Infective Endocarditis and Cardiovascular Device Infections

Nabin K. Shrestha, MD

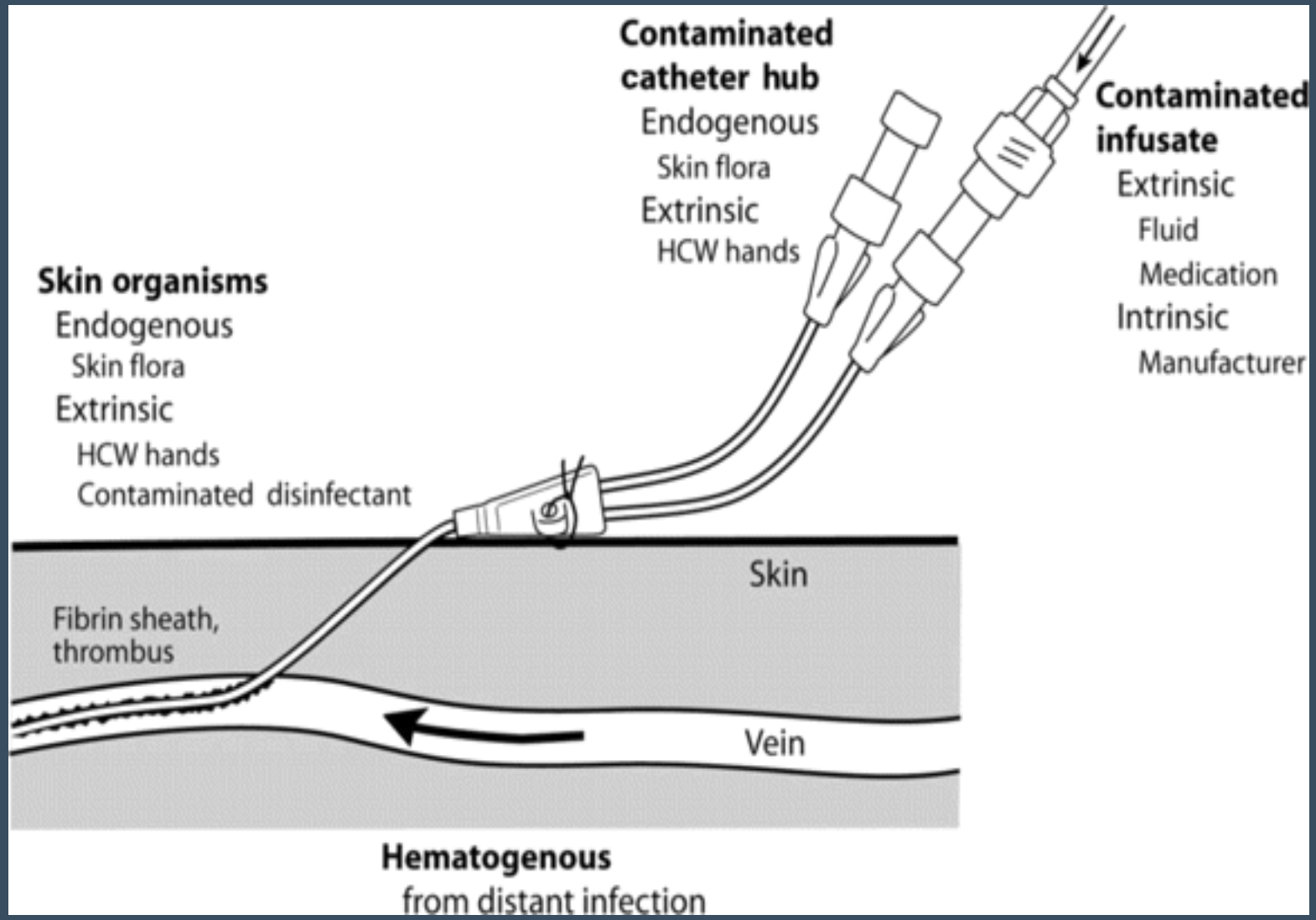
Infectious Disease Department, Cleveland Clinic

June 9, 2025

Objectives

- Discuss the approach to catheter associated bloodstream infection and its management
- Review the epidemiology, diagnosis, and management of infective endocarditis
- Review the prevention of infective endocarditis

Pathogenesis of CLABSI



Crnich CJ, Maki DG. Clin Infect Dis, 2002; 34: 1232–1242.

Intravascular Complications of Central Venous Catheterization by Insertion Site

Jean-Jacques Parienti, M.D., Ph.D., Nicolas Mongardon, M.D., Bruno Mégarbane, M.D., Ph.D., Jean-Paul Mira, M.D., Ph.D., Pierre Kalfon, M.D., Ph.D., Antoine Gros, M.D., Sophie Marqué, M.D., Marie Thuong, M.D., Véronique Pottier, M.D., Michel Ramakers, M.D., Benoît Savary, M.D., Amélie Seguin, M.D., Xavier Valette, M.D., Nicolas Terzi, M.D., Ph.D., Bertrand Sauneuf, M.D., Vincent Cattoir, Pharm.D., Ph.D., Leonard A. Mermel, D.O., and Damien du Cheyron, M.D., Ph.D., for the 3SITES Study Group*

N ENGL J MED 373;13 NEJM.ORG SEPTEMBER 24, 2015

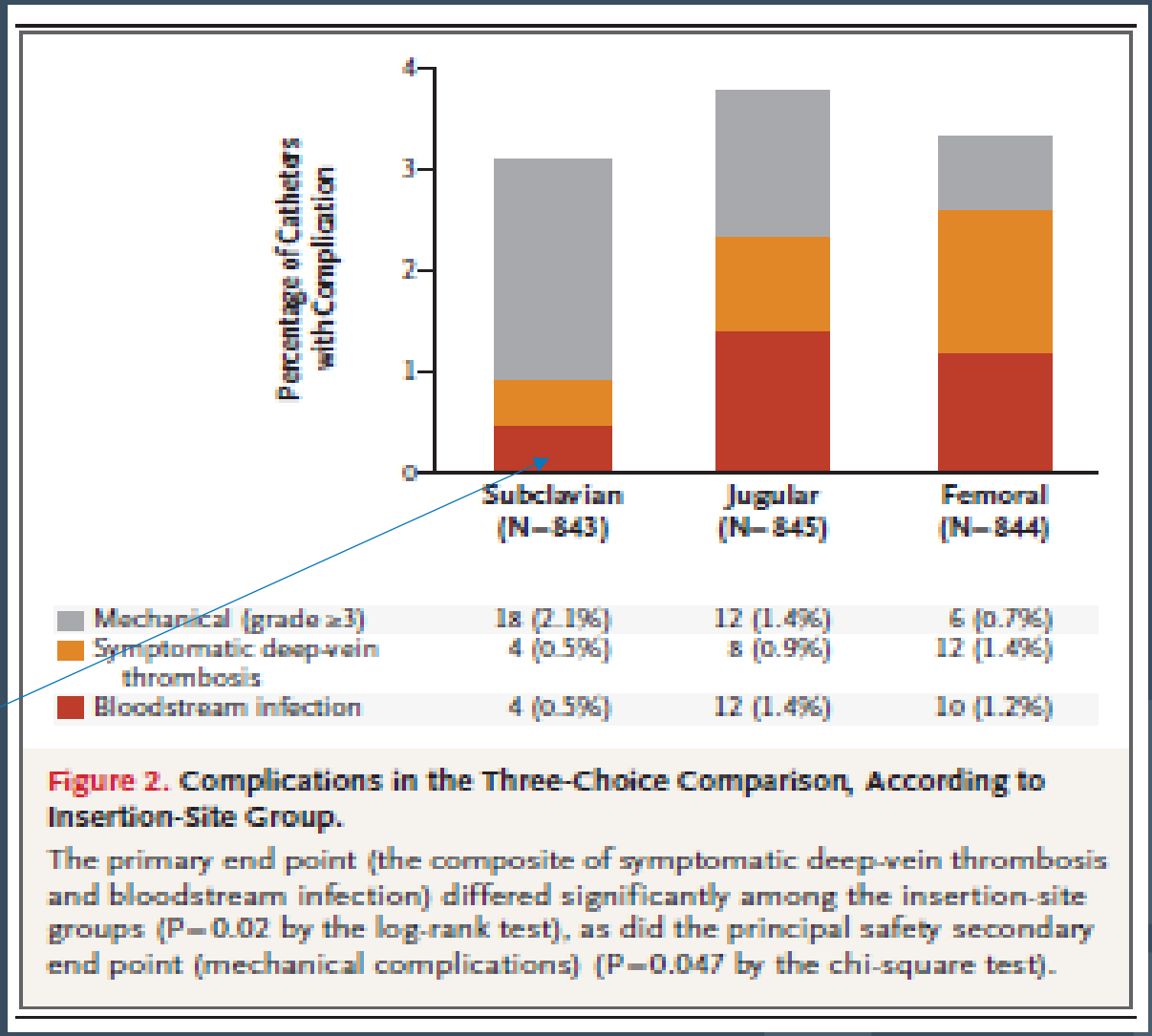


Figure 2. Complications in the Three-Choice Comparison, According to Insertion-Site Group.

The primary end point (the composite of symptomatic deep-vein thrombosis and bloodstream infection) differed significantly among the insertion-site groups (P=0.02 by the log-rank test), as did the principal safety secondary end point (mechanical complications) (P=0.047 by the chi-square test).

Subclavian site:

Lowest risk of CLABSI

Management of CVC-associated infection

Mermel LA, et al. Clin Infect Dis 2009; 49: 1-45. (IDSA guideline).

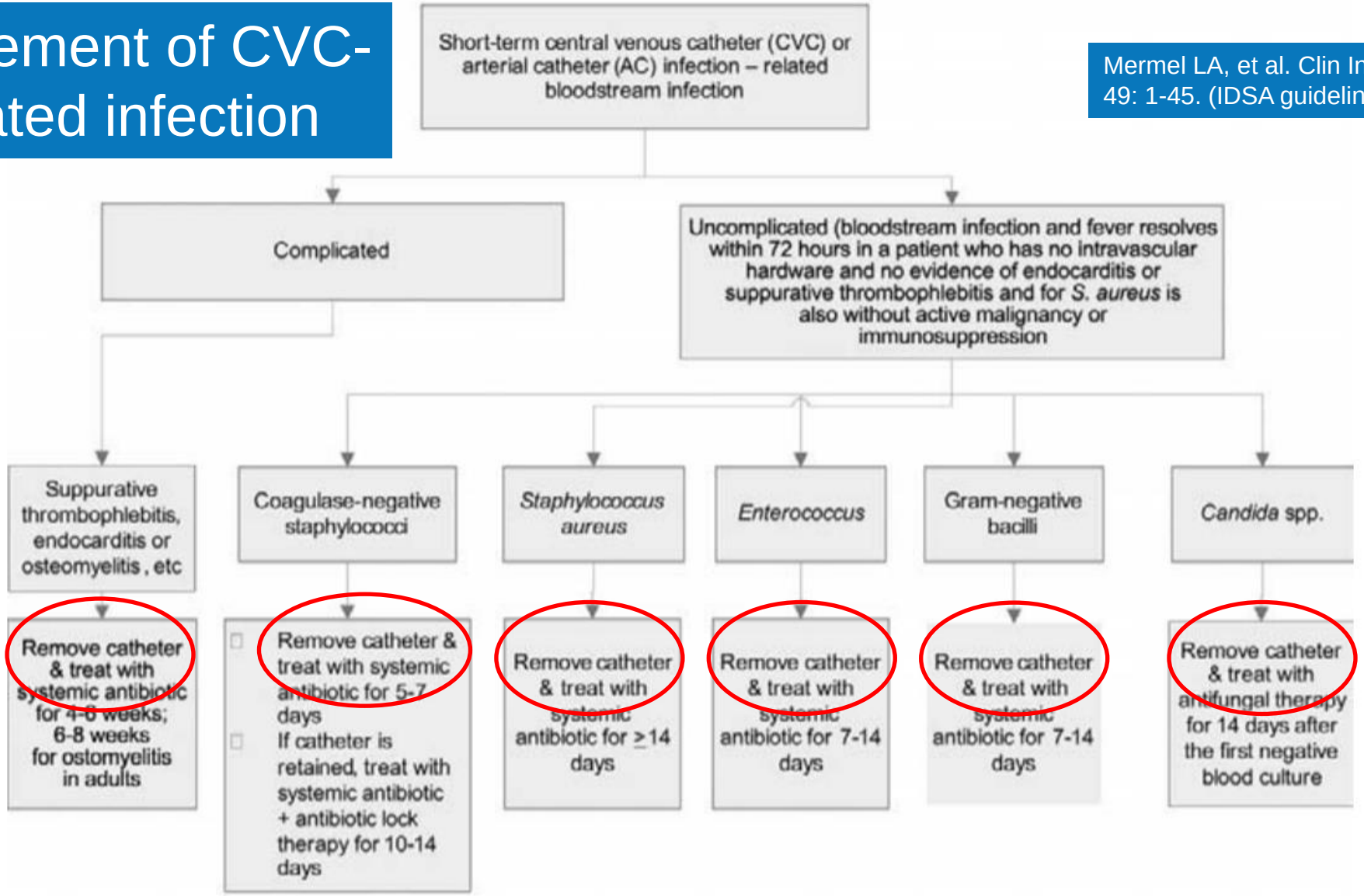


Figure 2. Approach to the management of patients with short-term central venous catheter–related or arterial catheter–related bloodstream infection. CFU, colony-forming units; *S. aureus, Staphylococcus aureus.*

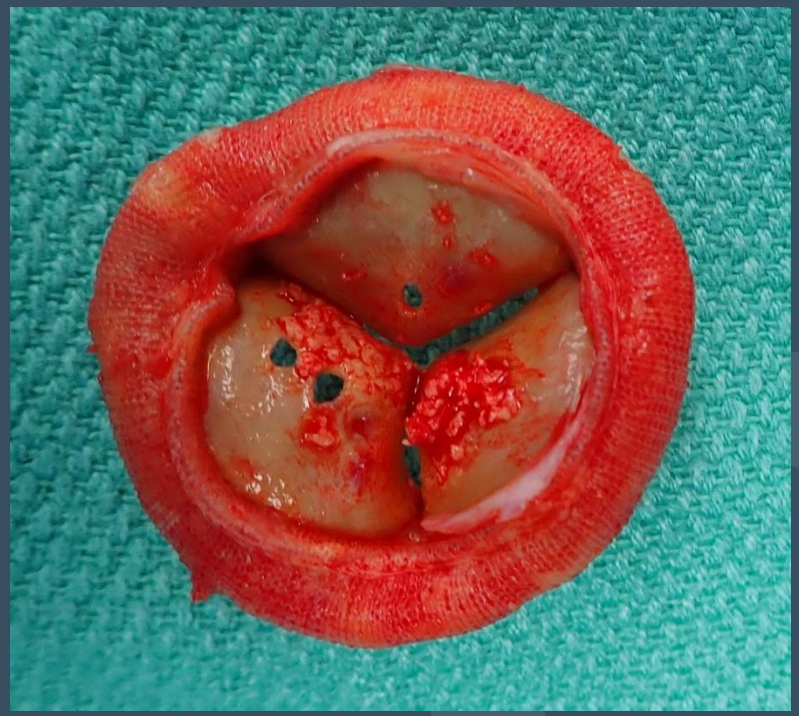
Peripheral vascular catheter infection

- Peripheral vascular catheter infections can be just as dangerous as central venous catheter infections
- If a hospitalized patient (or one recently discharged from hospital) is found to have bacteremia, consider the possibility of a vascular catheter infection (including a peripheral vascular catheter infection)

Infective endocarditis

- Classification
  - Type
    - Native valve endocarditis (NVE)
    - Prosthetic valve endocarditis (PVE)
  - Presentation
    - Acute
    - Subacute

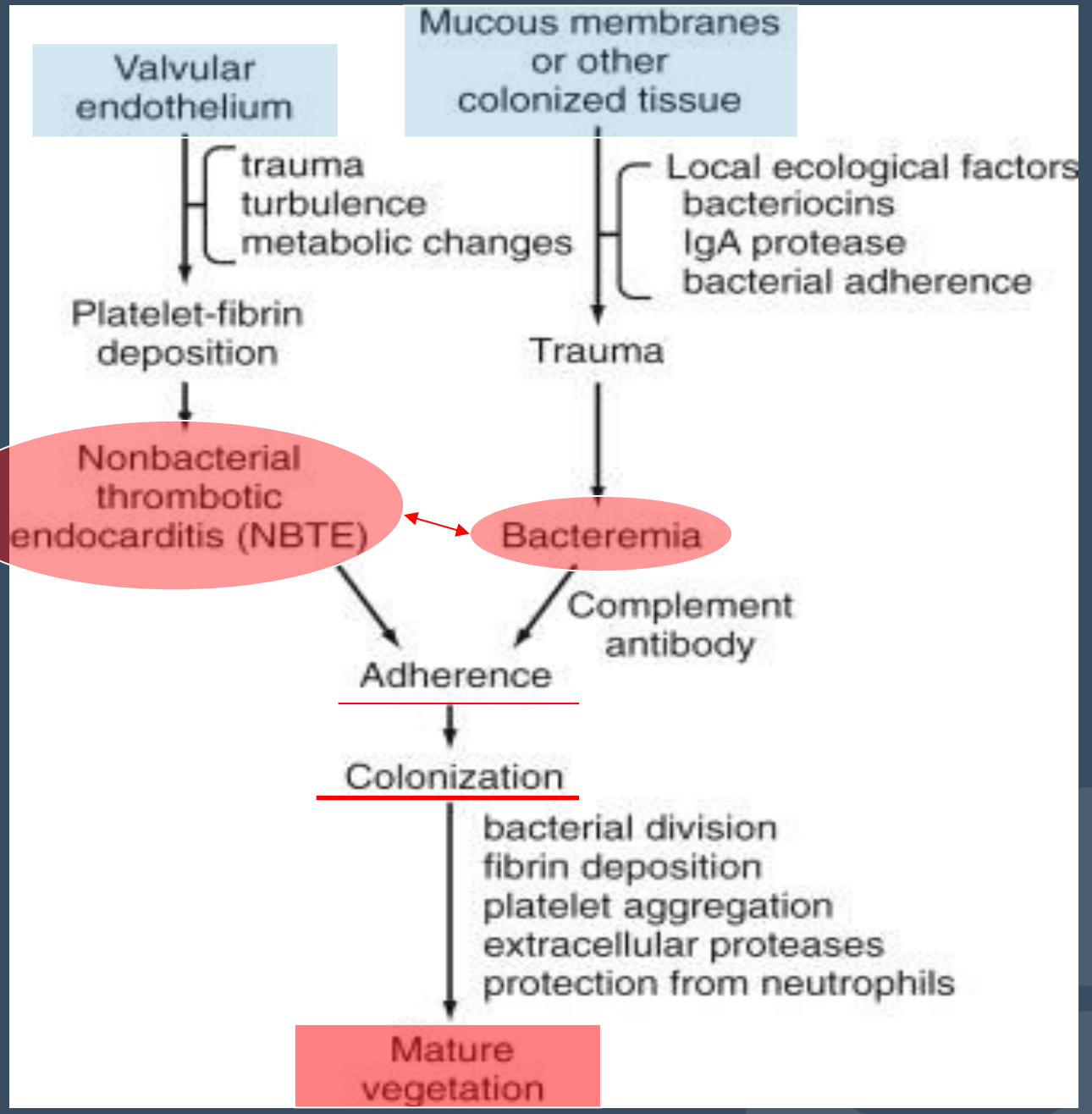




Epidemiology of infective endocarditis

- Annual US incidence is 10,000 – 30,000 new cases
- Over 80% are caused by staphylococci and streptococci
- Secular trends
  - Patients are getting older
  - A higher proportion have PVE
  - Increasing prevalence of staphylococcal and enterococcal infections and a lower prevalence of viridans group streptococcal infections
  - Higher proportion accounted for by PWID

Pathogenesis of IE



From Mandell, Douglas and Bennett's Principles and Practice of Infectious Diseases. Endocarditis and Intravascular Infections, Figure 77-1

Clinical presentation

- Predisposing cardiac conditions or injection drug use
- Fatigue (90%)
- Fever (70%)

- New regurgitant murmur
- In hemiplegia in young adults, always consider strongly the possibility of IE
- A presentation of a febrile illness followed by stroke should always prompt suspicion for IE

Peripheral Findings in IE

Conjunctival hemorrhage





Janeway lesion

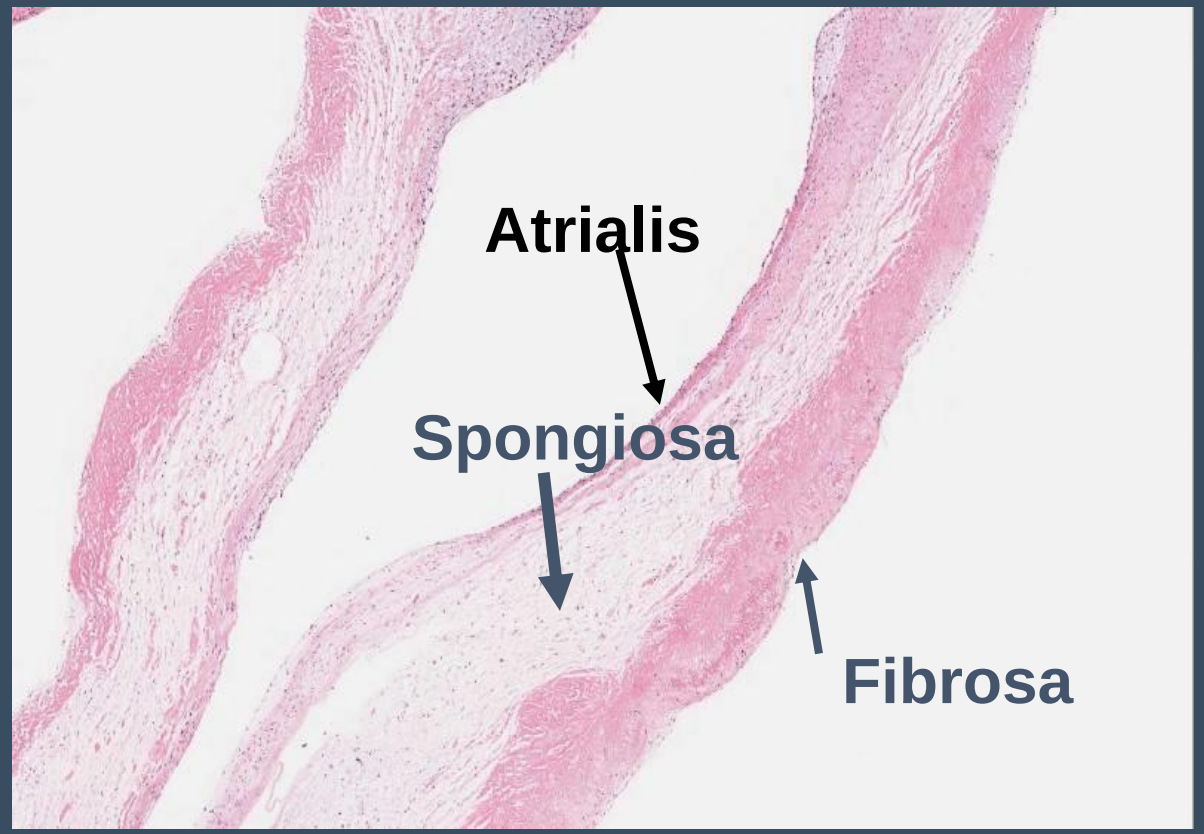
Osler node



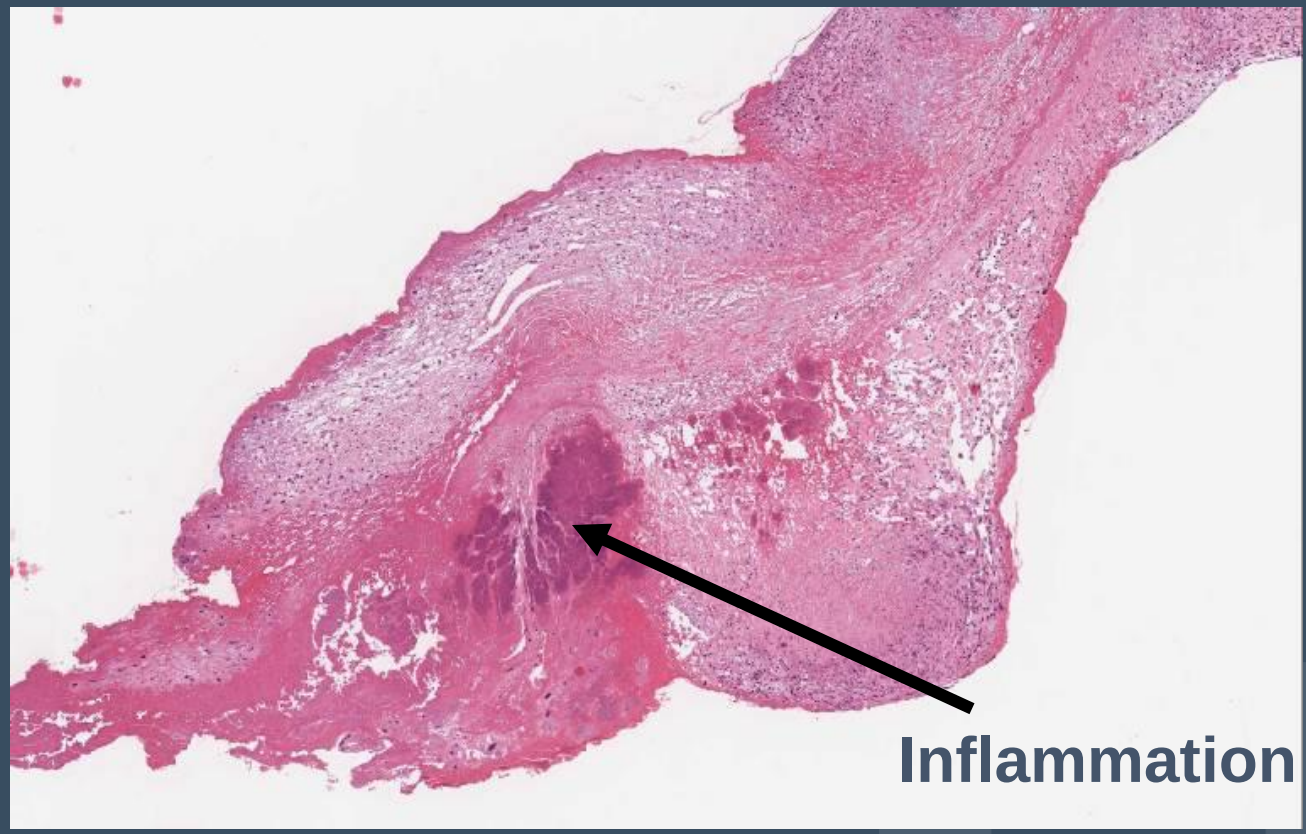


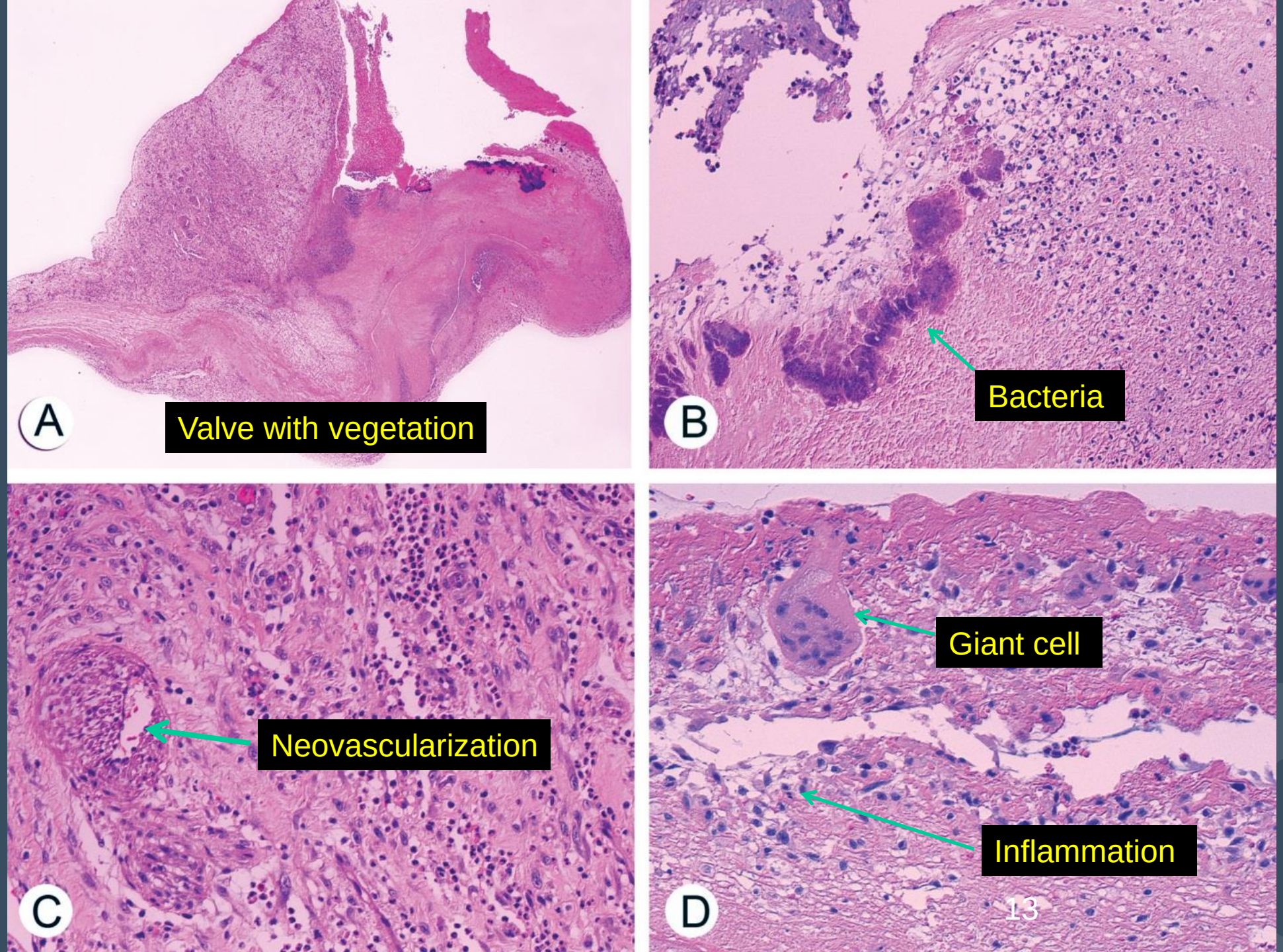
Embolic occlusion

Normal aortic valve anatomy



Infective endocarditis




A
Valve with vegetation
B
Bacteria
C
Neovascularization
D
Giant cell
Inflammation

13

Diagnosis of infective endocarditis

- Gold standard
  - Direct evidence of infective endocarditis on histopathology from surgery or autopsy or peripheral embolus:
    - Polymorphonuclear leukocytes, or
    - Microorganisms

- *In the absence of a pathological diagnosis*:
  - Duke Criteria

Reyn CF, Levy BS, Arbeit RD, Friedland G, Crumpacke CS. Infective endocarditis: an analysis based on strict case definitions. Ann Intern Med 1981; 94: 505 - 518

Elements of Duke Criteria

- Positive blood cultures
- Echocardiography findings

Major criteria

- Fever
- Predisposing conditions
- Embolic events
- Immunological findings
- “Minor” blood culture findings

Minor criteria

Diagnosis of infective endocarditis by Duke Criteria

- Definite endocarditis
  - 2 major criteria
  - 1 major and 3 minor criteria
  - 5 minor criteria

- Possible endocarditis
  - 3 minor criteria

Gold standard for diagnosis of infective endocarditis in 2025

- Histopathological examination
  - To make a diagnosis of infective endocarditis

- PCR of valve tissue
  - To identify the pathogen

Common causes of IE

- *Staphylococcus aureus*
- Viridans group streptococci
- *Enterococcus*
- Coagulase-negative staphylococci
- Other streptococci

Endocarditis pathogens not identifiable by routine blood culture

- *Cutibacterium acnes (*Formerly *Propionibacterium acnes)*
- *Bartonella spp.*
- *Histoplasma capsulatum*
- *Coxiella burnetii*
- *Tropheryma whippleii*
- *Brucella spp.*
- *Mycobacterium chimaera*

If you are considering a diagnosis of IE …

- Microbiological testing
  - Blood cultures
    - *3 sets of blood cultures (before antimicrobials) will yield the pathogen in > 85% of cases of IE*
    - *At least 3 sets (>= 1 hour between first and last set)*
    - *Each set should consist of 10 mL in each aerobic and anaerobic bottle*

- Imaging
  - Echocardiography
    - Transthoracic echocardiography (sensitivity 50 – 80%)
    - Transesophageal echocardiography (sensitivity 90%)
  - Whole body PET scan
  - CT aortography

Treatment of infective endocarditis

- Surgery
- Antibiotic therapy
- Treatment of injection drug use

Infective endocarditis treatment guidelines

AHA Scientific Statement

Infective Endocarditis in Adults: Diagnosis, Antimicrobial Therapy, and Management of Complications

A Scientific Statement for Healthcare Professionals From the American Heart Association

Endorsed by the Infectious Diseases Society of America

Larry M. Baddour, MD, FAHA, Chair; Walter R. Wilson, MD; Arnold S. Bayer, MD; Vance G. Fowler, Jr, MD, MHS; Imad M. Tleyjeh, MD, MSc; Michael J. Rybak, PharmD, MPH; Bruno Barsic, MD, PhD; Peter B. Lockhart, DDS; Michael H. Gewitz, MD, FAHA; Matthew E. Levison, MD; Ann F. Bolger, MD, FAHA; James M. Steckelberg, MD; Robert S. Baltimore, MD; Anne M. Fink, PhD, RN; Patrick O'Gara, MD, FAHA; Kathryn A. Taubert, PhD, FAHA; on behalf of the American Heart Association Committee on Rheumatic Fever, Endocarditis, and Kawasaki Disease of the Council on Cardiovascular Disease in the Young, Council on Clinical Cardiology, Council on Cardiovascular Surgery and Anesthesia, and Stroke Council

2023 ESC Guidelines for the management of endocarditis: Developed by the task force on the management of endocarditis of the European Society of Cardiology (ESC) *Endorsed by the European Association for Cardio-Thoracic Surgery (EACTS) and the European Association of Nuclear Medicine (EANM)*

FREE

Victoria Delgado ✉, Nina Ajmone Marsan, Suzanne de Waha, Nikolaos Bonaros, Margarita Brida, Haran Burri, Stefano Caselli, Torsten Doenst, Stephane Ederhy, Paola Anna Erba, Dan Foldager, Emil L Fosbøl, Jan Kovac, Carlos A Mestres, Owen I Miller, Jose M Miro, Michal Pazdernik, Maria Nazarena Pizzi, Eduard Quintana, Trine Bernholdt Rasmussen, Arsen D Ristić, Josep Rodés-Cabau, Alessandro Sionis, Liesl Joanna Zühlke, Michael A Borger ✉, ESC Scientific Document Group

Indications for surgery in infective endocarditis

ABSOLUTE INDICATIONS

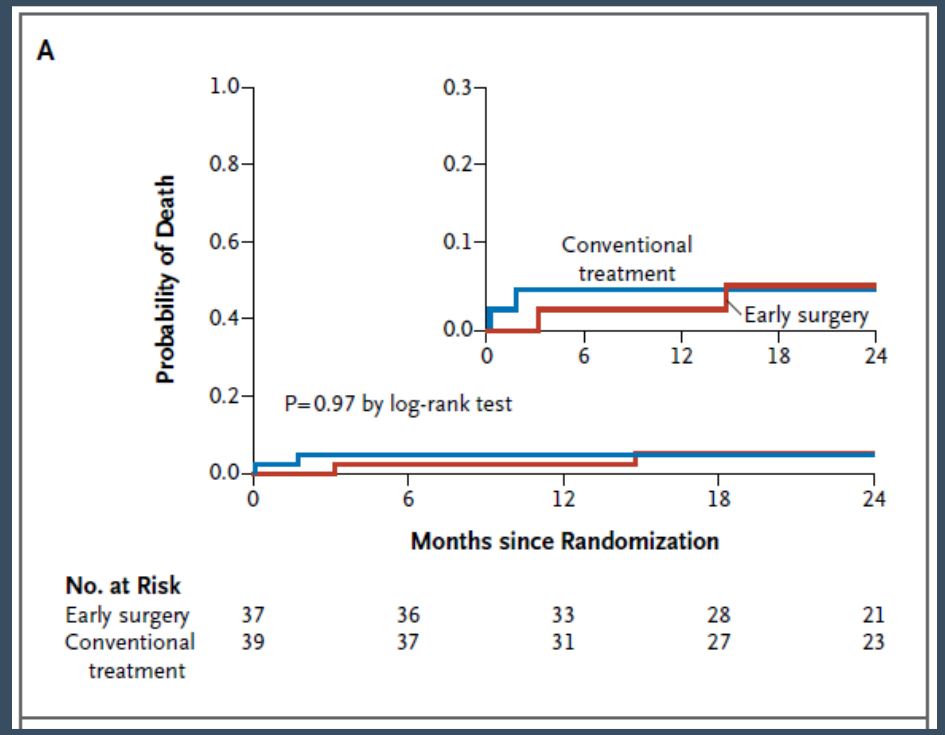
- Hemodynamic instability
  - Severe heart failure, particularly from acute aortic or mitral regurgitation
  - Significant valve obstruction from bulky vegetations
  - Prosthetic valve dehiscence
- Invasive disease
  - Paravalvular abscess
- Infections that cannot be controlled medically
  - *Pseudomonas aeruginosa* PVE
  - VRE PVE

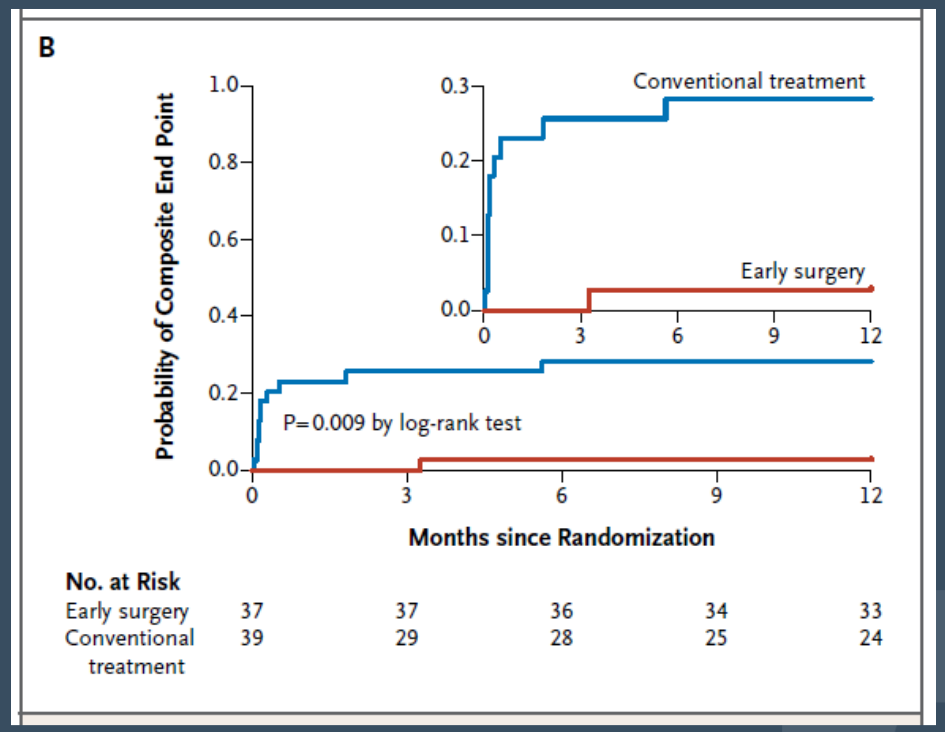
RELATIVE INDICATIONS

- Virulent pathogens
  - Fungal IE
  - *Staphylococcus aureus* PVE
- Significant embolic risk
- Large vegetation
- Failure of medical therapy
- PVE

Early versus late surgery for IE

In patients who have an indication for surgery, should surgery be performed promptly or should it be delayed until the infection is under control?



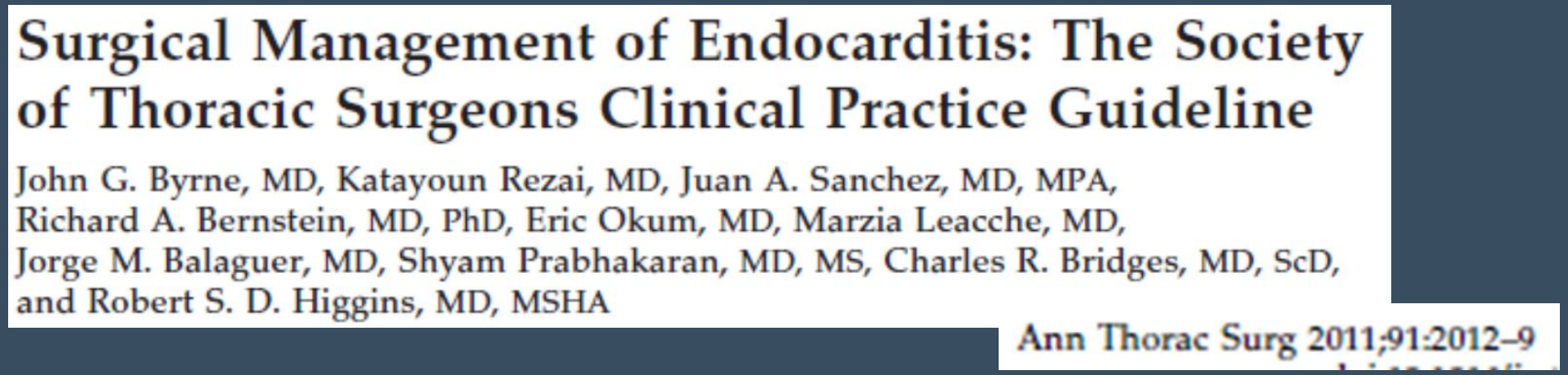


If there is an indication for surgery, it should be done without delay

The NEW ENGLAND JOURNAL of MEDICINE

Kang, D-H, et al. Early surgery versus conventional treatment for infective endocarditis. NEJM 2012;366:2466-73

When to delay surgery in infective endocarditis



Surgical Management of Endocarditis: The Society of Thoracic Surgeons Clinical Practice Guideline

John G. Byrne, MD, Katayoun Rezai, MD, Juan A. Sanchez, MD, MPA, Richard A. Bernstein, MD, PhD, Eric Okum, MD, Marzia Leacche, MD, Jorge M. Balaguer, MD, Shyam Prabhakaran, MD, MS, Charles R. Bridges, MD, ScD, and Robert S. D. Higgins, MD, MSHA

Ann Thorac Surg 2011;91:2012–9

- In patients who have had a major ischemic stroke or any intracranial hemorrhage, it is reasonable to delay valve replacement for at least 4 weeks from the stroke, if possible. (Class IIa, Level of evidence C)
- If there is a decline in cardiac function, recurrent stroke or systemic embolism or uncontrolled infection despite adequate antibiotic therapy, a delay of less than 4 weeks may be reasonable, particularly in patients with small areas of brain infarction. (Class IIb, Level of evidence C)

Antibiotic therapy

Pathogen	Antibiotic options
Staphylococci	Oxacillin/nafcillin, cefazolin, vancomycin, ceftaroline, daptomycin
Streptococci	Ceftriaxone, penicillin G, antibiotics effective against staphylococci
Enterococci	Ampicillin, vancomycin, daptomycin
HACEK group	Ceftriaxone
Candida	Micafungin
Bartonella	Doxycycline, ceftriaxone

Partial oral versus IV treatment for IE

Can infective endocarditis be treated with oral antibiotics?

- **Study design:** RCT, non-inferiority
- **Study sample: stable** adults with left-sided IE, on at least 10 days of IV antibiotics, 7 days after surgery, no abscess
- **Partial oral group:** Switched to oral antibiotic
- **IV group:** Continued IV antibiotic therapy
- **Outcomes:** all-cause mortality, unplanned cardiac surgery, clinical evident embolic events, relapse of bacteremia

Table 2. Distribution of the Four Components of the Primary Composite Outcome.*

Component	Intravenous Treatment (N = 199)	Oral Treatment (N = 201)	Difference	Hazard Ratio (95% CI)
	number (percent)		*percentage points (95% CI)*	
All-cause mortality	13 (6.5)	7 (3.5)	3.0 (−1.4 to 7.7)	0.53 (0.21 to 1.32)
Unplanned cardiac surgery	6 (3.0)	6 (3.0)	0 (−3.3 to 3.4)	0.99 (0.32 to 3.07)
Embolic event	3 (1.5)	3 (1.5)	0 (−2.4 to 2.4)	0.97 (0.20 to 4.82)
Relapse of the positive blood culture†	5 (2.5)	5 (2.5)	0 (−3.1 to 3.1)	0.97 (0.28 to 3.33)

Iverson K, et al. Partial oral versus intravenous antibiotic treatment of endocarditis. NEJM 2019;380:415-424

Partial oral versus IV treatment for IE

Iverson K, et al. Partial oral versus intravenous antibiotic treatment of endocarditis. NEJM 2019;380:415-424

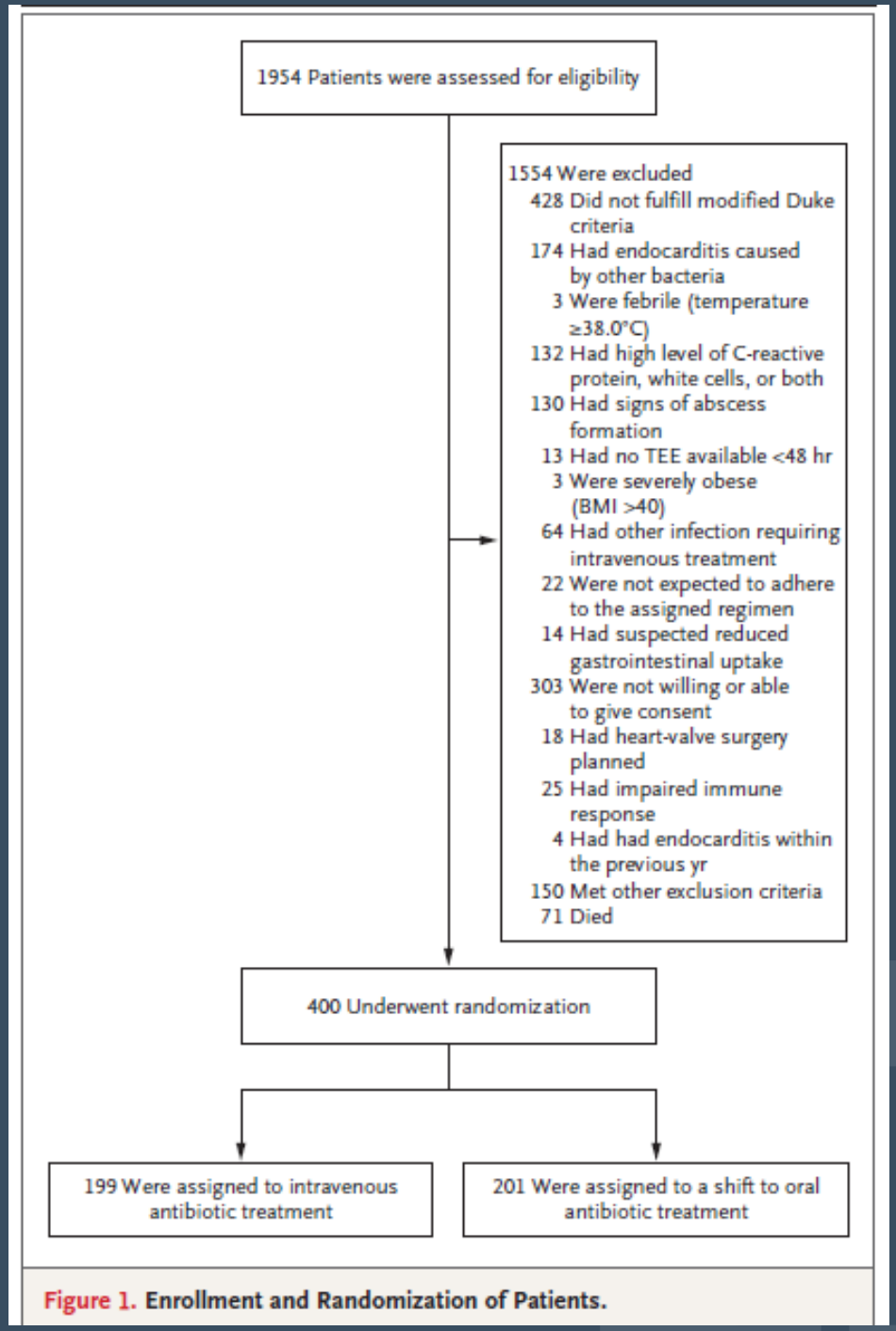


Figure 1. **Enrollment and Randomization of Patients.**

Treatment of infective endocarditis in persons who inject drugs

- Address the drug addiction
- Surgery when needed
  - Distinguish between an indication for surgery and an urgency for surgery
- Antibiotic treatment

Infective endocarditis prophylaxis

Rationale: patients with certain cardiac conditions are at high risk of developing endocarditis when undergoing certain procedures

Cardiac conditions for which prophylaxis is recommended

Procedures for which prophylaxis is recommended

Antimicrobial regimen

Infective endocarditis prophylaxis

Cardiac conditions for which prophylaxis is recommended:

- Prosthetic cardiac valves or material
- Prior history of IE
- Complex congenital heart disease (CHD)
  - Unrepaired cyanotic CHD
  - Completely repaired CHD with prosthetic material up to 6 months after the procedure
  - Repaired CHD with residual defects at the site or adjacent to the site of a prosthetic patch or prosthetic device
- Cardiac transplant recipients who develop cardiac valvulopathy

Infective endocarditis prophylaxis

Procedures for which prophylaxis is recommended:

- Dental procedures (VGS)
- Respiratory tract procedures involving incision of respiratory mucosa (VGS, SA)
- Urinary tract procedures in the setting of infected urine (Entc)
- Skin procedures through infected skin (SA, CoNS, BHS)
- Surgery to place prosthetic heart valves or prosthetic intravascular or intracardiac materials (SA, CoNS, Entc)

Microorganism abbreviations:
VGS: viridans group streptococci
SA: Staphylococcus aureus
Entc: Enterococcus
CoNS: coagulase negative staphylococci
BHS: beta hemolytic streptococci

Infective endocarditis prophylaxis regimens

Table 5. Antibiotic Regimens for a Dental Procedure Regimen: Single Dose 30 to 60 Minutes Before Procedure.

Situation	Agent	Adults	Children
Oral	Amoxicillin	2 g	50 mg/kg
Unable to take oral medication	Ampicillin OR	2 g IM or IV	50 mg/kg IM or IV
	Cefazolin or ceftriaxone	1 g IM or IV	50 mg/kg IM or IV
Allergic to penicillin or ampicillin—oral	Cephalexin* OR	2 g	50 mg/kg
	Azithromycin or clarithromycin OR	500 mg	15 mg/kg
	Doxycycline	100 mg	<45 kg, 2.2 mg/kg >45 kg, 100 mg
Allergic to penicillin or ampicillin and unable to take oral medication	Cefazolin or ceftriaxone†	1 g IM or IV	50 mg/kg IM or IV

Clindamycin is no longer recommended for antibiotic prophylaxis for a dental procedure.
IM indicates intramuscular; and IV, intravenous.
* Or other firstor second-generation oral cephalosporin in equivalent adult or pediatric dosing. † Cephalosporins should not be used in an individual with a history of anaphylaxis, angioedema, or urticarial with penicillin or ampicillin.

ACC/AHA guideline. Circulation 2020;143:e72-e227.

Cardiovascular implantable electronic device infections

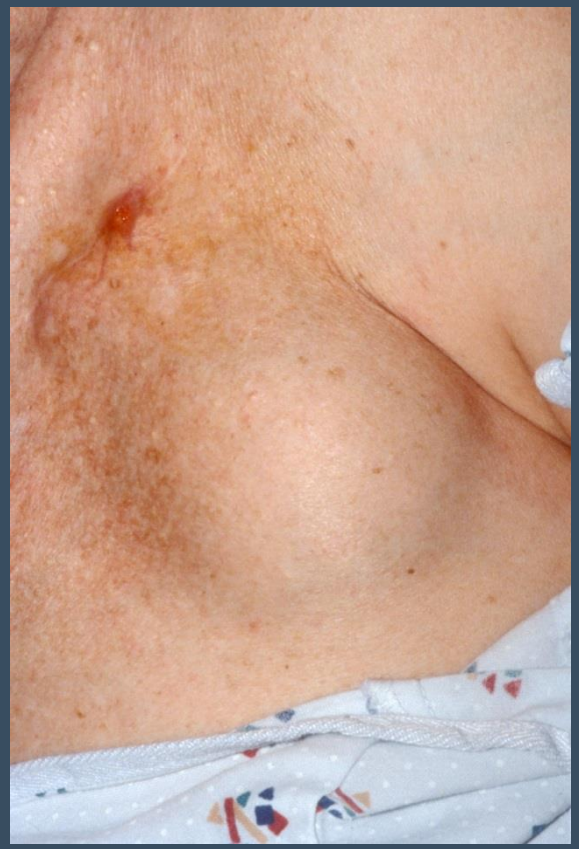
Clinical presentation

- CIED pocket infection
- Bacteremia
- Surgical site infection (SC ICD and loop recorders)

Investigation

- Blood cultures
- TEE to look for evidence of lead or valve vegetations
- Drainage culture

Cardiovascular implantable electronic device infections







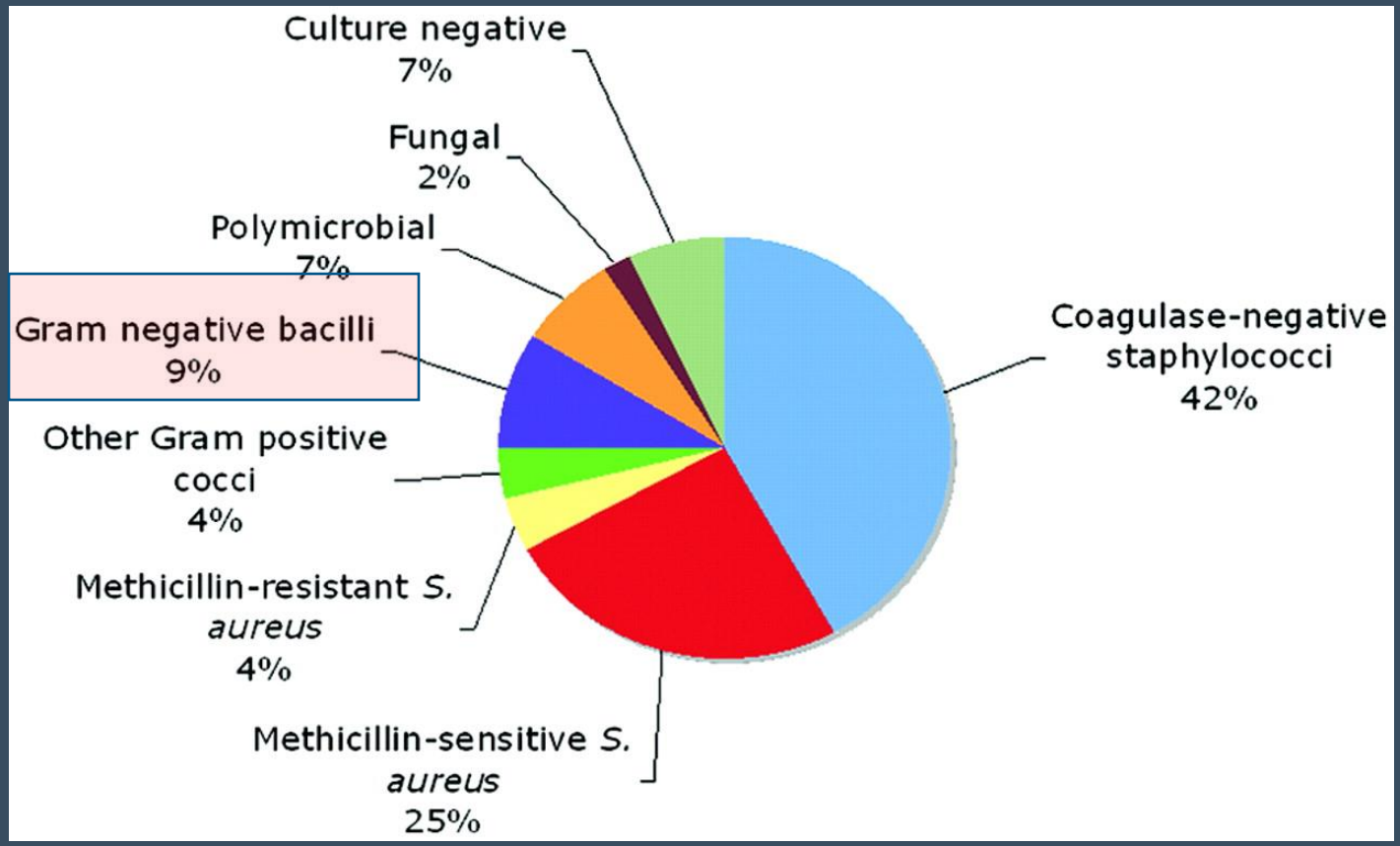








Microbiology of CIED infections



Nagpal A, et al. Microbiology and pathogenesis of cardiovascular implantable electronic device infections. Circulation: arrhythmia and electrophysiology 2012;5:433-441.

Management of CIED infections

REVIEW ARTICLE | Originally Published 4 December 2023 | Check for updates

Update on Cardiovascular Implantable Electronic Device Infections and Their Prevention, Diagnosis, and Management: A Scientific Statement From the American Heart Association

Larry M. Baddour, MD, FAHA, Chair, Zerelda Esquer Garrigos, MD, M. Rizwan Sohail, MD, Eva Havers-Borgersen, MD, Andrew D. Krahn, MD, Vivian H. Chu, MD, Connie S. Radke, MSN, NP, Jennifer Avari-Silva, MD, FAHA, Mikhael F. El-Chami, MD, Jose M. Miro, MD, PhD, and Daniel C. DeSimone, MD, Vice Chair on behalf of the American Heart Association Council on Lifelong Congenital Heart Disease and Heart Health in the Young (Young Hearts); and Council on Clinical Cardiology | AUTHOR INFO & AFFILIATIONS

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74,787 / 46 PDF/EPUB



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Remove the infected device

Circulation 2010; 121: 458-477.

Summary

- Fatigue and fever are the most common symptoms of IE
- Fever and stroke, fever and a new heart murmur, or stroke in a young person, should prompt investigation for IE
- Blood cultures and echocardiography (preferably TEE) are the most important tests for diagnosing IE
- Gold standard for diagnosing endocarditis is histopathology; best test for identifying the pathogen is PCR of excised cardiac valve tissue
- When surgery is needed for IE, early surgery is better
- Endocarditis prophylaxis only recommended for high risk cardiac conditions
- Primary treatment of vascular catheter and CIED infection is removal of the infected device



Cleveland Clinic

Every life deserves world class care.