



Brigham and Women's Hospital

Founding Member, Mass General Brigham

DIAGNOSIS AND MANAGEMENT OF INFECTIVE ENDOCARDITIS

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**CONTINUING MEDICAL EDUCATION
DEPARTMENT OF MEDICINE**



**HARVARD MEDICAL SCHOOL
TEACHING HOSPITAL**

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- Instructor of Medicine, Harvard Medical School
- Clinical Director of Transplant Infectious Diseases
 - Clinical focus: transplant and oncology infectious diseases and cardiac device infections
 - Research focus: Clinical investigator, clinical trials

DISCLOSURES

None



Key Learning Objectives

- *Understand updated criteria and imaging modalities for diagnosing infective endocarditis*
 - *Identify optimal approaches to medical and surgical management of infective endocarditis*
-

Objectives

- Epidemiology and Diagnostic Criteria for Endocarditis
 - Native valve endocarditis
 - Prosthetic valve endocarditis
 - Antibiotic Management of Endocarditis
 - Indications for surgery
 - Cardiac implantable device infections
 - Antibiotic prophylaxis prior to dental work
-

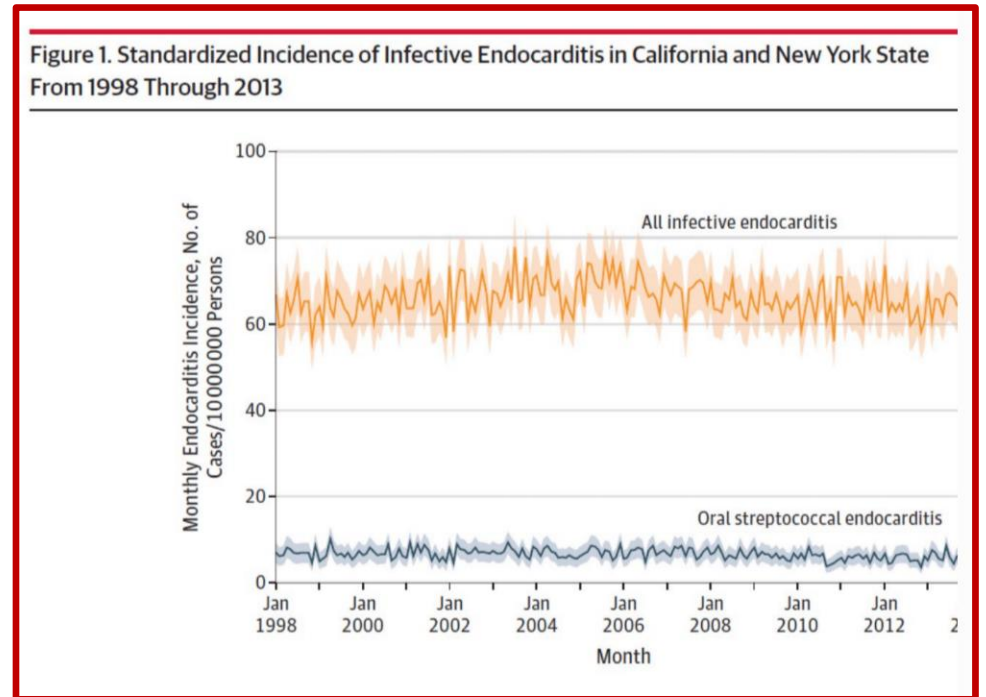
Changing Epidemiology

- *Then:*

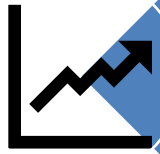
- Rheumatic heart disease
- Younger
- Native valve disease
- Streptococcus
- “Sub-acute” illness

- *Now:*

- Degenerative disease
- Older w/ comorbidities
- CIEDs, IV drug use disorder
- Staph aureus
- “Acute” illness



Impact of Infective Endocarditis in the US



~50K new IE cases annually; incidence is rising



1-year mortality for IE is 30%

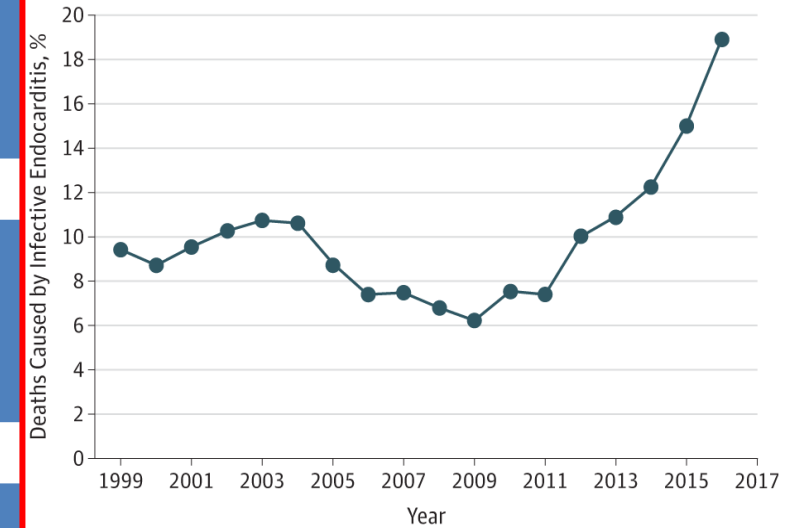


Average hospital charges >\$120,000 per patient



Management of IE is complex requiring clinical expertise of multiple sub-specialties

Rising Infective Endocarditis Mortality Among People Who Inject Drugs (1999-2016)



Diagnosis of Infective Endocarditis

- Duke Criteria
 - Originally published in 1994, modified in 2000
 - Primary purpose was to serve as a research tool to standardize the definition of this clinical diagnosis: *definite vs possible vs rejected IE*



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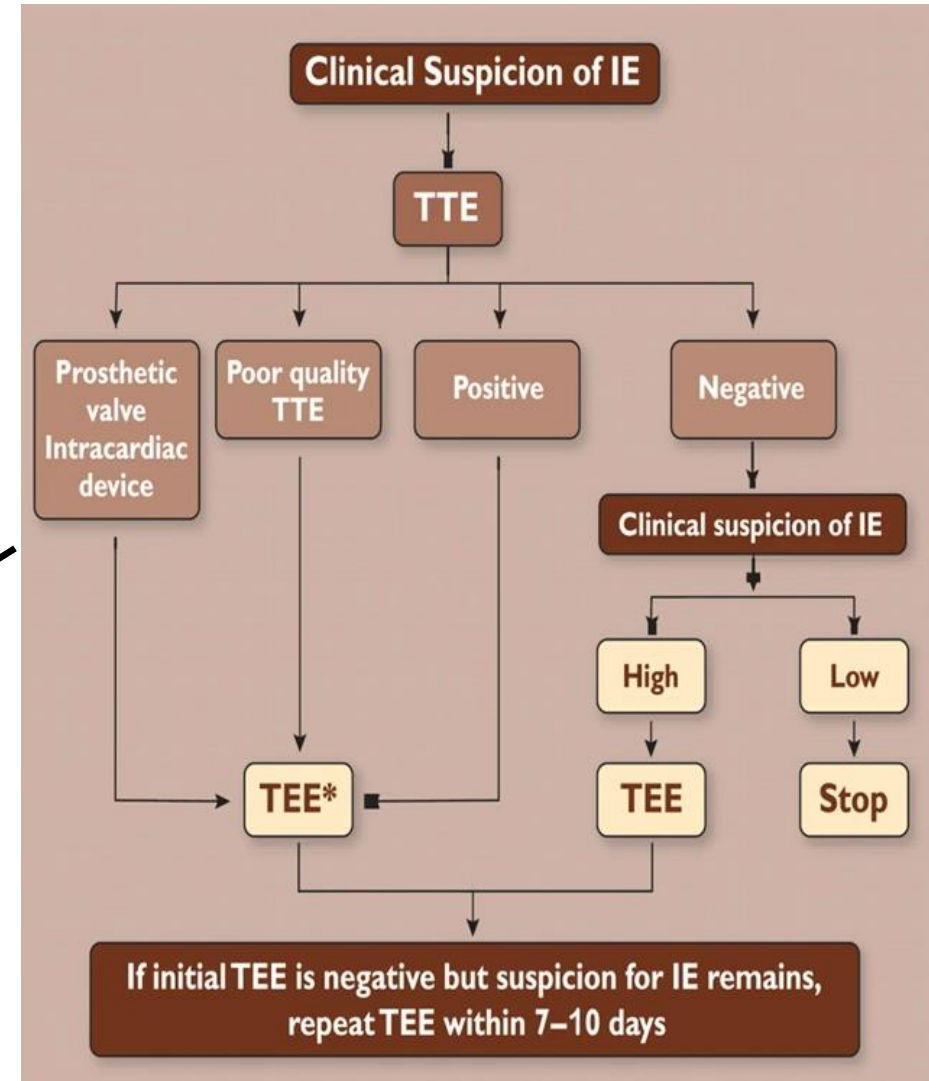
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Diagnosis

- Index of Suspicion
 - Physical exam and history
- Blood cultures x2

Modified Duke Criteria



How do we diagnose Infective Endocarditis?

- Duke Criteria
 - Originally published in 1994, modified in 2000
 - Primary purpose was to serve as a research tool to standardize the definition of this clinical diagnosis: *definite vs possible vs rejected IE*
- The microbiology, diagnostics, epidemiology, and treatment of IE have changed significantly in the last 20+ years
 - In 2015, the European Society of Cardiology proposed changes to the Modified Duke Criteria
 - 2023 Duke-ISCVID IE Criteria were developed



2023 Duke-ISCVID IE Criteria

Definite endocarditis:

- *Pathologic criteria*
- *Clinical criteria: 2 major or 1 major + 3 minor or 5 minor*

Possible endocarditis:

- *1 major + 1 minor or 3 minor*

Rejected endocarditis:

- *Firm alternate diagnosis explaining signs/symptoms or*
- ***Lack of recurrence despite antibiotic therapy for < 4 days or***
- *No pathologic or macroscopic evidence of IE at surgery or autopsy, with antibiotics <4 days or*
- *Does not meet criteria for possible IE*

2023 Duke-ISCVID IE Criteria – *MAJOR CRITERIA*

Microbiologic

- Positive blood cultures
 - **Typical** microorganisms that cause IE from ≥ 2 blood culture sets
 - **Nontypical microorganisms that cause IE from ≥ 3 blood culture sets**
- Positive laboratory tests
 - **Positive blood PCR for *Coxiella burnetii*, *Bartonella* species, or *Tropheryma whippelii***
 - *C. burnetii* antiphase I IgG titer $>1:800$, or isolated from blood culture
 - Indirect IFA for IgM/IgG to *Bartonella* (*henselae* or *quintana*) with IgG titer $\geq 1:800$

Imaging

- Echocardiography and **cardiac CT**
 - Vegetation, valvular/leaflet perforation or aneurysm, abscess, pseudoaneurysm, or intracardiac fistula
 - New valvular regurgitation
 - New dehiscence of prosthetic valve
- **FDG PET/CT imaging**
 - Abnormal metabolic activity of native or prosthetic valve, ascending aortic graft (with concomitant evidence of valve involvement), intracardiac device leads or other prosthetic material

Surgical

- **Evidence of IE documented by direct inspection during heart surgery when major imaging criteria nor histologic or microbiologic confirmation are available**

2023 Duke-ISCVID IE Criteria – *TYPICAL PATHOGENS*

Typical Pathogens

- *Staphylococcus aureus*
- Viridans group streptococci
- *Streptococcus Gallolyticus* (*S. bovis*)
- Nutritional variant strains (*Granulicatella* spp and *Abiotrophia defectiva*)
- HACEK group (*Haemophilus* spp, *Aggregatibacter*, *Cardiobacterium hominis*, *Eikenella* spp, *Kingella kingae*)
- Community-acquired enterococci

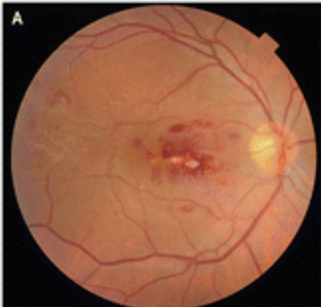
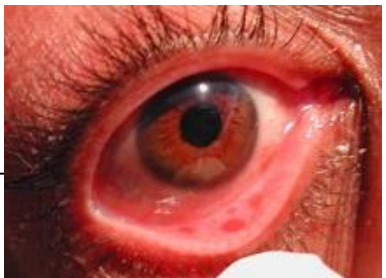
Additions include:

- All *Streptococcus* spp. except *S. pneumoniae* and *S. pyogenes*
- *Staphylococcus lugdunensis*
- *Enterococcus faecalis* regardless of primary source or setting of infection
- Clinical context in which bacteremia occurred:
 - With intracardiac prosthetic material: coagulase negative staphylococci, *Corynebacterium*, *Serratia marcescens*, *Pseudomonas aeruginosa*, *Cutibacterium acnes*, NTM (especially *Mycobacterium chimaerae*), and *Candida* spp.

2023 Duke-ISCVID IE Criteria – *MINOR CRITERIA*

- **Minor Criteria Categories**

- Predisposition
- Fever
- Vascular phenomena
- Immunologic phenomena
- Microbiologic evidence
- Imaging criteria
- Physical exam criteria



- **Additions to Minor Criteria include:**

- Predisposing conditions
 - Additional types of cardiac prosthetic material (eg, TAVR, endovascular leads or CIEDs)
 - Updated list of congenital heart conditions
 - Prior diagnosis of IE
- Additional vascular phenomenon: cerebral abscess and splenic abscess
- Practical definition of immune complex mediated glomerulonephritis within the immunologic phenomena category

Etiology of Native Valve Endocarditis

Organism	Percent of cases
Staph aureus	27-35%
Streptococci	33-35%
Enterococci	8-10%
Coagulase-negative staphylococci	4-9%
HACEK/Gram-negative bacilli	3-4%
Polymicrobial	2%
Candida	1%
Culture-negative	6%

Etiology of Native Valve Endocarditis *in Patients who Inject Drugs*

Organism	Right-sided	Left-sided
S. aureus	77%	23%
Streptococci	5%	15%
Enterococci	2%	24%
Gram-negative bacilli	5%	12%
Candida	<1%	12%
Culture-negative	3%	3%

Microorganisms Identified in Culture Negative IE

- Prior antibiotics
- Fastidious organisms
 - HACEK
 - *Abiotrophia defectiva*, etc.
 - *Brucella* spp
- “Non-cultivable” organism
 - Bartonella Quintana
 - *Coxiella burnetii*, *Tropheryma whipplei*, *Legionella* spp, *Mycoplasma*
- Fungi (molds)
- Not IE (Libman-Sacks, myxoma, APLS, marantic, tumor)

Microorganism	Present study ^a (n = 740)	Study by location [reference]			
		France [3] (n = 348)	France [29] (n = 88)	Great Britain [30] (n = 63)	Algeria [31] (n = 62)
→ <i>Bartonella</i> species	12.4	28.4	0	9.5	22.6
<i>Brucella melitensis</i>	0	0	0	0	1.6
<i>Chlamydia</i> species	0	0	2.2	1.6	0
<i>Corynebacterium</i> species	0.5	0	1.1	0	1.6
→ <i>Coxiella burnetii</i>	37.0	48	7.9	12.7	3.2
<i>Enterobacteriaceae</i>	0.5	0	0	0	0
HACEK bacteria	0.5	0	0	0	3.2
<i>Staphylococcus</i> species	2.0	0	3.4	11.1	6.4
→ <i>Streptococcus</i> species	4.4	0	1.1	6.3	3.2
→ <i>Tropheryma whipplei</i>	2.6	0.3	0	0	0
Other bacteria	3.0	1.1	1.1	1.6	1.6
Fungi	1.0	0	0	6.3	1.6
No etiology	36.5	22.1	82.9	50.8	54.8

NOTE. Data are percentages. HACEK, *Haemophilus*, *Actinobacillus*, *Cardiobacterium*, *Eikenella*, *Kingella*.

^a Patients classified as excluded were not included in this analysis.

Scoring Systems to Determine Need for Echocardiography when Bacteremic

Staphylococcus aureus

PREDICT (d5 sn 98.8% NPV 98.5%)

- Day 1 and day 5 score
- Community acquired vs Healthcare associated
- Intracardiac prosthesis
- Duration of bacteremia

VIRSTA (score ≤ 2 sn 95.8% NPV 98.8%)

- Intracardiac device/prior IE
- Native valve
- IV DU
- Community acquired
- Emboli
- Vertebral osteomyelitis
- Severe sepsis
- Meningitis
- CRP
- Duration of bacteremia

Enterococcus faecalis

NOVA (sn 100% sp 29%)

- Number of positive blood cultures
- Origin of bacteremia
- Previous valve disease
- Auscultation of heart murmur

DENOVA (sn 100% sp 83%)

- NOVA +
 - Long duration of symptoms
 - Embolization
-

PVE vs. NVE

- Similar presentations but...
 - Different microbiologic causes
 - More invasive infections, higher rates of
 - Heart failure
 - Conduction disturbances
 - New or changing murmurs
 - CNS events
-

Causes of Prosthetic Valve Endocarditis

- **Early (≤ 2 months post-op)**

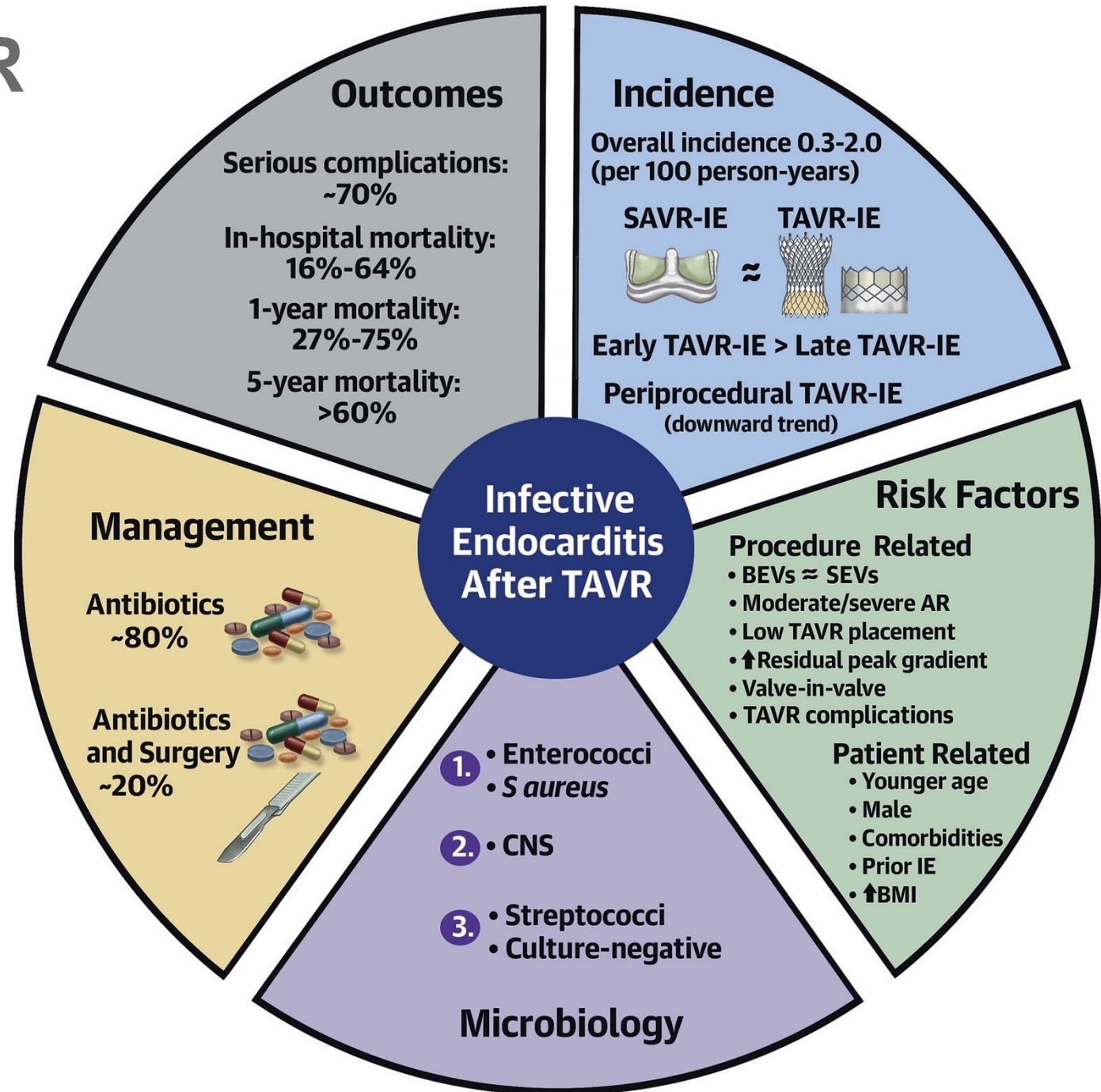
- Coagulase-negative Staph
- *S. aureus*
- Less common
 - Gram negative bacilli
 - *Enterococcus*
 - Fungi (*Candida*)
 - Diphtheroids

- **Late (> 12 months post-op)**

- Viridans streptococci group
 - *S. aureus*
 - Coagulase-negative Staph
 - Less common
 - *Enterococcus*
 - Gram negative bacilli
 - Fungi (*Candida*)
 - Diphtheroids
-

Endocarditis after TAVR

- Incidence of IE after TAVR
 - 0.3 – 2.0 per 100 person-yrs
 - Similar to SAVR
 - Has not changed over time, despite improvements in diagnosis and the evolving profile of TAVR patients
- Most common organisms: enterococcal & staphylococcal
- High rates of complications and in-hospital mortality
 - Patients who survive hospitalization have poor long-term prognosis



Non-Echo Imaging Modalities for Diagnosis of IE

- **Cardiac CT**

- Helpful for cases in which definitive evidence of IE and its complications cannot be demonstrated with TEE, and/or for surgical planning in patients with extra-valvular complications
- Cardiac CT may be superior to TEE for evaluation of paravalvular extension of infection and abscess

- Nuclear imaging modalities

- **FDG PET/CT**
 - Greater value for diagnosis of prosthetic valve IE
- **Radiolabeled leukocyte SPECT/CT**
- Spatial resolution is an Achilles heel of nuclear imaging modalities (ranges from 4 to 8 mm in PET and SPECT, respectively). Concomitant CT is needed for co-localization and confirmation of anatomic position of uptake of the radioisotope.

Diagnostic Performance of PET/CT in PVE

- Multicenter, 160 pts with prosthetic valve who underwent PET/CT due to concern for PVE, 77 patient controls
- Confounders: low CRP (<40 mg/L) and use of surgical adhesives
- Sensitivity: 74% → 91%
- Specificity: 91% → 95%
- PPV: 89% → 95%
- NPV: 78% → 91%
- FDG uptake value ratio of ≥ 2.0 was 100% sensitive, 91% specific predictor of PVE

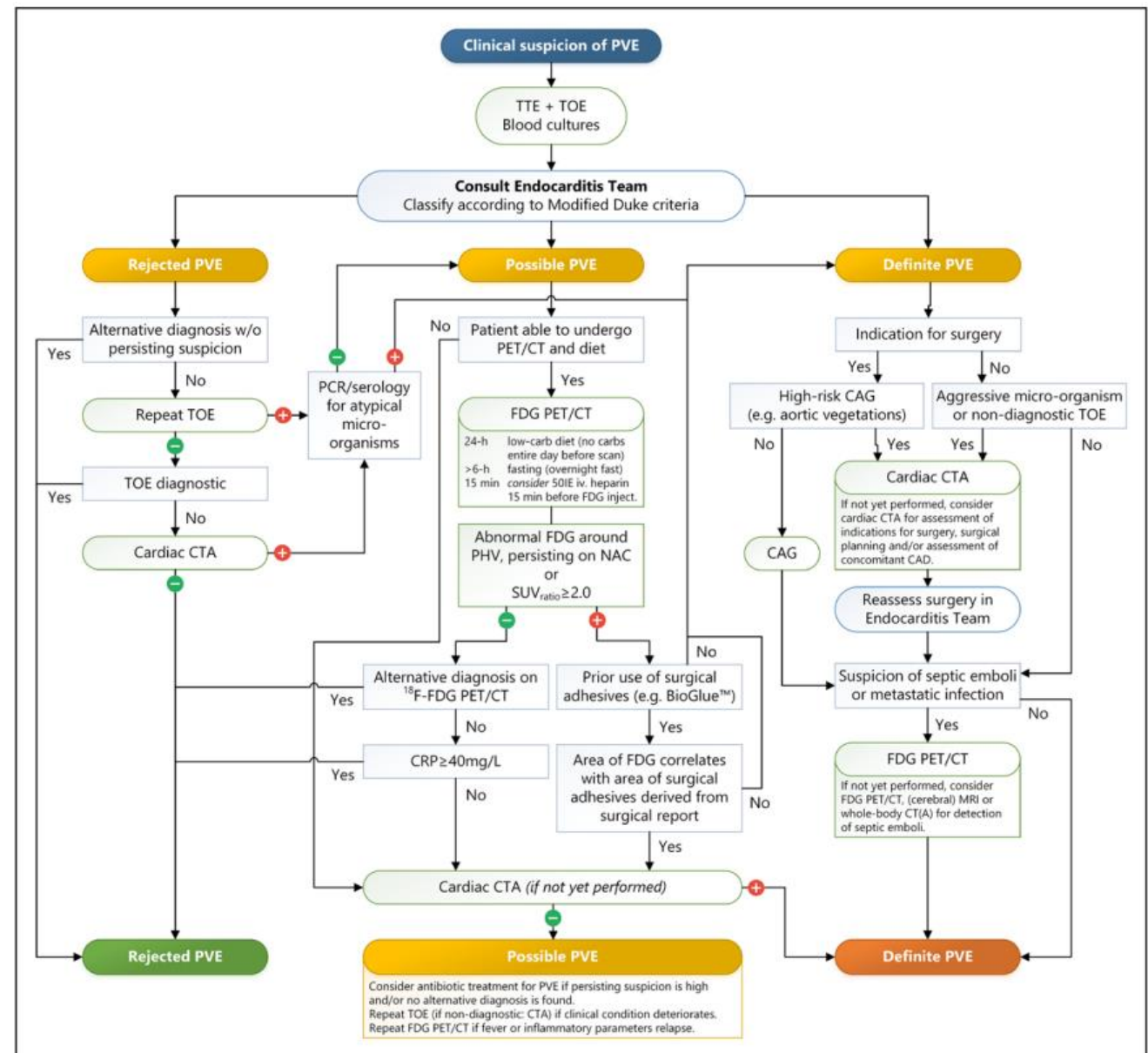


Figure 6. Flowchart for the proposed diagnostic workup of suspected PVE.

Diagnostic Performance between TEE and Cardiac CT

Table 3. Diagnostic Performance and Agreement Between TEE and Cardiac CT in Overall Patients

	TEE+	CT+	TEE+/CT–	TEE–/CT+	Agreement
Vegetation, n (%)					
Total (n=75)	73 (97.3)	54 (72.0)	19 (25.3)	0 (0)	56 (74.7)
Small (<10 mm, n=36)	34 (94.4)	19 (52.8)	15 (41.7)	0 (0)	21 (58.3)
Large (≥10 mm, n=39)	39 (100)	35 (89.7)	4 (10.3)	0 (0)	35 (89.7)
Intracardiac complications, n (%)					
Valve perforation	24 (32.0)	26 (34.7)	1 (1.3)	3 (4.0)	71 (94.7)
Valve aneurysm	5 (6.7)	5 (6.7)	0 (0)	0 (0)	75 (100)
Perivalvular abscess	10 (13.3)	15 (20.0)	1 (1.3)	6 (8.0)	68 (90.7)
Pseudoaneurysm	6 (8.0)	6 (8.0)	0 (0)	0 (0)	75 (100)
Intracardiac fistula	2 (2.7)	3 (4.0)	0 (0)	1 (1.3)	74 (98.7)
Prosthetic valve dehiscence	1 (1.3)	1 (1.3)	0 (0)	0 (0)	75 (100)

CT indicates computed tomography; and TEE, transesophageal echocardiography.

- Cardiac CT shows a comparable diagnostic performance with TEE for large vegetation and several IE-related complications
- TEE is better for detecting small vegetation
- CT is more useful for detecting perivalvular abscess and coronary artery disease

Objectives

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-

Native Valve *S. aureus* IE Treatment

Regimen	Duration	Comments
MSSA		
Nafcillin or oxacillin	6 weeks	2 weeks uncomplicated right sided IE
Cefazolin	6 weeks	Equivalent to nafcillin/oxacillin
MRSA		
Vancomycin	6 weeks	MSSA if beta-lactam hypersensitivity
Daptomycin	6 weeks	Alternative to vancomycin

**No gentamicin or rifampin*

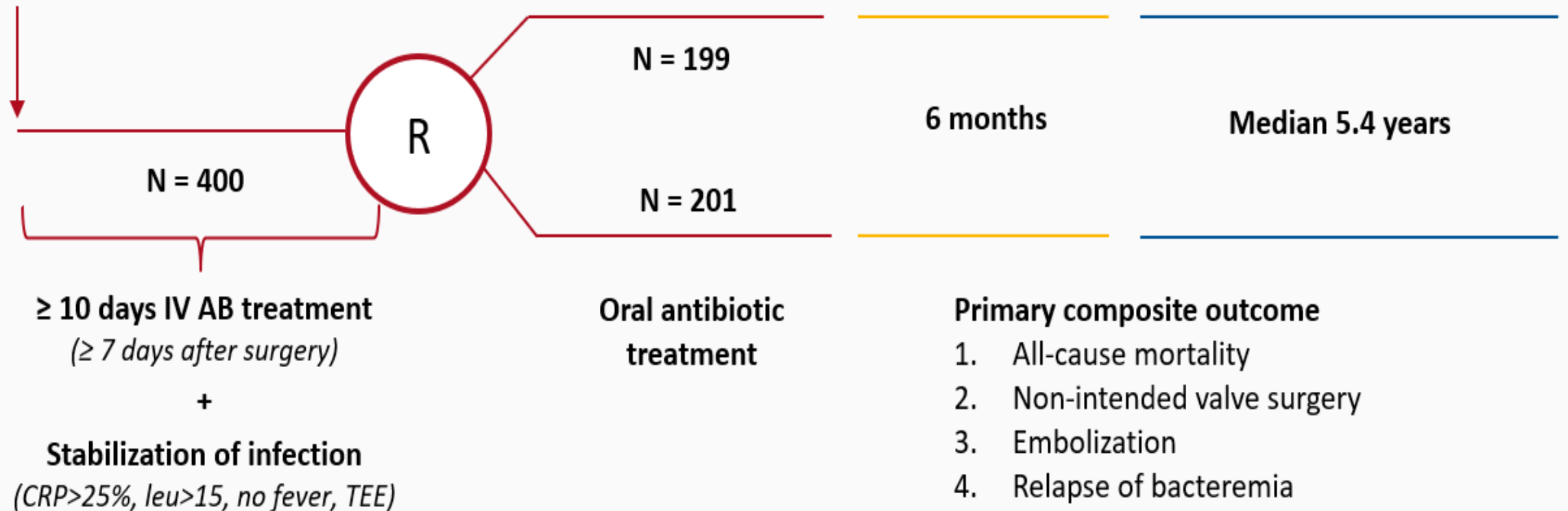
RIFAMPIN

- Not recommended for *S. aureus* NVE
 - Can quickly develop resistance
 - Associated with ↑adverse events (hepatotoxicity, drug interactions) and no difference or ↓survival
- Used in *S. aureus* PVE
- Biofilm activity

POET Trial:

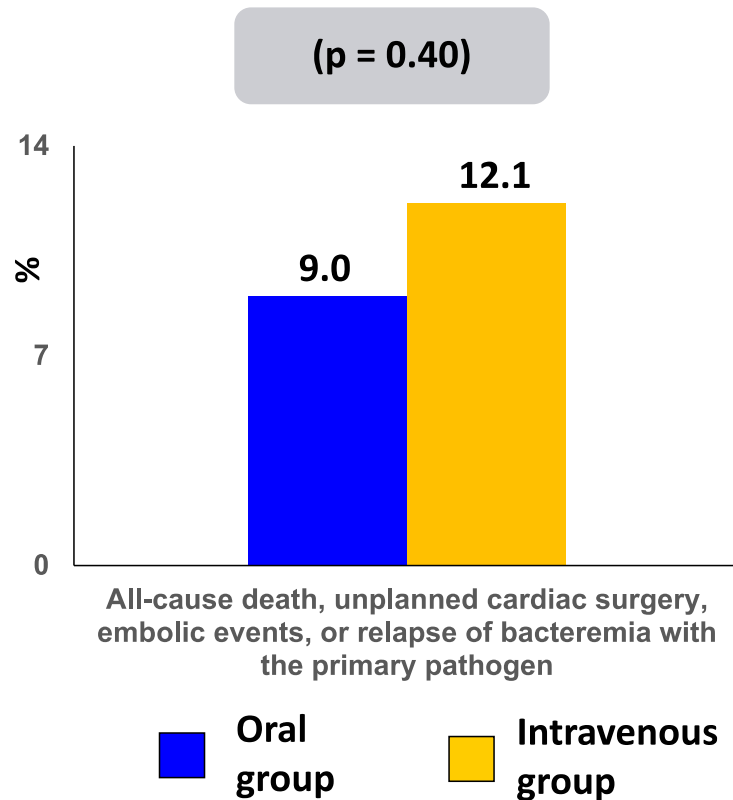
Partial Oral versus Intravenous Antibiotic Treatment of Endocarditis

Diagnosis of left-sided IE with
(*E. faecalis*, *Staph. A*, *Streptococci*, CoNS)



POET Trial

Trial design: Patients with infective endocarditis on the left side of the heart and stabilized with intravenous antibiotics were randomized to oral antibiotic therapy (n = 201) vs. continuation of intravenous antibiotic therapy (n = 199).



RESULTS

- All-cause death, unplanned cardiac surgery, embolic events, or relapse of bacteremia with the primary pathogen: 9.0% of the oral group vs. 12.1% of the intravenous group (p = 0.40; satisfying noninferiority)

CONCLUSIONS

- Among patients with infective endocarditis on the left side of the heart being treated with intravenous antibiotics, changing to oral antibiotic therapy was noninferior to remaining on intravenous antibiotics

Iversen K, et al. N Engl J Med 2018;Aug 28:[Epub]



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Partial Oral versus Intravenous Antibiotic Treatment of Endocarditis

Kasper Iversen, M.D., D.M.Sc., Nikolaj Ihlemann, M.D., Ph.D., Sabine U. Gill, M.D., Ph.D.,
Trine Madsen, M.D., Ph.D., Hanne Elming, M.D., Ph.D., Kaare T. Jensen, M.D., Ph.D.,
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Claus Moser, M.D., Ph.D., and Henning Bundgaard, M.D., D.M.Sc.

Long-Term outcomes of Partial Oral Treatment of Endocarditis

Bundgaard, H, Iversen, K., et al.

April 4, 2019

N Engl J Med 2019; 380:1373-1374

DOI: 10.1056/NEJMc1902096



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Five-Year Outcomes of the Partial Oral Treatment of Endocarditis (POET) Trial

Pries-Heje, M., Iversen, K.,

Bundgaard, H., et al

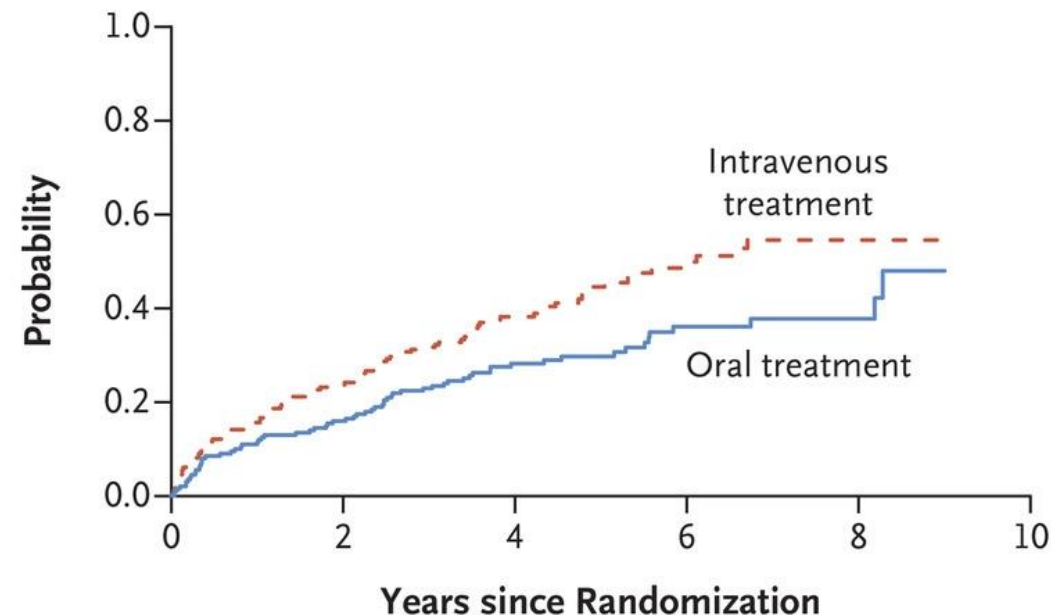
February 10, 2022

N Engl J Med 2022; 386:601-602



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A Composite Primary Outcome



No. at Risk

Intravenous treatment	199	152	90	41	11
Oral treatment	201	169	103	53	16

Culture Negative Endocarditis Treatment

- Empiric antibiotic treatment
 - Acute clinical presentation
 - Vancomycin + cefepime
 - Subacute clinical presentations
 - Vancomycin + ampicillin-sulbactam
 - OR –
 - Vancomycin + ceftriaxone

Objectives

- Epidemiology and Diagnostic Criteria for Endocarditis
 - Native valve endocarditis
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 - **Indications for surgery**
 - Cardiac implantable device infections
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-

Indications for Surgery

Class I

- Heart failure due to valvular dysfunction
- Heart block, annular or aortic abscesses
- Left sided IE due to fungi, Staph aureus, or highly resistant organism
- Persistent bacteremia or fevers (>7 days) despite antibiotics not attributable to alternative source

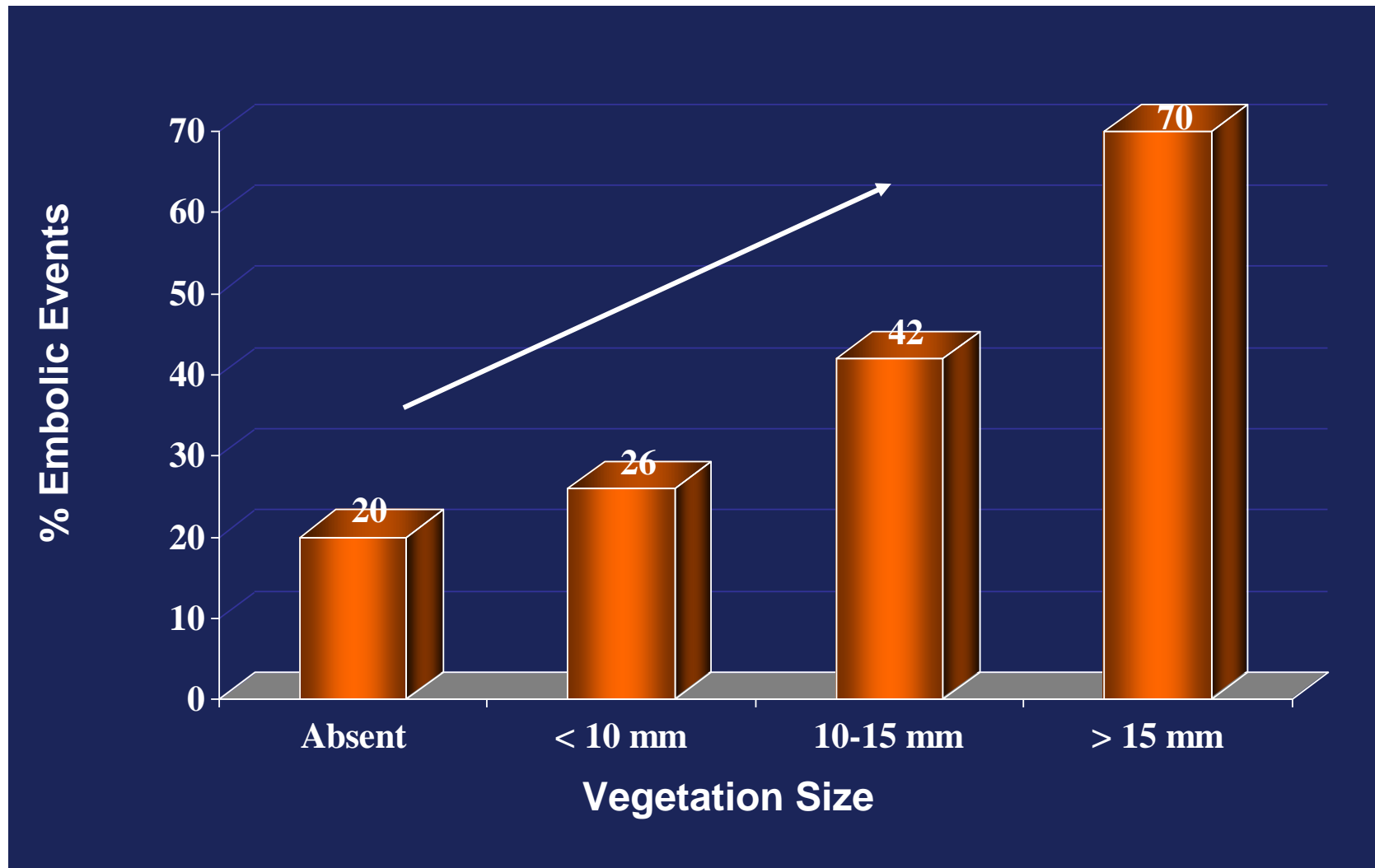
Class II

- PVE and relapsing infection
- Recurrent emboli and persistent vegetation despite antibiotics
- NVE or PVE with large, mobile vegetations (> 10mm) with clinical evidence of embolic phenomena
- In right-sided IE, NVE or PVE when large vegetations are present and persistent bacteremia or fevers (>7 days) despite antibiotics or evidence of septic PE

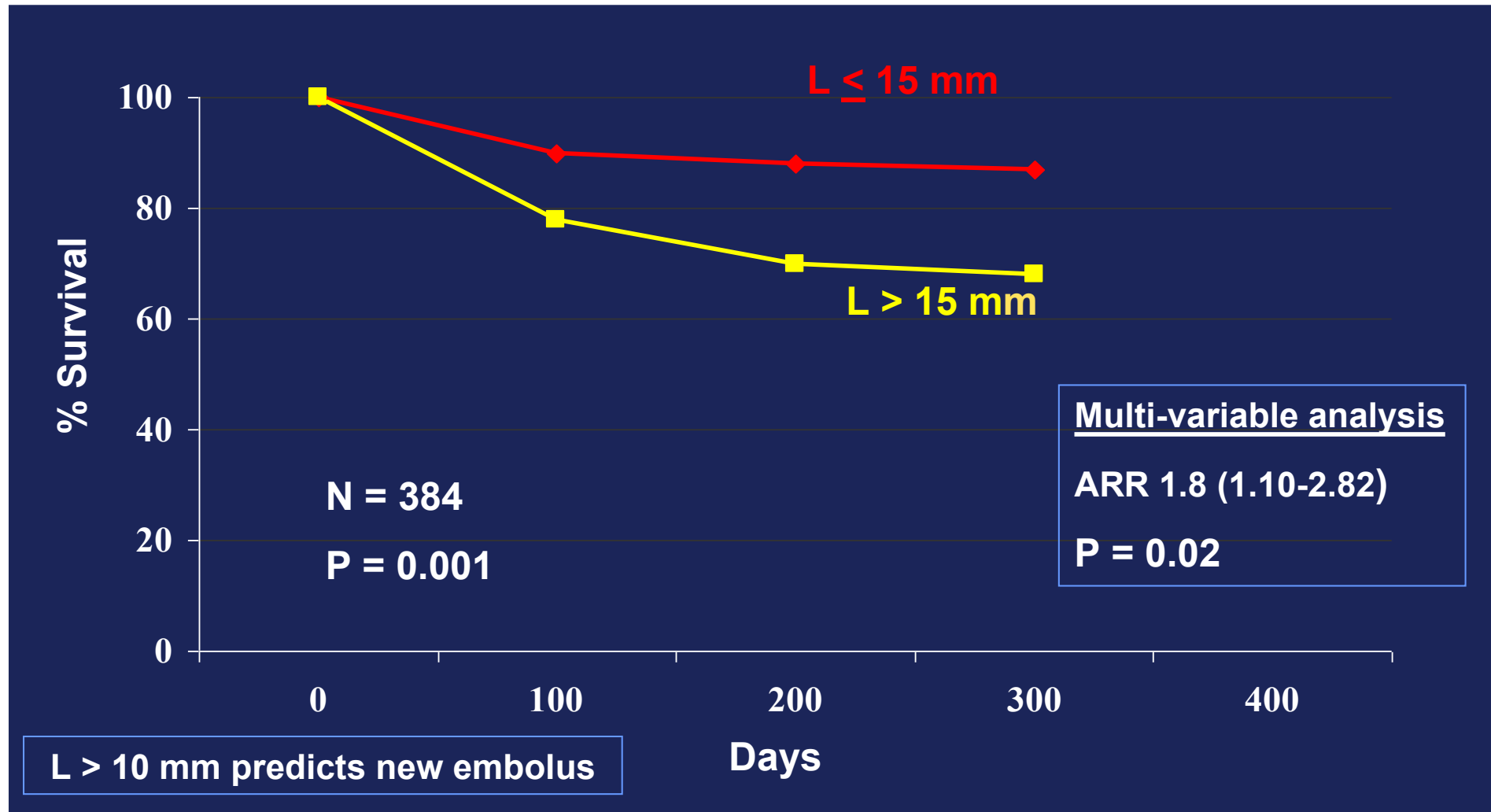
Timing of Surgery

2. When should the patient undergo operation?	COR	LOE
Once an indication for surgery is established, the patient should be operated on within days	I	B
Earlier surgery (emergency or within 48 hours) is reasonable for patients with large mobile vegetations at imminent risk of embolism	Ila	B
In patients with stroke and neurologic deficits, timing is decided by weighing the need for cardiac surgery against the risk of expanding the stroke or provoking intracranial bleeding during the operation (see specific question about neurologic complications)	Ila	B

Embolization Risk: *Native and Prosthetic Valve*



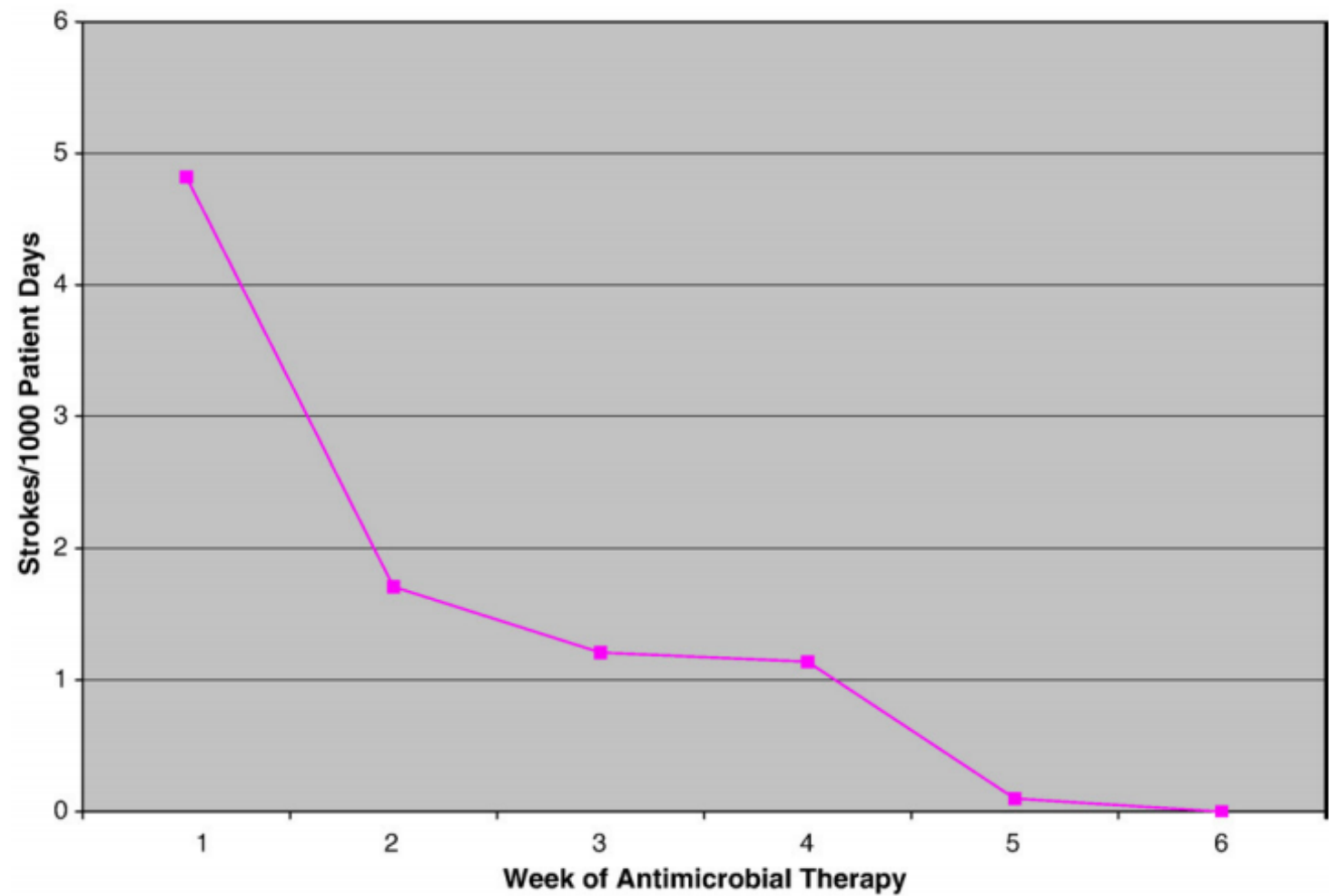
Impact of Vegetation Size: 1-year Survival



Risk of Emboli

- Highest incidence occurs with
 - Anterior mitral valve involvement
 - Prosthetic valve involvement
 - *S. aureus*, *Candida* spp, HACEK
- Marked decrease in embolic rates after 2-3 weeks of antibiotic treatment

Stroke Rate after Initiation of Antibiotics

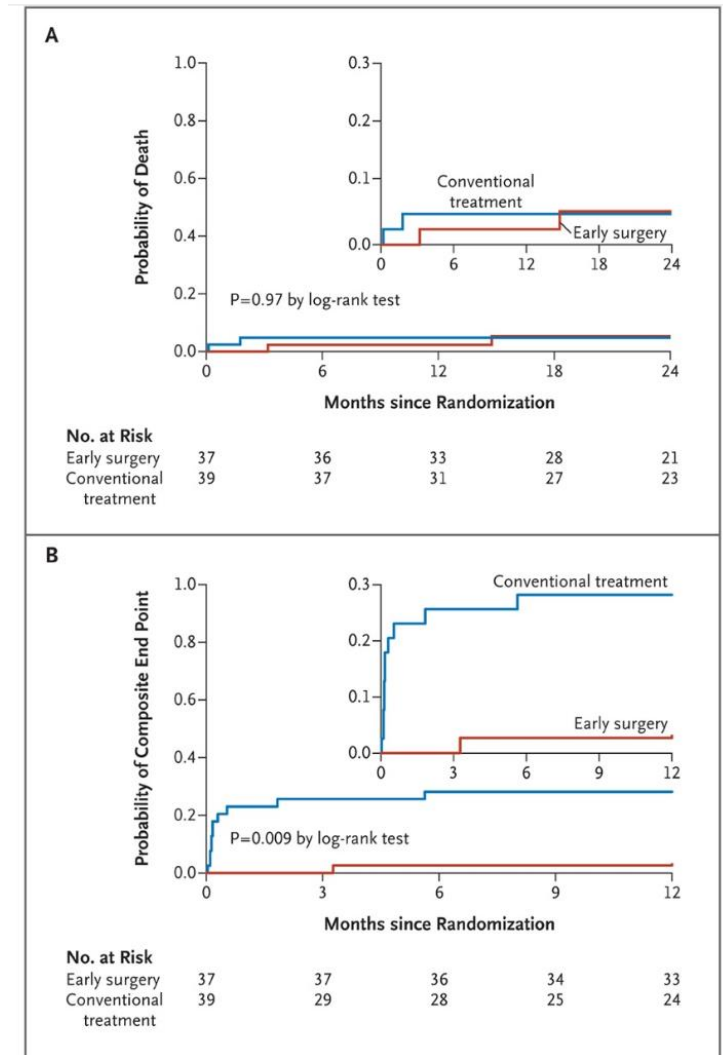


Variable	OR (95% CI)	P
Staph aureus	1.55 (1.10-2.17)	0.01
Viridans Strep	0.59 (0.35-0.98)	0.04
Abscess	1.56 (1.06-2.30)	0.02
MV veg	1.93 (1.49-2.50)	<0.0001

What is the optimal timing for surgical intervention?

Early Surgery vs. Conventional Treatment for IE

- 76 patients, 2 centers in Korea
- Left sided NVE, severe valvular disease, and large vegetations
- Randomized to early surgery vs. conventional treatment
- Primary end point: composite of in-hospital death and embolic events that occurred within 6 weeks
- Organisms: Strep (~60%), Staph aureus (~10%), Enterococcus (1-2%), culture negative (~20-30%)
- Results:
 - No significant difference in all-cause mortality at 6 months
 - Early surgery reduced the composite end point of death from any cause and embolic events (3% vs 28%)



Timing of Valve Replacement in IE after CNS Infarct

- 240 patients with IE and CNS infarct who underwent valve replacement
- Risk of neurological deterioration after valve replacement:
 - ≤ 3 days: 20%
 - Day 4-14: 20-50%
 - 2-4 weeks: $<10\%$
 - >4 weeks: $<1\%$
- Patients with IE and heart failure and CNS infarct – surgery should be performed <3 days of infarct or delayed until >4 weeks

Valve Surgery in Patients with Prior Emboli, Hemorrhage, Stroke

- AHA/IDSA Guidelines 2015
 - Valve surgery may be considered in IE patients with stroke or subclinical cerebral emboli and residual vegetation without delay if intracranial hemorrhage has been excluded by imaging studies and neurological damage is not severe (ie, coma) (*Class IIb; Level of Evidence B*)
 - In patients with major ischemic stroke or intracranial hemorrhage, it is reasonable to delay valve surgery for at least 4 weeks (*Class IIa; Level of Evidence B*)

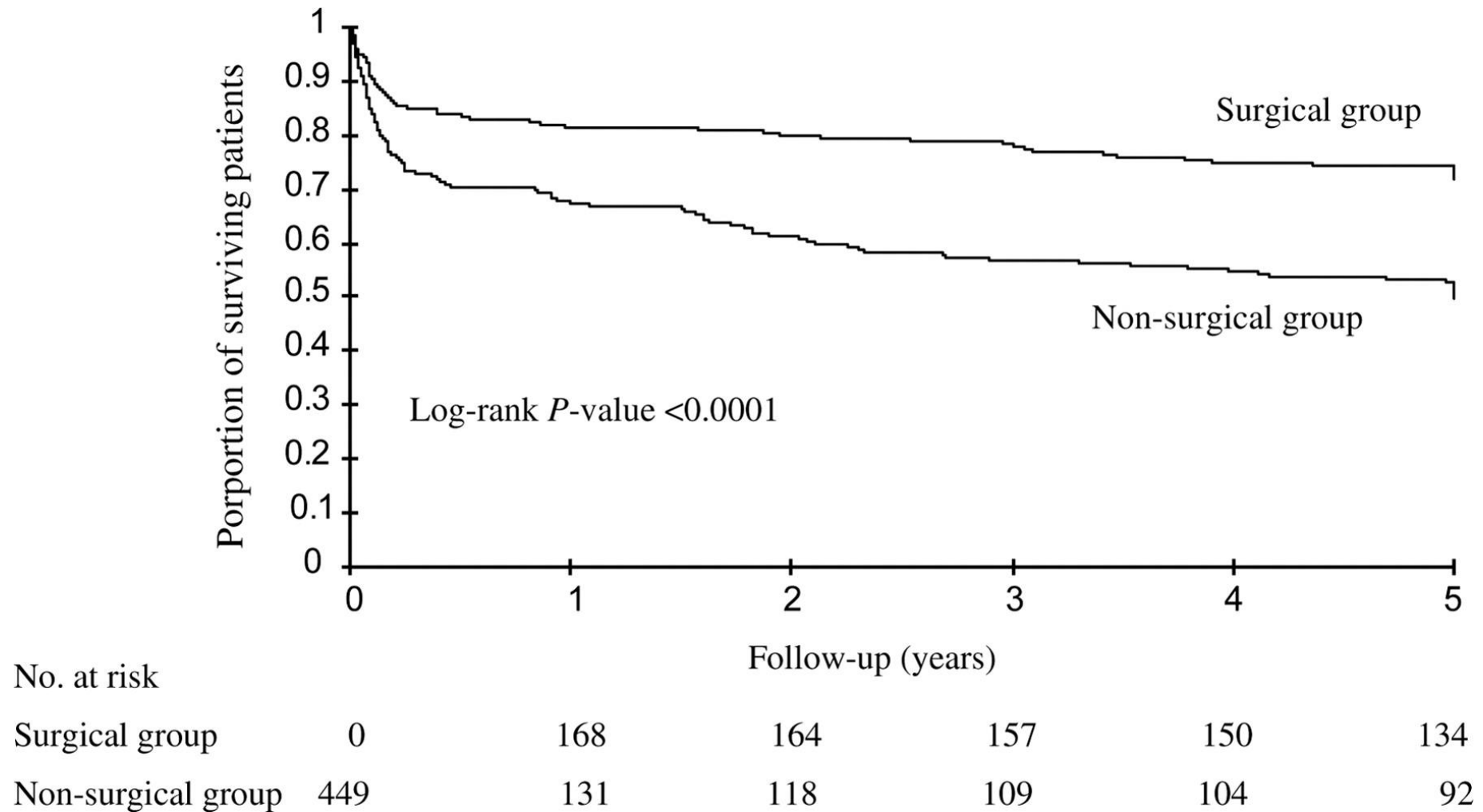
Table 3. Current Endocarditis Management Guidelines

Guideline	Year	Timing of Surgery		
		Silent Embolism/TIA	Ischemic Stroke	Hemorrhagic Stroke
AHA	2015	No Delay (class IIb; LOE B)	No delay if neurological damage is not severe (class IIb; LOE B) At least 4 wk for major ischemic stroke (class IIa; LOE B)	At Least 4 wk (class IIa; LOE B)
ESC	2015	No Delay (class I; LOE B)	No delay for heart failure, uncontrolled infection, abscess, persistent high embolic risk in absence of coma (class IIa; LOE B)	>1 mo (class IIa; LOE B)
STS	2011	-	Delay of <4 wk for cardiac dysfunction, recurrent stroke or systemic embolism or uncontrolled infection despite adequate antibiotic therapy (class IIb; LOE C) <u>At least 4 wk from the stroke, if possible, for major ischemic stroke (class IIa, LOE C)</u>	At least 4 wk from stroke

Table data from Baddour et al³¹, Habib et al³⁵, and Byrne et al.³⁶

AHA indicates American Heart Association; ESC, European Society of Cardiology; LOE, level of evidence; STS, Society of Thoracic Surgeons; and TIA, transient ischemic attack.

Impact of Valve Surgery in IE on Survival



Objectives

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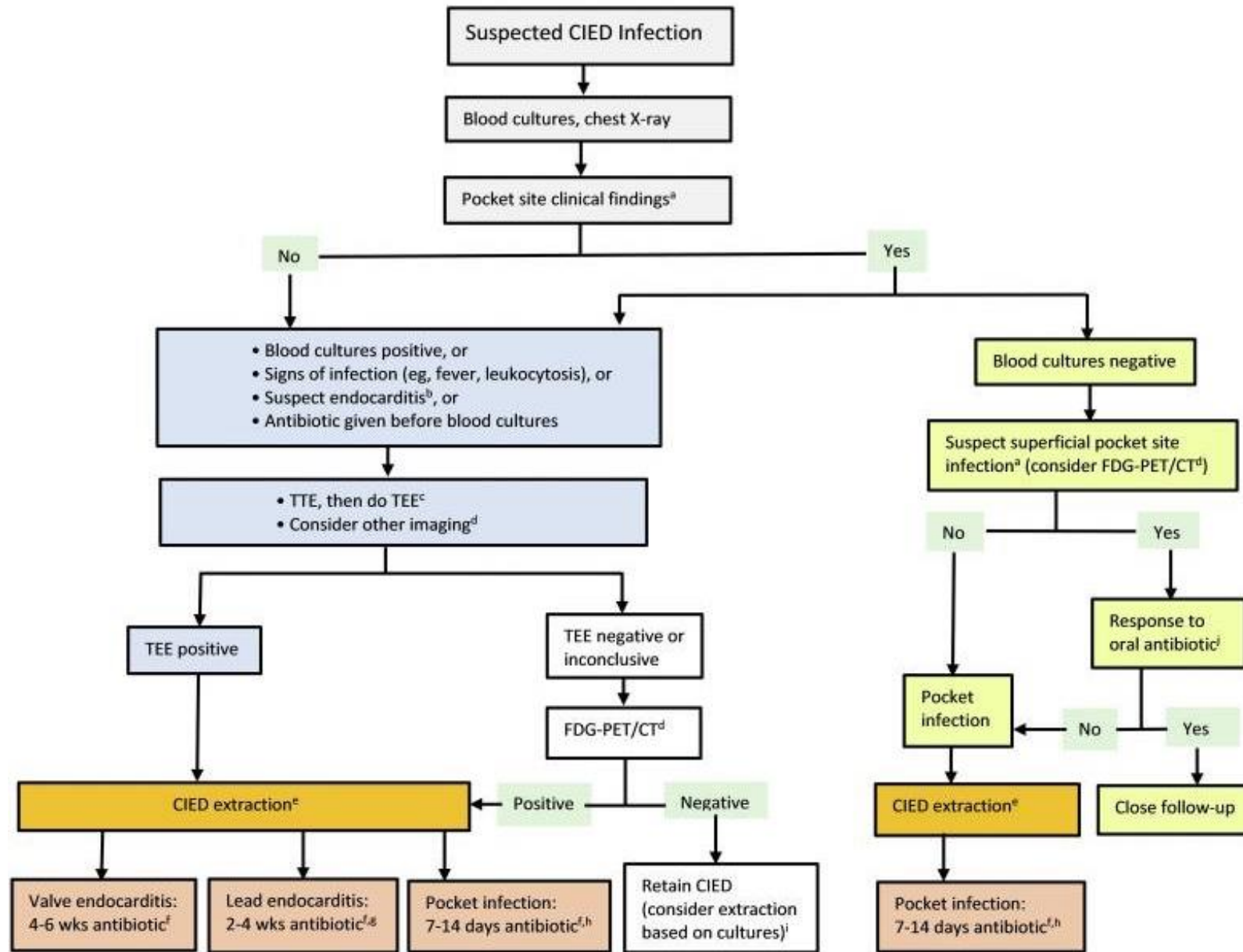
Microbiology of Cardiac Implantable Device Infections

Organism	Percent of cases
Coagulase-negative Staph	42%
<i>Staphylococcus aureus</i>	29%
Gram-negative bacilli	9%
Polymicrobial	7%
Culture-negative	7%
Fungal	2%
Other	4%

Cardiac Implantable Device Infection Types

- Pocket site only: ~60%
 - Blood culture positive <50%
 - Pocket infection or generator lead/erosion
 - Occult bacteremia/fungemia: ~7-30%
 - Lead infection +/- endocarditis: ~10-25%
-

Management of CIED Infection



AHA Guidelines for Management of CIED Infections

- Device removal for all infections and occult staphylococcal bacteremia (consider for gram negative rod bacteremia)
- Duration of treatment
 - Pocket infection: 10-14 days
 - Bloodstream infection: ≥ 14 days
 - Lead or valve vegetation: 4-6 weeks
- Reimplantation
 - Determine if reimplantation is necessary
 - New device on contralateral side
 - ≥ 72 hours negative blood cultures prior to reimplantation
 - If IE: reimplant ≥ 14 days after removal

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 - Prosthetic valve endocarditis
 - Antibiotic Management of Endocarditis
 - Indications for surgery
 - Cardiac implantable device infections
 - Antibiotic prophylaxis prior to dental work
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Rationale for Changes in Prophylaxis IE Guidelines

- Bacteremia
 - Tooth brushing 154,000 times greater/year than single extraction
 - Antibiotics do not eliminate bacteremia and not clear whether they reduce IE
 - No prospective studies supporting efficacy
 - Case-control study: dental event not increased in IE
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AHA Guidelines for Antibiotic Prophylaxis and Dental Work

- Prosthetic valve/material
 - Prior endocarditis
 - Congenital heart disease (CHD)
 - Unrepaired cyanotic CHD including shunts/conduits
 - Repaired CHD with prosthetic material/device \leq 6mo from procedure
 - Repaired CHD with residual defects
 - Cardiac transplant recipients with valvular disease
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Antibiotic Prophylactic Regimens for Dental Procedures

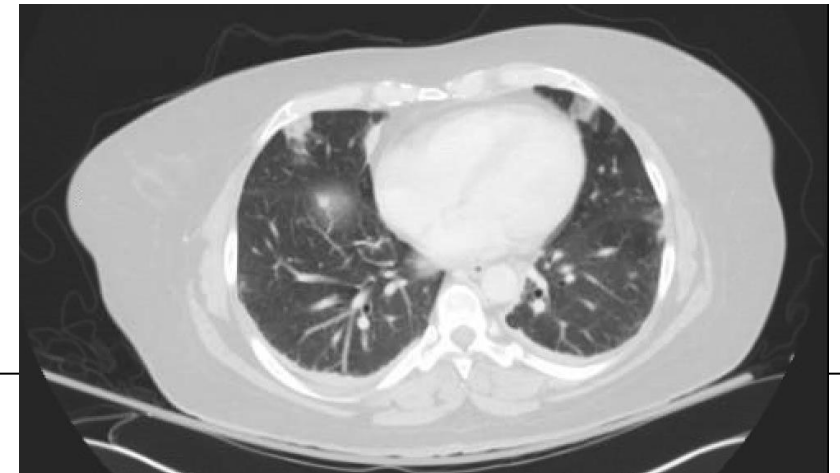
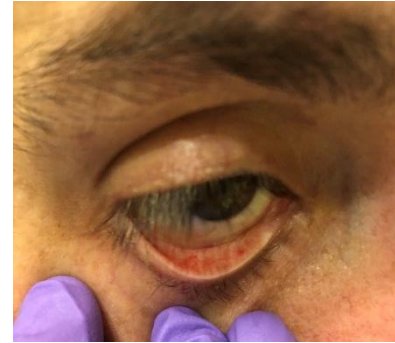
Preferred	30 - 60 minutes before
Oral	Amoxicillin 2 grams
I.V.	Ampicillin 2 grams or Ceftriaxone 1 gram
Allergy to penicillin	Azithromycin 500mg or Doxycycline 100mg or Cephalexin 2g

*No longer
Clindamycin*

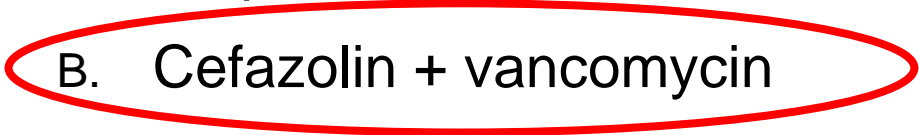
Questions

Question 1

- 63M with no significant past medical history presents with a week of fever, rigors, and progressive dyspnea on exertion
- Exam
 - T 39.5°C, BP 160/40, HR 110
 - Elevated JVP
 - Bilateral rales
 - Loud diastolic decrescendo murmur at the lower left sternal border



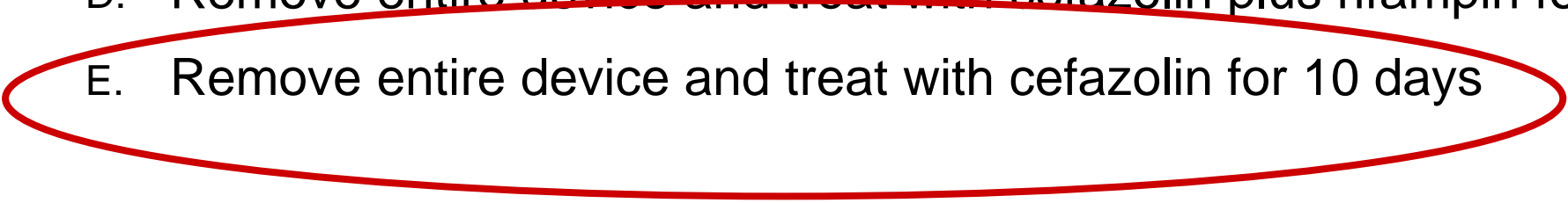
Question 1

- Which of the following is the most appropriate empirical regimen for this patient?
 - A. Ampicillin + gentamicin
 - B. Cefazolin + vancomycin
 - C. Cefepime + gentamicin
 - D. Nafcillin + rifampin
 - E. Vancomycin + gentamicin

Question 2

- 71M with a permanent pacemaker implanted 2 months ago for sick sinus syndrome/syncope presents with fevers
 - Exam
 - T 37.9°C, BP 122/75, HR 76 (paced)
 - Generator pocket is slightly tender and edematous with moderate warmth and erythema
 - Cultures
 - Purulence aspirated from the pocket grows MSSA
 - Blood cultures are negative
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Question 2

- Which is the best management and treatment for this patient's infection?
 - A. Cefazolin + rifampin for 6 weeks
 - B. Remove generator and treat with cefazolin plus rifampin for 10 days
 - C. Remove generator and treat with cefazolin plus rifampin for 6 weeks
 - D. Remove entire device and treat with cefazolin plus rifampin for 6 weeks
 - E. Remove entire device and treat with cefazolin for 10 days
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Question 3

- Which of the following patients should receive prophylactic antibiotics?
 - A. A 50 yo man with mitral valve prolapse and severe mitral regurgitation undergoing dental cleaning
 - B. A 65 year old woman with prior cyanotic congenital heart disease that was successfully repaired many years ago
 - C. A 56 yo man with history of ischemic cardiomyopathy who is status post a cardiac transplant 6 months ago
 - D. A 47 year old with prior history of endocarditis undergoing periodontal surgery

Key Take-Aways

- IE has an annual incidence of up to 10/100,000 and a mortality of up to 30% at 30 days. Healthcare related infections account for 25–30% of cases.
 - The modified Duke criteria now includes molecular imaging techniques for implanted heart valves where conventional echocardiography has reduced sensitivity.
 - Complicated IE cases that involve heart failure, valvular incompetence, structural destruction (abscess, perforation, fistula formation) should be managed at a reference center by a dedicated IE team.
 - Surgical intervention is often needed, but optimal timing of surgery remains unknown
 - Antibiotic management of IE is complex; choice of regimens should be provided by an ID specialist. In many cases, partial oral step-down antibiotic treatment is effective.
 - Antibiotic prophylaxis is recommended for individuals at high risk of developing IE (prosthetic heart valves or valve repair, prior IE and unrepaired cyanotic congenital heart disease or an unrepaired shunt) who are scheduled for dental extractions, subgingival scaling or manipulation of the gingival tissue, teeth or oral mucosa.
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