalization before completion of a full therapeutic course of antibiotics)

Early Surgery vs. Conventional Treatment for Infective Endocarditis (EASE)

- 76 Patients with left-sided native valve IE and vegetations >10 mm in size randomized to early surgery vs. conventional therapy

- No patient had another indication for early surgical intervention

- Evidence of embolism (cerebral and other sites) detected in 30% of all patients on admission

Kang DH, et al. NEJM 2012; 366: 2466
## Early Surgery vs. Conventional Treatment for Infective Endocarditis (EASE)

<table>
<thead>
<tr>
<th></th>
<th>Conventional Therapy (n=39)</th>
<th>Early Surgery (n=37)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Embolic event at 6 wks</td>
<td>21%</td>
<td>0%</td>
</tr>
<tr>
<td>In-hospital death</td>
<td>3%</td>
<td>3%</td>
</tr>
<tr>
<td><strong>Infecting organism</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Streptococcal species</td>
<td>56%</td>
<td>57%</td>
</tr>
<tr>
<td>Staph Aureus</td>
<td>13%</td>
<td>8%</td>
</tr>
<tr>
<td>Culture negative</td>
<td>18%</td>
<td>27%</td>
</tr>
<tr>
<td>Other</td>
<td>13%</td>
<td>8%</td>
</tr>
</tbody>
</table>

Kang DH, et al. NEJM 2012; 366: 2466
Systemic Embolism Complicating Infective Endocarditis

Class IIb Indication for Surgery

Early surgery* may be considered in patients with native valve infective endocarditis who exhibit mobile vegetations greater than 10 mm in length (with or without clinical evidence of embolic phenomenon)

*during initial hospitalization before completion of a full therapeutic course of antibiotics

74 y/o Female: Postoperative abdominal wound infection, Corynebacterium bacteremia, no embolic events
74 y/o Female: Corynebacterium bacteremia cleared, day 14 of antibiotic therapy; no embolic events
74 y/o Female, readmitted 7 mos later: Abdominal panniculitis with streptococcal bacteremia; still no embolic events
Comprehensive TTE and TEE are indispensable for the evaluation and diagnosis of infective endocarditis.

Echocardiography plays an pivotal role in the clinical risk stratification and management of the patient with infective endocarditis.